MGDS Annotated Outline

Chapter 3.0 Natural Systems Of the Geologic Setting

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3.0 NATURAL SYSTEMS OF THE GEOLOGIC SETTING

Skeleton Text Has Not Been Developed For This Section

REFERENCES

MGDS Annotated Outline Planning Package
Form 1: Text

Date: 4/17/92

1. Section No. & Title: **3.0 NATURAL SYSTEMS OF THE GEOLOGIC SETTING**

2. Lead Author & Phone No. Hank Lang (702) 794-1821

3. First Phase Planning Package Due: 6/21/91

   Second Phase Planning Package Due: 10/18/91

   First Phase Skeleton Draft Due: 12/30/91

   Second Phase Skeleton Draft Due: 3/15/92

4. Plan Approved: W.R. Griffin 8/27/91
   (Licensing Mgr & Lead Author)

5. Section Summary (Approximately 100 Words):

   This section describes the natural systems of the geologic setting of the region in which the repository is to be located. Included are descriptions of the overall purpose and function of the repository site and how the site fulfills the requirements of 10CFR Part 60. Descriptions and assessments focus on the function of the natural systems of the geologic setting in isolating high-level radioactive waste from the accessible environment.

6. Opening Statement:

7. Main Body Outline:

   See attached.

8. Conclusion:

9. Support Authors & Their Assignments:

   Bill Distel, [others].

The above Annotated Outline text is guidance that may be used for the future development of an MGDS License Application.

7. Main Body Outline: (Continued)

3.0.0 Introduction

3.0.1 Natural Systems

(Reference Table 3.0A). Describe the natural systems of the geologic setting of the region of the site, to include those within the controlled area (CA); additionally, any conditions outside the CA affecting isolation within the CA.

3.0.2 Geologic Setting of the Geologic Repository Region

(Reference Diagram 3.0B) and (Reference Photo 3.0C). Describe the geologic setting of the region in which the geologic repository is to be located.

3.0.3 Overall Purpose and Function of the Repository Site

(Reference Table 3.0D). Describe the overall purpose and function of the repository site.

3.0.4 Requirements of 10CFR60 for a Nuclear Repository

(Reference Table 3.0E). Describe how the site fulfills the requirements of 10CFR Part 60.

Indicate the major items in 10CFR Part 60 that are fulfilled for the nuclear waste site requirements.

3.0.5 Capability of the Natural Systems in Isolating High-Level Radioactive Waste from the Accessible Environment

(Reference Table 3.0F). Describe and assess the function of the natural systems of the geologic setting in isolating high-level radioactive waste from the accessible environment.

MGDS Annotated Outline Planning Package
Form 2: Figures & Tables

Date: 4/17/92

Section No. & Title: **3.0 NATURAL SYSTEMS OF THE GEOLOGIC SETTING**

Lead Author & Phone No. Hank Lang (702) 794-1821

A. Figure No. 3.0A

Caption: **Natural Systems of the Geologic Setting**

Content: See Paragraph 3.0.1

This will show the primary natural systems found and active in the geologic setting in the region of the geologic repository.

Natural Systems of the Geologic Setting

- Strata	- Zones	- Volcanos
- XTUFF	- UX	- YTUFF
- Z----	- SZ	

B. Figure No. 3.0B

Caption: **Geologic Setting of the Geologic Repository Region**

Content: See Paragraph 3.0.2

This diagram will provide a dimensional surface view of the geologic setting, in the geologic repository region.

C. Figure No. 3.0C

Caption: **Geologic Setting of the Geologic Repository Region**

Content: See Paragraph 3.0.2

This photo will be a N-S oriented photo at an oblique angle of between 45 degrees - 60 degrees, to show the physical aspects of the YM and surrounding surface geologic setting.

MGDS Annotated Outline Planning Package
Form 2: Figures & Tables

Date: 4/17/92

Section No. & Title: **3.0 NATURAL SYSTEMS OF THE GEOLOGIC SETTING**

Lead Author & Phone No. Hank Lang (702) 794-1821

A. Table No. **3.0D**

Title: **Overall Purpose and Function of the Repository Site**

Content: See Paragraph 3.0.3

Overall purpose is .....

Functions
Function 1
Function 2
Function 3
Function 4
Function 5

B. Table No. **3.0E**

Title: **Major Requirements of 10CFR 60 for a Nuclear Repository Site**

Content: See Paragraph 3.0.4

10CFR 60: Title: Disposal of HL Radioactive Waste in Geologic Repository

1. ---------
a. Cite major title items that pose
b. specific/major requirements
2. ---------

*See Paragraph 3.0.4

C. Table No. 3.0F

Title: Capability of the Natural Systems of the Geologic Setting in Isolating High Level Radioactive Waste from the Accessible Environment

Content: See Paragraph 3.0.5

Part 1: High Level Waste Special Requirement
1. ----
   a.
   b.
   etc.

Part 2: Natural Systems Isolation Capabilities
1. TUFF
   a. SZ
   b. UZ
2. Water Table?
   a.

MGDS Annotated Outline Planning Package
Form 3: References

Date: 4/17/92

Section No. & Title: 3.0 NATURAL SYSTEMS OF THE GEOLOGIC SETTING

Lead Author & Phone No.: Hank Lang (702) 794-1821

Instructions: List all books, articles, or other references that are expected to be used for the section. Indicate whether references are draft or final, and whether they are publicly available (i.e., published). Refer to the Writer's Guide, Appendix D of the Annotated Outline Management Plan for guidance on formatting reference information.

1. USGS Mapping and Photo Service.

2. DOE Satellite Imagery.

3. NASA Earth Resources Imagery.

4.

5.

6.

7.

8.

MGDS Annotated Outline Information Need Form Date: 4/17/92
Form A: Information Request

1. Log number: **HL-1**

2. Section no. & title: **3.0 NATURAL SYSTEMS OF THE GEOLOGIC SETTING**

3. Lead author & phone no: **Hank Lang (702) 794-1821**
   Placeholder for TBD

4. Information request date: **2/21/92**

5. Work location: **M&O - Las Vegas**

6. Type of information needed:

   A definition of "Natural Systems" and a short discussion of their capabilities to act as natural barriers to isolate radioactive HLW.

7. What is the information needed for?

   FCRG, in Section 3.0 requires a "Focus on the function of the natural systems of the geologic setting in isolating high level radioactive waste from the accessible environment".

8. What group is the probable information supplier?

9. When is the information needed?

   ASAP.

10. What kind of related information is already available in references, etc.?

    10 CFR 60.

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form B: Information Response

Date 4/17/92

1. Section No. & Title: **3.0 NATURAL SYSTEMS OF THE GEOLOGIC SETTING**

2. Person Supplying Information: Hank Lang (702) 794-1821

3. Phone No.:

4. Lead Author (Requester):

Instructions: Information suppliers may use this form to communicate information that has been requested by lead authors via Information Request Forms. The Log Number on this form should be identical to the Log Number of the Information Request Form.

5. Response by Information Supplier:

Note: Attach additional sheets if necessary.

MGDS Annotated Oultine Information Need Form Date: 4/17/92
Form C: Information Request Tracking Log

Note: This is a recommended format for a manual tracking system. Other tracking methods such as a simple computer data base are also acceptable.

Date:

Lead Author:

Log No.	Section	Date Issued	Date Response Received

Section 3.1 Description of Individual Systems and Characteristics of the Site

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3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE

3.1.0 Introduction

This section describes the natural systems of the geologic setting in the region of the site, specifically for the "controlled area". However, if conditions outside the controlled area affect waste isolation within the controlled area, then the relevant and material information on conditions outside the controlled area are included. The controlled area is defined in 10 CFR 60 as "a surface location, to be marked by suitable monuments, extending horizontally no more than 10 kilometers in any direction from the outer boundary of the underground facility, and the underlying subsurface, which area has been committed to use as a geologic repository and from which incompatible activities would be restricted following permanent closure".

The natural systems of the geologic setting in the region in the site consists of: geologic system, hydrologic system, geochemical system, and climatological and meteorological system. This section also contains the integrated natural system response to the maximum design thermal loading. [The extent of the geologic setting is to be described and must be determined in the future.]

3.1.1 Geologic System

This section describes the geologic conditions of both the geologic setting and the region of the site. It is demonstrated that the areas studied provide a representative description of the conditions throughout the region around the site and at the site. Detailed justification for the areal limits placed on regional studies are provided.

The pertinent data, analyses, and level of assessment of natural geological analogs are provided such as those selected for tectonic (faulting, seismic, and volcanic) models, natural resource assessment, and geomorphic evaluation of the site. The basis for selecting the analog and the basis for comparing and contrasting the analog conditions with those at the site are described. Similarities between the natural analog and the site, the process or features of interest, how the analog is used, the time frame of the comparative study, and any differences in scale or features between the analog and the site are described and discussed. Maps and cross sections are provided to illustrate the location and geological characteristics of the analog sites.

Sources of information and data collection methods used to obtain measurements and observations are described and documented. Geological and geophysical descriptions are accompanied by maps, cross sections, photographs, and fence diagrams. The variability and uncertainty of data and information is discussed.

The representativeness of the data, the effects of varying geologic conditions, the reliability of geological and geophysical interpretations made and uncertainties associated with the extrapolation of data and information to repository conditions are addressed in the discussions and descriptions. The use of conceptual models is discussed with respect to uncertainties in the data bases, the applicability and appropriateness of the geologic assumptions, the sensitivity of the model results to the uncertainty of the geologic input data and model validation.

3.1.1.1 Regional Geology

The geologic characteristics in the region of the site are described, accompanied with sufficient data and technical analyses to demonstrate a clear understanding of the regional geology.

3.1.1.1.1 Geomorphology and Topographic Features in the Region of the Site

The data, information, investigations, and analyses related to the geomorphology and topographic features in the region of the site is described (KKB-1 define "the region of the site", its extent and relation to the controlled area). The past, present, and future conditions such as climate and tectonism that influence the geomorphic and topographic features are described.

Identification of the geomorphic units and features within and abutting the controlled area, geomorphic processes that are acting and could be acting within the geologic system, and the paleogeomorphic processes that have occurred, could have occurred, or could re-occur within the geologic system are addressed here. Erosion rates that occurred within the Quaternary Period and on those rates projected to occur during the next 10,000 years are emphasized.

[In order to demonstrate compliance with all applicable regulatory requirements, the data and analyses presented here must demonstrate that the region surrounding Yucca Mountain has been stable during much of the middle and late Quaternary Period and the rate of geomorphic processes are likely to remain low during the next 10,000 years of repository performance period.]

Desert geomorphic processes acting in conjunction with extensional tectonism have molded the present topography of the Yucca Mountain area. Future tectonism, climatic change, or complex threshold-related changes could alter the intensity and distribution of these processes, thereby changing present pattern and rates of erosion and deposition. In turn, such changes could affect the surface drainage, erosion, ground water recharge, and subsurface water flow. These factors are all important to the construction and operation of the repository and waste isolation.

3.1.1.1.1.1 Regional Physiography

The physiographic areas surrounding Yucca Mountain include: 1) the large north-south trending basins and ranges of the central Great Basin; 2) the basins and ranges of the southeast Great Basin; 3) the massive ranges and deep basins of the southwest Great Basin; 4) the small, irregularly shaped ranges and basins of the northeast Mojave Desert and 5) the highly variable

Figure 3.1.1.1.1.1.A. Generalized Map showing Approximate Locations of the Physiographic Subdivisions of West Central and Southern Great Basin

Table 3.1.1.1.1.1A Morphometric Characteristics of Physiographic Areas in the Southern Great Basin terrain of the northwest-trending Walker Lane belt (Figure 3.1.1.1.1.1A, source SCP Figure 1-3). The general characteristics of these areas are summarized in Table 3.1.1.1.1.1A, source SCP Tables 1-1a and 1-1b).

The controlled area and the adjacent area of the Yucca Mountain area are subdivided into eight clearly defined physiographic areas: Bare Mountain, Crater Flat, Yucca Mountain, Fortymile Wash, Jackass Flats, the valley of the Beatty Wash, Pinnacles Ridge, and the northeast margin of the Amargosa Desert. These areas are shown in Figure 3.1.1.1.1.1B. Figures 3.1.1.1.1.1C and D are Landsat image and overlay for the Yucca Mountain area. Figures 3.1.1.1.1.1E and F show high-altitude photographs and overlay of the Yucca Mountain area respectively. (Source of these figures are SCP Figures 1-6, 1-7a, 1-7b, 1-8a, and 1-8b).

3.1.1.1.1.2 Geomorphic Process

The long-term geomorphic process that might affect the construction, operation, or long-term waste isolation capability of the repository is discussed below. The types and the rates of geomorphic processes operating in the region surrounding Yucca Mountain is described. The Quaternary erosion rates in the southern Great Basin and adjacent areas, and the more significant geomorphic processes presently active in the Yucca Mountain area are included in this discussion. Together with predictions of future tectonic activity and climatic change, this information is necessary for estimating the magnitude and the distributions of erosion and deposition on Yucca Mountain and the contiguous piedmonts in the next 10,000 years.

Figure 3.1.1.1.1.1B. Topography and Physiographic Subdivisions of the Yucca Mountain Area

Figure 3.1.1.1.1.1C. Landsat Image of the Yucca Mountain Area

Figure 3.1.1.1.1.1C. Overlay for the Landsat Image in Figure 3.1.1.1.1.1C (Continued)

Figure 3.1.1.1.1.1D. High-Altitude Oblique Aerial Photograph of the Yucca Mountain Area

Figure 3.1.1.1.1.1E. TBD

Figure 3.1.1.1.1.1F. TBD

Conditions Relevant to the Geomorphic Processes. The geomorphic processes in the southern Great Basin and the Northern Mojave Desert are largely determined by climate, existing topography, and tectonic activity, as well as the spatial and temporal relationship between these determinants.

Influence of Tectonism on Geomorphic Process. Differential vertical movement induced by regional extensional tectonism has probably been the most single important factor in the development of the landscape of the region surrounding Yucca Mountain. Specifically in the Yucca Mountain area, including Yucca Mountain, the average rate of relative vertical tectonic adjustment during the late Tertiary and Quaternary periods have been estimated by Carr (Reference 3.1.1.1.1.2-A, Carr, 1984) to be less than 3 cm per 1,000 years. Thus, it is unlikely that vertical tectonic movement will significantly affect the types and rates of geomorphic process in the Yucca Mountain in next 10,000 years.

Influence of Climate on Geomorphic Processes. Yucca Mountain is one of the warmest and driest regions in the United States. The present climate is characterized by hot summers, mild winters, and little precipitation. Glacial and periglacial processes have not been active (KKB-2, provide the evidence) in the Yucca Mountain area during most or all of middle and late Quaternary time. Thus, lacustrine processes were, at most, confined to limited basin areas.

The semiarid to arid climates of the past and present have tended to preserve the landscape of the region of Yucca Mountain. Weathering has been limited. Flow of surface water is intermittent and subjected to flash floods resulting in intermittent sediment transport. The late and middle Pleistocene ages of many of these landforms and radiometric ages attest to the slow and discontinuous nature of sediment transport throughout this region.

3.1.1.1.1.3 Average Erosion Rates in the Region of Yucca Mountain

The average Quaternary erosion rates for local areas of Southern Great Basin and northern Mojave Desert is estimated to range between (___ and ___ cm per 1000 yr). The general degradation of upland areas in the region surrounding Yucca Mountain is proceeding relatively slowly.

3.1.1.1.1.4 Significant Late Quaternary Geomorphic Process

Tectonic and Volcanic Processes. During the Quaternary period, tectonic and volcanic processes in the Yucca Mountain area have included: 1) less than 3 cm/1000 yr relative vertical tectonic adjustment; 2) local surface faulting along the eastern and western flank of the Bare Mountain, along the eastern and western flanks of the Yucca Mountain, and in Crater Flat; 3) horizontal movement on these fault systems (__ cm), and 4) local Strombolian volcanic activity from seven basaltic centers located 8 to 40 km from the proposed repository. The effects of these past activities have been limited, and comparable tectonic and volcanic activities during the next 10,000 years should induce a comparably limited effect on the late Quaternary landscape of Yucca Mountain (KKB-3 provide study report to support this assertion).

Surficial Processes. Investigation of tectonic movement, climatic history, and general geomorphic characteristics of Yucca Mountain area shows that only a limited number of geomorphic processes involving the significant movement of surficial materials have been operating in the Yucca Mountain area during the late Quaternary. (KKB-4, provide estimates of these movements of surficial material during the Quaternary). The processes are: 1) degradation of upper upland slopes by weathering; 2) degradation of lower upland slopes 3) alternating degradation and aggradation of intermittent streamflow in the lower valley and upper piedmont areas 4) net aggradation by intermittent streamflow in lower piedmont and basin areas and, 5) eolian deposition on piedmonts and on lower upland slopes.

3.1.1.1.2 Stratigraphy and Lithology of the Region

The stratigraphic and lithologic framework of the region surrounding the Yucca Mountain is described in this section. The description includes a discussion of the relationship between stratigraphic and lithologic units.

The history of pertinent stratigraphic and lithologic units include a discussion of processes of formation and alternation. Discussions of formation should consider sedimentation, provenance, environment of genesis, and deposition. Alteration history includes alteration effects resulting from processes such as tectonism, metamorphism, plutonism, volcanism with attendant hydrothermal processes.

Geologic formations, hydrogeologic units, and the lithologic character of pre-Cenozoic and Cenozoic rocks in the southern part of the Great Basin is shown in Figure 3.1.1.1.2A (source SCP, Figure 1-10, Generalized regional stratigraphic column showing geologic formations and hydrogeologic units in the southern Great Basin). The pre-Cenozoic and Cenozoic parts of the sequence are separated by regionally significant unconformity discernible in the subsurface by geophysical means. Surficial deposits rest on late Tertiary and Quaternary erosional unconformity which is regionally extensive. (KKB-5 provide rationale for stratigraphic boundaries such as mineralogical or geochemical characteristics).

3.1.1.1.3 Seismology

A complete list of all historically reported earthquakes in the region surrounding the site is provided in Table 3.1.1.1.3A (KKB-6, provide the table by updating table 1-10 of SCP). The seismic record is derived from primarily two sources: 1) the catalog of historical earthquakes occurring prior to the installation of the Southern Great Basin Seismic Network (SGBSN) (Reference 3.1.1.1.3A, Meremonte and Rogers, 1987), and 2) SGBSN earthquake catalog (Reference 3.1.1.1.3B, Rogers, et.al. 1981, 1983, 1987). The list encompasses all earthquakes that have been reported to have occurred in geologic settings or on geologic structures that lie at least partially within 200 miles (320 km) of the site. Figure 3.1.1.1.3A shows the seismic activity

Figure 3.1.1.1.2A. Generalized Regional Stratigraphic Column showing Geologic Formations and Hydrogeologic Units in the Southern Great Basin

Figure 3.1.1.1.3A. Seismicity Within a Circle of 200 Miles Radius Centered on Yucca Mountain During the Recorded History (1769 to 199-)

within a circle of 200 miles radius centered on Yucca Mountain during the recorded history (1769 to 199-). (Source of figure, SCP Figure 1-51).

3.1.1.1.3.1 Relationship of Seismicity to Geologic or Tectonic Characteristics of the Candidate Area

The correlation of earthquakes to recognized geologic structures on seismotectonic zones is discussed here. In assessing the earthquake potential of the Yucca Mountain area, the spatial and temporal description of the seismicity and the spatial and temporal geologic characteristics of the area are compared in order to identify geologic structures or types of structures that may be capable of producing damaging earthquakes. Understanding the nature of the seismicity and its relationship to geologic structures contributed to the development of a tectonic model that was used to characterize future seismic activity. (KKB-7 This relationship between seismicity and geologic structure and the tectonic model is yet to be developed by WCC or LANL).

A number of seismic source models have been used to evaluate if earthquakes are related to specific geologic structures or seismotectomic zones (____ name models) and the results are described here. (KKB-8, provide the model description and analyses). Table 3.1.1.1.3.1A shows significant earthquakes in or near the southern Great Basin.

Table 3.1.1.1.3.1A. Significant Earthquakes in or Near the Southern Great Basin

An analysis of the correlation between epicenters or regions higher intensity of historically reported earthquakes and the geologic setting or geologic structures within the setting is provided below (KKB-9, provide such analyses). The largest earthquakes associated with the geologic setting or each geologic structure within that setting are identified. Table 3.1.1.1.3.1B shows the data related to this correlation of earthquakes and geologic structures or setting.

3.1.1.1.4 Structural Geology and Tectonic Information

Structural and tectonic features in the site region, including a discussion and analysis of regional tectonic models and their applicability to the site are provided here.

3.1.1.1.4.1 Structural Features in the Yucca Mountain Region

The structures and structural history of the southern Great Basin and the Yucca Mountain and its immediate surroundings are discussed in the following section. The Tertiary and Quaternary structures including faulting and folding are described (text available in SCP 1.3.2.2 and is not repeated here). Figure 3.1.1.1.4.1A shows a schematic geologic cross section at Yucca Mountain region (Source figure 1-32 from SCP). Table 3.1.1.1.4.1A lists Quaternary faulting at and near Yucca Mountain (source SCP Table 1-7).

Table 3.1.1.1.3.1B. Data related to the Correlation of Earthquakes and Geologic Structures or Setting

Figure 3.1.1.1.4.1A. Schematic Geologic Cross Section at Yucca Mountain Region

Table 3.1.1.1.4.1A. List of Quaternary Faulting at and Near Yucca Mountain

Fractures are common in all the volcanic units in the Yucca Mountain region. The fractures were produced by cooling, by basin and range tectonism, and by unloading due to removal of overburden. (KKB-10, the regional fracture, discontinuities, and heterogeneity needs to be further investigated for the Yucca Mountain region).

3.1.1.1.4.2 Volcanic Features in the Yucca Mountain Region

The igneous history of the southern Great Basin and Yucca Mountain is discussed below. It provides the history of volcanism during the Tertiary and Quaternary periods. Figure 3.1.1.1.4.2 A, Figure 3.1.1.1.4.1B, Figure 3.1.1.1.4.2C, and Figure 3.1.1.1.4.1D show the distribution of the Cenozoic volcanic rocks in the southern Great Basin during the time periods of 0 - 43 million years ago (Source Figures 1-28a,b,c and d of SCP). Table 3.1.1.1.4.2A shows the characteristics of basaltic volcanism fields in the Yucca Mountain area (source, SCP Table 1-6).

3.1.1.1.5 Natural Resources

The natural resources near the site that are economic, marginally economic and sub-economic, and the exploitation of which could result in inadvertent intrusion into the repository, are described. Resources such as mineral, fuels, hydrocarbon, and geothermal resources are addressed. Potable, agricultural, and industrial waters including waters in the form of brine are included in the discussion.

Figure 3.1.1.1.4.2A. Distribution of the Cenozoic Volcanic Rocks in the Southern Great Basin During the Time Periods of 43-34 Million Years Ago

Figure 3.1.1.1.4.1B. Distribution of the Cenozoic Volcanic Rocks in the Southern Great Basin During the Time Periods of 34-17 Million Years Ago

Figure 3.1.1.1.4.2C. Distribution of the Cenozoic Volcanic Rocks in the Southern Great Basin During the Time Periods of 17-6 Million Years Ago

Figure 3.1.1.1.4.1D. Distribution of the Cenozoic Volcanic Rocks in the Southern Great Basin During the Time Periods of 6-0 Million Years Ago

Table 3.1.1.1.4.2A. Characteristics of Basaltic Volcanism Fields in the Yucca Mountain Area

The description of these resources include information on recourse type occurrence, location, extent, net worth, recoverability, and current and projected use. Also provided are: 1) a comparison of the site and environs with areas of mineral and hydrocarbon deposits with similar origins, host rocks and structural regimes, 2) an assessment of the near-site area based on comparisons with known mineral resources and models, and 3) the location, nature, and extent of any known or suspected mineralization, hydrocarbons, or waters of elevated temperatures.

3.1.1.1.5.1 Mineral Resources of the Yucca Mountain Region

Table 3.1.1.1.5.1A lists the non-fuel mineral production in Nevada for the years (199- to 2000). The mineral industry in Nevada remains highly ranked in comparison to other states and likely to remain so in the far future.

Interpretation of regional geophysical data including gravity and magnetic data provides information regarding the mineralization potential of the area. These data were used in ore genesis models (KKB-11, provide the description of the models and result of the analyses).

Precious and Base Metal Deposits. Precious and base metals deposits in Nevada have historically been the most important economically. Yucca Mountain is located in the southeastern part of the eastern metallogenic province of Nevada.

Table 3.1.1.1.5.1A. List of Non-Fuel Mineral Production in Nevada for the Years (199- to 2000)

Much of Nevada, including Nye county and all of Yucca Mountain at the surface, consists primarily of ash flow tuffs. However, 93 percent of all major metal mining in Nevada is in lithology other than silicic tuff. Areas within calderas are typically barren of economically important base and precious metals while strongly altered and metamorphosed rock located on the margins of the calderas are more economically important. Only (__) of the Nevada's (__) calderas have produced 1 million dollars or more of gold, silver, copper, lead, zinc, mercury, antimony, and iron.

Gold and Silver Resources.

(No skeleton text developed for this subsection.)

Mercury Resources. Only two of the eight potential mercury host rock characteristics are found in the Yucca Mountain. To date, no warm or hot spring deposits that would be associated with sulfurous mercury ores have been identified at or near Yucca Mountain.

Small amounts of mercury have been produced from highly silicified volcanic rock at the Thompson Mine at the northwest end of the Yucca Mountain. The production figures are less than (__) flasks. No indications of highly silicified, opalized, and mercury-bearing mineral have been recognized from north central or southern Yucca Mountain during surface mapping (KKB-12, confirm this finding during further mapping).

Data gathered from site characterization support the conclusion that there is very little potential for an economic deposit of mercury at Yucca Mountain. Mercury is considered to be a speculative, undiscovered resource of sub-economic grade. Geochemical sampling for mercury in surface outcrop and drill cores confirm these findings (KKB-12, provide the geochemical test data to support this conclusion).

Industrial Minerals and Rocks. This category includes a variety of minerals and rocks that are commonly equated with non-metallic and industrial minerals and rocks. Only the ones that have been found to occur or have a potential for occurring in the Yucca Mountain region are discussed here.

[From the results of investigation (define type of investigation) it is concluded that the geologic setting at Yucca Mountain is not favorable for the occurrence of barite deposits.] Only minor occurrence of barite is found in veins at great depths of (___ m or more). These deposits have none or very little economic potential because of their great depths of (___m or more), and due to the great abundance of their occurrence elsewhere in Nevada at surface level.

Yucca Mountain has a low potential for future economic deposits or future exploration for the industrial mineral fluorite because: 1) its known occurrences are rare and of low grade (___ indicate grade), 2) deposits in ash flow tuffs are typically low grade, 3) numerous deposits occur elsewhere in Nevada, 4) world-wide reserves are vast, and 5) known occurrence at Yucca Mountain are minor replacements of limited extent and size.

Zeolite at Yucca Mountain is not classified as a resource or a reserve because of widely distributed availability over the region, and low grade and tonnage available (___ tons reserve at ___ grade) at Yucca Mountain. Zeolite at Yucca Mountain occurs at a depth of 500 meters in solid rock, whereas vast reserves are available at surface in sedimentary form.

In addition to the industrial minerals, a variety of construction material occurs locally including clays, volcanic cinder, perlite, pumice, silica, sand, and gravel. No economically known currently or historically significant construction material deposits exist at Yucca Mountain. The construction material resources in the vicinity of Yucca Mountain are of local economic importance and only a few are being exploited. Table 3.1.1.1.5.1B shows a summary of all construction material in the vicinity of Yucca Mountain.

These construction materials do not occur in the bedrock of Yucca Mountain with the exception of silica resources that have been historically mined at the Silicon mine. More readily extractable and abundant silica is available elsewhere in the region and in the United States. There is no foreseeable potential for future exploration or exploitation of these resources that would result in drilling or other surface activities in close proximity to the Yucca Mountain site.

3.1.1.1.5.2 Energy Resources of Yucca Mountain Region

Energy resources consist of uranium, hydrocarbons, and geothermal sources. The potential for these sources are discussed below.

Table 3.1.1.1.51B. Summary of All Construction Material in the Vicinity of Yucca Mountain

Uranium Resources. [Based on historical data, examination of core samples, and geochemical analyses of surface and subsurface samples, it is concluded that uranium is a speculative, undiscovered resource of subeconomic grade (KKB-13, provide the result of yet to be performed geochemical analyses to support these conclusions).]

Geothermal Resources. The area surrounding Yucca Mountain has a low potential for intermediate and high-temperature geothermal fields, but is underlain by a deep seated (greater than 3 km) regional geothermal source whose surface characteristics are greatly affected by the overlying hydrologic system and thermal conductance of the rock. It is concluded from the data that the waters from Yucca Mountain are a potential resource for space heating and agricultural uses. However, Yucca Mountain is not currently considered a geothermal resource area because: 1) The use of low temperature water is only technologically feasible only in a few parts of the world and is cost prohibitive if transported rather than used at the site (__ provide substantiation of these statements at the end of the decade); 2) Topographic lows with shallow depths to the water table would be the most likely areas of use whereas Yucca Mountain is a topographic high with great depths to the water table, and 3) These low temperature and shallow resources are widely available elsewhere in Nevada at shallower depths.

Hydrocarbon Resources. The potential for conventional hydrocarbon resources (i.e., petroleum or crude oil and natural gas) and unconventional hydrocarbon resources including tar sands and oil shale, and coal (not strictly a hydrocarbon) are discussed here.

Coal, Tar Sands, and Oil Shales. [Coal, tar sands, and oil shales have extremely low potential for occurrence in the Yucca Mountain area. This is supported by historical data, regional geology, geologic mapping, drilling, geophysical logging and other data. (KKB-13, provide data on future drilling, geophysical logging and other data to support these conclusions).]

Oil and Natural Gas. Table 3.1.1.1.5.1C shows the location, date of discovery, producing formation, depth of production and cumulative production for Nevada oil and gas fields. [There are no oil or gas fields within the Death Valley Region or in southern Nye county. Extensive drilling, mapping, and geophysical logging and other investigations (_____ name these investigations) have shown no potential source rock for oil and natural gas occurrences. In addition, the calculated thermal maturation of any potential source rocks in the area of Yucca Mountain are not favorable for hydrocarbon resources.]

Potable, Agricultural, and Industrial Water Resources.

3.1.1.1.6 Geophysics

The results of geophysical investigations for issue resolution and a basic description of the region of the site are described here. Surface based geophysical investigations were performed for site characterization and included seismic reflection and refraction, gravity, magnetic, remote sensing,

Table 3.1.1.1.5.1C. Location, Date of Discovery, Producing Formation, Depth of Production and Cumulative Production for Nevada Oil and Gas Fields aeromagnetic, electrical and low-sun-angle mapping. These investigations provided information regarding natural resources, faulting, fractures and voids, potential magma chambers, magma sources, and other tectonic features of importance to the design and analyses of the repository. These investigations were also used to identify the major tectonics and natural resource features in the vicinity of the site.

3.1.1.1.6.1 Regional Geophysical Characteristics of the Site

[Generally, the region around the Yucca Mountain is a gravity low corresponding to the thick Cenozoic volcanic cover and presence of several caldera complexes. However, local magnetic and gravity highs have been interpreted to include the existence of a deep pluton that extends from (KKB-14, provide further results of magnetic and gravity surveys).]

3.1.1.2 Site Geology

3.1.1.2.1 Geomorphology and Topographic Features of the Site Area

The geomorphology and topographic features of the site are described here. The data, information, investigations, and analyses address the following: 1) whether extreme erosion is represented at the site or an adjacent area such that isolation of waste within the site may or may not be affected, 2) projections of the maximum erosion rates in the vicinity of facilities important to safety (critical structures) and engineered features (i.e., exploratory shafts, waste handling facilities, etc.), and 3) projections of the maximum erosion rates in areas (such as washes) overlying underground facilities having minimum thickness of overburden or vulnerability to denudation. In considering projection of the maximum erosion rates, the effects of subsidence and faulting are incorporated in the analysis.

Appropriate geomorphic and topographic maps and cross sections are provided to illustrate and clarify the characteristics of the site and the potential for erosion. [Additional Figures and Tables will be required]

3.1.1.2.1.1 Erosion at the Site

The Yucca Mountain site has been generally geomorphologically stable. However, episodes of rapid erosion have occurred locally in areas of concentrated alluvial activity (e.g. the ravines, valleys, and washes of the mountain and adjacent piedmonts). In these areas, the rates of stream incision, averaged over the past .15 to 0.3 million years range from (_ cm/year to _ cm/year). (KKB-15, provide site specific erosion rates in the areas of critical surface facilities once Title II designs of ESF and the repository is developed).

[Note: Information and data regarding the extreme erosion issue will be presented in this section. The information and data provided will demonstrate that erosion potential is not an adverse condition. Further, discussion of this issue will be provided in Section 3.2.]

3.1.1.2.2 Stratigraphy and Lithology of the Site

The stratigraphy and lithologic framework of the site is described here including: 1) accepted rock-stratigraphic unit names, 2) relative or isotopic age of units, 3) genetic relationships of delineated units, 4) rationale (i.e., mineralogical, geochemical, paleontological, etc.) for stratigraphic boundaries (contacts), and 5) alteration affecting the units. In discussing the formation of the units, sedimentation, provenance, genetic environment, and deposition is considered. Processes resulting from tectonism, plutonism, volcanism, and metamorphism with attendant hydrothermal processes will be considered in the alteration history of the units.

The stratigraphic and lithologic units surrounding or hosting (repository horizon) the waste including identification of mineralogical and paleontological constituents and physical characteristics are described in detail. The description includes texture, bedding, grain size, percent and size of cavities, degree of cementation, and schistocity. Zones of alteration, vertical or lateral variation of composition and/or physical characteristics within units including affects of faulting, folding, uplift, and subsidence should be discussed.

The information sources and methods used to obtain site specific data are documented. Geologic maps, isopach maps, and cross sections illustrating the stratigraphic and lithologic units at the site are provided. [Additional Figures/Tables will be needed].

The rocks at Yucca Mountain (Figure 3.1.1.2.2A, source SCP Figure 1-17) comprise a gently dipping of sequence of Miocene ash-flow tuffs, lavas, and volcanic breccia more than (_ meters) thick, interlaced with relatively thick units of volcaniclastic rock and flanked by younger alluvial deposits. The data from deep drillholes (up to _meters) provide the stratigraphic information on the sequence of rocks in Yucca Mountain (KKB-16, provide the stratigraphy to the depth necessary when deep geological holes are drilled and data analyzed. The data should include the rationale for stratigraphic units based on mineralogical, paleontological, and geochemical characteristics of the units). Figure 3.1.1.2.2B shows the location of the geological drill holes used to determine the stratigraphy of the site and the location of the geological cross-sections shown on Figure 3.1.1.2.2C and Figure 3.1.1.2.2D. These two latter figures show the north/south and east/west stratigraphic correlation between the selected drillhole data. Table 3.1.1.2.2A shows the stratigraphy, thickness, and age of the rock units at Yucca Mountain site.

3.1.1.2.2.1 Description of Lithology of the Units Surrounding the Repository Horizon

The following is a description of the lithologic units surrounding and hosting the waste. The mineralogical and paleontological constituents and physical characteristics such as texture, bedding, grain size, percent and size of cavities, degree of cementation, and schistosity are described.

Figure 3.1.1.2.2A. Generalized Map of Yucca Mountain Showing Major Faults and Stratigraphic Units

Figure 3.1.1.2.2B. Location of the Geological Drill Holes Used to Determine the Stratigraphy of the Site

Figure 3.1.1.2.2C. North-South Cross Section of Stratigraphic Correlation Between Selected Drill Holes

Figure 3.1.1.2.2D. East-West Cross Section of Stratigraphic Correlation Between Selected Drill Holes

Table 3.1.1.2.2A. Stratigraphy, Thickness, and Age of the Rock Units at the Yucca Mountain Site

The Paintbrush Tuff, more than 460 meters thick, constitutes nearly all of the exposed rocks at Yucca Mountain. In ascending order, the four members of the Paintbrush Tuff are:

- Tiva Canyon
- Yucca Mountain
- Pah Canyon
- Topopah Spring

The repository horizon lies within the Topopah Spring Member of the Paintbrush Tuff. This member is a multiple flow compound cooling unit. Figure 3.1.1.2.2.1 shows the sequence and thickness of the various cooling units within the Topopah Spring Member.

The tuffaceous beds of the Calico Hills unit underlies the Topopah Spring Member in the Yucca Mountain site. The tuffaceous beds of Calico Hills unit are considered as a major barrier to the downward migration of radionuclide from the repository horizon. This unit consists of massive, homogeneous, non-welded ash flow tuffs totaling (__ meters to __ meters) in thickness which are separated in places by ash fall and reworked tuff as much as (__ meters) thick. The non welded tuff is mostly crystal poor (less than ____ percent), but locally it is rich in lithic fragments, some as much as (__ cm) long. Underlying most of the northern part of the Yucca Mountain, the entire unit is zeolitized but it the remains vitric in the southern area. Zeolites constitute (__ to __) percent of the rock volume.

Figure 3.1.1.2.2.1. Sequence and Thicknesses of the Various Cooling Units Within the Topopah Spring Member

The zones of alteration with the stratigraphic units are described below (KKB-17, describe the zones of alteration from drilling data). The vertical and lateral variation of compositional and physical characteristics within each stratigraphic unit is also described here (WCC to provide such description).

3.1.1.2.3 Seismology

The ground motion at the site has been determined assuming seismic energy transmission effects are constant, and that the largest earthquake associated with each geologic structure or geologic setting occurs at the point of closest approach to the site. Ground motion determinations are related to [based on?] the site-specific material properties of each stratum. These properties include seismic compressional and shear velocities, bulk densities, soil properties and classification, shear modulus and its variation with strain level, and water table elevation and its variation.

Design response spectra corresponding to the design basis earthquake are defined and their conservation assessed by comparisons to ground motion expected from each potential maximum earthquake. (Table 3.1BC, Table 3.1BD, Tables 3.1BE and 3.1BF) [Additional Figures/Tables will be needed to illustrate probabilistic modeling and hazard assessment.]

[Note: This section will present information and data used in the resolution of the seismic design issue. This information and design will be used in the designs presented in Section 4.0, Geologic Repository Operational Area.]

3.1.1.2.3.1 Ground Motion at the Site from Earthquakes in the Area

(KKB-18 Provide ground motion calculations using deterministic or probabilistic or both approaches [this point needs to be clarified] when appropriate data are generated).

3.1.1.2.3.2 Material Properties of Rocks at the Site

(KKB-19, Provide seismic compressional and shear velocities, bulk densities, soil properties, and classification, shear modulus and its variation with strain level, and water table elevation and its variation. For static properties of soil and rock, refer to Section 3.1.1.2.7, Geoengineering. It is not clear whether laboratory determined dynamic and static properties or in situ properties are required for soil and rock units located under the site.).

3.1.1.2.3.3 Seismic Wave Type Effects of Wave Transmission

The types of seismic waves that produce the maximum ground motion for each set of conditions describing the occurrence of maximum potential earthquake were determined and results are provided herein. Also, the results of analyses to determine the effects of transmission in the site material for the identified seismic wave types in the significant frequency bands are included. The acceleration, effective frequency range, and duration corresponding to each maximum potential earthquake are provided both at ground surface, and at depth of the underground repository (KKB-20 provide this calculations and results when the necessary data are available).

3.1.1.2.3.4 Design Responses to Ground Motion from Potential Earthquake

Design response spectra corresponding to design basis earthquakes are described. The conservatism of the design is evaluated by comparing the design response spectra with the ground motion expected from potential earthquakes as presented in Section 3.1.1.2.3.3 (KKB-20 provide these calculation when Title II design of the repository is complete).

3.1.1.2.4 Structural Geology and Tectonics

The structural and tectonic features in the site area are described here including a discussion and analysis of local structural and tectonic models and their applicability to the site. The volcanic history, faulting history, folding history, jointing history, and the stress field at the site are discussed. Methods (i.e., remote sensing techniques, geophysical studies, age dating, mapping, trenching, etc.) used in arriving at faulting and volcanic histories (location, ages, and recurrence intervals of fault movements and volcanic episodes) are described and documented. It is demonstrated through the detailed discussions and description that features and conditions are representative of structural and tectonic features at the site and the range of tectonic conditions have been established. Individual tectonic features that may directly or indirectly affect waste isolation are described and discussed in detail. Possible relationships among tectonic processes, including coupled processes, are discussed. (Figures 3.1BH and 3.1BI) [Additional tables and figures will be needed].

3.1.1.2.4.1 Faulting at Yucca Mountain

Yucca Mountain is the erosional remnant of a volcanic plateau. It consists of a series of north trending structural blocks that have been tilted eastward along major west dipping, high angle normal faults. These blocks are (imbricate fault slices overlying one or more detachment faults ?). The major normal faults bounding the structural blocks at Yucca Mountain are typically only (_ to _) km apart. The component of strike slip faults at Yucca Mountain is (_ provide offset amount).

The major normal faults that bound the structural blocks generally strike north and dip steeply west. The faults generally have offsets of (___ meters). They decrease in both offset and abundance northward throughout Yucca Mountain (provide offset amount). Figure 3.1.1.2.4.1A shows the location of faults at Yucca Mountain and the location of cross sections throughout the site. Figure 3.1.1.2.4.1B and C are cross sections showing the faults and their characteristics in the site. Additionally, Quaternary deposits are offset or fractured by (__) faults in the (_ km^2) area of Yucca Mountain and are shown in Figure 3.1.1.2.4.1A.

Figure 3.1.1.2.4.1A. Location of Faults at Yucca Mountain and the Location of Cross Sections Through the Site

Figure 3.1.1.2.4.1B. East/West Cross Section Showing the Faults and Their Characteristics

Figure 3.1.1.2.4.1C. North/South Cross Section Showing the Faults and Their Characteristics

Seismic reflection, low altitude aeromagnetic surveys, electrical resistivity data, remote sensing, and geologic mapping (add other methods when site characterization is complete) were used to delineate and identify faults in the Yucca Mountain site and determine their characteristics. Figures 3.1.1.2.4.1D, E, F, and G show the faults interpreted from these methods. Table 3.1.1.2.4.1A shows the estimate of age of faults using radiometric dating and stratigraphic correlation (add any other methods used for fault dating) in the site.

3.1.1.2.4.2 Folding at Yucca Mountain

(No folding information is available in the SCP from a quick scan. If true, folding information including history, occurrence, age, and characteristics have to developed from site characterization.)

3.1.1.2.4.3 Fractures at Yucca Mountain

Fractures are common in all volcanic units at Yucca Mountain. The fractures were produced by cooling, basin and range tectonism, and unloading due to the removal of overburden. The fractures are commonly strata-bound (i.e. their vertical extent is limited to the individual stratigraphic unit or group of unit).

Figure 3.1.1.2.4.1D. TBD

Figure 3.1.1.2.4.1E. TBD

Figure 3.1.1.2.4.1F. TBD

Figure 3.1.1.2.4.1G. TBD

Table 3.1.1.2.4.1A. Estimate of Age of Faults Using Radiometric Dating and Stratigraphic Correlation

Detailed studies of fractures from surface mapping, drill core observation, down hole surveys (_ name the surveys, e.g. seisviewer, video tape etc.) and underground mapping were performed for all the units from ground surface down to Calico Hills. The (___ types of fractures) are found in the units. Table 3.1.1.2.4.3A shows the lithological unit, type of fracture, dip and strike, frequency and infilling. Figures 3.1.1.2.4.3A and B show rose diagrams for fracture measurements from surface and underground mapping at Yucca Mountain repository site (KKB-21 provide these diagrams after completion of surface and underground mapping in the ESF).

3.1.1.2.4.4 Volcanism at Yucca Mountain

The youngest volcanic centers near Yucca Mountain are in southern and northern Death Valley; near Crater Flat; immediately west of Yucca Mountain; and north of Beatty, Nevada. Depending on the age dating techniques used the Lathrop Wells cinder cone, at the southern edge of Crater Flat, is the youngest volcanic feature in the Yucca Mountain area. The age of the volcanic feature is estimated to be between (___ years and ____ years). Figure 3.1.1.2.4.4A shows the volcanic centers in the Yucca Mountain site.

[Note: Information and data regarding the volcanism issue will be presented in this section. The information and data provided demonstrates that volcanism is not an adverse condition. Further discussion of this issue will be provided in Section 3.2].

Table 3.1.1.2.4.3A. Lithological Units, Type of Fracture,Dip and Strike, Frequency and Infilling

Figure 3.1.1.2.4.4A. Volcanic Centers at the Yucca Mountain Site

3.1.1.2.5 Natural Resources

Natural resources at the site that are economic, marginally economic, or sub-economic, and the exploitation of which could result in inadvertent intrusion into the controlled area, are described. Natural resources considered include minerals (both metallic and non-metallic ore), fuels including hydrocarbons (gas, oil, tar sands, asphalt), geothermal resources, and water (potable, agricultural, industrial, and in the form of brine). The economic assessment includes sources such as literature, mapping, geochemical sampling, and comparison with models of known mines, prospects, and exploratory drill holes. The descriptions of the resource include resource type, occurrence, location, extent, net worth, recoverability, and current and projected use.

In addition the following information is provided:

- A comparison of the site with areas of mineral and hydrocarbon deposits with similar origins, host rocks, and structural regions
- An assessment of the site area based on comparisons with known mineral sources and models
- The location, nature, and extent of any known or suspected mineralization, hydrocarbons (included are the potential for hydrocarbons within the Paleozoic stratigraphic units and trap rocks underlying the site), or waters of elevated temperatures.

Possible presence of mineral deposits at the site and their association with stratigraphy or lithologic units of volcanic origin, veining, fault zones, alteration zones, and subsurface plutons are discussed. (Table 3.1-BJ) [Additional Figures and Tables will be needed to address various portions of regulations].

3.1.1.2.5.1 Mineral Resources at the Site

Gold, Silver, Base Metal Occurrence. The alteration of the type associated with gold, silver, and base-metals in the volcanic-hosted hydrothermal deposits is generally lacking at the Yucca Mountain site. No significant hydrothermal alterations have occurred since (__ million years) ago. Deposit of calcite and opaline silica are found locally along fault zones near Yucca Mountain. [Investigation shows that these deposits near Yucca Mountain (are/ are not) of commercial value.]

Gold analyses from (____ samples) from drill core and surface and underground have been analyzed and found to have (__ parts per million to ____ parts per million) of gold and silver. Table 3.1.1.2.5.1A summarizes the results of assays of gold and silver from rocks at the site. (Provide future chemical analyses in parts per billion range for further evaluation of gold and silver potential in Yucca Mountain).

[The data base demonstrates that Yucca Mountain is an unfavorable site for gold, silver and other base metals (provide conclusive evidence for this statement).]

Table 3.1.1.2.5.1A. Summary of the Results of Assays of Gold and Silver from Rocks at the Site

Mercury Occurrence. [There is very little potential for mercury deposits at or near Yucca Mountain. No indication of highly silicified, opalized, and mercury-bearing mineral have been found during the site characterization of Yucca Mountain. The tuffs shallower than 1,000 meters never reached sufficient temperature for mercury mineralization, having undergone alteration temperature of no greater than (____ degree C). Temperatures of 100 to 200 °C are necessary for mercury mineralization. No mercury mineralization has been found in drill holes or underground rock samples. (Provide analyses to prove this statement).]

3.1.1.2.5.2 Energy Resources at the Site

Energy resources, consisting of uranium, hydrocarbons (i.e. oil, gas, oil shale, tar deposits [asphalt ?], and coal), at the Yucca Mountain site are discussed below. The data supporting the description of energy resource of the site were collected from literature search, surface and underground mapping, drill hole sampling, geochemical analyses, and comparison with working models of known mines, and exploratory drill holes.

Uranium. Data on the variation of uranium content found in the Topopah Spring Member and other tuff units present at the site show uranium content in the range of (___ ppm to ___ ppm). [Analyses of data reflect that little remobilization of uranium has occurred at the site and that the processes responsible for vein or disseminated deposits have not been active. Silicified bleached rock, extensive fluorite veins, carbonized wood, or other associations indicative of uranium were not discovered during site characterization.]

Hydrocarbon Resources at the Site. [No evidence of occurrence of any coal or tar sand deposit has been found during the site characterization activity at the site. No surface exposure or underground evidence of oil shale occurrence has been found during drilling, mapping, and underground exploration at the Yucca Mountain site.]

[There are no known oil or gas fields within the Death Valley region or in southern Nye County. The thermal history of potential source rocks under the site provides the necessary evidence (for/against) preservation of any hydrocarbons (KKB-22 provide evidence of oil and gas occurrence below the mountain).]

Geothermal Resources. The vicinity of site has potential for low temperature geothermal energy. Figure 3.1.1.2.5.2A shows the occurrence of hot springs and geothermal wells and low temperature resources in the vicinity of the site. The spring and down hole temperature range from (__ to___ ^{0}C). The average thermal gradient under Yucca Mountain is (__ degree Celsius) per km of depth. The measured heat flow from drill holes in the site ranges from (___ to __ cal/cm2s.

Water chemistries and the isotopic character of waters from springs and drillholes were evaluated and used to estimate the temperature at depth with which the thermal water equilibrated. The water temperature of equilibration is less than (___ ^{0}C) and average approximately (___^{0}C).

Figure 3.1.1.2.5.2A. Occurrence of Hot Springs and Geothermal Wells and Low Temperature Resources in the Vicinity of the Site

Isotopic data were used to assess whether waters have equilibrated with meteoric water, hot thermal waters, or result from a mixture of the two. The results show that the source (provide results when available).

3.1.1.2.6 Geophysics

The results of geophysical investigations conducted for issue resolution and basic understanding of the site are described. Data consist of surface-based geophysical investigation such as: seismic reflection, seismic refraction, gravity, magnetic, aeromagnetics, resistivity, and electromagnetic and borehole geophysical investigations such as:

- Downhole and crosshole seismic surveys
- Nuclear logs
- Acoustic logs
- Borehole gravity, magnetic, and radar.

The limitations of the data collected are discussed with regard to level of detail, resolution quality, and other sources of uncertainty. Detailed characterization of tectonic features, physical properties of the formations, and fracture characteristics are provided from the investigation (Table 3.1BK).

(Note: This subsection would be difficult to prepare because most of the geophysical investigation is in support of determination of lithology, stratigraphy, structural geology, tectonics, natural resources, and other subsystem of the geological system of the site. These other subsections under site should be referred to in this section).

3.1.1.2.7 Geoengineering

The geoengineering properties of the rock units present at the site are described and discussed in detail below.

For each rock unit or rock discontinuity, the geoengineering properties should include a set of mechanical properties, a set of thermal and thermomechanical properties, and the existing stress field. These properties include, but are not limited to confined and unconfined compressive strength, Young's modulus, Poisson's ratio, tensile strength, thermal conductivity, and thermal expansion. The properties determined by testing, the testing procedure, the logic for selection of rock samples, the stratigraphic framework for testing (include the strategy for testing intact rock units as well as discontinuities within or between rock units), sample size, the number of joints or fractures, and the conceptual rock mechanics models that used the collected data are described. The effects of anisotropy lithophysae, porosity, density, and water saturation on the resultant geoengineering properties of the rock units should be included in the description of the testing. The stress field discussions should include geologic and tectonic evidence, results of field testing, and estimates on the variability of the stress field around the site and within the GROA.

Excavation characteristics of the rock mass, the methods chosen for excavation of the shafts, ramps, and underground facility, changes in geoengineering properties resulting from excavation and the application of thermal load, estimated in flow of ground water, and estimated ground support requirements under both ambient and elevated temperature conditions are discussed.

3.1.1.2.7.1 Geoengineering Properties of Rock Units at the Site

Tests Performed and Methodology. Table 3.1.1.2.7.1A shows the geoengineering properties that have been determined by testing of rock samples from the site. The tests were performed to meet regulatory requirements and design issues related to configuration of underground facilities, waste retrievability, non-radiological health and safety, and pre-closure design and technical feasibility. The testing procedures for each type of test is described. Where available and appropriate, ASTM or ISRM methodology were used as basis for test development.

Logic for Sample Selection. The logic for selection of rock samples (both intact and containing discontinuities) included attaining a confidence level in the representativeness of data from the rock units present at the site. Sampling strategy required collection of samples from each unit to represent the spatial and vertical variability of the rock properties.

Stratigraphic Framework for Testing. The formal stratigraphic units at the site have been subdivided into further functional stratigraphy depending on the thermo-mechanical properties of the rock units. The functional stratigraphy is better suited for the presentation of the geoengineering

Table 3.1.1.2.7.1A. Geoengineering Properties Determined by Testing of Rock Samples From the Site properties than the formal stratigraphic units which encompass a wide variation in mineralogic composition, porosity, and fracturing. Figure 3.1.1.2.7.1A shows the thermal/mechanical stratigraphy at Yucca Mountain.

Thermal and Mechanical Properties. Table 3.1.1.2.7.1B shows the thermal and mechanical properties for rock (compressive strengths, Young's Modulus, Poisson's ratio, tensile strength, thermal conductivity, and thermal expansion, creep function (?) and others) from each thermo-mechanical equivalent unit. Both intact and discontinuous (joint) properties are shown.

Figures 3.1.1.2.7.1B, C, D, E, G show the variation of compressive strengths, Young's Modulus, tensile strength, thermal conductivity, thermal expansion and other properties with changes in moisture content, lithophysae, anisotropy, density of the rock units.

Stress Field. Measurements of in situ stresses at the site were made to determine the stress field. The results of individual stress measurements in drill holes at various location within the site are shown in Figure 3.1.1.2.7.1H. The stress measurement data from underground measurements are shown in Figure 3.1.1.2.7.1I. The maximum principal stress at the site is vertical. The secondary principal stresses are oriented at the axis (____ provide directions). Figure 3.1.1.2.7.1J shows the least (horizontal) and maximum (vertical) principal stress values plotted against depth at Yucca Mountain.

Figure 3.1.1.2.7.1A. Thermal/Mechanical Stratigraphy at Yucca Mountain

Table 3.1.1.2.7.1B. Thermal and Mechanical Properties for Rock (Compressive strengths Young's Modulus, Poisson's ratio, tensile strength, thermal conductivity, and thermal expansion, creep function (?) and others)

Figure 3.1.1.2.7.1B. Variation of Compressive Strengths

Figure 3.1.1.2.7.1C . Variation of Young's Modulus

Figure 3.1.1.2.7.1D. Variation of Tensile Strengths

Figure 3.1.1.2.7.1E. Variation of Thermal Conductivities

Figure 3.1.1.2.7.1F. Variation of Thermal Expansions

Figure 3.1.1.2.7.1G. Variation of Other Properties

Figure 3.1.1.2.7.1.H. Stress Measurements in Drill Holes

Figure 3.1.1.2.7.1I. Stress Measurements From Underground Locations

Figure 3.1.1.2.7.1J. Least (Horizontal) and Maximum (Vertical) Principal Stress Values Plotted Against Depth at Yucca Mountain.

Excavation Characteristics of Rock Mass. The excavation characteristics of the rock mass were evaluated from tests on core samples, shaft and ramps construction, and underground drifting using a variety of equipment. Both mechanical and drill and blast mining method have been used at the site. Table 3.1.1.2.7.1C provides the rate of advance, assessed damage to the rock, and support requirement for excavation of the rock units present at the site by various mechanical excavators and by drill and blast.

Methods Chosen for Excavation of the Repository. The repository shafts are to be excavated by (___ method). Ramps are to be excavated by (___ method). The underground facilities are to be excavated by (____ method). The rationale for the selection of excavation methods are provided (_____ provide a discussion for each method selected).

Changes in Geoengineering Properties. The changes in the geoengineering properties due to excavation by various methods and application of thermal loads were evaluated using underground measurements, laboratory testing, and numerical analyses (described the measured and estimated changes in mechanical and thermal properties when data are available).

Estimated in Flow of Ground Water. The repository is located in the unsaturated zone. The ramps and shafts (encounter/do not encounter) some perched water zones during construction. It is estimated that (__ gpm) of ground water inflow may be expected from the shafts and ramps. In the underground facility, it is estimated that (___ gpm) of water may inflow over the life of

Table 3.1.1.2.7.1C. Rate of Advance, Assessed Damage to the Rock, and Support Requirement for Excavation of the Rock Units Present at the Site By Various Mechanical Excavators and by Drill and Blast the repository. Table 3.1.1.2.7.1D shows the estimated inflow of groundwater from the underground facility over the operational life of the facility.

Estimated Ground Support System. The ground support system is devised from stress field data, in situ and laboratory measurements of intact and discontinuous rock properties, and using numerical thermo-mechanical analyses and empirical rock mass classification type of analyses. Figures 3.1.1.2.7.1K-O shows the rock mass classification and support requirement for the thermal-mechanical units encountered at the repository and shaft and ramps. The rock at the repository horizon is classified as (___ to ___) and requiring (___describe type of support) in the emplacement and non-emplacement areas of the facility. Details of the ground support system are described in Section 4.1.3.1, Excavation and Ground Support System.

3.1.1.3 Future Variation in Geologic Process

Assessment of future changes that might be expected to occur in the geologic system are discussed in this section. This assessment includes the potential for earthquake on any faults in the geologic system the potential for new and any extended faulting and fracturing currently unfaulted and unfractured areas, including location and nature of rupture, and the potential for volcanism including location, extent, and proximity to the site. Also described are features of interest, how the analog is used; the time frame of the comparative study, and any differences in scale or features between the analog and the site.

Table 3.1.1.2.7.1D. Estimated Inflow of Ground Water From the Underground Facility Over the Operational Life of the Facility

Figure 3.1.1.2.7.1K. Rock Mass Classification and Support Requirements at Tiva Canyon Unit

Figure 3.1.1.2.7.1L. Rock Mass Classification and Support Requirements at Paint Brush Unit

Figure 3.1.1.2.7.1M. Rock Mass Classification and Support Requirements at Topopah Spring (TSw1) Unit

Figure 3.1.1.2.7.1N. Rock Mass Classification and Support Requirements at Topopah Spring (TSw2) Unit

Figure 3.1.1.2.7.1O. Rock Mass Classification and Support Requirements at Topopah Spring (TSw3) Unit

Potential for Earthquake on any Faults. (Describe the potential for earthquake on the faults identified within 10 km of the repository).

Potential for New and Extended Faulting. (The movement potential of faults within the vicinity of Yucca Mountain is being studied and provide the results when available).

Potential for Volcanism. (Studies are to be performed for the potential for volcanic eruption within the vicinity of the Yucca Mountain site and will be described here when completed).

3.1.2 Hydrologic System

This section describes the hydrologic conditions of the geologic setting of the region and the site. A description of the hydrology of the site and the surrounding area is presented. The surface water, groundwater (both saturated and unsaturated flow), the interrelationship between the surface and groundwater flow, flooding potential, site drainage, and other hydrologic phenomena is described. It is demonstrated that the areas studied provide a representative description of the conditions throughout the region, around the site, and at the site. Detailed justification for the areal limits of regional studied is presented.

3.1.2.1 Surface Water Hydrology

This section describes the surface water hydrology characteristics of the hydrologic system. The areas covered by this study include the site, the area surrounding the site, and all areas downstream of the site which could be impacted by the site.

3.1.2.1.1 Description of Surface Water Bodies and Physical Characteristics of Drainage Areas

The general hydrographic area studied for the Yucca Mountain site and region is shown in Figure 3.1.2.1.1A. The peak streamflow data for selected crest-stage sites in the hydrographic study area shown in Table 3.1.2.1.1A.

There are no perennial streams in or near the Yucca Mountain area. However, the many ephemeral stream channels, including the large drainage system of Fortymile Wash and the Amargosa River, flow following significant storms. The Yucca Mountain region has high average annual potential evaporation (___ mm/ year to___ mm/year), low average precipitation (_____ mm/year), and infrequent storms (average frequency ____/year).

Figure 3.1.2.1.1A. General Hydrographic Study Area for Yucca Mountain Site and Region

Table 3.1.2.1.1A Peak Streamflow Data for Selected Crest-Stage Sites in the Hydrographic Study Area

Throughout the hydrographic study area, perennial surface water comes only from springs, and restricted to some short reaches of the Amargosa River, to source pools at some large springs, and to some marshes around the edge of the salt pan in Death Valley. One small lake, locally known as Crystal Reservoir, with a storage capacity of 2.27×10^6 m^3 occurs in the Ash Meadows part of the upper Amargosa hydrographic area (Figure 3.1.2.1.1A). There are no playas in the site area (____ confirm this statement).

3.1.2.1.2 Surface-Water Monitoring Network

This subsection provides information on the surface water monitoring network. The network is described as to location (see Figure 3.1.2.1.2B), type and number of stations, and measurement frequencies. Data have been collected using a network of crest-stage gages and (___ name other types of gages). These gages were monitored (____ cite frequency of monitoring). The data collected are summarized in Table 3.1.2.1.2A. (KKB-23, Provide the surface water monitoring data when available).

3.1.2.1.3 Water Control Structures and Diversions

Surface water structures that may influence or be influenced by the site are described. These structures include existing and planned manmade structures that may influence the potential for flooding. Figure 3.1.2.1.3A shows the location of reservoirs, mining, lumbering and other structures (KKB-24 no data appears to be available at this time and needs to be developed during site characterization.

Figure 3.1.2.1.2B. Surface Water Monitoring Network at the Yucca Mountain Region

Table 3.1.2.1.2A. Summary of Surface Water Monitoring Data

Figure 3.1.2.1.3A. Locations of Reservoirs, Mining, Lumbering and Other Structures

3.1.2.1.4 Flood History

Flooding in the Yucca Mountain region can occur over an extensive area, however, intense floods are generally restricted to relatively small areas and occur as flash floods of short duration. Table 3.1.2.1.4A shows maximum unit peak flood discharges ranging from (___m^3/s to ___m^3/s) for drainage areas greater than 100 km^2 to more than (___ m^3/s) for areas of 10 km^2.

Table 3.1.2.1.5A shows the major flood occurrences in some of the washes. The date, level, peak discharge, and related information for these major floods are shown in this table. (Flooding induced by landslides and other causes should be included in this table). Because the Yucca Mountain area is located inland and has no significant water bodies or water control structures located near the site, there is no potential for such features as surges, seiches, tsunamis, dam failures, ice jams that could affect the site, nor is there any potential for future dam development.

Geologic evidence of Quaternary flooding in the region of Yucca Mountain with emphasis on the Holocene is presented here (KKB-25, this information needs to be developed from further studies).

3.1.2.1.5 Flood Potential

Studies have been performed for flood prediction in the region and site using regional stream flow, precipitation, channel morphology data and modeling. These studies are supplemented by investigation of paleoflood sediments which provide history of major floods in the area.

Table 3.1.2.1.4A. Maximum Unit Peak Flood Discharges

Table 3.1.2.1.5A. Date, Level, and Peak Discharge for Major Flood Occurrences Washes in the Region

Estimates of the magnitudes of the 100 and 500 year flood peaks and the regional maximum peaks are shown in Figure 3.1.2.1.5A. The design basis water level at the location of the surface facilities and underground accesses are shown in Figure 3.1.2.1.5B. Table 3.1.2.1.5B provides the elevation of all structures and systems related to the surface facilities and underground openings.

The method for calculating the probable maximum flood is based on a determination of maximum probable precipitation over the drainage or drainage being considered. Detailed information of the drainage basin including stream flow data, precipitation and storm data, infiltration runoff characteristics and other information were used in flood prediction calculation.

Protection of potential flooding at the site was considered in choosing the proposed locations for the surface facilities and underground accesses. Topographic maps, direct observation, PMF flows and level have been considered in the design of the repository.

3.1.2.1.6 Chemical Composition of Identified Bodies of Surface Water

The chemical composition of bodies of water that could be affected by releases from the facility is described. The seasonal cycles of physical and chemical limnological parameters, bottom and shoreline configuration, sedimentation rates (suspended and bed load), and sorption rates (as asked for in the Reg Guide DG-3003) are not applicable in the discussion of the chemical

Figure 3.1.2.1.5A. Estimates of Magnitudes of 100 and 500 Year Flood Peaks and Regional Maximum Peaks in the Yucca Mountain Region

Figure 3.1.2.1.5B. The Design Basis Water Level at the Location of the Surface Facilities and Underground Accesses

Table 3.1.2.1.5B. Elevation of all Structures and Systems related to the Surface Facilities and Underground Openings composition of surface water in the Yucca Mountain region because of the arid to semiarid climate.

Surface water samples have been collected from the Yucca Mountain hydrographic area. The location of the samples are shown in Figure 3.1.2.1.6A. The chemical composition of the watercourses in the vicinity of Yucca Mountain is shown in Table 3.1.2.1.6A .

3.1.2.1.7 Location, Quantity, and Quality of Surface Water Extracted

Very little surface water exists in the vicinity of Yucca Mountain because of the arid to semiarid climate. No perennial stream exists except short reaches of the Amargosa River which is fed by springs. Other sources of perennial surface water are small spring fed ponds in Oasis Valley, the Amargosa Desert, and Death Valley. The locations of perennial sources of surface water are shown in Figure 3.1.2.1.7A. Table 3.1.2.1.7A shows the water source location, owner, type of intake, population served, maximum daily and average quantities of water pumped. Table 3.1.2.1.7B provides the water quality of these sources.

3.1.2.1.8 Projected Surface Water Use

A projection into the foreseeable future of the quantities and potential areas of surface water use for the region is provided here. Arid conditions of the region and the absence of perennial streams and lakes make surface water an unlikely source of use for the Yucca Mountain region.

Figure 3.1.2.1.6.A. Locations of Surface Water Samples Collected from the Yucca Mountain Hydrographic Area

Table 3.1.2.1.6A. Chemical Composition of the Watercourses in the Vicinity of Yucca Mountain

Figure 3.1.2.1.7A. Locations of Perennial Sources of Surface Water at the Yucca Mountain Area

Table 3.1.2.1.7A. Water Source Location, Owner, Type of Intake, Population Served, Maximum Daily and Average Quantities of Water Pumped From the Vicinity of Yucca Mountain

Table 3.1.2.1.7B.Water Quality of Perennial Surface Water Sources

Surface water use by man would probably increase (___ provide justification of statement) only in the event of climate change to a wetter one.

3.1.2.2 Regional Hydrogeology

This section will provide general information on the regional hydrogeology. This will describe the regional groundwater conditions that may be affected by the MGDS. In addition, the existing and projected users and uses of groundwater will be described.

3.1.2.2.1 Regional Flow System Boundaries and Hydrogeologic Units

This section describes the physical boundaries and hydrogeologic units of the regional hydrogeological system. A hydrogeologic unit is a geologic unit with consistent hydraulic properties such that the unit may be classified as an aquifer, confining layer, or a combination of both. The hydrogeologic units at the Yucca Mountain region have been defined on the basis of stratigraphy, lithology, and structural considerations. Figure 3.1.2.2.1A shows the distribution of the hydrogeologic units in the saturated zone Yucca Mountain region. Table 3.1.2.2.1A shows the relation between stratigraphic and geohydrologic units in the Yucca Mountain region.

Figure 3.1.2.2.1A. Distribution of the Hydrogeologic Units in the Saturated Zone

Yucca Mountain Region

Table 3.1.2.2.1A. Relation Between Stratigraphic and Geohydrologic Units in the Yucca Mountain Region

3.1.2.2.2 Potentiometric Levels and Hydraulic Gradients

The time history and areal distribution of measured potentiometric levels of each hydrogeological unit are described. The observed hydraulic gradients within and between units are also discussed. Figure 3.1.2.2.2A shows the location of the wells and the potentiometric surface of the regional geohydrologic area. Potentiometric data have been collected from regional potentiometric levels, monitoring well network, and local water-level monitoring.

3.1.2.2.3 Characteristics of the Hydrological Units

The hydraulic characteristics of each hydrogeologic unit is described below, and geostatistical analysis of the hydraulic characteristics of each unit are presented. Table 3.1.2.2.3A shows the hydraulic characteristics of each major unit in the Yucca Mountain region. Table 3.1.2.2.3B shows the geostatistical analyses of the hydraulic characteristics for each unit.

3.1.2.2.4 Recharge and Discharge

The recharge and discharge areas in the ground water basin is shown in Figure 3.1.2.2.4A. Recharge occurs from surface water runoff along major channels (__ provide name of channels). Ground-water discharges from the basin by spring flow, evapotranspiration, and, evaporation from bare soil area. The principal areas of discharge are in the southern Amargosa Desert. Smaller,

Figure 3.1.2.2.2A. Locations of the Wells and the Potentiometric Surface of the Regional Geohydrologic Area

Table 3.1.2.2.3A. Hydraulic Characteristics of Each Major Hydrogeologic Unit in the Yucca Mountain Region

Table 3.1.2.2.3B. Geostatisitcal Analyses of the Hydraulic Characteristics for Each Hydrogeologic Unit less significant areas are near Beatty, Indian Springs and in Death Valley are shown in Figure 3.1.2.2.4A. Table 3.1.2.2.4A shows major ground water discharge in the hydrogeologic region of Yucca Mountain.

3.1.2.2.5 Age of Regional Ground Water

An estimate of the regional ground waters based on hydrochemical information is provided. Table 3.1.2.2.5A shows the estimated age of the major regional ground water ages.

3.1.2.2.6 Ground-Water Flow Paths

Ground water movement is mostly from recharge areas in the (___ parts of the area) to the discharge areas in the (___ parts of the area) basin. Groundwater generally flows (___ in the direction) through most of the area with local variation (___ provide local direction). Figure 3.1.2.2.6A shows the regional ground-water flow paths. Figure 3.1.2.2.6B shows a cross section providing the flow net through the region.

The flow paths have been developed from hydraulic characteristics, gradients, hydrochemistry, recharge, discharge, temperature profiles in wells (___ add any other studies for flow path determination). Numerical modeling have been performed using the codes (___ name the codes and methodology, and provide documentation, verification, calibration and other associated information for the numerical models).

Figure 3.1.2.2.4A. Recharge and Discharge Areas in the Ground Water Basis in the Yucca Mountain Area

Table 3.1.2.2.4A. Major Ground Water Discharge in the Hydrogeologic Region of Yucca Mountain

Table 3.1.2.2.5A. Estimated Age of the Major Regional Ground Waters

Figure 3.1.2.2.6A. Regional Ground Water Flow Paths

Figure 3.1.2.2.6B. Cross Section Showing Ground Water Flow Net Through the Region

3.1.2.2.7 Paleohydrology

The geologic evidence of hydrogeologic conditions throughout the region that have occurred during the Quaternary Period with emphasis on the Holocene Age is described here. Figure 3.1.2.2.7A shows the south central Great Basin location of uranium-series dated veins which is evidence of former high levels of water in this basin. This indicates that higher levels of water occurred during the Pleistocene time, (__ yr to __ ago). The Quaternary water table may have been (____ meters to _____ meters) above the current water table.

Figure 3.1.2.2.7B shows the probable ground water flow paths during the Quaternary Period. During the late Wisconsin, 21,000 to 10,000 years ago, average annual precipitation may have been (___ percent) greater, and temperature may have been (____ degree C) cooler. (Provide discussion of groundwater during the late Wisconsin.)

3.1.2.2.8 Regional Ground Water Use

The regional aquifers in the hydrogeologic study area that are used of human activities are the valley fill aquifer and the lower carbonate aquifer. The welded tuff aquifer is locally important; it is developed only in the southwestern areas of the NTS in support of the former Nevada research and development area. Figure 3.1.2.2.8A shows areas of heavy withdrawal and injection of ground-water in the regional hydrologic area. Table 3.1.2.2.8A shows a list of wells in the region with location, rates of withdrawal, typical well construction, and specific hydrologic unit

Figure 3.1.2.2.7A. South Central Great Basin Location of Uranium Series Date Veins Which is Evidence of Former High Levels of Water in This Basin

Figure 3.1.2.2.7B. Probable Ground Water Flow Paths During the Quaternary Period

Figure 3.1.2.2.8A. Areas of Heavy Withdrawal and Injection of Ground Water in the Regional Hydrologic Area

Table 3.1.2.2.8A. List of Wells in the Region with Location, Rates of Withdrawal, Typical Well Construction, and Specific Hydrologic Unit Source

source. Ground water usage for irrigation, municipal, domestic, livestock, and energy resources (mining ?, geothermal) are included.

Table 3.1.2.2.8B shows a list of wells in the region where water is injected, the location of the wells, method of construction, rate of injection, and the hydrologic unit where water is injected. Figure 3.1.2.2.8B shows the location of these injection wells in the regional geohydrologic area.

3.1.2.2.9 Regional Ground Water Management Plan

Water use in Nevada is governed by the Office of the State Engineer, and the Division of Water Resources. Chapter 534 (Title 48-Water) of the Nevada Water Laws outline and delineate the allowable uses of ground water. The State of Nevada uses a recharge-use philosophy in its management of ground water resources. At the first indication of an aquifer overdraft, measures are taken to carefully regulate ground water withdrawals. The State Engineer has the authority to designate ground water basin boundaries where he considers the ground water resources are being depleted. Such designation has been issued in the regional areas of (___ name any such designated area at the time of License Application. (Also provide an assessment of the regional ground-water projection at that time depending the policy of the State of Nevada).

3.1.2.3 Site Hydrogeology

This section describes the site hydrogeologic system and supporting data and technical analyses.

Table 3.1.2.2.8B. List of Wells in the Yucca Mountain Region Where Water is Injected (The Location of the Wells, Method of Construction, Rate of Injection, and the Hydrologic Unit Where Water is Injected)

Figure 3.1.2.2.8B. Locations of Injection Wells in the Regional Geohydrologic Area

3.1.2.3.1 Baseline Monitoring Network

Monitoring wells are established in the saturated and unsaturated zone at the site.

Unsaturated Zone. The monitoring program is designed to quantify the energy status of the variably saturated rock system at Yucca Mountain. Fluid potentials that govern variably saturated rock are the two-phase (liquid-gas) flow and are measured by the monitoring network. These potentials are: 1) matric potential for the liquid phase, 2) gas-phase or pneumatic phase, 3) osmotic potential, and 4) thermal potential. Gravitational potential is given directly by the height of the monitoring point above an arbitrary datum.

Figure 3.1.2.3.1A shows the locations of the bore holes that are being used to monitor the unsaturated zone at Yucca Mountain site. Figures 3.1.2.3.1(B-R ?) show the construction, wellhead elevation, total depth, casing type and depth, seals, screened intervals, monitoring intervals, instrumentation, and time since instrument installation in the monitoring bore holes. The selection process for choosing the locations and depth of the data collection system is described below (KKB-26 provide this information when monitoring wells are selected).

Saturated Zone. In the saturated zone, water table levels are measured in order to determine the potentiometric surface at Yucca Mountain. The location of the saturated zone monitoring wells are shown in Figure 3.1.2.3.1S. Figure 3.1.2.3.1T shows the typical construction of these monitoring wells. Table 3.1.2.3.1A shows a list of all monitoring wells in the saturated zone at

Figure 3.1.2.3.1A. Locations of the Bore Holes That Are Being Used to Monitor the Unsaturated Zone at Yucca Mountain Site

Figure 3.1.2.3.1B-R. Construction, Wellhead Elevation, Total Depth, Casing Type, and Depth, Seals, Screened Intervals, Monitoring Intervals, and Instrumentation in the Monitoring Bore Holes

Figure 3.1.2.3.1S. Locations of the Saturated Zone Monitoring Wells

Figure 3.1.2.3.1T. Typical Construction of Monitoring Wells

Table 3.1.2.3.1A. List of All Monitoring Wells in the Saturated Zone at the Site Including: Location, Wellhead Elevation, Total Depth, Diameter, Depth of Completion, Construction of Each Well, Monitoring Interval, Seals Etc.

the site, and includes the location, wellhead elevation, total depth, diameter of well, depth of completion, construction of each well, monitoring interval, seals etc.

Reasons for the selection of these wells are detailed below (KKB-26 provide the rationale when monitoring wells are completed).

3.1.2.3.2 Site Flow System Boundaries and Hydrogeologic Units

The site hydrogeologic units and their correlation with rock stratigraphic units for the unsaturated (vadose) zone and saturated zone are shown in Figure 3.1.2.3.2A. A discussion of the basis for selection of these hydrogeologic units is described below (KKB-27 provide this discussion once hydrogeologic units are confirmed).

3.1.2.3.3 Potentiometric Levels, Matric Potentials, and Gradients

Unsaturated Zone. In situ measurements of matric potential within the unsaturated zone at Yucca Mountain have been measured in instrumented boreholes. See Figure 3.1.2.3.3A for the location of these instrumented boreholes. Figure 3.1.2.3.3A shows a representative profile of matric-potential measured in the boreholes by various instrumentation (__ name instrumentation e.g. heat-dissipation probes, thermocouple psychrometers).

Figure 3.1.2.3.2A. The Site Hydrogeologic Units and Their Correlation with Rock Stratigraphic Units for the Unsaturated and Saturated Zones

Figure 3.1.2.3.3A. Representative Profile of Matrix Potential Measured in the Boreholes by Various Instrumentation

The time history and areal distribution of the measured matric potentials and moisture contents (including osmotic potential) are discussed for each hydrogeologic unit at the site. (KKB-28, provide this discussion when data are available).

The temporal and spatial extent of the perched water system encountered at the site is described below. (KKB-28 provide perched water system information if found during site characterization).

Saturated Zone. Potentiometric data are obtained in the saturated form measuring water levels and observing their variation with time. Water levels in the monitoring well from the site at selected dates are shown in Table 3.1.2.3.3A and Figure 3.1.2.3.3A. The water level range in elevation (___ meters to ___ meters) above sea level and generally represent water-table or unconfined conditions. Figure 3.1.2.3.3B displays a cross section through the Yucca Mountain site showing the potentiometric surface and its relationship with the stratigraphic units.

The gradient of the saturated zone is (KKB-28 provide discussion of water surface gradient within and between individual geohydrological units at the site).

Hydrographs of water level data are not provided (KKB-29 verify this when data are available). In Yucca Mountain ground water levels do not show short term or seasonal fluctuations that can be correlated with precipitation. This is because of extremely low rate of net infiltration (___ provide number) and recharge attributable to local precipitation, the great

Table 3.1.2.3.3A. Water Levels in the Monitoring Well From the Site at Selected Dates

Figure 3.1.2.3.3B. Cross Section Through the Yucca Mountain Site Showing the Potentiometric Surface and Its Relationship with the Stratigraphic Units depths to water table (___ meters to ____ meters), and very long ground water travel time (ranging from ___ mm/year to ___ mm/year). Characteristic fluctuations resulting from various factors such as seasonal pumping variations, seasonal response to surface water bodies, barometric data are presented. Figure 3.1.2.3.3C shows potentiometric fluctuation due to pumping at the site. Figure 3.1.2.3.3D shows a typical response to barometric variation and water table at the site.

3.1.2.3.4 Characteristics of Hydrogeologic Units

The characteristics of each hydrogeologic unit at the site is described in detail below.

3.1.2.3.4.1 Saturated Media

General Physical Characteristics. Table 3.1.2.3.4.1A shows the total and effective porosity including the nature of porosity (interstitial, fracture, or solution). Figure 3.1.2.3.4.1A shows the fracture geometry, orientation, filling and fracture matrix sealing along the surface for each hydrogeologic unit in the saturated zone.

General Hydraulic Characteristics. Table 3.1.2.3.4.1B presents the summary of hydrologic characteristics of the major hydrogeologic units at Yucca Mountain. Characteristics include intrinsic permeability transmissivity, hydraulic conductivity (with saturated thickness), leakage coefficients for aquitards, and the storage coefficient.

Figure 3.1.2.3.3C. Potentiometric Fluctuations Due to Pumping at the Site

Figure 3.1.2.3.3.D. Typical Response to Barometric Variation and Water Table at the Site

Table 3.1.2.4.3.1A. Total and Effective Porosity of Hydrogeologic Units in the Saturated Zone Including the Nature of Porosity (Interstitial, Fracture, or Solution)

Figure 3.1.2.3.4.1A. Fracture Geometry, Orientation, Filling and Fracture Matrix Sealing Along Surface for Each Hydrogeolgic Unit in the Saturated Zone

Table 3.1.2.3.4.1B. Summary of Hydrologic Characteristics of the Major Hydrogeologic Units at Yucca Mountain

General Transport Characteristics. The longitudinal and transverse dispersivity and tortuosity of each hydrogeological unit at Yucca Mountain is described here. Table 3.1.2.3.4.1C provides the data for these transport characteristics.

3.1.2.3.4.2 Unsaturated Zone

General Physical Characteristics. Table 3.1.2.3.4.2A shows the mean values of total and effective porosity, bulk and skeletal density of the unsaturated units at the site. Figure 3.1.2.3.4.2A shows the fracture geometry and orientation. Figure 3.1.2.3.4.2B shows the pore geometry and pore size distribution for the hydrogeological units.

Additional Fracture Surface Characteristics. A description of the characteristics of fractured media including fracture-matrix sealing along surfaces, fracture surface profiles, roughness, fracture permeability, drainage suction (capillary aperture), and fracture conductance (conductivity normal to fracture plane) are provided here. See Figure 3.1.2.3.4.2C and Table 3.1.2.3.4.2B.

General Hydraulic Characteristics. Table 3.1.2.3.4.2C shows the mean values of hydraulic characteristics of unsaturated zone including air or water intrinsic permeability and Klinkenberg coefficient. Figures 3.1.2.3.4.2D, and E show unsaturated hydraulic conductivity as a function of water content and matric potential. Figure 3.1.2.3.4.2E shows the moisture characteristic curves (both wetting and drying) for the hydrogeologic units of the unsaturated zone. Figure 3.1.2.3.4.2F presents moisture diffusivity as function of water content and matric potential, and

Table 3.1.2.3.4.1C. Data for the Longitudinal and Transverse Dispersivity and Tortuosity of Hydrogeoligcal Unit in the Saturated Zone

Table 3.1.2.3.4.2A. Mean Values of Total and Effective Porosity, Bulk and Skeletal Density of the Unsaturated Units at the Site

Figure 3.1.2.3.4.2A. A Fracture Geometry and Orientation in the Unsaturated Units at the Site

Figure 3.1.2.3.4.2B. Pore Geometry and Pore Size Distribution for the Hydrogeological Units

Figure 3.1.2.3.4.2C. Characteristics of Fractured Media in the Unsaturated Zone

Table 3.1.2.3.4.2B. Characteristics of Fractured Media in the Unsaturated Units at the Site

Table 3.1.2.3.4.2C. Mean Values of Hydraulic Characteristics of Unsaturated Zone Including Air or Water Intrinsic Permeability and Klinkenberg Coefficient

Figure 3.1.2.3.4.2D. Unsaturated Hydraulic Conductivity as a Function of Water Content and Matric Potential

Figure 3.1.2.3.4.2E. Moisture Characteristic Curves (Both Wetting and Drying) for the Hydrogeologic Units of the Unsaturated Zone

Figure 3.1.2.3.4.2F. Moisture Diffusivity as Function of Water Content and Matric Potential

Figure 3.1.2.3.4.2G shows specific water capacity as a function of both water content and matric potential.

General Transport Characteristics. Table 3.1.2.3.4.2D shows the longitudinal and transverse dispersivity for the unsaturated zone units at the site.

General Pneumatic and Vapor Transport Characteristics. Table 3.1.2.3.4.2E presents the unsaturated pneumatic permeability and the relevant diffusion characteristics. The variation of existing gaseous components as well as existing gaseous flow and transport conditions are described.

Parameters for Hydrologic Models

:

3.1.2.3.5 Site Ground Water Recharge

The ultimate source of moisture in the unsaturated zone in Yucca Mountain site is by net infiltration from precipitation on the mountain. From measurements performed, the average annual precipitation in Yucca Mountain site is (__ mm/year). The spatial and temporal variation of net infiltration have been evaluated at the Yucca Mountain site; however, because of the great depth of the saturated zone, the temporal variation and spatial distribution beneath Yucca Mountain is not expected to be equal to the temporal distribution and surficial distribution of net infiltration. Slow temporal variation of the moisture flux at any horizon is expected to occur

Figure 3.1.2.3.4.2G. Specific Water Capacity as a Function of both Water Content and Matric Potential

Table 3.1.2.3.4.2D. Longitudinal and Transverse Dispersivity for the Unsaturated Zone Units at the Site

Table 3.1.2.3.4.2E. Unsaturated Pneumatic Permeability and the Relevant Diffusion Characteristics generally only in response to long term climatic changes (provide results of analyses to support this assertion).

[Note: This section will present information and dates used in determining the groundwater travel time used in resolving the pre-emplacement issue. The pre-emplacement groundwater travel times will be fully discussed in Section 3.3.2.]

The present rate of net infiltration over the surface of Yucca Mountain is not a reliable indicator of either the net recharge beneath Yucca Mountain or the net moisture flux at or below the repository horizon.

A recharge rate has been estimated using regional relationship among recharge, altitude zones, precipitation, runoff during intense storms, local rainfall distribution, temperature, vegetation cover (KKB-30, provide the results of this study when completed). Ground water modeling analyses have been performed in support of recharge estimates. Figure 3.1.2.3.4.2H shows the ground water recharge at the site.

3.1.2.3.6 Site Ground Water Discharge

Figure 3.1.2.3.6A shows the springs, seeps, stream base flow and other local ground water discharge in the Yucca Mountain area.

Figure 3.1.2.3.4.2H. Ground Water Recharge at the Site

Figure 3.1.2.3.6A. Springs, Seeps, Stream Base Flow and Other Local Ground Water Discharge in the Yucca Mountain Area

3.1.2.3.7 Age of Ground Water

An estimate of the age variation of the site ground waters and velocity of movement at the site based on hydrochemical information is provided. Table 3.1.2.3.7A summarizes this information. The method of ground water age and velocity determination as well as error analyses of all results are described and documented in this subsection.

3.1.2.3.8 Site Pathway Analysis

This section describes the fluid pathways (e.g. liquid or gas) to the accessible environment. The methodology used to develop the description of fluid pathways considered the distribution of flux and used information on hydraulic characteristics, gradients, hydrochemistry, recharge, discharge and other data developed through site characterization activities. The variability and uncertainty of data are accounted for in the analyses and justification for neglecting any contradiction information is provided. The transience of baseline conditions and the sensitivity of baseline conditions to the perturbation in the context of existing or near term time frame (not thousands of years) were assessed.

Numerical modeling using (____ name computer codes) were used to develop fluid pathways at the site. The numerical analyses type (____ finite difference, finite element, closed form solution etc.) documentation of code and verification, calibration, and other associated information are provided. (KKB-31, provide fluid flow numerical code information when analyses is complete). Figures 3.1.2.3.8A and B show the generalized east-west and north-south

Table 3.1.2.3.7A. Summary of the Age Variation of the Site Ground Waters and Velocity of Movement

Figure 3.1.2.3.8A. Generalized East-West Fluid Flow System Under Natural Conditions

Figure 3.1.2.3.8B. Generalized North-South Fluid Flow System Under Natural Conditions fluid flow system under natural conditions. Figure 3.1.2.3.8C shows the generalized ground water flow in the Yucca Mountain site.

3.1.2.3.9 Local Ground Water Use

All the local ground water users and their locations, rates, typical well construction, and hydrogeologic unit source are identified. Figure 3.1.2.3.9A shows the location of the local ground-water users. Table 3.1.2.3.9A shows the information regarding the local water users.

3.1.2.3.10 Paleohydrology

The hydrological conditions during the Quaternary Period, with emphasis on Holocene, that differ significantly from present conditions at the site are described.

The paleohydrology of the site was assessed from field studies (____ name these studies) and computer modeling (____ name codes, and provide documentation). On the basis of mineralogy, ground water level in the Quaternary was estimated to be (between ___ meters and ____ meters) above the current level at the site.

Figure 3.1.2.3.8C. Generalized Ground Water Flow in the Yucca Mountain Site

Figure 3.1.2.3.9A. Locations of the Local Ground Water Users

Table 3.1.2.3.9A. Locations, Rates, Typical Well Construction, and Hydrologic Source of Local Ground Water Users

The pluvial related water table levels beneath the Yucca Mountain have been analyzed using numerical (____ provide type of model) modeling of ground water at the site. The results conclude that in the past, water levels at the site in the past have been (____ meters) above the current level.

Deposits along the fault zones have been investigated for evidence of change in hydrologic conditions. [The origin of deposits prove that minerals have been deposited as a result of (KKB-34, provide results of trench 14 and other future tests).]

3.1.3 Geochemical System

This section describes the geochemical characteristics of the geologic setting and the site, including information on anomalies, properties, and conditions affecting the stability of geochemical characteristics. It is demonstrated that the areas studied provide a representative description of the conditions throughout the region around and at the site. Detailed justification for the areal limits placed on regional studies is provided. The difference between unsaturated zone and saturated zone geochemical characteristics, properties, and conditions are also included.

3.1.3.1 Regional Geochemistry

The saturated and unsaturated zone geochemical characteristics, conditions, and properties of the region are described in this section. Specifically, the conditions and processes that exist and have existed during the Quaternary Period, with emphasis on those differing from the present conditions, are described below. An assessment of changes that might be expected in the future is presented. Sufficient details are provided to allow independent analysis of the results. The use of natural analogs for describing geochemical systems of the region and site is addressed, and the role of expert judgment in the various analyses is documented.

3.1.3.1.1 Information and Investigations on the Geochemistry of the Regional Rock

The regional saturated and unsaturated zone mineralogy, petrology, and chemistry are described in this section including:

- Bulk rock chemistry (Figure 3.1.3.1.1A, Table 3.1.3.1.1A)
- Mineral distributions in bulk rock (Figure 3.1.3.1.1B, Table 3.1.3.1.1B)
- Mineral chemistry (Table 3.1.3.1.1C)
- Mineral distributions in fractures (Figure 3.1.3.1.1C, Table 3.1.3.1.1D)
- Chemistry of fracture deposits (Figure 3.1.3.1.1D, Table 3.1.3.1.1E)
- Information on rock, mineral and glass origins, mineral and glass stability, and general thermal characteristics. Differences between the geochemistry of the regional saturated and unsaturated zones (Table 3.1.3.1.1F) are also discussed.

Figure 3.1.3.1.1A. Bulk Rock Chemistry

Table 3.1.3.1.1A. Regional Bulk Rock Chemistry

Figure 3.1.3.1.1B. Mineral Distribution in Bulk Rock

Table 3.1.3.1.1B. Mineral Distributions in Regional Bulk Rock

Table 3.1.3.1.1C. Regional Bulk Rock Mineral Chemistry

Figure 3.1.3.1.1C. Mineral Distribution in Fractures

Table 3.1.3.1.1D. Mineral Distributions in Fractures in Regional Bulk Rock

Figure 3.1.3.1.1D. Chemistry of Fracture Deposits

Table 3.1.3.1.1E. Chemistry of Fracture Deposits

Table 3.1.3.1.1F. Differences Between the Geochemistry of the Regional Saturated and Unsaturated Zones

The codes used to model saturated and unsaturated zone rock/fracture geochemistry are described including the uncertainties related to the thermodynamic data bases, the applicability of specific models, the appropriateness of the assumptions used in models, the sensitivity of model results to variability and uncertainty of input data, the propagation of errors, and the input/output data, and interpretations of data used in models.

3.1.3.1.2 Information and Investigations on the Regional Geochemistry of the Ground Water and Gas

The regional properties and chemistry of the saturated and unsaturated zone ground water are described in this section. Including:

- Ground water chemistry (Table 3.1.3.1.2A)
- Dissolved gas content (Table 3.1.3.1.2B)
- Major and minor inorganic and organic content (Table 3.1.3.1.2C and Table 3.1.3.1.2D)
- Trace element content (Table 3.1.3.1.2E)
- Stable and radioactive isotopes (Table 3.1.3.1.2F), particulate, colloids, and mineral controls on water composition.
- Discussion and rationale for the selection of ground water used in conducting experiments.

Table 3.1.3.1.2A. Ground Water Chemistry

Table 3.1.3.1.2B. Dissolved Gas Content of Regional Saturated and Unsaturated Zone Ground Water

Table 3.1.3.1.2C. Major and Minor Inorganic Content of Saturated and Unsaturated Zone Ground Water

Table 3.1.3.1.2D. Major and Minor Organic Content of Saturated and Unsaturated Zone Ground Water

Table 3.1.3.1.2E. Trace Element Content of Saturated and Unsaturated Zone Ground Water

Table 3.1.3.1.2F. Stable and Radioactive Isotopes of Saturated and Unsaturated Zone Ground Water

- Differences between the regional saturated and unsaturated zone ground water geochemistry (Table 3.1.3.1.2G).

The regional properties and chemistry of the saturated and unsaturated zone gas are described herein including an analyses of inorganic context and discussions on stable and radioactive isotopes, aerosols, and temperature and pressure.

The location of samples and data collection methods are presented in this section and include an evaluation of data representativeness, the effects of scale differences between laboratory and field data sources, the effects of varying hydrologic conditions, and uncertainties associated with the extrapolation of data and information.

The codes used to model saturated and unsaturated zone ground water geochemistry include uncertainties related to the thermodynamic data bases, the applicability of specific models, the appropriateness of the assumptions used in models, the sensitivity of model results to variability and uncertainty of input data, propagation of errors, and the input/output data and interpretations of data used in models.

Table 3.1.3.1.2G. Differences Between Regional Saturated and Unsaturated Zone Ground Water Geochemistry

3.1.3.1.3 Information and Investigations on the Regional Geochemistry Governing Radionuclide Mobility

The regional saturated and unsaturated zone geochemical properties and conditions that affect radionuclide mobility are discussed herein and include: 1) solubility and precipitation as a function of radionuclide speciation (Table 3.1.3.1.3A); water chemistry (Table 3.1.3.1.2B); radiation field; 2) sorption and desorption as a function of ground water composition (Table 3.1.3.1.3C); mineralogy and surface structure (Table 3.1.3.1.3D); speciation; waste element concentration; gas composition; temperature; colloidal material; organic complexity; 3) sorption kinetics; 4) biological sorption and desorption; 5) dispersive, diffusive, and adjective process; and 6) transport of gaseous radionuclides. Differences between regional saturated and supersaturated zone radionuclide transport characteristics are presented.

Sources of information, location of samples, and data collection methods are described and documented in this section. Included are:

- Evaluation of data representativeness
- Effects of scale difference between laboratory and field data sources
- Effects of varying conditions
- Uncertainties associated with the extrapolation.

Table 3.1.3.1.3A. Solubility and Precipitation as a Function of Radionuclide Speciation

Table 3.1.3.1.3B. Water Chemistry

Table 3.1.3.1.3C. Sorption and Desorption as a Function of Ground Water Composition

Table 3.1.3.1.3D. Mineralogy and Surface Structure

3.1.3.2 Site Geochemistry

Sufficient data and technical analyses are provided to describe the saturated and unsaturated zone geochemical characteristics, conditions, and properties of the site. Specifically, the geochemical conditions and processes that exist and have existed during the Quaternary (with emphasis on those that differ significantly from present conditions), are presented. Assessments of changes that might reasonably be expected to occur in the future are included. The use of natural analogs is addressed. The role of expert judgment is documented.

3.1.3.2.1 Information and Investigations on the Geochemistry of the Site Rock

The site saturated and unsaturated zone mineralogy, petrology, and chemistry are described here. This information includes: bulk rock chemistry, mineral distributions in bulk rock, mineral chemistry, mineral distributions in fractures, chemistry of fracture deposits, information on rock, mineral, and glass origins; alteration history of bulk rock and fracture mineralization; mineral and glass stability, and general thermochemical characteristics. The differences between the geochemistry of the site saturated and unsaturated zones are also discussed.

The sources of information, location of samples, and data collection methods are discussed and documented. The discussion includes:

- Evaluation of data representativeness
- Effects of scale difference between laboratory and field data sources

- Effects of varying conditions
- Uncertainties associated with the extrapolation of data and information

The codes used to model saturated and unsaturated zone rock/fracture geochemistry are discussed including the uncertainties related to the thermodynamic data bases; applicability of specific models; appropriateness of the assumptions used in models; sensitivity of model results to variability and uncertainty of input data; propagation of errors; and input/output data, and interpretations of data used in models.

3.1.3.2.2 Information and Investigations on the Geochemistry of the Site Ground Water and Gas

The properties, character, and chemistry of the saturated and unsaturated zone ground water and gas at the site are described herein and the discussion includes:

- Ground water chemistry
- Major and minor inorganic and organic content
- Trace element content
- Stable and radioactive isotopes
- Dissolved gas content
- Particulates
- Colloids
- Mineral controls on water composition.

Discussion and the rationale for the selection of ground water used in conducting experiment and the differences between the site saturated and unsaturated zone ground water geochemistry are also described.

The site properties and chemistry of the saturated and unsaturated zone gas are described, and included in the description are the analyses of inorganic context; stable and radioactive isotopes; aerosols; and temperature and pressure.

The sources of information and data collection methods used to obtain measurements and observations are presented. The discussion includes an evaluation of data representativeness; effects of scale difference between laboratory and field data sources; effects of varying hydrologic conditions; and uncertainties associated with the extrapolation of data and information.

The codes used to model saturated and unsaturated zone ground water geochemistry are also discussed and include the uncertainties related to the thermodynamic data bases; applicability of specific models; appropriateness of the assumptions used in models; sensitivity of model results to variability and uncertainty of input data; propagation of errors; input/output data, and interpretations of data used in models.

3.1.3.2.3 Information and Investigations on the Site Geochemistry Governing Radionuclide Mobility

The site saturated and unsaturated zone geochemical properties and conditions that affect radionuclide mobility are described including: 1) solubility and precipitation as a function of radionuclide speciation, water chemistry, and radiation field, 2) sorption and desorption as a function of ground water composition, mineralogy and surface structure; speciation; waste element concentration; gas composition; temperature; colloidal material; and organic complexity, 3) sorption kinetics, 4) biological sorption and desorption, 5) dispersive, diffusive and adjective processes, and 6) the transport of gaseous radionuclides.

The sources of information, locations of sampling, and data collection methods used to obtain measurements and observations are described and documentation is provided. The discussion includes the evaluation of data representativeness, the effects of difference of scale between laboratory and field data sources, the effects of varying conditions, and uncertainties associated with the exploration data and information.

The conceptualizations and the documentation and validation of codes used to model saturated and unsaturated zone radionuclide mobility are discussed with respect to uncertainties related to thermodynamic data bases, the applicability of specific models, the appropriateness of assumptions used to model site radionuclide mobility in the saturated and unsaturated zone, and the sensitivity of model results to the uncertainty of the geochemical input date are discussed.

The variability and uncertainty of data and information, as well as the propagation of errors are also presented. Input/output data and interpretations are also provided.

3.1.4 Climatological and Meteorological Systems

Past and present climatological and meteorological conditions of the geologic setting and the site are described herein. An assessment of future climatic variation of the site is also provided. It is demonstrated that the areas studied provided representative descriptions of the conditions throughout the region around the site and at the site.

3.1.4.1 Present Climate and Meteorology

The baseline climatological and meteorological conditions of the site are described in this sub-section.

3.1.4.1.1 Climate

The general climate of the region and site is described with respect to types of air masses, synoptic features, frontal systems, airflow patterns, and relationships between synoptic-scale atmospheric processes and site meteorological conditions. Climactic characteristics attributable to the terrain are also identified.

Site and regional climatological data for Yucca Mountain have been collected from (____ number of) monitoring stations at the site, and weather stations operated by National Weather Service (NWS). This data has been supplemented by information obtained from the National Oceanic and Atmospheric Administration (NOAA), and the National Climatic Center (NCC), government facilities (NTS ?), and universities (____ name any). Figure 3.1.4.1.1AG shows the locations of the climatological data stations in the Yucca Mountain region.

The Yucca Mountain site is situated in an area bordering two NWS climatological zones of Nevada, south central and extreme southern. Lower elevations in the vicinity of Yucca Mountain experience conditions typical of southwestern desert zones within the United States that are characterized by hot summers, mild winters, and limited amounts of precipitation. Higher elevations have less severe summer temperatures and greater, but still limited amounts, of precipitation.

The major air masses affecting the weather at Yucca Mountain originate either over the Pacific Ocean or over polar-continental regions. A thermally induced area of low pressure is created during the summer months over most desert regions (Reference 3.1.4.1.1A, Wallace and Hobbs, 1977), and prevails over the southwestern United States during the summer. Although this thermal low is generally associated with weak cyclonic motion (Reference 3.1.4.1.1B, Huschke, 1959), it brings south to southwesterly wind to the Yucca Mountain area. Another less frequent summer circulation pattern that brings moisture to the area is a semipermanent subtropical high-pressure system called a Bermuda High (Reference 3.1.4.1.1B, Huschke, 1959).

Figure 3.1.4.1.1A. Locations of the Climatological Data Stations in the Yucca Mountain Region

In addition to these synoptic-scale climatic influences, the rugged terrain of the Yucca Mountain area can create micrometeorological variations of a given parameter within relatively short distances. Drainage winds are an example of this phenomenon. These winds can locally affect wind speed, wind direction, and temperature (Reference 3.1.4.1.1C, Eglinton and Dreicer, 1984).

Another example of micrometeorological variations induced by the terrain is the variability in precipitation amounts between stations at different elevations, and between those with differing exposure to prevailing storm tracks or occurrences. Table 3.1.4.1.1A provides a general outline of the climatic conditions experienced at Yucca Mountain.

The relationship between synoptic-scale processes and their effect on site-specific meteorology have been established using the multi-tower monitoring program implemented at Yucca Mountain (KKB-35, provide the data when this program is established and data become available).

The climatological conditions at the site impact the design and operation of the repository. The surface facilities are designed to withstand temperature, wind, and precipitation conditions. The potential for flooding at the surface facilities and underground accesses are considered in the design. The ventilation system for the surface and underground facilities are impacted by the climatological conditions.

Table 3.1.4.1.1A. General Outline of the Climatic Conditions Experienced at Yucca Mountain

3.1.4.1.2 Site Meteorological Monitoring Network

The network of meteorological monitoring instruments used to develop baseline information for the site is described. The key meteorological data that indicate local climate are temperature, precipitation, relative humidity, insolation, ground surface infrared radiation, soil temperature, barometric pressure, wind speed, and wind direction. The site monitoring program is also collecting both synoptic-scale meteorological influences and specific terrain-induced perturbations. Meteorological data at the site have been collected from monitoring stations. The locations of these stations are shown in Figure 3.1.4.1.2A. Table 3.1.4.1.2A provides specific information as to elevation, type and period of measurements for each of these stations. The instrumentation of these stations is described in Table 3.1.4.1.2B including the frequency of measurements. Regulatory Guide 1.23, "Onsite Meteorological Programs" has been used for guidance in setting up the onsite meteorological measurement and data format.

3.1.4.1.3 Site Meteorology

The site meteorological conditions, including temperature, humidity, average and extreme durations and intensity of precipitation, and average and extreme wind vectors are described herein. Table 3.1.4.1.3A shows the temperature data at the site including: average daily maximum, highest daily, average daily minimum, lowest daily, and monthly average for the period of record (19xx to 20xx). Table 3.1.4.1.3B shows the relative humidity and wet-bulb data for the site.

Figure 3.1.4.1.2A. Location of Monitoring Sites

Table 3.1.4.1.2A. Elevation, Type of Measurements, and Period of Measurements for Each Stations in the Meteorological Monitoring Network

Table 3.1.4.1.2B. Instrumentation of Stations In Meteorological Network, Including the Frequency of Measurements

Table 3.1.4.1.3A. Temperature Data at the Site Including: Average Daily Maximum, Highest Daily, Average Daily Minimum, Lowest Daily, and Monthly Average for the Period of Record (19xx to 20xx)

Table 3.1.4.1.3B. Relative Humidity and Wet-Bulb Data for the Site

Table 3.1.4.1.3C shows the average and extreme duration and intensity of precipitation at the site. Figure 3.1.4.1.3A shows the monthly average precipitation for stations located at the Yucca Mountain. Table 3.1.4.1.3D shows the maximum 1 and 24 hour precipitation levels at the site. The seasonal variation of wind direction and speed are shown in Figures 3.1.4.1.3B and C for elevations of (____ meters and ____ meters). The same data is presented in Table 3.1.4.1.3E and Table 3.1.4.1.3F. Annual extreme wind speed at (____ meters) above ground at the site is provided in Table 3.1.4.1.3G.

3.1.4.2 Paleoclimatology

An analysis of the Quaternary climatology of the site is presented here including the atmospheric, hydrospheric, and cryospheric aspects of the successive climatic regimes in the context of determining the magnitude of the climatic changes and the rates at which the changes occurred. Changes in precipitation regimes, glaciated areas, and windflow patterns were identified.

Historical and prehistorical climatic, limnologic, hydrologic, and vegetational date obtained from near Yucca Mountain and the surrounding region are used to increase and supplement the paleoclimatic data base use for characterization of the Yucca Mountain site. These data were used in the calibration of vegetation-climate and lake-climate models, as well as in the development of a regional climate mode. Pollen and pack rat midden macrofossil assemblages from the (____ name area) were collected and correlated with climatological data. Table 3.1.4.2A provides a summary of palynological and pack rat midden data from the Yucca Mountain site.

Table 3.1.4.1.3C. Average and Extreme Duration and Intensity of Precipitation at the Site

Figure 3.1.4.1.3A. Monthly Average Precipitation for Stations Located at the Yucca Mountain

Table 3.1.4.1.3D. Maximum 1 and 24 Hour Precipitation at the Site

Figure 3.1.4.1.3B. Seasonal Variation of Wind Direction

Figure 3.1.4.1.3C. Seasonal Variation of Wind Speed

Table 3.1.4.1.3E. Seasonal Variation of Wind Direction

Table 3.1.4.1.3F. Seasonal Variation of Wind Speed

Table 3.1.4.1.3G. Annual Extreme Wind Speed at (__m) Above Ground at the Site

Table 3.1.4.2A. Summary of Palynological and Pack Rat Midden Data from the Yucca Mountain Site

Sediment cores were obtained from playas, paleomarshes, and lakes near Yucca Mountain and the site which provided a dated time series of:

- Changes in size, chemistry, and productivity of lakes.
- Wet phases in now dry playas and marshes.
- A generalized model of the site was developed for the Quaternary climatic variation at the site and surrounding region (KKB-36, provide the results of modeling when complete).

The size (areal extent and thickness) of glaciers and their accumulation and ablation rates, and the impact of glaciers on precipitation regimes and windflow patterns are presented (KKB-36, provide glacier information at the site if appropriate). The relationship between air temperature and regional precipitation, in relationship to the water balance of the area is also discussed. (KKB-36, provide such discussion).

3.1.4.3 Future Climatic Variation

An assessment is made of the magnitude and rate of climatic changes that might reasonably be expected to occur in the future. The assessment is based on the reconstruction of the paleoclimate and the recent climate, and considers human activities for both the present and near-term future. Long-term estimates of climatic variations are also included.

The paleoenvironmental record for the Quaternary shows that significant variations have occurred in the past, and similar variations can be expected in the future. The repeated fluctuations between glacial and interglacial climates during the Quaternary have occurred in response to changes in the seasonal and latitudinal receipt of solar radiations as determined by the earth's orbital elements (Reference 3.1.4.2A, Hays et. al., 1976).

For the near-term future (the next 10 to 1000 years), predictions of climate, the effects of large inputs of anthropogenic aerosols, carbon dioxide, and other trace gases in the climate system are taken into account. In addition, climatic, stream flow, and vegetational data for the region and site during the past (____ years) are used for modeling purposes. Vegetational, geologic, and hydrologic time-series data were also used in developing the future climate modeling effort. (KKB-37, describe the results of near-term future climatic modeling effort).

Over the long-term (1000 to 100,000 years), climatic variation estimates include: 1) potential maximum and minimum changes and rates of change in precipitation and air temperature from the present, 2) potential regional windflow and precipitation patterns that may evolve in the future as a result of climatic and geologic changes, 3) the potential for glaciation, including estimates of times of onset of glaciation and lengths and severity of glacial regimes in the site area, and 4) future fluctuations in sea levels and the cryosphere caused by climatic changes. Models for the Yucca Mountain site were formulated using (____ name of code, documentation) and methodology (____ describe methodology) was used to perform the estimate. (KKB-37, provide the results of the modeling and other analyses for the long-term estimate).

3.1.5 Integrated Natural System Response to the Maximum Design Thermal Loading

The anticipated response of the geomechanical, hydrologic, and geochemical subsystems to the maximum design level thermal loading, considering the discontinuities and the heat transfer properties of the rock mass and ground water are described here. The maximum design thermal load of the repository is (____ W/m ^{2}).

3.1.5.1 Response of Geomechanical Subsystem

The design level thermal load, due to the emplacement of waste in the repository, will affect the geomechanical subsystem in the near and far field.

Emplacement of hot nuclear waste in relatively cold (____ ^{0} C), partially saturated tuff produces a geomechanical response in the rock mass. Both the temperature and temperature gradient change with development of thermal stresses and strains. A number of phenomena, including mineral phase changes, dehydration, and mineral and water expansion, contribute to the response of the rock mass to the application of thermal load.

The thermal load induces stresses in the rock mass that can produce new fractures, and opening or closing of existing discontinuities. The existing stress regime can change in a transitory manner due to the heat flux and affect the stability of the repository during its development and operation.

The intact mechanical properties of the rock at the site are affected by the thermal load imposed on them. These effects on intact rock properties are discussed in Section 3.1.1.2.7.

Thermomechanical analyses were conducted using (____ type of code, name and documentation) to assess the response of near and far field rock mass to thermal loading. Figures 3.1.5.1A-D show the resultant temperature and stress distribution in the repository scale.

Figures 3.1.5.1E-H show the region of joint aperture changes in the repository scale (____ years, years, ____ years, and ____ years) after emplacement. Figures 3.1.5.1-I and J show the region of slip along joints (____ years and ____ years) after emplacement. (KKB-38 discuss the results of the response of the geomechanical subsystem here.)

3.1.5.2 Hydrologic Response to Thermal Loading

The hydrologic response to thermal loading includes dehydration, expansion of water, changes in fluid permeability due to creation of new fractures, and opening or closure of existing ones. The predominant flow may change from matrix to fracture flow or vice versa.

Numerous analyses were performed to evaluate the response of the hydrological subsystem using numerical analyses (____ name computer codes and provide documentation). The results are discussed here. (KKB-39 provide the results of analyses).

3.1.5.3 Response of Geochemical System to Thermal Loading

(No skeleton text has been developed for this subsection.)

Figure 3.1.5.1A. TBD

Figure 3.1.5.1B. TBD

Figure 3.1.5.1C. TBD

Figure 3.1.5.1D. TBD

Figure 3.1.5.1E. Regions of Joint Aperture Changes In The Repository Scale At ____ Years

Figure 3.1.5.1F. Regions of Joint Aperture Changes In The Repository Scale At ____ Years

Figure 3.1.5.1G. Regions of Joint Aperture Changes In The Repository Scale At ____ Years

Figure 3.1.5.1H. Regions of Joint Aperture Changes In The Repository Scale At ____ Years

Figure 3.1.5.1I. Region Of Slip Along Joints At ____ Year

Figure 3.1.5.1J Region Of Slip Along Joints At ____ Years

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1. Section No. & Title: **3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE**

2. Lead Author & Phone No. Kal Bhattacharyya (702) 794-1872

3. First Phase Planning Package Due: 6/21/91

   Second Phase Planning Package Due: 10/18/91

   First Phase Skeleton Draft Due: 12/30/91

   Second Phase Skeleton Draft Due: 3/15/92

4. Plan Approved: W.R. Griffin 8/27/91
   (Licensing Mgr & Lead Author)

5. Section Summary (Approximately 100 Words):

   This section describes the natural systems of the geologic setting of the region of the site, specifically for the "controlled" area. However, if conditions outside the controlled area may affect isolation within the controlled are, that "outside" information or conditions will be included provided such information is relevant.

6. Opening Statement:

7. Main Body Outline:

   3.1 Introduction

8. Conclusion:

9. Support Authors & Their Assignments

   Bill Distrel
   John Blair

MGDS Annotated Outline Planning Package
Form 2: Figures & Tables

Date: 4/17/92

Section No. & Title:

Lead Author & Phone No.

A. Figure/Table No.

Caption/Title:

Content:

B. Figure/Table No.

Caption/Title:

Content:

C. Figure/Table No.

Caption/Title:

Content:

The above Annotated Outline text is guidance that may be used for the future development of an MGDS License Application.

Section No. & Title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEM AND CHARACTERISTICS OF THE SITE

Lead Author & Phone No. Kal Bhattacharyya (702) 794-1872

Instructions: List all books, articles, or other references that are expected to be used for the section. Indicate whether references are draft or final, and whether they are publicly available (i.e., published). Refer to the Writer' Guide, Appendix D of the Annotated Outline Management Plan for guidance on formatting reference information.

1.

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MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-1

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.1.1)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Define "the region of the Site", its extent, and relation to the controlled area. This phrase is in the Regulatory Guide DG 3003, but is not defined in 10 CFR 60.

7. What is the information needed for?

   The definition is necessary for determining the extent of the area around Yucca Mountain for which the geologic setting has to be described for SAR Section 3.1.

8. What group is the probable information supplier?

   Regulatory and Licensing Group.

9. When is the information needed?

   This definition is fundamental to the writing of Chapter 3. Therefore, it is needed ASAP.

10. What kind of related information is already available in references, etc.?

    Don't know.

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: **KKB-2**

2. Section no. & title: **3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE**
   (Subsection 3.1.1.1.2 Geomorphic Process)

3. Lead author & phone no: **Kal Bhattacharyya (702) 794-1872**

4. Information request date: **2/21/92**

5. Work location: **M&O - Las Vegas**

6. Type of information needed:

   Provide evidence that glacial and periglacial processes have not been active in the Yucca Mountain area during most or all late Quaternary time.

7. What is the information needed for?

   For response to FCRG, Section 3.1.1.1.1 - Geomorphology and Topographic Features in the Region of the Site Area.

8. What group is the probable information supplier?

   The information will probably be generated by USGS and WCC will be able to get this information from USGS.

9. When is the information needed?

   Whenever available (mid-1990s).

10. What kind of related information is already available in references, etc.?

    SCP Chapter 1.1, Vol I.

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-3

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.1.1.4 - Significant Late Quaternary Geomorphic Process in the Yucca Mountian Area.)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   The effect of tectonic and volcanic processes in the late Quaternary Period have been limited and comparable tectonic and volcanic activities during the next 10,000 years should induce a limited effect on the landscape of Yucca Mountain. This statement needs to be substantiated by study of volcanism and tectonics at Yucca Mountain.

7. What is the information needed for?

   Response to FCRG Section 3.1.1.1.1. - Geomorphology and Topographic Features in the Region of Yucca Mountain Site Area.

8. What group is the probable information supplier?

   Crowe of LANL will probably be the PI who will perform the study. WCC may collect the specific information from the study.

9. When is the information needed?

   Mid 1990s.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 1.1.3.3.1, Vol I.

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11. Response by (name):

12. Response date:

13. Response:

The above Annotated Outline text is guidance that may be used for the future development of an MGDS License Application.

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: **KKB-4**

2. Section no. & title: **3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE** (Subsection 3.1.1.1.1.4, Significant Late Quaternary Geomorphic Process in the Yucca Mountain Area)

3. Lead author & phone no: **Kal Bhattacharyya (702) 794-1872**

4. Information request date: **2/21/92**

5. Work location: **M&O - Las Vegas**

6. Type of information needed:

   Provide an estimate of the movement of surficial material during the Quaternary in the Yucca Mountain Site area.

7. What is the information needed for?

   The information is requested in FCRG Section 3.1.1.1.1.

8. What group is the probable information supplier?

   USGS may generate this information. WCC should be able to collect this from future work by others.

9. When is the information needed?

   Long-term need.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 1.1.3.3.2.

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-5

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.1.2 - Stratigraphy and Lithology of the Region)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Provide rationale for stratigraphic boundaries of the Yucca Mountian region such as mineralogical and geochemical characteristics.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.1.1.2 - Stratigraphy and Lithology of the Region.

8. What group is the probable information supplier?

   USGS and WCC.

9. When is the information needed?

   At the end of surface-based testing (1993-94).

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 1.2.1.

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form Date: 4/17/92
Form A: Information Request

1. Log number: KKB-6

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.1.3 - Seismology)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   A complete list of all historically reported earthquakes in the region surrounding the site is needed.

7. What is the information needed for?

   Asked for in FCRG Subsection 3.1.1.1.3 - Seismology.

8. What group is the probable information supplier?

   LANL, WCC.

9. When is the information needed?

   Mid 1990s.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 1.4.1.1.1, Table 1-10.

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-7

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.3.1 - Relationship of seismicity of geologic or tectonic characteristics of the candidate area)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Relationship between seismicity and geologic structure and a tectonic model of the region is needed.

7. What is the information needed for?

   For FCRG Section 3.1.1.1.3 - Seismology.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   Mid 1990s.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 1.4.1.2.

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-8

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.1.2.1 - Relationship of seismicity to geologic or tectonic characteristics of the candidate area).

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Causative mechanism of earthquakes in the southern Great Basin.

7. What is the information needed for?

   Response to FCRG Section 3.1.1.1.3 - Seismology.

8. What group is the probable information supplier?

   LANL, WCC.

9. When is the information needed?

   Mid 1990s.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 1.4.1.2.

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-9

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.1.3.1 - Relationship of seismicity to geologic or tectonic characteristics of the candidate area)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Correlation between epicenters or regions of higher intensity of historically reported earthquakes and the geologic setting of geologic structures within the setting is to be provided.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.1.1.3 - Seismology.

8. What group is the probable information supplier?

   LANL, WCC.

9. When is the information needed?

   Mid-1990s.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 1.4.1.2.

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-10

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.1.4.1 - Structural features in the Yucca Mountain)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   The regional fracture, discontinuities, and heterogeneity in the Yucca Mountain region.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.1.1.4 - Structural Geology and Tectonic Information FCRG.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   Before 1994 (will need it for subsurface design).

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 1.3.2.2.2.

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11. Response by (name):

12. Response date:

13. Response:

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MGDS Annotated Outline Information Need Form Date: 4/17/92
Form A: Information Request

1. Log number: **KKB-11**

2. Section no. & title: **3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.1.5.1 - Mineral Resources of Yucca Mountain)**

3. Lead author & phone no: **Kal Bhattacharyya (702) 794-1872**

4. Information request date: **2/21/92**

5. Work location: **M&O - Las Vegas**

6. Type of information needed:

   Provide ore genesis models and results of analyses regarding mineralization potential of the Yucca Mountain area.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.1.1.5 - Mineral Resources.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   This information is a site suitability condition and needs to be answered as soon as possible, probably within the next 2-3 years (1993-94).

10. What kind of related information is already available in references, etc.?

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-12

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.5.1 - Mineral Resources of the Yucca Mountain Region)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Occurrences of precious - and base - metal deposits such as opalized and mercury bearing mineral in the Yucca Mountain region. Geochemical sampling for mercury in surface outcrop and drill core to confirm absence of mercury bearing rocks in the region.

7. What is the information needed for?

   In response to FCRG Section 3.1.1.1.5 - Natural Resources.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   Mid-1990s.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 1.7.1.2 and 1.7.1.3.

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-13
2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.1.5.2 - Energy Resources of Yucca Mountain Region)
3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872
4. Information request date: 2/21/92
5. Work location: M&O - Las Vegas
6. Type of information needed:

   Confirmatory information that uranium is a sub-economic grade occurrence in the Yucca Mountain region. Similarly coal, tar sands, and oil shale have low potential for occurrence in the region.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.1.1.5 - Natural Resources.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   1994-95.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 1.7.1.5.

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11. Response by (name):
12. Response date:
13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-14

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.6.1 - Regional Geophysical Characteristics of the Site)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Provide results of magnetic and gravity surveys to identify geophysical characteristics of the region.

7. What is the information needed for?

   Response to FCRG Section 3.1.1.1.6 - Geophysics.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   Mid-1990s.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter xxxxx.

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-15

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.2.1 - Erosion at the site)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Site specific erosion rate in the areas of critical surface facilities.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.1.2.1 - Geomorphology and Topographic Features of the Site Area.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   Needed for Title II design of the ESF (by 1994-95).

10. What kind of related information is already available in references, etc.?

    SCP Chapter 1.1.2.3 and 1.1.2.4.

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-16

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.2.2 - Stratigraphy and Lithology of the Site)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Stratigraphy at depth under the Yucca Mountain site.

7. What is the information needed for?

   Response to FCRG Section 3.1.1.2.2 - Stratigraphy and Lithology of the Site.

8. What group is the probable information supplier?

9. When is the information needed?

   After drilling is complete, mid-1990s.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 1.2.2.

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-17

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.2.2.1 - Description of Lithology of the Units Surrounding the Repository Horizon).

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872.

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Description of the zone of alteration with the stratigraphic units surrounding the repository horizon and the vertical and lateral variation of compositional and physical characteristics within each stratigraphic unit.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.1.2.2 - Stratigraphy and Lithology of the Site.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   Late 1990s.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 1.2.2.

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-18

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.2.3.1 Ground Motion at the Site from Earthquakes in the Area)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Ground motion calculations using deterministic and/or probabilistic methods (this also needs to be clarified) at the site from earthquakes in the area.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.1.2.3 - Seismology.

8. What group is the probable information supplier?

   LANL, WCC.

9. When is the information needed?

   During Title II design of ESF, mid-1990s.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 1.4.2.1.

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-19

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.2.3.2 - Material Properties of Rocks at the Site)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Static and dynamic properties of soil and rock at the site, water table elevation, and variations.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.1.2.7 - Geoengineering.

8. What group is the probable information supplier?

   SNL, WCC, MK.

9. When is the information needed?

   During Title II design of ESF, by 1994.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 2, RIB, SNL reports SAND81-1664; SAND82-1315; SAND80-1453; SAND84-0221; SAND81-0212; SAND82-1723; SAND86-0177.

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-20

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.2.3.4 - Design response to Ground Motion from Potential Earthquake)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Acceleration, effective frequency range, and duration corresponding to each maximum potential earthquake are to be provided both at the ground surface and at depth of the underground repository. Also compare the design response spectra with the ground motion expected from potential earthquakes to assess conservatism of design.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.1.2.3 - Seismology.

8. What group is the probable information supplier?

   SNL (for ESF), Fluor-Daniel, MKE (for repository).

9. When is the information needed?

   During ESF Title II design, 1994.

10. What kind of related information is already available in references, etc.?

    TBD.

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-21

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.2.4.3 - Fractures at Yucca Mountain)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Fracture mapping from surface and underground mapping at the Yucca Mountain repository site.

7. What is the information needed for?

   Section 3.1.1.2.4 of the FCRG asks for this information.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   At the completion of underground mapping at the ESF (late 1990s).

10. What kind of related information is already available in references, etc.?

    None readily available.

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-22

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.1.2.5.2 - Energy Resources at the Site)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Evidence for (or against) occurrence of hydrocarbon (specifically oil and gas) beneath the Yucca Mountain site.

7. What is the information needed for?

   This information is asked for in Section 3.1.1.2.5 of the FCRG.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   At the conclusion of SBT (mid-1990s).

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 1.7.2.2.1.

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11. Response by (name):

12. Response date:

13. Response:

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MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-23

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.2.1.2 - Surface Water Monitoring Network)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Surface water monitoring data from the Yucca Mountain site.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.2.1.2 - Surface Water Monitoring Network.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   Mid-1990s.

10. What kind of related information is already available in references, etc.?

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-24

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.2.1.3 - Water Control Structures and Diversions)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Description of surface water structures, existing or planned, that may influence the potential for flooding at the site.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.2.1.3 - Water Control Structures and Diversions.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   Before completion of Title II design of ESF (1995?).

10. What kind of related information is already available in references, etc.?

    Not readily available to my knowledge.

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11. Response by (name):

12. Response date:

13. Response:

The above Annotated Outline text is guidance that may be used for the future development of an MGDS License Application.

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-25
2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.2.1.4 - Flood History)
3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872
4. Information request date: 2/21/92
5. Work location: M&O - Las Vegas
6. Type of information needed:

   Geologic evidence of flooding in the Yucca Mountain region with emphasis on the Holocene.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.2.1.4 - Flood History.

8. What group is the probable information supplier?

   USGS, FCC.

9. When is the information needed?

   Before completion of the ESF Title II design (1995).

10. What kind of related information is already available in references, etc.?

    No specific information is available to my knowledge.

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11. Response by (name):
12. Response date:
13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-26

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.2.3.1 - Baseline Monitoring Network)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Description of the selection process for the location and depth of the data collection system for baseline hydrologic monitoring network for the site.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.2.3.1 - Baseline Monitoring Network.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   Late 1990s.

10. What kind of related information is already available in references, etc.?

    None available yet.

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-27

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.2.3.2 - Site Flow System Boundaries and Hydrogeologic Units)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Provide basis for selection of hydrogeologic units at the site for the unsaturated and saturated zones.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.2.3.2 - Site Flow System Boundaries and Hydrologic Units.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   Mid-1990s, this selection is the basis for most of the hydrogeologic analyses.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 3.6.1 describes the regional hydrogeologic units.

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-28

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.2.3.3 - Potentiometric Levels, Matric Potential, and Gradients)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   The time history and areal distribution of the measured matric potentials and moisture contents (including osmotic potential) for each hydrogeologic unit as the site. Also the spatial and temporal extent of the perched water system at the site. Description of hydraulic gradient between the hydrologic units at the site.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.2.3.3 - Potentiometric Levels, Matric Potentials, and Gradients.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   At the conclusion of field activities (late 1990s).

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 3.6.3 provides regional information.

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-29

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.2.3.3 Potentiometric Levels, Matric Potentials, and Gradients)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Verify that hydrographs are not necessary as a part of the information to be provided for monitoring points.

7. What is the information needed for?

   Section 3.1.2.3.3 of the FCRG calls for hydrographs.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   Late 1990s.

10. What kind of related information is already available in references, etc.?

    SCP.

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-30

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.2.3.5 Site Ground-Water Recharge)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   The mode and the spatial and temporal distribution of moisture infiltration at the site.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.2.3.5.

8. What group is the probable information supplier?

   USGS, LLL, and WCC.

9. When is the information needed?

   Mid-1990s.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 3.9.3.3.

---

11. Response by (name):

12. Response date:

13. Response:

The above Annotated Outline text is guidance that may be used for the future development of an MGDS License Application.

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-31

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.2.3.8 Site Pathway Analysis)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Fluid flow path analysis at the site.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.2.3.8 - Site Pathway Analysis.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   Late 1990s.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 3.9.3.

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-34

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.2.3.10 Paleohydrology)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Results of field investigation for evidence of change in hydrologic conditions during the Quaternary Period, including origin of deposits of minerals along fault zones.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.2.3.10 - Paleohydrology.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   This information is part of the site suitability question and results are required at the earliest availability.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 3.7.4.

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: **KKB-35**

2. Section no. & title: **3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE**
   (Subsection 3.1.4.1.1 - Climate)

3. Lead author & phone no: **Kal Bhattacharyya (702) 794-1872**

4. Information request date: **2/21/92**

5. Work location: **M&O - Las Vegas**

6. Type of information needed:

   Synoptic scale processes and their effects on site specific meteorological conditions.

7. What is the information needed for?

   Asked for in FCRG Section 3.1.4.1.1 - Climate.

8. What group is the probable information supplier?

   EG&G, WCC.

9. When is the information needed?

   Late 1990s.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 5.1.1.

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-36
2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.4.2 - Paleoclimatology)
3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872
4. Information request date: 2/21/92
5. Work location: M&O - Las Vegas
6. Type of information needed:

   Results of a generalized model of the Quaternary climatological model of the site and surrounding area to predict climatic changes. The impact of glaciers on precipitation regimes and windflow patterns at the site (if appropriate). Relationship between air temperature and regional precipitation, in relationship to the water balance of the area is also discussed.

7. What is the information needed for?

   To respond to FCRG Section 3.1.4.2 - Paleoclimatology.

8. What group is the probable information supplier?

9. When is the information needed?

   Late 1990s.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 5.2.1.2.

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11. Response by (name):
12. Response date:
13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-37

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (3.1.4.3 - Future Climatic Variation)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Description of the results of near-term (0 to 1,000 years) and long-term (1,000 to 10,000 year) future climatic modeling effort.

7. What is the information needed for?

   In response to FCRG Section 3.1.4.3 - Future Climatic Variation.

8. What group is the probable information supplier?

   EG&G, WCC.

9. When is the information needed?

   In late 1990s.

10. What kind of related information is already available in references, etc.?

    SCP, Chapter 5.2.2.

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-38

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.5.1 Geomechanical System Response)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Results of thermo-mechanical analyses to assess the response of near and far field rock mass to the maximum design thermal loading.

7. What is the information needed for?

   To respond to FCRG Section 3.1.5 - Integrated Natural System Response to the Maximum Design Thermal Loading.

8. What group is the probable information supplier?

   SNL, MKE.

9. When is the information needed?

   During the Title II repository design (1994).

10. What kind of related information is already available in references, etc.?

    SAND86-7011, NUREG/CR-5427, NUREG/CR-5390, NUREG/CR-5426, NUREG/CR-5335, STP On Geologic Repository Operations Area Underground Facility Design--Thermal Loads, etc.

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11. Response by (name):

12. Response date:

13. Response:

The above Annotated Outline text is guidance that may be used for the future development of an MGDS License Application.

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB-39

2. Section no. & title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE (Subsection 3.1.5.2 - Hydrologic Subsystem Response)

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Results of thermo-hydrological studies to determine the near and far field response to maximum design thermal load of the repository.

7. What is the information needed for?

   To respond to FCRG Section 3.1.5 - Integrated Natural System Response to the Maximum Design Thermal Load.

8. What group is the probable information supplier?

   SNL, LLL, MKE.

9. When is the information needed?

   During the Title II repository design (by 1994).

10. What kind of related information is already available in references, etc.?

    SAND, LLL reports (to be filled in).

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form B: Information Response

Date: 4/17/92

1. Section No. & Title: 3.1 DESCRIPTION OF INDIVIDUAL SYSTEMS AND CHARACTERISTICS OF THE SITE

2. Person Supplying Information: Kal Bhattacharyya (702) 794-1872

3. Phone No.:

4. Lead Author (Requester):

   Instructions: Information suppliers may use this form to communicate information that has been requested by lead authors via Information Request Forms. The Log No. on this form should be identical to the Log No. of the Information Request Form.

5. Response by Information Supplier:

Note: Attach additional sheets if necessary.

MGDS Annotated Outline Information Need Form
Form C: Information Request Tracking Log

Date: 4/17/92

Note: This is a recommended format for a manual tracking system. Other tracking methods such as a simple computer data base are also acceptable.

Date:

Lead Author:

Log No.	Section	Date Issued	Date Response Received

The above Annotated Outline is guidance that may be used for the future development of an MGDS facility License Application.

Section 3.2 Description of the Anticipated Processes and Events and Unanticipated Processes and Events

TABLE OF CONTENTS

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LIST OF FIGURES

3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

3.2.0 Introduction

This section describes the characteristics of anticipated and unanticipated processes (KKB3.2A, need to know what are the anticipated events and processes and what are the unanticipated events and processes) and events together with a rationale for the selection of each specific process and event described (KKB3.2A, need to know the rationale for each selected process and events). Background information on each process and event is summarized in this section.

[It must be demonstrated that the data base is sufficient to determine which events are anticipated and which are unanticipated.]

[It must be further demonstrated in this section that the models used to make the projections of processes and events are applicable and the interaction between the various natural, repository-induced, and human-induced processes, and events that may affect waste isolation are well understood and considered in the analyses.]

3.2.1 Description of Data Base

The data base related to the natural process and events that occurred during the pre-Quaternary and Quaternary periods and that may be significant to waste isolation are described in this section.

The characteristics of emplaced waste and the area of waste emplacement are briefly described here. References to other sections are provided where detailed descriptions can be found. Human activities that have occurred in the past that may have an effect on waste isolation are also discussed.

3.2.1.1 Natural Processes and Events

The nature, rate, and effects of natural processes and events that have occurred within the geologic setting during the pre-Quaternary and Quaternary periods are described in this section. The interrelationship of the events to the underlying processes have been considered. Only the pre-Quaternary processes and events that are assessed to have a probability of 1 in 10,000 during the intended period of performance of the repository are discussed here (KKB3.2B need to know which processes and events have probability of at least 1 in 10,000 of occurrence during the performance period of the repository).

3.2.1.1.1 Natural Events During the Pre-Quaternary and Quaternary Periods

Natural events that are significant to waste isolation and which occurred during the pre-Quaternary and Quaternary periods are described below. This description also includes the time of occurrence, recurrence rate, duration and their effects of the repository waste isolation.

3.2.1.1.1.1 Volcanism

A discussion of the Tertiary and Quaternary volcanism is related to the stratigraphy, lithology, mechanical and thermal properties, jointing and faulting, hydraulic and geochemical characteristics of the host rock and the surrounding rock. Therefore, volcanism is an event important to the discussion of the waste isolation capability of the repository. A discussion of the pre-Quaternary volcanism provides the basis for assessing the likelihood of future igneous activity that could affect the repository.

This section summarizes the history of middle Tertiary volcanism in the Great Basin and Sonoran Desert of Arizona. Most of the volcanic rocks at Yucca Mountain were formed during this time. (Figure 3.2A).

The youngest volcanic rocks in the southern Great Basin are mostly basalt flows of late Miocene to Holocene epoch and are 6 to 8 million years old. The Death Valley-Pancake Range zone, extends from southern Death Valley north-northeast through Yucca Mountain into the central

Figure 3.2A. Volcanic Rocks at the Yucca Mountain Region During Middle-Tertiary Period

Nevada volcanic field which occurred approximately 8 million years ago. (Figure 3.2B). Some basalt fields in the Death Valley-Pancake-range zone contain a large volume of rock, were relatively long-lived (active for several million years), bimodal and consisted of scoria cones or clusters of cones and associated basaltic lavas (Table 3.2A). The basalts younger than 6.5 million years occurred near Yucca Mountain and in the Southern Death Valley.

The rate of volcanic activity during the last 8 million years in the Yucca Mountain area is consistently low. The Lathrop Wells cinder cone, at the southern edge of Crater Flat, is the youngest volcanism feature in the Yucca Mountain area. Crowe and Carr (Reference 3.2A) give the age of this cone as between 200,000 and 300,000 years.

The most likely effect of renewed silicic volcanism is deposits of fine-grained volcanic ash at Yucca Mountain ranging from a few millimeter to tens of centimeters thick. Such deposition would pose no recognized hazard to the repository after closure. There is little potential that a silicic eruption near the margins of the Great Basin would affect the geohydrology, geochemistry, and rock properties at the Yucca Mountain because of the great distance separating Yucca Mountain from the potential volcanic centers.

3.2.1.1.1.2 Faulting

The following is a summary of the Tertiary and Quaternary faults in the region of the repository. A detailed description is provided in Sections 3.1.1.1.4 and 3.1.1.2.4, including the features that

Figure 3.2B. Volcanic Rocks at the Yucca Mountain Region During Late Miocene to Holocene Epoch

Table 3.2A. Characteristics of Volcanic Rocks in the Yucca Mountain Region may affect the construction and operation of a repository and its post-closure isolation capability. The discussion also includes the potential for the repository being disrupted by a fault. Some faults show evidence of Quaternary movement in the area surrounding Yucca Mountain. A zone of faults having demonstrable Pleistocene displacement extends southward from the Sand Springs Valley, 120 kilometers northeast of Yucca Mountain, through Yucca Flat and continues toward the Amargosa Desert.

At Yucca Mountain, major normal faults bound by the structural blocks generally strike north and dip steeply west (Figure 3.2C). The faults are typically 1 to 2 kilometers apart and generally have vertical offset of more than 100 meters. Most offset in the normal faults occurred between 12.9 and 11.6 million years ago.

The repository is constructed mainly in the relatively unfaulted western part of one typical structural block. The repository is bounded on the west side by the Solitario Canyon fault, on the northeast by the Drill Hole Wash fault, and the east and southeast by the western edge of an imbricate normal fault zone. Within the repository boundary, offset on faults is (___ meters) or less, except for the Ghost Dance fault, which has (_____ meters) of vertical offset at the (location).Quaternary deposits are offset or fractured by (__) faults in the (__km^2) area around Yucca Mountain site. Radiometric dating and correlation of stratigraphy demonstrates that (__) of them moved (___) million years ago.

[Quaternary offset has been demonstrated on five of the major normal faults at and near Yucca Mountain: the Bare Mountain, Windy Wash, Solitario Canyon, Bow Ridge, and Paintbrush

Figure 3.2C. Major Faults Bounding the Structural Blocks at the Yucca Mountain Site

Canyon. These faults are shown in Figure 3.2E and their characteristics are summarized in Table 3.2B. (KKB3.2C, Provide description of movements on these faults in the pre-Quaternary and Quaternary periods. Provide the direction of fault movements in the area).]

3.2.1.1.1.3 Seismicity

The rate of occurrence, the nature of seismic events and the effects of seismicity on waste isolation are discussed below. A detailed description of seismicity in the region and vicinity of Yucca Mountain is provided in Section 3.1.1.3. The north-south-trending California-Nevada seismic belt is a part of the regional seismicity with epicenters within 400 km of Yucca Mountain. Six major historical earthquakes of M> 6.5, have occurred in the Nevada-California seismic belt. The nearest recorded major earthquake was in Owens Valley, about 150 km west of Yucca Mountain and occurred in 1872. Yucca Mountain is located in a large, historically quiescent area that includes the southwest quadrant of the NTS and the eastern Mojave Desert.

The pattern of local seismicity (Figure 3.2F), as defined by hypocenters within 150 km of Yucca Mountain, is a widespread but diffuse background corresponding principally to the east-west seismic belt, punctuated by clusters of intense activity, and by large nearly aseismic areas. Yucca Mountain is in a locally quiescent area characterized by few hypocenters and low energy density. Focal depths of hypocenters range from 1 km above to 17 km below sea level. Only a few small scattered earthquakes have occurred within the zero to 10 km distance of Yucca Mountain. The

Figure 3.2E. Major Normal Faults At and Near Yucca Mountain

Table 3.2B. Summary of Fault Characteristics in the Yucca Mountain Area

Figure 3.2F. Patterns of Local Seismicity maximum such earthquake has a magnitude (M= ___) and occurred within (____km) of Yucca Mountain. The energy density of the area within a 10 km radius of Yucca Mountain is scarcely more than the background level and two to three orders of magnitude below the regional level.

The correlation of earthquakes to recognized geological structures in the seismotectonic zones is presented below. A number of models (KKB3.2E provide names of computer models and results of analysis) have been used to determine this correlation.

3.2.1.2 Characteristics of Emplaced Waste

The characteristics of emplaced waste and the emplacement area is described herein. Characteristics of the waste that can modify the natural system and affect waste isolation are emphasized. The hydrological, geochemical, thermal, and mechanical effects of waste emplacement on the geologic system are discussed.

The waste form is presented in detail in Section 5.1.2. The characteristics of waste such as thermal output, chemical characteristics of the waste package and engineered barrier that can modify the natural system are also discussed.

Packages for high-level waste have been designed so that interactions between the chemical, thermal, and nuclear properties of the waste package do not compromise the waste isolation capability of the natural system.

3.2.1.2.1 Expected Thermal Output

Spent fuel waste packages are designed to generate a thermal output of between (___kw and _ kw) per container. Processed high-level waste packages are designed to generate an output of (_kw) per container. The outer wall temperature of the waste packages is calculated to be (___^{0}C) for the spent fuel packages and (___^{0}C) for the high-level waste packages (KKB3.2F).

3.2.1.2.2 Chemical Characteristics of the Waste Package and Engineered Barrier

(To Be Developed).

3.2.1.2.3 Location and Size of the Emplacement Panels

A detail discussion of the waste emplacement system is provided in Section 4.1.3.4, Waste Emplacement System. The waste is emplacement in the (___ mode of emplacement) in the Topopah Spring unit (provide exact geologic/ thermomechanical unit). Waste is emplaced in (_ numbers of panels of covering an area of (___km^2). The areal thermal density is (-w/m^2). Calculated peak rock temperatures in the near field (around the waste packages), room scale (around drifts) and far field (in the repository horizon) are (___ ^{0} C) (KKB3.2G, provide the above data from repository design report).

3.2.1.2.4 Effects from Excavation on the Natural System

The natural system will undergo changes due to excavation of the shafts, ramps, and repository facilities. The effects of excavation on the surrounding rock mass are discussed in Section 3.1.1.2.7, Geoengineering. (Further text to be developed).

3.2.1.2.5 Expected Effects on the Natural System

(Skeleton text has not been developed for this subsection.)

3.2.1.3 Past Human Activities

Human activities that have occurred within the geologic setting or that have affected the geologic setting of Yucca Mountain are described below. Such activities as drilling and excavation within or near the controlled area, effects to the atmosphere from pollution, effects from ground water withdrawal or injection are also described. This description includes the location and severity of such activities and the interrelations of such activities with natural processes and events.

3.2.1.3.1 Drilling

All known drilling within 10 km of the GROA has been under the control of either the Nevada Test Site Office or the Nuclear Rocket Development Station (NRDS) currently within the NTS. No mining excavation has been found in this area.

All available drilling and mining records including those of NTS, USGS and others have been examined. Two drill holes have been found that were drilled prior to the NNWSI Project. An additional (__) vertical and angle drill holes have been drilled within the controlled area during the site characterization activities including exploration and construction. Figure 3.2G shows a map with all the drill holes within controlled area of the repository. Table 3.2C lists the location, elevation, sampling and drilling method, casing and hole diameter and depths, spud date and completion date.

3.2.1.3.2 Mining Activities

Documents regarding the status of active and inactive mines at and within 10 km of the Yucca Mountain repository site were examined and the results are discussed below. Documents included the Nevada Bureau of Mines reports and maps, air photos; Nye County, Nevada records of mining claims; BLM records, and USGS geologic reports and topographic maps and reports.

At present there are (___) mill sites and (___) lode claims on file for the area within 10 km of the GROA. (KKB3.2H, provide description of mill site, lode claims). The past records of mining in southern Nevada show no mining activities with the controlled area of the Yucca Mountain site. The closest mining activities were in Bare Mountain district, 15 km west of the site. The only reference to Yucca Mountain concerned the Thompson and Silicon Mines. Both are located at the northwest end of the Yucca Mountain, located approximately 10 km west from the repository.

Figure 3.2G. Locations of all Drill Holes Within the Controlled Area of the Repository

Table 3.2C. Location, Elevation, Sampling and Drilling Method, Casing and Hole Diameter and Depths, Spud Date and Completion Date

No evidence of any surface mining activities have been found within 10 km of the Yucca Mountain site.

3.2.1.3.3 Ground Water Injection and Withdrawal

There are (__) injection wells located within the controlled area of the repository. The injection of wells occurred during the site characterization activities and are shown in Figure 3.2H. (Provide a map showing the location of wells within the controlled area where injection of wells have occurred). Table 3.2D shows the location, size, casing, drilling method, water level, and rate and amount of water withdrawal and injection. (Provide such a table).

3.2.1.3.4 Underground Nuclear Tests

The size of current nuclear testing is limited to 150 kilotons by the Threshold Test Ban Treaty and the Treaty on Underground Nuclear Explosions for Peaceful Purpose. The option for larger yield is being retained by the Nuclear Test Site (NTS) and estimated to be (__) kilotons in the Yucca Flats, (__) kilotons in Rainier Mesa, and (__) kilotons at Palhute Mesa (Figure 3.2D). The shortest distance between the repository and an area of Underground Nuclear Event (UNE) is 23 km. Calculations shows that the repository is stable at a distance of (__) km from a UNE of (___) kiloton yield as designed for a (___)g ground acceleration. Ground motion from aftershocks that follow a large UNE have been considered in the design, and are shown to cause no stability problems. (KKB3.2D, provide such stability calculations in repository design).

Figure 3.2H. Map Showing the Location of Wells Within the Controlled Area Where Injection of Wells have Occurred

Table 3.2D Location, Size, Casing, Drilling Method, Water Level, and Rate and Amount of Water Withdrawal and Injection

Figure 3.2D. Locations of Underground Nuclear Testing in the Yucca Mountain Area

Aftershocks fall off to the background level within a period of several weeks and are at least 2 magnitude units (on a logarithmic scale) less than the UNE.

The predicted mean peak vector ground acceleration at Yucca Mountain from UNE at a maximum allowable yield of (__) kiloton is calculated to be (__)g. Using a very conservative design criterion of three standard deviations, or 99 percent of all probable values, the mean peak vector ground acceleration for Yucca Mountain is calculated to be (__)g (these values to be supplied).

The repository design considers the effects of UNE at the NTS and the design is safe for the effects of UNE.

3.2.2 Anticipated Processes and Events and Unanticipated Processes and Events

3.2.2.1 Natural Processes and Events

The projected rate of each process, including the "best estimate" and "extremes" are provided using statistical parameters to describe the uncertainties of this projection. The model or models used to provide these projections are described, and justification for using the specific models are provided. Other known and generally recognized models that were rejected for making these predictions are described along with the basis for their rejection.

Events that could be projected to occur as a result of each process are described below. This description includes intensity, duration, effect, and location of the events. In general, events that have a probability of occurrence of less than 1 chance in 10,000 during the period of intended performance are not considered. Quantification of the probabilities are achieved by using the best scientific techniques available.

3.2.2.1.1 Volcanism

The potential for renewed silicic volcanism is suggested by the youngest (7 to 8 million years old) silicic volcanic center in the vicinity of Yucca Mountain, at the Black Mountain center, which is located 50 kilometers north of Yucca Mountain. However, the occurrence of silicic volcanism is considered unlikely during the next 10,000 years (Volcanist Crowe,et.al.) because:

A. No silicic volcanism has occurred in the south central Great Basin during at least the past 6 million year period.

B. Silicic volcanism has decreased throughout the central and southern parts of the Great Basin during the past 10 million years and, in most areas silicic volcanism appears to have ceased.

C. Silicic volcanism has been restricted entirely to the margins of the Great Basin during the Quaternary period (the past 2 million years).

Future silicic eruptions from Crater Flat were considered unlikely from review of data related to future bimodal volcanism. No rhyolite has been found associated with basaltic eruptions during the past 8 to 9 million years.

Additional studies were conducted to estimate the potential for silicic volcanism, and the results indicate that this type of volcanism has no significant potential for initiating a disruptive event after the closure repository (KKB3.2I, provide studies to back-up this conclusion).

The likelihood of future basaltic volcanism at Yucca Mountain was evaluated by Crowe, et. al. (1982,1983, 1986). Crowe, et. al. (1982) estimated the probability that the repository would be penetrated by magma during basaltic volcanism during the next 10,000 years as 3.3×10^{-6} to 4.7×10^{-4} (KKB3.2J, studies to be performed to update this probability calculation).

Consequence Analyses of Volcanism on Waste Isolation. In the event of a basaltic eruption (_____ per cent) of the waste will remain in the flow material and (_____ per cent) would be dispersed in the scoria sheet. A lesser amount (____ per cent) would be dispersed in fine-grained (<65 microns) in the wind-borne particles and in the scoria cone (KKB3.2K, provide estimates of effects of a basaltic volcanic eruption on the emplaced nuclear waste).

The consequence analyses of radiological release during a basaltic eruption includes a scenario of early stage hydrovolcanic activity followed by isolated small-volume and short-duration (Strombolian) eruptions that form scoria and lave flaws.

3.2.2.1.2 Faulting

The potential for faulting at Yucca Mountain is indicated by the history of Quaternary faulting in the vicinity. Evidence is presented here to document the recurrent nature of faults (provide text from SCP). The effect of faulting on the pre-closure and post-closure period of the repository is also presented here.

Studies have determined the estimate of fault reoccurrence at an interval of (____ years) (KKB3.2L, need this estimate). Displacements along the principal and secondary faults at Yucca Mountain can affect the facilities placed across these faults, particularly during the preclosure period. [Studies must demonstrate that the faulting is not expected to adversely impact the safe operation of the repository, or compromise the waste isolation characteristics of the repository. (Present the results of these studies when they are completed).]

Probability of Faulting. Studies have been performed to determine the rates and magnitude of faulting in the vicinity of Yucca Mountain. The analysis of data shows that the rates of faulting events range from (__) per year per 1000 km^2. Average rates of vertical displacement during the

Quaternary period are estimated to be (__ mm to __ mm) per year. Reoccurrence intervals of faults having such displacement rates are on the order of (___ to ___) years for earthquakes of M equaling approximately (___).

The amount of strike-slip fault movement during the Quaternary Period is estimated to range from (___ mm to ___ mm) per year. The probabilities of occurrence of both vertical and strike-slip faults are estimated to be (_____) (KKB3.2M, need estimates regarding all of the above numbers).

3.2.2.1.3 Seismicity

Effects of Earthquake on Waste Isolation. Earthquake induced phenomena such as liquefaction, landslides, and lurching of soil masses are expected to be minimal during the operational phase or post-closure period of the repository. The very deep water table, arid climate, scarcity of thixotropic materials make liquefaction highly unlikely. Similarly, landslides and lurching of soil at the site are not expected because of highly competent rock types and favorable topography.

The seismic hazards in the southern Great Basin were assessed, and recurrence rates were determined for a magnitude (M = __) within a 10,000 km^2 area to be (___ per year). This rate is equivalent to a return rate of (____ yrs).

The potential vibratory ground motion at Yucca Mountain has been calculated using deterministic and probabilistic approaches. Table 3.2E depicts the deterministic estimates of ground motion (KKB3.2N, provide mean peak accelerations at Yucca Mountain for earthquakes on potentially susceptible faults in or near southern Great Basin). This table shows that the mean peak

Table 3.2E. Deterministic Estimates of Ground Motion for Yucca Mountain During Repository Operation acceleration at Yucca Mountain is less than (___ g) and the repository design accounts for such magnitude of vibratory motion.

Table 3.2F depicts the probabilistic estimates of ground motion for Yucca Mountain. The probability of exceeding (__ g) is in the range of (__ to ___) per year. It is concluded that the vibratory ground motion values of (___ g to ___ g) has probability range of 10^{-3} to 10^{-4}. These probabilities are implicitly equated with the safe shutdown earthquake of nuclear reactors and should not cause any problems with the repository operation.

Ground motion resulting from both earthquakes and weapons testing have been assessed at the underground repository facilities. The results of the experimental and model testing are discussed below (provide results of underground motion calculations). [It must be concluded from the results that the ground motion is less at underground and estimated to be within the range of (_ g to ___ g).]

3.2.2.2 Repository Effects

The expected effect on each natural process or event from the emplacement of waste is described below. The description includes changes to the local stress field, thermal drying, convection cell, and geochemical modifications. This description includes a discussion of those expected effects that could significantly change the nature of the natural process and discussion of those expected effects that could "trigger" an event. The expected changes over time, and the models used to

Table 3.2F. Probabilistic Estimates of Ground Motion for Yucca Mountain During Repository Operations determine the expected changes are described. Information included in other sections are noted by reference.

3.2.2.2.1 Expected Effects of Waste Emplacement on the Natural System

Emplacement of waste is expected to effect the hydrology, geochemistry, thermal, and mechanical state of the rock mass surrounding the repository. The effects that can be expected from the emplacement of the waste packages are:

A. Physical changes in the rock unit due to mining activities
B. Changes in the physical and chemical properties of the rock and water of the unsaturated zone due to the waste-related radiation field
C. Heat induced mechanical effects
D. Modification of the in situ groundwater system due to the thermal load generated by the waste package.

The neutron and gamma radiation from the waste form will penetrate through the waste package and interact with the environment it immediately surrounds. Neutrons can cause damage to material by displacing atoms as a result of atomic collision. The damage to the rock from atomic displacement is very limited due to the low level of flux present in the waste form, and would not significantly alter the properties of rock. The neutron radiation would not significantly affect the water chemistry due to the low flux present in the waste form. (Wilcox and Van Konynenburg, 1981).

Less than three percent of the total thermal energy released by the waste package will be deposited in the host rock by gamma radiation. Over 99 percent of the gamma radiation energy will be deposited within 1 meter of the rock surrounding the waste package. Effects of gamma radiation on the tuff will be transient and are not expected to cause significant changes in the rock mineral properties (Durham et al, 1985). Gamma radiation will cause some significant changes in the water and vapor chemistry due to the production of radiolytic species.

Radiolysis products will be those restricted to those resulting from interaction of gamma radiation with moist air. At temperatures below 120 ^{0}C the most abundant products with relatively long lifetimes are HNO_3, N_2O, and small amounts of O_3. (KKB3.2O, provide interaction of gamma radiation with rock).

The resulting rise in temperature from waste package thermal loads will alter the local hydrologic system and would cause initial dehydration in the (KKB3.2P, hydrological analyses to provide the event of near and far field effects of thermal load on the water transportation within the rock by vapor transport, matrix flow, and fracture flow) rock and eventual rehydration as the rock temperature drops with time. The emplacement of waste packages will alter the hydrologic regime within the vicinity of the repository.

The elevated temperature due to the placement of waste package will also encourage rock and water interaction, and will change the chemistry of the water in the geohydrologic system. (KKB3.2Q, provide the results of modeling and theoretical studies of rock-water interaction).

Effects of waste emplacement on intact and jointed rock properties are discussed below. The primary effect of temperature changes on the near-field rock is a change in the rock volume due to isobaric thermal expansion. The isobaric thermal expansion of the tuff is (____ /K). The maximum temperature in the near field rock is calculated by modeling to be (____ ^{0}C) and results in total volume change of about (____ percent) based on the numerical calculation.

Cristobalite, which is present in the near-field rock, undergoes a structural transition from tetragonal to cube symmetry. This phase transition results in a volume increase of five percent. The temperature at which this transition occurs is found to be (____ ^{0}C). The effect of the associated volume change in the rock in the near field of waste package is discussed here (KKB3.2R, need a study result describing the volume change in rock containing cristobalite at waste package environment).

Other effects of thermal output from waste package emplacement on the surrounding rock are increases in the stress field due to heating, cooling and creep in the rock. (KKB3.2S, provide results of analyses of changes in rock stress and creep and any stability consideration in the very near-field and near-field).

3.2.2.3 Human Activities

The human activities that are projected to occur during the intended period of performance and that could affect waste isolation are described below. The models used to make these projections, the direct expected effects of these projected activities, and the human activities that can have an effect on the natural process, are also described below.

Controls that are designed to be in place are presented together with the expected effects that such controls will have to prevent or mitigate such human activities.

3.2.2.3.1 Effects of Human Interference from Exploitation of Natural Resources at the Site

The natural resources potential of the site are described in Section 3.1.1.1.5, Natural Resources. Studies have been performed to identify, analyze, and evaluate the potential human activities that could adversely affect the waste isolation capabilities of the repository or could lead to inadvertent intrusion to the repository. All credible anthropogenic disruption scenarios have been identified and their potential consequences have been assessed. This information has been used as input to models (Intera to provide the name of the models, justification of their use, and the results obtained) to determine the total system release to the accessible environment caused by inadvertent human activities.

Investigations have been performed to identify all resources at the site with current markets, or those that could potentially be marketable in the future. These resources have been identified as to their estimated grades and tonnage, and the impact of the potential usage of these resources have been evaluated using computer models (____ name model, provide results of the potential use of natural resources at the site).

At present ground water is the only known commodity classified as a resource in the immediate vicinity of the site. Exploitation of this resource is expected to become economically feasible in the near future. The quantity and quality of the ground water resource has been evaluated, and the current and future value of the resource, and the probable rates and locations of ground water exploitation in the near future have been calculated. These factors have been used in the calculation of the probability for human interference and in assessing the potential effects of ground water exploitation on the isolation capabilities of the site during the 10,000 year post-closure period.

3.2.2.3.2 Underground Nuclear Test

(Text To Be Developed).

3.2.2.3.3 Controlling Mechanism to Prevent or Mitigate Human Activities

Studies have been performed and assessed to determine the type of human activity controlling methods such as surface markers, and their long-term survivability during the 10,000 year post-closure period. Investigations have been performed to determine all events, both natural and anthropogenic, that could destroy or degrade the surface markers and monuments to control human activities. The primary data utilized in the assessment of marker and monument design are; the magnitude and location of the fault ruptures and seismically induced ground motion, the rate, magnitude, and locations of potential igneous activities, and the potential effects of tectonic activity and future climatic conditions on the locations, and rates of erosion and deposition of the geologic medium.

REFERENCES

3.2A Crowe, B. M. and Carr. W. J, 1980. Preliminary Assessment of the Risk of Volcanism at a Proposed Nuclear Waste Repository in the Southern Great Basin, USGS-OFR-80-357, Open-File Report, U.S. Geological Survey, Denver, Colorado.

3.2B Wilcox, T. P., and R.A. Van Konynenburg, 1981. Radiation Dose Calculations for Geologic Media Around Spent Fuel Emplacement Holes in the Climax Granite, Nevada Test Site, UCRL-53159, Lawrence Livermore National Laboratory, Livermore California.

3.2C Durham, N. B., J. M. Beiriger, M. Axelrod, and S. Tretle, 1985. The Effect of Gamma Irradiation on the Strength and Elasticity of Climax Stock and Westerly Granites, UCRL-92526, Reprint, Lawrence Livermore National Laboratory, Livermore, California.

MGDS Annotated Outline Planning Package
Form 1: Text

Date: 4/17/92

1. Section No. & Title: 3.2 **DESCRIPTION OF THE ANTICIPATED PROCESSESAND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS**

2. Lead Author & Phone No. Kal Bhattacharyya (702) 794-1872

3. First Phase Planning Package Due: 6/21/91

   Second Phase Planning Package Due: 10/18/91

   First Phase Skeleton Draft Due: 12/30/91

   Second Phase Skeleton Draft Due: 3/15/92

4. Plan Approved: W.R. Griffin 8/27/91
   (Licensing Mgr & Lead Author)

5. Section Summary (Approximately 100 Words):

   This section describes the characteristics of anticipated and unanticipated processes and events along with a rational for the selection of each specific process and event described. This section also summarizes the background on these processes and events, describes in detail the methods of projecting these events in the future, and describes the bases for these projections. Sufficient data are given to determine which events are anticipated and which are unanticipated and to demonstrate models used to make the projections are applicable. Interactions between the various natural, repository-induced, and human-induced processes and events that may affect waste isolation are evaluated and factored into the analysis.

6. Opening Statement:

   This section describes the characteristics of anticipated and unanticipated processes and events along with a rationale for the selection of each specific process and event described.

The above Annotated Outline text is guidance that may be used for the future development of an MGDS License Application.

7. Main Body Outline:

3.2 DESCRIPTION OF ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

3.2.1 Description of Data Base

3.2.1.0 Introduction

3.2.1.1 Natural Processes and Events

3.2.1.2 Characteristics of the Emplaced Waste

3.2.2 Anticipated Processes and Events and Unanticipated Processes and Events

3.2.2.1 Natural Processes and Events

3.2.2.2 Repository Effects

3.2.2.3 Human Activities

8. Conclusion:

Anticipated processes and events and unanticipated processes and events have been evaluated to determine their effects on repository performance and design. Based on these analyses it appears that virtually all anticipated processes and events and unanticipated processes and events either will not adversely impact performance of the repository either during pre- or postclosure or can be effectively mitigated by appropriate design. Those anticipated process and events and unanticipated processes and events that cannot be properly mitigated by appropriate design have been mitigated by resiting of critical facilities.

9. Support Authors & Their Assignments:

MGDS Annotated Outline Planning Package
Form 2: Figures & Tables

Date: 4/17/92

Section No. & Title: 3.2 **DESCRTIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS**

Lead Author & Phone No. Kal Bhattacharyya (702) 794-1872

A. Table No. 3.2A

Title: **Characteristics of Volcanic Rocks in the Yucca Mountain Region**

Content:

B. Table No. 3.2B

Title: **Summary of Fault Characteristics in the Yucca Mountain Area**

Content:

C. Table No. 3.2C

Title: **Location, Elevation, Sampling and Drilling Method, Casing and Hole Diameter and Depths, Spud Date and Completion Date**

Content:

D. Table No. 3.2D

Title: Location, Size, Casing, Drilling Method, Water Level, and Rate and Amount of Water Withdrawal and Injection

Content:

E. Table No. 3.2E

Title: Deterministic Estimates of Ground Motion for Yucca Mountain During Repository Operation

Content:

F. Table No. 3.2F

Title: Probabilistic Estimates of Ground Motion for Yucca Mountain During Repository Operation

Content:

G. Figure No. 3.2A

Caption: Volcanic Rocks at the Yucca Mount Region During Middle-Tertiary Period

Content:

H. Figure No. 3.2B

Title: Volcanic Rocks at the Yucca Mountain Region During Late Miocene to Holocene Epoch

Content:

I. Figure No. 3.2C

Title: Major Faults Bounding the Structural Blocks at the Yucca Mountain Area Site

Content:

J. Figure No. 3.2D

Caption: **Locations of Underground Nuclear Testing in the Yucca Mountain Area**

Content:

K. Figure No. 3.2E

Title: **Major Normal Faults At and Near Yucca Mountain**

Content:

L. Figure No. 3.2F

Title: **Patterns of Local Seismicity**

Content:

M. Figure No. 3.2G

Caption: **Locations of all Drill Holes Within the Controlled Area of the Repository**

Content:

N. Figure No. 3.2H

Title: **Map showing the Location of Wells within the Controlled Area where Injection of Wells have occurred**

Content:

MGDS Annotated Outline Planning Package
Form 3: References

Date: 4/17/92

Section No. & Title: 3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

Lead Author & Phone No. Kal Bhattacharyya (702) 794-1872

Instructions: List all books, articles, or other references which are expected to be used for the section. Indicate whether references are draft or final, and whether they are publicly available (i.e., published). Refer to the Writer's Guide, Appendix D of the Annotated Outline Management Plan for guidance on formatting reference information.

1.

2.

3.

4.

5.

6.

7.

8.

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB3.2A

2. Section no. & title: 3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Need to know what are the anticipated events and processes and what are the unanticipated events and processes along with a rationale for the selection of each specific process and event described.

7. What is the information needed for?

   Asked for in the introduction of Section 3.2 - Description of the Anticipated Processes and events and Unanticipated Processes and Events of the FCRG.

8. What group is the probable information supplier?

   INTERA (Performance assessment group).

9. When is the information needed?

   ASAP.

10. What kind of related information is already available in references, etc.?

    TO BE DETERMINED.

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11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB3.2B

2. Section no. & title: 3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Need to know which processes and events have probability of at least 1 in 10,000 of occurrence during the performance period of the repository.

7. What is the information needed for?

   Asked for in Section 3.2.1.1 - Natural Processes and Events of the FCRG.

8. What group is the probable information supplier?

   INTERA.

9. When is the information needed?

10. What kind of related information is already available in references, etc.?

---

11. Response by (name):

12. Response date:

13. Response:

The above Annotated Outline text is guidance that may be used for the future development of an MGDS License Application.

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB3.2C

2. Section no. & title: 3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Description of movements on major faults at and near Yucca Mountain including: Bare Mountain, Windy Wash, Solitario Canyon, Bow Ridge, and Paintbrush Canyon during, the Pre-Quaternary and Quaternary Periods. Provide the direction of fault movements in the area.

7. What is the information needed for?

   In response to Section 3.2.1.1 - Natural Processes and Events of the FCRG.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   Late 1990s, after the surface mapping, trenching, geological drilling is completed.

10. What kind of related information is already available in references, etc.?

    SCP Section 1.3.2.2.2 - Structure and structural history of Yucca Mountain.

---

11. Response by (name):

12. Response date:

13. Response:

The above Annotated Outline text is guidance that may be used for the future development of an MGDS License Application.

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB3.2D

2. Section no. & title: 3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Provide stability calculations in repository design showing that the ground motion form aftershocks that follow large Under Ground Nuclear Events (UKE) has been considered in the design and are shown to cause no stability problem.

7. What is the information needed for?

   In response to Section 3.2.1.1 - Natural Processes and Events of the FCRG.

8. What group is the probable information supplier?

   MKE for repository, RSN for ESF.

9. When is the information needed?

   Before completion of ESF and repository Title II design (1995-96).

10. What kind of related information is already available in references, etc.?

    SCP 1.4.2.2.10 The evaluation of ground motion at depth.

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB3.2E

2. Section no. & title: 3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Provide names of computer models and results of analysis used to determine the correlation of earthquakes to recognized geological structures in the seismotectonic zones in the Yucca Mountain area.

7. What is the information needed for?

   Section 3.2.1.1 - Natural Processes and Events.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   Late 1990s.

10. What kind of related information is already available in references, etc.?

    SCP Section 1.4.1.3 - Determination of earthquake - generating potential of geologic structures and seismotectonic zones within the Great Basin.

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB3.2F

2. Section no. & title: 3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Provide waste package thermal output levels and temperature profiles for spent fuel and high level waste.

7. What is the information needed for?

   Response to Section 3.2.1.2 - Characteristics of the Emplaced Waste of the FCRG.

8. What group is the probable information supplier?

   B & W.

9. When is the information needed?

   Early stages of Title II design of repository (1994?).

10. What kind of related information is already available in references, etc.?

    As waste package design is anticipated to be different from the baseline design, this information will have to be developed.

---

11. Response by (name):

12. Response date:

13. Response:

The above Annotated Outline text is guidance that may be used for the future development of an MGDS License Application.

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB3.2G

2. Section no. & title: 3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Provide number of panels and area where waste is emplaced. Include, areal thermal density, peak rock temperatures in the very near-field (around the waste packages), near-field (emplacement room), and far-field (repository scale).

7. What is the information needed for?

   This information is asked for in Section 3.2.1.2 - Characteristics of the Emplaced Waste of the FCRG.

8. What group is the probable information supplier?

   B & W, MKE.

9. When is the information needed?

   This information will be developed during the Title II repository and waste package design (by 1996?).

10. What kind of related information is already available in references, etc.?

    This information is not available now as new concepts of repository design and waste package is being developed and the available information will probably be inapplicable.

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: **KKB3.2H**

2. Section no. & title: **3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS**

3. Lead author & phone no: **Kal Bhattacharyya (702) 794-1872**

4. Information request date: **2/21/92**

5. Work location: **M&O - Las Vegas**

6. Type of information needed:

   Provide information regarding the mill sites and lode claims for an area within 10 km of the GROA.

7. What is the information needed for?

   In response to Section 3.2.1.3 - Past Human Activities.

8. What group is the probable information supplier?

   WCC.

9. When is the information needed?

   Late 1990s.

10. What kind of related information is already available in references, etc.?

    SCP Section 1.6.4 - Underground Mining Activities.

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: **KKB3.2I**

2. Section no. & title: **3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS**

3. Lead author & phone no: **Kal Bhattacharyya (702) 794-1872**

4. Information request date: **2/21/92**

5. Work location: **M&O - Las Vegas**

6. Type of information needed:

   Provide evidence that silicic volcanism has no significant potential for initiating a disruptive event after the closure of the repository during the performance period.

7. What is the information needed for?

   To respond to Section 3.2.2.1 - Natural Processes and Events.

8. What group is the probable information supplier?

   LANL, WCC.

9. When is the information needed?

   Late 1990s.

10. What kind of related information is already available in references, etc.?

    SCP Section 1.5.1.1.2 - Likelihood of Silicic Volcanism.

---

11. Response by (name):

12. Response date:

13. Response:

The above Annotated Outline text is guidance that may be used for the future development of an MGDS License Application.

MGDS Annotated Outline Information Need Form Date: 4/17/92
Form A: Information Request

1. Log number: **KKB3.2J**

2. Section no. & title: **3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS**

3. Lead author & phone no: **Kal Bhattacharyya (702) 794-1872**

4. Information request date: **2/21/92**

5. Work location: **M&O - Las Vegas**

6. Type of information needed:

   Provide an estimate of the probability that the repository would be penetrated by magma during basaltic volcanism during the next 10,000 yrs.

7. What is the information needed for?

   To respond to Section 3.2.1.1 - Natural Processes and Events of the FCRG.

8. What group is the probable information supplier?

   LANL, WCC, AND INTERA.

9. When is the information needed?

   Late 1990s.

10. What kind of related information is already available in references, etc.?

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form Date: 4/17/92
Form A: Information Request

1. Log number: KKB3.2K

2. Section no. & title: 3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Provide an estimate of the effects of a basaltic volcanic eruption on the emplaced nuclear waste.

7. What is the information needed for?

   Section 3.2.2.1 - Natural Processes and Events of the FCRG.

8. What group is the probable information supplier?

   LANL, WCC, INTERA.

9. When is the information needed?

   Late 1990s.

10. What kind of related information is already available in references, etc.?

    SCP, Section 1.5.1.2.3 Likelihood of basaltic volcanism.

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form Date: 4/17/92
Form A: Information Request

1. Log number: KKB3.2L

2. Section no. & title: 3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Provide an estimate of fault recurrence interval of faults in the Yucca Mountain area.

7. What is the information needed for?

   Section 3.2.2.1 of the FCRG.

8. What group is the probable information supplier?

   USGS, WCC.

9. When is the information needed?

   Late 1990s.

10. What kind of related information is already available in references, etc.?

    SCP Section 1.5.2.2 - Likelihood of faulting.

---

11. Response by (name):

12. Response date:

13. Response:

The above Annotated Outline text is guidance that may be used for the future development of an MGDS License Application.

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB3.2M

2. Section no. & title: 3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Estimate of the amount of strike-slip fault movement during the Quaternary Period and the probabilities of occurrence of both vertical and strike-slip faults.

7. What is the information needed for?

8. What group is the probable information supplier?

9. When is the information needed?

10. What kind of related information is already available in references, etc.?

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form Date: 4/17/92
Form A: Information Request

1. Log number: KKB3.2N

2. Section no. & title: 3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

3. Lead author & phone no: Kal Bhattacharyya (702) 794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Provide mean peak acceleration at Yucca Mountain for earthquakes on potentially susceptible faults.

7. What is the information needed for?

   For response to Section 3.2.2.1 - Natural Processes and Events of the FCRG.

8. What group is the probable information supplier?

9. When is the information needed?

10. What kind of related information is already available in references, etc.?

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB3.2O

2. Section no. & title: 3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

3. Lead author & phone no: Kal Bhattacharyya 702-794-1872

4. Information request date 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Provide interaction of gamma radiation with rock

7. What is the information needed for?

   Section 3.2.2.2 - Repository Effects of the FCRG.

8. What group is the probable information supplier?

   LANL, WCC, INTERA

9. When is the information needed?

   By late 1990s.

10. What kind of related information is already available in references, etc.?

    SCP Section 4.2 Geochemical effects of waste emplacement.

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB3.2P

2. Section no. & title: DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

3. Lead author & phone no: Kal Bhattacharyya 702-794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Hydrological analyses to provide the event of near and far field effects of thermal load on the water transportation within the rock by vapor transport, matrix flow, and fracture flow.

7. What is the information needed for?

   Response to Section 3.2.2.2 - Repository Effects of the FCRG.

8. What group is the probable information supplier?

   LLL, WCC, MKE

9. When is the information needed?

   Before completion of Title II design of repository, (1996?)

10. What kind of related information is already available in references, etc.?

    This information has to be developed in concert with the repository design. SCP Section 2.7.2 - Thermally Induced Water Migration is a source.

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB3.2Q

2. Section no. & title: 3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

3. Lead author & phone no: Kal Bhattacharyya 702-794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   The elevated temperature due to the placement of waste package will encourage rock-water interaction and will change the chemistry of the water in the geohydrologic system. Provide the results of modeling and theoretical studies of rock-water interaction.

7. What is the information needed for?

   To respond to Section 3.2.2.1 - Repository Effects of the FCRG.

8. What group is the probable information supplier?

   LANL, WCC

9. When is the information needed?

   By late 1990s.

10. What kind of related information is already available in references, etc.?

    To Be Determined.

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: **KKB3.2R**

2. Section no. & title: **3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS**

3. Lead author & phone no: **Kal Bhattacharyya 702-794-1872**

4. Information request date: **2/21/92**

5. Work location: **M&O - Las Vegas**

6. Type of information needed:

   Need a study result describing the volume change in rock containing cristobalite at waste package environment.

7. What is the information needed for?

   To respond Section 3.2.2.2 - Repository Effects of the FCRG.

8. What group is the probable information supplier?

   LANL, WCC

9. When is the information needed?

   By late 1990s.

10. What kind of related information is already available in references, etc.?

    To Be Determined.

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number: KKB3.2S

2. Section no. & title: 3.2 DESCRIPTION OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

3. Lead author & phone no: Kal Bhattacharyya 702-794-1872

4. Information request date: 2/21/92

5. Work location: M&O - Las Vegas

6. Type of information needed:

   Provide results of analyses of changes in rock stress and creep and any stability consideration in the very near-field and near-field.

7. What is the information needed for?

   To respond to Section 3.2.2.2 - Repository Effects of the FCRG.

8. What group is the probable information supplier?

   MKE, SNL

9. When is the information needed?

   During Title II design of repository (1996)

10. What kind of related information is already available in references, etc.?

    (Sandia National Lab (SAND) Reports - to be named.)

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form B: Information Response

Date: 4/17/92

1. Section No. & Title: 3.2 DESCRIPTIONS OF THE ANTICIPATED PROCESSES AND EVENTS AND UNANTICIPATED PROCESSES AND EVENTS

2. Person Supplying Information: Kal Bhattacharyya (702) 794-1872

3. Phone No.:

4. Lead Author (Requester):

   Instructions: Information suppliers may use this form to communicate information that has been requested by lead authors via Information Request Forms. The Log No. on this form should be identical to the Log No. of the Information Request Form.

5. Response by Information Supplier:

Note: Attach additional sheets if necessary.

MGDS Annotated Outline Information Need Form
Form C: Information Request Tracking Log

Date: 4/17/92

Note: This is a recommended format for a manual tracking system. Other tracking methods such as a simple computer data base are also acceptable.

Date:

Lead Author:

Log No.	Section	Date Issued	Date Response Received

The above Annotated Outline is guidance that may be used for the future development of an MGDS facility License Application.

Section 3.3 Assessment of Compliance with 10 CFR 60

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3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60

Skeleton Text Has Not Been Developed For This Section

REFERENCES

1. Section No. & Title: **3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60**

2. Lead Author & Phone No. John A. Blair 202-488-2308
Placeholder for TBD

3. First Phase Planning Package Due: 6/21/91

   Second Phase Planning Package Due: 10/18/91

   First Phase Skeleton Draft Due: 12/30/91

   Second Phase Skeleton Draft Due: 3/15/92

4. Plan Approved: W.R. Griffin 8/27/91
(Licensing Mgr & Lead Author)

5. Section Summary (Approximately 100 Words):

   This section describes the geology, geophysics, hydrogeology, geochemistry, climatology, and meteorology of Yucca Mountain, Nevada (10CFR60.21(c) (1) (ii) (A)). Analyses of these factors has determined the degree to which potentially favorable or unfavorable conditions are present. (10CFR60.21 (c) (1) (ii) (B)).

   Sufficient investigations have been conducted to assess critical pathways for radionuclide migration from the underground facility to the accessible environment and to analyze the pre-wastes-emplacement ground-water travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment.

   Natural barriers important to the isolation of high-level waste from the accessible environment including barriers that may or may not themselves be part of the geologic repository operations area have been identified and evaluated for effectiveness against the release of radioactive material to the environment. (10CFR60.21(c) (1) (ii) (D)).

6. Opening Statement:

   This section describes how the Yucca Mountain Project Site complies with the requirements of 10CFR60 with respect to the geologic, geophysical, hydrogeologic, geochemical, climatologic, and meteorologic requirements.

7. Main Body Outline:

3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR PART 60

3.3.1 Geologic System

3.3.1.1 Assessment of Favorable Conditions

3.3.1.1.1 Tectonic and geomorphic processes which by their nature and rate as demonstrated during the Quaternary Period would affect the waste isolation capability favorably or would not adversely affect the repository. (10 CFR 60.122(b) (1))

3.3.1.1.2 Conditions permitting waste emplacement at a minimum depth of 300 meters below ground surface. (10 CFR 60.122(b) (5)).

3.3.1.1.3 A low population density within the geologic setting and a controlled area remote from population centers. (10 CFR 60.122 (b) (6)).

3.3.1.2 Assessment of Potentially Adverse Conditions

3.3.1.2.1 Evidence for or against dissolutioning. (10 CFR 60.122(c) (10))

3.3.1.2.2 Evaluation of structural deformation during the Quaternary Period. (10 CFR 60.122 (c) (11))

3.3.1.2.3 Historic earthquakes that could significantly affect the site if repeated. (10 CFR 60.122 (c) (12))

3.3.1.2.4 Evaluation to determine if the frequency or magnitude of earthquakes may increase. (10 CFR 60.122(c) (13))

3.3.1.2.5 Evaluation to determine if the frequency of earthquakes is higher than the regional frequency. (10 CFR 60.122(c) (14))

3.3.1.2.6 Evaluation to determine extent of igneous activity since the start of the Quaternary Period. (10 CFR 60.22(c) (15))

7. Main Body Outline (Continued)

3.3.1.2.7 Evaluation to determine extent of erosion during the Quaternary Period. (10 CFR 60.22(c) (16))

3.3.1.2.8 Evaluation of naturally occurring materials whether identified or undiscovered specifically to determine if:

3.3.1.2.8.1 Economic extraction is currently feasible or potentially feasible during the foreseeable future. (10 CFR 60.122 (c) (17) (i)).

3.3.1.2.8.2 Such materials have greater gross or net value than the average for other areas of similar size that are representative of and located within the geologic setting. (10 CFR 60.122(c) (17) (ii)).

3.3.1.2.9 Results of exploration for evidence of subsurface mining for resources within the site. (10 CFR 60.122(c) (18))

3.3.1.2.10 Results of exploration for evidence of drilling for any purpose within the site. (10 CFR 60.122(c) (19))

3.3.1.2.11 Evaluation to determine if geomechanical properties permit design of underground openings that will remain stable through permanent closure. (10 CFR 60.122(c) (21)_).

3.3.2 Hydrologic System

3.3.2.1 Favorable Conditions

3.3.2.1.1 Hydrogeologic processes which by their nature and rate as demonstrated during the Quaternary Period would affect the waste isolation capability favorably or would not adversely affect the repository. (10 CFR 60.122 (b) (1))

7. Main Body Outline (Continued)

3.3.2.1.2 Pre-waste-emplacement ground-water travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment that substantially exceeds 1000 years. (10 CFR 60.122 (b) (7))

3.3.2.1.3 Favorable conditions for disposal in the unsaturated zone.

3.3.2.1.3.1 Results of search for evidence of low moisture flux in the host rock and in the overlying and underlying hydrogeologic units. (10 CFR 60.122 (b) (8) (i))

3.3.2.1.3.2 Results of search for evidence of a water table sufficiently below the underground facility such that fully saturated voids contiguous to the water table do not encounter the underground facility. (10 CFR 60.122(b) (8) (ii))

3.3.2.1.3.3 Results of exploration for evidence of a laterally extensive low-permeability hydrogeologic unit above the host rock that would inhibit the forward movement of water or divert downward moving water to a location beyond the limits of the underground facility. (10 CFR 60.122(b) (8) (iii))

3.3.2.1.3.4 Results of exploration for evidence that the host rock provides for free drainage. (10 CFR 60.122(b) (8) (iv))

3.3.2.2 Potentially Adverse Conditions

3.3.2.2.1 Potential for flooding the underground facility. (10 CFR 60.122(c) (1))

7. Main Body Outline (Continued)

3.3.2.2.2 Potential for adverse effects on the ground-water withdrawal system by human activity. (10 CFR 60.122(c) (2))

3.3.2.2.3 Potential for impoundments to form by natural catastrophic means so as to adversely impact the ground-water with respect to the repository. (10 CFR 60.122(c) (3))

3.3.2.2.4 Potential for geologic structural deformation to adversely affect the regional ground-water flow system. (10 CFR 60.122(c) (4)

3.3.2.2.5 Potential for changes in hydrologic conditions that would adversely affect migration of radionuclides to the accessible environment. (10 CFR 60.122(c) (5))

3.3.2.2.6 Evaluation of rock or ground-water conditions to determine the extent to which complex engineering measures in the design and construction of the underground facility or in the sealing of boreholes and shafts might be required. (10 CFR 60.122(c) (20))

3.3.2.2.7 Potential for the water table to rise sufficiently to cause saturation of the facility. (10 CFR 60.122(c) (22))

3.3.2.2.8 Potential for existing or future perched water bodies that may saturate portions of the underground facility or provide a faster flow path from an underground facility located in the unsaturated zone to the accessible environment. (10 CFR 60.122(c) (23))

3.3.3 Geochemical System

The description of the analyses of favorable and potentially adverse conditions related to the geochemical system.

7. Main Body Outline (Continued)

3.3.3.1 Favorable Chemical Conditions

Analyses and results used to determine the degree by which each favorable condition has been characterized and to which it contributes to isolation.

3.3.3.1.1 Geochemical Processes

Nature and rates of geochemical processes operating within the geologic setting during the Quaternary Period that, when projected, would not affect or would favorably affect the ability of the repository to isolate waste. (See Figure 3.3.3.1.1A). Reference 10 CFR 60.122(b)(1).

Analyses of the geochemical process (i.e., modelling efforts, laboratory testing, etc.).

3.3.3.1.2 Geochemical Conditions

Summary of Geochemical Conditions.

Conditions that promote precipitation or sorption of radionuclides. Reference 10 CFR 60.122 (b)(3)(i).

Conditions that inhibit the formation of particulates, colloids, and inorganic and organic complexes that increase the mobility of radionuclides. Reference 10 CFR 60.122 (b)(3)(ii).

Condition that inhibit the transport of radionuclides by particulates, colloids, and complexes. References 10 CFR 60.122 (b)(3)(iii).

3.3.3.1.3 Mineral Assemblages

Mineral assemblages and analyses which when subjected to anticipated thermal loading, will remain unaltered or alter to mineral assemblages having equal or increased capacity to inhibit radionuclide migration. (See Table 3.3.3.1.3A).

7. Main Body Outline (Continued)

3.3.3.2 Potentially Adverse Geochemical Conditions

This section describes the potentially adverse conditions. (See Table 3.3.3.2A).

3.3.3.2.1 Groundwater Conditions

Groundwater conditions in the host rocks, including chemical composition, high ionic strength, or ranges of Eh-ph, that could increase the solubility or chemical reactivity of the Engineered Barrier System (EBS), Reference 10 CFR 60.122 (c)(7).

3.3.3.2.2 Evaluation of Geochemical Processes

Evaluation of geochemical processes that might reduce sorption of radionuclides, result in degradation of the rock strength, or adversely affect the performance of the engineered barrier system. Reference 10 CFR 60.122 (c)(8).

3.3.3.2.3 Evaluation of Evidence

Evaluation of evidence to determine if groundwater conditions in the host rock are not reducing. Reference 10 CFR 60.122 (c)(9).

3.3.3.2.4 Potential Radionuclide Movement

Potential for the movements of radionuclides in a gaseous state through air filled spaces of an unsaturated geologic medium to the accessible environment. Reference 10 CFR 60.122 (c)(24).

3.3.4 Climatological and Meteorological Systems

Describe analyses that resulted in determination of favorable and potentially adverse conditions (present or absent).

For favorable conditions found to be present, describe analysis determining degree to which each condition has been characterized.

7. Main Body Outline (Continued)

For favorable conditions found to be present, describe analysis determining extent to which each contributes to isolation.

For potentially adverse conditions found to be present, describe analysis determining degree to which each condition has been characterized.

For potentially adverse conditions found to be present, describe analysis determining extent to which each detracts from isolation.

- Also, describe analysis demonstrating that:

The condition has been adequately investigated

- Include extent to which the condition may be undetected considering degree of resolution achieved by investigations.

The effect of the condition has been adequately evaluated:

- Use analyses that are sensitive to the potentially adverse condition.
- Use assumptions that are not likely to underestimate the condition's effects.

The condition does not significantly affect the ability of the repository to meet the performance objectives or:

- The condition is compensated by favorable conditions.
- The condition can be remedied.

Describe criteria used to determine that any potentially adverse condition is compensated by the presence of one or more favorable conditions or that the potentially adverse condition can be remedied

Provide an explanation of measures supporting the models used to perform analyses.

- Support analyses and models used to predict future conditions and changes in the system by using an appropriate combination of methods:
    - Field tests
    - In-situ tests

7. Main Body Outline (Continued)

- Laboratory tests representing field conditions
- Monitoring data
- Natural analog studies.

  -- Discuss variability and uncertainty of data and the propagation of errors
  -- Discuss evaluations of data representativeness and uncertainties associated with extrapolation of data
  -- Discuss conceptualizations and the documentation and validation of codes and models with respect to:

- Uncertainties related to the data on which the model is based
- Applicability of specific models
- Appropriateness of assumptions used in modelling
- Sensitivity of model results to the uncertainty of the input data.
- Provide input and output data and interpretations, with the bases for the interpretations to:

  -- Provide sufficient detail to allow independent analysis of results.
  -- Document the role of expert judgement, when needed.

3.3.4.1 Favorable Conditions

Evaluation of potential for favorable conditions as shown by evidence for a climatic regime in which the average annual historic precipitation is a small percentage of the average annual potential evapotranspiration. 10 CFR 60.122 (b)(8)(v).

3.3.4.2 Potentially Adverse Conditions

Evaluation of evidence for adverse conditions as shown by potential for changes in hydrologic conditions resulting from reasonably foreseeable climatic changes. Ref. 10 CFR 60.122 (c)(6).

3.3.5 Assessment of Compliance with Performance Objectives

Assessment of Compliance with Performance Objectives. Ref. 10 CFR 60.113 (a)(2)/10 CFR 60.113 (b)/10 CFR 60.122 (a)(1).

7. Main Body Outline (Continued)

3.3.5.1 Disturbed Zone

Description of the boundaries of the disturbed zone and documentation and description of the criteria and analytic techniques to establish those boundaries.

3.3.5.2 Ground Water Travel Time

Description of the pre-waste-emplacement ground-water travel time along the fastest path of radionuclide travel from the disturbed zone to the accessible environment. Reference 10 CFR 60.113 (b)/Section 3.1.2 (Hydrologic System). 10 CFR 60.122.

3.3.6 Effectiveness of Natural Barriers Against the Release of Radioactive Material to the Environment

Identification of natural barriers that may not themselves be part of the GROA, but important to isolating HLW from the accessible environment. Also determine the effectiveness of those barriers against the release of radioactive material to the environment. Reference Section 3.1/3.3.1/3.3.4/3.3.5.

8. Conclusion:

Evaluation of the Yucca Mountain Repository Site shows that the majority of natural characteristics are such that the site is favorable for the construction of a nuclear waste repository. Those features that are not favorable are mitigated by proper repository design.

9. Support Authors and their assignments:

TBD.

MGDS Annotated Outline Planning Package
Form 2: Figures & Tables

Date: 4/17/92

Section No. & Title: 3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60

Lead Author & Phone No. John A. Blair 202-488-2308
Placeholder for TBD

A. Figure/Table No. To Be Determined.

Caption/Title:

Content:

B. Figure/Table No.

Caption/Title:

Content:

C. Figure/Table No.

Caption/Title:

Content:

MGDS Annotated Outline Planning Package
Form 3: References

Date: 4/17/92

Section No. & Title: 3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60

Lead Author & Phone No. John A. Blair 202-488-2308
Placeholder for TBD

Instructions: List all books, articles, or other references that are expected to be used for the section. Indicate whether references are draft or final, and whether they are publicly available (i.e., published). Refer to the Writer' Guide, Appendix D of the Annotated Outline Management Plan for guidance on formatting reference information.

1. Numerous references are listed i the SCP dealing with this subject. These references should be examined to determine which ones are still relevant. Many other references remain to be developed including topical reports on volcanism, erosion, seismicity, and calcite-silica deposits.

2.

3.

4.

5.

6.

7.

8.

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number:
2. Section no. & title: **3.3 ASSESSMENT OF COMPLIANCE WITH 10 CFR 60**
3. Lead author & phone no: **J. A. Blair (202) 488-2308**
4. Information request date:
5. Work location:
6. Type of information needed:
7. What is the information needed for?
8. What group is the probable information supplier?
9. When is the information needed?
10. What kind of related information is already available in references, etc.?

---

11. Response by (name):
12. Response date:
13. Response:

The above Annotated Outline text is guidance that may be used for the future development of an MGDS License Application.

MGDS Annotated Outline Information Need Form
Form B: Information Response

Date 4/17/92

1. Section No. & Title:

2. Person Supplying Information:

3. Phone No.:

4. Lead Author (Requester):

Instructions: Information suppliers may use this form to communicate information that has been requested by lead authors via Information Request Forms. The Log Number on this form should be identical to the Log Number of the Information Request Form.

5. Response by Information Supplier:

Note: Attach additional sheets if necessary.

MGDS Annotated Oultine Information Need Form **Date: 4/17/92**
Form C: Information Request Tracking Log

Note: This is a recommended format for a manual tracking system. Other tracking methods such as a simple computer data base are also acceptable.

Date:

Lead Author:

Log No.	Section	Date Issued	Date Response Received

MGDS Annotated Outline

Chapter 4.0 Geologic Repository Operations Area: Physical Facilities

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4.0 GEOLOGIC REPOSITORY OPERATIONS AREA: PHYSICAL FACILITIES

Skeleton Text Has Not Been Developed For This Section

REFERENCES

1. Section No. & Title: 4.0 GEOLOGIC REPOSITORY OPERATIONS AREA: PHYSICAL FACILITIES

2. Lead Author & Phone No.: TBD
[T.M. Williamson 702-794-1821]

3. First Phase Planning Package Due: 6/21/91

   Second Phase Planning Package Due: 10/18/91

   First Phase Skeleton Draft Due: 12/30/91

   Second Phase Skeleton Draft Due: 3/15/92

4. Plan Approved: W.R. Griffin 8/27/91
(Licensing Mgr & Lead Author)

5. Section Summary (Approximately 100 Words):

This chapter presents information describing the physical facilities for the Geologic Repository Operations Area (GROA). It also demonstrates compliance with all applicable regulatory requirements for GROA surface facilities, shafts, ramps, and underground facilities. Sufficient information is provided to facilitate an independent review of GROA design and verification of compliance. Structures, systems, and components (SSCs) important to safety, isolation, and retrievability are identified and justified. Physical measures to provide radiation protection are described in detail. Section 4.1 describes the physical facilities and Sections 4.2-4.5 demonstrate compliance with all applicable regulatory requirements.

6. Opening Statement:

GROA SSCs are designed to prevent or mitigate the consequences of design basis accidents, ensure waste isolation, and facilitate waste retrievability. Analyses provided in this chapter demonstrate that GROA SSCs comply with all applicable regulatory requirements.

7. Main Body Outline:

4.0 INTRODUCTION

- Provide a general description of the repository or reference the general description in preceding chapters.

7. Main Body Outline (Continued)

- The overall repository layout is shown in Figure 4.0-A. [This figure may be provided in preceding chapters.].
- Use the above opening statement, summary, and closing statement to introduce the chapter.

4.1 DESCRIPTION OF THE GROA STRUCTURES, SYSTEMS, AND COMPONENTS

- Refer to Planning Package for Section 4.1

4.2 ASSESSMENT OF COMPLIANCE FOR SURFACE FACILITIES

- Refer to Planning Package for Section 4.2

4.3 ASSESSMENT OF COMPLIANCE FOR SHAFTS AND RAMPS

- Refer to Planning Package for Section 4.3

4.4 ASSESSMENT OF COMPLIANCE FOR UNDERGROUND FACILITIES

- Refer to Planning Package for Section 4.4

4.5 INTEGRATED GROA COMPLIANCE WITH PERFORMANCE OBJECTIVES

- Refer to Planning Package for Section 4.5

8. Conclusion:

GROA SSCs are designed to prevent or mitigate the consequences of design basis accidents, ensure waste isolation, and facilitate waste retrievability. Analyses provided in this chapter demonstrate that GROA SSCs comply with all applicable regulatory requirements. Therefore, there are no credible circumstances by which GROA operations threaten the health and safety of plant personnel or the public.

9. Support Authors & Their Assignments:

T.M. Williamson (M&O Licensing)

Section No. & Title: 4.0 GEOLOGIC REPOSITORY OPERATIONS AREA: PHYSICAL FACILITIES [Chapter Introduction]

Lead Author & Phone No.: TBD
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A. Figure No. 4.0A

Caption: Repository Layout

Content:

General arrangement drawing of the entire repository with major features identified. Local surface facilities, shafts and ramps, and underground facility. Show site boundary.

[This drawing may be found in preceding changes.]

B. Figure/Table No.

Caption/Title:

Content:

C. Figure/Table No.

Caption/Title:

Content:

MGDS Annotated Outline Planning Package
Form 3: References

Date: 4/17/92

Section No. & Title:

Lead Author & Phone No.

Instructions: List all books, articles, or other references that are expected to be used for the section. Indicate whether references are draft or final, and whether they are publicly available (i.e., published). Refer to the Writer's Guide, Appendix D of the Annotated Outline Management Plan for guidance on formatting reference information.

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The above Annotated Outline text is guidance that may be used for the future development of an MGDS License Application.

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number:
2. Section no. & title: 4.0 GEOLOGIC REPOSITORY OPERATIONS AREA: PHYSICAL FACILITIES [Chapter Introduction]
3. Lead author & phone no: T. M. Williamson (702) 794-1821
4. Information request date:
5. Work location:
6. Type of information needed:
7. What is the information needed for?
8. What group is the probable information supplier?
9. When is the information needed?
10. What kind of related information is already available in references, etc.?

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11. Response by (name):
12. Response date:
13. Response:

MGDS Annotated Outline Information Need Form

Date: 4/17/92

Form B: Information Response

1. Section No. & Title:

2. Person Supplying Information:

3. Phone No.:

4. Lead Author (Requester): Marshall Weaver (702) 794-1871

Instructions: Information suppliers may use this form to communicate information that has been requested by lead authors via Information Request Forms. The Log No. on this form should be identical to the Log No. of the Information Request Form.

5. Response by Information Supplier:

Note: Attach additional sheets if necessary.

MGDS Annotated Outline Information Need Form
Form C: Information Request Tracking Log

Date: 4/17/92

Note: This is a recommended format for a manual tracking system. Other tracking methods such as a simple computer data base are also acceptable.

Date:

Lead Author:

<u>Log No.</u>	<u>Section</u>	<u>Date Issued</u>	<u>Date Response Received</u>

Section 4.1 Description of the GROA Structures, Systems, and Components

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4.1 DESCRIPTION OF THE GROA STRUCTURES, SYSTEMS AND COMPONENTS

Skeleton Text Has Not Been Developed For This Section

REFERENCES

1. Section No. & Title: 4.1 DESCRIPTION OF THE GROA STRUCTURES, SYSTEMS, AND COMPONENTS

2. Lead Author & Phone No. TBD
T. M. Williamson 702-794-1821

3. First Phase Planning Package Due: 6/21/91

   Second Phase Planning Package Due: 10/18/91

   First Phase Skeleton Draft Due: 12/30/91

   Second Phase Skeleton Draft Due: 3/15/92

4. Plan Approved: W.R. Griffin 8/27/91
(Licensing Mgr & Lead Author)

5. Section Summary (Approximately 100 Words):

   In this section, a general overview of Geologic Repository Operations Area (GROA) physical facilities is followed by detailed descriptions of the surface facilities, ramps and shafts, and underground facilities. The detailed descriptions of GROA structures, systems, and components (SSCs) include the purpose, function, design, location, and layout of SSC features. Design bases are provided, including the characteristics of the waste and its package, the characteristics of the site, and repository functional requirements. Those SSCs important to safety, waste retrievability, and waste isolation are identified. Supporting information is provided in the form of flow diagrams, instrumentation diagrams, equipment drawings, and plant layout drawings to facilitate an independent review of GROA SSCs. Sufficient information is provided to demonstrate compliance with all applicable regulatory requirements. Compliance with applicable regulatory requirements is assessed in Section 4.2.

6. Opening Statement:

   GROA SSCs are designed to prevent or mitigate the consequences of design basis accidents, facilitate waste retrievability, and ensure waste isolation.

7. Main Body Outline: See attached.

8. Conclusion:

GROA SSCs are designed to prevent or mitigate the consequences of design basis accidents, facilitate waste retrievability, and ensure waste isolation. Therefore, there are no credible circumstances by which repository operations threaten the health and safety of plan personnel or the public.

9. Support Authors & Their Assignments:

Section 4.1.1 - Jerry Fredrickson
Section 4.1.2 - Paul McKie
Section 4.1.3 - Paul McKie
Section 4.1.4 - Mark Fourtesch
Section 4.1.5 - Don Schutt

ATTACHMENT: Main Body Outline

4.1 DESCRIPTION OF THE GROA STRUCTURES, SYSTEMS, AND COMPONENTS

4.1.0 Introduction

- General description of GROA (include quote of 10 CFR 60.2 definition)
- Discuss site features that affect GROA design and performance
- Location of GROA relative to accessible environment is shown in Figures 4.1A and B
- Schedules for GROA construction, receipt of waste, and emplacement of waste are provided in Table 4.1A.

4.1.0.1 Selected Design

- Describe major design features important to waste isolation.
- Describe the overall purpose, function, and design features of GROA SSCs
- The location and layout of GROA SSCs is shown in Figure 4.1C.
- Flow diagrams, piping drawings, and instrumentation diagrams are provided in Sections 4.1.1, 4.1.2, and 4.1.3, as appropriate.
- Describe the design bases for GROA SSCs.
- The principal design criteria and the resulting value of design parameters are provided in Table 4.1B. Specific system and component design parameters are provided in Sections 4.1.1, 4.1.2, and 4.1.3.
- Describe the design of GROA SSCs including the design bases.
- Discuss the bases of the principal design parameters, including the uncertainties associated with each parameter and the treatment of parameter uncertainties.
- The applicable standards and codes used in the design are provided for each GROA SSC in Table 4.1C.
- Waste design basis information is summarized in Table 4.1D. The characteristics and history of the waste are described in detail in Section 5.1. Waste treatment processes are also described in Section 5.1, including waste treatment processes.
- Waste package design basis information is summarized in Table 4.1E. Detailed waste package design information is provided in Section 5.1.

7. Main Body Outline: (Continued)

4.1.0.1 Selected Design (Continued)

- Discuss site design basis, including compilation and interpretation of all physical data relevant to GROA design, including:

    1) Interpretation of site geology such as stratigraphy, structural features, major and minor faults, old volcanos, and history of seismic activity. The physical geologic data is provided in Section 3.1.1.

    2) Interpretation of surface and groundwater hydrologic data including surface drainage characteristics, drainage through strata penetrated by ramps and shafts, above and below ground. The physical data are provided in Section 3.1.2.

    3) Soil properties and other relevant data for the design of foundations are provided in Table 4.1F.

    4) Interpretation of weather and other relevant meteorological, including human-induced phenomena such as nuclear detonations and aircraft travel. The data are provided in Section 3.1.4.

    5) Interpretation of rock data and properties that are relevant to the design of surface facilities, shafts and ramps, and the underground facility.

    6) Interpretation of engineered components that are placed within the underground facility. These data are provided in Table 4.1I.

4.1.0.2 Alternative Designs

- Discuss comparative evaluations of the selected design features.

- Emphasize alternatives that would provide for longer waste isolation.

7. Main Body Outline: (Continued)

4.1.0.3 Regulatory Design Criteria

- Discuss general descriptions of design criteria of 10 CFR 60, DOE documents, system and subsystem design requirements documents, and DOE mission plans. These requirements are summarized in Table 4.1J.
- Discuss how GROA meets any other Federal, State, and local design requirements such as OSHA, mine safety, EPA, etc. [FCRG comment]

4.1.0.4 Regulatory Performance Objectives

- Discuss regulatory GROA performance objectives.

4.1.0.5 Identification of SSCs Important to Safety, Retrievability, and Isolation

- Discuss activities and events, either planned or unplanned, that could interfere with SSC performance.
- The SSCs important to safety, retrievability, or isolation are identified in Table 4.1K.
- Discuss framework for identification.

4.1.0.6 SSCs Requiring Design Verification

- Identify SSCs requiring R&D to confirm adequacy of design.
- Discuss programs to confirm adequacy.
- Justify proceeding with construction before research is complete, if necessary, including contingency if design is not confirmed.

4.1.1 Surface Facilities

- Cross reference section 1.4 "Certification of Safeguards" and Section 1.5 "Physical Security Plan" to address as necessary.
- The location and layout of surface facilities is shown in Figure 4.1C.
- The design bases and design descriptions are provided for all surface facility SSCs.

4.1.1.1 Hot Cell Waste-Handling System, Buildings, and Equipment

- Describe the design bases for the hot cell for receiving, transporting, handling, storing, treating, or preparing waste for transfer and disposal.

7. Main Body Outline: (Continued)

- Provide design descriptions including features that are important to safety.

4.1.1.1 Hot Cell Waste-Handling System, Buildings, and Equipment (Continued)

- Describe all features, systems, or special handling techniques that are important to safety under both normal and off-normal conditions. Instrumentation diagrams are provided in Figure 4.1D. Major components are illustrated in Figure 4.1E. Major component design parameters are listed in Table 4.1J.
- Describe any temporary storage facilities. Figure 4.1C shows their location.
- Describe waste retrievability operations.

4.1.1.2 On-Site Radioactive Waste Management System

- Describe system and subsystem design basis.
- Describe each waste source.
- For each waste source, describe collection, treatment, packaging, and disposal system and subsystem designs. Flow diagrams and piping drawings are provided in Figures 4.1F and 4.1G, respectively. Major component design parameters are listed in Table 4.1J.
- Describe effluent control and monitoring systems during normal operations. Instrumentation diagrams are provided in Figure 4.1H.

4.1.1.3 Fire and Explosion Protection System

- Describe surface facility fire and explosion protection system design bases. A list of unusually hazardous or combustible materials is provided in Table 4.1L.
- Describe system design, including building features that contribute to the prevention of fires. Flow diagrams and piping drawings are provided in Figures 4.1I and 4.1J, respectively. Major component design parameters are listed in Table 4.1M. The locations of fire walls are shown in Figure 4.1K. Sprinkler coverage is illustrated in Figure 4.1L. The locations of fire extinguishes, alarms, and stand pipes are shown in Figure 4.1M.

7. Main Body Outline: (Continued)

4.1.1.4 Emergency Systems

- To provide design bases of GROA emergency systems to maintain control of radioactive waste and effluent
- [Describe system design]
- Discuss system failures and emergency situations:

  - Offsite power failures
  - Floods
  - Seismic events
  - Sabotage
  - Military action
  - Other emergencies.

- Provide design bases
- Describe system design within GROA and to offsite locations:

  - Surface
  - Surface to underground.

4.1.1.5 Communications Systems

- Provide design bases
- Describe system design within GROA and to offsite locations:

  - Surface
  - Surface to underground
  - Within underground.

- The location of communication devices and alarms are shown in Figure 4.1N.

4.1.1.6 Utility Systems

- Provide design bases for utility systems
- Describe designs including operating feature for each system including:

  - Electrical power
  - Compressed air
  - Water supply

7. Main Body Outline: (Continued)

- Steam supply
- Fuels supply
- Sanitary sewage treatment
- Chemical sewage treatment
- Auxiliary or back-up systems.

4.1.1.6 Utility Systems (Continued)

- Flow diagrams and piping drawings are provided in Figures 4.1O and 4.1P, respectively. Electrical system one-line diagrams are provided in Figure 4.1Q. Major component design parameters are listed in Table 4.1N.
- Discuss operating features, including redundant design features that are essential to safety under normal and accident conditions. Instrumentation diagrams are provided in Figure 4.1R.

4.1.1.7 Instrumentation and Control Systems

- Add data management (including support to waste management and tracking) to the listing of computer systems. Also add data management systems that track personnel.

- Describe design of GROA computer systems, including:

  - Data acquisition
  - Meteorological monitoring
  - Hydrological monitoring
  - Geophysical monitoring
  - Seismic monitoring
  - Surface-based testing
  - In situ testing
  - Performance conformation.

- Describe monitoring instruments and control systems that monitor and control safety related systems and equipment. The architecture of computers and controls is provided in Figure 4.1S. The control room is illustrated in Figure 4.1T.

4.1.1.8 Onsite Transportation Systems

- Provide the design bases for the onsite transportation systems.

7. Main Body Outline: (Continued)

- Describe the system designs. Figure 4.1U illustrates location of onsite railroads and paved roads. Detailed engineering of hoist buildings and ramp buildings is provided in Figure 4.1V.

4.1.1.9 Ventilation Systems

- HVAC system design parameters are provided in Table 4.1O.
- Describe surface facilities' systems including:
  - Surface portion supporting underground
  - Emplacement vent system
  - Development system
  - HEPA filters
  - Absorption systems
  - Vent monitoring systems
  - Refrigeration plant system.
- Include safety measures for operation under normal and accident conditions.
- Major component design parameters are provided in Table 4.1P. Flow diagrams and duct drawings are provided in Figures 4.1W and 4.1X, respectively.

4.1.1.10 Operations Support Systems

- Describe the design and operations of support systems, including:
  - Maintenance shop
  - Supplies warehouse
  - Storage yard
  - Lockers and showers
  - Visitors center
  - Office buildings.
- The physical location of the support facilities is shown in Figure 4.1C. A general arrangement drawing of each of the support facility buildings is provided in Figures 4.1Y through 4.1AD.

7. Main Body Outline: (Continued)

4.1.1.11 Decommissioning System

- Describe all equipment, systems, or facilities requiring decommissioning. These are identified in Table 4.1Q.
- Describe decommissioning methods and procedures, reclamation of land, installation of fences, and markers.
- Describe procedures for decommissioning of surface facilities:
  - Waste handling building
  - Waste treatment building
  - Performance conformation building
  - Ventilation exhaust building
  - Decontamination building.
- Discuss decommissioning operations that may impact long-term isolation of waste.

4.1.1.12 Other Surface Systems

- Describe the design bases for any other surface facility, including:
  - Much piles
  - Surface lagoons.

4.1.2 Shafts and Ramps

- Provide the layout, overall design bases, and overall design descriptions of all shafts and ramps. The layout of all shafts and ramps is illustrated in Figure 4.1E. The shaft and ramp SSCs are identified in Table 4.1R. Schedules for SCC inspections, testing, and maintenance are provided in Tables 4.1S, T, and U.

4.1.2.1 Waste Shaft or Ramp

- Add roof control plan, mining method, etc.
- Describe all other mining equipment .
- Describe design bases for ramp.
- Describe the ramp design in detail. Detailed engineering drawings are provided in Figure 4.1AG.
- The general arrangement and layout of the waste ramp is provided in Figure 4.1AF.

7. Main Body Outline: (Continued)

- Provide the following details:

  -Portals
  -Liners (if any)
  -Hauling arrangements.

- Describe hauling equipment. Hauling equipment is illustrated in Figure 4.1AH. Design parameters of hauling equipment are provided in Table 4.1V.
- Cross sections at various rock types are provided in Figure 4.1AF.
- Waste types, volumes, and weights are summarized in Table 4.1W. Details regarding wastes are provided in Section 5.1.
- Discuss safety measures
- Provide detailed information about:

  - Ventilation
  - Operational and post-closure seals (if any)
  - Drainage
  - Instrumentation and control systems for the ramp and design validation and performance monitoring. Instrumentation diagrams are provided in Figure 4.1AI.

- Schedules for operations and maintenance are provided in Table 4.1S, T, and U.
- [This section changes slightly if we go with waste shaft instead of ramp.]

4.1.2.2 Muck Shaft or Ramp

- Describe all other mining equipment .
- Add roof control plan, mining method, etc.
- Describe design bases for ramp.
- Describe the ramp design in detail. Detailed engineering drawings are provided in Figure 4.1AJ
- The general arrangement and layout of the muck ramp is provided in Figure 4.1AK.
- Provide the following details:

  - Portals
  - Liners (if any)
  - Hauling arrangements.

7. Main Body Outline: (Continued)

- Describe hauling equipment. Hauling equipment is illustrated in Figure 4.1L. Design parameters of hauling equipment are provided in Table 4.1X.
- Cross sections at various rock types are provided in Figure 4.1AK.
- Waste types, volumes, and weights are summarized in Table 4.1W. Details regarding wastes are provided in Section 5.1.
- Discuss safety measures.
- Provide detailed information about:

  - Ventilation
  - Operational and post-closure seals (if any)
  - Drainage
  - Instrumentation and control systems for the ramp and design validation and performance monitoring. Instrumentation diagrams are provided in Figure 4.1AM.

- Schedules for operations and maintenance are provided in Table 4.1S, T, and U.
- [This section changes slightly if we go with muck shaft instead of ramp.]

4.1.2.3 Ventilation Intake Shafts

- Provide shaft sealing method and reference Mine Safety Plan
- Describe design bases for shaft.
- Describe the shaft design in detail. Detailed engineering drawings are provided in Figure 4.1AN.
- The general arrangement and layout of the vent intake shaft is provided in Figure 4.1AO.
- Provide the following details:

  - Shaft collar
  - Liners
  - Average and maximum quantities of air.

- Cross sections at various rock types are provided in Figure 4.1AO.
- Provide detailed information about:

  - Operational and post-closure seals (if any)
  - Linings (if any)

7. Main Body Outline: (Continued)

-Drainage
-Instrumentation and control systems for the shaft and design validation and performance monitoring. Instrumentation diagrams are identified in Figure 4.1AP.

- Schedules for operations and maintenance are provided in Table 4.1S, T, and U.

4.1.2.4 Ventilation Exhaust Shafts

- Provide shaft sinking method and safety plan or reference Mine Safety Plan.
- Describe design bases for shaft.
- Describe the shaft design in detail. Detailed engineering drawings are provided in Figure 4.1AQ.
- The general arrangement and layout of the vent exhaust shaft is provided in Figure 4.1AR.
- Provide the following details:

  - Shaft collar
  - Liners
  - Average and maximum quantities of air.

- Cross sections at various rock types are provided in Figure 4.1AR.
- Provide detailed information about:

  - Operational and post-closure seals (if any)
  - Linings (if any)
  - Drainage
  - Instrumentation and control systems for the shaft and design validation and performance monitoring. Instrumentation diagrams are identified in Figure 4.1AS.

- Schedules for operations and maintenance are provided in Table 4.1S, T, and U.

4.1.2.5 Personnel and Materials Shafts

- Add the shaft sinking method and the ventilation plan for the shaft.
- Describe design bases for shaft.

7. Main Body Outline: (Continued)

- Describe the shaft design in detail. Detailed engineering drawings are provided in Figure 4.1AT.
- The general arrangement and layout of the personnel and materials shaft is provided in Figure 4.1AU.
- Provide the following details:

  - Shaft colar
  - Liners.

- Describe hoisting equipment including cage capacity. Hoisting equipment is illustrated in Figure 4.1L. Design parameters of hoisting equipment are provided in Table 1Y.
- Cross sections at various rock types are provided in Figure 4.1AU.
- Provide detailed information about:

  - Operational and post-closure seals (if any)
  - Linings (if any)
  - Drainage
  - Instrumentation and control systems for the shaft and design validation and performance monitoring. Instrumentation diagrams are identified in Figure 4.1AX.

- Discuss safety measures to prevent free falling and other accidents
- Schedules for operations and maintenance are provided in Table 4.1S, T, and U.

4.1.2.6 Decommissioning System

- Describe backfilling and sealing system to close shafts and ramps.
- The proposed materials for backfilling and sealing and the method for emplacement are provided in Table 4.1Z.
- Describe methods of emplacement and installation of plugs and bulkheads.
- Discuss operational seals and whether they will remain in place.

4.1.2.7 Other Shaft or Ramp Systems

7. Main Body Outline: (Continued)

- Provide the same detailed information for any other shaft or ramp.

4.1.3 Underground Facility

- Provide overall underground facility design bases and design descriptions. Include:
  - Development and emplacement areas
  - Other underground areas such as:
  - Maintenance shops
  - Personnel showers
  - Decontamination facilities.

- The underground facility is illustrated in Figure 4.1AX.
- Underground facility SSCs are identified and classified in Table 4.1AA.
- Schedules for SCC inspections, testing, and maintenance are provided in Tables 4.1AB, AC, and AD.

4.1.3.1 Excavation and Ground Support Systems

- Provide design bases, design descriptions, and operating descriptions for each of the excavation and support systems. Design parameters for excavation equipment are provided in Table 4.1AE. The equipment used for excavation is shown in Figure 4.1Z. Ground support equipment is shown in Figure 4.1BA.
- Discuss the extent of damaged zone including:
  - Mechanical
  - Thermomechanical
  - Hydrological
  - Chemical
  - Drill and blast methods (if any)
  - Mechanical methods
  - Boring machines
  - Ground support systems used to support excavated openings
  - Response of support systems under thermal loading and retrieval operations
  - Tonnages of excavated rock
  - Rates of advance.

7. Main Body Outline: (Continued)

- The configuration of machinery is shown in Figure 4.1AZ.

4.1.3.2 Muck Handling System

- Provide design bases, design descriptions, and operating descriptions for each of the muck handling systems. Design parameters for muck handing equipment are provided in Table 4.1AF. The layout of muck handling equipment is shown in Figure 4.1BB. Include:
  - Units or systems such as load-haul-dump and belt conveyors
  - Disposition of tuff rock removed from development and emplacement areas.

4.1.3.3 Ventilation System

- Add construction and emplacement air cooling requirements.

- Provide design bases for both development and emplacement areas. The general layout is illustrated in Figure 4.1BC. The design capacities and other parameters are provided in Table 4.1AG. The design parameters for major equipment, including fans, are provided in Table 4.1AH.
- Discuss requirements for air cooling for:
  - Test
  - Maintenance
  - Retrieval operations
  - Number of days needed to cool drifts.

- Determination of ability of system to meet requirements.
- Discuss instrumentation for control and maintenance system.
- Schedules are provided in Tables 4.1AB, AC, and AD.

4.1.3.4 Waste Emplacement System

- The characteristics of waste and packages are provided in Section 5.1.
- The general arrangement of emplacement drifts is provided in Figure 4.1BD. The EBS is described in Section 5.1, including bore hole, liners power per package, etc.

7. Main Body Outline: (Continued)

- Waste emplacement construction is discussed in Section 4.1.3.1.
- Discuss transport methods to emplacement areas.
- Waste emplacement equipment design parameters are provided in Table 4.1AI. It is illustrated in Figure 4.1BE.
- Discuss emplacement operations.

4.1.3.5 Waste Retrieval System

- Provide design bases and detailed retrieval plans to locate, access, retrieve, and transport waste packages to surface.
- Discuss drift roof and wall supports. Ventilation system requirements during retrieval are provided in Section 4.1.3.3.
- Discuss operations under normal and off-normal conditions.
- Discuss shielding requirements.

4.1.3.6 Emergency Systems

- Add emergency response equipment, vehicle recovery systems, underground ambulance support, and other emergency systems.
- Add mine evacuation plan, ventilation plan in case of fire, and mine rescue stations.
- Discuss emergency systems, including:
  - Alarm systems
  - Emergency power systems
  - Systems to prevent the spread of floods and fires

4.1.3.7 Communication System

- The system design within the underground facility and to the surface is described in Section 4.1.1.5.

4.1.3.8 Operations Support System

- Describe the designs and operating features of the support systems within the underground facility, including:
  - Mine waste-water drainage
  - Lighting system
  - Power systems
  - Electrical

7. Main Body Outline (Continued)

- Compressed air
- Fuels supply
- Steam supply
- Water supply
- Auxiliary systems or back-up systems
- Maintenance shops
- Supply rooms
- Offices.

• Discussions should include design features considered important to safety under normal and accident conditions.

[Much of this material is covered in 4.1.1 with surface facility systems.]

4.1.3.9 Decommissioning System

• Backfilling and sealing systems, materials, and equipment are described in Section 4.1.2.6.
• Discuss provisions for dealing with sealing fractures, perched water zones, and fault areas.
• Discuss in detail sealing waste emplacement areas, including consideration of:

  - Boreholes
  - Drifts
  - Panels
  - Removal of underground equipment
  - Removal of operational underground systems and structures, including:

    -- Belt conveyors
    -- Ventilation doors
    -- Regulators

  - Bulkheads
  - Ways of dealing with operations seals
  - Injection of grouts.

• Discuss long term repository drainage.

7. Main Body Outline (Continued)

4.1.3.10 Other Underground Systems

- Provide descriptions of all systems that are part of the underground facility in similar detail.

4.1.4 Radiation Protection

- Describe general features of the GROA design that permit safe handling of radioactive material during operations and retrieval.
- Layout for radiation protection and radiological design features are provided below.

4.1.4.1 Layout Drawings of Radiological Areas and Facilities

- Layout drawings of the GROA are provided in Figure 4.1BF. The drawings show the following:

  - Location of shield walls
  - Thickness of shield walls
  - Controlled access areas
  - Equipment decontamination areas
  - Traffic patterns
  - Location of health physics facilities
  - Location of laboratories
  - Location of counting room.

  - Describe facilities and equipment involved, including equipment especially designed for radiation protection.
  - Describe type of controls for contaminated areas.

4.1.4.2 ALARA Design Consideration

- Describe ALARA design principles for GROA systems. Refer to Figure 4.1BF for layout of equipment.
- Describe how experience from past applications has been incorporated to minimize contamination incidents.
- The descriptions should include radiological safety features for:

  - Processing radwaste
  - Transporting radwaste
  - Handling radwaste
  - Storage of radwaste

7. Main Body Outline (Continued)

- Retrieval of radwaste-emplacement of radwaste
- Isolation of radwaste.

• Describe how designs are directed toward:

  - Reducing equipment maintenance
  - Reducing radiation levels and maintenance time
  - Controlling contamination in handling, transfer, and storage of radioactive material.

• Describe how design guidance in Position 2 of Regulatory Guide 8.8 was followed. Indicate alternatives to guidance, if any.
• Identify ventilation and off-gas treatment systems by reference to Figures 4.1X, W, and BC. Describe the following:

  - Releases will be ALARA during normal operation
  - Capacity is sufficient to confine material during projected operating conditions
  - Adequate monitors are incorporated
  - Design features are incorporated to interface with other effluent and vent systems
  - Spread of material will be controlled.

• Discuss program for measuring the efficiency of filters and treatment devices. Discuss how filter changes facilitate ALARA.

4.1.4.3 Characterization of Shielding

• Describe the source radiations used and design basis information in shielding design for each of the facilities in Section 4.1. All radioactive sources are tabulated in Table 4.1AJ.
• X-ray, gamma ray, and neutron sources are characterized in Table 4.1AK.
• The location of storage containers, tanks, and other equipment expected to require shielding is identified in Figure 4.1BG.
• Describe the shielding used for each of the sources identified. Design parameters for shielding are provided in Table 4.1AK.

7. Main Body Outline (Continued)

- Describe geometric arrangement, specialized protection features, or remote handling to ensure dose to workers is ALARA. Refer to Section 4.1.4.2.
- Describe use of portable shielding, if applicable.

4.1.4.4 Radiological Monitoring Instrumentation

- Describe fixed-area monitors and continuous airborne monitoring instrumentation. The location of monitors is shown in Figure 4.1BF. The equipment is illustrated in Figure 4.1BH, including sample pumps and collectors.
- Describe criteria for setpoints for alarms.
- Monitoring instrumentation design parameters are tabulated in Table 4.1AL.
- Provide details of represented sample gathering.

4.1.5 Interface of Structures, Systems, and Components

- Discuss interfaces between the GROA and waste management systems such as transportation systems.

- Describe SSCs that provide interface between surface facilities, shafts and ramps, and the underground facility. These SSCs are identified in Table 4.1AM. The discussion should include:

  - Ventilation system
  - Hoisting system
  - Communication system
  - Instrumentation and control system
  - Utility system
  - Operation support system
  - Emergency system.

- Discuss interface between safety-related and non-safety-related systems. Reference the above sections where appropriate.

MGDS Annotated Outline Planning Package
Form 2: Figures & Tables

Date: 4/17/92

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. **4.1A**

Caption: **Location of GROA Relative to Accessible Environment Surface Facilities**

Content:

Map showing GROA surface facilities relative to accessible environment boundary.

B. Figure No. **4.1B**

Caption: **Location of GROA Underground Facility Relative to Accessible Environment**

Content:

Map showing GROA Underground Facility superimposed on map of accessible environment.

C. Table No. **4.1A**

Title: **Schedules for GROA Construction, Receipt of Waste, and Emplacement of Waste**

Content:

	2001	2002	2003	:	:	:	2040
GROA Construction							
Receipt of Waste							
Emplacement of Waste							
Etc.							

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. 4.1C

Caption: Location of GROA SSCs

Content:

General arrangement drawing including plan views, elevation views, and appropriate section drawings of GROA. SSCS are identified on drawings.

B. Table No. 4.1B

Title: Principal Design Parameters

Content:

These should be site related design parameters

Parameter	Criteria	Design Value
Design Basis Earthquake		
Maximum Acceleration		
Maximum Displacement		
etc.		

C. Table No. 4.1C

Title: Applicable Code and Standards Used in Design

Content:

SSC	Standards and/or Codes

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. **4.1D**

Title: **Radioactive Waste Design Bases**

Content:

Waste Type	Quantity	Receipt Rates	Thermal Output
Spent Fuel			
Defense HLW			
etc.			

B. Table No. **4.1E**

Title: **Waste Package/Container Design Bases**

Content:

	Design Parameters
Waste Containment	
Waste Container	
Waste Package	

C. Table No. **4.1F**

Title: **Soil Properties and Other Relevant Foundation Design Data**

Content:

Foundation Design Parameter	Design Bases	Data
Soil Properties, etc.		

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. 4.1G

Title: Weather and Other Relevant Meteorological Data

Content:

Parameter	Design Basis Value
Annual Rain	
Maximum Wind	
Average Wind	
etc.	

B. Table No. 4.1H

Title: Rock Data Pertinent to GROA Design

Content:

Rock Type	Mechanical Data	Thermal Data	Thermo-Chemical Data	Hydrological Data	Geochemical Data

C. Table No. 4.1I

Title: Engineered Components Design Basis Data-Underground Facility

Content:

Component	Material	Permeability	Absorption Coefficient, etc
Injected Grouts			
Backfill in boreholes			
Backfill in Drifts, Shafts, and Ramps			
Liners			

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. **4.1J**

Title: **Summary of Regulatory Design Criteria and Performance Objectives**

Content:

SSC	10 CFR 60	DOE Requirements	EPA
Waste Handling System			
Etc.			

B. Table No. **4.1K**

Title: **SSCs Important to Safety, Retrievability, or Isolation**

Content:

SSC	Safety	Retrievability	Isolation

Section No. & Title: 4.1 **DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS**

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. **4.1AF**

Caption: **Layout of Waste Ramp**

Content:

General arrangements - Elevation view
Plan view

B. Figure No. **4.1AG**

Caption: **Engineering Drawings - Waste Ramp**

Content:

Cross sections, etc.

C. Figure No. **4.1AH**

Caption: **Hauling Equipment Drawings**

Content:

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. 4.1AJ

Caption: Layout of Muck Ramp

Content:

General arrangements - Elevation view
Plan view

B. Figure No. 4.1AK

Caption: Engineering Drawings - Muck Ramp

Content:

Cross sections, etc.

C. Figure No. 4.1AL

Caption: Hauling Equipment Drawings

Content:

Section No. & Title: 4.1 **DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS**

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. **4.1AO**

Caption: **Layout of Ventilation Intake Shaft**

Content:

General arrangements - Elevation view
Plan view

B. Figure No. **4.1AN**

Caption: **Engineering Drawings - Ventilation Intake Shaft**

Content:

Cross sections, etc.

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. 4.1AR

Caption: Layout of Ventilation Exhaust Shaft

Content:

Cross sections, etc.

B. Figure No. 4.1AQ

Caption: Engineering Drawings - Ventilation Exhaust Shaft

Content:

General arrangement - Elevation view
Plan view

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. 4.1F

Caption: **Flow Diagrams-On-Site Radioactive Waste Management System**

Content:

Many figures.

B. Figure No. 4.1G

Caption: **Piping Drawings On-Site Radioactive Waste Management System**

Content:

Many figures.

C. Figure No. 4.1H

Caption: **Instrumentation Diagrams On-Site Radioactive Waste Management System**

Content:

Many figures.

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. 4.1K

Caption: Fire Wall Locations

Content:

General arrangement drawing of surface facilities with fire walls cross-hatched.

B. Figure No. 4.1L

Caption: Sprinkler Coverage

Content:

General arrangement drawing with sprinkler coverage cross-hatched.

C. Figure No. 4.1M

Caption: Fire Extinguisher, Alarms, and Standpipe Locations

Content:

General arrangement drawing with legend marks for fire extinguishes, standpipes and fire alarms.

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. 4.1N

Caption: Communications Devices and Alarms

Content:

General arrangements drawing with legend marks.

B. Figure No. 4.1O

Caption: Flow Diagram - Utility System

Content:

Many figures (>10).

C. Figure No. 4.1P

Caption: Piping Drawings Utility Systems

Content:

Many figures.

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Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. 4.1Q

Caption: Electrical One-Line Diagrams

Content:

Many diagrams.

B. Table No. 4.1N

Title: Major Component-Utility Systems

Content:

Many tables.

C. Figure No. 4.1R

Caption: Instrumentation Diagram-Utility System

Content:

Many figures.

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. 4.1S

Caption: Computer and Control System Architecture

Content:

Logic diagram illustrating structure of system.

B. Figure No. 4.1T

Caption: Control Room Layout

Content:

Many drawings.

C. Figure No. 4.1U

Caption: Location of On-Site Transportation Systems

Content:

Maps showing railroads and paved roads.

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. **4.1V**

Caption: **Detailed Engineering Drawings of Hoist Building and Ramp Buildings**

Content:

Many drawings.

B. Table No. **4.1P**

Title: **Major Component Design Parameters - Ventilation Systems**

Content:

Component

Fans
Filters

C. Table No. **4.1O**

Title: **HVAC System Design Parameters**

Content:

Area	Temp	Humidity	Purity, etc.
Waste Handling Building			
Etc.			

Section No. & Title: 4.1 **DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS**

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. 4.1W

Caption: **Flow Diagrams - Ventilation Systems**

Content:

Many figures.

B. Figure No. 4.1X

Caption: **Duct Work Drawings - Ventilation Systems**

Content:

Many drawings.

C. Figure No. 4.1Y through - AD

Caption: **General Arrangement of Support System Buildings**

Content:

Many drawings.

Section No. & Title: **4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS**

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. **4.1AT**

Caption: **Engineering Drawings - Personnel and Materials Shaft**

Content:

Drawings.

B. Figure No. **4.1AU**

Caption: **Layout of Personnel and Material Shaft**

Content:

General arrangement - Elevation view
Plan view

C. Figure/Table No.

Caption/Title:

Content:

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. 4.1XX

Title: **Design Parameters for Hauling Equipment**

Content:

Equipment	Load Capacity	Etc.
Crane		
Etc.		

B. Figure No. 4.1AM

Caption: **Instrumentation Diagrams - Waste Ramp**

Content:

General arrangement - Elevation view
Plan view

C. Figure/Table No.

Caption/Title:

Content:

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. **4.1V**

Title: **Design Parameters for Hauling Equipment**

Content:

Equipment	Load Capacity	Etc.
Crane		
Etc.		

B. Table No. **4.1W**

Title: **Waste Types to be Transported in Ramp**

Content:

Waste Type	Volume	Weight
Spent Fuel		
Etc.		

C. Figure No. **4.1AI**

Caption: **Instrumentation Diagrams - Waste Ramp**

Content:

Diagrams.

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. 4.1Q

Title: **Equipment, Systems, or Facilities Requiring Decommissioning**

Content:

System, Facility or Equipment	Location	Decontamination Required	Radwaste Volume
Waste Handling Sys			
Etc.			

B. Figure No. 4.1AE

Caption: **Layout of GROA Shafts and Ramps**

Content:

General arrangement drawing of shafts and ramp - elevation view and plan view.

C. Table No. 4.1R

Title: **Identification of Shaft and Ramp SSCs**

Content:

SSC	Safety	Retrievability	Isolation

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. 4.1L

Title: **Hazardous and/or Combustible Materials**

Content:

Material	Properties		Location
	Heating Value	Self-Ignition Temp	

B. Figure No. 4.1J

Caption: **Piping Drawings - Fire and Explosion Protection System**

Content:

Many figures.

C. Table No. 4.1M

Title: **Major Components Fire and Explosion Protection System**

Content:

Component	Design Parameters
Pump	
Tanks	
Etc.	

Section No. & Title: 4.1 **DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS**

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. 4.1S

Title: **Schedule for SSC Inspections**

Content:

Milestone Chart

SSC	2001	:	:	:	:	2050

B. Table No. 4.1T

Title: **Schedule for SSC Testing**

Content:

Milestone Chart

SSC	2001	:	:	:	:	2050

C. Table No. 4.1U

Title: **Schedule for SSC Maintenance**

Content:

Milestone Chart

SSC	2001	:	:	:	:	2050

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Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. 4.1AP

Caption: Instrumentation Diagram - Ventilation Intake Shaft

Content:

B. Figure/Table No.

Caption/Title:

Content:

C. Figure/Table No.

Caption/Title:

Content:

Section No. & Title: 4.1 **DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS**

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. **4.1J**

Title: **Major Component Design Parameters - Hot Cell System**

Content:

Component	Lifting Capacity	Etc.
Cranes		
Etc.		

B. Table No. **4.1K**

Title: **Major Component Design Parameters - On-Site Radioactive Waste Management System**

Content:

Component	Flow	Head	Type	HP	etc.
Pump					
Etc.					

C. Figure No. **4.1I**

Caption: **Flow Diagram - Fire and Explosion Protection System**

Content:

Diagram.

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. 4.1AS

Caption: Instrumentation Diagrams - Ventilation Exhaust Shaft

Content:

Diagram.

B. Figure/Table No.

Caption/Title:

Content:

C. Figure/Table No.

Caption/Title:

Content:

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. 4.1Y

Title: Design Parameters for Hoisting Equipment

Content:

Equipment	Load Capacity
Crane	
Etc.	
Cage Capacity	

B. Figure No. 4.1AV

Caption: Instrumentation Diagrams-Personnel and Materials Shaft

---

Content:

C. Table No. 4.1Z

Title: Shaft and Ramp Backfill and Sealing Materials

Contents:

Shaft or Ramp	Backfill Material	Method of Employment	Equipment Used in Emplacement

Section No. & Title: **4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS**

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. **4.1AX**

Caption: **Underground Facility Layout Drawing**

Content:

General arrangement of underground facility
- Elevation view
- Plan view

B. Table No. **4.1AA**

Title: **Identification and Classification of Underground Facility SSCs**

Content:

SSC	Safety	Retrievability	Isolation

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. 4.1AZ

Caption: Excavation Equipment Drawing

Content:

B. Figure No. 4.1BA

Caption: Ground Support Equipment Drawings

Content:

C. Table No. 4.1AE

Title: Excavation Equipment Design Parameters

Content:

Equipment	Rate of Advance	Tonnage of Excavation Rock	Etc.
Boring Machine			

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Form 2: Figures & Tables

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Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. 4.1AF

Title: **Muck Handling Equipment Design Parameters**

Content:

Equipment	Design Parameters

B. Figure No. 4.1BB

Caption: **Layout of Muck Handling Equipment**

Content:

Elevation view
Plan view

C. Figure No. 4.1BC

Caption: **General Layout of Ventilation System**

Content:

Elevation and plan view of ductwork include mains and submains and panel layout.

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. 4.1AB

Title: Schedule for Underground Facility SSC Inspections

Content:

SSC	2001	:	:	:	:	2050

B. Table No. 4.1AC

Title: Schedules for Underground Facility SSC Testing

Content:

SSC	2001	:	:	:	:	2050

C. Table No. 4.1AD

Title: Schedules for Underground Facility SSC Maintenance

Content:

SSC	2001	:	:	:	:	2050

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. **4.1AG**

Title: **Ventilation System Design Parameters**

Content:

System	System Capacity	Max. Vent. Require-ments	Design Air Velocity	System Leakage	Drift Wall Temp	Drift Air Temp
Dev. Area						
Emplacement Area						
Refrigeration Plant						

B. Table No. **4.1AH**

Title: **Ventilation Equipment Design Parameters**

Content:

Equipment	Design Flow	Design Head	Other Characteristics
Fans			

C. Figure No. **4.1BD**

Caption: **Waste Emplacement Drift General Arrangement**

Contents:

Plan view
Elevation view

Section No. & Title: 4.1 **DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS**

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. **4.1AI**

Title: **Waste Emplacement Equipment Design Parameters**

Content:

Equipment	Load Capacity	etc.	Shielding
Upender			

B. Figure No. **4.1BE**

Caption: **Waste Emplacement Outline Drawings**

Content:

C. Figure No. **4.1BF**

Caption: **Layout Drawings of Radiological Areas and Facilities**

Content:

General arrangement drawing including:

- Location of shield walls
- Thickness of shield walls
- Controlled access areas
- Equipment decontamination areas
- Contamination control areas
- Traffic patterns
- Location of health physics areas
- Location of radiation monitors
- Location of control panels for radwaste equipment
- Location of labs and counting room.

Section No. & Title: 4.1 **DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS**

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. **4.1AM**

Title: **Identification of SSCs That Perform Interface Functions**

Content:

SSC	Surface Facilities	Shafts and Ramps	Underground Facility
Ventilation System			
Hoisting System			
Communication System			
I&C System			

B. Figure No.

Caption:

Content:

C. Figure/Table No.

Caption/Title:

Content:

Section No. & Title: 4.1 **DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS**

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. **4.1AK**

Title: **Shielding Design Parameters**

Content:

Source	Material	Thickness	Coefficient	Attenuation Factor	Buildup Assumptions	Codes
Spent Fuel						
HLW						
Tank A						
Tank B						

B. Figure No. **4.1BH**

Caption: **Outline Drawing of Radiation Monitors**

Content:

C. Table No. **4.1AL**

Title: **Radiation Monitor Instrumentation Design Parameters**

Content:

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Date: 4/17/92

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No.

Title:

Content:

B. Figure No. **4.1D**

Caption: **Instrumentation Diagrams - Hot Cell System**

Content:

Many Figures.

C. Figure No. **4.1E**

Caption: **Major Component Illustrations - Hot Cell System**

Content:

Many Figures.

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. 4.1AJ

Title: Tabulation of Radioactive Sources by Isotopic Composition

Content:

Radioactive Source	
Spent Fuel:	
	ST
	AL
	U
NLW:	
	-
	-
Tank:	
	-
	-
Equipment:	
	-
	-

B. Table No. 4.1AM

Table: X-Ray, Gamma Ray, and Neutron Source Characteristics (Grouped by Energy - 0=Max Energy)

Content:

Source	Neutron Yield	Photon Yield	Geometry
Tank A			

Section No. & Title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

C. Figure No. 4.1BG

Caption: Location of Radiation Sources in GROA

Content:

Scaled general arrangement and layout drawing of GROA with legend identifying sources.

Include designations of each restricted area, including boundary of area and type of interface (partition, locked door, or barriers).

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Form 3: References

Date: 4/17/92

Section No. & Title:

Lead Author & Phone No.

Instructions: List all books, articles, or other references that are expected to be used for the section. Indicate whether references are draft or final, and whether they are publicly available (i.e., published). Refer to the Writer's Guide, Appendix D of the Annotated Outline Management Plan for guidance on formatting reference information.

1.

2.

3.

4.

5.

6.

7.

8.

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number:

2. Section no. & title: 4.1 DESCRIPTION OF GROA STRUCTURES, SYSTEMS, AND COMPONENTS

3. Lead author & phone no: T. M. Williamson (702) 794-1821

4. Information request date:

5. Work location:

6. Type of information needed:

7. What is the information needed for?

8. What group is the probable information supplier?

9. When is the information needed?

10. What kind of related information is already available in references, etc.?

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form B: Information Response

Date: 4/17/92

1. Section No. & Title:

2. Person Supplying Information:

3. Phone No.:

4. Lead Author (Requester): Marshall Weaver (702) 794-1871

   Instructions: Information suppliers may use this form to communicate information that has been requested by lead authors via Information Request Forms. The Log No. on this form should be identical to the Log No. of the Information Request Form.

5. Response by Information Supplier:

Note: Attach additional sheets if necessary.

The above Annotated Outline text is guidance that may be used for the future development of an MGDS License Application.

MGDS Annotated Outline Information Need Form
Form C: Information Request Tracking Log

Date: 4/17/92

Note: This is a recommended format for a manual tracking system. Other tracking methods such as a simple computer data base are also acceptable.

Date:

Lead Author:

Log No.	Section	Date Issued	Date Response Received

Section 4.2 Assessment of Compliance for Surface Facilities

TABLE OF CONTENTS

LIST OF TABLES

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LIST OF FIGURES

Page

4.2 ASSESSMENT OF COMPLIANCE FOR SURFACE FACILITIES

Skeleton Text Has Not Been Developed For This Section

REFERENCES

1. Section No. & Title: 4.2 ASSESSMENT OF COMPLIANCE FOR SURFACE FACILITIES

2. Lead Author & Phone No.: TBD
[T.M. Williamson 702-794-1821]

3. First Phase Planning Package Due: 6/21/91

   Second Phase Planning Package Due: 10/18/91

   First Phase Skeleton Draft Due: 12/30/91

   Second Phase Skeleton Draft Due: 3/15/92

4. Plan Approved: W.R. Griffin 8/27/91
(Licensing Mgr & Lead Author)

5. Section Summary (Approximately 100 Words):

   Analyses of surface facility SSCs are provided in this section to demonstrate compliance with all applicable regulatory requirements, particularly 10 CFR 60. Appropriate design parameters are provided and the bases for their compliance with 10 CFR 60 are discussed. Specific requirements other than those established by 10 CFR 60 are identified and compliance is demonstrated for each surface facility system. Sufficient information is provided to facilitate an independent verification of compliance with all applicable regulatory requirements.

6. Opening Statement:

   Analyses provided in this section demonstrate that GROA surface facility SSCs comply with all applicable regulations.

7. Main Body Outline:

4.2 ASSESSMENT OF COMPLIANCE FOR SURFACE FACILITIES

4.2.0 Introduction

- Refer to surface facility descriptions in Section 4.1
- Provide a general description of the regulatory requirements and overall methods for assessing compliance.

7. Main Body Outline (Continued)

4.2.0.1 Compliance with 10 CFR 60 Requirements

- All of the surface facility SSCs in each subsection of Section 4.1 that are subject to 10 CFR 60 requirements are listed in Table 4.2A.
- Provide an analysis demonstrating compliance with applicable 10 CFR 60 requirements for each SSC.
    - Demonstrate compliance with general requirements applicable to all GROA SSCs
    - Demonstrate compliance with individual design requirements applicable to GROA systems.
- Describe how design parameters presented in Section 4.1 result in compliance with 10 CFR 60 requirements.
- Justify how applicable industry codes and standards used in the design result in compliance with 10 CFR 60 requirements.

4.2.0.2 Accident Analyses

- Describe overall approach to accident analyses including the selection of the accident scenarios
- Discuss (list) accidents that SSCs are designed to withstand and how each system is intended to perform during each accident
- Demonstrate that surface facility SSCs are designed to withstand the effects of each accident
- Describe design features that prevent accidents, including those caused by natural phenomena. [Provide DOE Petition for Rulemaking, 55 FR28771, 7/13/90.]

4.2.0.3 Basis for Identification of SSCs Important to Safety

- Provide the bases for the SSCs important to safety, waste isolation, and retrievability. These SSCs are listed in Table 4.1K.
- Provide an analysis that demonstrates the margin of safety in the design under normal conditions and anticipated operational occurrences, including those of natural origin.

7. Main Body Outline (Continued)

4.2.0.4 Description of Models

- The models used to perform the analyses are listed in Table 4.2B.
- Explain measures supporting models used in both design applications and accident analyses.
- Support analyses and models used to predict future conditions with an appropriate combination of the following:

  - Field tests
  - In situ tests
  - Laboratory tests
  - Monitoring data
  - Natural analog studies.

- Discuss variability and uncertainty of data and the propagation of errors.
- Discuss the representativeness of data and uncertainties associated with extrapolation of data.
- Discuss conceptualizations, documentation, and validation of models and codes with respect to:

  - Uncertainties in the input data
  - Applicability of specific models
  - Appropriateness of assumptions
  - Sensitivity of results to the uncertainty of input data.

- Input and output data for each of the models are provided in Table 4.2C.
- Provide interpretations of input and output data along with the basis of interpretations. Provide sufficient detail to facilitate independent analysis of results.
- Document role of expert judgement.

4.2.1 Applicable Requirements and Criteria

- [Consider FCRG comment to bulletize list of SSC's in section 4.1.]

4.2.1.0 Introduction

7. Main Body Outline (Continued)

- In this subsection, compliance is demonstrated for all surface subsystems with the additional requirements and criteria presented herein, as applicable.

4.2.1.1 Airborne Radioactive Materials

- Demonstrate that the concentrations of airborne radioactive materials in restricted areas (including discharges from other GROA systems) are consistent with the inhalation limits as required by 10 CFR 20.103. The restricted areas are shown in Figure 4.2A. The estimated concentrations in each restricted area is provided in Table 4.2D.
- Each source term used to estimate these concentrations is provided in Table 4.2E.
- Those areas potentially contaminated with airborne radioactivity that are accessible to operating personnel are shown in Figure 4.2B.
- Estimates of maximum individual and total person-hours of occupancy are provided in Table 4.2F. Anticipated concentrations during occupancy are provided in Table 4.2D.
- Projected concentrations and estimated intake of radionuclides in restricted areas until permanent closure are provided in Table 4.2G.
- Models and model parameters used in calculations are provided in Table 4.2H.
- A comparison of projected intakes to intake limits in 10 CFR 20 are provided in Table 4.2I.
- Indicate provisions for personnel protective measures such as respiratory equipment or exhaust hoods.

4.2.1.2 Occupancy Time

- Demonstrate the means to limit the occupancy time required to perform work in restricted areas.
- Ensure each system is designed for compliance with 10 CFR 20 requirements for occupancy time.

7. Main Body Outline (Continued)

4.2.1.3 Shielding

- Demonstrate that each system is provided with suitable shielding. Refer to Section 4.1 for locations of shielding.
- Provide cost/benefit analysis for each shield to demonstrate compliance with ALARA conditions of 10 CFR 20 and dose limitations requirements of 10 CFR 20.101.

4.2.1.4 Contamination Control

- Demonstrate the means to monitor and control the dispersal of radioactive contamination between radiation zones in restricted areas. The radiations zones are illustrated in Figure 4.1BF.
- Ensure compliance with ALARA requirements in 10 CFR 20.1(c), dose limitations in 10 CFR 20.101, and concentration in air required by 10 CFR 20.103.

4.2.1.5 Access Control

- Describe means to control access to high-radiation areas or airborne radioactivity areas.
- Describe the monitoring of access.

4.2.1.6 Radiation Alarm Systems

- Describe radiation alarm systems that warn operating personnel of:
    - Significant increases in radiation levels
    - Significant increases in airborne material concentrations
    - Increased radioactivity in effluents.
- Describe provisions for calibration and operability testing. [Reference provided here.]

4.2.1.7 Dose Rates in Restricted Areas

- Demonstrate that the levels of radiation in restricted areas are in compliance with 10 CFR 20.101.
- Provide the objectives and criteria for design dose rates in various areas. [What are various areas?]

7. Main Body Outline (Continued)

- Estimates of the annual collective person-rem doses are provided in Table 4.2J.
- Estimated annual occupancy times for each restricted area are provided in Table 4.2F. Provide the bases, models, assumptions for values presented. [See Section 4.2.1.1]
- Identify dose conversion factors and illustrate how they are used to calculate exposure.
- Describe biological and dosimetry models and ensure compliance with 10 CFR 20.

4.2.1.8 ALARA

- Describe how exposures and effluent discharges are ALARA for each system per 10 CFR 20.1(c).
- Describe management policy regarding ALARA in sources and with respect system design and operation.
- Describe how guidelines in Reg Guide 8.8 were used for each individual system. If not used, justify. [Reference provided here.]

4.2.1.9 Natural Phenomena and Environmental Conditions

- Demonstrate that the SSCs important to safety are designed so that natural phenomena and environmental conditions do not interfere with safety functions.

4.2.1.10 Dynamic Effects

- Demonstrate that the SSCs important to safety are designed to withstand missile impacts, etc, without loss of safety function operability.

4.2.1.11 Performance During and After Fires and Explosions

- Demonstrate that the SSCs important to safety are designed to perform safety functions during and after credible fires and explosions. [Reference Section 4.1.1.3.]

4.2.1.12 Noncombustible and Heat-resistant Materials

- Demonstrate that the SSCs important to safety are designed to incorporate the use of noncombustible and heat-resistant materials. [Reference Section 4.1.1.3.]

7. Main Body Outline (Continued)

4.2.1.13 Fire and Explosion Protection Systems

- Demonstrate that the GROA is designed with sufficient fire and explosion system capacity and redundancy to reduce adverse effects of fires and explosions on SSCs important to safety. [Reference Section 4.1.1.3.]

4.2.1.14 Adverse Safety Effects of Fire and Explosion System Operation or Failure

- Demonstrate that GROA surface facility SSCs are designed to withstand the effects of fire protection system operation or failure and still perform safety function. [Reference Section 4.1.1.3.]

4.2.1.15 Control of Radioactive Materials

- Demonstrate that SSCs important to safety are designed to maintain control of radioactive waste and effluents, safely shutdown, and permit safe evacuation during an emergency. [Reference Section 4.1.1.4.]

4.2.1.16 Response to Emergency Conditions

- Demonstrate how emergency systems are designed to include facilities and services that ensure safe and timely response to emergency conditions. [Reference Section 4.1.1.4.]
- Demonstrate that emergency system facilitate the us of offsite services such as:
  - Fire
  - Police
  - Medical
  - Ambulance.

4.2.1.17 Utility System Performance During Normal and Accident Conditions

- Demonstrate that each utility system important to safety is designed to perform intended safety functions under both accident and normal conditions. [Reference Section 4.1.1.6.]

7. Main Body Outline (Continued)

4.2.1.18 Utility System Redundancy

- Demonstrate that utility system design incorporates adequate redundancy to perform safety functions. [Reference Section 4.1.1.6.]

4.2.1.19 Emergency Power

- Demonstrate that emergency power is available in the event of a loss of primary power for the following:
  - Instruments
  - Utility systems
  - Operating systems
  - Alarm systems.

4.2.1.20 SSC Operability Verification

- Demonstrate that SSCs important to safety have been design to facilitate periodic inspection, testing, and maintenance to ensure operability.

4.2.1.21 Criticality

- Demonstrate that all systems dealing with nuclear material are designed in compliance with the Double Contingency Principle precluding nuclear criticality.
- Demonstrate that each system has been designed for criticality safety under normal and accident conditions.
- Ensure that k_{eff} is sufficiently below unity to show at least 5% margin after allowances for the bias in calculation methods and validation. The effective multiplication factor for all masses and configurations of radioactive material is shown in Table 4.2K.

4.2.1.22 Instrumentation

- Demonstrate that instrumentation and control systems include adequate provisions to monitor and control systems important to safety over anticipated ranges of normal operation and accident conditions. [Reference Section 4.1.1.7.]

7. Main Body Outline (Continued)

4.2.1.23 Worker Protection

- Demonstrate that the design includes adequate provisions for worker protection to assure that SSCs important to safety can perform intended function. [Reference Federal Mine Safety and Health Act of 1977.]

- Note any deviations from the design requirements of 30 CFR Chapter I, subchapters D, E, and N.

4.2.1.24 Hoists

- Demonstrate that hoists important to safety are designed to:

  - Preclude cage freefall
  - Have a reliable cage location system
  - Have a reliable system of interlocks that will fail safely upon malfunction
  - Include two independent indicators to indicate when waste packages are in place and ready for transfer.

4.2.1.25 Handling and Storage of Wastes

- Demonstrate that GROA surface facilities are designed to zallow safe handling and storage of wastes during emplacement and retrieval operations.

4.2.1.26 Ventilation Systems

- Demonstrate that surface facility ventilation systems are designed to protect against radiation exposures and offsite release during the following operations:

  - Waste transfer
  - Waste inspection
  - Decontamination
  - Waste processing
  - Waste packaging.

- [Reference Section 4.1.1.9.]

7. Main Body Outline (Continue)

4.2.1.27 Radioactive Effluents

- Demonstrate that surface facilities are designed to control the release of radioactive materials on effluents during normal operations in compliance with 10 CFR 60.111(a).

4.2.1.28 Effluent Monitoring

- Demonstrate that the effluent monitoring systems are designed to measure the amount and concentration of radionuclides with adequate precision. The accuracy and effluent monitoring equipment is provided in Table 4.2L
- Demonstrate that the monitoring systems include alarms that can be periodically tested.

4.2.1.29 Radioactive Waste Treatment

- Demonstrate that the radioactive waste treatment systems are designed to process all radioactive wastes at the GROA into forms suitable for safe storage onsite or transportation offsite, meeting all applicable regulations.

4.2.2 Systém Specific Compliance with Applicable Requirements and Criteria

4.2.2.0 Introduction

- Provide a general description of surface facility design requirements and the procedures for identifying regulatory requirements and ensuring compliance. System specific compliance is demonstrated in this section for all surface facility systems.

  [The FCRG outline requirement for system specific treatment of requirements will be repetitive.]

4.2.2.1 Hot Cell

- Demonstrate compliance with all applicable requirements and criteria.

4.2.2.2 Onsite Radioactive

7. Main Body Outline (Continue)

- Demonstrate compliance with all applicable requirements and criteria.

4.2.2.3 Fire and Explosion Protection Systems

- Demonstrate compliance with all applicable requirements and criteria.

4.2.2.4 Emergency Systems

- Demonstrate compliance with all applicable requirements and criteria.

4.2.2.5 Communication Systems

- Demonstrate compliance with all applicable requirements and criteria.

4.2.2.6 Utility Systems

- Demonstrate compliance with all applicable requirements and criteria.

4.2.2.7 Instrumentation and Controls

- Demonstrate compliance with all applicable requirements and criteria.

4.2.2.8 Onsite Transportation System

- Demonstrate compliance with all applicable requirements and criteria.

4.2.2.9 Ventilation systems

- Demonstrate compliance with all applicable requirements and criteria.

4.2.2.10 Operations Support Systems

- Demonstrate compliance with all applicable requirements and criteria.

7. Main Body Outline (Continue)

4.2.2.11 Decommissioning System

- Demonstrate compliance with all applicable requirements and criteria.

4.2.2.12 Other Surface Systems

- Demonstrate compliance with all applicable requirements and criteria.

8. Conclusion:

Analyses provided in this section demonstrate that GROA surface facility SSCs comply with all applicable regulatory requirements. Therefore, there are no credible circumstances by which surface facility operations threaten the health or safety of plant personnel or the public.

9. Support Authors & Their Assignments:

Tom Williamson (M&O Licensing)

Section No. & Title: **4.2 ASSESSMENT OF COMPLIANCE FOR SURFACE FACILITIES**

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. **4.2A**

Title: Surface Facility SSCs and Applicable 10 CFR 60 Requirements

Content:

SSC	Reference to 10 CFR 60 Requirement	Description of Requirement
Systems Structures Component	10 CFR 60.20i [ex]	

B. Table No. **4.2B**

Title: Analytical Models for Surface Facilities

Content:

Model	Analysis

C. Table No. **4.2C**

Title: Data for Surface Facility Models and Codes

Content:

Code or Model	Input Data	Output Data

Section No. & Title: 4.2 ASSESSMENT OF COMPLIANCE FOR SURFACE FACILITIES

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. 4.2A

Caption: Restricted Areas in the Surface Facilities

Content:

Plant layout showing restricted areas with legend.

B. Table No. 4.2D

Title: Estimated Concentration of Airborne Radioactive Materials for the Restricted Areas in Surface Facilities

---

Content:

Area	Concentration

C. Table No. 4.2E

Title: Source Terms in Surface Facilities

Content:

Source Term	Quantity Discharged per Unit Time	Particle Size (AMAD)	Chemical Form	Physical Form	Lung Solubility Class

Section No. & Title: 4.2 **ASSESSMENT OF COMPLIANCE FOR SURFACE FACILITIES**

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. **4.2B**

Caption: **Areas Potentially Contaminated with Radioactive Materials that are Accessible to Operating Personnel in the Surface Facilities**

Content:

Layout drawing of GROA surface facilities with subject areas cross-hatched.

B. Table No. **4.2F**

Title: **Maximum Individual and Total Person-Hours of Occupancy in the Surface Facilities**

Content:

Area	Individual Person-Hours/yr.	Total Person-Hours/yr.

C. Table No. **4.2G**

Title: **Radionuclide Concentration and Intake Estimates During Operational Activities in the Surface Facilities**

Content:

Operation Activity	Projected Concentration	Estimated Intake
Handling		
Storage		
Retrieval		
Emplacement		
Isolation		

Section No. & Title: 4.2 ASSESSMENT OF COMPLIANCE FOR SURFACE FACILITIES

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. 4.2H

Title: Analytical Models and Model Parameters for the Surface Facilities

Content:

Analysis	Model	Model Parameters
Concentration Estimates		
Intake Estimates		
Etc.		

B. Table No. 4.2I

Title: Comparison of Projected Intakes to 10 CFR 20 Limits in the Surface Facilities

Content:

Area	Projected Intake	Intake Limit

C. Table No. 4.2J

Title: Collective Person - Rem Doses by Function in the Surface Facilities

Content:

Function	Annual Collective	Estimated Annual Time (Person Hours)
Spent Fuel Transfer		
HLW Transfer		
Off-Gas Handling		
Waste Treatment		
Maintenance		
Rad Waste Handling		
Decontamination		
In-Service Inspections		

Section No. & Title: 4.2 ASSESSMENT OF COMPLIANCE FOR SURFACE FACILITIES

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. 4.2K

Title: Multiplication Factors (Keff) for the Surface Facilities

Content:

System or Component	Worst Case Calculated Keff
Transportation Cask	0.9
Radwaste Storage Container	0.6
Etc.	Etc.
Etc.	

B. Table No. 4.2L

Title: Effluent Monitoring Equipment in the Surface Facilities

Content:

Effluent	Equipment	Accuracy Quantity/Concentration	Setpoint	Alarm

---

C. Figure No.

Caption:

Content:

The above Annotated Outline text is guidance that may be used for the future development of an MGDS License Application.

MGDS Annotated Outline Planning Package
Form 3: References

Date: 4/17/92

Section No. & Title:

Lead Author & Phone No.

Instructions: List all books, articles, or other references that are expected to be used for the section. Indicate whether references are draft or final, and whether they are publicly available (i.e., published). Refer to the Writer's Guide, Appendix D of the Annotated Outline Management Plan for guidance on formatting reference information.

1.

2.

3.

4.

5.

6.

7.

8.

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number:
2. Section no. & title: 4.2 ASSESSMENT OF COMPLIANCE FOR SURFACE FACILITIES
3. Lead author & phone no: T. M. Williamson (702) 794-1821
4. Information request date:
5. Work location:
6. Type of information needed:
7. What is the information needed for?
8. What group is the probable information supplier?
9. When is the information needed?
10. What kind of related information is already available in references, etc.?

---

11. Response by (name):
12. Response date:
13. Response:

MGDS Annotated Outline Information Need Form
Form B: Information Response

Date: 4/17/92

1. Section No. & Title:

2. Person Supplying Information:

3. Phone No.:

4. Lead Author (Requester): Marshall Weaver (702) 794-1871

Instructions: Information suppliers may use this form to communicate information that has been requested by lead authors via Information Request Forms. The Log No. on this form should be identical to the Log No. of the Information Request Form.

5. Response by Information Supplier:

Note: Attach additional sheets if necessary.

MGDS Annotated Outline Information Need Form
Form C: Information Request Tracking Log

Date: 4/17/92

Note: This is a recommended format for a manual tracking system. Other tracking methods such as a simple computer data base are also acceptable.

Date:

Lead Author:

Log No.	Section	Date Issued	Date Response Received

Section 4.3 Assessment of Compliance for Shafts or Ramps

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4.3 ASSESSMENT OF COMPLIANCE FOR SHAFTS OR RAMPS

Skeleton Text Has Not Been Developed For This Section

REFERENCES

1. Section No. & Title: 4.3 ASSESSMENT OF COMPLIANCE FOR SHAFTS OR RAMPS

2. Lead Author & Phone No. TBD
[T.M. Williamson 702-794-1821]

3. First Phase Planning Package Due: 6/21/91

   Second Phase Planning Package Due: 10/18/91

   First Phase Skeleton Draft Due: 12/30/91

   Second Phase Skeleton Draft Due: 3/15/92

4. Plan Approved: W.R. Griffin 8/27/91
(Licensing Mgr & Lead Author)

5. Section Summary (Approximately 100 Words):

   Analysis of shaft and ramp SSCs are provided in this section to demonstrate compliance with all applicable regulatory requirements, particularly 10 CFR 60. Appropriate design parameters are provided and the bases for their compliance with 10 CFR 60 are described. Specific requirements other than those established by 10 CFR 60 are identified and compliance is established for each shaft and ramp system. Sufficient information is provided to facilitate an independent verification of compliance with all applicable regulatory requirements.

6. Opening Statement:

   Analyses provided in this section demonstrate that GROA shaft and ramp SSCs comply with all applicable regulations.

7. Main Body Outline: See attached.

8. Conclusion:

   Analyses provided in this section demonstrate that GROA shaft and ramp SSCs comply with all applicable regulatory requirements. Therefore, there are no credible circumstances by which shaft and ramp operations threaten the health or safety of plant personnel or the public.

9. Support Authors & Their Assignments:

   Tom Williamson (M&O Licensing)

7. Main Body Outline (Continued)

4.3 ASSESSMENT OF COMPLIANCE FOR SHAFTS OR RAMPS

4.3.0 Introduction

- Refer to shaft and ramp descriptions in Section 4.1
- Provide a general description of the regulatory requirements and overall methods for assessing compliance.

4.3.0.1 Compliance with 10 CFR 60 Requirements

- All of the shaft and ramp SSCs in each subsection of Section 4.2 that are subject to 10 CFR 60 requirements are listed in Table 4.3A.
- Provide an analysis demonstrating compliance with applicable 10 CFR 60 requirements for each SSC.
  - Demonstrate compliance with general requirements applicable to all GROA SSCs
  - Demonstrate compliance with individual design requirements applicable to GROA systems.
- Describe how design parameters presented in Section 4.1 result in compliance with 10 CFR 60 requirements.
- Justify how applicable industry codes and standards used in the design result in compliance with 10 CFR 60 requirements.

4.3.0.2 Accident Analyses

- Describe overall approach to accident analyses including the selection of the accident scenarios
- Discuss (list) accidents that SSCs are designed to withstand and how each system is intended to perform during each accident
- Demonstrate that shaft and ramp SSCs are designed to withstand the effects of each accident
- Describe design features that prevent accidents, including those caused by natural phenomena.

7. Main Body Outline (Continued)

4.3.0.3 Basis for Identification of SSCs Important to Safety

- Provide the basis for the SSCs important to safety, waste isolation, and retrievability. These SSCs are listed in Table 4.1K.
- Provide an analysis that demonstrates the margin of safety in the design under normal conditions and anticipated operational occurrences, including those of natural origin.

4.3.0.4 Description of Models

- The models used to perform the analyses are listed in Table 4.3B.
- Explain measures supporting models used in both design applications and accident analyses.
- Support analyses and models used to predict future conditions with an appropriate combination of the following:
    - Field tests
    - In situ tests
    - Laboratory tests
    - Monitoring data
    - Natural analog studies.
- Discuss variability and uncertainty of data and the propagation of errors.
- Discuss the representativeness of data and uncertainties associated with extrapolation of data.
- Discuss conceptualizations, documentation, and validation of models and codes should be discussed with respect to:
    - Uncertainties in the input data
    - Applicability of specific models
    - Appropriateness of assumptions
    - Sensitivity of results to the uncertainty of input data.
- Input and output data for each of the models are provided in Table 4.3C.
- Provide interpretations of input and output data along with the basis of interpretations. Provide sufficient detail to facilitate independent analysis of results.
- Document role of expert judgement.

7. Main Body Outline (Continued)

4.3.1 Applicable Requirements and Criteria

- [Consider FCRG comment to bulletize list of SSC's listed in Section 4.1]

4.3.1.0 Introduction

- In this subsection, compliance is demonstrated for all shaft and ramp subsystems with the additional requirements and criteria presented herein, as applicable.

  [Note that organization of this subsection differs from Section 4.2.1.]

4.3.1.1 Airborne Radioactive Materials

- Demonstrate that the concentrations of airborne radioactive materials in restricted areas (including discharges from other GROA systems) are consistent with the inhalation limits as required by 10 CFR 20.103. The restricted areas are shown in Figure 4.3A. The estimated concentrations in each restricted area is provided in Table 4.3D.
- Each source term used to estimate these concentrations is provided in Table 4.3E.
- Those areas potentially contaminated with airborne radioactivity that are accessible to operating personnel are shown in Figure 4.3B.
- Estimates of maximum individual and total person-hours of occupancy are provided in Table 4.3F. Anticipated concentrations during occupancy are provided in Table 4.3D.
- Projected concentrations and estimated intake of radionuclides in restricted areas until permanent closure are provided in Table 4.3G.
- Models and model parameters used in calculations are provided in Table 4.3H.
- A comparison of projected intakes to intake limits in 10 CFR 20 are provided in Table 4.3I.
- Indicate provisions for personnel protective measures such as respiratory equipment or exhaust hoods.

  - Ensure compliance with ANSI N13.1-1969. [Reference provided here.]

7. Main Body Outline (Continued)

4.3.1.2 Contamination Control

- Demonstrate the means to monitor and control the dispersal of radioactive contamination between radiation zones in restricted areas. The radiations zones are illustrated in Figure 4.1BF.
- Ensure compliance with ALARA requirements in 10 CFR 20.1(c), dose limitations in 10 CFR 20.101, and concentration in air required by 10 CFR 20.103.

4.3.1.3 Dose Rates in Restricted Areas

- Demonstrate that the levels of radiation in restricted areas are in compliance with 10 CFR 20.101.
- Provide the objectives and criteria for design dose rates in various areas. [What are various areas?]
- Estimates of the annual collective person-rem doses are provided in Table 4.3J.
- Estimated annual occupancy times for each restricted area are provided in Table 4.3F. Provide the bases, models, assumptions for values presented. [See Section 4.3.1.1]
- Identify dose conversion factors and illustrate how they are used to calculate exposure.
- Describe biological and dosimetry models and ensure compliance with 10 CFR 20.

4.3.1.4 Natural Phenomena and Environmental Conditions

- Demonstrate that the SSCs important to safety are designed so that natural phenomena and environmental conditions do not interfere with safety functions.

4.3.1.5 Dynamic Effects

- Demonstrate that the SSCs important to safety are designed to withstand missile impacts, etc, without loss of safety function operability.

4.3.1.6 Performance During and After Fires and Explosions

- Demonstrate that the SSCs important to safety are designed to perform safety functions during and after credible fires and explosions.

7. Main Body Outline (Continued)

4.3.1.7 Noncombustible and Heat-resistant Materials

- Demonstrate that the SSCs important to safety are designed to incorporate the use of noncombustible and heat-resistant materials.

4.3.1.8 Fire and Explosion Protection Systems

- Demonstrate that the GROA fire protection and suppression systems have sufficient capacity to reduce adverse effects on SSCS important to safety. [Reference Section 4.1.1.3.]

4.3.1.9 Adverse Safety Effects of Fire and Explosion System Operation or Failure

- Demonstrate that GROA shaft and ramp SSCs are designed to withstand the effects of fire protection system operation or failure and still perform safety function. [Reference Section 4.1.1.3.]

4.3.1.10 Control of Radioactive Materials

- Demonstrate that SSCs important to safety are designed to maintain control of radioactive waste and effluents, safely shutdown, and permit safe evacuation during an emergency. [Reference Section 4.1.1.4.]

4.3.1.11 Utility System Performance During Normal and Accident Conditions

- Demonstrate that each utility system important to safety is designed to perform intended safety functions under both accident and normal conditions. [Reference Section 4.1.1.6.]

4.3.1.12 Utility System Redundancy

- Demonstrate that utility system design incorporates adequate redundancy to perform safety functions. [Reference Section 4.1.1.6.]

7. Main Body Outline (Continued)

4.3.1.13 Emergency Power

- Demonstrate that emergency power is available in the event of a loss of primary power for the following:
  - Instruments
  - Utility systems
  - Operating systems
  - Alarm systems.

4.3.1.14 SSC Operability Verification

- Demonstrate that SSCs important to safety have been designed to facilitate periodic inspection, testing, and maintenance to ensure operability.

4.3.1.15 Criticality

- Demonstrate that all systems dealing with nuclear material are designed in compliance with the Double Contingency Principle precluding nuclear criticality.
- Demonstrate that each system has been designed for criticality safety under normal and accident conditions.
- Ensure that K_{eff} is sufficiently below unity to show at least 5% margin after allowances for the bias in calculation methods and validation. The effective multiplication factor for all masses and configurations of radioactive material is shown in Table 4.2K. [Assume that shaft and ramp configurations are bounded by surface facility configurations.]

4.3.1.16 Instrumentation

- Demonstrate that instrumentation and control systems include adequate provisions to monitor and control systems important to safety over anticipated ranges of normal operation and accident conditions. [Reference Section 4.1.1.7.]

7. Main Body Outline (Continued)

4.3.1.17 Worker Protection

- Demonstrate that the design includes adequate provisions for worker protection to assure that SSCs important to safety can perform intended functions. [Reference Federal Mine Safety and Health Act of 1977.]
- Note any deviations from the design requirements of 30 CFR Chapter I, subchapters D, E, and N.

4.3.1.18 Shaft and Borehole Seals

- Demonstrate that seals for shafts and boreholes are designed so that they do not become pathways that compromise the GROA's ability to meet performance objectives following permanent closure. [Reference NRC technical position on seals.]

4.3.1.19 Seal Materials and Placement Methods

- Demonstrate that seal materials and placement methods are selected to reduce:
  - Creation of a pathway for water to contact waste packages
  - Radionuclide migration through existing pathways.

4.3.2 System Specific Compliance with Applicable Requirements and Criteria

4.3.2.0 Introduction

- Provide a general description of shaft and ramp design requirements and the procedures for identifying regulatory requirements and ensuring compliance. System specific compliance is demonstrated in this section for all shafts or ramps systems.

  [The FCRG outline requirement for system specific treatment of requirements will be repetitive.]

7. Main Body Outline (Continued)

4.3.2.1 Waste Shaft or Ramp

- Demonstrate compliance with all applicable requirements and criteria.

4.3.2.2 Muck Shaft or Ramp

- Demonstrate compliance with all applicable requirements and criteria.

4.3.2.3 Ventilation Intake Shafts

- Demonstrate compliance with all applicable requirements and criteria.

4.3.2.4 Ventilation Exhaust Shafts

- Demonstrate compliance with all applicable requirements and criteria.

4.3.2.5 Personnel and Materials Shafts

- Demonstrate compliance with all applicable requirements and criteria.

4.3.2.6 Decommissioning System

- Demonstrate compliance with all applicable requirements and criteria.

4.3.2.7 Other Shaft or Ramp Systems

- Demonstrate compliance with all applicable requirements and criteria.

Section No. & Title: **4.3 ASSESSMENT OF COMPLIANCE FOR SHAFTS AND RAMPS**

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. **4.3A**

Title: **Shaft and Ramp SSCs and Applicable 10 CFR 60 Requirements**

Content:

SSC	Reference to 10 CFR 60 Requirement	Description of Requirement
Systems Structures Component	10 CFR 60.20i [ex]	

B. Table No. **4.3B**

Title: **Analytical Models for Shafts and Ramps**

Content:

Model	Analysis

C. Table No. **4.3C**

Title: **Data for Shaft and Ramp Models and Codes**

Content:

Code or Model	Input Data	Output Data

Section No. & Title: 4.3 ASSESSMENT OF COMPLIANCE FOR SHAFTS AND RAMPS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. 4.3A

Caption: Restricted Areas in Shafts and Ramps

Content:

Plant layout showing restricted areas with legend.

B. Table No. 4.3D

Title: Estimated Concentration of Airborne Radioactive Materials for the Restricted Areas; Shafts and Ramps

Content:

Area	Concentration

C. Table No. 4.3E

Title: Source Terms in Ramps or Shafts

Content:

Source Term	Quantity Discharged per Unit Time	Particle Size (AMAD)	Chemical Form	Physical Form	Lung Solubility Class

Section No. & Title: 4.3 ASSESSMENT OF COMPLIANCE FOR SHAFTS AND RAMPS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. 4.3B

Caption: **Areas Potentially Contaminated with Radioactive Materials that are Accessible to Operating Personnel in Shafts and Ramps**

Content:

Layout drawing of GROA shafts and ramps with subject areas cross-hatched.

B. Table No. 4.3F

Title: **Maximum Individual and Total Person-Hours of Occupancy in Shafts and Ramps**

Content:

Area	Individual Person-Hours/yr.	Total Person-Hours/yr.

C. Table No. 4.3G

Title: **Radionuclide Concentration and Intake Estimates During Operational Activities in Shafts and Ramps**

Content:

Operational Activity	Projected Concentration	Estimated Intake
Handling		
Storage		
Retrieval		
Emplacement		
Isolation		

Section No. & Title: 4.3 ASSESSMENT OF COMPLIANCE FOR SHAFTS AND RAMPS

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. 4.3H

Title: Analytical Models and Model Parameters for Shaft and Ramp Analyses

Content:

Analysis	Model	Model Parameters
Concentration Estimates		
Intake Estimates		
Etc.		

B. Table No. 4.3I

Title: Comparison of Projected Intakes to 10 CFR 20 Limits in Shafts and Ramps

Content:

Area	Projected Intake	Intake Limit

C. Table No. 4.3J

Title: Collective Person - Rem Doses by Function in Shafts and Ramps

Content:

Function	Annual Collective	Estimated Annual Time (Person Hours)
Spent Fuel Transfer		
HLW Transfer		
Off-Gas Handling		
Waste Treatment		
Maintenance		
Rad Waste Handling		
Decontamination		
In-Service Inspections		

Section No. & Title: **4.3 ASSESSMENT OF COMPLIANCE FOR SHAFTS AND RAMPS**

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. 4.3K

Title: **Effective Multiplication Factors (Keff) for Shafts and Ramps**
[This might be redundant.]

Content:

System or Component	Worst Case Calculated Keff
Transportation Cask	0.9
Radwaste Storage Container	0.6
Etc.	Etc.
Etc.	

B. Table No.

Title:

Content:

C. Figure No.

Title:

Content:

MGDS Annotated Outline Planning Package
Form 3: References

Date: 4/17/92

Section No. & Title:

Lead Author & Phone No.

Instructions: List all books, articles, or other references that are expected to be used for the section. Indicate whether references are draft or final, and whether they are publicly available (i.e., published). Refer to the Writer's Guide, Appendix D of the Annotated Outline Management Plan for guidance on formatting reference information.

1.

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8.

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number:

2. Section no. & title: 4.3 ASSESSMENT OF COMPLIANCE FOR SHAFTS AND RAMPS

3. Lead author & phone no: T. M. Williamson (702) 794-1821

4. Information request date:

5. Work location:

6. Type of information needed:

7. What is the information needed for?

8. What group is the probable information supplier?

9. When is the information needed?

10. What kind of related information is already available in references, etc.?

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form B: Information Response

Date: 4/17/92

1. Section No. & Title:

2. Person Supplying Information:

3. Phone No.:

4. Lead Author (Requester): Marshall Weaver (702) 794-1871

   Instructions: Information suppliers may use this form to communicate information that has been requested by lead authors via Information Request Forms. The Log No. on this form should be identical to the Log No. of the Information Request Form.

5. Response by Information Supplier:

Note: Attach additional sheets if necessary.

MGDS Annotated Outline Information Need Form
Form C: Information Request Tracking Log

Date: 4/17/92

Note: This is a recommended format for a manual tracking system. Other tracking methods such as a simple computer data base are also acceptable.

Date:

Lead Author:

Log No.	Section	Date Issued	Date Response Received

Section 4.4 Assessment of Compliance for Underground Facilities

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4.4 ASSESSMENT OF COMPLIANCE FOR UNDERGROUND FACILITIES

Skeleton Text Has Not Been Developed For This Section

REFERENCES

MGDS Annotated Outline Planning Package
Form 1: Text

Date: 4/17/92

1. Section No. & Title: 4.4 ASSESSMENT OF COMPLIANCE FOR UNDERGROUND FACILITIES

2. Lead Author & Phone No. TBD
[T.M. Williamson 702-794-1821]

3. First Phase Planning Package Due: 6/21/91

   Second Phase Planning Package Due: 10/18/91

   First Phase Skeleton Draft Due: 12/30/91

   Second Phase Skeleton Draft Due: 3/15/92

4. Plan Approved: W.R. Griffin 8/27/91
(Licensing Mgr & Lead Author)

5. Section Summary (Approximately 100 Words):

   Analyses of underground facility SSCs are provided in this section to demonstrate compliance with all applicable regulatory requirements, particularly 10 CFR 60. Appropriate design parameters are provided and the bases for their compliance with 10 CFR 60 are discussed. Specific requirements other than those established by 10 CFR 60 are identified and compliance is demonstrated for each underground facility system. Sufficient information is provided to facilitate an independent verification of compliance with all applicable regulatory requirements.

6. Opening Statement:

   Analyses provided in this section demonstrate that GROA underground facility SSCs comply with all applicable regulations.

7. Main Body Outline: See attached.

8. Conclusion:

   Analyses provided in this section demonstrate that GROA underground facility SSCs comply with all applicable regulatory requirements. Therefore, there are no credible circumstances by which underground facility operations threaten the health or safety of plant personnel or the public.

9. Support Authors & Their Assignments:

   Tom Williamson (M&O Licensing)

7. Main Body Outline (Continued)

4.4 ASSESSMENT OF COMPLIANCE FOR UNDERGROUND FACILITIES

4.4.0 Introduction

- Refer to underground facility descriptions in Section 4.1.
- Provide a general description of the regulatory requirements and overall methods for assessing compliance.

4.4.0.1 Compliance with 10 CFR 60 Requirements

- All of the underground facility SSCs in each subsection of Section 4.1 that are subject to 10 CFR 60 requirements are listed in Table 4.4A.
- Provide an analysis demonstrating compliance with applicable 10 CFR 60 requirements for each SSC.
  - Demonstrate compliance with general requirements applicable to all GROA SSCs
  - Demonstrate compliance with individual design requirements applicable to GROA systems.
- Describe how design parameters presented in Section 4.1 result in compliance with 10 CFR 60 requirements.
- Justify how applicable industry codes and standards used in the design result in compliance with 10 CFR 60 requirements.

4.4.0.2 Accident Analyses

- Describe overall approach to accident analyses including the selection of the accident scenarios
- Discuss (list) accidents that SSCs are designed to withstand and how each system is intended to perform during each accident
- Demonstrate that underground facility SSCs are designed to withstand the effects of each accident
- Describe design features that prevent accidents, including those caused by natural phenomena.

4.4.0.3 Basis for Identification of SSCs Important to Safety

7. Main Body Outline (Continued)

- Provide the basis for the SSCs important to safety, waste isolation, and retrievability. These SSCs are listed in Table 4.1K.

- Provide an analysis that demonstrates the margin of safety in the design under normal conditions and anticipated operational occurrences, including those of natural origin.

4.4.0.4 Description of Models

- The models used to perform the analyses are listed in Table 4.4B.
- Explain measures supporting models used in both design applications and accident analyses.
- Support analyses and models used to predict future conditions with an appropriate combination of the following:

  - Field tests
  - In situ tests
  - Laboratory tests
  - Monitoring data
  - Natural analog studies.

- Discuss variability and uncertainty of data and the propagation of errors.
- Discuss the representativeness of data and uncertainties associated with extrapolation of data.
- Discuss conceptualizations, documentation, and validation of models and codes with respect to:

  - Uncertainties in the input data
  - Applicability of specific models
  - Appropriateness of assumptions
  - Sensitivity of results to the uncertainty of input data.

- Input and output data for each of the models are provided in Table 4.4C.
- Provide interpretations of input and output data along with the basis of interpretations. Provide sufficient detail to facilitate independent analysis of results.
- Document role of expert judgement.

7. Main Body Outline (Continued)

4.4.1 Applicable Requirements and Criteria

- [Consider FCRG comment to bulletize list of SSC's in Section 4.1]

4.4.1.0 Introduction

- In this subsection, compliance is demonstrated for all underground subsystems with the additional requirements and criteria presented herein, as applicable.

4.4.1.1 Airborne Radioactive Materials

- Demonstrate that the concentrations of airborne radioactive materials in restricted areas (including discharges from other GROA systems) are consistent with the inhalation limits as required by 10 CFR 20.103. The restricted areas are shown in Figure 4.4A. The estimated concentrations in each restricted area is provided in Table 4.4D.
- Each source term used to estimate these concentrations is provided in Table 4.4E.
- Those areas potentially contaminated with airborne radioactivity that are accessible to operating personnel are shown in Figure 4.4B.
- Estimates of maximum individual and total person-hours of occupancy are provided in Table 4.4-F. Anticipated concentrations during occupancy are provided in Table 4.4-D.
- Projected concentrations and estimated intake of radionuclides in restricted areas until permanent closure are provided in Table 4.4G.
- Models and model parameters used in calculations are provided in Table 4.4H.
- A comparison of projected intakes to intake limits in 10 CFR 20 are provided in Table 4.4I.
- Indicate provisions for personnel protective measures such as respiratory equipment or exhaust hoods.

4.4.1.2 Personnel Occupancy Time

- Demonstrate the means to limit the occupancy time required to perform work in restricted areas.
- Ensure each system is designed for compliance with 10 CFR 20 requirements for occupancy time.

7. Main Body Outline (Continued)

4.4.1.3 Shielding

- Demonstrate that each system is provided with suitable shielding. Refer to Section 4.1 for locations of shielding.
- Provide cost/benefit analysis for each shield to demonstrate compliance with ALARA conditions of 10 CFR 20 and dose limitations requirements of 10 CFR 20.101.

4.4.1.4 Contamination Control

- Demonstrate the means to monitor and control the dispersal of radioactive contamination between radiation zones in restricted areas. The radiations zones are illustrated in Figure 4.1BF.
- Ensure compliance with ALARA requirements in 10 CFR 20.1(c), dose limitations in 10 CFR 20.101, and concentration in air required by 10 CFR 20.103.

4.4.1.5 Access Control

- Describe means to control access to high-radiation areas or airborne radioactivity areas
- Describe the monitoring of access.

4.4.1.6 Radiation Alarm Systems

- Describe radiation alarm systems that warn operating personnel of:

  - Significant increases in radiation levels
  - Significant increases in airborne material concentrations
  - Increased radioactivity in effluents.

- Describe provisions for calibration and operability testing [Reference provided here.]

4.4.1.7 Dose Rates in Restricted Areas

- Demonstrate that the levels of radiation in restricted areas are in compliance with 10 CFR 20.101.

7. Main Body Outline (Continued)

- Provide the objectives and criteria for design dose rates in various areas. [What are various areas?]

- Estimates of the annual collective person-rem doses are provided in Table 4.4J.
- Estimated annual occupancy times for each restricted area are provided in Table 4.4F. Provide the bases, models, assumptions for values presented. [See Section 4.4.1.1.]
- Identify dose conversion factors and illustrate how they are used to calculate exposure.
- Describe biological and dosimetry models and ensure compliance with 10 CFR 20.

4.4.1.8 ALARA (As low as reasonably achievable)

- Describe how exposures and effluent discharges are ALARA for each system per 10 CFR 20.1(c).
- Describe management policy regarding ALARA in sources and with respect system design and operation.
- Describe how guidelines in Reg Guide 8.8 were used for each individual system. If not used, justify. [Reference here.]

4.4.1.9 Natural Phenomena and Environmental Conditions

- Demonstrate that the SSCs important to safety are designed so that natural phenomena and environmental conditions do not interfere with safety functions.

4.4.1.10 Dynamic Effects

- Demonstrate that the SSCs important to safety are designed to withstand missile impacts, etc., without loss of safety function operability.

4.4.1.11 Performance During and After Fires and Explosions

- Demonstrate that the SSCs important to safety are designed to performed safety functions during and after credible fires and explosions. [Reference 4.1.1.3.]

7. Main Body Outline (Continued)

4.4.1.12 Noncombustible and Heat-resistant Materials

- Demonstrate that the SSCs important to safety are designed to incorporate the use of noncombustible and heat-resistant materials. [Reference Section 4.1.1.3.]

4.4.1.13 Fire and Explosion Protection Systems

- Demonstrate that the GROA fire protection and suppression systems have sufficient capacity to reduce adverse effects on SSCs important to safety. [Reference Section 4.1.1.3.]

4.4.1.14 Adverse Safety Effects of Fire and Explosion System Operation or Failure

- Demonstrate that GROA underground facility SSCs are designed to withstand the effects of fire protection system operation or failure and still perform safety function. [Reference Section 4.1.1.3.]

4.4.1.15 Control Of Radioactive Materials

- Demonstrate that SSCs important to safety are designed to maintain control of radioactive waste and effluents, safely shutdown, and permit safe evacuation during an emergency. [Reference Section 4.1.1.4.]

4.4.1.16 Use of Offsite Services

- Demonstrate how emergency systems are designed to include facilities and services that ensure safe and timely response to emergency conditions. [Reference Section 4.1.1.4.]
- Demonstrate that emergency system facilitate the use of offsite services such as:

  - Fire
  - Police
  - Medical
  - Ambulance.

7. Main Body Outline (Continued)

4.4.1.17 Utility System Performance During Normal and Accident Conditions

- Demonstrate that each utility system important to safety is designed to perform intended safety functions under both accident and normal conditions. [Reference Section 4.1.1.6.]

4.4.1.18 Utility System Redundancy

- Demonstrate that utility system design incorporates adequate redundancy to perform safety functions. [Reference Section 4.1.1.6.]

4.4.1.19 Emergency Power

- Demonstrate that emergency power is available in the event of a loss of primary power for the following:

  - Instruments
  - Utility systems
  - Operating systems
  - Alarm systems.

4.4.1.20 SSC Operability Verification

- Demonstrate that SSCs important to safety have been designed to facilitate periodic inspection, testing, and maintenance to ensure operability.

4.4.1.21 Criticality

- Demonstrate that all systems dealing with nuclear material are designed in compliance with the Double Contingency Principle precluding nuclear criticality.
- Demonstrate that each system has been designed for criticality safety under normal and accident conditions.
- Ensure k_{eff} is sufficiently below unity to show at least 5% margin after allowances for the bias in calculation methods and validation. The effective multiplication factor for all masses and configurations of radioactive material is shown in Table 4.4K.

7. Main Body Outline (Continued)

4.4.1.22 Instrumentation

- Demonstrate that instrumentation and control systems include adequate provisions to monitor and control systems important to safety over anticipated ranges of normal operation and accident conditions. [Reference Section 4.1.1.7.]

4.4.1.23 Worker Protection

- Demonstrate that the design includes adequate provisions for worker protection to ensure that SSCs important to safety can perform intended function. [Reference Federal Mine Safety and Health Act of 1977]
- Note any deviations from the design requirements of 30 CRF Chapter I, subchapters D, E, and N.

4.4.1.24 Orientation and Depth

- Demonstrate that the orientation, layout, and depth of the underground facility and the design of the underground facility engineered barriers contribute to the containment and isolation of radionuclides.

4.4.1.25 Disruptive Events

- Demonstrate that the underground facility design ensures that credible disruptive events during the period of operations do not spread through the facility.

  - Fires
  - Floods
  - Explosions.

4.4.1.26 Flexibility

- Demonstrate that the underground facility has been designed with sufficient flexibility to allow adjustments to accommodate site specific conditions identified through:

  - In situ monitoring
  - Testing
  - Excavation.

7. Main Body Outline (Continued)

4.4.1.27 Retrieval of Waste

- Demonstrate that the underground facility has designed to permit retrieval of waste in accordance with the performance objective of 10 CFR 60.11.

4.4.1.28 Water or Gas Intrusion

- Demonstrate that the underground facility design controls water or gas intrusion.

4.4.1.29 Openings

- Demonstrate that openings in the underground facility are designed for safe operations and retrievability.

4.4.1.30 Structural Integrity of Openings

- Demonstrate that openings are designed to reduce the potential for deleterious rock movement or fracturing of overlying or surrounding rock.

4.4.1.31 Excavation Methods

- Demonstrate that the excavation methods do not create a preferential pathway for ground water to contact the waste packages and contribute to radionuclide migration to the accessible environment.

4.4.1.32 Ventilation Systems

- Demonstrate that the ventilation systems are designed to:

  - Control transport or radioactive particulate and gases within the underground facility in accordance with 10 CFR 60.111(a)
  - Control transport of radioactive particulate and gases from the underground facility in accordance with 10 CFR 60.111(a)
  - Ensure continued functions during normal operations and under accident conditions

7. Main Body Outline (Continued)

- Separate the ventilation of excavation and waste emplacement areas.

4.4.1.33 Engineered Barriers

- Demonstrate that the engineered barriers in the underground facility are designed to assist the natural setting in meeting the performance objectives after permanent closure.

4.4.1.34 Thermal and Thermochemical Response

- Demonstrate that the underground facility design meets performance objectives taking into account predicted thermal and thermochemical response of the:
  - Host rock
  - Surrounding area
  - Ground-water system.

4.4.2 System Specific Compliance with Applicable Requirements and Criteria

- Provide a general description of underground facility design requirements and the procedures for identifying regulatory requirements and ensuring compliance. System specific compliance is demonstrated in this section for all underground facility systems. [The FCRG outline requirements for system specific treatment of requirements will be repetitive.]

4.4.2.1 Excavation and Ground Support Systems

- Demonstrate compliance with all applicable requirements and criteria.

4.4.2.2 Muck Handling System

- Demonstrate compliance with all applicable requirements and criteria.

4.4.2.3 Ventilation System

- Demonstrate compliance with all applicable requirements and criteria.

7. Main Body Outline (Continued)

4.4.2.4 Waste Emplacement System

- Demonstrate compliance with all applicable requirements and criteria.

4.4.2.5 Waste Retrieval System

- Demonstrate compliance with all applicable requirements and criteria.

4.4.2.6 Emergency Systems

- Demonstrate compliance with all applicable requirements and criteria.

4.4.2.7 Communication System

- Demonstrate compliance with all applicable requirements and criteria.

4.4.2.8 Operations Support System

- Demonstrate compliance with all applicable requirements and criteria.

4.4.2.9 Decommissioning System

- Demonstrate compliance with all applicable requirements and criteria.

4.4.2.10 Other Underground Systems

- Demonstrate compliance with all applicable requirements and criteria.

MGDS Annotated Outline Planning Package
Form 2: Figures & Tables

Date: 4/17/92

Section No. & Title: 4.4 ASSESSMENT OF COMPLIANCE FOR UNDERGROUND FACILITIES

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. 4.4A

Title: Underground Facility SSCs and Applicable 10 CFR 60 Requirements

---

Content:

SSC	Reference to 10 CFR 60 Requirement	Description of Requirement
Systems Structures Component	10 CFR 60.20i [ex]	

B. Table No. 4.4B

Title: Analytical Models of the Underground Faulting

Content:

Model	Analysis

C. Table No. 4.4C

Title: Data for Underground Facility Models and Codes

Content:

Code or Model	Input Data	Output Data

The above Annotated Outline text is guidance that may be used for the future development of an MGDS License Application.

Section No. & Title: **4.4 ASSESSMENT OF COMPLIANCE FOR UNDERGROUND FACILITIES**

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. 4.4A

Caption: **Restricted Areas in the Underground Facility**

Content:

Plant layout showing restricted areas with legend.

B. Table No. 4.4D

Title: **Estimated Concentration of Airborne Radioactive Materials for the Restricted Areas in the Underground Facilities**

Content:

Area	Concentration

C. Table No. 4.4E

Title: **Source Terms in the Underground Facility**

Content:

Source Term	Quantity Discharged per Unit Time	Particle Size (AMAD)	Chemical Form	Physical Form	Lung Solubility Class

Section No. & Title: 4.4 ASSESSMENT OF COMPLIANCE FOR UNDERGROUND FACILITIES

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Figure No. 4.4B

Caption: Areas Potentially Contaminated with Radioactive Materials that are Accessible to Operating Personnel in the Underground Facility

Content:

Layout drawing of GROA surface facilities with subject areas cross-hatched.

B. Table No. 4.4F

Title: Maximum Individual and Total Person-Hours of Occupancy in the Underground Facility

Content:

Area	Individual Person-Hours/yr.	Total Person-Hours/yr.

C. Table No. 4.4G

Title: Radionuclide Concentration and Intake Estimates During Operational Activities in the Underground Facility

Content:

Operation Activity	Projected Concentration	Estimated Intake
Handling		
Storage		
Retrieval		
Emplacement		
Isolation		

Section No. & Title: 4.4 ASSESSMENT OF COMPLIANCE FOR UNDERGROUND FACILITIES

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. 4.4H

Title: Analytical Models and Model Parameters for the Underground Facility

Content:

Analysis	Model	Model Parameters
Concentration Estimates		
Intake Estimates		
Etc.		

B. Table No. 4.4I

Title: Comparison of Projected Intakes to 10 CFR 20 Limits in the Underground Facility

Content:

Area	Projected Intake	Intake Limit

C. Table No. 4.4J

Title: Collective Person - Rem Doses by Function in the Underground Facility

Content:

Function	Annual Collective	Estimated Annual Time (Person Hours)
Spent Fuel Transfer		
HLW Transfer		
Off-Gas Handling		
Waste Treatment		
Maintenance		
Rad Waste Handling		
Decontamination		
In-Service Inspections		

MGDS Annotated Outline Planning Package
Form 2: Figures & Tables

Date: 4/17/92

Section No. & Title: 4.4 ASSESSMENT OF COMPLIANCE FOR UNDERGROUND FACILITIES

Lead Author & Phone No. TBD
T. M. Williamson (702) 794-1821

A. Table No. 4.4K

Title: Effective Multiplication Factors (Keff) for the Underground Facility
[This might be redundant.]

Content:

System or Component	Worst Case Calculated Keff
Transportation Cask	0.9
Radwaste Storage Container	0.6
Etc.	Etc.
Etc.	

B. Table No.

Title:

Content:

C. Figure No.

Caption:

Content:

MGDS Annotated Outline Planning Package
Form 3: References

Date: 4/17/92

Section No. & Title:

Lead Author & Phone No.

Instructions: List all books, articles, or other references that are expected to be used for the section. Indicate whether references are draft or final, and whether they are publicly available (i.e., published). Refer to the Writer's Guide, Appendix D of the Annotated Outline Management Plan for guidance on formatting reference information.

1.

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3.

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MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number:
2. Section no. & title: 4.4 ASSESSMENT OF COMPLIANCE FOR UNDERGROUND FACILITIES
3. Lead author & phone no: T. M. Williamson (702) 794-1821
4. Information request date:
5. Work location:
6. Type of information needed:
7. What is the information needed for?
8. What group is the probable information supplier?
9. When is the information needed?
10. What kind of related information is already available in references, etc.?

---

11. Response by (name):
12. Response date:
13. Response:

The above Annotated Outline text is guidance that may be used for the future development of an MGDS License Application.

MGDS Annotated Outline Information Need Form
Form B: Information Response

Date: 4/17/92

1. Section No. & Title:

2. Person Supplying Information:

3. Phone No.:

4. Lead Author (Requester): Marshall Weaver (702) 794-1871

Instructions: Information suppliers may use this form to communicate information that has been requested by lead authors via Information Request Forms. The Log No. on this form should be identical to the Log No. of the Information Request Form.

5. Response by Information Supplier:

Note: Attach additional sheets if necessary.

MGDS Annotated Outline Information Need Form
Form C: Information Request Tracking Log

Date: 4/17/92

Note: This is a recommended format for a manual tracking system. Other tracking methods such as a simple computer data base are also acceptable.

Date:

Lead Author:

Log No.	Section	Date Issued	Date Response Received

MGDS Annotated Outline

Section 4.5 Integrated GROA Compliance with Performance Objectives

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4.5 INTEGRATED GROA COMPLIANCE WITH PERFORMANCE OBJECTIVES

Skeleton Text Has Not Been Developed For This Section

REFERENCES

MGDS Annotated Outline Planning Package
Form 1: Text

Date: 4/17/92

1. Section No. & Title: 4.5 INTEGRATED GROA COMPLIANCE WITH PERFORMANCE OBJECTIVES

2. Lead Author & Phone No. TBD
   [T.M. Williamson 702-794-1821]

3. First Phase Planning Package Due: 6/21/91

   Second Phase Planning Package Due: 10/18/91

   First Phase Skeleton Draft Due: 12/30/91

   Second Phase Skeleton Draft Due: 3/15/92

4. Plan Approved: W.R. Griffin 8/27/91
   (Licensing Mgr & Lead Author)

5. Section Summary (Approximately 100 Words):

   Analyses of integrated GROA systems are provided in this section to demonstrate compliance with the performance objectives in 10 CFR 60 related to radiation protection for the public and waste retrievability. Appropriate design parameters are provided and the bases for their compliance with 10 CFR 60 are provided and the bases for their compliance with 10 CFR 60 are discussed. Specific requirements other than those established by 10 CFR 60 are identified for the GROA as a system, and compliance with each is demonstrated. Sufficient information is provided to facilitate an independent verification of compliance with 10 CFR 60 performance objectives.

6. Opening Statement:

   Analyses provided in this section demonstrate that the GROA as a system complies with all applicable performance objectives.

7. Main Body Outline: See attached.

8. Conclusion:

   Analyses provided in this section demonstrate that the GROA as a system complies with all applicable regulatory requirements and performance objectives. Therefore, there are no credible circumstances by which GROA operations threaten the health or safety of plant personnel or the public.

9. Support Authors & Their Assignments:

   Tom Williamson (M&O Licensing)

7. Main Body Outline (Continued)

4.5 INTEGRATED GROA COMPLIANCE WITH PERFORMANCE OBJECTIVES

4.5.0 Introduction

- Refer to the general description of the GROA in Section 4.0.
- Provide a general description of the performance objectives and overall methods for assessing compliance.
- Compliance with 10 CFR 60 performance objectives associated with public radiation protection is demonstrated for the GROA as a system in Section 4.5.1.
- Compliance with 10 CFR 60 performance objectives associated with waste retrievability is demonstrated for the GROA as a system in Section 4.5.2.

4.5.0.1 Compliance with 10 CFR 60 Performance Objectives

- Demonstrate compliance with applicable 10 CFR 60 performance objectives as follows:
  - Demonstrate compliance with general requirements applicable to all GROA systems discussed in previous sections
  - Demonstrate compliance with individual design requirements applicable to specific GROA systems.
- Include those engineered barrier subsystems described in Chapter 5 that interact with or otherwise effect the ability of the GROA to meet performance objectives.
- Describe how design parameters presented in Section 4.1 result in compliance with 10 CFR 60 performance objectives.
- Justify how applicable industry codes and standards used in the design result in compliance with 10 CFR 60 objectives.

4.5.0.2 Accident Analyses and Prevention

- Describe overall approach to accident analyses including the selection of the accident scenarios.
- Discuss (list) accidents that SSCs are designed to withstand and how each system is intended to perform during each accident.
- Demonstrate that GROA SSCs are designed to withstand the effects of each accident.
- Describe design features that prevent accidents, including those caused by natural phenomena.

7. Main Body Outline (Continued)

4.5.0.3 Basis for Identification of SSCs Importance to Safety

- Provide the basis for the SSCs importance to safety, waste isolation, and retrievability. These SSCs are listed in Table 4.1K.
- Provide an analysis that demonstrates the margin of safety in the design under normal conditions and anticipated operational occurrences, including those of natural origin.

4.5.0.4 Description of Models

- The models used to perform the analyses are listed in Table 4.5A.
- Explain measures supporting models used in both design applications and accident analyses.
- Support analyses and models used to predict future conditions with an appropriate combination of the following:

  - Field tests
  - In situ tests
  - Laboratory tests
  - Monitoring data
  - Natural analog studies.

- Discuss variability and uncertainty of data and the propagation of errors.
- Discuss the representativeness of data and uncertainties associated with extrapolation of data.
- Discuss conceptualizations, documentation, and validation of models and codes with respect to:

  - Uncertainties in the input data
  - Applicability of specific models
  - Appropriateness of assumptions
  - Sensitivity of results to the uncertainty of input data.

- Input and output data for each of the models are provided in Table 4.5C.

- Provide interpretations of input and output data along with the basis of interpretations. Provide sufficient detail to facilitate independent analysis of results.
- Document role of expert judgement.

7. Main Body Outline (Continued)

4.5.1 Protection Against Radiation Exposures and Releases of Radioactive Material to Unrestricted Areas

4.5.1.0 Introduction

- Demonstrate that the design of the GROA complies with the requirements for radiological safety of the public in 10 CFR 60.
- The projected levels of radiation and the concentrations of radionuclides expected are provided in Table 4.5B for normal operations and anticipated operational occurrences.
- The projected levels of radiation and the concentrations of radionuclides expected are provided in Table 4.5C for accident conditions.
- Demonstrate that the GROA is designed to maintain radiation exposures and levels, and concentrations of radioactive materials released to unrestricted areas within the limits specified in 10 CFR 20.105 & 106. Also demonstrate compliance with applicable standards for radioactivity established by EPA.
- Refer to the Section 4.1.4 for information concerning radiation protection.
- The models used to estimate concentrations and exposures for the GROA as a system are provided in Table 4.5D, including references to Chapter 3 for meteorological data.
- The estimated values are compared to numerical limits to demonstrate compliance in Table 4.5E.
- Discuss compliance with ALARA requirements of 10 CFR 20.1(c).
- Describe mathematical or physical models required to perform analyses of radiological consequences of the activities associated with the GROA. Include simplifications and assumptions and provide sufficient detail for independent verification of results.
- Discuss uncertainties in calculational methods and equipment performance.
- Describe conservatism in assumptions.
- Reference published data used in analyses.
- Identify computer programs used in analyses.
- Provide computer listings of input data and output from all analytical models. [This will add many tables to the section or make up an Appendix.]

7. Main Body Outline (Continued)

4.5.1.1 Radioactivity in Effluents to Unrestricted Areas

- Demonstrate compliance with 10 CFR 20.106 for the following wastes discharged from the GROA:

  - Airborne gaseous and particulate effluents
  - Liquid effluents
  - Solid wastes.

- The consequence analyses for effluents are supported by the following information:

  - Each effluent and type of waste is identified in Table 5.5F.
  - Source terms for each radionuclide discharged are provided in Table 4.5G.
  - The locations beyond the restricted areas that are potentially impacted by radioactive materials in effluents are shown in Figure 4.5A.
  - The anticipated concentrations of each radionuclide at the boundary of the restricted areas and the contribution of each to the radiation dose to humans is provided in Table 4.5H.
  - Provide sample calculations and explain measures to support biological and transport models, emphasizing critical pathways to humans.
  - Describe the constraints imposed on process systems and equipment for each affluent to ensure compliance with 10 CFR 60.111(a) performance objectives.

4.5.1.2 Compliance with Permissible Levels of Radiation in Unrestricted Areas

- Demonstrate that the levels of radiation in unrestricted areas comply with the dose limits in 10 CFR 20.105.
- Anticipated average radiation levels and occupancy times are provided for each unrestricted area in Table 4.5I.
- Describe the characteristics pertinent to its release and eventual biological impact for each radionuclide that contributes more than 10% of the total dose in unrestricted areas.
- Provide details of assumptions and sample calculations with emphasis on critical pathways to humans.

7. Main Body Outline (Continued)

4.5.1.3 Compliance with Environmental Radiation Protection Standards

- Demonstrate that the GROA complies with 40 CFR 191, Section 191.03. [FCRG comment]
- Estimates of the largest annual dose equivalent to any member of the public are provided in Table 4.5J for the following:
  - Discharge of radioactive material
  - Direct radiation
  - All operations covered by 40 CFR 190
- The annual whole body collective doses (and affected organ doses) attributable to effluents and direct radiation for each compass section and radii are provided in Table 4.5K. The GROA compass sectors are illustrated in Figure 4.5B.

4.5.1.4 Compliance with ALARA Principles

- Demonstrate that radiation exposures and releases of radioactive materials in effluents to unrestricted areas are ALARA as required by 10 CFR 20.1(c).
- Describe the management policy that ensures that radiation exposure to the public is ALARA. The ALARA organizational structure is shown in Figure 4.5C.
- Describe the applicable activities of individuals having responsibility for radiation protection.
- Describe the policy with respect to designing and operating the GROA to achieve ALARA objectives.

4.5.2 Retrievability of Waste

- Demonstrate that the GROA is designed to preserve the option of waste retrieval:
  - Throughout emplacement
  - Until the completion of a performance conformation program and subsequent NRC review of performance conformation program
  - Within the same time devoted to construction of the GROA and the emplacement of wastes.

Section No. & Title: **4.5 INTEGRATED GROA COMPLIANCE WITH PERFORMANCE OBJECTIVES**

Lead Author & Phone No. **TBD**
T. M. Williamson (702) 794-1821

A. **Table No. 4.5A**

Title: Analytical Models for Integrated GROA

Content:

Model	Analysis

B. **Table No. 4.5B**

Title: Projected Levels of Radiation and Concentrations of Radionuclides for Discharges of Radioactive Materials During Normal Operations and Anticipated Operational Occurrences Until Permanent Closures

---

Content:

Operations (Normal Operations)	Discharge of Radioactive Materials (Concentrations of Radionuclides)		Radiation Fields (Radiation Levels)	
	Unrestricted Areas	General Environment	Unrestricted Areas	General Environment
Waste Handling				
Waste Storage				
Waste Retrival				
Waste Emplacement				
Waste Isolation				
Anticipated Operational Occurrences				

C. Table No. 4.5C

Title: **Projected Levels of Radiation and Concentrations of Radionuclides after Failure of Radiological Monitoring Equipment During Accident Conditions**

Content:

	Discharge of Radioactive Materials (Concentrations of Radionuclides)		Radiation Fields (Radiation Levels)	
Accident	Unrestricted Areas	General Environment	Unrestricted Areas	General Environment
Waste Handling				
Equipment Failure #1				
Equipment Failure #2				
Waste Storage				
Equipment Failure #1				
Equipment Failure #2				
Waste Retrival				
Equipment Failure #1				
Equipment Failure #2				
Waste Emplacement				
Equipment Failure #1				
Equipment Failure #2				
Waste Isolation				
Equipment Failure #1				
Equipment Failure #2				
Anticipated Operational Occurrences				
Equipment Failure #1				
Equipment Failure #2				

Section No. & Title: 4.5 INTEGRATED GROA COMPLIANCE WITH PERFORMANCE OBJECTIVES

Lead Author & Phone No. TBD
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A. Table No. 4.5D

Title: Computer Codes and Models Used in Radiological Analyses

Content:

Analysis	Computer Codes or Model	Release Rate (Source Term)	Meteorological Date (Reference to Chapter 3)

B. Table No. 4.5E

Title: Analytical Results of Radiological Calculations vs. Numerical Limits

Content:

Analysis	Results	Regulatory Requirements Numerical Limits	Margin of Compliance

C. Table No. 4.5F

Title: Effluents and Types of Wastes

Content:

Effluent Source	Types of Wastes	Amount of Effluent Generated Per Metric Ton of Waste Stored per Unit Time
Treated Process Effluents		
Sewage		
Drinking Water		
Rain Runoff		
Laundry Waste		
Others		

Section No. & Title: 4.5 INTEGRATED GROA COMPLIANCE WITH PERFORMANCE OBJECTIVES

Lead Author & Phone No. TBD
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A. Table No. 4.5G

Title: Source Terms for Radionuclides Discharged as Airborne or Liquid Effluent

Content:

Effluent Stream Radionclide	Particle Size (AMAD)	Chemical Form	Physical Form	Lung Solubility Classes	Total Quantity and Concentration of Radionuclide Disharged per Unit Time
Treated Process Effluents	StU Co				
Sewage	N/A				
Drinking Water	N/A				
Rain Runoff					
Laundry Wastes					

B. Figure No. 4.5A

Caption: Locations Beyond the Restricted Areas that are Potentially Affected by Radioactive Materials in Effluents

Content:

General arrangement drawing showing cross-hatched areas.

C. Table No. 4.5H

Title: Radionuclide Concentrations at Restricted Area Boundary

Content:

Radionuclide	Concentration	Contribution to Total Dose (%)	Characteristics Pertinent to Release (If >10% Dose)	Biological Impact (If>10% Dose)
St90				
C060				
U238				
etc.				

Section No. & Title: 4.5 **INTEGRATED GROA COMPLIANCE WITH PERFORMANCE OBJECTIVES**

Lead Author & Phone No. TBD
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A. Table No. 4.5I

Title: **Anticipated Average Radiation Levels and Occupancy Times in Unrestricted Areas**

Content:

Unrestricted Area	Anticipated Average Radiation Level	Average Occupancy Time

B. Table No. 4.5J

Title: **Estimated Maximum Annual Dose Equivalents**

Content:

C. Table No. 4.5K

Title: Annual Collective Whole Body Doses Estimates Attributable to Effluents and Direct Radiation

Content:

	Compass Sector	Radii (mi)	Whole Body Dose (person-rem/SV)	Organ Dose Thyroid	Organ Dose Kidney	Lung P&C
	1	1				
		2				
		3				
		4				
		5				
		10				
		20				
		30				
		40				
		50				
	2					
thru	16					

Section No. & Title: 4.5 INTEGRATED GROA COMPLIANCE WITH PERFORMANCE OBJECTIVES

Lead Author & Phone No. TBD
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A. Figure No. 4.5B

Caption: GROA Compass Sectors

Content:

General arrangements drawing overlaid by 16 compass sectors. Each radii should be shown as a circle out to 50 mi. (1,2,3,4,5,10,20,30,40,50 mi.)

B. Figure No. 4.5C

Caption: ALARA Organization Structure

Content:

Organizational chart of ALARA group.

C. Figure No.

Title:

Content:

MGDS Annotated Outline Planning Package
Form 3: References

Date: 4/17/92

Section No. & Title:

Lead Author & Phone No.

Instructions: List all books, articles, or other references that are expected to be used for the section. Indicate whether references are draft or final, and whether they are publicly available (i.e., published). Refer to the Writer's Guide, Appendix D of the Annotated Outline Management Plan for guidance on formatting reference information.

1.

2.

3.

4.

5.

6.

7.

8.

MGDS Annotated Outline Information Need Form
Form A: Information Request

Date: 4/17/92

1. Log number:

2. Section no. & title: 4.5 INTEGRATED GROA COMPLIANCE WITH PERFORMANCE OBJECTIVES

3. Lead author & phone no: T. M. Williamson (702) 794-1821

4. Information request date:

5. Work location:

6. Type of information needed:

7. What is the information needed for?

8. What group is the probable information supplier?

9. When is the information needed?

10. What kind of related information is already available in references, etc.?

---

11. Response by (name):

12. Response date:

13. Response:

MGDS Annotated Outline Information Need Form
Form B: Information Response

Date: 4/17/92

1. Section No. & Title:

2. Person Supplying Information:

3. Phone No.:

4. Lead Author (Requester): Marshall Weaver (702) 794-1871

Instructions: Information suppliers may use this form to communicate information that has been requested by lead authors via Information Request Forms. The Log No. on this form should be identical to the Log No. of the Information Request Form.

5. Response by Information Supplier:

Note: Attach additional sheets if necessary.

MGDS Annotated Outline Information Need Form
Form C: Information Request Tracking Log

Date: 4/17/92

Note: This is a recommended format for a manual tracking system. Other tracking methods such as a simple computer data base are also acceptable.

Date:

Lead Author:

Log No.	Section	Date Issued	Date Response Received

The above Annotated Outline text is guidance that may be used for the future development of an MGDS facility License Application.