Site Identification Presentation Basalt Waste Isolation Project

Staff

November 1979

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Prepared for the United States
Department of Energy
Under Contract DE-AC06-77RL01030

Rockwell International

Rockwell Hanford Operations
Energy Systems Group
Richland, WA 99352

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PRELIMINARY REPORT

This Report contains information of a preliminary nature. It is subject to revision or correction and therefore does not represent a final Report. It was prepared primarily for internal use within The Rockwell Hanford Operations. Any expressed views and opinions are those of the Author and not necessarily of the Company.

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RHO-BWI-LD-22
Informal Report

SITE IDENTIFICATION PRESENTATION

Basalt Waste Isolation Project

Staff

November 1979

Rockwell International
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Energy Systems Group
Richland, Washington 99352

SUMMARY REPORT - BASALT WASTE ISOLATION PROJECT

SITE IDENTIFICATION

The Basalt Waste Isolation Project of Rockwell Hanford Operations, under contract with the U.S. Department of Energy, is aimed at examining the feasibility of disposing of nuclear waste in a deep repository in basalt beneath the Hanford Site.

One of the major tasks of the Basalt Waste Isolation Project consists of identifying any sites within Hanford which are suitable locations for a nuclear waste repository. This site identification task began in 1978 with preliminary geologic and hydrologic reconnaissance studies and will be completed in September 1981 with the submittal of a Site Characterization Report describing the site identified for locating such a repository. The Site Characterization Report will also contain a plan detailing the work to be done to assess fully whether or not the site identified satisfies the U.S. Nuclear Regulatory Commission criteria for nuclear waste repositories.

The site identification process to date has involved:

1. The development of guidelines and decision theory;
2. The assemblage and cataloging of existing data;
3. The screening of the data using a structured process;
4. The identification of candidate sites; and,
5. The selection of preferred sites for preliminary characterization.

All of these steps have now been completed. A final step in the site identification process, which is now under way, involves reducing the several preferred sites to only one.

Guidelines for screening were developed based on a careful analysis of existing and proposed regulations.⁽¹⁻⁶⁾ The resulting guidelines are presented at the end of this report. The decision theory used was drawn from acceptable methodology used in nuclear reactor siting analysis.

The data required for identification were based on the U.S. Nuclear Regulatory Commission's proposed general statement of work⁽¹⁾ that the proposed repository site would comply with the National Environmental Policy Act. Thus, it was concluded that the site must meet the following objectives:

1. Assure public health and safety;
2. Mitigate adverse environmental and socioeconomic impacts; and,
3. Minimize cost necessary to attain the requisite levels of safety, as well as cost of mitigation.

Data used for site identification included all the existing geologic, hydrologic, and engineering data available to date within the Pasco Basin (Figure 1). The Pasco Basin was selected as the study area since it is the structural entity within which the Hanford Site is located. The basin corresponds to one of the thickest accumulations of Columbia Plateau basalts.

FIGURE 1. The Study Area.

The geology and hydrology of the Pasco Basin have been intensely studied for the past 10 years with more concentrated study during the last 2 years. A principal result of these studies was the discovery that, at depths of between 2,500 to 4,500 feet beneath the Hanford Site, there are a few laterally extensive Columbia River Basalt lava flows which are internally dense and thick (nearly 200 feet). The thick, dense interiors of these lava flows are the candidate host rock units for a repository. Such candidate host rock units can be identified with a high degree of certainty in surface outcrops and in core holes, and their locations can be projected between boreholes with confidence.

The screening process used the guidelines to reduce the study area to 9 candidate sites of approximately 10 square miles in size (Figure 2). Each of these sites satisfies the guidelines imposed in the screening process.

FIGURE 2. Candidate Sites Obtained through the Screening Process.

Trade-off studies using the techniques of dominance analysis^(7,8) are being conducted to preferentially order the sites identified. By September 1981, one of these nine sites will be finally selected as the preferred site for further characterization studies. The recommended site will be described in the Site Characterization Report.

The site evaluation activities to be initiated in September 1981 will conform to the criteria defined by the U.S. Nuclear Regulatory Commission as provided in the final version of Title 10, Code of Federal Regulations, Part 60, "Licensing Requirements for Nuclear Repositories." The current siting studies for a repository in basalt are based upon the siting requirements for nuclear power plants and the most recent drafts of the above-named regulation.

The objective of site evaluation will be to accurately define the geologic and environmental conditions to assure public safety and to obtain approval for construction and, subsequently, an operating license for a nuclear waste repository. This objective will be attained by means of additional research investigations.

Results of site evaluation activities will be reported in the Construction License application and in the Environmental Report to be completed by September 1983.

REFERENCES

1. Proposed Statement of General Policy: Licensing Procedures for Geologic Repositories for High-Level Radioactive Wastes, Federal Register 78-53869 - 78-53872, U. S. Nuclear Regulatory Commission, Washington, D.C., 1978.
2. 10 CFR Part 60, Draft, Licensing Requirements for Nuclear Repositories.
3. Geologic Criteria for Repositories for High-Level Radioactive Wastes, National Research Council pamphlet, National Academy of Sciences, Washington, D.C., 1978.
4. Site Selection Factors for Repositories of Solid High-Level and Alpha-Bearing Wastes in Geological Formations, Technical Reports Series Number 177, International Atomic Energy Agency, Vienna, Austria, 1978.
5. Draft, NWTS Criteria for the Geologic Disposal of Radioactive Waste, ONWI 33-2 (2), Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, Ohio, 1979.
6. Environmental Protection Guidance on Radioactive Waste Disposal for Federal Agencies, U.S. Environmental Protection Agency, Washington, D.C., 1970.
7. Keeney, R. L. and Nair, K., Evaluating Potential Nuclear Power Plant Sites in the Pacific Northwest using Decision Analysis: Energy Policy, V. 5, No. 1, Woodward-Clyde Consultants, San Francisco, California, 1977.
8. Raiffa, H., Decision Analysis, Introduction Lectures on Choices under Uncertainty, Addison-Wesley Publishing Company, Reading, Massachusetts, 1968.

INTRODUCTION

IDENTIFICATION OF CANDIDATE SITES

STUDY GOAL

**IDENTIFY POTENTIALLY SUITABLE SITES FOR A
NUCLEAR WASTE REPOSITORY IN BASALT**

RHO-BMI-LD-22

V7910-6.11

STUDY AREA

RHO-BWI-LD-22

SITING PROCESS

RHO-BWI-LD-22

AGENDA

- **SUMMARY OF GEOLOGY OF THE PASCO BASIN**
- **SUMMARY OF HYDROLOGY OF THE PASCO BASIN**
- **SITE IDENTIFICATION METHODOLOGY**
- **SCREENING AND IDENTIFICATION**
- **GEOLOGIC SUPPORT INFORMATION**
- **SUMMARY**

V7912-1.3

SITE IDENTIFICATION METHODOLOGY

RHO-BWI-LD-22

SITE IDENTIFICATION APPROACH

V7910-6.20

RHO-BMI-LD-22

SAMPLE BASELINE REQUIREMENTS USED IN GUIDELINE DEVELOPMENT

- **TOTAL SURFACE AREA REQUIRED**
- **DEPTH TO REPOSITORY LEVEL**
- **TOTAL SUBSURFACE AREA REQUIRED**
- **NOMINAL CONFIGURATION**
- **DESIGN BASIS EARTHQUAKE**
- **DIP OF BASALT FLOWS**
- **THICKNESS OF BASALT FLOWS**
- **TIME FRAME OF OPERATIONAL AND ISOLATION PERIODS**
- **EXCLUSION OF RADIOLOGICALLY CONTAMINATED AREAS**
- **LICENSING AUTHORITY**

SAMPLE BASELINE SOURCES FOR GUIDELINE DEVELOPMENT

- **NUCLEAR REGULATORY COMMISSION**

10 CFR 60 RADIOACTIVE WASTE DISPOSAL

10 CFR 50 REPROCESSING PLANTS

10 CFR 100 POWER PLANT SITING

- **ENVIRONMENTAL PROTECTION AGENCY**

CLEAN AIR ACT

NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM

- **NATIONAL ACADEMY OF SCIENCES**

- **INTERNATIONAL ATOMIC ENERGY AGENCY**

- **OFFICE OF NUCLEAR WASTE ISOLATION**

- **ROCKWELL TECHNICAL REQUIREMENTS**

- **INDUSTRIAL AND SCIENTIFIC EXPERIENCE**

RELATIONSHIPS OF TERMS USED IN SITE IDENTIFICATION

OVERALL GOAL

**IDENTIFY CANDIDATE SITES WHICH HAVE A HIGH
LIKELIHOOD OF CONTAINING SUITABLE SITES
FOR LOCATING A RADIOACTIVE WASTE REPOSITORY**

GENERAL OBJECTIVES

- **ASSURE PUBLIC HEALTH AND SAFETY**
- **MITIGATE ADVERSE ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS**
- **MINIMIZE SYSTEM COSTS**

SPECIFIC CONSIDERATIONS

**TECHNICAL CONCERNS THAT DESCRIBE THE SUBJECT
MATTER THAT MUST BE ADDRESSED TO ORIENT
THE SITING STUDY TOWARD ACHIEVEMENT
OF THE GENERAL OBJECTIVES**

MEASURES

**PROVIDE A MEANS OF ASSESSING THE DEGREE
TO WHICH A REPOSITORY CAN ACHIEVE AN OBJECTIVE
IN TERMS OF SPECIFIC CONSIDERATIONS**

INCLUSIONARY GUIDELINE

**REPRESENTS AN ACCEPTABLE LEVEL OF ACHIEVEMENT
FOR AN OBJECTIVE IN TERMS OF THE CONSIDERATION
UNDER STUDY, BASED ON REGULATORY OR STATUTE
REQUIREMENTS, TECHNOLOGICAL LIMITATIONS,
OR GROSS ECONOMICS**

CLASSIFYING GUIDELINE

**IDENTIFIES GROUPS OF AREAS WITH SIMILAR
CHARACTERISTICS AND CLASSIFIES EACH AREA WITH
RESPECT TO THE DIFFICULTY IN ACHIEVING ACCEPTABLE
LEVELS OF SAFETY OR PERFORMANCE WITHOUT
REQUIRING A FINITE LEVEL OF ACHIEVEMENT**

SITE ATTRIBUTE

**QUANTIFIABLE MEASURES WHICH DESCRIBE
A PARTICULAR CHARACTERISTIC OF CANDIDATE SITES
AND ARE USED TO COMPARE SITES TO ARRIVE AT A
PREFERRED ORDER OR GROUPING**

EXAMPLE OF GUIDELINES USED FOR SCREENING

OBJECTIVE: ASSURE PUBLIC HEALTH AND SAFETY

CONSIDERATION

MEASURE

GUIDELINE

A) NATURAL HAZARDS

1) FAULT RUPTURE

a) HORIZONTAL AND VERTICAL
DISTANCE FROM KNOWN FAULTS
INTERPRETED TO BE CAPABLE

a) INCLUDE AREAS > 5 MILES, HORIZONTALLY
AND VERTICALLY, FROM KNOWN FAULTS
INTERPRETED TO BE CAPABLE

b) INCLUDE AREAS > 5 MILES, HORIZONTALLY
AND VERTICALLY, FROM KNOWN FAULTS
WHOSE CAPABILITY IS UNKNOWN WHICH
HAVE LOW POTENTIAL FOR A CAPABILITY
EVALUATION

b) HORIZONTAL AND VERTICAL
DISTANCE FROM KNOWN FAULTS
INTERPRETED TO BE NOT
CAPABLE AND ZONES OF
FRACTURING AND JOINTING

a) INCLUDE AREAS > 1/2 MILE FROM KNOWN
FAULTS INTERPRETED TO BE NOT CAPABLE
AND FROM ZONES OF FRACTURING AND
JOINTING

b) INCLUDE AREAS > 1/2 MILE FROM KNOWN
FAULTS WHOSE CAPABILITY IS UNKNOWN
BUT WHICH HAVE A HIGH POTENTIAL FOR
A CAPABILITY EVALUATION

c) LOCATION WITH RESPECT TO
LINEAMENTS AND POSTULATED
FAULTS

EVALUATE AREAS ON BASIS OF PROXIMITY TO
LINEAR FEATURES (LINEAMENTS) AS INTERPRETED
FROM REMOTE SENSING AND GEOPHYSICAL DATA
AND POSTULATED FAULTS

RELATIONSHIP OF AREA DESIGNATIONS

PASCO BASIN SCREENING AREA

CANDIDATE AREA

4 SUB-AREAS

5 SITE LOCALITIES

9 CANDIDATE SITES

**PREFERRED SITES FOR
FURTHER CHARACTERIZATION**

V7910-6.37

THE OVERLAY PROCESS

DATA ASSEMBLY OBJECTIVE

**LOCATE, ACQUIRE AND SCREEN SOURCES OF PERTINENT
DATA BASED ON THEIR PROBABLE UTILIZATION IN THE
SITING PROCESS AND ALSO BASED ON READILY
AVAILABLE PUBLISHED AND UNPUBLISHED LITERATURE**

EXAMPLE OF USE OF KEY WORD INDEX AND ANNOTATED REFERENCES DATA CATALOGING

1. SAMPLE TOPIC

Internal structures of basalt flows

2. LOCATE THE MOST APPROPRIATE KEY WORD

Key words are arranged in outline format
under major subject headings

3. ENTRY IN KEY WORD INDEX

Intrabasalt structures

143 150 184 201 283 447

4. TURN TO ANNOTATED REFERENCES AND LOCATE THE REFERENCES WITH THE NUMBERS ON THE KEY WORD INDEX

Example from references →

143. Hodges, C. A., 1978, Basaltic ring structures of the Columbia Plateau: Geological Society of America Bulletin, v. 89, p. 1281-1289.

The ring structure found in the Roza Member near Odessa is described and features are related to rising ground water as thick flows cooled over a topographic low.

150. Hoyt, C. L., 1961, The Hammond Sill—An intrusion in the Yakima Basalt near Menatchee, Washington: Northwest Science, v. 35, no. 2, p. 58-64. The basalt structures in western Douglas County are discussed. The Hammond Sill is an invasive sill with subsidiary dikes within the Rock Island interbed.

184. Long, P. E., 1978, Characterization and recognition of intraflow structures, Grande Ronde Basalt: Rockwell International, Informal Report RHO-BWI-LD-10, prepared for the U.S. Department of Energy, Contract EY-77-C-06-1030.

This report describes various intraflow structures in the Grande Ronde flows and their usefulness in correlating drill hole data.

201. McKee, B., and Stradling, D., 1970, The sag flowout: a newly described volcanic structure: Geological Society of America Bulletin, v. 81, p. 2035-2044.

This article describes the ring structures occurring in the Roza Member near Odessa, Washington. They were formed by fluid lava escaping along concentric dikes in the partly solidified flow.

283. Ryan, M. P., and Samies, C. G., 1978, Cyclic fracture mechanisms in cooling basalt: Geological Society of America Bulletin, v. 89, p. 1295-1308.

This paper addresses the question of how hexagonal polyhedra are found and how vertical joints grow longer (crack tip deformation) in cooling basalts.

447. Waters, A. C., 1960a, Determining direction of flow in basalts: American Journal of Science, v. 258-A, p. 350-366.

A determination of flow direction using columnar joints, spiracles, pipe vesicles and cylinders, and primary foreset bedding in palagonite.

RHO-BWI-LD-22

V7910-6.2

SCREENING AND IDENTIFICATION

CONSIDERATIONS USED IN SCREENING FOR CANDIDATE AREA

- **TRANSPORTATION**
- **OPERATIONAL RADIATION RELEASE**
- **AIRCRAFT IMPACT**
- **FAULT RUPTURE**
- **GENERATION OF NEW FAULTS**
- **GROUND MOTION**
- **PROTECTED ECOLOGICAL AREAS**
- **SITE PREPARATION COSTS
(TERRAIN RUGGEDNESS)**

CONSIDERATIONS USED IN SCREENING FOR SUB-AREAS

- **FAULT RUPTURE**
- **FLOODING**
- **GROUND FAILURE**
- **EROSION/DENUATION**
- **SEPARATION FROM DEFENSE FACILITIES**
- **INDUCED SEISMICITY**
- **SITE PREPARATION**

V7912-1.4

**NO SUB-AREA WITHIN THE SCREENING
AREA, BUT OUTSIDE THE HANFORD SITE
BOUNDARY, WAS FOUND TO BE
TECHNICALLY SUPERIOR TO THE
SUB-AREAS WITHIN THE HANFORD SITE**

GEOLOGICAL SUPPORT

RHO-BMI-LD-22

AREAS OF BASALT EXPOSURE

AREAS OF TOP-OF-BASALT DIP ≥ 5 DEGREES

FOLDING IN THE PASCO BASIN

DOE Richland, WA

FAULTING IN THE PASCO BASIN

0 1 2 3 MILES
0 1 2 3 4 5 KILOMETERS

MAJOR FAULTS ($\geq 200'$ DISPLACEMENT) ———
MINOR FAULTS ($< 200'$ DISPLACEMENT) - - - -

RADIATION ZONES WITHIN THE HANFORD SITE

GEOPHYSICAL SURVEY SITES

DOE Richland, WA

RHO-BWI-LD-22

APPROXIMATE PERCENTAGE OF LAND USE FOR REPOSITORY SURFACE FACILITIES

TOTAL 1,425 acres

V7910-6.38

RHO-BWI-LD-22

PRECONCEPTUAL REPOSITORY SURFACE FACILITIES

V7910-6.50

RCP8001-44

CANDIDATE SITE R

V7910-6.36

CANDIDATE SITE S

V7910-6.29

RHO-BMI-LD-22

CANDIDATE SITE T

V7910-6.32

CANDIDATE SITE U

V7910-6.33

RHO-BMI-LD-22

CANDIDATE SITE V

V7910-6.34

RHO-BMI-LD-22

CANDIDATE SITE W

V7910-6.31

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CANDIDATE SITE X

V7910-6.35

RHO-BMI-LD-22

CANDIDATE SITE Y

V7910-6.30

CANDIDATE SITE Z

V7910-6.28

RHO-BMI-LD-22

AREA FOR SITE CHARACTERIZATION

V7912-1.1

SUMMARY OF GUIDELINES USED FOR SCREENING

Consideration	Measure	Guideline	Possible Use to Obtain	Applicability and Time Frame (1,2)
<u>OBJECTIVE: ASSURE PUBLIC HEALTH AND SAFETY</u>				
<u>A) Natural Hazards</u>				
1) Fault Rupture	a) Horizontal and vertical distance from known faults interpreted to be capable	a) Include areas > 5 miles, horizontally and vertically, from known faults interpreted to be capable	Candidate Area Sub-area Site Locality	0 and I S and U
		b) Include areas > 5 miles, horizontally and vertically, from known faults whose capability is unknown which have low potential for a capability evaluation	Candidate Area Sub-area Site Locality	
	b) Horizontal and vertical distance from known faults interpreted to be not capable and zones of fracturing and jointing	a) Include areas > 1/2 mile from known faults interpreted to be not capable and from zones of fracturing and jointing	Site Locality	0 and I S and U
		b) Include areas > 1/2 mile from known faults whose capability is unknown, but which have a high potential for a capability evaluation	Site Locality	
	c) Location with respect to lineaments and postulated faults	Evaluate areas on basis of proximity to linear features (lineaments) as interpreted from remote sensing and geophysical data and postulated faults	Site Locality	0 and I S and U
2) Generation of New Faults	Location with respect to future potentially capable tectonic structures	Include areas > 5 miles from folds interpreted to be capable of forming new faults	Sub-area Site Locality	0 and I S and U
3) Ground Motion	Location with respect to potential earthquake sources and estimated levels of ground motion	a) Include areas that may be subject to < 40% g peak surface acceleration from known and interpreted earthquake sources	Candidate Area	0 and I S and U
		b) Include areas > 12 miles from the felt epicenters > MM V and > 6 miles from instrumental epicenters > magnitude 4.0 which occur in concentrations or clusters as interpreted from historic earthquake epicenter plot maps	Sub-area	0 and I S and U

(1) 0 = Operation Phase (0 to 60 years); I = Isolation Phase (10,000 years)

(2) Applicability of guidelines to the surface (S) repository facilities and/or the subsurface (U) repository facilities

Summary of Guidelines Used for Screening (continued)

SUMMARY OF GUIDELINES USED FOR SCREENING (continued)

Consideration	Measure	Guideline	Possible Use to Obtain	Applicability and Time Frame (1,2)
		c) Evaluate areas and their locations with respect to isolated earthquakes of epicentral intensities > MM V and magnitude > 4.0 based on estimated location errors and geologic and tectonic setting	Site Locality	O and I S and U
		d) Evaluate areas and their locations with respect to shallow (< 35 miles depth) microearthquakes based on location error, geologic and tectonic setting, and local and regional stress regime	Site Locality	O and I S and U
4) Tectonic Movement	Location with respect to potential bedrock folding	Evaluate areas on basis of proximity to bedrock folds (anticlines, synclines, or monoclines)	Site Locality	I U
5) Groundwater Contamination	Location with respect to natural and man-made discharge areas	Evaluate areas on basis of distance from discharge areas and interpreted contaminant travel time	Site Locality	I U
6) Flooding	Height above selected floor level	a) Include areas outside of primary floodplains and published maximum flood levels	Sub-areas Site Locality	O and I S and U
		b) Evaluate areas on basis of height above primary floodplains and estimated published maximum flood levels	Site Locality	I U
		c) Evaluate areas on basis of location with respect to areas where catastrophic flooding (i.e., Spokane Floods) has occurred in Quaternary	Site Locality	I U
7) Volcanic Effects	Distance from Quaternary ashfall sources	Evaluate areas on basis of exposure to tephra fall from Quaternary stratovolcanoes	Site Locality	O S and U
		A = > 150 miles to source		
		B = 40 to 150 miles to source		
		C = < 40 miles to source		

(1) O = Operation Phase (0 to 60 years); I = Isolation Phase (> 10,000 years)

(2) Applicability of guidelines to the surface (S) repository facilities and/or the subsurface (U) repository facilities

Summary of Guidelines Used for Screening (continued)

Consideration	Measure	Guideline	Possible Use to Obtain	Applicability and Time Frame (1,2)
8) Future New Volcanic Activity	Location with respect to probability of new volcanic sources	Evaluate areas on basis of probability and proximity to areas of interpreted new volcanic sources and effects	Site Locality	I U
9) Ground Failure	a) Location with respect to landslides and potential landslides	a) Include areas not on mapped landslides	Site Locality	O S
		b) Evaluate areas on basis of probability of landsliding	Site Locality	O S
		A = Low probability of a landslide		
		B = Slight probability of a landslide		
	b) Characteristics of foundation conditions	C = Higher probability of a landslide		
		Evaluate general foundation conditions	Site Locality	O
		A = Bedrock area (0 to 20 feet consolidated material)		
		B = Shallow alluvial area (20 to 100 feet unconsolidated material)		
10) Erosion/Denudation	Location with respect to potential areas of reosion or denudation	C = Deep alluvial area (> 100 feet unconsolidated material)		
		a) Include areas > 1/2 mile from steep-walled canyons or slopes	Site Locality	I U
		b) Evaluate areas on basis of height of underground repository above base level	Site Locality	I U
		A = Repository elevation below base level (sea level)		
11) Stratigraphic Characteristics	a) Bedrock dip	B = Repository elevation above base level (sea level)		
		Evaluate areas on basis of bedrock dip	Site Locality	O U
		A = 0 to 5 degrees		
		B = 5 to 10 degrees		
		C = < 10 degrees		

(1) O = Operation Phase (0 to 60 years); I = Isolation Phase (10,000 years)

(2) Applicability of guidelines to the surface (S) repository facilities and/or the subsurface (U) repository facilities

Summary of Guidelines Used for Screening (continued)

Consideration	Measure	Guideline	Possible Use to Obtain	Applicability and Time Frame (1,2)
	b) Presence of suitable stratigraphic characteristics	Include areas where basalt flow with desirable internal flow structure, density, porosity, extent, continuity, etc. are > 100 feet thick within the proposed repository depth zone	Site Locality	O and I U
	c) Thickness of underlying basalt	Include areas where thickness of underlying repository host rock-type material at the repository depth is > 500 feet	Site Locality	O and I U
B) Man-Made Hazards				
1) Aircraft Impact	a) Distance from airports	<p>a) Include areas > 5 miles from airports shown on state airport plans, accommodating aircraft > 12,500 lbs. gross weight or any military airport</p> <p>b) For airports with > 12,500 operations per year but less than 50,000, include areas > d miles from airport</p> $d = \sqrt{0.002 (\text{operations})}$ <p>c) For airports with 50,000 to 100,000 operations per year, 10 miles from airport. For airports with > 100,000 operations per year, include areas > d miles from airport</p> $d = \sqrt{0.001 (\text{operations})}$	<p>Candidate Area</p> <p>Sub-area</p> <p>Sub-area Site Locality</p>	<p>O S</p> <p>O S</p> <p>O S</p>
	b) Locations with respect to commercial jet routes and military routes	Evaluate areas with respect to proximity to high-frequency routes	Sub-area	O S
	c) Location with respect to restricted airspace	Include areas away from the limits of restricted airspace defining military airspace usage	Sub-area	O S
2) Hazardous Facilities	a) Location with respect to hazardous facilities, possible missile generators and possible vapor sources	<p>a) Include areas away from facilities occupying 18,000 acres or more</p> <p>b) Include areas > 0.6 mile from potential explosion, fire, missile hazards</p>	<p>Candidate Area</p> <p>Sub-area</p>	<p>O S</p> <p>O S</p>

(1) O = Operation Phase (0 to 60 years); I = Isolation Phase (10,000 years)

(2) Applicability of guidelines to the surface (S) repository facilities and/or the subsurface (U) repository facilities

Summary of Guidelines Used for Screening (continued)

Consideration	Measure	Guideline	Possible Use to Obtain	Applicability and Time Frame (1,2)
3) Transportation	b) Distance from transportation corridors	c) Include areas > 0.6 mile from potential sources of noxious or flammable vapors	Site Locality	O S
		d) Evaluate areas on basis of proximity to hazardous facilities	Site Locality	O S
		a) Include areas > 0.6 mile from U.S. highways, interstate highways, railroads, and navigable highways	Site Locality	O S
		b) Evaluate areas on basis of proximity to transportation corridors	Site Locality	O S
4) Induced Seismicity	Locations with respect to sources of induced seismicity and potential future earthquake sources	a) Include areas > 5 miles from existing reservoirs > 100 feet deep	Sub-area	O and I S and U
		b) Evaluate areas on basis of proximity to future reservoirs and interpreted sources of induced seismicity	Site Locality	I U
		A = > 5 miles		
		B = 0 to 5 miles		
5) Subsurface Mineral Exploration and Extraction	Location with respect to existing and potential future mineral exploration and extraction	a) Include areas away from existing subsurface mineral extraction	Site Locality	O and I U
		b) Evaluate areas on basis of proximity to potential future mineral exploration or extraction	Site Locality	I U
6) National Defense and Security	Proximity to facilities or areas interpreted to be possible defense or security risks	Evaluate areas on basis of proximity to facilities or areas interpreted to be attractive military or terrorist targets	Site Locality	O and I S and U
C) Repository-Induced Events				
1) Thermo-mechanical Effects	Thickness of host rock flow and general rock characteristics	Evaluate flow thicknesses and characteristics of potential host rock	Site Locality	O and I U

(1) 0 = Operation Phase (0 to 60 years); I = Isolation Phase (10,000 years)

(2) Applicability of guidelines to the surface (S) repository facilities and/or the subsurface (U) repository facilities

Summary of Guidelines Used for Screening (continued)

Consideration	Measure	Guideline	Possible Use to Obtain	Applicability and Time Frame (1,2)
2) Operational Radiation Release	Distance from population	a) Include areas > 3 miles from populations of > 2,500 b) Include areas > 1 mile from any incorporated community c) Include areas > 1 mile from any urbanized area	Candidate Area Sub-area Sub-area	O S O S O S
OBJECTIVE: MITIGATE ADVERSE ENVIRONMENTAL IMPACTS				
1) Protected Ecological Areas	Location with respect to protected ecological areas	Include areas outside of designated protected ecological areas of a) $\geq$ 18,000 acres b) 5 to 18,000 acres c) < 5,000 acres	Candidate Area Sub-area	O S
2) Culturally Important Areas	a) Location with respect to designated scenic areas b) Location with respect to all designated areas	Include areas greater than a calculated distance based on height of surface repository Include areas outside of designated culturally important areas a) $\geq$ 18,000 acres b) 5 to 18,000 acres c) < 5,000 acres	Candidate Area Sub-area Candidate Area Sub-area	O S O S
Indian reservations, parks, monuments, wilderness, primitive areas, roadless area of national forest, Bureau of Land Management roadless recreation area, archaeological sites				
3) Protected and Endangered Species	Location with respect to protected and endangered species	Include areas outside of known locations of protected and endangered species	Sub-area	O S
4) Biologically Important Areas	Location with respect to biologically important areas	Evaluate areas based on proximity to biologically important areas	Site Locality	O

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- (1) O = Operation Phase (0 to 60 years); I = Isolation Phase (>0,000 years)
 (2) Applicability of guidelines to the surface (S) repository facilities and/or the subsurface (U) repository facilities

Summary of Guidelines Used for Screening (continued)

Consideration	Measure	Guideline	Possible Use to Obtain	Applicability and Time Frame (1,2)
5) Existing Significant, Specialty, or Incompatible Land Uses	Location with respect to significant, specialty, or incompatible land uses	Include areas outside of mapped extent of specialty, agriculture, irrigated agriculture, incompatible facilities, or other land uses that are locally limited and regionally significant	Sub-area	O S
6) Potential Significant or Incompatible Land Uses	Location with respect to potential future significant or incompatible land uses	Evaluate areas with respect to potential future uses. The evaluation will focus on agriculture a) Potentially irrigable lands b) Arable soils c) Marginal soils d) Submarginal soils	Site Locality	I S
OBJECTIVE: MINIMIZE SYSTEM COSTS				
1) Site Preparation (Surface)	a) Terrain ruggedness	Subjective evaluation for terrain characteristics (i.e., slope approximately > 15%, relief and degree of dissection)	Candidate Area	O S
	b) Usable land area	Evaluate available land area for dominant site preparation costs, slope, local relief, degree of dissection, size of area, location and juxtaposition of relatively level areas, water supply, access, and amount of excavation and fill necessary to fit 2,400 acres of surface facilities	Site Locality	O S
2) Site Preparation (Subsurface)	Mining and excavation costs	Evaluate areas on basis of thickness of overburden, depth of shafts, host rock characteristics, configuration, and length of tunnels (spoil, etc.), excavated volume, etc.	Site Locality	O S

(1) O = Operation Phase (0 to 60 years); I = Isolation Phase (10,000 years)

(2) Applicability of guidelines to the surface (S) repository facilities and/or the subsurface (U) repository facilities

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