FACILITIES FOR A REPOSITORY IN TUFF--

A DESIGN COMPATIBLE WITH THE YUCCA MOUNTAIN SITE*

H. R. MacDougall
Nuclear Waste Engineering Projects
Sandia National Laboratories**
Albuquerque, New Mexico 87185

N. A. Norman
Bechtel National, Inc.
San Francisco, California 94119

ABSTRACT

This paper delineates some of the major relevant characteristics of the candidate site for a radioactive-waste repository at Yucca Mountain, Nevada, that must be addressed in the conceptual design of surface and subsurface facilities.

INTRODUCTION

The conceptual design of a repository for radioactive waste, in tuff at Yucca Mountain, Nevada, is being prepared by Sandia National Laboratories (SNL) for the Nevada Nuclear Waste Storage Investigations (NNWSI) Project, under the direction of the Nevada Operations Office (NVO) of the Department of Energy (DOE). The candidate area, which is being studied as a potential site for permanent disposal of spent fuel from nuclear power plants, is located near the southwest corner of the Nevada Test Site (NTS) and adjacent Federal property. The SNL effort is being conducted in conjunction with other NNWSI Project participants including Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), the U.S. Geological Survey (USGS), Science Applications International Corporation (SAIC), and their contractors.

The Yucca Mountain site is one of three preferred locations for site characterization as candidates for the development of the first repository for radioactive waste in the United States. The remaining two other competing sites selected, as well, from the original nine, are (1) on the Hanford Site in Washington, and (2) in Deaf Smith County, Texas. Each of these sites was studied, evaluated, and considered for nomination for site characterization in accordance with the requirements of the Nuclear Waste Policy Act (NWPA) of 1982 (Ref. 1) and DOE Siting Guidelines 10 CFR 960 (Ref. 2). The results of these studies and evaluations are reported in the Draft Environmental Assessment (EA) documents that were released for public comment in December 1984 (Ref. 3, Chap. 6, p. 22).

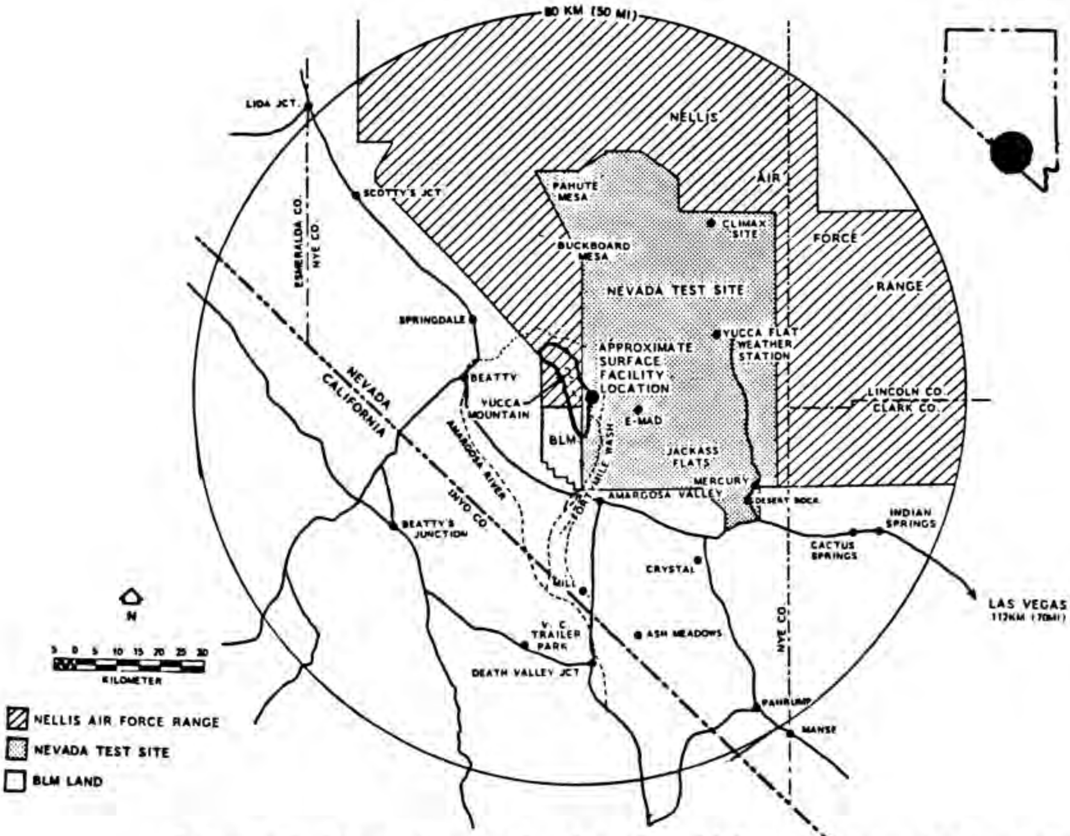
SURFACE CHARACTERISTICS AT THE YUCCA MOUNTAIN SITE

It is the responsibility of the Nuclear Waste Engineering Projects Division of SNL to develop a conceptual design of surface and subsurface facilities that will accommodate all characteristics of Yucca Mountain site. The principal site for surface facilities (Ref. 4) is located on gently sloping alluvium east of Yucca Mountain near the western boundary of the Nevada Test Site (NTS). The location is shown in Fig. 1 . However, support facilities for subsurface development and for several shaft-related surface activities would be at sites on the Nellis Air Force Range (NAFR) to the west. The access road and rail line would cross Bureau of Land Management (BLM) and NTS land. Figures 1 and 2 show the location, boundaries, and jurisdiction of the site, and its access routes. Thus, all land necessary for the development and operation of the repository is currently under the jurisdiction of three Federal agencies. Ultimately, however, these lands would be placed under the exclusive control and administration of the DOE (Ref. 5 as cited in Ref. 3, Chap. 6, p. 22). Figure 3 provides an overview of the layout of surface and subsurface facilities.

Land use in the vicinity of the site includes federal priorities, agriculture and grazing, mining, recreation, and private or commercial development. No major conflicts over land use have been identified or are anticipated. NTS activities, involving underground nuclear weapons and explosives testing, do not include or preclude use of this site, nor do they jeopardize potential repository operations. Security restrictions at the NTS and the need for an efficient and reliable transportation system will require construction of a new access road and railroad line. The road would extend from US Highway 95 near the town of Amargosa Valley (Lathrop Wells), 26 km (16 mi) south of Yucca Mountain site, and the railroad would connect to a terminal at Dike Siding, north of Las Vegas, about 137 km (85 mi) southeast of the site (Ref. 3, Chap. 5, p. 12, and Fig. 2).

BLM land, though currently in the public domain and designated for multi-purpose use, including recreation, grazing, forest and wildlife management, is not used to any significant degree by the public. A portion of the extensive Federal lands in southern

* This work was supported by the U.S. Department of Energy (DOE) under contract DE-AC04-DP00789.
** A U.S. DOE facility.



General Location of the Candidate Area and Site

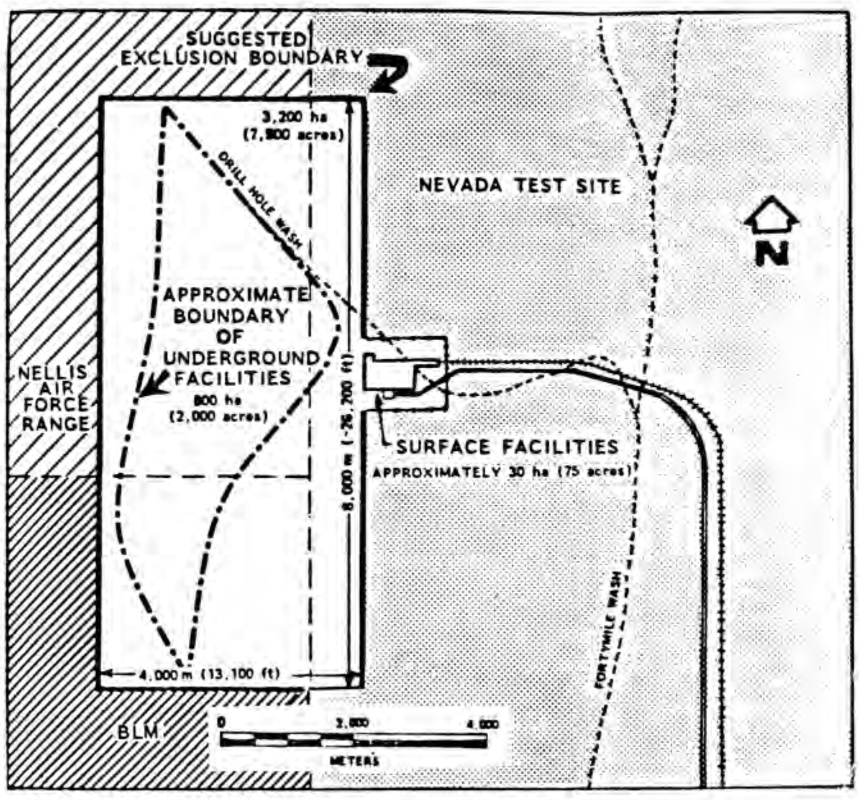


Fig. 1. Preliminary Boundary of the Underground Facilities, Suggested Exclusion Boundary, and Surface Facilities Location.

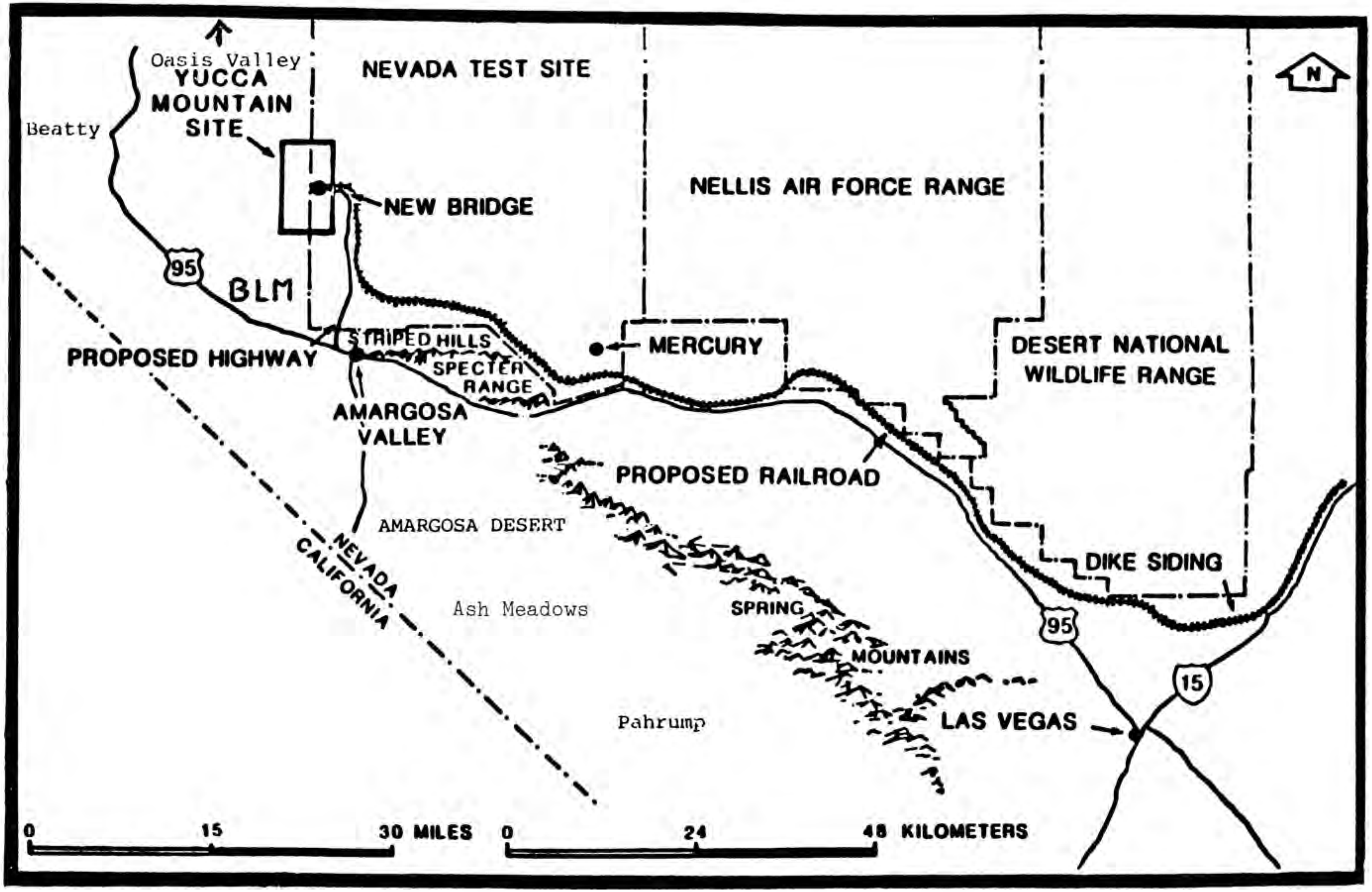


Fig. 2. Proposed highway and rail access routes to the Yucca Mountain repository.

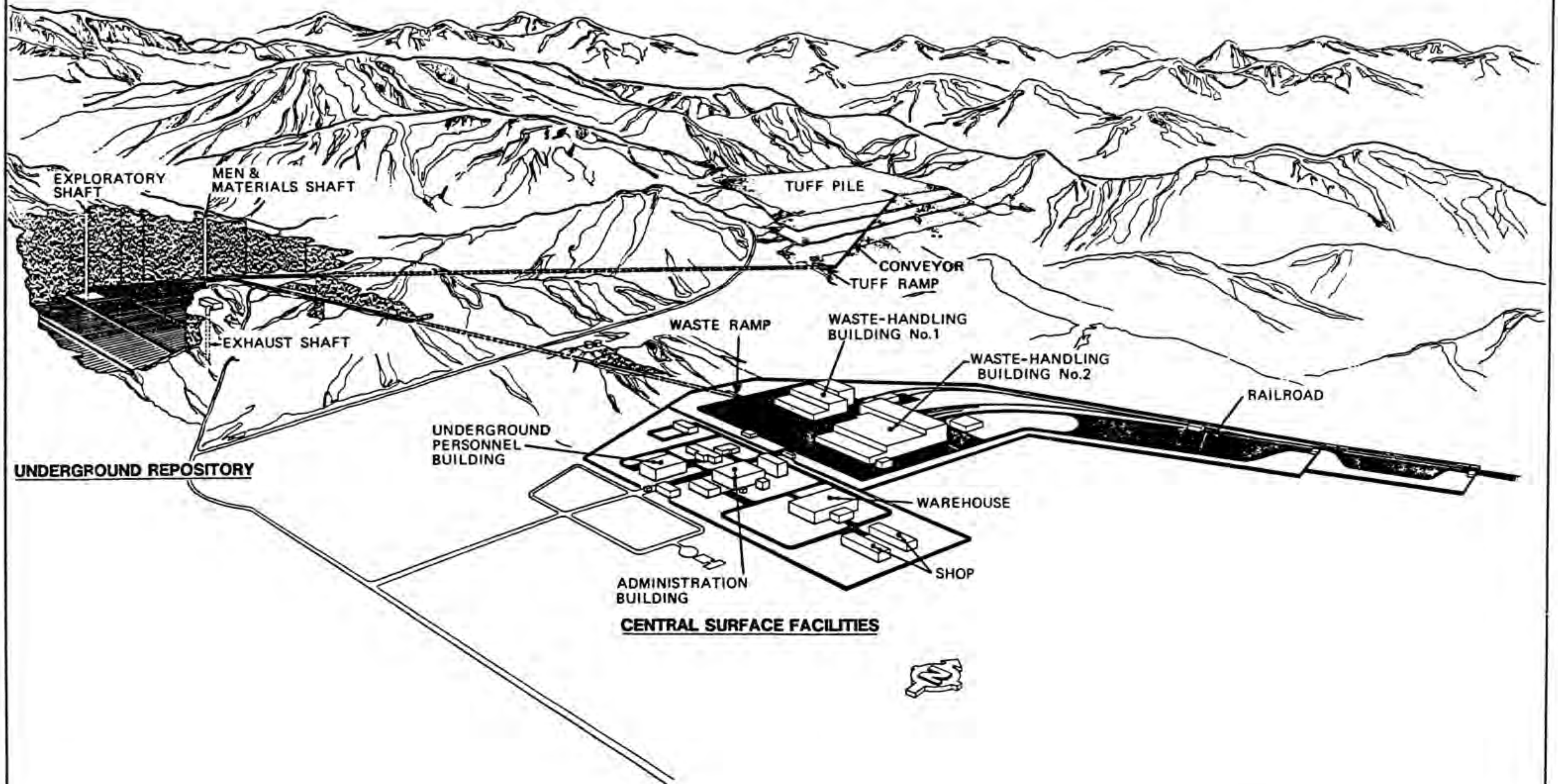


Fig. 3. Layout of surface & subsurface facilities for Yucca Mountain site.

numerous old faults in the vicinity, a relatively high value for seismic acceleration will probably be imposed as a design criteria. Precise building locations and foundation designs will be specified to eliminate the risk of hazardous effects from any potential movement along nearby faults. Site characterization activities will include extensive testing and evaluation to determine which faults, if any, might be subject to movement during the operating phase.

In addition to natural seismicity, this site will experience induced vibratory ground motion caused by underground nuclear explosions (UNE) at the Nevada Test Site. Levels for induced accelerations are more easily predictable than those caused by natural seismicity and will be a basis in developing design criteria for the repository facility. Although firm values for these accelerations have not been established yet, the upper limit for these UNE accelerations is expected to be similar to that for natural seismicity.

DESIGN OF SURFACE FACILITIES FOR THE YUCCA MOUNTAIN SITE

Studies indicate that soil conditions at Yucca Mountain Site are favorable for construction of all required surface facilities. Figures 4 and 5 provide plan and section views, respectively, of the preliminary conceptual design of the waste-handling building (WHB)No. 2, which includes up to 5-foot-thick walls necessary for hot-cell shielding. In many specific areas, the thickness of walls will be dictated by the requirements for effective radiation shielding, rather than by seismic structural constraints. This feature of the WHB, in conjunction with its low ratio of vertical to horizontal dimensions, makes it even less vulnerable to damage from seismically induced vibrations. Design features such as a more massive pad foundation, caissons, or base isolation through the use of elastomeric bearings can be added, if necessary, to provide for ground motion from potential seismic events. These design approaches will be evaluated in system studies as the site characterization data become available and the design progresses.

The Yucca Mountain site is unique because underground repository development will be located above the water table, in the unsaturated zone of tuff, and because ramp access between the surface and subsurface facilities is possible. The use of ramps offers significant advantages. The unsaturated-zone location exerts only a limited influence on surface facility designs; however, the ramp access does simplify facility design and operations, and provides for a higher potential probability of safety than shaft transfer of waste. Systems that do not use ramps must rely on hoists for transferring radioactive waste underground; this raises the level of risk for accidents that could cause damage to the canister by its being dropped during several of the necessary transfer operations, as well as in the hoist shaft itself.

The two ramps that are part of the preliminary conceptual design are shown on Fig. 3. The ramp for waste transport to the underground will extend 7,000 ft with an 8.5% slope, from west of the waste-handling buildings to the subsurface development area at Yucca Mountain. The difference in elevation from the surface to subsurface, is approximately 152 to 183 m (500 to 600 ft). A single vehicle and driver can be employed for transferring the radioactive-waste package from the WHB to emplacement borehole. This specialized vehicle will receive the waste canister and transport it in a horizontal position. The reference design is for vertical emplacement of the waste canister. This would require that the transporter raise the canister to a vertical position before lowering it into the borehole.

Mined tuff rock will also be removed from the repository by means of an access ramp. The 15% slope of this ramp will permit the use of conveyor systems to move tuff (muck) directly from the mining face to the surface and onto the tuff pile as shown in Fig. 3. This capability allows great flexibility in subsurface mining rates because the quantity of rock to be removed from the underground is not constrained by hoist-load limits. Operating reliability will be improved by this development-rate flexibility. A higher potential level of safety for personnel can also result from the use of ramp accesses, because underground workers would be provided with two avenues of escape that are not subject to constraint by power or hoist failures.

Present plans include the option of using two waste-handling buildings to support a shorter construction schedule (Ref. 6). Initial packaging of unconsolidated spent fuel would be performed in a waste-handling building designed to accommodate 400 metric tons per year of high-level radioactive waste. This would be followed after 4 years by several incremental increases conducted over a subsequent three year time span, until a 3,000-MTU/yr capacity is reached, for receiving, consolidating, and packaging in a second, larger, independent waste-handling building. Both waste-handling buildings would be located near the portal to the waste ramp, but separated far enough apart to permit operation of the Stage 1 building during construction of the Stage 2 full-scale waste-handling installation.

Implementation of this two-stage plan would permit initial waste-receival operations to begin within approximately 3-1/2 years from notification of construction authorization. Full-scale operation, including spent-fuel consolidation, could be achieved after a minimum of 66 months from the initial licensing for construction authorization. The two-stage concept would allow the DOE greater flexibility in meeting the commitment to receive spent fuel at the repository by Jan. 31, 1998, and ensure that sufficient time is available for licensing and public commentary.

Further development of repository facilities will require engineering system studies in order to evaluate various alternatives and establish design criteria. Some of the major areas requiring investigation and additional data include

- o Wet versus dry environments for receiving, handling, and disposal of spent fuel
- o Consolidation versus nonconsolidation of spent fuel
- o Methods of controlling and cleaning up dislodged extraneous radioactive materials from fuel rods*

*"CRUD" is the term used for deposits on fuel assemblies originating from corrosion products in a reactor's primary coolant system that are transported by the coolant into reactor cores (Ref. 7).

Nye County is used for cattle grazing, which is regarded as the major agricultural resource near Yucca Mountain Site. Blocks of private land in Oasis Valley, Ash Meadows, Amargosa Desert, and Pahrump Valley areas support the only farming and ranching operations in the region, with extensive cultivation only in the vicinity of the latter two areas (See Fig. 2). All of these locations are more than 24 km (15 mi) from the site. Two grazing leases have been granted for land west of the site and north of US 95. However, no BLM grazing leases have been issued for either Yucca Mountain or for lands lying north of US 95 or east of the site. Consequently, no stock grazing or other agricultural activities are taking place at the site or along the access route from US 95 (Ref. 3, Chap. 3, p. 32 and Chap. 5, p. 12).

NAFR land, currently under the administration of the Department of the Air Force (BLM serves as the official protector of the land in public domain and custodian of all surface and subsurface rights) is used for training personnel, testing military weapons, and bombing and gunnery activities. However, the portion of the range in the vicinity of the site is reserved merely for occasional overflights, providing air access to the bombing and gunnery areas located farther north and west of Yucca Mountain (Ref. 3, Chap. 6, p. 22).

Studies have been conducted to identify natural resources on or near the site. Some construction gravel has been obtained from Fortymile Wash, adjacent to the site; however, the overall economic potential for the development of energy or mineral resources at or near Yucca Mountain site is low. (Ref. 3, Chap., 3, p. 22).

Most private and commercial development is concentrated in the Las Vegas Valley area. Private land is scarce in the vicinity of Yucca Mountain and adjacent Federal land parcels (Ref. 3, Chap. 3, p. 35).

There are no plants or animals in the area currently designated as official candidates for Federal protection under the Endangered Species Act of 1973. However, the status of the desert tortoise, a state-protected species identified as rare, and the Mojave fishhook cactus, which are found in the site vicinity, with respect to such classification as "threatened" species worthly of Federal protection, is now under advisement (Ref. 3, Chap. 3, p. 41).

One hundred and seventy-eight (178) prehistoric, aboriginal, archeological sites have been identified in the area. Prior to development operations, artifacts will be collected from those locations where potential repository activities would be expected to disturb the terrain, and wherever possible such sites would be avoided or otherwise protected (Ref. 3, Chap. 3, p. 47 and Chap. 5, p. 54).

Meteorological conditions conducive to tornado formation are generally lacking in southern Nevada; consequently, there is a very low potential for the occurrence of such an event. The EA for the site (Ref. 3, Table 5-27) notes that tornado probability is less than 9.1×10^{-11} per year. High winds do occasionally occur during winter storms and must be allowed for in the building design. Because of the relatively low ratio of vertical to horizontal dimensions and massive construction required for buildings in which radioactive waste will be handled, seismic, rather than wind-induced loads, will probably be the controlling factor for developing criteria to ensure structurally sound surface installations.

The DOE (10CFR 960.5-2-8) siting guideline on surface characteristics (Ref. 3, Chap. 6, p. 253) requires that the location of facilities be made in conjunction and in compliance with guidelines on ease and cost of siting, construction, operation, and closure. It states that consideration must be given to the surface-water system and the topography of the site area. This siting guideline is applicable to the onsite surface facilities, underground access openings, and transportation routes to the site. Although the mean annual precipitation is only about 4 inches, incidents of flash flooding, though rare, do occur from occasional heavy precipitation of short duration. At these times, the normally dry washes can be inundated with large volumes of water that exceed the capacity of the channels to contain them. However, the location of surface facilities is entirely outside the main-channel flood zones. Furthermore, wherever necessary in the vicinity of any surface facilities, channels will be constructed to increase flow efficiency and containment, or surface facilities would be otherwise protected by flow-diversion features considered standard drainage control measures (Ref. 3, Chap. 6, p. 279).

Maximum flood potential will be evaluated according to the probable maximum flood (PMF) technique prescribed in Nuclear Regulatory Commission (NRC) Regulatory Guide 4.17 and American National Standards Institute (ANSI) Standard N170-1976. This is the most conservative approach to flood analysis in common use and allows for site-specific consideration of the maximum rainfall rate and the topography of the terrain. Facilities in which hazardous material is handled will be located above the PMF area, to provide even greater assurances against accidental release of radiological material. This precaution would be taken for other structures and shafts as well, where the potential movement of large volumes of water and debris could present a risk, however infrequent the possibility of occurrence.

Engineered drainage systems involving the use of berms, culverts, grading, etc., are being designed to divert water and provide for flood control. These devices will be used to resolve the problem of drainage at the adjacent locations of 1) the surface storage area for mined tuff, to prevent destabilization of the pile, and 2) the men-and-materials shaft, to prevent water from flooding it. The major engineered structure that is required, to ensure easy access and safe transport of waste to the repository facilities, will be the 780-ft bridge over Fortymile Canyon 1-1/2 miles southeast of the surface facilities. It will support both truck and rail traffic. By providing for this dual capability in a single structure, a significant saving in project cost can be realized.

There are numerous geologic faults in the vicinity of the site, which is typical for the Basin and Range Province. Tectonic and volcanic activity has steadily decreased over the last 10 million years. Some faults in the area show evidence of movement over the last 2 million years although no evidence of Quaternary (Holocene) surface displacement has been discovered near the site (Ref. 3, Chap. 6, p. 227). A multiple-recorder seismic network system around the site has recorded several microearthquakes since 1978 with a magnitude of 2 or less. Building and facility design will meet the seismic criteria that are now being developed. These criteria will include the probability of occurrence of seismic events, failure scenarios that can be credibly postulated, and the consequences that could result from earthquakes or tremors. In view of the

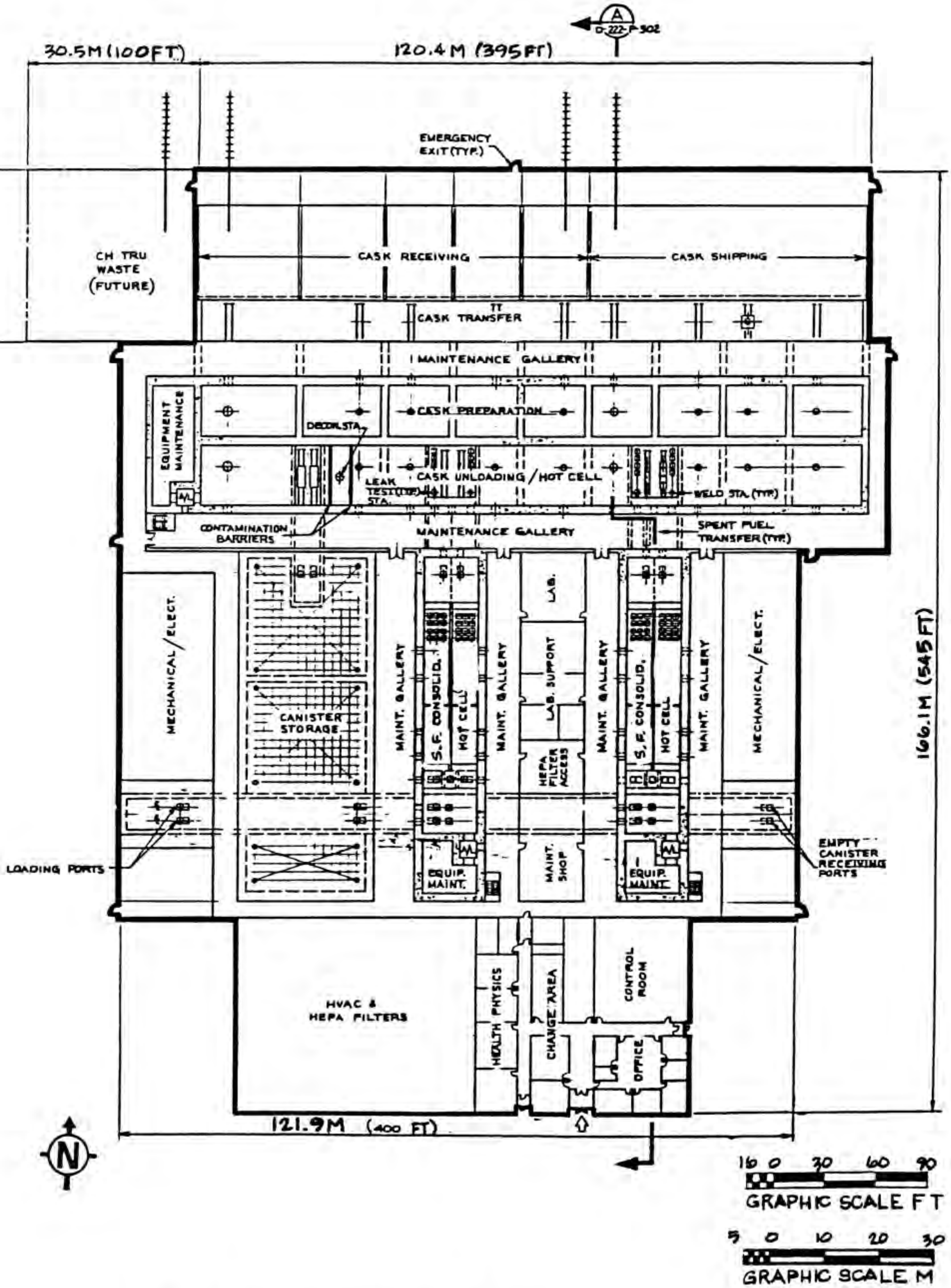


Fig. 4. Waste-Handling Building No. 2 Plan.

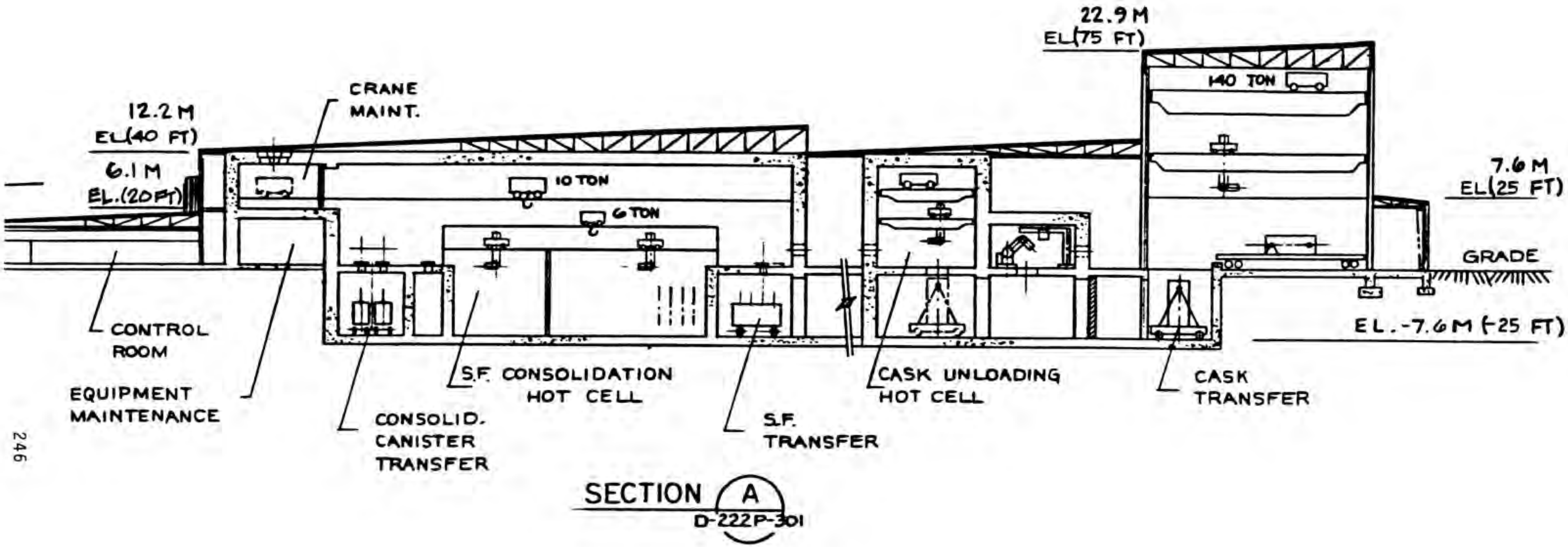


Fig. 5. Waste-Handling Building No. 2.

- o Cleanup of shipping casks on receival, and decontamination before their return to the utility plants
- o Method of waste-canister transport from waste-handling building to emplacement area
- o Design of waste-canister-retrieval equipment and operations
- o Development of tectonic characterization and design criteria
- o Assessment of natural seismicity versus weapon test ground motion
- o Development of structural designs to accommodate projections for natural or UNE ground motion

CONCLUSION

The remote location of Yucca Mountain site, present government ownership of land needed for development, limited land use, desert climate and environment, and ramp-access capability to storage rooms that are situated above the water table, represent some of the advantages of Yucca Mountain for the development of the first repository in the United States for disposal of commercial high-level radioactive waste. Project activities will concentrate on the utilization of these favorable conditions for design and construction of a secure and safe repository.

REFERENCES

1. Nuclear Waste Policy Act of 1982. Public Law 92-425, 42 USC 10101-10226, 1983.

2. 10 CFR Part 960, "General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories," Code of Federal Regulations, Title 10, Part 60.

3. DOE "Draft Environmental Assessment. Yucca Mountain Site, Nevada Research and Development Area, Nevada," DOE/RW-0012, U.S. Department of Energy, Office of Civilian Waste Management, December 1984.

4. J. T. NEAL, "Location Recommendation for Surface Facilities for the Prospective Yucca Mountain Nuclear Waste Repository," SAND84-2015, Sandia National Laboratories, Albuquerque, NM, April 1985.

5. R. RICHARDS and D. VIETH, "Land Use and Withdrawal Actions Necessary for and in Support of the NNWSI Project," U.S. Department of Energy, Nevada Operations Office, Las Vegas, September 23, 1983.

6. "Two-Stage Repository Development at Yucca Mountain: An Engineering Feasibility Study," compiled by H. R. MacDougall, SAND84-1351, Sandia National Laboratories, Albuquerque, NM, December 1984.

7. W. BERRY, Corrosion in Nuclear Applications, p. 90, Wiley & Son, 1971.