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M E M O R A N D U M

DATE: August 1, 1985

FOR: Avi Bander, WMPC
623-SS

FROM: Paul T. Prestholt, Sr. OR-NNWSI

SUBJECT: Attached

Attached is the NNWSI Project Reference Information Base, draft. We have kept no copy.

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PRELIMINARY OUTLINE OF A REFERENCE INFORMATION BASE FOR THE NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS PROJECT

Compiled by:

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I. Introduction

The NNWSI Reference Information Base (RIB) is intended to serve as a central focus for all information that will be used in support of site characterization, design, and performance assessment activities for license application. It is the intent that the RIB be the primary information used in such activities; thus, the RIB will serve as a clearinghouse to maintain and control the flow of technical information for the NNWSI project.

The form and content of the RIB is determined largely by the NNWSI Issues Hierarchy. Within the Issues Hierarchy are four "key issues." For each key issue there are three subsets of issues, "Characterization Issues," "Design Issues," and "Performance Issues." Each issue within each of these subsets leads to a need for specific types of information which will comprise the Reference Information Base.

The first step in the production of the RIB is the collection of large quantities of experimental data and information about the Yucca Mountain site and about the technical requirements and design configurations of the proposed repository. These site and design data must then be condensed (via analysis and professional judgment) to reference values that comprise the RIB. These reference values will be the only ones used in analyses aimed at assessing the suitability of the site and design. Some of the analyses will themselves constitute reference information, either as final products of analyses or input to subsequent reference calculations. Thus, site and design information as well as results of numerical analyses will eventually crystallize into a single set of reference values describing: (1) the site; (2) the design; and (3) prediction of performance, i.e., the Reference Information Base will provide the necessary and sufficient information for the licensing application package.

II. Concept of Reference Properties

Intuitively, the concept of reference information is clear, but it is more difficult to formulate in words. The concept clearly includes all geometrical, geological, hydrological, geochemical, thermal, and mechanical properties required for design and performance assessment at the Yucca Mountain site. In this context, a reference property has traditionally been thought of either as a single representative ("average") value for a given property which may be associated with the entire rock mass, or as a limited set of values, each one of which is associated with (for instance) a particular thermomechanical horizon. We wish the extend this concept in several ways.

First, we will include reference-information related to the design of the repository. This information will consist of two kinds: requirements and current configurations. The first category of information consists of a limited set of technical data specifying selected requirements that the repository must satisfy. We say that the information is limited, because it is <u>not</u> our intention to reproduce the Code of Federal Regulations, other statutory information, or Project requirement's documents. Rather, our information will consist of a distillation of statutory regulations, safety requirements, and the like that impose quantifiable physical limitations on repository/site performance, that must be met by a design concept; examples might be the maximum temperature that the surface of a drift may attain during pre-closure operation, or the maximum daily radiation exposure permitted for repository workers. The information on design configurations is the current set of design concepts. This includes drift dimensions, wasteform descriptions, canister spacings, etc., which may be used in calculations to evaluate the feasibility of a concept or the performance of the repository. We recognize that these design properties will change in the iterative process of designing, evaluating, and redesigning. Thus the RIB will, by no means, be static; it will change as experimental and analytical understanding of the problem(s) improves. However, the existence and use of a set of reference information will ensure that at any instant a single set of recommended, traceable values will be available to all project participants.

Second, it will be useful to extend the concept of reference properties beyond the notion of a single value for a given property. In some instances a range of values, or a distribution function, will be associated with a given property. These distributions will be standardized to the extent possible for analytical purposes, and thus will constitute reference information.

Finally, the results of all calculations used in licensing activities, or interim calculations used as input to such analyses, will be considered reference information. Calculations using other than reference values (unless appropriately cleared) or nonapproved codes, will not be admitted for consideration.

The intention for the RIB is to be both accurate and flexible. It will be accurate in the sense that it will maintain the best current estimates for particular values. It is intended to be flexible in the sense that there are various levels of data distillation. As an example, the RIB will contain detailed descriptions (reference values) for particular wasteforms (O'Brien, 1984). These are average "pictures" of the particular types of packages. If a calculation or estimate requires a particular wasteform, these reference values are the ones to use. In a different vein, if a single calculation is performed which is intended to represent repository-wide performance, i.e. involving several waste form types, then an expanded description of the reference waste package set is probably needed, perhaps a time-weighted average of the averages for each waste-package type. This type of amalgamated information will also be available in the RIB. The principal objectives of the RIB are to ensure consistency, provide needed information in a timely fashion, and be available to all users in a form compatible with demonstrating the licensability of the Yucca Mountain site.

III. Organization of the Reference Information Base

As mentioned above, the NNWSI Issues Hierarchy divides issues into three categories: characterization, design, and performance assessment. We have similarly organized the RIB, recognizing that certain types of information address several issues.

Subsections of the RIB correspond to the issues. Table 1 illustrates the general organization of the RIB and the issues addressed by each major section.

The site chapter of the RIB has 17 sections corresponding to the 19 characterization issues. The types of information addressed by two types of issues in the hierarchy, rock characteristics (Issues 1.3 and 4.2) and tectonics (Issues 1.7 and 4.4) are sufficiently similar that they were combined in single sections of the RIB.

The design chapter has six sections, five of which are organized according to the type of facility or structure (waste package, underground facilities, seals, surface facilities, transportation structures). This organization is compatible with capturing all information required to resolve 11 of the 12 design issues. For each of these facility-based sections, two major subsections are included to provide reference information on relevant requirements and design configurations. The sixth design section, costs and schedules, addresses the corresponding, and twelfth, design issue.

Table 1. General Organization of the NNWSI Reference Information Base and Corresponding Issues Addressed

1. SITE CHARACTERISTICS	**ISSUES(S) ADDRESSED**
1.1 Geohydrological	1.1
1.2 Geomechanical	1.2
1.3 Rock Characteristics	1.3, 4.2
1.4 Climatological	1.5
1.5 Erosional	1.5
1.6 Dissolution	1.6
1.7 Tectonic/Seismic	1.7, 4.4
1.8 Natural Resources	1.8
1.9 Population	2.1
1.10 Land Ownership & Rights	2.2
1.11 Meterological	2.3
1.12 Offsite Installations	2.4
1.13 Environmental	3.1
1.14 Socioeconomic	3.2
1.15 Transportation Conditions	3.3
1.16 Surface Conditions	4.1
1.17 Surface Hydrology	4.3
2. DESIGN CONFIGURATIONS & REQUIREMENTS	
2.1 Waste Package	
2.1.1 Waste Package Requirements	
2.1.2 Waste Package Character	1.9, 2.5, 4.5
2.2 Underground Facilities	
2.2.1 Design Requirements	
2.2.2 Design Configuration	1.10, 2.6, 3.4, 3.5, 3.6, 4.6, 4.7
2.3 Seals	
2.3.1 Design Requirements	
2.3.2 Design Characteristics	1.11
2.4 Surface Facilities	
2.4.1 Design Requirements	
2.4.2 Design Configuration	2.6, 3.4, 3.5, 3.6, 4.6, 4.7
2.5 Waste Transport Facilities	
2.5.1 Design Requirements	
2.5.2 Design Configuration	
2.6 Costs & Schedules	4.8
3. PERFORMANCE ASSESSMENT RESULT AND METHODS*	
3.1 Postemplacement Conditions	1.12
3.2 Waste Package Lifetime	1.13
3.3 EBS Release Rates	1.14
3.4 Groundwater Travel Time	1.15
3.5 Releases to Accessible Environ.	1.16
3.6 Effects of Fav. & (ampersand) Pot. Adv. Conds	1.17
3.7 Preclosure Radiation Levels	2.7
3.8 Environmental Impacts	3.7, 3.10
3.9 Socioeconomic Impacts	3.8
3.10 Transportation-Related Impacts	3.9
3.11 Retrieval Capability	4.9
3.12 Compliance with 10 CFR 960	1.18, 2.8, 3.11, 4.10

* Note: Each performance assessment section has two major subsections
- Results
- Methods

The performance assessment chapter of the RIB contains 12 sections corresponding to the 16 performance assessment issues in the Issues Hierarchy. The information needed to resolve two of the environmental assessment issues (3.7, environmental impacts, and 3.10, unmitigatable environmental impacts) are sufficiently similar that the RIB addresses these issues in a single section. Also, all issues dealing with higher-level findings with respect to DOE's siting guidelines (issues 1.18, 2.8, 3.11, and 4.10) are addressed by a single section in the RIB. Each section in the performance assessment chapter is divided into two major subsections, methods and results. The methods subsections include the relevant conceptual and mathematical models, as well as a listings of the appropriate computer codes to be used for assessments of a particular issue. The current, reference results of analyses are contained in the results subsections.

Under each subsection for each of the issue types (RIB Chapters) are further subdivisions that allow each item of information contained in the RIB to be uniquely identified with an organizational number. For example, a reference value for the bulk porosity of the lithophysae-poor Topopah Spring thermal/mechanical rock unit is identified as item 1.3 1.2 1.5. In this example 1.3 directs the user to the rock characteristics section (i.e. 3) of the Site Chapter (i.e. 1). The next digit (1) refers to the first subsection of Rock Characteristics, thermal/mechanical stratigraphy. Similarly the following 2 refers to bulk properties, the next 1 to porosity, and the final 5 to the fifth rock unit from the surface, i.e. the low-lithophysal Topopah Spring unit.

The complete outline of the Reference Information Base as currently developed is provided in the next several pages.

SITE CHARACTERISTICS

1. Geohydrological Information

   1. Three-dimensional model of dehydrologic units (on IGIS)
   2. Three dimensional Location of water table
   3. Ambient level of saturation (for each unit)
   4. Hydraulic Conductivity
      1. Effective hydraulic conductivity vs saturation (for unsaturated units)
      2. Saturated hydraulic conductivity
      3. Saturated hydraulic conductivity (for bulk rock mass of all units)
   5. Infiltration flux (as a function of subsection)
   6. Percolation flux (in all units)
   7. Recharge rates (as a function of site location)
   8. Effective porosity
      1. Matrix
      2. Fracture
   9. Vapor phase transport data

2. Geochemical Information

   1. Three-dimensional model of geochemical units (on IGIS)
   2. Whole-rock chemistry (for each unit)
      1. Mineralogy
      2. Phase assemblage stability
      3. Fracture mineralogy (for each unit)

   3. Water chemistry
      1. Anion/cation/species[6]
      2. Concentration[6]

4. Radionuclide retardation capacity (for each unit and each radionuclide)

    1. Total retardation coefficients
    2. Solubilities/solubility products
    3. Diffusive transport coefficients
    4. Sorption/desorption coefficients
    5. Radionuclide solubilities (for each radionuclide in reference water chemistry)

3. Rock Characteristics

1. Thermomechanical stratigraphy (intact and rock mass)

    1. Three-dimensional model of thermal/mechanical units (on IGIS)[10]
    2. Bulk properties
        1. Porosity[3]
        2. Grain density[3]
        3. Saturated bulk density[3]
        4. Dry bulk density[3]
    3. Thermal properties
        1. Saturated thermal conductivity[3]
        2. Dry thermal conductivity[3]
        3. Saturated thermal capacitance[3]
        4. Dry thermal capacitance[3]
        5. Coefficient of linear thermal expansion[3]
    4. Mechanical properties
        1. Modulus of elasticity[3]
        2. Poisson's ratio[3]
        3. Unconfined (uniaxial) compressive strength[3]
        4. Cohesion[3]
        5. Angle of internal friction[3]
        6. Tensile strength[3]

5. In situ stress[3]
6. Geothermal Gradient

2. Geologic/stratigraphy and structure

1. Three-dimensional model of geologic units (on IGIS)[11]
2. Lithologic descriptions
3. Mineralogy (to accompany lithology)
4. Structure
    1. Fault locations and orientations[1]
    2. Joints and fractures
        1. Density/frequency
        2. Orientation
        3. Aperture

5. Useable emplacement volume[1,2]

4. Climatological Scenarios
    1. Maximum credible climatic conditions
        1. Precipitation curves (monthly)
        2. Temperature curves (monthly)
        3. Evapotranspiration curves (monthly)
    2. Most likely future climate
        1. Precipitation curves (monthly)
        2. Temperature curves (monthly)
        3. Evapotranspiration curves (monthly)
    3. Effects of maximum and most likely climate change of site hydrology

5. Erosional Scenarios
    1. Erosional rates (m/yr) (as function of site location)
    2. Depositional rates (m/yr) (as function of site location)
    3. Depth of underground facilities
    4. Effects of erosion on in situ stress and depth of repository

6. Dissolution
    1. Dissolution rate of silica in Topopah Spring
    2. Dissolution rate of glass in virtrophyre
    3. Influence of dissolution on site characteristics

7. Tectonics
    1. Seismic ground accelerations
        1. Maximum credible acceleration
        2. Design accelerations
        3. Maximum credible earthquakes (location, magnitude, and return period)
        4. Design earthquake (location, magnitude and return period)
        5. Effects of ground acceleration on site characteristics

    2. Volcanic Eruptions
        1. Magnitude
        2. Style
        3. Probability
        4. Effects of volcanic eruptions on site characteristics

    3. Maximum credible fault offset
        1. Locations
        2. Probability
        3. Effects on hydrologic and thermal mechanical properties

8. Natural Resources
    1. Assay of metals in core from site
    2. Yield of aquifers of site
    3. Depth of aquifer
    4. Estimated value of zeolites at site

9. Population
    1. Location of population within 100 km of the site
    2. Population of towns, counties, communities
    3. Distance to population center

10. Land ownership and rights

   1. Land ownership status in site vicinity
   2. Mineral and water rights control in site vicinity
      1. Location and holders of mineral claims
      2. Owners of water rights to aquifer water in site vicinity

11. Meteorology

   1. Month
      1. Temperature
         1. Daily maximum (average)[5]
         2. Daily minimum (average)[5]
         3. Daily average[5]
         4. Highest/lowest[5]
   2. Precipitation
      1. Monthly average[5]
      2. Highest/lowest[5]
      3. Daily maximum[5]
      4. Snow
         1. Average[5]
         2. Greatest monthly[5]
         3. Greatest daily[5]
   3. Relative humidity
      1. 4:00 am[5]
      2. 10:00 am[5]
      3. 4:00 pm[5]
      4. 10:00 pm[5]
   4. Barometric pressure
      1. Average[5]
      2. High[5]
      3. Low[5]
   5. Prevailing wind
      1. Average speed[5]
      2. Peak speed[5]
      3. Prevailing direction[5]

12. Offsite Installations

  1. Location of NTS Facilities
     1. Weapons Testing Areas
     2. NTS Facilities
     3. low level waste site
  2. Distance to relevant offsite facilities

13. Environmental Conditions

(TBD)

14. Socioeconomic Conditions

(TBD)

15. Transportation Conditions

  1. Locations of current roads and railroads
  2. Locations of potential roads and railroads
  3. Potential routes through Nevada for waste shipments
  4. Transportation casks
     1. Types
     2. Dimensions
     3. Weight (tare)
     4. Internal (cavity) dimensions
     5. Shielding
     6. Type of containment
     7. Seals
     8. Atmosphere
     9. Maximum thermal output
     10. Outer surface configurations
     11. Impact limiters
         1. External
         2. Internal
     12. Wasteform type
     13. Capacity
     14. Cask weight (full)
     15. Gross vehicle weight
     16. Percent of allowable weight
     17. Trunions
         1. Lifting
         2. Tie-down

16. Surface Conditions

    1. Topographic Contours at site
    2. Location of potential floodways at site
    3. Soil mechanical properties at surface facility location

17. Surface Hydrology

    1. Location, magnitude, and return period of floods
        1. 100 yr
        2. 500 yr.
        3. maximum
    2. Typical hydrograph of flash flood
        1. 40 mile wash
        2. Typical wash of Yucca Mountain

2. Design Requirements and Configurations
    1. Waste Package Requirements and Configurations
        1. Waste Package Requirements
            1. Spent fuel
                1. Centerline Temperature
                2. etc. (TBD)
            2. Commercial High Level Waste
                1. Centerline Temperature
                2. etc. (TBD)
            3. Defense High-Level Waste
                1. Centerline Temperature
                2. etc. (TBD)
            4. Transuranic and Low Level Waste
               (TBD)

2. Waste Package Configuration

   1. Spent Fuel

      1. Waste Form

         1. Typical Initial Radionuclide Inventory
         2. Typical Radionuclide Decay Curves
         3. UO_2 corrosion rate (in reference water)
         4. Number of fuel rods, fuel pins
         5. Dimensions of fuel rods, fuel pins, and cladding hulls
         6. Typical number of breached cladding hulls

      2. Canisters

         1. Typical dimensions and weight
         2. Composition of canister components
         3. Corrosion rate of canister components
         4. Amount of spent fuel per canister

      3. Overpack

         (TBD)

      4. Backfill

         (TBD)

2.1.2.2-4 Commercial High Level Waste, Defense High Level Waste, and Transuranic and Low Level Waste to be developed similar to 2.1.2.1 for spent fuel.

2. Underground Facilities Requirements and Configurations

1. Underground Facility Requirements
    1. Ultimate capacity
    2. Design capacity
    3. Minimum emplacement depth
    4. Retrievability
    5. Release rates

2. Underground Facility Configurations
    1. Spent fuel horizontal emplacement[8]
        1. Panel width
        2. Emplacement drift--height
        3. Emplacement drift--width
        4. Alcove--width
        5. Perimeter drift--diameter
        6. Total canisters--repository
        7. Number of canisters per hole
        8. Borehole length
        9. Borehole diameter
        10. Minimum borehole spacing
        11. Standoff from emplacement drift
        12. Total Number of Panels
        13. TYPICAL PANEL (for yr 2011)#:
            1. Spacing of boreholes
            2. Areal heat load
            3. Waste age
            4. Average canister heat output
            5. Maximum canister heat output

    2. Spent fuel vertical emplacement[8]
        1. Panel width
        2. Panel access drift--height
        3. Panel access drift--width
        4. Emplacement drift--height
        5. Emplacement drift--width
        6. Mid panel drift--height
        7. Mid panel drift--width
        8. Perimeter drift--diameter
        9. Panel barrier pillar--width
        10. Total canisters--repository
        11. Number of canisters per hole
        12. Borehole length
        13. Borehole diameter
        14. Minimum borehole spacing

        Total Number of Panels

15. TYPICAL PANEL (for yr 2011)#:
    1. Spacing of boreholes
    2. Spacing of emplacement drifts
    3. Number of canisters per drift
    4. Standoff from panel access drift
    5. Areal heat load
    6. Waste age
    7. Average canister heat output
    8. Maximum canister heat output

3. DHLW and WVHLW vertical emplacement[8]
    1. Panel width (max)
    2. Panel access drift--height
    3. Panel access drift--width
    4. Emplacement drift--height
    5. Emplacement drift--width
    6. DHLW exhaust drift--height
    7. DHLW exhaust drift--width
    8. Panel barrier pillar-width
    9. Total DHLW canisters
    10. Total WVHLW canisters
    11. Number of canisters per hole
    12. Borehole length
    13. Borehole diameter
    14. Borehole layout/drift
    15. Spacing between rows
    16. Spacing between holes (each row)
    17. Standoff to access drift
    18. Spacing of emplacement drifts (center to center)
    19. Areal heat load (for SCP design)

4. Shafts and mains, horizontal configuration[8]
    1. Men and materials shaft--diameter
    2. Exploratory shaft--diameter
    3. Escape/ventilation shaft--diameter
    4. Emplacement exhaust shaft--diameter
    5. Waste ramp-diameter
    6. Tuff ramp--diameter
    7. Waste main--diameter
    8. Tuff main--height
    9. Tuff main--width
    10. Service main--height
    11. Service main--width

5. Shafts and mains, vertical configuration[8]
   1. Men and materials shaft--diameter
   2. Exploratory shaft--diameter
   3. Escape/ventilation shaft--diameter
   4. Emplacement exhaust shaft--diameter
   5. Waste ramp-diameter
   6. Tuff ramp--diameter
   7. Waste main--diameter
   8. Tuff main--height
   9. Tuff main--width
   10. Service main--height
   11. Service main--width

6. Repository location
   1. Three-dimensional representation or layout
   2. Elevation of floor of repository
   3. Representative depth of repository
   4. Location of surface facilities

2.2 through 2.6, Seals, Surface Facilities, Transportation Facilities and Equipment, and Costs and Schedules to be filled in later.

3. Performance Assessment Results and Methods
    1. Postemplacement Conditions affected by repository
        1. Analysis Results
            1. Stress State (as a function of time)
                1. Borehole scale
                2. Room-pillar scale
                3. Repository scale
                4. Far Field
            2. Temperature
                1. Borehole scale
                2. Room-pillar scale
                3. Repository scale
                4. Far Field
            3. Hydrologic Behavior
                1. Borehole scale
                2. Room-pillar scale
                3. Repository scale
                4. Far Field
            4. Geochemical Behavior
                1. Borehole scale
                2. Room-pillar scale
                3. Repository scale
                4. Far Field
            5. Location of Disturbed Zone Boundary
        2. Analysis Methods
            1. Stress State
                1. Conceptual Models
                2. Mathematical formulation
                3. Numerical codes
            2. Temperature
                1. Conceptual Models
                2. Mathematical formulation
                3. Numerical codes
            3. Hydrology
                1. Conceptual Models
                2. Mathematical formulation
                3. Numerical codes
            4. Geochemistry
                1. Conceptual Models
                2. Mathematical formulation
                3. Numerical codes
    2. Waste Package Lifetime
        1. Analysis Results
            1. Time of initial releases
            2. Probability of initial failure as a function of time
        2. Analysis Methods
            1. Conceptual Models of failure mechanisms
            2. Numerical Codes

3. Releases from Engineered Barrier System
    1. Analysis Results
        1. Solubility Limited Release Rates
        2. Corrosion-Rate limited release rates
        3. Diffusion-Rate limited release rates
            1. Solubility bases
            2. Corrosion rate limited
        4. Probability of release rates as a function of time

    2. Analysis Methods
        1. Conceptual Models of releases
        2. Mathematical Formulations
        3. Numerical Codes

4. Groundwater Travel Time
    1. Analysis Results
        1. Location of fastest path of likely radionuclide travel
        2. Water flow time distribution along fastest path
        3. Flow time distribution from entire repository area
    2. Analysis Methods
        1. Conceptual models of groundwater flow
        2. Mathematical formulations
        3. Numerical codes

5. Releases to the Accessible Environment
    1. Analysis Results
        1. Location of the boundary of the accessible environment
        2. Listing of anticipated scenarios
        3. Listing of unanticipated scenarios
        4. Cumulative releases under representative anticipated scenarios
        5. Cumulative releases under representative unanticipated scenarios
        6. Complimentary cumulative distribution function of releases under all credible scenarios
        7. Concentrations of curies in aquifers for 1000 years
    2. Analysis Methods
        1. Conceptual Models
        2. Mathematical Formulations
        3. Numerical Codes

Sections 3.6 through 3.12 to be developed later.

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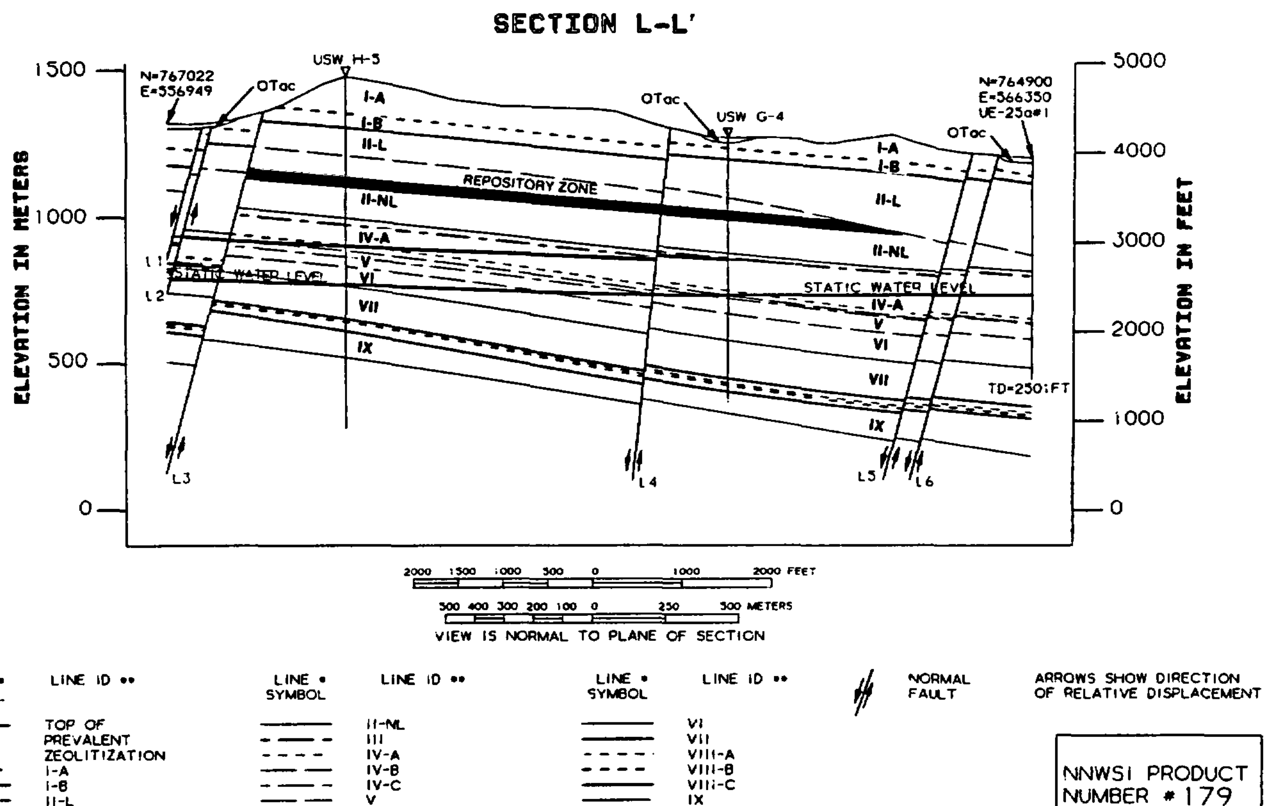
NNWSI REFERENCE INFORMATION BASE

CHAPTER: 1	**TITLE:** Site Characterisitics
SECTION: 1.1	**TITLE:** Geohydrology
SUBSECTION: 1.1.1	**TITLE:** Three-dimensional Model of Units
ITEM: 1.1.1.1	**NAME:** Representative Cross Sections
VERSION: Example	**DATE:** 6/24/85 **SOURCE:** Ortiz et al., 1985
DESCRIPTION:	**PAGE 1 OF 2**

1.1.1.1.3 Section L-L′



NNWSI PRODUCT NUMBER # 179

• LINE SYMBOL REPRESENTS BASE OF UNIT. •• SEE TEXT FOR DESCRIPTION OF UNITS. FEBRUARY 1985

APPROVALS

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NNWSI REFERENCE INFORMATION BASE

CHAPTER: 1	**TITLE:** Site Characterisitics	
SECTION: 1.3	**TITLE:** Rock Characterisitics	
SUBSECTION: 1.3.1	**TITLE:** Thermal-Mechanical Stratigraphy	
ITEM: 1.3.1.2	**NAME:** Bulk Properties	
VERSION: Example	**DATE:** 6/21/85	**SOURCE:** Nimick et al., 1984
DESCRIPTION:		**PAGE 1 OF 1**

Bulk Properties (Porosity, Grain Density, Bulk Density):

These data are mean values calculated from experimental results. The values listed for Unit TS2 are for nonlithophysal matrix. Many portions of the unit contain lithophysae, in some cases up to 20 volume percent additional boid space. This 20 percent is not included in the pososity value given in Table 1, but has been used in the calculation of some thermal and mechanical properties. The average properties for Unit TS2 are between the two extremes since Unit TS2 has both lithophysae-poor and lithophysae-rich intervals.

The properties of the matrix of tuff units from Yucca Mountain are based upon experimental data from any or all of the following drill holes: UE-25a#1, UE-25b#1, USW G-1, USW G-2, USW G-3, USW GU-3, and USW G-4. In some units, experimental data are not available. Estimation of data for units for which this is the case is described where appropriate.

VALVES

STRATIGRAPHIC UNIT	POROSITY (%)	GRAIN DENSITY (g/cm^3)	SATURATED BULK DENSITY (g/cm^3)	BRY BULK DENSITY (g/cm^3)
UO	NA	NA	NA	NA
TC	11.4	2.51	2.32	2.23
PT	44.8	2.37	1.86	1.31
TS1	14.8	2.53	2.29	2.15
TS2	12.1	2.55	2.36	2.24
TS3	4.3	2.39	2.33	2.28
CH1v	36.5	2.34	1.85	1.49
CH1z	32.7	2.41	1.95	1.62
CH2	28.6	2.54	2.10	1.82
CH3	36.0	2.41	1.90	1.55
PP	24.0	2.58	2.20	1.96
CFU	29.7	2.43	2.00	1.71
BF	23.8	2.60	2.23	1.98
CFM1	24.6	2.41	2.08	1.84
CFM2	24.2	2.52	2.16	1.91
CFM3	26.7	2.44	2.06	1.79
TR	18.8	2.63	2.32	2.14

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CHAPTER: 2	**TITLE:** Design Configuration & Requirements
SECTION: 2.2	**TITLE:** Underground Facilities
SUBSECTION: 2.2.2	**TITLE:** Design Configuration
ITEM: 2.2.2.4	**NAME:** Typical Panel Dimensions
VERSION: Example	**DATE:** 6/24/85 — **SOURCE:** Mansure & Stinebaugh, 1985
DESCRIPTION:	**PAGE 1 OF 4**

2.2.2.4.1 Spent Fuel
2.2.2.4.1.1 Horizontal Emplacement

a)	Panel width	1400 ft
b)	Emplacement drift — height	13 ft
c)	Emplacement drift — width	18 ft
d)	Alcove — width	31 ft
e)	Perimeter drift — diameter	20 ft
f)	Number of canisters per hole	35 ea
g)	Borehole length	682 ft
h)	Borehole diameter	33 in.
i)	Minimum borehole spacing	8.0 ft
j)	Canister length	15 ft
k)	Dolly length	16.5 ft
l)	Canister diameter	26 in.
m)	Standoff distance	102 ft
n)	Typical panel(for yr 2011)#:	
	1) Spacing of boreholes	102 ft
	1) Areal heat load	49.5 kW/acre
	1) Waste age	12.8 yr
	1) Average canister heat output	2.312 kW/can
	1) Maximum canister heat output	2.848 kW/can

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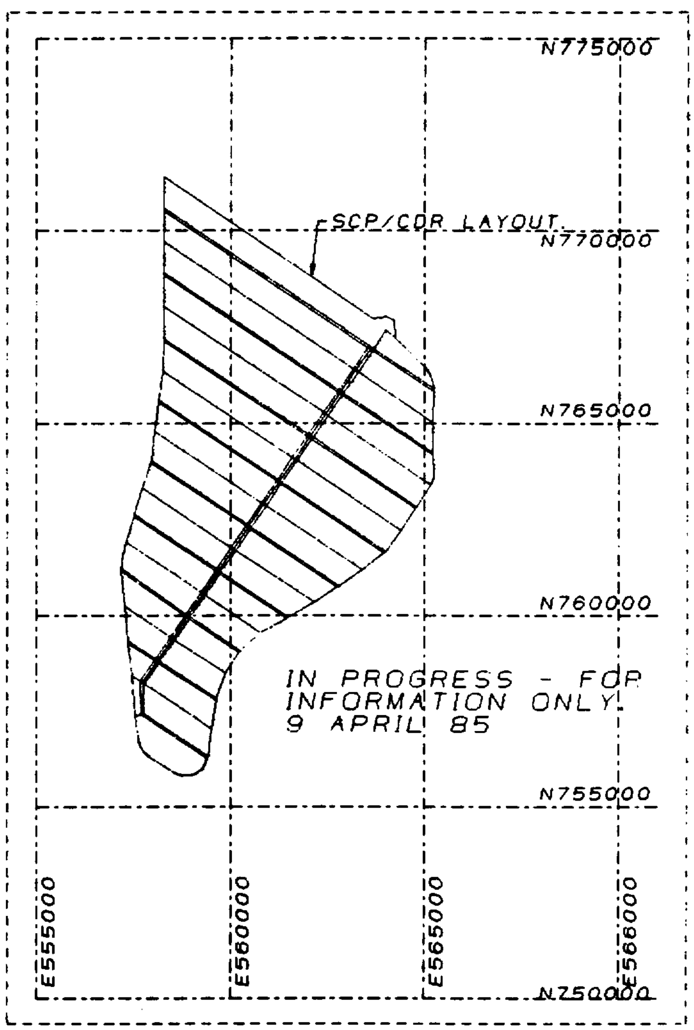
NNWSI REFERENCE INFORMATION BASE

CHAPTER: 2	**TITLE:** Design Configuration & Requirements	
SECTION: 2.2	**TITLE:** Underground Facilities	
SUBSECTION: 2.2.2	**TITLE:** Design Configuration	
ITEM: 2.2.2.5	**NAME:** Repository Location	
VERSION: Example	**DATE:** 6/21/85	**SOURCE:** IGIS Product #
DESCRIPTION:		**PAGE** 1 **OF** 3



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