land produces some pasture, alfalfa, and small grains. Most of the farms are operated on a part-time basis with the owner working full-time at another job (DOI, 1975).

Beatty, population 800 (Smith and Coogan, 1984), is located approximately 72 kilometers (45 miles) northwest of the proposed location of the surface facilities at Yucca Mountain. Originally established during the mining boom of the early twentieth century, Beatty became an important supply center to several boomtowns after construction of the Tonopah and Tidewater railroad. Beatty was the only town to survive after early mines were abandoned (Writer's Program, 1940; DOI, 1975). Mining is now of minor importance, and Beatty has been characterized as beginning to become a retirement community (Research and Educational Planning Center, 1984).

Pahrump, located about 97 kilometers (60 miles) south and east of the proposed location of the surface facilities, has both the land and tax base to support expansion. Unlike most of Nevada, nearly 50 percent of the land is privately owned; and in the late 1960s and early 1970s, significant amounts of agricultural land were subdivided and some permanent housing was constructed. Between 1976 and 1982, the population grew at an average annual rate of 16 percent; the 1982 population was 3,965 (Mooney et al., 1982). Recent estimates showed a population of 5,500 (Smith and Coogan, 1984). Surveys of community residents indicate that almost 50 percent view the optimum Pahrump population at between 10,000 and 20,000, and that almost 20 percent would like to see the population at 20,000 to 40,000 (Mooney, et al., 1982). The proportion of construction and mining employment relative to agricultural employment increased between 1976 and 1982, and the trend has been for more residents to work in Pahrump or at the NTS rather than in Las Vegas. The proportion of retirees has also increased, while younger persons have been leaving the area (Mooney et al., 1976; 1982).

Indian Springs lies on both sides of U.S. Highway 95, adjacent to and south of the Indian Springs Air Force Base in northwestern Clark County. This location is about 95 kilometers (59 miles) southeast of the proposed location of the Yucca Mountain surface facilities. The estimated 1984 population was about 1,500 (Smith and Coogan, 1984). First known as a camping spot by California-bound 49ers seeking a cutoff from the Spanish Trail, the community later became known as Mile Post 44 on the Las Vegas-Tonopah railroad serving the Bullfrog mining district (Nauert, 1979). The town has been historically dependent on the NTS and the Air Force Base for employment (Clark County Department of Comprehensive Planning, 1980). In 1980, approximately one-third of the 1,446 residents were military personnel (Clark County Department of Comprehensive Planning, 1983b). Only limited commercial facilities are available. However, Las Vegas is within one hour's drive and the community has benefited from the sharing of some amenities and services by the Air Force base. Residents have been characterized as committed to the values of small-town rural life (Nauert, 1979). A State medium-security prison, which was designed to house 600 inmates upon completion in 1982, (DOI, 1981), is located near U.S. Highway 95 approximately 13 kilometers (8 miles) southeast of Indian Springs.

3.6.4.1.2 Social organization and structure in urban Clark County

The most striking features of Clark County are its high population growth and inmigration rates (Table 3-26). While the United States had a 1 percent average annual population growth rate in the decade between 1970 and 1980, Clark County grew at a 5.4 percent average annual growth rate (Clark County Department of Comprehensive Planning, 1983b). Also notable are the heterogeneous racial and ethnic mix and the relatively low percentage of homeowners. These data, when examined in light of the dependence of the economy on gaming and tourism, suggest a complex and transient social entity. Indicators of social stress, such as rates of homicide, divorce, and crime, which are high relative to national and regional data (Table 3-26), are inflated by the large number of nonresidents. Suicide rates for Clark and Nye counties were calculated from data on suicide by county of residence, and therefore are not inflated.

Considerable variation exists among the governmental entities that form urban Clark County. Their histories have been different, and census tract data show that social characteristics and indicators of social problems vary (DOC, 1983b). Political and economic relationships in Clark County are more formal and bureaucratic than those in rural Nye County. Metropolitan Las Vegas is the most complex social grouping in the study area, with numerous subgroups including civic and social organizations. As might be expected, those groups having the greatest stake in the economic base have played the greatest role in formulating the direction and development of the area (Greater Las Vegas Chamber of Commerce, 1981). Also significant are four Federal installations (Hoover Dam, Basic Magnesium Industries, Nellis Air Force Base, and the Nevada Test Site) that have played an important role in Clark County growth since 1930 (Clark County Department of Comprehensive Planning, 1982b).

3.6.4.2 Culture and lifestyle

Culture, as used in the following discussion, is defined as the enduring and deeply felt set of attitudes and beliefs held by an identifiable group of people. The overt part of culture is manifested in actual behavior in the institutions, associational life, artifacts, traditions, and overall life-style of the group. Essentially, however, these are the expressions of group ideas, values, and beliefs. The rich diversity of cultures and lifestyles exhibited in Nye and Clark counties is outlined in the following sections. The absence of a homogeneous culture, coupled with the large numbers of inmigrants who have been assimilated over the past few decades, are important features of the area. They suggest that a wide variety of subcultures can be easily assimilated and accepted and provide the basis for the assessment, presented in Chapter 5, of the potential impact of inmigrating repository workers on the existing cultural environment.

3.6.4.2.1 Rural culture

Available data for Nye County suggest an informal, personal organization and lifestyle. In 1982, the county supported 9 churches, 13 motels or hotels, 11 service organizations, and 5 fraternal organizations (State of Nevada, OCS, 1982b, 1985b), A rich social life can be discerned, based on less formal organizations. In addition, the Nye County government is relatively informal.

Noteworthy aspects of the rural culture include pride in a western heritage; "boom and bust" mining history; and religious, tribal, and ethnic influences. Pride in the western heritage is shown by commemorative celebrations such as Jim Butler Days in Tonopah, Amargosa Valley Days, and the Harvest Festival Rodeo at Pahrump. There are frequent reminders of the boom and bust associated with the mining activities that figured prominently in Nevada history; these include railroads that have been abandoned and ghost towns such as Rhyolite, which previously had a population of 6,000 (Paher, 1970). Nevada has the lowest percentage of church adherents in the United States (26.2 percent in Nye County, 29.7 percent in Clark County) (Quinn et al., 1982). The communities of Bunkerville, Overton, and Logandale in eastern Clark County were settled by members of the Church of Jesus Christ of Latter Day Saints (Clark County Department of Comprehensive Planning, 1982b).

Three American Indian reservations are located in rural parts of the bicounty area (Facilitators, Inc., 1980), although all are distant from Yucca Mountain. The Moapa Paiute Reservation in northeastern Clark County had a 1980 population of 185 (DOC, 1982) and is located approximately 249 kilometers (155 miles) from Yucca Mountain. The Yomba and Duckwater Shoshone reservations in northern Nye County, with 1980 populations of 60 and 106, respectively, (DOC, 1982), are approximately 322 to 467 kilometers (200 to 290 miles) and 443 kilometers (275 miles) from the proposed site, respectively. Actual distances from Yucca Mountain depend on routes selected.

3.6.4.2.2 Urban culture

The most notable aspect of Las Vegas is its image as "the Entertainment Capital of the World" (Las Vegas Review-Journal et al., 1985). The "Strip," with its high-rises, explosive colors of nightlighting, and reflective surface materials, is visually the most dominant feature of the urbanized area (Clark County Department of Comprehensive Planning, 1982b). Culturally, the influences of gaming and tourism are felt throughout the area. Las Vegas has been characterized as a city of "open dualities" (Adams, 1978) and as one where "two faces" are created by residents' separation of the gaming city from the residential city in which the emphasis is on family and neighborhood values (Elliott, 1973). The metropolitan area, with its many social and civic organizations, exhibits cultural characteristics common to cities of its size. A marked cultural diversity results from the combination of many out-of-state visitors and a high percentage of residents born outside Nevada. In addition, the Las Vegas Tribe of the Paiute Indians (1980 population 113 (DOC, 1982)) is located midway between the cities of North Las Vegas and Las Vegas, just off Main Street (Facilitators, Inc., 1980) and is approximately 161 kilometers (100 miles) from the Yucca Mountain site.

3.6.4.3 Community attributes

An important component of the quality of life in any region or community is the subjective evaluation of persons who live there. Residents' opinions about their community indicate characteristics that could be negatively or positively affected by repository activities. From these attitudes it may be possible to anticipate public reaction to repository siting.

The following data are based on two surveys of Nevada residents' attitudes toward their State. The first survey was undertaken for the Governor of Nevada and published in Report of the Governor's Commission on the Future of Nevada (State of Nevada, Governor's Commission on the Future of Nevada, 1980). The survey was not systematically distributed; however, the number of forms returned was roughly proportional to the population of each county. The second survey was undertaken by Dr. James Frey of the University of Nevada, Las Vegas, to assess citizens' perceptions of the proposed U. S. Department of the Air Force MX missile system (Frey, 1981). In this survey, a proportionate stratified random sample of counties throughout the State was selected. The sample size permitted an overall rural-urban comparison only. The proposed MX missile system would have been a significantly larger construction project than the proposed repository, employing as many as 22,000 workers at peak (Department of the Air Force, 1980).

Significant findings from the Governor's survey (State of Nevada, Governor's Commission on the Future of Nevada, 1980) included:

1. More than 70 percent of Nye and Clark County residents would like their region to grow at a slow or moderate pace.

2. The three most valued features of Nevada life for Nye County residents were the open spaces; relaxed lifestyle, freedom, and individuality; and clean air and lack of pollution. For Clark County residents, these values were climate; open spaces; and relaxed lifestyle, freedom, and individuality.

3. The most serious problems for Nye County residents were housing availability; water and sewage; and roads, transporation, and traffic. For Clark County residents, the problems were roads, transportation and traffic; crime; and the environment.

4. Changes that Nye County residents would be most unwilling to accept are reduced access to the outdoors, a deterioration in air quality, increased Federal regulation, and water scarcity. Clark County residents are most unwilling to accept a deterioration in air quality, water scarcity, reduced access to the outdoors, and increased traffic congestion.

Findings from the University of Nevada, Las Vegas, survey (Frey, 1981) included:

1. A majority of Nevadans are satisfied with their State as a place to live. Satisfaction is particularly pronounced among rural residents, 79 percent of whom rated Nevada as very desirable.

2. Urban counties most often cited crime, drug abuse, cost of food and services, and road conditions as serious problems facing communities, rural counties rated the availability of housing, medical care, recreational facilities, and the cost of food and services as serious problems.

3. Urban areas rated the friendliness of other residents, medical care, and availability of housing as specific nonproblems. Rural areas most often rated air pollution, friendliness, raising children, and police protection as specific nonproblems.

4. Although both urban and rural groups welcomed the employment that the MX project would bring, all other possible impacts of the proposed project were rated negatively. Rural groups were particularly opposed to the social disruption (crime and drug abuse, for example) they feared would accompany the project.

3.6.4.4 Attitudes and perceptions toward the repository

Attitudes and perceptions regarding the possible siting of the repository are important both in themselves and because they form the basis from which social change may occur. Attitudes are multi-dimensional and will comprise a mix of special concerns (that is, radiological risk) and standard or more general concerns regarding community growth and the expected inmigration of workers.

No publicly available survey of Nevada citizens' views on the issue of repository siting has been made. However, a recent survey of Las Vegas area residents' opinions on a variety of topics was undertaken by the University of Nevada, Las Vegas (UNLV), Center for Survey Research (UNLV, 1984). Included in the survey was one question that asked whether residents strongly favored, favored, opposed, or strongly opposed the idea of locating a nuclear waste repository "on the Test Site in southern Nevada." Almost two-thirds of those surveyed opposed the idea. Complete survey responses were: strongly favor, 6.4 percent; favor, 23.9 percent; oppose, 26.7 percent; strongly oppose, 37.4 percent; undecided/don't know, 5.6 percent (UNLV, 1984).

Citizens' views expressed during the March 1983 Las Vegas and Reno public hearings on the potential repository were reviewed as a means of discerning specific concerns of Nevada residents. A count of the issues raised, as reported in the Public Hearings Panel Report (DOE/NVO, 1983), indicates that concerns related to health and safety, transportation, and socioeconomics and community impacts, were voiced most frequently. (Issues were counted according to their location throughout Appendix C and were not restricted to their location under a particular subheading.) Many witnesses also expressed distrust of the Federal Government and a desire for public participation, concerns not restricted to the disposal of high-level radioactive waste.

3.6.5 FISCAL AND GOVERNMENTAL STRUCTURE

This section discusses the fiscal and governmental structure of the bicounty region surrounding the Yucca Mountain site. Governmental entities within Nye and Clark counties include incorporated and unincorporated towns, both rural and urban. Unincorporated towns in southern and central Nye County include Amargosa Valley, Beatty, Pahrump, and Tonopah. Incorporated cities in central and western Clark County include Las Vegas, North Las Vegas, Henderson, Boulder City. Unincorporated towns and communities in urban Clark County include East Las Vegas, Enterprise, Grandview, Lone Mountain, Paradise, Spring Valley, Sunrise Manor, and Winchester. The unincorporated town of Indian Springs is located in rural Clark County, northwest of the Las Vegas urban area. In 1983 more than half of Clark County residents and more than 90 percent of Nye County residents lived in unincorporated areas of those counties.

As noted in Section 3.6.3, the incorporated cities are generally responsible for providing public services within their boundaries, while counties, county-wide agencies, and local special-purpose districts are responsible for providing services to residents in the unincorporated areas. Within the unincorporated towns, provision of some services is coordinated by town boards, advisory councils, and town advisory boards, which are either publicly elected or appointed by the County Commission. In Nye County, three county commissioners are elected to 4-year terms from individual geographic districts. Day-to-day government operations are handled by a professional manager and staff. In Clark County, seven commissioners have jurisdiction over the unincorporated areas of the county. They are elected in even-numbered years from single-seat geographic districts, three in one election year and four the next. Clark County employs a professional manager and staff to implement commission policy.

Some local governmental entities have been granted the power of taxation by the Nevada Legislature. For example, in Clark County, specific taxing authority is held by the incorporated cities of Las Vegas, North Las Vegas, Henderson, Boulder City, and Mesquite; the Clark County School District; and a variety of special districts, including library, water, and fire protection districts. In addition, several governmental entities receive taxes or other public revenue but do not have specific taxing authority.

Revenue sources for some governmental entities in the region are shown in tables 3-27 and 3-28. Fiscal year 1982-83 was chosen to represent the most recent fiscal data in light of substantial changes in Nevada tax law during the previous legislative sessions. The presence of legalized gaming in Nevada gives the State a unique fiscal structure. Gaming revenue contributed almost $230 million to the State's general fund in the 1982-83 fiscal year (State of Nevada, OCS, 1984). This is about one-half of the 1982-83 general fund. Other major sources of State income included sales and insurance taxes (State of Nevada, 1981).

At the local level, revenue sources for the various governmental units are similar, although income from these sources varies widely. Local sources of revenue include property taxes (ad valorem taxes on real property); other taxes (city and county relief taxes, collected by the State and returned to local governments, and income from franchises granted by local governments);

licenses and permit fees (e.g., business, liquor, and local gaming licenses); intergovernmental resources (e.g., cigarette and liquor taxes, local gaming taxes, motor vehicle privilege taxes); charges for services (e.g., recreation, sewer, building inspections); fines and forfeits (court fines and forfeited bail); and miscellaneous revenues.

Table 3-27. School district general fund revenue sources for Nye and Clark counties

Revenue source	Nye County[a]		Clark County[b]	
	Amount	Percentage of budget	Amount	Percentage of budget
State	$3,700,000	59.1	$105,900,000	52.2
County	2,400,000	38.4	86,800,000	42.8
Federal	56,000	0.9	2,170,000	1.1
Other	101,000	1.6	7,800,000	3.8

[a]Data from the Nye County School District (1983).
[b]Data from the Clark County School District (ca. 1983).

Table 3-28. Local governmental revenue sources in millions of dollars in southern Nevada, 1982-1983[a,b]

Revenue Source	County: Nye (MM$)	County: Clark (MM$)	City: North Las Vegas (MM$)	City: Las Vegas (MM$)	City: Henderson (MM$)	City: Boulder City (MM$)
Property taxes	0.819 (7%)	51.0 (14%)	9.17 (8%)	1.2 (4%)	0.382 (2%)	0.084 (1%)
Other taxes	2.34 (20%)	56.1 (16%)	6.85 (6%)	4.68 (16%)	0.616 (3%)	1.47 (18%)
Licenses and permits	0.237 (2%)	34.0 (10%)	7.07 (6%)	1.79 (6%)	0.783 (4%)	0.183 (2%)
Intergovernmental resources	2.42 (21%)	15.9 (5%)	62.6 (57%)	11.0 (36%)	5.16 (23%)	1.68 (20%)
Charges for services	4.74 (41%)	139.0 (39%)	19.3 (18%)	9.38 (31%)	0.240 (1%)	4.43 (53%)
Fines and forfeits	0.07 (<1%)	2.38 (<1%)	2.06 (2%)	0.964 (3%)	0.225 (1%)	0.056 (<1%)
Miscellaneous	0.838 (7%)	57.7 (16%)	3.47 (3%)	1.33 (4%)	14.8 (67%)	0.481 (6%)
TOTAL	11.5	356.1	110.5	30.5	22.2	8.4

[a] Data from Schedule S-1, State of Nevada Department of Taxation (1983).
[b] All percentages are of total revenue and, because of rounding, may not add to 100 percent in each column.

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CODES AND REGULATIONS

10 CFR Part 20 (Code of Federal Regulations), 1984 Title 10, "Energy," Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, D.C.

40 CFR Part 141 (Code of Federal Regulations), 1982 Title 40, "Protection of Environment," Chapter 1, Subchapter D, "Water Programs" Part 141, "National Interim Primary Drinking Water Regulations," U.S. Government Printing Office, Washington, D.C.

EXPECTED EFFECTS OF SITE CHARACTERIZATION ACTIVITIES

Before a site can be finally judged suitable for development as a repository, extensive geologic and hydrologic data describing it must be collected. At none of the nine potentially acceptable sites have enough data been collected to make such a judgment possible. The U.S. Department of Energy (DOE) will therefore carry out a program of site characterization to collect the needed data.* Such a program is required by the Nuclear Waste Policy Act of 1982 (NWPA, 1983) (the Act), by the regulations promulgated for repositories by the Nuclear Regulatory Commission in 10 CFR Part 60 (1983), and by the implementation guidelines that are included in the DOE siting guidelines (10 CFR Part 960, 1984). In accordance with the Act, the program will be carried out at the three sites selected through the process described in Chapter 1. The impacts that site characterization would exert on the environment of the Yucca Mountain site, if the site is one of the three selected, are described in this chapter.

A major part of this characterization will be the investigations performed in an exploratory shaft facility. At each of the three sites, two shafts will be sunk deep below the surface, to approximately the level where a repository could be built. Underground drifts connecting these shafts and underground rooms will also be excavated. In these rooms and in the shafts, the DOE will conduct tests and make experimental measurements that will supply data needed for fully characterizing the site.

Other studies of the site will also take place during site characterization. They will include additional geologic, geophysical, and hydrologic investigations, both at the ground surface and in boreholes not connected with the exploratory shaft facility.

Concurrently with site characterization, the DOE will conduct a site investigation program to collect nongeologic information important in determining the suitability of the site. Included in this program will be studies of environmental conditions (e.g., the weather, the quality of the air, plant

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* The Nuclear Waste Policy Act of 1982 defines site characterization as "... activities, whether in the laboratory or in the field, undertaken to establish the geologic condition and the ranges of parameters of a candidate site relevant to the location of a repository, including borings, surface excavations, excavations of exploratory shafts, limited subsurface excavations and borings, and in situ testing needed to evaluate the suitability of a candidate site for the location of a repository, but not including preliminary borings and geophysical testing needed to assess whether site characterization should be undertaken ..." (NWPA, 1983).

and animal communities, and noise levels); archaeological, cultural, and historical resources; population density and distribution; the transportation network; and social and economic conditions in the area that could be affected by the repository.

Before beginning to sink the exploratory shafts, the DOE is required by the Act to prepare a Site Characterization Plan that is to include a description of the site; a description of the site characterization activities, including the extent of planned excavations and plans for any onsite testing; and plans for the decommissioning of the exploratory shaft facility as well as the mitigation of any significant adverse environmental impacts caused by site characterization if the site is not selected for repository development. This plan is to be submitted for review and comment to the Nuclear Regulatory Commission, the Governor and the legislature of the State, and the governing body of any affected Indian Tribe; it is also to be made available to the public. Furthermore, the Act requires the DOE to hold public hearings in the vicinity of the site selected for characterization to inform the residents of the area of the Site Characterization Plan and to receive their comments.

During site characterization, the DOE is required by the Act to report at least once every 6 months to the Nuclear Regulatory Commission and to the State or any affected Indian Tribe about the nature and extent of the site characterization activities and the information developed from such activities.

The data-gathering activities planned during site characterization are described in Section 4.1. The environmental effects expected from these activities are described in Section 4.2; these effects will be due mainly to the exploratory shaft facility, the construction of which will require extensive work at the site. The last section of this chapter (4.3) describes alternative site characterization activities that might be undertaken to avoid the expected impacts.

4.1 SITE CHARACTERIZATION ACTIVITIES

This section contains a description of the site characterization activities currently planned for the Yucca Mountain site. The activities consist primarily of field studies, the construction of the exploratory shaft facility, and the tests conducted in that facility. Other studies that would be performed to characterize the site are also discussed, even though they have little or no potential for environmental impacts. All site characterization activities are currently scheduled to be completed within 55 months.

4.1.1 FIELD STUDIES

Since 1978, the U.S. Department of Energy (DOE) has been conducting tests and surveys in the vicinity of the Yucca Mountain site to obtain preliminary information on the geologic, hydrologic, and geophysical characteristics of the site and the surrounding area. These tests and surveys include exploratory drilling and testing, the geomechanical testing of core samples, geophysical surveys, and geologic mapping. Similar tests and surveys would continue to be conducted if Yucca Mountain is recommended for site characterization.

4.1.1.1 Exploratory drilling

Exploratory drilling and testing activities provide data that allow the three-dimensional characterization of the geologic, hydrologic, and geochemical characteristics of the site and the surrounding area. By drilling exploratory holes one can (1) collect cores, describe the geology of the cores, and analyze the geochemical and physical properties of the cores; (2) investigate geophysical properties below the surface; (3) measure in situ stress; (4) test hydraulic conditions beneath the water table; (5) test and monitor the unsaturated zone; and (6) collect water samples for chemical analysis.

Since 1978, the U.S. Department of Energy (DOE) has drilled several exploratory holes and conducted geologic and hydrologic investigations at Yucca Mountain. Because a site characterization plan has not been completed for the Yucca Mountain site, the following assumptions, which represent the best estimates currently available, have been made for the purpose of assessing the type and magnitude of impact that might be expected from further exploratory drilling if Yucca Mountain is recommended for site characterization:

- Twenty new exploratory holes would be drilled from surface-based drill pads to complete the characterization of the site's hydrologic and geologic conditions.

- The new exploratory holes would be drilled within 8 kilometers (5 miles) of the Yucca Mountain site.

- An access road 8 kilometers (5 miles) long would be constructed to each drill pad. This is a worst-case assumption used for calculating environmental impacts.

- Access roads would be bladed smooth, boulders would be pushed aside, fill dirt would be added as required, hillside cuts would be made where required, and some roads would be graveled.

- Road width, including shoulders, would average 15 meters (50 feet).

- Roads would be sprinkled with water both to aid in soil compaction and to provide dust control.

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

Equipment and facilities that would be used at the drill site include a diesel-powered drill rig, pumps for circulating the drilling fluid, drill pipe, drilling and coring tools, two trailers for supervisory and laboratory space, an electric generator, and an air compressor. Solid waste would be hauled from the site to an existing landfill on the Nevada Test Site (NTS). The water that would be used for drilling, dust suppression, compaction, and human consumption would be trucked daily to the drill site. Waste drilling fluids and cuttings would be confined in the mud-and-cuttings pits.

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

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

Any radioactive sources used in the logging or hydrologic tests would be licensed by the Nevada Division of Radiologic Health. The licensing of these sources requires that the contractor receive formal training in radiological safety and in the use of the logging tool. In addition, the NTS radiation safety program that governs activities at the site has safety and use requirements that are comparable to those required by the State.

4.1.1.2 Geophysical surveys

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

Seismic reflection and refraction surveys are made by sending sound waves through earth materials. Either seismometers or geophones are then used to detect, amplify, and record the sound-wave patterns. The sound waves are reflected and refracted when they encounter materials with different rock properties (e.g., density and sonic velocity) as they travel from the seismic source to the receiver. The resultant seismic reflection and refraction patterns are mathematically analyzed and are used to determine the types of rock materials and three-dimensional structures that would be expected to produce the observed patterns.

Seismic reflection surveys at Yucca Mountain have been conducted by using dynamite charges set off in shot holes that were drilled in a linear pattern. These holes did not require drill pads; however, it was necessary to clear some vegetation for vehicle access and geophone positioning. Another type of seismic reflection survey was conducted in the eastern foothills of Yucca Mountain. Low-frequency sound waves were generated by using large, four-wheel-drive trucks specially designed with large plates attached to their bottoms. Hydraulic jacks were used to press the plate against the ground while simultaneously lifting and vibrating the truck on the plate. Data were recorded from geophones that were placed in an array on the ground surface at specific distances from the trucks. Similar seismic reflection studies may be conducted during site characterization.

A seismic refraction survey was conducted as part of the preliminary investigations of Yucca Mountain. For this survey, a north-south line approximately 80 kilometers (50 miles) long was selected in the eastern portion of Crater Flat. A truck-mounted rig was used to drill holes for emplacing explosives, which were detonated to generate sound waves. An array of geophones was deployed to collect the refraction data. Another refraction survey was conducted east of Yucca Mountain along the road to Drill Hole Wash. Small drill pads were constructed and holes were drilled for the emplacement of explosives. Similar seismic refraction surveys may be conducted during site characterization.

Gravity surveys are conducted to detect subsurface geologic structures by measuring small differences in the strength of the earth's gravitational field. Positive and negative gravity anomalies, which are the result of differences in the density of underlying rock materials, are recorded and interpreted. Gravity measurements are taken at discrete locations defined by a grid system consisting of cells that are typically 60 by 60 meters (200 by 200 feet). Off-road vehicles are used to get to the sites of gravity surveys. Some gravity surveys have already been made in the Yucca Mountain area, and additional surveys are planned during site characterization.

Magnetic surveys are conducted to measure differences in the earth's magnetic field from place to place and are used to determine the subsurface configuration of rocks with different magnetic properties. Magnetic surveys may be conducted from the ground. Off-road vehicles are used to get to these sites. Magnetic surveys may also be conducted from specially equipped aircraft. Both survey methods have been used at Yucca Mountain, and additional surveys are planned during site characterization.

A number of other geophysical techniques may be used to enhance the understanding of the position and the characteristics of subsurface rock units. Electrical surveys that measure the characteristics of earth materials that affect the passage of natural and induced electrical currents (e.g., resistivity, self-potential) have been made in the vicinity of Yucca Mountain. Another technique, commonly used in the petroleum industry, is vertical seismic profiling (VSP). This technique is useful for mapping fractures and for determining the extent of interconnection between the fractures. The attenuation of high-frequency electromagnetic waves by fluid-filled fractures has also been used successfully to map fractures. Off-road vehicles are commonly used to travel to the sites of electrical and other surveys.

4.1.1.3 <u>Geologic mapping</u>

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

4.1.1.4 <u>Standard operating practices for reclamation of areas disturbed by field studies</u>

When the U.S. Department of Energy (DOE) determines that an exploratory hole is no longer needed for gathering data, the exploratory hole will be sealed. State of Nevada requirements, as well as cooperative agreements with the Bureau of Land Management (BLM) (BLM/DOE, 1982) and the Department of the Air Force (1985), call for the proper sealing and capping of exploratory holes upon abandonment or termination of DOE activities at the site. All exploratory holes that are not currently being used are capped temporarily. If a decision is made to abandon an exploratory hole, the hole will be sealed according to accepted practice. If any specific sealing requirements are necessary, they would be determined using the data obtained during site characterization. A permanent marker that gives pertinent data about the exploratory hole would be emplaced after surface restoration.

Standard operating practices for reclamation and habitat restoration include the following:

1. Removing and disposing of concrete and surface debris from drill pads to a landfill at the Nevada Test Site (NTS).

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

3. Filling the mud-and-cuttings pit with stockpiled topsoil after the removal of drilling fluids or sludge, as appropriate.

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

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

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

Because reclamation and habitat restoration in fragile, arid ecosystems are not completely understood and because long periods of time are required to reestablish mature vegetation associations, the effectiveness of habitat restoration is not clear. Consequently, each practice previously identified would be individually evaluated and adjusted in response to continuing restoration studies.

About 10 hectares (25 acres) of land surface would be disturbed for geophysical and geological surveys. The disturbed exploration areas and off-road vehicle paths would be disked to relieve compaction and to encourage revegetation. Geologic trenches would be filled with the material removed during excavation, and the land would be restored to its original contours. If appropriate, the recontoured surface would be treated to encourage moisture retention and to hasten revegetation, based upon the results of habitat-restoration studies.

4.1.2 EXPLORATORY SHAFT FACILITY

If Yucca Mountain is approved for site characterization, the U.S. Department of Energy (DOE) will construct an exploratory shaft facility to provide access for detailed study of the potential host rock as well as the overlying and underlying strata. The excavation and construction of this exploratory shaft facility would be the primary source of potential environmental impacts during site characterization. The exploratory shaft facility would consist of (1) an exploratory shaft large enough for the transport of people, materials, and equipment (inside finished diameter of 3.7 meters (12.1 feet)), (2) underground testing areas, (3) a secondary egress shaft (inside diameter of 1.8 meters (5.9 feet)), and (4) the surface facilities needed to support construction and testing (Figure 4-1). Both shafts would extend slightly beyond the proposed depth of the repository. The underground testing areas would be excavated from breakout rooms at three levels. A main test facility with drifts and rooms would be excavated into the host rock from the middle breakout room. The secondary egress shaft would be used for ventilation and would provide another means of egress from the underground areas. It would be connected to the exploratory shaft by a drift. Exploratory holes would also be drilled as a part of the exploratory shaft testing program.

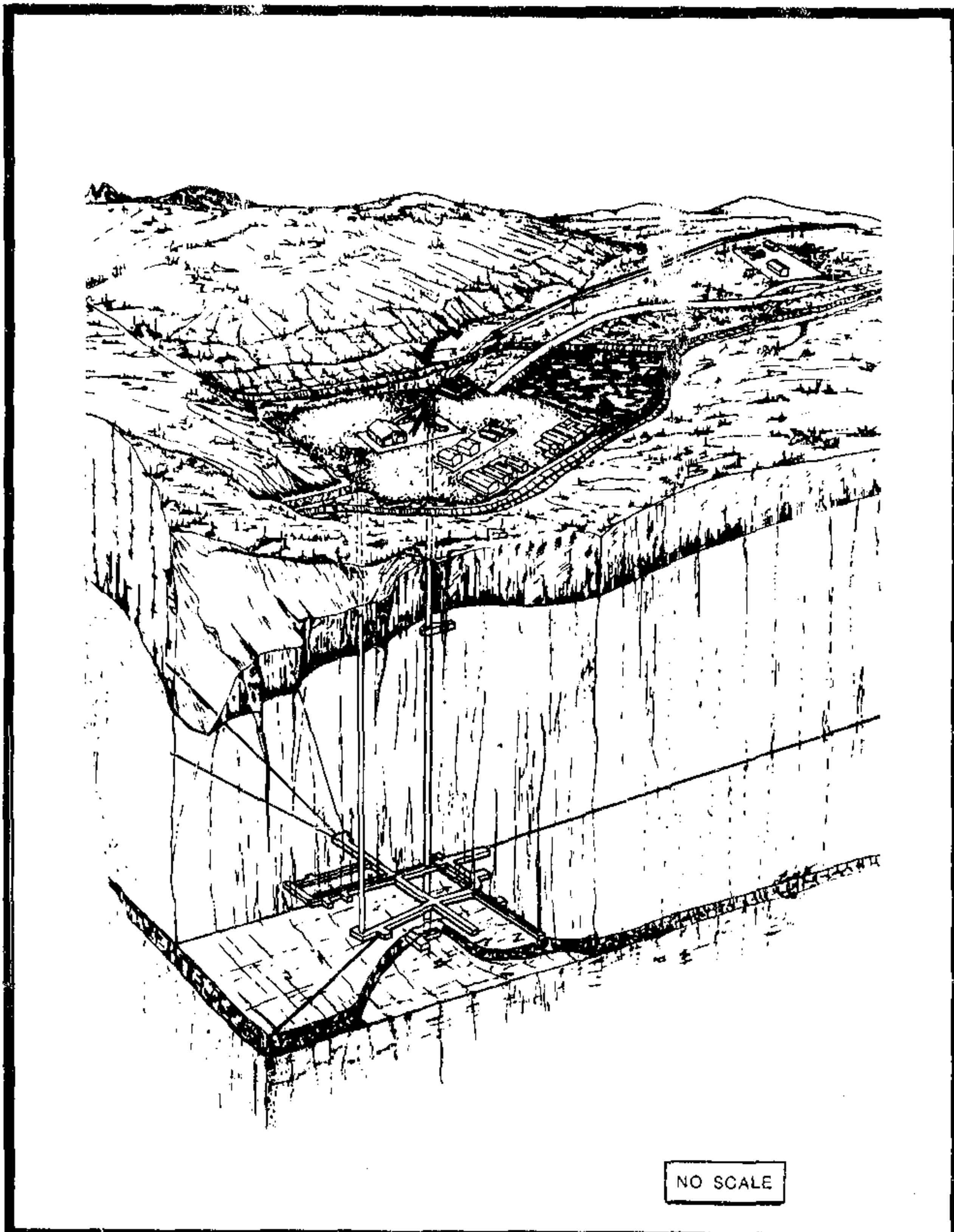

Figure 4-1. Three-dimensional illustration of the exploratory shaft facility.

The exploratory shaft facility would be located in Coyote Wash on the eastern side of Yucca Mountain at an elevation of about 1,300 meters (4,200 feet). Figure 4-2 shows the proposed site, utility lines, and the access road. It also shows the administrative boundaries of the Nevada Test Site, the Nellis Air Force Range, and the Bureau of Land Management. This site was selected from five sites that were considered as possible locations for the exploratory shaft (Bertram, 1984). The secondary egress shaft would be located about 85 meters (280 feet) southwest of the exploratory shaft. The site plan at Coyote Wash is shown in Figure 4-3.

Facility design and construction specifications require that equipment and systems meet the requirements set forth by the DOE (1983); applicable local, State, and Federal regulations (Section 6.2.1.6); and national standards. It is also required that construction disturb only the minimum amount of land necessary to accomplish the project. Design criteria include considerations of site restoration; the site would be restored to approximately its original condition if Yucca Mountain is eliminated from the list of potential repository locations. Portions of the facility may alternatively be preserved for other uses. The following sections describe the presently conceived exploratory shaft facility, the plans for testing, and the practices being considered to minimize environmental damage.

4.1.2.1 Surface facilities

Construction of the surface facilities is expected to take from six to seven months to complete. The site would first be cleared and graded; then it would be stabilized with 15 centimeters (6 inches) of gravel.

As shown on Figure 4-3, two existing natural drainage channels would be diverted to control potential runoff from a probable maximum precipitation event. In 1982 the drill pad for the principal borehole, USW G-4, was constructed at the exploratory shaft facility location. Site preparation would require cut and fill to provide a level pad (the exploratory shaft site pad) for the surface structures and for the parking area. About 70,000 cubic meters (2,500,000 cubic feet) of fill material would be removed from borrow areas east and west of the pad. Both the exploratory shaft and the secondary egress shaft would be located on this exploratory shaft site pad. In addition, an auxiliary pad would be located about 240 meters (800 feet) to the east of the main pad and would be used for a visitor center and to accommodate support buildings, trailers, and additional parking. The surface area that would be required for all of the exploratory shaft facilities is about 8 hectares (20 acres).

The parking area and the access road would be paved with a double oil-and-chip layer. Access to the exploratory shaft site pad from the east would be controlled by a chain-link fence and gates; the natural terrain provides a barrier to vehicle access from elsewhere on the site. The access road from Jackass Flats has been improved to the boundary of the Nevada Test Site (NTS) to accommodate heavy equipment. The road is 7 meters (23 feet) wide, has 1-meter (3-foot) shoulders, and is surfaced with a double oil-and-chip layer.

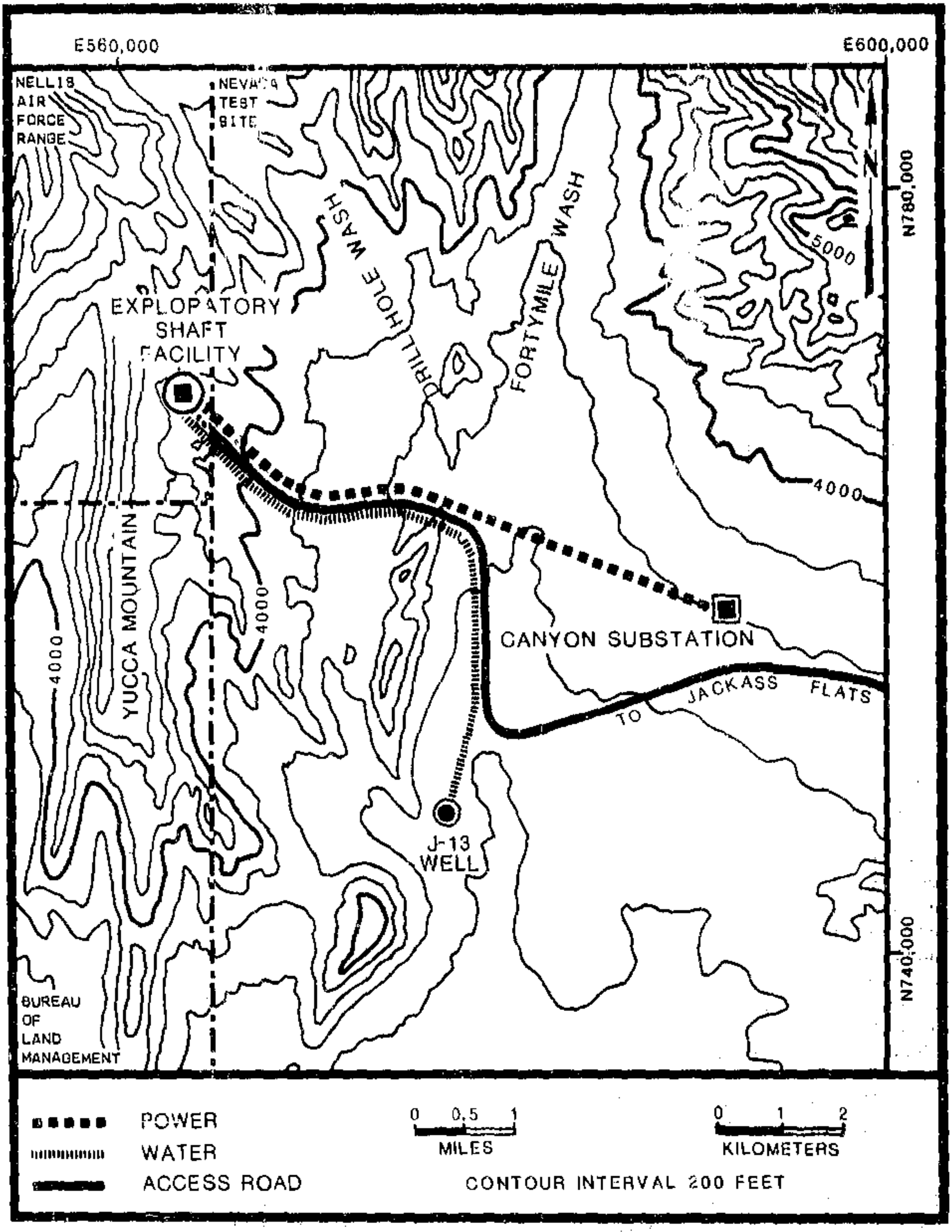

Figure 4-2. Location of proposed exploratory shaft facility and utilities.

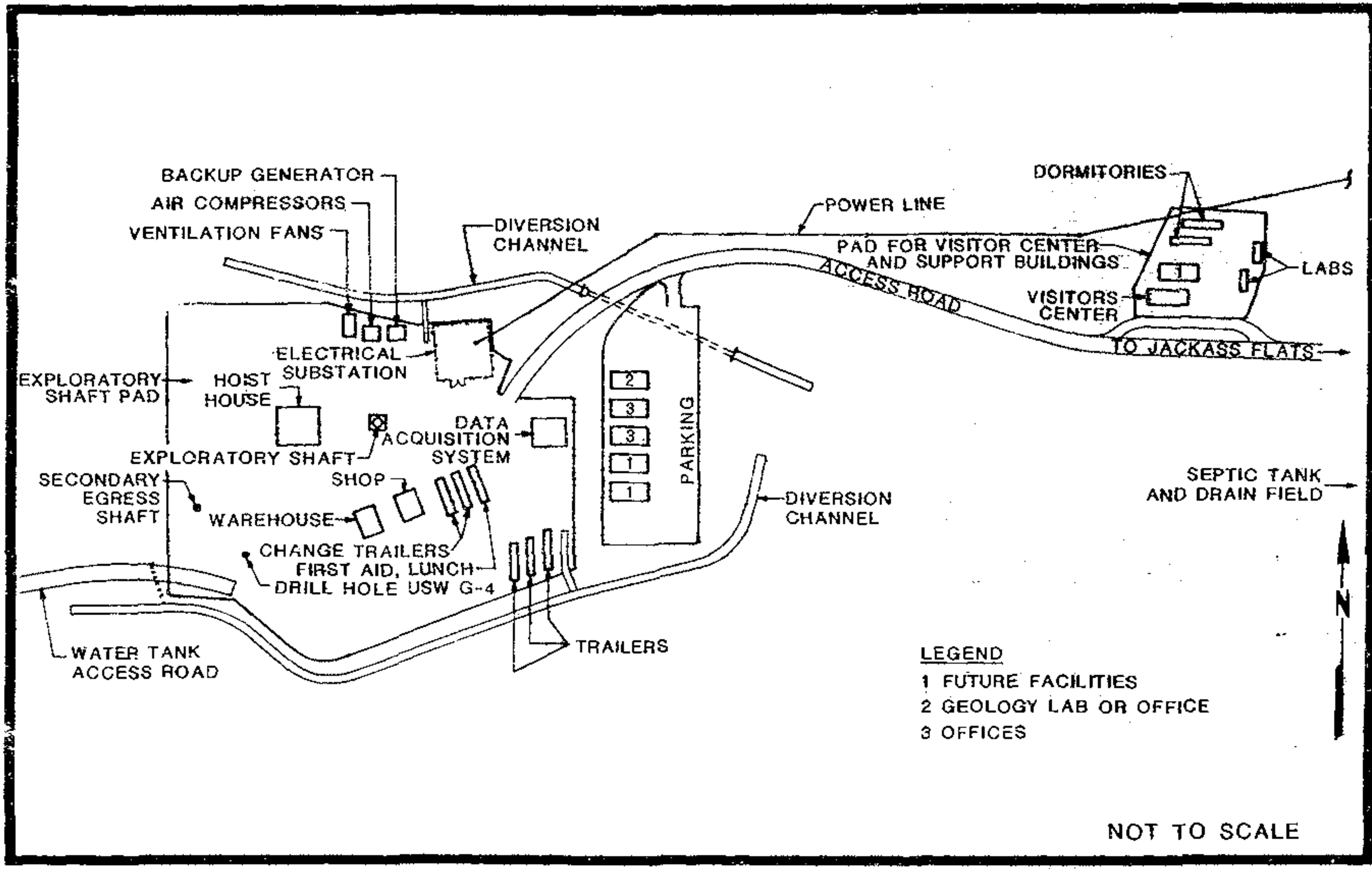

Figure 4-3. Site plan for exploratory shaft facility.

The remaining 400 meters (1,300 feet) of the road to the exploratory shaft site pad would be constructed on fill to maintain a grade that would not be greater than 10 percent. This road would disturb a path 50 meters (160 feet) wide, including drainage channel modification.

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

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

The utilities and communication systems would consist of (1) aboveground electrical supply and underground distribution; (2) emergency electrical supply; (3) water supply and distribution; (4) sanitary, industrial, and refuse waste collection and disposal; and (5) telephone communications. The normal supply of electrical power would be provided by a substation to be constructed at the site. Power for this substation would be supplied from an existing 69-kilovolt overhead power line extending from Canyon Substation in Jackass Flats to the NTS boundary 10 kilometers (6.2 miles) away (Figure 4-2). The site substation would include a 5-megawatt transformer to supply 4.16-kilovolt power to the hoists and air compressors, and secondary transformers to supply 480-volt, 220-volt, and 110-volt power to the other surface facilities. The substation would require cutouts, distribution panels, conduit and wire, fencing, trenching, and some concrete work. A second power line would be placed on the same aet of poles as the 69-kilovolt line to supply 4.16 kilovolts to a booster station to pump water to the site. Area flood-lights on wood poles would provide night lighting. To provide a backup source in the event of power failures, an emergency power generation system would be provided; it would consist of two 500-kilovolt-ampere diesel generators.

The water supply would be pumped from existing Well J-13 on the NTS through a 10-kilometer (6.2-mile) long, 15-centimeter (6-inch) diameter polyvinylchloride pipe buried about 0.6 meter (2 feet) below grade. The pipeline, constructed in the bed of the old access road to the NTS boundary, is adjacent to the new paved road. One pumping station is at Well J-13 and a booster pumping station is at about the half-way point (based on elevation). Water would be pumped to a 600-cubic meter (150,000-gallon) water tank located 500 meters (1,600 feet) west of the site at an elevation of 1,320 meters (4,325 feet). The water distribution system from the tank would supply water for all needs at the exploratory shaft facility, including fire protection.

Sewage will be disposed of by means of collection piping from all buildings and trailers to a septic tank and drain field located east of the exploratory shaft facility (beyond the perimeter of the proposed repository subsurface facility). Rock removed from the underground workings will be stored in a rock-storage pile. The location of the rock-storage pile has not yet been determined, but it will be placed to the east of the exploratory shaft facility beyond the perimeter of the proposed repository subsurface facility. The rock debris removed from the construction of the shafts, from breakout rooms, from the drift connecting the two shafts, and from the main underground test facility would be transported to the surface and hauled to the rock-storage pile. The 0.6-hectare (1.5-acre) rock-storage pile area would be sufficient to accommodate the 39,000 cubic meters (1,300,000 cubic feet) of broken rock that would be produced during shaft and drift mining. Dust from the dumping operation would be controlled by appropriate wet suppression techniques. Water and other fluids that would be used for core drilling, including air-water mist, bentonitic mud with water control agents, and polymer foam would be disposed of on the rock-storage pile. The rock-storage pile will be bermed and lined with an impermeable liner to minimize discharge of these fluids to the surface or to the ground water. This berm would be designed to contain a volume of 1,400 cubic meters (375,000 gallons) of liquid. Solid refuse would be hauled to an existing landfill on the NTS.

A concrete batch plant would be established to provide for storage and mixing of the materials that would be used to make concrete and grout for site characterization activities. Concrete would be used for building foundations, drilling pads, and the exploratory shaft liner. Grout would be used in conjunction with the steel liner in the secondary egress shaft. Approximately one acre will be cleared for the batch plant. Aggregate (crushed rock), sand, and perhaps cement would be stored in this area. These materials would be mixed with water to make concrete and grout. Water would also be used to wash out the trucks that would be used to mix and carry the concrete and grout. Both the washdown water and the batches that do not meet specifications would be disposed of on the rock-storage pile. Some equipment and trucks may be washed down at the batch plant, and the wash water may be disposed of at the batch plant site. Approximately 110 cubic meters (30,000 gallons) of water may be used for washdown during surface and subsurface construction.

The ventilation fans located at the surface would be capable of providing 1,135 cubic meters per minute (40,000 cubic feet per minute) of air to the underground workings. The ventilation system would meet all the requirements of the Tunnel and Mine Safety Orders of the State of California as specified by the U.S. Department of Energy (DOE) orders 5480.1A and 5480.4 (DOE, 1981, 1984). With a rock temperature of 27°C (80°F) at the 370-meter (1,200-foot) depth, the system would maintain underground temperatures at a level that is suitable for a work regimen of 75 percent work and 25 percent rest. The fans would have reverse-flow capability to exhaust smoke, fumes, and dust from blasting in the underground workings. Shaft ventilation after blasting (smoke-out) would normally be accomplished by sucking out the gases produced by the blasting before they have a chance to diffuse throughout the drift.

Backup fans and emergency power for the ventilation system would also be provided. Two air compressors would supply primary and backup capability for air drilling of underground boreholes. Each would have a capacity to compress 40 cubic meters per minute (1,500 cubic feet per minute) of free air to a gauge pressure of 860 kilopascals (125 pounds per square inch) on a sustained basis. This system would include foundations, electrical supply controls, and distribution piping. The air compressors would be located near the power substation to separate the shaft and buildings from the noise.

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

4.1.2.2 Exploratory shaft and underground workings

The current plans are to mine the exploratory shaft to a total depth of about 450 meters (1,480 feet), which is about 23 meters (75 feet) below the contact between the overlying Topopah Spring Member and the underlying tuffaceous beds of Calico Hills. This total depth would provide about 15 meters (50 feet) of penetration into the pervasively zeolitized interior of the Calico Hills unit and would leave undisturbed a minimum thickness of about 85 meters (280 feet) of the Calico Hills unit above the water table. The design diameter of the excavated shaft is 4.3 meters (14.1 feet), and the finished diameter would be 3.7 meters (12.1 feet).

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

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

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

4.1.2.3 Secondary egress shaft

The location of the secondary egress shaft relative to the exploratory shaft is shown in Figure 4-3. According to the current plans, a 200-millimeter (8-inch) pilot hole would be drilled from the surface using a down-hole compressed-air hammer drill. Because this type of drill uses air in the drilling process instead of a water-based drilling fluid, it avoids introducing water into the host rock. The pilot hole would be drilled to a depth of 370 meters (1,200 feet), which is the depth of the main underground test facility. A dust-filtering system would be used to catch airborne dust.

The pilot hole would be expanded from 200 millimeters (8 inches) to 2.1 meters (7 feet) by raise boring (a mining technique involving drilling upward with the drilling rig at the surface). Before the expansion of the pilot hole, a 3.7- by 3.7-meter (12- by 12-foot) drift would be mined from the exploratory shaft test level to the bottom of the pilot hole. From there, the pilot hole would be raise bored creating the secondary egress shaft. The rock debris would be removed through the exploratory shaft and would be dumped on the rock-storage pile.

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

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

4.1.2.4 Exploratory shaft testing program

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

A number of assumptions have been established to provide a consistent basis for planning the exploratory shaft testing program. These assumptions include

1. The underground workings would be restricted to the unsaturated zone beneath Yucca Mountain.

2. The candidate host rock would be the densely welded Topopah Spring Member of the Paintbrush Tuff.

3. The tests that would be conducted would be focused on obtaining site characterization information necessary for licensing.

4. The tests would be planned to provide timely input for assessing the long-term performance of the site.

All exploratory shaft construction, operations, and maintenance functions would be performed in accordance with applicable Federal, State, and Nevada Test Site (NTS) safety codes and procedures.

The tests in the exploratory shaft facility that are being considered at this time can be grouped into two general categories

1. Construction phase tests: Tests that would be initiated concurrently with shaft sinking (some construction phase tests would continue into the in situ test phase).

2. In situ phase tests: Tests that would be initiated after shaft sinking is complete.

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

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

The remaining five tests would be at selected depths. These tests represent nonroutine operations and would require planned pauses in shaft sinking operations of from several hours to several days. The five tests are (1) vertical coring; (2) lateral coring to confirm the adequacy of geologic and hydrologic conditions before constructing breakouts at the 160-meter (520-foot) level, at the 370-meter (1,200-foot) level, and at the shaft bottom at 450 meters (1,480 feet); (3) overcore drilling to measure in situ stress conditions; (4) the breakout room tests to assess the constructibility and the stability of repository-sized drifts; and (5) shaft-convergence tests between the 160-meter (520-foot) and 370-meter (1,200-foot) breakouts.

Fifteen in situ phase tests are currently planned. These tests would begin after the shaft has been completed to the required depth. Most of the in situ tests would be at the 370-meter (1,200-foot) level. The in situ phase tests can be grouped into six categories according to the site information that would be obtained. Geologic information on fracture frequency and orientation would be obtained by mapping the walls of the drifts in the testing area. Lateral coring would provide geologic information on the continuity and structure of the proposed host rock. Hydrologic data would be obtained from permeability and infiltration tests both in the Topopah Spring Member and in the underlying tuffaceous beds of Calico Hills. Geochemical tests would investigate the potential for retardation of radionuclide movement by various physical and chemical sorption processes. Geomechanical tests would simulate the effects on the host rock of the temperature increases caused by the heat emitted by the emplaced waste. Tests are also planned to assess the stability of mined openings and to make other in situ measurements required to design a safe repository. The tests in the remaining category would investigate the physical and chemical characteristics of the emplacement environment to provide information necessary for proper design of waste disposal containers and engineered barriers.

4.1.2.5 Final disposition

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

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

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

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

Because final decisions about techniques for shaft sealing may require data from site characterization, the following decommissioning strategies are only representative of those that might be implemented:

1. If an alternative use for the exploratory shaft facility is identified before decommissioning, a limited "standby decommissioning" would occur after site characterization. The utilities and ventilation system would be left in place, and periodic maintenance would preserve the structural integrity of the facility. Adequate surface physical security would be retained to prevent unauthorized access and accidents.

2. A second strategy that would preserve the exploratory shaft facility for future use entails removing the utilities and any salvageable materials from the interior of the facility and welding steel covers over the openings to prevent accidents or unauthorized access. After reclamation and habitat restoration of the surface, the sealed facility would be marked to identify pertinent history and details of the excavation. This sealing option would require a minimum degree of security to protect the shafts from vandalism and accidents.

3. A third decommissioning strategy includes removing all utilities and salvageable material from the underground workings and closing both shafts by backfilling with material removed during the initial excavation. Depending upon the backfill technique used, about 50 percent of the rock debris removed from the facility would be used for backfill. Horizontal and vertical boreholes in the shafts would be sealed with an appropriate cement-based grout as required. The composition of sealing grout and the need for it would be clarified during site characterization. After the closure of the shafts and restoration of the surface, a small concrete structure containing a marker would be installed to record the pertinent history and details of the excavation.

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

A variety of subsurface utilities, such as the water supply line, water distribution and collection pipes, and electrical cables, would have been installed for the exploratory shaft facility. The excavation and removal of these utilities are generally more costly and more environmentally disturbing than leaving them buried in place. Consequently, if the site is abandoned, any portion of the utilities that extends above the ground would be cut off below grade, and the structures would be covered during the reclamation of the surface. Other subsurface structures would be backfilled and closed if no longer needed, using generally accepted procedures.

4.1.2.6 Standard operating practices that would minimize potential environmental damage

Reclamation and habitat restoration would follow the practices described in Section 4.1.1.4. In addition to these procedures, the rock-storage pile would be stabilized by reducing slope angles and applying either available topsoil or fill to encourage revegetation.

It is not likely that the improved roads, developed to provide access to the exploratory shaft site, would be reclaimed. Not only would restoration be more disruptive to the area than abandoning the road but also future activities on the Nevada Test Site (NTS) could benefit from the access provided by the improved roadways.

Other standard operating practices that would be implemented during site characterization include the following:

1. Containing fluids and effluents generated during site characterization in either the rock-storage pile or the sewage system and establishing a leachate monitoring program for the rock-storage pile.

2. Stockpiling topsoil so that during later reclamation the seed bank and the beneficial soil microorganisms might be used advantageously (if recommended by future restoration studies).

3. Controlling slope angles to minimize erosion and to stabilize slopes.

4. Using scarification and microtopographic features to promote moisture retention on disturbed areas (if recommended by future restoration studies).

5. Seeding disturbed areas with native and naturalized winter annuals and planting native shrub seedlings (if recommended by future restoration studies).

6. Siting borrow pits where the least damage would occur.

7. Implementing field studies before construction activities begin to identify and avoid Mojave fishhook cacti and desert tortoises.

8. Reducing dust by spraying with water, by using dust-binding agents, or by paving some roads.

9. Spacing surface facilities and clearing vegetation in the vicinity of the facilities to reduce fire potential.

10. Avoiding or salvaging archaeological sites and establishing a 50-meter (160-foot) buffer zone around significant archaeological sites near construction locations. Restricting off-road travel and informing workers of policies regarding archaeological sites and of the penalties for unauthorized collection and excavation of these sites.

4.1.3 OTHER STUDIES

Some ongoing activities, including both field and laboratory studies, would be continued during site characterization. These activities are perceived to have little or no potential for environmental impacts. Among them are studies of past hydrologic conditions, paleohydrology, tectonics, seismicity, volcanism, and ground motion induced by weapons testing. Field experiments would be conducted in the G-Tunnel facilities at Rainier Mesa (Figure 2-7). Laboratory analyses of cores and water from boreholes would be made. The repository-sealing technology developed in the laboratory would be tested in the field, and techniques for dry horizontal drilling would be developed to provide that capability if it is required in the exploratory shaft. Each of these studies is discussed below.

4.1.3.1 Geodetic surveys

Geodetic surveys to monitor any tectonic movements that may occur in the Yucca Mountain area began in 1983 and would be continued during site characterization. The surveys use a 70-kilometer (43-mile) level line that extends from the southwest corner of Crater Flat at U.S. Highway 95 along existing roads in Crater Flat; crosses Yucca Mountain, Jackass Flats, and Skull Mountain; and finally ends in Rock Valley. In addition, a quadrilateral network has been installed across selected faults in the Yucca Mountain area. Both the installation of bench marks and the initial survey were completed in June 1983. A resurvey was made near the end of 1983, and yearly resurveys will be made to measure changes, if any, of the Earth's crust in this area. Wherever possible, the required bench marks were installed along existing roadways. However, some were installed where no roads existed. Future access to these bench marks would require the use of either an off-road vehicle or a helicopter.

4.1.3.2 Horizontal core drilling

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

4.1.3.3 Studies of past hydrologic conditions

Potential future changes in the regional ground-water system are being estimated on the basis of studies of past climates. These studies include investigation of the paleohydrology of the Amargosa Desert, coring of lake sediments in southern Nevada, and studies of fossilized packrat middens that help in describing the late Quaternary climates. It is expected that these studies would continue during site characterization.

4.1.3.4 Studies of tectonics, seismicity, and volcanism

The potential for faulting, earthquakes, volcanic activity, and accelerated erosion in the Yucca Mountain area is being assessed. These studies include investigating the rate, intensity, and distribution of faulting; monitoring and interpreting present seismicity; studying the history of volcanism; and evaluating past rates of erosion and deposition. Volcanic and tectonic studies focus on the history of Pliocene and Pleistocene activity within the southern Great Basin and particularly, the Yucca Mountain region. These studies use data from boreholes, trenches, mapping, geophysical surveys, and seismic-monitoring stations, and they would be continued during site characterization.

4.1.3.5 Studies of seismicity induced by weapons testing

The purpose of these investigations is to measure the ground motion at Yucca Mountain caused by underground nuclear explosions at the Nevada Test Site (NTS). These investigations relate ground motion at Yucca Mountain to such parameters as the distance to the explosion site, the depth of burial, and the yield of the explosion. Measurements are made in boreholes and on the surface at Yucca Mountain. These investigations may be continued during site characterization.

4.1.3.6 Field experiments in G-Tunnel facilities

In situ physical and mechanical properties of tuffaceous rocks similar to those at Yucca Mountain are currently being measured under simulated repository conditions in G-Tunnel, which is a test facility at the Nevada Test Site (NTS). G-Tunnel is being used for preliminary investigations because it is in a layer of welded tuff whose thermal and mechanical properties are similar to some of the welded tuffs at Yucca Mountain. The completed and ongoing tests include small-diameter heater tests and a heated-block experiment. The purpose of these experiments is to measure the thermal and mechanical behavior of welded tuff in situ. Predictions can then be made of the rock's response to heat that radioactive waste would introduce into a repository. The heated-block experiment used an in situ block of welded tuff 2-meters (6-feet) square bounded by vertical slots. Both stress and thermal loads were imposed on the block to achieve combinations of stress and temperature for evaluating deformation, thermal conductivity, thermal expansion, and fracture permeability. Moisture changes within the block were examined with piezometers, ultrasonic instruments, and a neutron probe. These tests provide valuable experience for developing instrumentation and field techniques that can be used for in situ testing during site characterization.

4.1.3.7 Laboratory studies

Laboratory activities necessary to characterize the tuff at Yucca Mountain include studies in geochemistry, mineralogy and petrology, mineral stability, and geochronology. In addition, methods for sealing shafts and boreholes are being developed in the laboratory. Most of the laboratory work for site characterization and technology development would be done using existing offsite facilities and equipment.

4.2 EXPECTED EFFECTS OF SITE CHARACTERIZATION

The effects that might result from the site characterization activities described in Section 4.1 have been divided into two categories: the effects on the physical environment, described in Section 4.2.1, and the effects on socioeconomic and transportation conditions, described in Section 4.2.2. Both positive and negative effects are described in these two sections. A brief discussion of resource commitments is provided in Section 4.2.3, and the activities and environmental effects are summarized in Section 4.2.4.

4.2.1 EXPECTED EFFECTS ON THE ENVIRONMENT

Site characterization activities are expected to result in localized environmental effects on geologic and hydrologic conditions; land use; surface soils; ecosystems; air quality; noise levels; aesthetic quality; and cultural, historical, and archaeological resources.

4.2.1.1 Geology, hydrology, land use, and surface soils

4.2.1.1.1 Geology

The activities scheduled for site characterization would have a negligible effect on the geologic conditions at Yucca Mountain. Rock would be removed physically during excavation of the exploratory shaft facility and from several boreholes. Only minor spalling is expected to occur along the insides of these openings (see the discussion of rock-characteristics guidelines in sections 6.3.1.3 and 6.3.3.2). Radiation sources used in geophysical logging would be contained and retrievable. On the basis of the information now available, there are no site characterization activities scheduled that would significantly impact the geologic conditions at the Yucca Mountain site.

4.2.1.1.2 Hydrology

There are no perennial sources of surface water at Yucca Mountain. Heavy precipitation may cause locally accelerated erosion and gullying, especially on steep slopes. Water sprayed on dirt roads or on the rock-storage pile will not contribute to erosion because it will infiltrate into the soil or quickly evaporate. Proper design and construction of new access roads and other facilities would be used to minimize accelerated erosion and gullying to the extent possible. A significant increase in erosion is not expected. None of the runoff from the mountain is used by humans for any purpose.

Neither the quality nor the quantity of ground water would be affected significantly by site characterization activities. The septic tank and drain field would be located where the ground water is of sufficient depth to minimize the possibility of adversely affecting the ground-water quality. Handling of radioactive material would be in strict accordance with accepted procedures. Personnel responsible for handling the material would be trained in proper handling procedures, including procedures for emergencies. The quantities of material involved generally would be very small. In hydrologic tests, the material would be dispersed rapidly and diluted by the ground water. Wherever possible, the tests would be designed to recover as much of the radioactive materials as possible. Additionally, tracers with very short half-lives would be used.

The water table is about 535 meters (1,765 feet) below the surface at the exploratory shaft location, and it is about 85 meters (280 feet) below the bottom of the proposed exploratory shaft. The water table would not be significantly affected by the exploratory shaft. However, hydrologic exploratory boreholes would be drilled so that the water table could be mapped. These wells would be capped and sealed after completing ground-water studies. The regional effects of withdrawing ground water for site characterization at Yucca Mountain are expected to be negligible. Thordarson (1983) reports that the water level in Well J-13 has remained essentially constant after long periods of pumping between 1962 and 1980. The large volume of water produced from this well (approximately 494,000 cubic meters (400 acre-feet) per year), along with the minor drawdown during pumping tests (Young, 1972), suggests the aquifers underlying Yucca Mountain can produce an abundant quantity of ground water for long periods without lowering the regional ground-water table (sections 6.3.1.1 and 6.3.3.3). Site characterization activities are expected to use substantially less than 494,000 cubic meters (400 acre-feet) per year.

4.2.1.1.3 Land use

The Yucca Mountain site is located entirely on federally administered lands that are not being actively used, and there is no plan for either private or public use of the lands during the time proposed for site characterization. A class I resource survey (Bell and Larson, 1982) found no evidence of significant mineral or energy resources in the region surrounding Yucca Mountain, and therefore future exploration and development is not expected. The Department of the Air Force uses the airspace over Yucca Mountain to support tactical air missions into and out of the Nellis Air Force Range. The proposed site characterization activities would not interfere with use of the airspace; therefore, no land use impacts are predicted.

4.2.1.1.4 Surface soils

Most field activities to be conducted during site characterization would occur within 8 kilometers (5 miles) of the Yucca Mountain site, and only a small portion of this area would be disrupted. Soils would be disturbed during site preparation for exploratory holes and for the exploratory shaft facility and during construction of access roads and surface facilities. Assuming construction of 20 exploratory hole access roads, each 8 kilometers (5 miles) long and 15 meters (50 feet) wide, about 245 hectares (605 acres) of surface soil may be disturbed. Each of the 20 drilling pads with its associated facilities and equipment may disturb an additional 1 hectare (2.5 acres), for a total of 20 hectares (50 acres). An estimated 8 hectares (20 acres) of soil would be cleared and graded in preparation for construction of the exploratory shaft facilities. An additional 0.6 hectare (1.6 acres) would be covered by the rock-storage pile. The above activities would disrupt a total of approximately 275 hectares (680 acres) of surface soil. In addition, about 10 hectares (25 acres) in the Yucca Mountain area may be disturbed by off-road driving, constructing small drill pads, clearing and grading areas for geophysical studies, and trenching for fault studies.

Removal and compaction of soils during site characterization would disrupt the existing physical, chemical, and biotic soil processes. Disturbing the soil would temporarily accelerate wind and water erosion, although engineering measures can minimize these potential impacts to some extent. Reclamation of these disturbed lands would be undertaken; the effectiveness of reclamation in arid environments is being studied. The acreage that potentially would be disturbed is small compared with the tens of thousands of acres of relatively undisturbed desert land surrounding the Yucca Mountain site.

4.2.1.2 Ecosystems

The major impact associated with site characterization activities would be the removal of wildlife habitat. Drill pads, roads, utility lines, trenches, seismic lines, and off-road driving would result either in removal or compaction of soil and destruction of vegetation with the subsequent disturbance or destruction of the indigenous wildlife. Approximately 285 hectares (705 acres) of habitat would be disturbed throughout the study area.

As a standard operating practice, before beginning any activity that would disturb an area, field surveys would be conducted to assess impacts and to ensure protection of the desert tortoise and the Mojave fishhook cactus. Construction activities would be sited to avoid the cactus and desert tortoise whenever possible. When found, tortoises may be relocated from activity sites if subsequent studies show relocation to be effective. Cacti would not be relocated.

Wildlife may be adversely affected by the destruction of natural catch basins or the contamination of ephemeral water in these basins. Physical destruction of catch basins could occur during construction and the water could be adversely affected by fugitive dust and other air pollutants.

Surrounding vegetation may be adversely affected if fluids escape from the bermed rock-storage pile.

Increased human activity could increase the potential for range fires during site characterization activities. The vegetation associations that are dominated by black brush are commonly considered to present the greatest fire hazard. In wet years, the annual grass desert brome also is a hazard. Range fires can be ignited by catalytic converters on off-road vehicles, especially in stands of dry grasses. Fire hazard would be reduced by spacing buildings, removing vegetation in work areas, and controlling off-road driving.

Wildlife displaced because of noise and the movement of heavy equipment would probably return to the area after the activity ceases.

4.2.1.3 Air quality

Construction and operation of the exploratory shaft and the concomitant site characterization activities would generate particulate and gaseous emissions of air pollutants. Most particulates would be generated by drilling, blasting, rock removal and storage, batch concrete plant operation, surface grading and leveling, wind erosion, and vehicle travel on paved and unpaved roads, with a small contribution from diesel and gasoline combustion. Gaseous air pollutant emissions would consist of carbon monoxide (CO), nitrogen oxides (NO_x), sulfur oxides (SO_x), particulate matter (PM), and hydrocarbons (HC). These pollutants would be produced by diesel- and gasoline-powered construction equipment and motor vehicles and by diesel-powered drilling engines and electric generators.

Construction phase emissions are not expected to create adverse air-quality effects because construction activities are temporary and the surface disturbance is limited to small areas. Particulate emissions would be controlled by watering and by paving the most frequently used roadways as described in Section 4.1.2.6. Rock debris mined from the exploratory shaft would be stockpiled away from the shaft entrance and would be watered lightly to control particulate emissions during and after stockpiling. Combustion-related emissions from the construction equipment would be minimal because of the small amount of activity required. The use of commercial line power with only emergency backup diesel generators on the site would further minimize combustion emissions.

Because Yucca Mountain is in an area where the existing air quality is considered to be better than State and Federal ambient air-quality standards, emissions associated with the operation (in situ testing) phase of the exploratory shaft would be subject to examination under the Nevada Department of Environmental Protection (NDEP) Prevention of Significant Deterioration (PSD) regulations.

A screening-level calculation of operation phase atmospheric emissions was made to determine whether the exploratory shaft would be considered a "major stationary source" that would require a full PSD review. Because the exploratory shaft is not one of the 28 specific source types listed in the

PSD regulations, fugitive emissions were not considered in that calculation. Only nonfugitive emissions were evaluated.

For all nonfugitive sources associated with site characterization, estimates were made of such activities as test-drilling frequency, ventilation parameters, engine horsepower ratings, etc. Table 4-1 summarizes the data used to calculate the operation-phase nonfugitive emissions and presents the resultant emission rates. For conservatism, the fugitive particulate emissions that would be generated by the underground drilling activities were treated as nonfugitive since they would be exhausted from the exploratory shaft via the ventilation system. Also, the combustion emissions from the concomitant borehole-drilling activities were added to the exploratory shaft emissions even though the drilling-related emissions are likely to be considered "secondary emissions" under PSD regulations since the borehole drilling is not an integral part of the exploratory shaft operation.

Even with these conservative calculations, the exploratory shaft emissions are expected to be considerably less than the 250-ton per year emission threshold level for each pollutant criteria that would classify the source as major and would trigger the requirement for PSD review and permitting (Table 4-1). However, because the surface area disturbed for the exploratory shaft facility may exceed 8 hectares (20 acres), a Nevada registration certificate may be required before beginning the site preparation activities. A formal PSD applicability determination would be made by the NDEP at the time of application for any required registration certificates. That application would require a complete emission calculation for both fugitive and nonfugitive sources using the most recent data available along with air-quality modeling to determine whether any State or Federal ambient air quality standards would be violated. The very small amount of emission-generating activity during in situ testing makes it highly unlikely that significant air quality impacts would be experienced.

The impact of fugitive particulate emissions, which are excluded from the PSD applicability determination discussed above, has not been quantified for the exploratory shaft activities. This impact, however, is expected to be minimal and in compliance with applicable State and Federal ambient air quality standards. This conclusion is supported by information presented in Section 5.2.5.2, which deals with repository construction. The analysis presented in Section 5.2.5.2 includes both fugitive and nonfugitive particulate sources (see Table 5-12), and concludes that no ambient standards would be violated during repository construction. Many of the activities that would be taking place during construction of the exploratory shaft would be similar to the activities assumed for repository construction but on a smaller scale (e.g., concrete batching, rock excavation and dumping, grading). Because the impacts predicted to occur during repository construction include fugitive particulate emissions and still are not predicted to violate applicable ambient air quality standards, violations during exploratory shaft construction are not anticipated.

Table 4-1. Summary of nonfugitive atmospheric emissions from site characterization

Source	Number of units	Rating per unit (hp)	Use (hr/yr)	Load factor	Control factor	Emission rates (tons/year)[a] CO	HC	NO_x	SO_x	PM
				EXPLORATORY SHAFT						
Generators[b]	2 systems	700	52	0.80	-	0.2	0.1	0.9	0.1	0.1
Drilling[c]	500 holes	NA[d]	NA	-	80%	NA	NA	NA	NA	0.1
				BOREHOLE DRILLING						
Drill engines[b]	2 rigs	700	6570	0.75	-	23.0	8.5	106.5	7.1	7.6
Generators[b]	2 rigs	469	6570	0.80	-	16.5	6.1	76.1	5.1	5.4
TOTAL						39.7	14.7	183.5	12.3	13.2

[a]CO = carbon monoxide; HC = hydrocarbons; NO_x = nitrogen oxides; SO_x = sulfur oxides; PM = particulate matter.

[b]Emission factors from EPA (1977): CO = 3.03 grams per horsepower-hour, HC = 1.12 grams per horsepower-hour, NO_x = 14.0 grams per horsepower-hour, SO_x = 0.931 grams per horsepower-hour, PM = 1.00 grams per horsepower-hour.

[c]Emission factor for particulate matter is 1.5 lb/hole (PEDCo--Environmental, Inc., 1978).

[d]NA = not applicable.

4.2.1.4 Noise

Wildlife would be the only sensitive noise receptor in the vicinity of site characterization activities. The effects of noise on wildlife are speculative. Laboratory experiments have shown both temporary and permanent physical and behavioral effects if the wildlife is repeatedly exposed to levels in the 75 dBA to 95 dBA range (EPA, 1971; Ames, 1978; Brattstrom and Bondello, 1983). For instantaneous noise, such as single blasts, levels exceeding 140 dBA have been tolerated by animals with little or no effect (Cottereau, 1978). For this analysis, the level of exposure at which wildlife could be affected is assumed to be 75 dBA for continuous noise and 140 dBA for exposure to single incidents, such as blasting.

The construction of surface facilities in Coyote Wash would produce the highest sustained noise levels associated with site characterization. Other site characterization activities would not contribute significantly to these sustained noise levels because of their small magnitude, direction, and/or location. Since construction techniques have not yet been specified, it is assumed that construction equipment requirements would be similar to those of other large facilities. The maximum noise level attributed to each piece of construction equipment assumed to be used are listed in Table 4-2. This table also contains the estimated maximum noise level at 150 meters (500 feet) from the focal point of construction activities. Because the estimated noise level at 150 meters (500 feet) is based on the highest levels possible, the analysis is conservative. Furthermore, the analysis assumes that the geometric divergence of the sound waves provides the only attenuation. Again, this analysis is conservative because it excludes the possible attenuation due to absorption and barrier effects. With the estimated noise level of 88 dBA at 150 meters (500 feet), wildlife may be affected within 0.6 kilometers (0.4 miles) of the construction site (Table 4-2).

Mining of the exploratory shaft would also entail blasting. To assess the effect of blasting noise on wildlife, a maximum instantaneous discharge of approximately 32 kilograms (70 pounds) of explosives was assumed, which would result in a noise level of 120 to 130 dBA at 150 meters (500 feet). Since this level is substantially below the single blast level assumed to affect animals (140 dBA), no wildlife impacts are predicted.

During operation of the exploratory shaft facility, the ventilation fan would be used continuously. Because of Occupational Safety and Health Administration (OSHA) noise standards, the maximum noise level to which a worker may be exposed for eight hours must be less than or equal to 90 dBA. At 90 dBA, the ventilation fan would be the loudest continuous source of noise. (However, the estimated noise levels during the operation phase would be far less than those during the construction phase since the boring machine and drill rig would no longer be in use.) Consequently, no significant long-term impacts to wildlife are anticipated.

Table 4-2. Maximum noise from construction of the exploratory shaft facility[a]

Equipment	Number	Maximum noise level at 15.2 meters (50 feet)[b] (dBA)
Air compressors	1	81
Backhoes	1	85
Boring machines	1	98
Bulldozers	1	80[c]
Concrete mixers	1	85
Cranes	6	83
Drill rigs	1	101[c]
Dump trucks	6	88[c]
Earth movers	6	78[c]
Front-end loaders	6	76[c]
Grader scrapers	1	88
Gravel elevators	1	88
Service vehicles	30	88
Shovels	1	82
Steam rollers	1	75[c]
Truck handling conveyor	1	88
Maximum estimated noise level at 150 meters (500 feet):		88 dBA

[a]Methods for all calculations are given in Chanlett (1973).
[b]Data estimated from EPA (1974) unless otherwise indicated.
[c]Data from Henningson, Durham and Richardson Sciences (1980).

Site characterization could include the use of explosives at the surface. Assuming a maximum unconfined surface discharge of 45 kilograms (100 pounds), noise levels in excess of 140 dBA could occur for up to 1,525 meters (5,000 feet) from the blast site. Hence, if such a charge were detonated, wildlife could be affected up to almost a mile away. Because the maximum possible charge was assumed and because no barrier and absorption attenuation were assumed, this estimate is considered conservative.

The effect of noise is expected to be insignificant because, as explained in Section 3.4.2, the area propoeed to be disturbed during site characterization contains no unique or critical habitat and no federally protected species. In addition, some of the wildlife in the area that is expected to be subjected to continuous noise above 75 dBA will have been displaced during clearing and grading for site preparation. Residents of the nearest town (Amargosa Valley) are not expected to be affected by noise produced by site characterization.

4.2.1.5 Aesthetics

The two access roads from Fortymile Canyon to the top of Yucca Mountain can be seen from eastern Jackass Flats and Skull Mountain, both of which are on the Nevada Test Site (NTS). From the ground, the site characterization activities would not be visible from major population centers or public recreation areas, but may be visible from public highways and some portions of Amargosa Valley. The entire project area can also be seen from the commercial airline flight path that follows U.S. Highway 95 south of the NTS. Considering this limited public visual exposure, the visual impact would not be significant.

4.2.1.6 Archaeological, cultural, and historical resources

The Desert Research Institute has conducted an intensive cultural resources survey of all areas that are likely to be disturbed by the characterization and development of the exploratory shaft facility (Pippin et al., 1982). That survey identified two significant cultural resources (26Ny2969 and 26Ny2970) in Drill Hole Wash. Two additional cultural resources (26Ny2993 and 26Ny3039) were recorded along the power line route to the proposed exploratory shaft facility. Test excavations at these sites revealed that the cultural remains at all four sites were restricted to the present ground surface and that all four sites were significant with respect to the potential information that those cultural remains offered concerning past adaptive strategies of hunters and gatherers (Pippin, 1984). All four sites were eligible for nomination to the National Register. The sites have been collected in consultation with the State Historic Preservation Officer.

Although direct impacts to the two cultural resources in the immediate vicinity of Coyote Wash could be avoided during screening activities, it was determined through consultation with the Nevada Division of Historic Preservation and Archaeology that both sites were in danger of indirect impact from those activities. It was also determined through consultation with the same agency that both archaeological sites along the power line route to the proposed exploratory shaft facility might be directly and adversely impacted by the construction of that powerline. Consequently, it was decided that the systematic collection of cultural remains at all four archaeological sites would adequately mitigate these potential adverse impacts. Surface collections were conducted during 1984 and a report is being written concerning the findings.

Direct impact to other sites both on and around Yucca Mountain may occur during site preparation for exploratory drilling, geophysical surveys, or other surface-disturbing activities. Before activities begin, archaeological or cultural resource sites would be identified in affected areas and evaluated for their significance and National Register eligibility. The standard operating practice would be to avoid these sites whenever possible. If a site cannot be avoided, it would be salvaged, and the findings would be documented. The artifacts and important knowledge about the site would be preserved. Indirect impacts, which result from unauthorized excavation or the collection of artifacts, can be induced by improved access to the area. However, workers would be prohibited from such excavation or collection.

4.2.2 SOCIOECONOMIC AND TRANSPORTATION CONDITIONS

The evaluation of the potential socioeconomic effects of site characterization activities considered economic, population, community services, social, and fiscal and governmental effects. The evaluation of transportation effects was centered on U.S. Highway 95, which would be used for the transportation of both workers and materials to the site. For the socioeconomic analysis, the affected region is defined as the bicounty area of Nye and Clark counties (Figure 3-21 and Section 3.6). Most site characterization activities would take place at the Yucca Mountain site in southern Nye County, which is about 161 kilometers (100 miles) by road from the Las Vegas urban area. Some other Nevada Nuclear Waste Storage Investigations Project activities would take place in the Las Vegas area, including work that would be performed at the U.S. Department of Energy (DOE) offices presently in Las Vegas.

The social and economic impacts of site characterization-related population increases are expected to be small and insignificant. The fiscal effect of State and local participation in the repository-related planning processes may be significant. However, the Nuclear Waste Policy Act provides for grants to States for the purpose of participating in such activities (NWPA, 1983).

4.2.2.1 Economic conditions

The assessment of the effect on economic conditions in the region is based upon an evaluation of site-characterization employment and materials requirements, and related population effects. As described below, this effect is considered positive but insignificant.

4.2.2.1.1 Employment

Direct labor requirements for site characterization consist of onsite and offsite workers. Most offsite workers would be located at the U.S. Department of Energy (DOE) and contractor offices in the Las Vegas area. Other offsite workers include employees of national research organizations, such as the national laboratories, who would conduct brief visits to the area.

Table 4-3 shows the anticipated peak number of onsite and offsite workers directly required for the site characterization activities described in the previous sections of this chapter. The table also indicates the number of indirect workers that are likely to be associated with the direct workers. Indirect employment is a result of the services required by the direct workers and their families. The peak number of total (direct plus indirect) site characterization-related workers is estimated to be about 690. This represents about 0.3 percent of the historical 1983 Nye and Clark county total wage and salary employment (State of Nevada ESD, 1984; State of Nevada OCS, 1985). Any growth in baseline wage and salary employment would make the total site characterization-related employment an even smaller fraction of actual employment in the bicounty area in the late 1980s. Therefore, the employment impact of site characterization is considered to be insignificant.

Based on the similarities between the site characterization activities described in the previous sections of this chapter, and construction and drilling activities currently carried out by the DOE and its contractors at the Nevada Test Site (NTS), it is estimated that about 60 percent of the direct workers shown in Table 4-3 are currently employed in DOE activities.

Table 4-3. Peak number of site characterization workers

Category of worker	Surface construction[a]	Subsurface construction and testing[b]	Testing only[c]
Direct			
Onsite	72	147[d]	96
Offsite	126	126	126
Total direct	198	273	222
Total indirect[e]	305	420	342
Total direct and indirect	503	693	564

[a]Assumed to take 6 months.
[b]Assumed to take 23 months.
[c]Assumed to take 26 months.
[d]Includes a maximum of 9 workers for the construction of the secondary egress shaft, which was estimated to take 3 to 4 months.
[e]Assumes 1.54 indirect workers associated with each direct worker (see Section 5.4.1.1).

Accordingly, only about 40 percent of the 273 workers employed during the peak employment period, or 109 workers, would represent new Nevada Nuclear Waste Storage Investigations Project employees. Using an indirect multiplier of 1.54 (see Section 5.4.1.1), the indirect employment effect would be about 168 new jobs. Adding these indirect workers to the 109 direct workers results in a total of about 277 new jobs in southern Nevada over the first two years of site characterization. This same increase could occur over a period as brief as six months under alternative budgetary scenarios being considered by the DOE. In either case, the employment impact would be positive but insignificant.

4.2.2.1.2 Materials

Most of the materials used in site characterization would be required to construct the exploratory shaft facility. Table 4-4 displays the estimated material requirements for the exploratory shaft facility. It is expected that a substantial portion of these materials would be procured through contractors located in southern Nevada. Materials not available in southern Nevada would ultimately be obtained from outside the bicounty region.

4.2.2.2 Population density and distribution

The estimated maximum population impact of site characterization activities (assuming 273 new direct workers) would be to increase the bicounty population by 2,080, assuming that onsite and offsite employees would bring an average of 1.28 dependents and related indirect workers would bring an average of 2.47 dependents (DOE, 1979; see also McBrien and Jones, 1984). This is about 0.4 percent of the projected 1985 population (tables 3-15 and 3-16) of the bicounty area. A more realistic analysis would assume that 60 percent of the workers required to conduct site characterization activities are already employed in other U.S. Department of Energy activities in the same area. The actual population increase due to site characterization activities using this assumption is expected to be only about 830 persons. The population impact in the bicounty area is considered to be insignificant using either assumption.

The estimated maximum population increase of 2,080 associated with site characterization would not be significant even when considered at the community level. Using recent settlement patterns of Nevada Test Site (NTS) workers (Table 5-26), Table 4-5 shows the expected distribution of this maximum population increase to Clark and Nye county communities nearest the Yucca Mountain site. That table also shows recent published population estimates for those communities and the percent of the historical population that each community's share of the maximum site characterization population increase represents. These percentages of the maximum population increases are not considered significant and would actually be smaller when considered

Table 4-4. Resources committed to the exploratory shaft facility[a]

Resource[b]		Surface construction[c]	Subsurface construction and testing[d,e]	Testing only[f]	Decommissioning
Energy					
Gasoline:	gallons	100,000	190,000	190,000	100,000
	liters	380,000	720,000	720,000	380,000
Diesel fuel:	gallons	240,000	230,000	65,000	120,000
	liters	910,000	870,000	246,000	450,000
Electricity:	MWhr[b]	140	8,600	6,500	140
Explosives:	pounds	none	135,000	none	none
	kilograms		61,000		
Materials					
Cement:	pounds	130,000	2,500,000	none	none
	kilograms	59,000	1,100,000		
Steel:	pounds	300,000	1,120,000	none	none
	kilograms	140,000	508,000		
Copper wire:	pounds	80,000	6,000	none	none
	kilograms	36,000	2,700		
Wood power poles		100	none	none	none

[a]Transportation effects in Section 4.2.2.6 were calculated using the following assumptions on capacity per truck: 17,000 kilograms cement; 17,960 kilograms structural steel; 56,800 liters fuel; 6,800 kilograms explosives; 7,300 kilograms copper wire; and 100 wood poles.

[b]1 gallon = 3.785 liters; 1 pound = 0.4536 kilograms; MWhr = megawatt-hours

[c]Assumed to take 6 months.

[d]Includes secondary egress shaft.

[e]Assumed to take 23 months.

[f]Assumed to take 26 months.

Table 4-5. Distribution of maximum population increase associated with site characterization activities to communities in Clark and Nye county nearest the Yucca Mountain site

Community	Historical population[a]	Maximum population increase[b]	Percentage of historical population
Unincorporated urban Clark County and Las Vegas	376,628[c]	1,364	0.4
North Las Vegas	42,739	208	0.5
Indian Springs	1,446[d]	85	5.9
Henderson	24,363	64	0.3
Boulder City	9,590	8	0.1
Pahrump	5,500	127	2.3
Tonopah	2,500	40	1.6
Beatty	800	2	0.3
Town of Amargosa[e]	1,825	6	0.3

[a]Historical population estimates for Clark County communities are for 1980 (Clark County Department of Comprehensive Planning, 1983); those for Nye County communities are for 1984 (Smith and Coogan, 1984). Population data from these sources correspond generally to geographic areas of ZIP codes reported by Nevada Test Site workers and summarized in Table 5-26. However, there may be cases where the community boundaries and ZIP code boundaries are not coincident.

[b]Calculation based on data in Table 5-26. Note column does not sum to 2,080 since all zip code areas shown in Table 5-26 are not included.

[c]Population of unincorporated Las Vegas Valley plus Las Vegas.

[d]Includes 491 military personnel.

[e]Includes population concentrations in the settlements of Amargosa Valley, the Amargosa Farm area, and the American Borate housing complex.

relative to the populations of those communities in the late 1980s when site characterization activities are expected to peak. A more realistic analysis, assuming approximately 60 percent of the site characterization work force is already located in the area, would also show that population impacts to these communities would be insignificant.

4.2.2.3 Community services

Effects on community services would result from significant changes in the service-area population or from smaller population increases in areas where service capacities have been reached. Because no significant population changes are projected, the only effects on community services would be an exacerbation of the present water-supply problem in Beatty, described in Section 3.6.3.3, if new workers were to settle there. However, since only two additional people are expected to settle in Beatty (Table 4-5), the impact of site characterization on this existing problem would be very small.

4.2.2.4 Social Conditions

Social impacts often associated with significant changes in community population levels are not expected to occur, because no significant changes in either regional or community population levels are expected to accompany Yucca Mountain site characterization activities. However, some social effects could result from an increase in the public's awareness of the Nevada Nuclear Waste Storage Investigations Project. This might result if a decision to select Yucca Mountain for site characterization were to create an increased local and regional controversy and dissent over the prospect of a high-level radioactive waste repository at Yucca Mountain. The effects might include changes in social organization that are associated with the formation of opposition and support groups, disputes within existing groups, and a focused attention on repository-related issues.

4.2.2.5 Fiscal and governmental structure

Effects on fiscal and governmental structure are related to employment, population, community services, and State and local government agency participation in site characterization activities. Site characterization activities at Yucca Mountain are not expected to have a significant effect either on regional and local employment or on population and community services. Therefore, no significant fiscal impacts are expected from either population or employment effects of site characterization. While the social effects of any changes in the level of controversy surrounding the Nevada Nuclear Waste Storage Investigations Project may affect the political organization and potentially the governmental structure of the area, such effects are not expected to be significant.

A potentially significant effect of recommending Yucca Mountain for site characterization would be an increase in State and local participation in planning activities. Section 116(c)(1)(B) of the Nuclear Waste Policy Act (NWPA, 1983) explicitly recognizes the fiscal implications of State participation and provides a mechanism for financial assistance for the following purposes:

1. To review the U.S. Department of Energy activities undertaken to assess the potential economic, social, public health and safety, and environmental impacts of a repository.

2. To develop a request for assistance to alleviate impacts associated with the development of a repository.

3. To engage in any monitoring, testing, or evaluation activities with respect to site characterization programs.

4. To provide information to State residents about State and Federal activities concerning the potential repository.

5. To request information from, and to make comments and recommendations to, the Secretary of Energy regarding the siting of a repository.

Additionally, Section 116(c)(3) of the Nuclear Waste Policy Act provides for grants-equal-to-taxes (GETT), to the State and units of general local government in which a site for a repository is located, if such site is approved for site characterization (NWPA, 1983).

4.2.2.6 Transportation

During site characterization, transportation effects would be concentrated along U.S. Highway 95 as workers and materials are transported to and from the site. Table 4-3 indicates that the maximum onsite work force is expected to be 147 people. As stated in Section 4.2.2.1.1, about 60 percent of these workers currently are employed by the U.S. Department of Energy and its contractors. Therefore, little additional traffic is anticipated. Assuming a worst case in which each new worker would drive a private automobile, the resulting increment of approximately 60 vehicles during the evening peak hour from 5 p.m. to 6 p.m. would not cause the service levels (Table 3-8) to change on any segment of U.S. Highway 95.

The transportation of materials would occur during all phases of site characterization. Material requirements and time frames are listed in Table 4-4. The per-shipment quantities noted in Table 4-4 suggest that the maximum amount of daily shipments is expected to occur during exploratory shaft facility construction. Assuming 250 work days per year, approximately one truck shipment per day would be required. Peak shipments may require several additional trucks per day. This increase in number of vehicles would not present any adverse effects on any part of U.S. Highway 95.

4.2.3 WORKER SAFETY

A preliminary estimate of accidental injuries and fatalities during site characterization was calculated using the expected number and type of workers to be employed during exploratory shaft facility construction and operation, and 1982 statistics on worker injuries and fatalities provided by the National Safety Council (1983). To obtain an upper-bound estimate, all workers in the underground facility were assumed to be miners, although scientists, technicians, and supervisors are also expected to work in the underground portion of the facility. Approximately 14 injuries could be expected to result during the exploratory shaft facility construction and operation period of 55 months; less than one (0.13) of these accidents is expected to result in a death.

Protection of worker health will be maintained by application of all appropriate health and safety regulations to the maximum extent; however, unique developmental requirements (e.g., dry drilling) may require the use of developing technology.

4.2.4 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Most of the resources that would be committed to site characterization would be devoted to the exploratory shaft facility. Therefore, this section focuses on resources committed to construction and operation of this facility (Table 4-4). The quantities listed in Table 4-4 are estimates. Items such as gasoline consumption are not customarily included as part of engineering construction design studies. The estimates in Table 4-4 were therefore obtained by consulting several experienced engineers, and these estimates may change as additional information becomes available. No adverse effects are expected to result from the commitment of these resources.

4.2.5 SUMMARY OF ENVIRONMENTAL EFFECTS

A summary of the characterization activities and their potential impacts is shown in Table 4-6. The table lists the activities and their effects, outlines standard operating practices to minimize environmental effects, and evaluates the extent of any environmental impact remaining after standard operating practices have been implemented.

Land-surface disturbance would result in the most widespread and lasting impact on the physical environment. Removing vegetation from approximately 285 hectares (705 acres) is expected to result in adverse impacts on air quality, surface hydrology, the local ecosystem, and visual aesthetics. None of these impacts, however, are considered extensive or severe enough either individually or cumulatively to be judged as significant.

Equipment used during site characterization will increase the emissions of hydrocarbons and particulates and will increase the noise levels around Yucca Mountain. Nonfugitive emissions during operation of the exploratory shaft facility were calculated to be considerably less than the level required to classify the site as a major source under Nevada and Federal regulations. Increased noise is not expected to have significant effects because residents closest to Yucca Mountain would not be disturbed, and the wildlife that may be affected would probably already have been displaced by site-preparation activities (clearing).

A qualified archaeologist has surveyed a large area surrounding Yucca Mountain. In addition, preconstruction surveys will be conducted if areas outside those already surveyed are likely to be disturbed by project activities. If identified sites cannot be avoided, the sites will be scientifically excavated and documented. Workers will be advised of legislation prohibiting unauthorized collection or excavation of sites.

The U.S. Department of Energy (DOE) does not expect site characterization-related population increases to result in any significant adverse socioeconomic impacts. Approximately 690 direct and indirect jobs are expected to result from conducting site characterization at Yucca Mountain. This employment impact is considered insignificant either at the bicounty or community level. Inmigration is not expected to significantly affect community services or social conditions, although support or opposition groups may form and mobilize in the communities. The costs of increased local and State participation in the planning process during site characterization could be significant. However, the Nuclear Waste Policy Act (the Act) provides for grants to host states for these purposes (NWPA, 1983).

If the Yucca Mountain site is recommended and approved for site characterization, the DOE would establish a monitoring program to validate the expected socioeconomic impacts of site characterization presented in this chapter. The DOE would prepare a socioeconomic monitoring and corrective action plan to be released after the recommendation and approval process. This monitoring and corrective action plan would (1) describe how the DOE would monitor site characterization activities at the Yucca Mountain site, (2) outline the process the DOE would follow to work with States, affected Indian Tribes, and local governments to share such monitoring information, and (3) identify the mechanisms by which the DOE would determine appropriate and timely corrective action for any unexpected significant adverse social or economic impacts that are identified by the monitoring program.

States and affected Indian Tribes may apply for grants under the Act to engage in monitoring activities with respect to DOE site characterization activities. Additionally, the State and units of general local government in which a proposed repository site has been approved for site characterization are eligible to apply for funding under the grants-equal-to-taxes (GETT) provisions of the Act (Section 116(c)(3)), (NWPA, 1983).

Transportation of workers and materials is not expected to affect the level of service along U.S. Highway 95, and emissions from these vehicles are not expected to significantly increase air pollution in the U.S. Highway 95 corridor.

4.3 ALTERNATIVE SITE CHARACTERIZATION ACTIVITIES

At-depth in situ site characterization is mandated by the Nuclear Regulatory Commission (10 CFR Part 60, 1983). Therefore, alternatives to developing an exploratory shaft facility during site characterization have not been addressed. However, there are alternative methods to accomplish at-depth in situ site characterization. The major alternative is drilling (as opposed to mining) the exploratory shaft. Other alternatives include varying the size, number, and location of underground test facilities.

Some variations in the design of surface support facilities and in the degree of site disturbance would occur if the shaft were drilled. For example, preconstruction site disturbance for a drilled shaft would require sinking two confirmatory boreholes that would be used for geologic and hydrologic testing. Only one confirmatory hole is required if the shaft were to be mined, and this would result in less surface disturbance. In addition, maintaining access to the additional borehole for future testing would reduce the area available to optimally site other surface support facilities.

Drilling of the exploratory shaft would require the inclusion of a lined mud pit in which to hold the cuttings and drilling fluid. The size of the mud pit would be constrained by the topography of the site. Therefore, it would be necessary to periodically dredge the mud pit by dragline or similar mechanical means and to transport the cuttings to a second lined pit located away from the immediate shaft vicinity. Dredging the mud pit may also increase the potential for disturbing the liner and allowing fluids to infiltrate into the unsaturated zone.

During the drilling process, the shaft is partially filled with a drilling fluid consisting of water, clay, and polymer. This fluid provides hydrostatic support to the shaft wall, lubricates and cools the drill bits and reamers, and carries rock chips to the surface. These construction practices severely limit the ability to characterize the natural hydrologic setting of the unsaturated zone. The most important potentially adverse impact of drilling would be the potential alteration of existing in situ moisture conditions due to introduced drilling fluids. Drilling the shaft would also preclude mapping the shaft wall, which would be done if the mining technique is used.

In conclusion, the drilling alternative to shaft mining is not considered desirable. Varying the size, number, and location of the underground test facilities would have either little or no impact on the environmental consequences of site characterization.

Table 4-6. Summary of environmental effects associated with site characterization

Impact category	Activity and effects	Standard operating practice	Residual impacts of significance
Geology	Excavation of the exploratory shaft facility may result in minor spalling.	Line both the exploratory shaft and the secondary egress shaft. Drifts in the main test facility can be supported by conventional rockbolts, wire mesh, and shotcrete.	None
	Use of radiation sources in geophysical logging may result in a release of radionuclides to the subsurface.	Contain geophysical logging sources and ensure sources are retrievable. Train workers in routine handling and emergency procedures. Obtain State of Nevada license for sources.	None
Hydrology	Diverting natural drainage channels, building surface facilities, and filling areas (the rock-storage pile) may concentrate local runoff in the event of a heavy rainfall, resulting in locally accelerated erosion and gullying, particularly on steep slopes.	Use proper engineering designs for surface facilities and runoff diversions. Construct a containment berm around the rock-storage pile.	None
	Use of radioactive tracers in some boreholes may have worker health and safety effects and may introduce radionuclides to the subsurface.	Use proper handling procedures and short half-life tracers.	None

Table 4-6. Summary of environmental effects associated with site characterization (continued)

Impact category	Activity and effects	Standard operating practice	Residual impacts of significance
Hydrology (Continued)	Drilling of hydrologic exploratory boreholes and excavation of the exploratory shaft may affect the quality or quantity of the local ground water.	Minimize amount of ground water withdrawn; cap and seal exploratory boreholes after completion of ground-water studies.	None
Land use	All activity would occur on Federal lands not currently in use.	Acquire appropriate permits, clearances, and approval for activities on Bureau of Land Management and U.S. Air Force lands.	None
Soils	Construction of access roads and site preparation for exploratory holes and the exploratory shaft facility may disturb soils over approximately 273 hectares (675 acres). An additional 12 hectares (30 acres) of surface soils may be disturbed by rock-storage pile, off-road driving, trenching, and geophysical studies.	Stockpile topsoil. Use appropriate design to minimize disruption and the potential for increased runoff and erosion. Establish traffic corridors in off-road areas and confine traffic to these. Minimize the number of corridors and use existing trails where possible. When access routes are no longer required, rip or disc road surface and recontour to promote revegetation.	None

Table 4-6. Summary of environmental effects associated with site characterization (continued)

Impact category	Activity and effects	Standard operating practice	Residual impacts of significance
Ecosystems	Site characterization activities will result in the removal of wildlife habitat (see Soils) and displacement of the resident populations.	Conduct preconstruction surveys to map resident populations. Locate activities to avoid sensitive species when possible. Possibly relocate desert tortoise if avoidance is not possible. Restore physical habitat and implement revegetation program.	Significant for short term in affected areas. Insignificant over the long term and on a regional basis.
	Site characterization activities may expose wildlife to elevated noise levels, resulting in displacement of wildlife or behavior modifications.	None	None
	Fugitive dust and other emissions may destroy or contaminate ephemeral water in catch basins.	Suppress dust and particulate resuspension by spraying water. Minimize emissions from other sources.	None
	Fluid escape from rock-storage pile may result in adverse effects to surrounding vegetation.	Berm rock-storage area.	None
	Off-road driving and increased human activity may result in an increased potential for range fires.	Control off-road driving; space buildings adequately; remove vegetation in working areas.	None

Table 4-6. Summary of environmental effects associated with site characterization (continued)

Impact category	Activity and effects	Standard operating practice	Residual impacts of significance
Air quality	Drilling, blasting, removing and storing rock debris, operating the concrete batch plant, grading and leveling the surface, wind erosion, vehicle travel on paved and unpaved roads, and equipment emissions will generate particulate and gaseous air pollutants.	Control particulate emissions by spraying unpaved roads, rock debris in transit, and the rock-storage pile. Combustion-related emissions will be minimal and temporary.	None
Noise	Construction of surface facilities will result in increased noise.	None	None
	Blasting relating to seismic studies and excavation of the exploratory shaft will result in increased noise.	None	None
	Operation of the exploratory shaft facility will result in increased noise.	Use baffles or silencers in response to Occupational Safety and Health Administration limits on continuous noise.	None
Aesthetics	Site characterization activities will only be visible from portions of Amargosa Valley and U.S. Highway 95.	None	None

Table 4-6. Summary of environmental effects associated with site characterization (continued)

Impact category	Activity and effects	Standard operating practice	Residual impacts of significance
Archaeological, cultural, and historical resources	Surface disturbing activities may result in destruction or disturbance of sites.	Conduct a preconstruction survey of areas to be disturbed. Avoid sites when possible; excavate and/or salvage site and document findings when avoidance is not possible.	None
	Indirect impact to sites not directly affected by surface disturbance may occur due to off-road driving and increased human activity in the vicinity of Yucca Mountain.	Inform workers of legislation that protects sites from unauthorized excavation or other damage.	None
Socioeconomics	Site characterization activities are expected to employ a peak of 690 direct and indirect workers, which represents about 0.3 percent of historical Nye and Clark county total wage and salary employment.	None	None
	State and local participation in planning activities will increase resulting in increased costs to State and local governments.	Provide for financial assistance to State and local governments in accordance with provisions in the Nuclear Waste Policy Act (NWPA, 1983).	None

Table 4-6. Summary of environmental effects associated with site characterization (continued)

Impact category	Activity and effects	Standard operating practice	Residual impacts of significance
Transportation	Transportation of construction materials and workers along U.S. Highway 95 may result in 60 additional worker vehicles between 5 and 6 p.m. and one truck shipment per day.	None	None
Worker safety	Excavation of the exploratory shaft facility may result in approximately 14 worker injuries over 55 months.	Establish worker safety and training programs. Comply with the California Tunnel and Mine Safety Orders.	Average for the mining industry.

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

Chapter 5

REGIONAL AND LOCAL EFFECTS OF LOCATING A REPOSITORY AT THE SITE

This chapter presents an evaluation of the regional and local effects that might result from locating a repository at Yucca Mountain. This preliminary evaluation is based on information about the environment of Yucca Mountain and vicinity, the social and economic conditions in the bicounty area that can be expected to experience the majority of the effects of construction and operation of the repository, the transportation system and access routes that would be used for transporting waste and other materials to the repository, and on the design of the repository. A detailed analysis of regional and local effects would be performed in conjunction with site characterization activities and will be reported in the environmental impact statement prepared by the U.S. Department of Energy (DOE) before the selection of a repository site.

The repository design is not complete, and it is evolving as more data are gathered and as the design process continues. The design that is the basis for Chapter 5 is called the two-stage repository design concept. A previous design, the basis for evaluations in the draft Environmental Assessment (EA), is now called the reference repository design concept; it is not used in the final EA except in a few evaluations where it provides an upper bound to the effects of the later designs.

The two-stage repository design concept is discussed in Section 5.1. This design, however, is continuing to evolve and should be considered a preliminary step in the design process. As an indication of the way the design is evolving, the introductory part of Section 5.1 contains a discussion of newer ideas called the current design concept. Table 5-1 presents a comparison of the characteristics of the reference repository design concept, the two-stage repository design concept, and the current design concept. It also provides a reasonable representation of the expected change in environmental, socioeconomic, and transportation related impacts from a repository in tuff based on the current design concept as compared to the two-stage repository design concept. The intention of Table 5-1 is to assist the reader in understanding the evolutionary process of the repository design; not to provide a limiting analysis for design and impacts. As seen from Table 5-1, the differences in the environmental, socioeconomic, and transportation impacts are comparatively insignificant for the compared design concepts. Both the current design concept and the two-stage repository design concept call for construction in two stages, and for that reason the effects of construction, especially those arising from employment numbers and schedules, are expected to be similar.

The description of the two-stage repository design presented in Section 5.1 and the description of the site presented in Chapter 3 provide the basis on which the assessment of the potential effects on the environment (Section 5.2), on transportation systems (Section 5.3), and on socioeconomic conditions (Section 5.4) are evaluated. Appendix A presents additional information, including the basic assumptions on which the transportation analyses (Section 5.3) are based.

Table 5-1. Comparison of alternative repository design concepts

REPOSITORY CHARACTERISTIC[b]		REFERENCE DESIGN (DRAFT EA) Vertical	REFERENCE DESIGN (DRAFT EA) Horizontal	TWO-STAGE DESIGN (FINAL EA) Vertical	TWO-STAGE DESIGN (FINAL EA) Horizontal	CURRENT DESIGN CONCEPTS (MISSION PLAN) Vertical	CURRENT DESIGN CONCEPTS (MISSION PLAN) Horizontal	CHANGES IN IMPACTS[a] Socio-economic	CHANGES IN IMPACTS[a] Environ-mental	CHANGES IN IMPACTS[a] Trans-portation
INCORPORATES EXPLORATORY SHAFTS?		YES	YES	YES	YES	YES	YES	NSD	NSD	NSD
SUBSURFACE ACCESS										
Ramps	- Waste - air intake	15-ft x 20-ft	15-ft x 20-ft	24-ft dia.	24-ft dia.	21-ft dia.	19-ft dia.			
	- Muck and mine exhaust	15-ft x 20-ft	15-ft x 20-ft	19-ft dia.	19-ft dia.	24-ft dia.	20-ft dia.			
Shafts	- Men and material	20-ft dia.	14-ft dia.	25-ft dia.	25-ft dia.	20-ft dia.	20-ft dia.	NSD	NSD	NSD
	- Repository exhaust	16-ft dia.	14-ft dia.	20-ft dia.	20-ft dia.	20-ft dia.	20-ft dia.			
	- Supply	16-ft dia.	10-ft dia.	12-ft dia. ES	12-ft dia. ES	12-ft dia. ES	12-ft dia. ES			
	- Supply	12-ft dia. ES	12-ft dia. ES	6-ft dia. ES	6-ft dia. ES	6-ft dia. ES	6-ft dia. ES			
Excavated rock - tons		20,000,000	2,200,000	21,600,000	6,580,000	20,700,000	4,630,000		(c)	
Total area - Main surface complex		75 acres	75 acres	150 acres	150 acres	150 acres	150 acres	NSD	NSD	NSD
- Subsurface		1520 acres	1520 acres	1520 acres	1520 acres	1520 acres	1520 acres			
Preclosure period[d] - Construction		1993-1998	1993-1998	1993-2000	1993-2000	1993-2000	1993-2000			
- Operation[e]		1998-2047	1998-2047	1998-2047	1998-2047	1998-2047	1998-2047	NSD	NSD	NSD
- Decommission		2048-2052	2048-2052	2048-2055	2048-2050	2048-2055	2048-2050			
Total capacity		70,000 MTU	70,000 MTU	70,000 MTU	70,000 MTU	70,000 MTU	70,000 MTU	NSD	NSD	NSD
Annual receipt rate[f] - MTU		Yr 1-23 3,000	Yr 1-23 3,000	Yr 1-3 400	Yr 1-3 400	Yr 1-3 400	Yr 1-3 400			
		Year 24 1,000	Year 24 1,000	Year 4 900	Year 4 900	Year 4 900	Year 4 900			
				Year 5 1,800	Year 5 1,800	Year 5 1,800	Year 5 1,800	(g)	(g)	(g)
				Yr 6-27 3,000	Yr 6-27 3,000	Yr 6-24 3,400[h]	Yr 6-26 3,400[h]			
				Year 28 100	Year 28 100	Year 25 1,500	Year 25 1,500			
Waste inventory - spent fuel		35,000 MTU	35,000 MTU	70,000 MTU	70,000 MTU	62,000 MTU	62,000 MTU			
- CHLW		35,000 MTU	35,000 MTU					NSD	NSD	NSD
- TRU		20,000 Pkgs	20,000 Pkgs							
- DHLW						8,000 MTU[i]	8,000 MTU[i]			

Table 5-1. Comparison of alternative repository design concepts (continued)

REPOSITORY CHARACTERISTIC	REFERENCE DESIGN (DRAFT EA) Vertical	REFERENCE DESIGN (DRAFT EA) Horizontal	TWO-STAGE DESIGN (FINAL EA) Vertical	TWO-STAGE DESIGN (FINAL EA) Horizontal	CURRENT DESIGN CONCEPTS (MISSION PLAN) Vertical	CURRENT DESIGN CONCEPTS (MISSION PLAN) Horizontal	CHANGES IN IMPACTS[a] Socio-economic	CHANGES IN IMPACTS[a] Environ-mental	CHANGES IN IMPACTS[a] Trans-portation
Waste handling buildings	One	One	Two	Two	Two	Two	NSD	NSD	NSD
Peak annual usage									
Water - gallons per year	58,600,000	58,600,000	120,000,000	120,000,000	120,000,000	120,000,000			
Electrical - kWh per year	137,000,000	82,000,000	115,000,000	83,000,000	115,000,000	83,000,000	NSD	NSD	NSD
Diesel - gallons per year	1,660,000	946,000	5,500,000	5,500,000	5,500,000	5,500,000			
Peak annual number of direct workers									
Construction period	3,348	2,800	1,905[j]	1,651[j]	1,905[j]	1,651[i]			
Operation - Emplacement phase	2,313	1,442	1,905[j]	1,651[j]	1,905[j]	1,651[i]	NSD	NSD	NSD
- Caretaker phase	594	453	162	146	162	146			
Decommissioning period	1,548	653	412	441	412	441			
Access improvements - Highway	16 miles	16 miles	16 miles	16 miles	16 miles	16 miles			
- Railroad	85 miles	85 miles	100 miles	100 miles	100 miles	100 miles	NSD	NSD	NSD
Total construction materials									
Concrete - cubic yards	554,400	264,700	547,300	266,700	547,300	266,700			
Structural steel - tons	26,100	19,700	201,930	80,940	201,930	80,940	NSD	NSD	NSD
Number of stages	One	One	Two	Two	Two	Two	NSD	NSD	NSD
Fuel consolidation?	Yes	Yes	Stage Two	Stage Two	Stage Two	Stage Two			

[a] Change noted for the difference between the two-stage design and the current design. NSD = No substantial difference.
[b] MTU = metric tons uranium; CHLW = commercial high-level waste; TRU = transuranic waste; DHLW = defense high-level waste.
[c] Less excavation and surface area disturbed will result in less habitat destroyed and more fugitive emissions.
[d] Except for September 1993 (start of construction), the dates indicated above are from January thru December of the year listed.
[e] "Operation" is defined to include the emplacement and the caretaker or retrievability phases.
[f] Year 1 = 1998, i.e. 1st year of waste receipt.
[g] Increasing the number of shipments increases the traffic impacts.
[h] 3,400 MTU includes 3,000 MTU spent fuel plus 400 MTU high-level waste (including DHLW and West Valley high-level waste).
[i] Includes DHLW and West Valley high-level waste.
[j] Construction and operation periods overlap in the year of maximum direct employment. See tables 5-5a and 5-5b.

5.1 THE REPOSITORY

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

Some of the most important features of a repository are illustrated in Figure 5-1. Although it is an artist's rendition of the two-stage repository design concept, it serves as a guide to the following discussion of the evolution of the Yucca Mountain repository design. The conceptual design of the prospective repository consists of a surface facility, a subsurface facility, and a means of access from one to the other. Figure 5-1 shows ramps as the means of access from the surface to the underground repository where mined access drifts connect with other mined drifts in which the waste is emplaced. The waste would be emplaced in holes drilled either horizontally into the walls of the emplacement drifts or vertically into the floors.

As explained in the general introduction to this chapter, three different design concepts can be identified in the continuing evolution of the repository design. The first was the reference repository design described in Jackson (1984). This concept was summarized in Section 5.1 of the December, 1984 draft Environmental Assessment for Yucca Mountain. The second, which is the basis for most of the evaluations found in Sections 5.2 and 5.4 of this document, is the two-stage repository design concept (MacDougall, 1985). This design has evolved through minor changes to a concept called the current design concept that is described in the Mission Plan (DOE, 1985). The characteristics of and expected differences in the three design concepts are summarized in Table 5-1. The most important differences among these concepts are the proposed waste inventory and the staging of construction and waste-receipt activities. The reference design concept was a single-stage facility designed to accept a waste inventory of 35,000 MTU spent fuel and 35,000 MTU-equivalent of commercial high-level waste and reprocessed waste. In the two-stage repository concept, the repository would accept only spent fuel (70,000 MTU) and would be constructed in two phases and operated in two stages. In the current design concept, the repository would receive 62,000 MTU of spent fuel and 8,000 MTU-equivalent of defense high-level waste (including commercial high-level waste from the West Valley Demonstration Project); it would be constructed in two stages; and it would be able to receive spent fuel as early as five years out of the reactor.

The two-stage repository design (MacDougall, 1985) is the design for which the most complete data are available. This design integrates preliminary repository concepts embodied in the reference repository design concept (Jackson, 1984) with recent changes and additions as described in the "Generic Requirements for a Mined Geologic Disposal System" (DOE, 1984). This document stipulates the following design requirements:

- The quantity of waste emplaced in the repository may not exceed 70,000 metric tons of heavy metal (MTHM) as spent fuel, or its

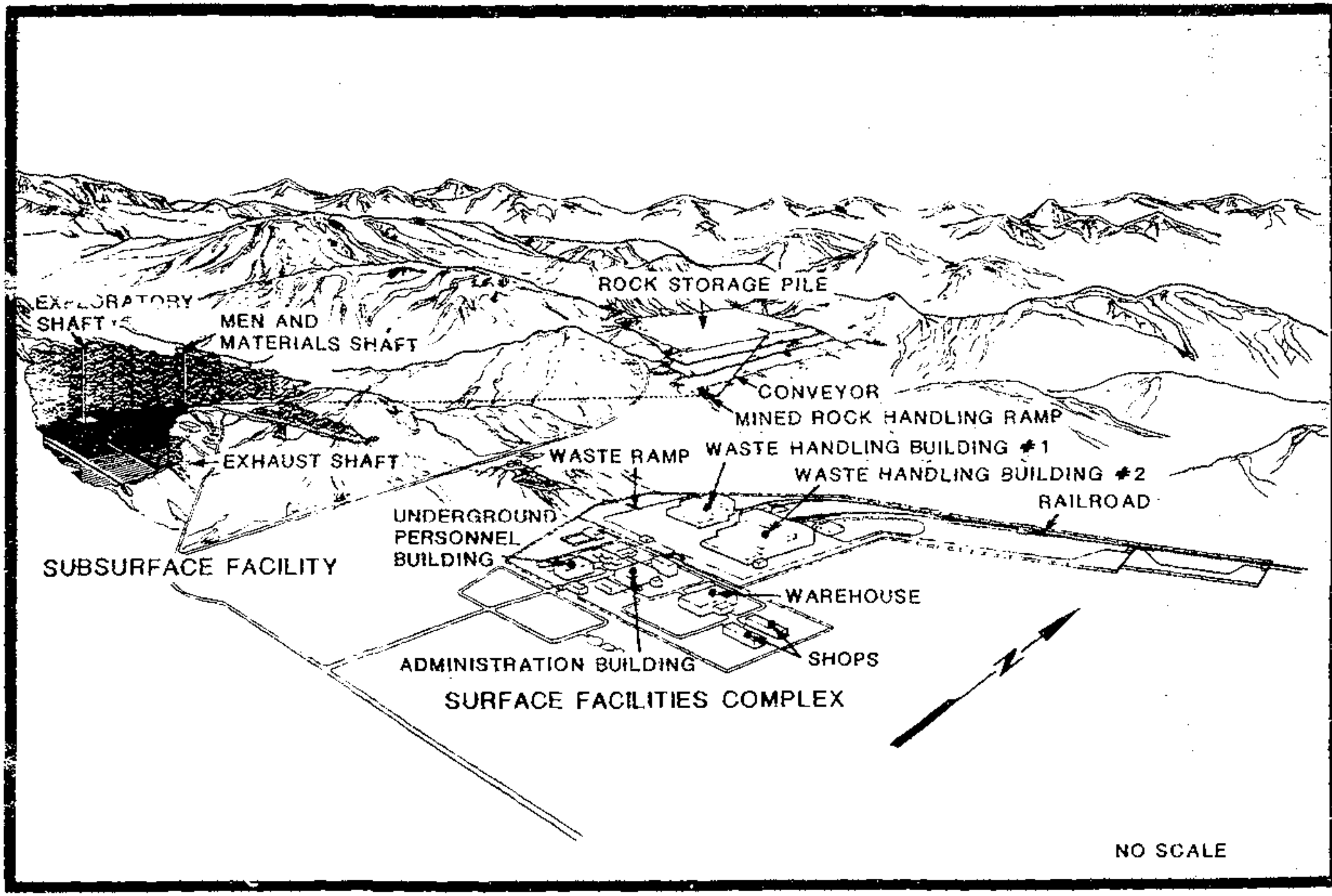

Figure 5-1. Artist's rendition of the proposed Yucca Mountain repository.

equivalent in high-level waste, until a second repository is in operation. Although the waste form most likely to be received for disposal is spent fuel, the design will not preclude the capability to receive, handle, and dispose of reprocessed commercial high-level waste and defense high-level waste.

- The repository will be designed to permit the initiation of waste retrieval operations at any time during the waste-emplacement phase and up to 50 years after emplacement operations have begun, for recovery of any or all of the waste.

- The receipt rate during the first 5 years will increase from an initial rate of 400 MTHM per year to 1,800 MTHM per year. For the remainder of the emplacement phase it will be 3,000 MTHM per year.

- A surface facility with a surge storage capacity for accommodating the equivalent of a three-month accumulation of waste receipts will be provided, (i.e., 100 MTU equivalent for Stage 1 operation and up to 750 MTU equivalent for Stage 2 operation). This capability will help to minimize the impact of scheduled or unscheduled interruptions in repository operations on the offsite transportation system and waste shippers. The storage facility will be capable of accommodating both the waste receipts from offsite sources and the waste packages prepared on the site.

Under the current design concept (DOE, 1985) the repository would receive defense high-level waste at a rate of 400 MTU-equivalent per year beginning in 2003, the sixth year of operation. The waste would be in the form of borosilicate glass contained in waste disposal containers approximately 0.6 meter (2 feet) in diameter, 3 meters (10 feet) high, and weighing about 1.8 metric tons (4,000 pounds). Shipment may be by either truck or rail. If shipment were by truck, this design would result in approximately three shipments per day for defense waste or 800 waste disposal containers per year. In either the two-stage repository concept or the current design concept, the Stage 1 waste-handling building, designed to receive up to 400 MTU per year, would no longer be used to receive spent fuel after 2002 when the Stage 2 facility becomes fully operational. In the current design concept, the Stage 1 facility could then be used for the receipt and handling of defense waste beginning in 2003. Since the defense waste has lower thermal and radiation levels than spent fuel, the Stage 1 facility would be totally suitable to perform this function.

The addition of defense waste to the inventory would have little effect on the characteristics of the two-stage repository concept. The defense-waste disposal containers would be placed into the waste disposal container, welded, inspected, transported underground, and placed in the disposal location. Additional personnel would be required for waste-handling and emplacement crews, but the number required for approximately three additional packages per day is considered to be within the uncertainties of the manpower estimate for the two-stage repository concept. The waste-handling ramp into the repository could accommodate the additional packages, and the mining activities could prepare the emplacement holes on schedule. Since repository area is based on thermal loading, the overall size of the repository would not be increased.

The "Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste" (10 CFR Part 961, 1985) establishes the contractual terms and conditions under which the U.S. Department of Energy (DOE) will make available nuclear-waste disposal services to the owners and generators of spent nuclear fuel and high-level radioactive waste as provided in Section 302 of the Nuclear Waste Policy Act of 1982 (NWPA, 1983) (the Act). The contract designates spent fuel aged as little as 5 years out of reactor as "... standard spent fuel." The Standard Contract (10 CFR Part 961, 1985) and the DOE Mission Plan (DOE, 1985) both specify that the DOE will accept fuel for disposal on an "... oldest first ..." basis. Therefore, for most of the emplacement phase, the average age will be greater than 10 years with an estimated 5 to 10 percent aged as little as 5 years. The two-stage repository concept, described in this document, is based on 10-year-old fuel.

The DOE has not yet conducted studies to assess the impact of accommodating this amount of 5-year-old waste. These studies will be performed during the advanced conceptual design phase of the repository design process. Higher thermal and radiation levels could be expected, but can be accommodated by changes in operating procedures and by increased shielding. If a monitored retrievable storage (MRS) facility (briefly discussed in the following paragraphs) is approved and built, the 5-year-old fuel may be aged there before it is taken to the repository. The extent of future changes in the repository design may depend principally on decisions regarding a MRS facility.

Section 141 of the Act directs the DOE to study the need for and the feasibility of a monitored retrievable storage facility for spent fuel and high-level waste (NWPA, 1983). The DOE analyzed the provisions of the Act and programmatic options in the June 1985 Mission Plan (DOE, 1985) and is evaluating an integrated waste-management system that consists of both storage and disposal components. The primary function of the MRS facility is waste preparation for emplacement in a geologic repository; it has a secondary role of providing temporary backup storage. Performing the waste-preparation functions (i.e., spent-fuel consolidation and packaging) in an integrated MRS facility instead of at the repository may simplify the design, construction, and operation of the repository facilities. By providing a processing and storage capacity between waste acceptance from the utilities and emplacement in a repository, the MRS facility would help maintain better and more consistent control over the flow of waste from reactors to repository. An integrated MRS facility would also provide a central location for the management of spent-fuel transportation, cask-fleet operations, and cask-fleet servicing. However, there are many trade-offs that must be considered before determining the functions of a MRS facility versus a repository. Considering that fewer facilities and activities at the repository site would be needed if an integrated MRS/repository system was developed since waste consolidation would be accomplished at the MRS site, the nonradiological impacts discussed in this EA should encompass those for a repository design coupled to the MRS facility if Congress authorizes the MRS facility.

Appendix A of this EA presents general background information on transportation topics and issues. Qualitatively, the nonradiological environmental impacts discussed in the EA should encompass those involving transportation coupled with the MRS facility, if Congress authorizes a MRS facility. The MRS transportation analysis is found in Appendix A. It should be noted that the MRS impacts are not considered in the preparation of Table 5-1.

The Act directs the DOE to submit to Congress a proposal that establishes a program for the siting, construction, and operation of MRS facilities (NWPA, 1983). The DOE plans to submit this proposal to Congress in January 1986. To provide a technical basis for the Congressional decision, the following documents would be included in or would accompany, the proposal to Congress: (1) site-specific facility designs, (2) a need and feasibility report, (3) a program plan (funding, integration, deployment), and (4) an environmental assessment. Studies conducted during the summer of 1985 to support the January 1986 proposal will define more precisely the waste-preparation functions that would be performed by a MRS facility in an integrated waste-management system.

Should Yucca Mountain be selected for site characterization, the design of the repository would progress from feasibility and conceptual studies, to Site Characterization Plan (SCP) conceptual design, to advanced conceptual design, license application design, and final procurement and construction design. The SCP conceptual design and advanced conceptual design would resolve the current uncertainties in the design and serve as the basis for the environmental impact statement that would be prepared during site characterization.

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

The Yucca Mountain site is described in Section 3.1. The surface facility would be along the eastern foothills of Yucca Mountain. The subsurface facility would be located approximately beneath the ridge line of Yucca Mountain. The proposed highway and rail access routes to the site are shown on Figure 5-2. The proposed highway access would originate at U.S. Highway 95, approximately 1 kilometer (0.5 mile) west of the town of Amargosa Valley and extend about 26 kilometers (16 miles) northward to the site. The proposed rail line would originate at Dike Siding, 18 kilometers (11 miles) northeast of downtown Las Vegas and extend approximately 161 kilometers (100 miles) to the site.

The lifetime of a repository at Yucca Mountain, before it is permanently closed, may be divided into several periods: construction, operations, and decommissioning. These periods are discussed in detail in Sections 5.1.1 though 5.1.4 and are illustrated in Figure 5-3a and 5-3b. Here they are simply summarized. All of the Stage 1 and a portion of the Stage 2 facilities would be constructed and some of the subsurface facilities would be excavated during the first 4.3 years of the 7.3-year construction period. The Stage 2 facilities would be completed in the last 3 years of the construction period, which would overlap with the first 3 years of the operations period. The operations period, which would last for 50 years, would consist of two phases. Radioactive waste would be received and emplaced during the 28-year emplacement phase. The underground facilities and surrounding environment would be monitored during this phase. The 22-year caretaker phase would follow completion of waste-emplacement operations; the facilities, as well as the surrounding environment, would

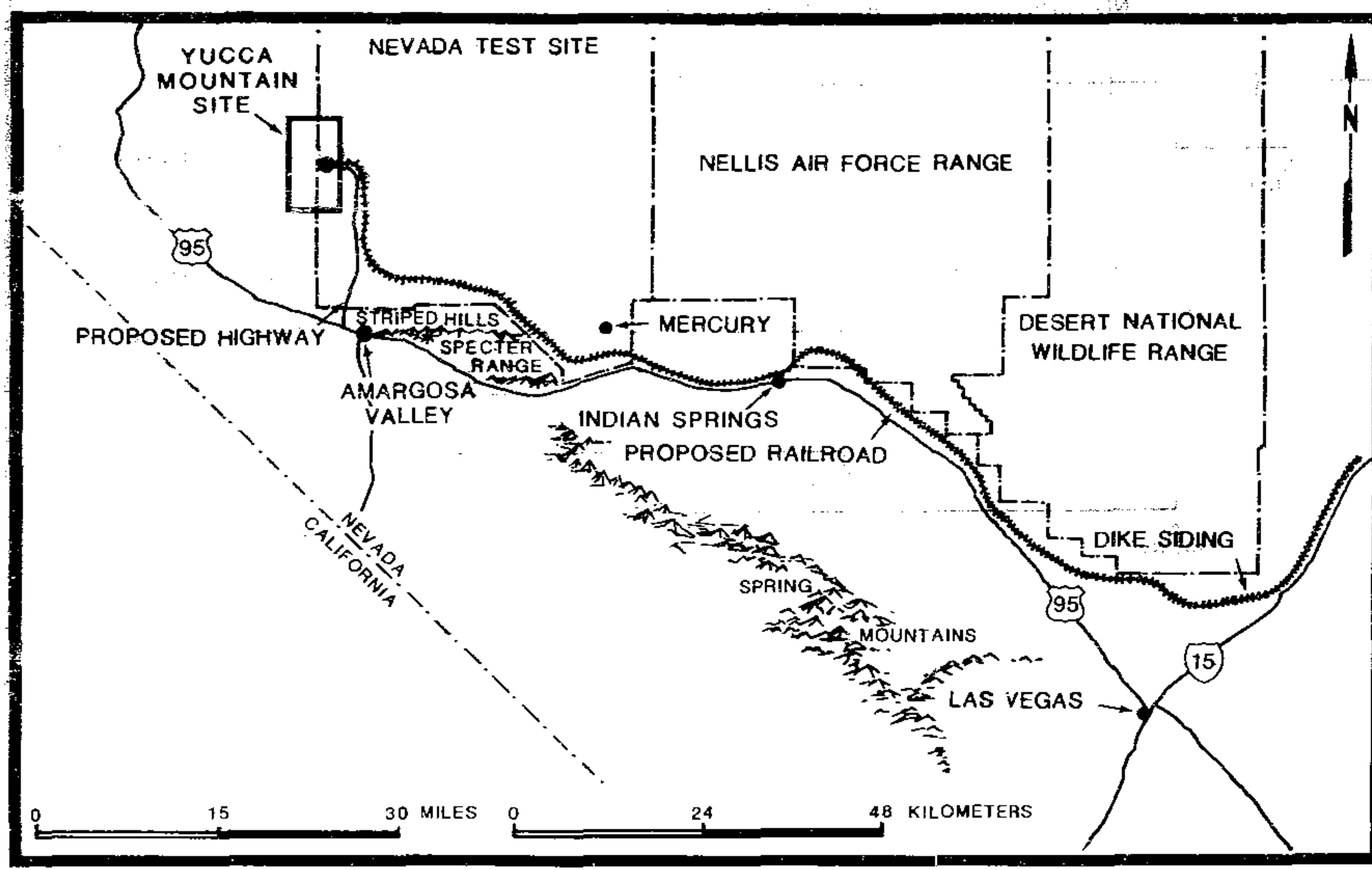

Figure 5-2. Proposed highway and rail access routes to the Yucca Mountain repository.

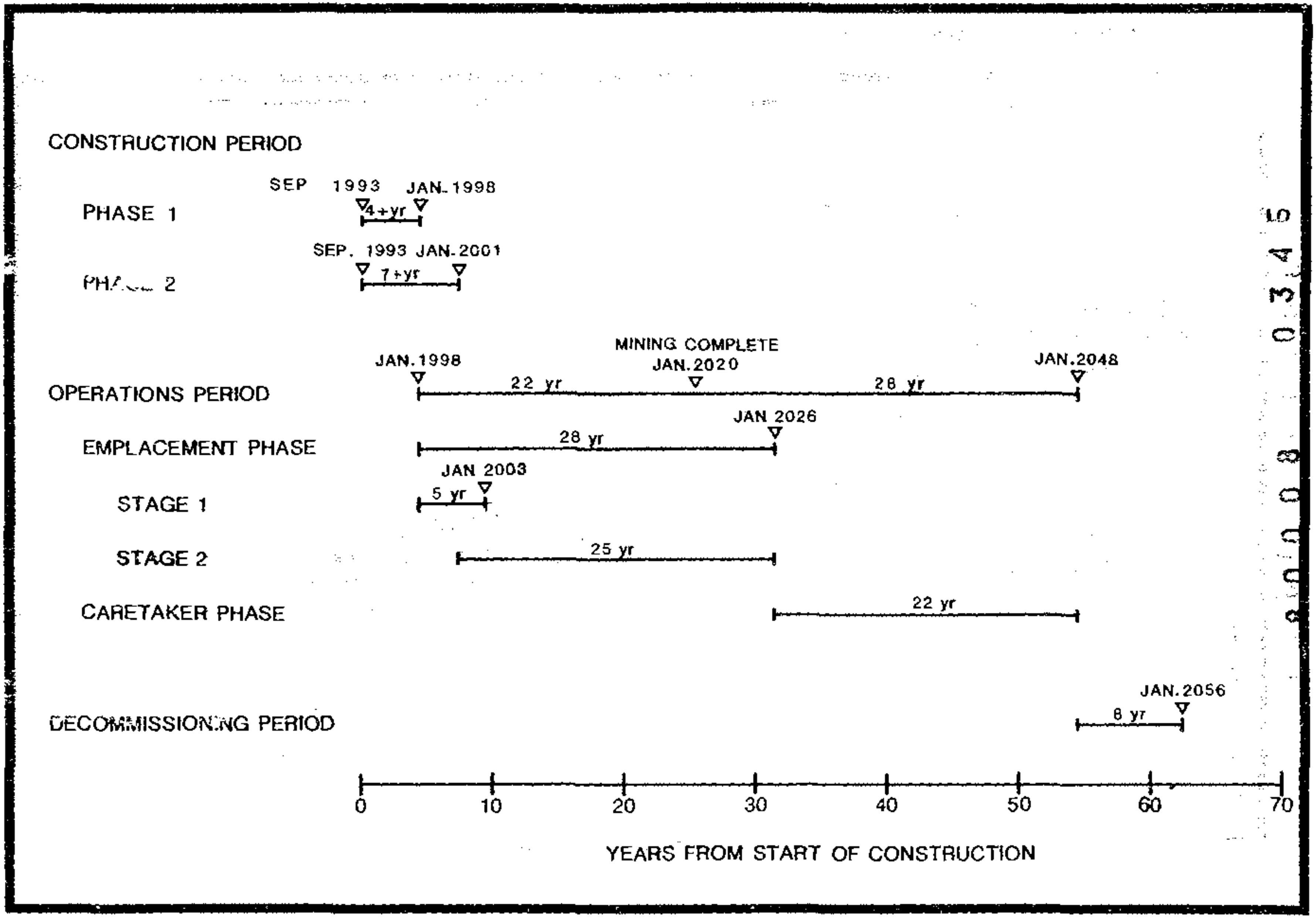

Figure 5-3a. Repository schedule for vertical emplacement.

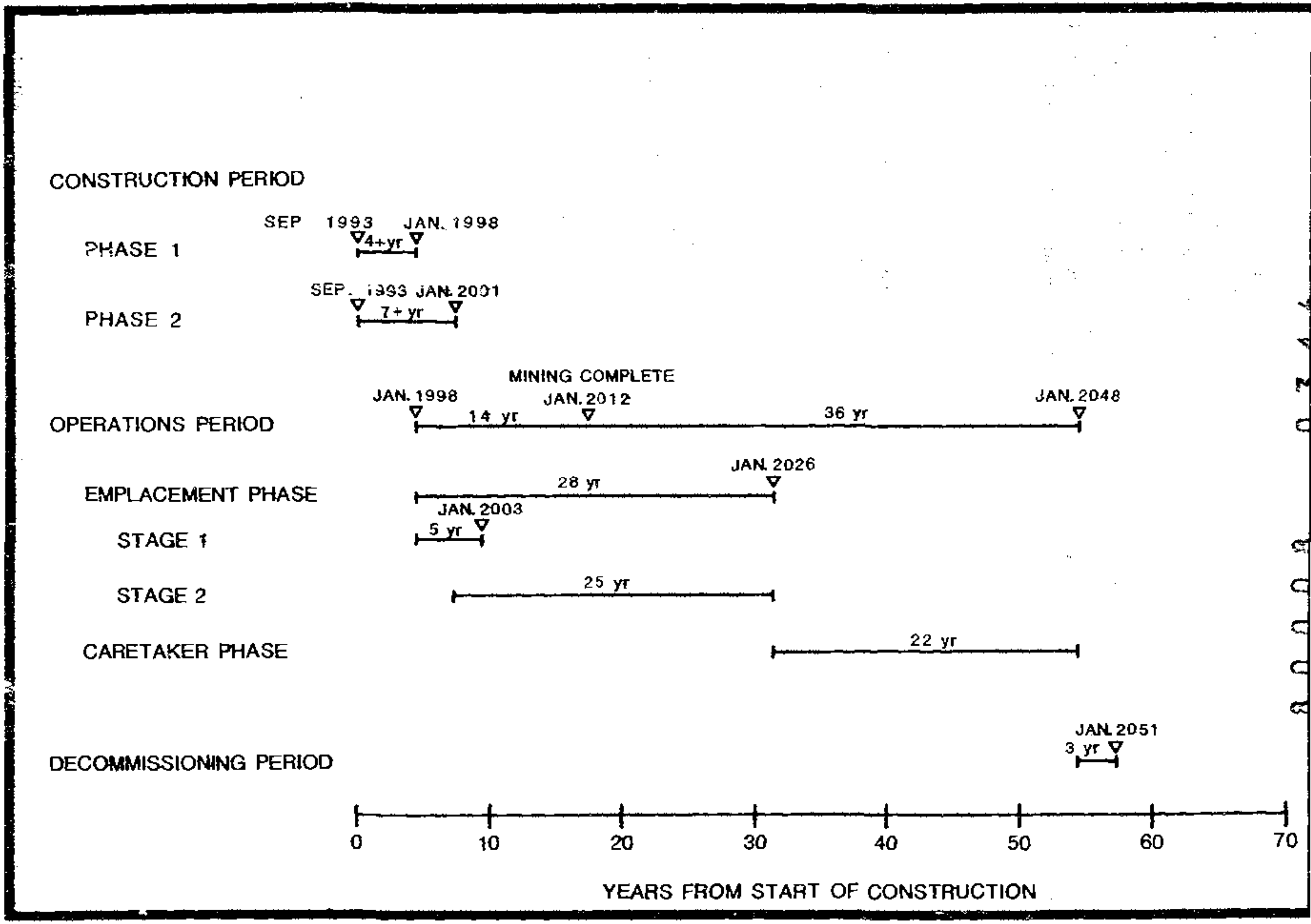

Figure 5-3b. Repository schedule for horizontal emplacement.

continue to be monitored, and the retrievability option would be maintained in compliance with Nuclear Regulatory Commission requirements (10 CFR Part 60, 1983) for ensuring retrievability at any time up to 50 years after waste emplacement begins. If a decision to retrieve the waste were made during the caretaker phase, the lifetime of the project would be extended approximately 30 years during which actual waste retrieval would be accomplished. A decision to close and decommission the repository could be made at any time during the caretaker phase. The decommissioning and closing of the repository would last for an 8-year period under the vertical-emplacement alternative or a 3-year period under the horizontal-emplacement alternative.

5.1.1 CONSTRUCTION

The construction period begins after construction authorization is received from the Nuclear Regulatory Commission. Repository construction would proceed in two phases that would begin simultaneously.

Phase 1 construction, which takes place from 1993 to 1998, consists of construction and acceptance and start-up testing of the Stage 1 surface facility and underground facilities required to accept and emplace 400 metric tons uranium (MTU) per year. Phase 2 construction, which ends in the year 2000, consists of the completion of all the facilities, including the Stage 2 waste-handling building, required to consolidate and accept 3,000 MTU per year. It should be noted that Phase 2 construction overlaps the operations period, which begins in 1998. Underground excavation, which would begin in the construction period, would continue throughout most of the operations period.

Most surface construction would occur at the main surface facilities complex. Construction of these facilities is discussed in the following section (Section 5.1.1.1). Surface construction away from the main surface facility complex would include highways and rail connections, mine ventilation buildings, and other ancillary facilities. Surface facilities constructed away from the main surface facility complex are described in Section 5.1.1.4.

5.1.1.1 The surface facilities

The actual location of the surface facilities has not yet been determined. However, a candidate location has been identified for the purpose of preparing this document. The candidate location for these facilities is along the gently sloping east side of Yucca Mountain, as shown on Figure 5-4. The surface facilities complex proposed at Yucca Mountain would encompass approximately 60 hectares (150 acres) of land, all of which would be enclosed by a security fence.

A preliminary site plan of the proposed surface facilities at Yucca Mountain is shown on Figure 5-5. The surface facilities in the complex would be used for waste-handling and packaging operations in support of the underground activities and to provide general repository support services. The restricted-access area for waste-handling and packaging facilities would

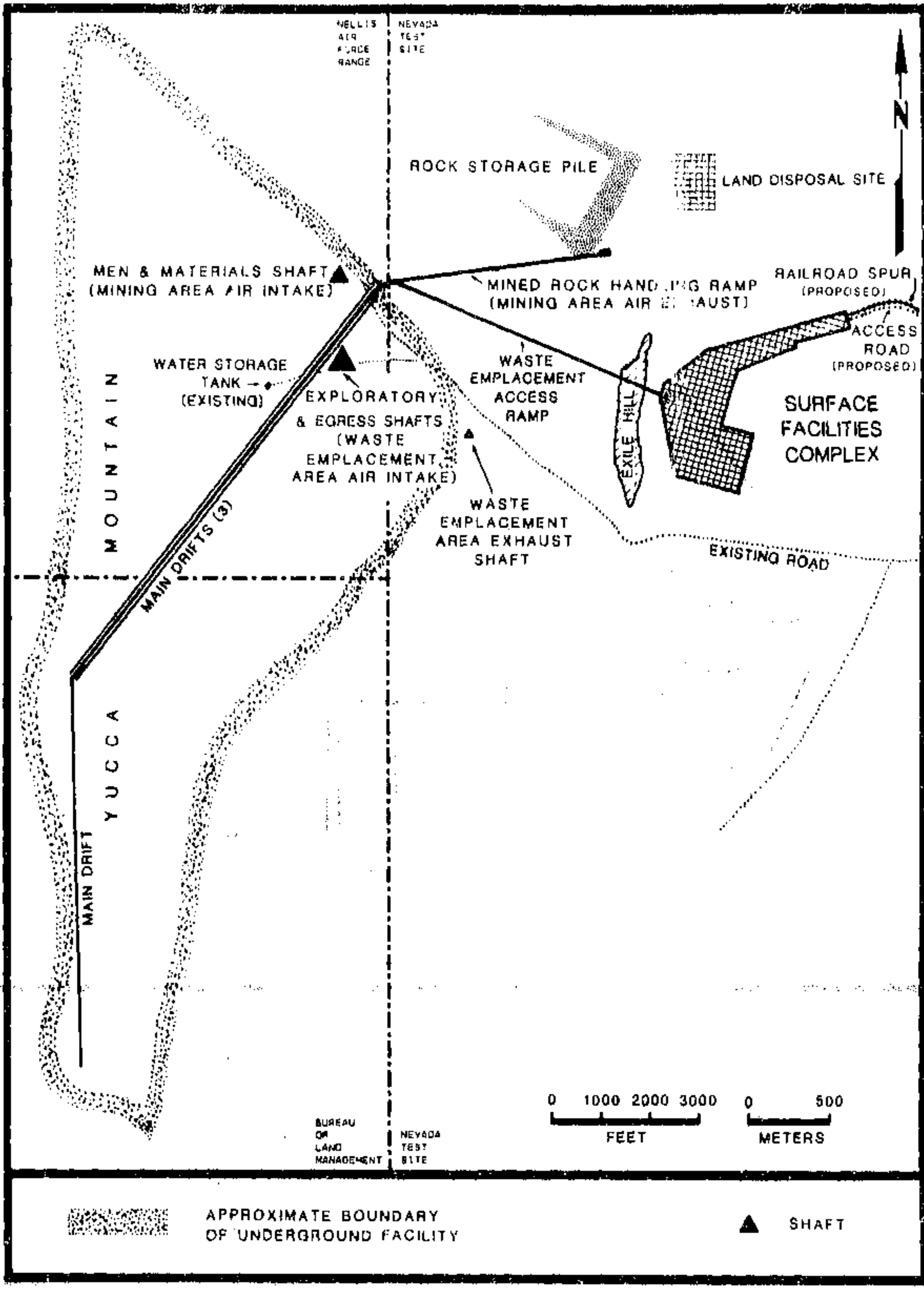

Figure 5-4. Two-stage repository site plan. Modified from MacDougall, 1985.

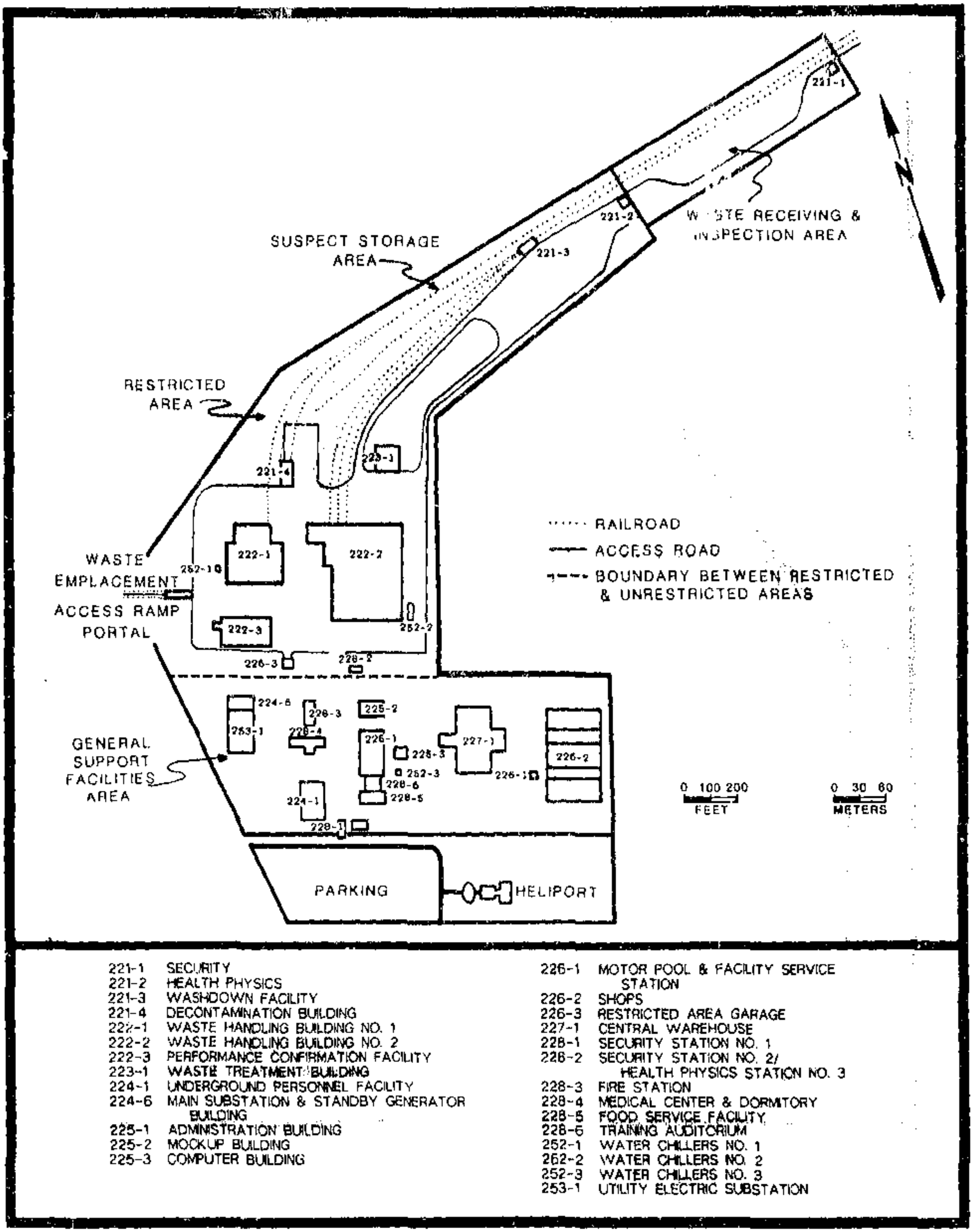

Figure 5-5. Preliminary site plan for proposed surface facilities for a two-stage repository. Modified from MacDougall (1985).

include buildings and equipment for receiving and packaging all incoming wastes (see Section [illegible].1.2.1.2 for more details). A facility would also be constructed for processing all the radioactive waste generated by onsite operations, such as protective clothing, decontamination fluids, and ventilation filters.

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

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

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

5.1.1.2 Access to the subsurface

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

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

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

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

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

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

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

5.1.1.3 <u>The subsurface facilities</u>

The subsurface facilities would be located within Yucca Mountain, approximately 1.7 kilometers (1 mile) west of the proposed location of the surface facilities complex (Figure 5-4). This facility would encompass approximately 615 hectares (1,520 acres) of subsurface area. The repository horizon would be more than 230 meters (750 feet) below the surface within the Topopah Spring Member of the Paintbrush Tuff. The water table in the vicinity of Yucca Mountain is approximately 200 to 400 meters (650 to 1,300 feet) below the potential repository horizon. Except for possible scattered pockets of perched water, the underground openings are expected to be dry. An artist's rendition of the proposed subsurface facilities is shown in Figure 5-6.

The subsurface facilities consist of main access drifts to the emplacement areas, the emplacement drifts, and service areas near the shafts and ramps. The layout of the facilities depends upon whether the waste is emplaced vertically or horizontally. For vertical emplacement, waste disposal containers would be emplaced in vertical boreholes in the floors of the emplacement drifts. An extraction ratio of 24 percent has been adopted for the vertical emplacement alternative (Dravo, 1984a). Cross-sectional dimensions of these openings are listed in Table 5-2. The total amount of rock excavated for the facility would be about 21.6 million tons.

For horizontal emplacement, waste disposal containers would be emplaced in horizontal boreholes in the draft pillars (walls). The subsurface layout for horizontal waste-emplacement requires considerably less excavation. The total amount of rock excavated for the facility would be about 6.6 millon tons. Table 5-2 lists the dimensions of the openings for horizontal waste emplacement.

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

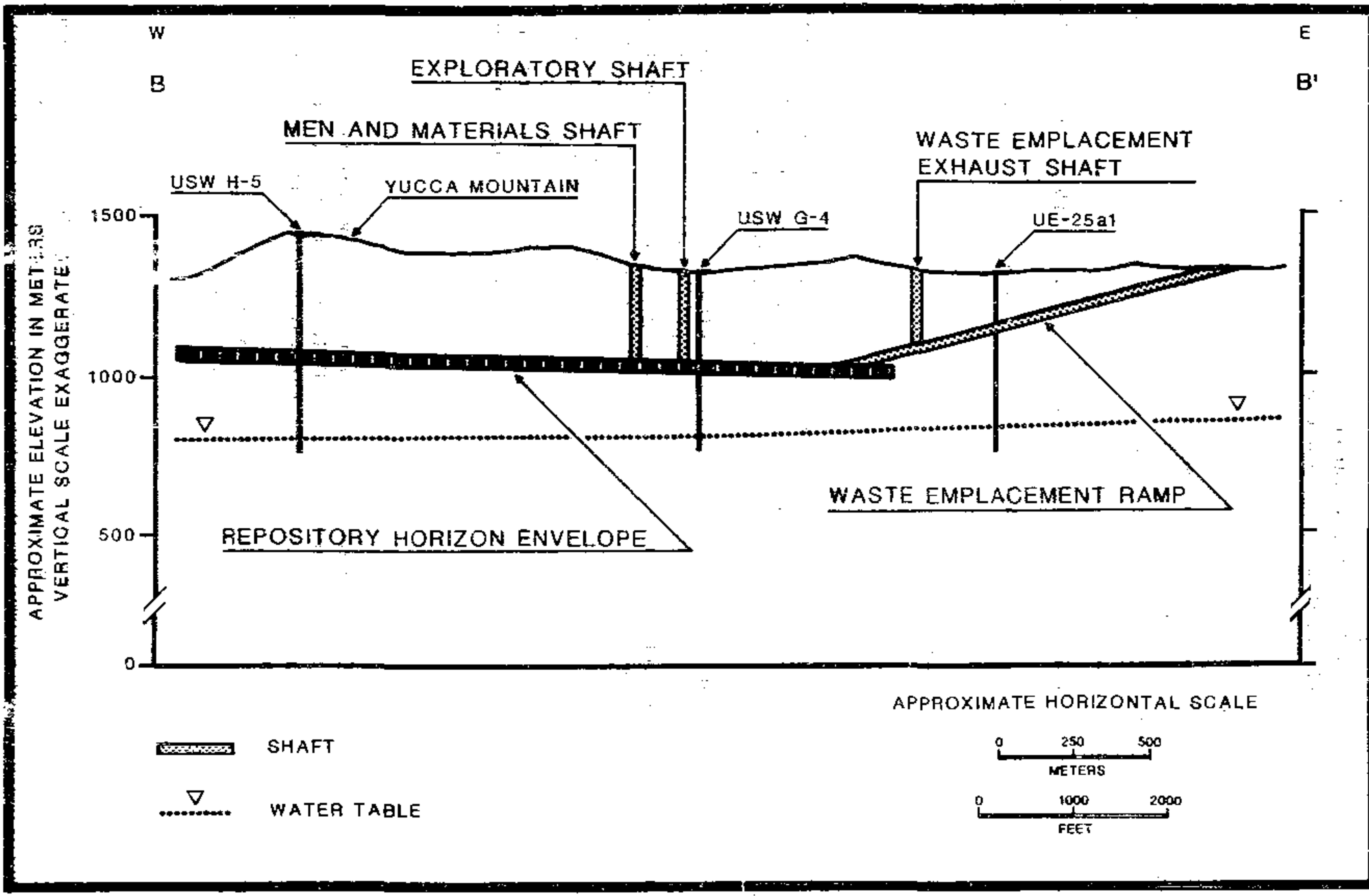

Figure 5-6. Artist's rendition of the proposed subsurface facilities.

Table 5-2. Dimensions of underground openings for vertical and horizontal waste emplacement[a]

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

[a]Data from MacDougall (1985).

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

The excavated rock would be placed near the site in a hypalon-lined rock storage pile (see Figure 5-4). The rock-storage pile would be constructed on the surface using conventional mined-rock handling equipment and would be sprayed with water to suppress dust. Runoff from precipitation would be intercepted by dikes, ditches, and liquid-collection sumps. The present design does not require backfilling of the excavated access and emplacement drifts to maintain the structural integrity of the underground openings. If backfilling of a portion of the repository is required before closure and decommissioning, some of the excavated rock would be used for that purpose.

5.1.1.4 Other construction

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

5.1.1.4.1 Access route

A highway for truck and automobile access would be constructed between U.S. Highway 95 and the site (Figure 5-2). The two-lane highway would originate approximately 1.0 kilometer (0.5 mile) west of the Town of Amargosa

Valley. The highway would be 9 meters (30 feet) wide and 26 kilometers (16 miles) long; it would be rated for trucks with a gross weight of 36 metric tons (80,000 pounds). Each roadway shoulder would be 2.5 meters (8 feet) wide. The total required right-of-way would be about 31 meters (100 feet); the total land area needed will be about 79 hectares (195 acres).

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

5.1.1.4.2 Railroad

For rail access to the site, a rail spur is proposed to be constructed from the Las Vegas area (see Figure 5-2.) The proposed railhead facility would be constructed in the vicinity of Dike Siding, approximately 18 kilometers (11 miles) northeast of downtown Las Vegas. The proposed rail connection from Dike Siding would require approximately 161 kilometers (100 miles) of track (MacDougall, 1985) and a bridge over Fortymile Wash. A right-of-way 31 meters (100 feet) wide would be required; the land committed to the rail line would total about 486 hectares (1,200 acres). A railhead facility would be constructed at Yucca Mountain to provide for railcar handling and temporary storage. Detailed plans for this facility have not been formulated.

The route shown on Figure 5-2 and described by MacDougall (1985) is the currently proposed route and could change as additional information is gathered. For example, portions of the rail line may be located on the south west side of U.S. Highway 95. Other rail access alternatives are currently being evaluated.

5.1.1.4.3 Mined rock handling and storage facilities

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

5.1.1.4.4 Shafts and other facilities

Exhaust shafts for the mine and emplacement areas, described in Section 5.1.1.2, would be located away from the surface complex. The exact locations would depend on the design of the underground facilities. The configuration, assuming that ramps for waste-emplacement access and mined material removal would be used, is shown in Figure 5-4. A fenced waste-emplacement ventilation exhaust and filtration facility would be installed at the surface and would require an area of less than 1 hectare (about 1 to 2 acres). The exhaust stack at this facility would extend about 31 meters (100 feet) above the land surface. Improved roads would connect this site to the surface complex.

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

5.1.2 OPERATIONS

The operations period is the time following receipt of the first waste into the repository (after receipt of the Nuclear Regulatory Commission license to receive and possess radioactive material) until site decommissioning begins. The operations period of a repository for radioactive waste at Yucca Mountain would begin in the fifth year after the start of facility construction with Stage 1 emplacement operations. Stage 2 emplacement operations would begin approximately 7 years after start of construction. As noted in Section 5.1.1, the operations period overlaps the completion of the Stage 2 facilities (end of Phase 2 construction).

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

5.1.2.1 Emplacement phase

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

5.1.2.1.1 Waste receipt

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

During Stage 1 operations, surface and underground facilities would be constructed to receive and emplace a limited amount (400 metric tons uranium (MTU) per year) of spent, unconsolidated fuel. This would be packaged at the site for disposal in the repository. The Stage 2 facilties to be completed 3 years later than the Stage 1 facilities, would have a capacity of 3,000 MTU per year and they would be capable of receiving other types of waste and of consolidating spent fuel. Receipt rates would gradually increase in the early years of repository operation (see Table 5-3).

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

The receiving facilities would provide for (1) rail and truck inspection stations where both incoming and outgoing traffic would be inspected (where, for example, radiation surveys, security inspections, and shipping document transactions would take place); (2) a suspect storage area where incoming shipments that do not meet repository acceptance standards would be held until corrective measures are taken; (3) a loading area for incoming and outgoing shipments; (4) a vehicle washdown facility; (5) a loading and unloading bay where the shipping packages would be removed from and loaded onto their carriers; (6) a decontamination station in the waste-handling building where waste packages would be checked and decontaminated; and (7) a station in the waste-handling building where cask closure(s) would be prepared for connecting the casks to the hot-cell port for unloading (Figure 5-5).

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

5.1.2.1.2 Waste emplacement

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

Before disposal, spent fuel would be sealed in waste disposal containers designed to meet the minimum lifetime requirements set by the Nuclear Regulatory Commission (10 CFR Part 60, 1983). To meet these requirements, the minimum life time of the waste packages would be between 300 and 1,000 years under the expected subsurface environmental conditions in the repository. These waste disposal containers are one component of a system of engineered barriers, including waste forms, overpacks, and packing materials that may be used as part of the repository system.

Table 5-3. Spent-fuel waste receipts by year, metric tons uranium equivalent[a]

Repository year	Calendar year	Stage 1	Stage 2	Annual total	Cumulative total
5	1998	400	NA[b]	400	400
6	1999	400	NA[b]	400	800
7	2000	400	NA[b]	400	1,200
8	2001	400	500	900	2,100
9	2002	400	1,400	1,800	3,900
10-30	2003-2024	NA[b]	3,000	3,000	69,900
31	2025	NA[b]	100	100	70,000

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

Table 5-4. Waste quantities by waste category[a]

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

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

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

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

5.1.2.2 Caretaker phase

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

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

5.1.3 RETRIEVABILITY

The Yucca Mountain repository would be designed to allow retrieval of emplaced waste as required by 10 CFR 60.111 (1983). The requirements state that waste must be retrievable for a period of up to 50 years after waste emplacement begins. The requirements also state that if retrieval becomes necessary, the waste should be retrieved in about the same amount of time that was devoted to the initial construction and the emplacement of the waste. The capability to retrieve emplaced waste packages would be maintained until the satisfactory completion of a performance confirmation program as stipulated by 10 CFR 60.111 (1983) and until decommissioning activities are authorized by the Nuclear Regulatory Commission (NRC) (unless a longer or shorter time period is specified by the Secretary U.S. Department of Energy (DOE) and approved by the NRC).

Designs for the subsurface facilities would incorporate features to ensure that the openings would remain intact for at least 92 years (which includes a 4-year, Stage 1 construction phase, a 28-year operations phase, a 22-year caretaker phase during which retrieval could be initiated, a possible 30-year retrieval period, and/or a 8-year decommissioning period; see figures 5-3a and 5-3b). These features may include minimizing the extraction ratio, optimizing rock temperatures through spacing of emplacement holes and ventilation, and the use of steel liners for emplacement holes. In addition, periodic inspections and maintenance programs would be used to monitor and verify the stability of the subsurface openings throughout the operations period.

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

The DOE developed a position on retrievability to fully describe and document all design, construction, operation, and maintenance equipment requirements associated with retrievability. An evaluation of the effects of these requirements on the repository design and the associated equipment needs has not been completed at this early stage in the repository design process. These retrieval effects would be analyzed and addressed during the site characterization period and subsequent design phases supporting the license application.

5.1.4 DECOMMISSIONING AND CLOSURE

After the planned 22-year caretaker phase during which retrievability must be ensured and after the performance confirmation program has been completed, the U.S. Department of Energy (DOE) would request Nuclear Regulatory Commission approval for an amended license for closure of the repository. After approval had been granted, decommissioning of the repository would begin. To decommission the subsurface facilities, salvageable materials would be brought to the surface. During closure, all subsurface access areas (e.g., shafts and ramps) would be sealed using multiple materials and techniques to ensure that the seal offers isolation properties equivalent to or better than the host rock (Fernandez and Freshley, 1984).

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

5.1.5 SCHEDULE AND LABOR FORCE

The proposed schedules for constructing, operating, and decommissioning the repository, based on either a vertical or horizontal emplacement configuration, are shown in Figures 5-3a and 5-3b. The schedules address the three periods defined in sections 5.1.1, 5.1.2 and 5.1.4 (i.e., the construction, operations, and decommissioning periods). The construction and operations periods overlap in the two-stage repository design concept. During the first 4.3 years of the construction period, the railroad, highway, surface-support facilities, and Stage 1 waste-handling building would be completed in preparation for the first receipt of waste by January 1998 at a rate of 400 metric tons uranium (MTU) per year. The first receipt of waste marks the beginning of the operations period. During the same 4.3-year first construction phase, the underground portion of the repository would be developed sufficiently to permit initial emplacement of waste, and construction of the Stage 2 waste-handling building would begin. During the initial portion of the operations period, after the start of Stage 1 operations, the Stage 2 waste-handling building would be completed in preparation for receipt of waste by January 2001 at a rate of 500 MTU per year. This quantity would be increased to a rate of 3,000 MTU per year by January 2003, at which time the Stage 1 waste-handling building would no longer receive spent fuel, as shown in Table 5-3.

The operations period, scheduled to start in January 1998, would continue for 50 years. As shown in Figures 5-3a and 5-3b, the operations period is divided into an emplacement phase (28 years) and a caretaker phase (22 years). The emplacement phase is subdivided into Stage 1 and Stage 2 emplacement activities, lasting for 5 and 25 years, respectively, and overlapping by 2 years. Underground repository development would continue during the emplacement phase, but would be completed 6 years prior to the completion of vertical emplacement, if that configuration is used, or 14 years prior to the completion of horizontal emplacement. If it is determined that retrieval of waste is necessary, it could be initiated at any time during the operations period. The length of time required for retrieval would be approximately equal to the elapsed emplacement time plus 5 years, to allow sufficient time for required facility modifications, equipment procurement, and mobilization.

The decommissioning period begins at the end of the operations period, contingent upon repository performance confirmation. If all of the underground rooms and drifts are backfilled, approximately 8 years will be required to decommission the repository if vertical emplacement is used and 3 years if horizontal emplacement is used. The figures and tables in this subsection are based on the assumption that all of the underground rooms and drifts will be backfilled. If backfilling of the underground rooms and drifts is not required, it is estimated that decommissioning would require approximately 2 years to complete for either of the emplacement configurations.

As stated in MacDougall (1985), the size of the labor force required during the construction, operations, and decommissioning periods depends upon whether vertical or horizontal emplacement is used. Preliminary estimates of the average annual number of workers, are summarized in Table 5-5a for the vertical emplacement method and Table 5-5b for the horizontal emplacement method.

For purposes of preparing the estimates, it was assumed that three principal organizations would be involved: 1) a surface construction contractor or contractors who would build the railroad, highway, surface support buildings and facilities, and the waste-handling buildings; 2) a mining contractor who would develop all of the underground portions of the repository; and 3) an operating contractor who would be responsible for all

Table 5-5a. Average annual number of repository related workers for vertical emplacement[a,b]

					[——OPERATIONS PERIOD——]											
	[——CONSTRUCTION PERIOD——]														[—DECOMMISSIONING PERIOD—]	
	[—Phase 1 Construction—] / [——Phase 2 Construction——]				[——Emplacement Phase——]								[—Caretaker Phase—]			
YEARS	1993	1994	1995 and 1996	1997	1998	1999	2000	2001	2002 thru 2018	2019	2020 thru 2024	2025	2026 thru 2046	2047	2048 thru 2054	2055
SKILL OF DIRECT WORKERS																
Construction Contractor(s)																
Construction[c]	87	346	519	433	344	173	82							39	77	39
Construction Support[c]	10	39	58	48	42	21	10							5	9	5
Mining Contractor																
Mining	35	140	210	175	149	149	149	149	169	75				57	113	57
Mining Support	70	280	420	350	253	253	253	253	253	127				57	113	57
Operating Contractor																
Construction Managers[c]	20	81	121	101	82	41	20									
Inspectors	12	48	72	60	46	23	10									
Quality Assurance	12	47	70	87	91	78	79	79	84	75	67	37	8	14	20	10
Surface Emplacement					44	44	54	54	107	107	107	57	7	6		
Surface Support				529	800	800	936	1,058	1,058	1,058	1,058	574	89	59	29	15
Underground Emplacement					20	20	40	40	80	80	80	44	7	4		
Underground Support				34	34	34	34	34	34	60	86	69	51	51	51	26
Total Workers																
Direct	246	981	1,470	1,817	1,905	1,636	1,667	1,667	1,765	1,582	1,398	781	162	290	412	209
Indirect	379	1,511	2,264	2,798	2,934	2,519	2,567	2,567	2,718	2,436	2,153	1,203	249	447	634	322
Total vertical emplacement	625	2,492	3,734	4,615	4,839	4,155	4,234	4,234	4,483	4,018	3,551	1,984	411	737	1,046	531

[a]Data from MacDougall (1985).

[b]Assumptions:
1. The average annual number of workers includes a 10% allowance for vacation, sick leave, and other absenteeism, plus a 30% contingency allowance.
2. 10% of the total number of construction workers are support personnel.
3. 1.54 indirect workers for each direct worker (see Section 5.4.1.1).
4. Except for September 1993 (start date) the dates indicated above are from January through December of the listed year.

[c]Data from Morales (1985). The number of workers for the year 1998 to 2001 in categories indicated differ from those in MacDougall (1985) in order to reflect the latest philosophy of DOE's June 1985 Mission Plan (DOE, 1985).

Table 5-5b. Average annual number of repository related workers for horizontal emplacement[a,b]

YEARS	1993	1994	1995 and 1996	1997	1998	1999	2000	2001	2002 thru 2010	2011	2012 thru 2024	2025	2026 thru 2046	2047	2048 thru 2049	2050
	[——CONSTRUCTION PERIOD——]														[—DECOMMISSIONING PERIOD—]	
	[—PHASE 1 CONSTRUCTION—]				[——OPERATIONS PERIOD——]											
	[——PHASE 2 CONSTRUCTION——]				[——Emplacement Phase——]								[—Caretaker Phase—]			
SKILL OF DIRECT WORKERS																
Construction Contractor(s)																
Construction[c]	85	338	507	423	340	173	86							58	116	58
Construction Support[c]	9	37	56	47	40	20	11							7	13	7
Mining Contractor																
Mining	29	115	172	143	57	37	37	37	37	19				57	113	57
Mining Support	57	229	344	287	115	64	64	64	64	32				57	113	57
Operating Contractor																
Construction Managers[c]	18	72	108	90	75	38	19									
Inspectors	11	43	65	54	45	23	11									
Quality Assurance	10	42	63	79	76	60	62	62	67	65	64	35	7	14	21	11
Surface Emplacement					44	44	54	54	107	107	107	57	7	4		
Surface Support				511	768	768	895	1,022	1,022	1,022	1,022	556	89	59	29	15
Underground Emplacement					23	23	45	45	90	90	90	49	7	4		
Underground Support				17	17	17	17	17	17	35	53	45	36	36	36	18
Total Workers																
Direct	219	876	1,3[illegible]	1,651	1,600	1,267	1,301	1,301	1,404	1,370	1,336	742	146	296	441	223
Indirect	337	1,349	2,025	2,543	2,464	1,951	2,004	2,004	2,162	2,110	2,057	1,143	225	456	679	343
Total Horizontal Emplacement	556	2,225	3,340	4,194	4,064	3,218	3,305	3,305	3,566	3,480	3,393	1,885	371	752	1,120	566

[a]Data from MacDougall (1985).

[b]Assumptions: 1. The average annual number of workers includes a 10% allowance for vacation, sick leave, and other absenteeism, plus a 30% contingency allowance.
2. 10% of the total number of construction workers are support personnel.
3. 1.54 indirect workers for each direct worker (See Section 5.4.1.1).
4. Except for September 1993 (start date) the dates indicated above are from January through December of the listed year.

[c]Data from Morales (1985). The number of workers for the year 1998 to 2001 in categories indicated differ from those in MacDougall (1985) in order to reflect the latest philosophy of DOE's June 1985 Mission Plan (DOE, 1985).

waste-handling and emplacement functions and support services, mine maintenance after the mining contract is complete, and caretaking. It was also assumed that the operating contractor would have administrative responsibility for Title III services, construction management, quality assurance, and decommissioning activities. Therefore, estimates of the labor requirements for the operating contractor include these activities.

The average annual number of workers required to fill the commitments of construction was estimated from the total number of man-years given in MacDougall (1985). Estimates are based on the assumption of an increase in manpower over the first two years to a peak, which is maintained for two years and then decreases constantly during the last four years of construction.

Workers for operations are based on unit operations given in Dennis et al., (1984) and summarized in MacDougall (1985). Management, inspection and QA activities will begin with the start of construction. Emplacement and surface support workers will arrive before the start of waste receipt for training and preliminary start-up. The number of workers will increase for Stage 1 operations, increase again for Stage 2 operations and remain constant for the next 24 years of operations, after which they will decrease to a small caretaker force until decommissioning and closure begin.

Mining workers are estimated from the calculations of the number of drifts and emplacement holes to be mined (MacDougall, 1985) and experience with mining in similar media.

Mining would be completed 21 years after the beginning of vertical emplacement. At that time the mining staff would be reduced from 305 to 36. In the horizontal emplacement alternative, mining would be completed 13 years after start of emplacement and the mining staff would be reduced from 83 to 25.

Work force is shown by activity in Table 5-5a and 5-5b. The total of direct workers is plotted in Figures 5-7a and 5-7b. Schedules for these activities are shown in Figure 5-3a and 5-3b.

The number of workers on the site at any one time would vary with the time of day. Mining activities would be conducted on a three-shift basis for 250 days per year. Although most surface operations would run on a one-shift basis, some activities may require two or three shifts. In all instances the day shift would employ the most workers.

5.1.6 MATERIAL AND RESOURCE REQUIREMENTS

The amounts and types of construction materials for the repository are only estimates at this time. Because concrete and steel represent the greatest quantities of construction material, estimates of these are given as an indication of the quantities of materials that would be required. The estimated amounts of energy resources and construction materials that would be required annually for the repository and the total amounts required are listed in Table 5-6. Construction materials would be shipped to the

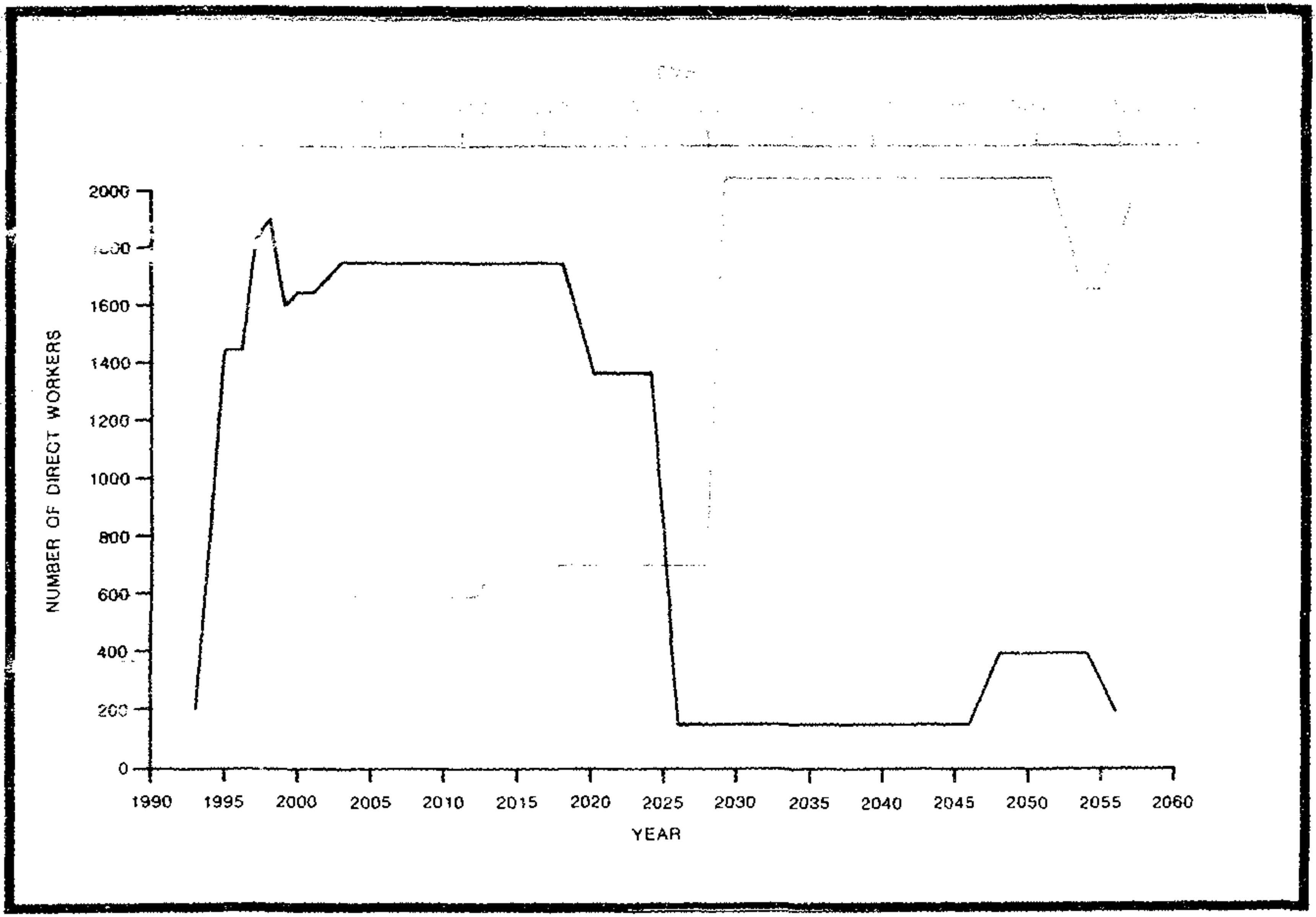

Figure 5-7a. Number of direct workers over time for vertical emplacement.

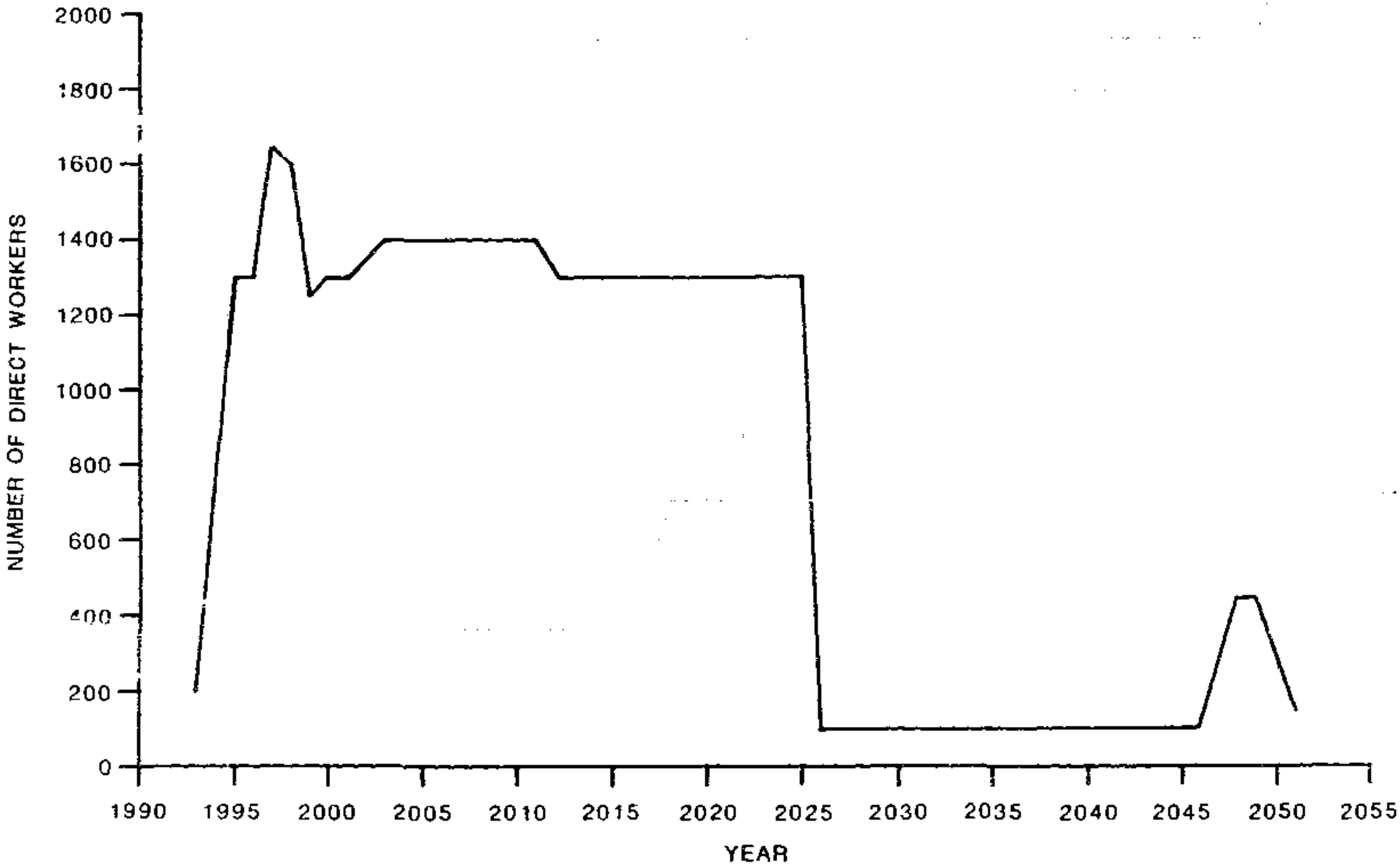

Figure 5-7b. Number of direct workers over time for horizontal emplacement.

Table 5-6. Repository requirements for power, fuel, and construction materials[a,b]

Requirement	1994	1995	1996	1997	1998	1999 thru 2018	2019 thru 2024	2025 thru 2046	2047 thru 2054	Totals
REQUIREMENTS - VERTICAL EMPLACEMENT										
Annual Electrical Usage										
Millions of kWh	36	70	74	90	112	115	68	22	76	4,302
Annual Diesel Usage										
Thousands of Gallons	4,310	5,500	3,750	1,880	1,000	1,000	55	10	40	61,570
Truckloads	287	367	75	38	20	20	15	0	1	1,285
Railcars	0	0	88	44	23	23	18	0	1	731
Annual Concrete Usage										
Cubic Yards	64,400	70,200	71,200	23,700	16,600	13,700	0	0	3,400	547,300
Truckloads	6,440	7,020	2,136	711	498	411	0	0	102	25,841
Railcars	0	0	1,359	452	317	262	0	0	65	7,888
Annual Steel Usage										
Tons	5,530	8,840	9,240	5,590	3,990	7,310	3,730	0	20	201,930
Truckloads	277	442	139	84	60	110	56	0	1	3,546
Railcars	0	0	65	39	28	51	26	0	0	1,308
Total Annual Shipments										
Truckloads	7,004	7,829	2,350	833	578	541	71	0	104	30,672
Rail-carloads	0	0	1,512	535	368	336	44	0	66	9,927
REQUIREMENTS - HORIZONTAL EMPLACEMENT										
Annual Electrical Usage										
Millions of kWh	29	61	68	74	83	73	71	14	76	2,721
Annual Diesel Usage										
Thousands of Gallons	4,310	5,500	3,750	1,750	750	750	730	5	20	35,450
Truckloads	431	550	113	53	23	23	22	0	1	1,757
Railcars	0	0	72	33	14	14	14	0	0	483
Annual Concrete Usage										
Cubic Yards	63,300	59,900	52,700	6,400	4,300	4,400	0	0	9,100	266,700
Truckloads	6,330	5,990	1,581	192	129	132	0	0	273	16,625
Railcars	0	0	1,006	122	82	84	0	0	174	2,740
Annual Steel Usage										
Tons	5,440	7,640	7,130	3,570	1,240	3,040	1,380	0	40	80,940
Truckloads	272	382	107	54	19	46	21	0	2	1,686
Railcars	0	0	50	25	9	21	10	0	0	476
Total Annual Shipments										
Truckloads	7,033	6,922	1,801	299	171	201	43	0	276	20,068
Railcars	0	0	1,128	180	105	119	24	0	174	3,699

[a]Data from MacDougall, 1985.

[b]Notes: (1) All quantities include a contingency allowance of 30%.

(2) The following assumptions were used for shipping loads:
Diesel: 15,000 gallons per truckload and 30,000 gallons per railcar.
Concrete: Raw Materials (sand, gravel, and cement) shipped at 15 cubic yards per truckload and 55 cubic yards per railcar, 1.5 cubic yards of raw materials per cubic yard of concrete and 0.1 tons of steel per cubic yard of reinforced concrete.
Steel: 20 tons per truckload and 100 tons per railcar.

(3) Shipments assumed to be by truck only in years 1 and 2 and 70% by rail and 30% by truck for following years.

(4) To convert from gallons to liters, multiply by 3.785; to convert from cubic yards to cubic meters, multiply by 0.765.

repository, highway, and railroad construction sites by highway and rail. The estimated number of annual shipments of material over the repository lifetime is shown in Table 5-6.

Significant quantities of the bulk materials and total costs required for construction of the highway and railroad have been estimated in Table 5-7 (MacDougall, 1985). Materials and total costs for the bridge(s) over Fortymile Wash are also included in these estimates. The number of shipments required for delivery of these materials to the various sites along the routes are also indicated in the table.

Table 5-7. Highway, bridge, and railroad construction materials[a]

	Cost[b] (millions of dollars)	Quantity	Units[c]	Units per shipment	Number of shipments
Highway[d]	12.5				
Asphalt		42,000	yd^3	15	2,800
Bituminous base		63,700	yd^3	15	4,250
Aggregate base		120,800	yd^3	15	8,050
Bridge	6.7				
Concrete		4,000	yd^3	15	270
Precast girders		140	each	2	70
Total Truck Shipments					15,440
Railroad[e,f]	144				
Rails and tie plates		34,000	tons[c]	100	340
Ties		300,000	each	500	600
Ballast		350,000	tons	100	3,500
Sub-ballast		600,000	yd^3	55	10,900
Total Rail Shipments					15,340

[a]Data from MacDougall (1985).
[b]Costs include labor, materials, and markup extension, including contingency.
[c]1 cubic yard (yd^3) = 0.765 cubic meters; 1 ton = 0.907 metric tons.
[d]A contingency allowance of 30% was added to highway and bridge quantities.
[e]A contingency allowance of 10% was added to railroad quantities.
[f]Only the major bridge over Fortymile Wash has been included.

During the early years of construction, all shipments would be by truck while the railroad is being constructed. Upon completion of the railroad, materials would also be shipped to the site by train. Because of the volumes of construction material required and the remoteness of the site, railroads would be an efficient means of material supply. Typical equipment requirements for the construction of the repository are shown in Table 5-8. Most of this equipment would be removed after construction. Some equipment, however, would remain during the operations phase.

Over the lifetime of this project, various resources, such as cleared land and water, would be required at the repository. Estimates of the amount of these resources required for two-stage repository development, assuming vertical emplacement of waste, are listed in Table 5-9. The commitment for a rock storage pile and for water would be slightly less for a horizontal emplacement configuration.

Table 5-8. Estimated use of construction equipment

Typical types of equipment

Bulldozers	Earthmovers	Dump trucks
Drilling machines	Front-end loaders	Gravel elevators
Graders/scrapers	Backhoes	Shovels
Cranes	Earth compactors	Air compressors
Concrete mixers	Drill rigs	Rock handling elevators
Scaling machines	Rock bolting machines	Boring machines
Truck cranes	Service vehicles	

Equipment use by category

Category	Number of units[a]	Fuel consumption rate[b] (gallons per hour)
Heavy duty (400-hp)	60	30
Medium duty (250-hp)	60	10
Light duty (150-hp)	90	6

[a] Assumed operating time is 1,500 hours per year.
[b] 1 gallon = 3.785 liters.

Table 5-9. Estimated repository resource requirements[a]

Resource	Requirement
Cleared land (acres)[b]	
Main surface complex[c]	150
Other facilities[c]	25
Mined rock disposal, vertical emplacement[d]	110
Mined rock disposal, horizontal emplacement[d]	35
Railroad[e]	1,200
Highway[f]	195
Total cleared land, vertical emplacement (acres)	1,680
Total cleared land, horizontal emplacement (acres)	1,605
Controlled area (acres)[g]	24,710
Subsurface area (acres)	1,520
Water use[h] (gallons per year)[b]	120,000,000

[a]MacDougall (1985), except as noted.

[b]1 acre = 0.405 hectares; 1 gallon = 3.785 liters = 3.785 x 10^{-3} cubic meter = 3.07 x 10^{-6} acre feet.

[c]Includes a 30 percent contingency. Does not include land to be developed as a land disposal site or visitor center.

[d]Assumes a mined rock pile 100 feet high. Quantities are from MacDougall (1985): 21,600,000 tons for vertical emplacement and 6,580,000 tons for horizontal emplacement, including a contingency allowance of 25 percent. The density was assumed to be 90 pounds per cubic foot.

[e]Assumes a railroad right-of-way 31 meters (100 feet) wide and 161 kilometers (100 miles) long.

[f]Assumes a highway right-of-way 31 meters (100 feet) wide and 26 kilometers (16 miles) long.

[g]According to 40 CFR Part 191, the boundary of the controlled area is not to exceed 5 kilometers (3.1 miles) in any direction from the emplaced waste.

[h]As reported in Morales (1985), water consumption at the repository will rise to a peak of approximately 120 million gallons per year during the first 6 years. Use is expected to decrease to about 115 million gallons per year and remain at this level during the emplacement phase, about 26 years, and then decrease to approximately 2,500,000 gallons per year during the 22-year caretaker phase. There would be a moderate increase in usage to approximately 25 million gallons per year during decommissioning and until closure.

5.2 EXPECTED EFFECTS ON THE PHYSICAL ENVIRONMENT

This section describes the potential local and regional impacts on the physical environment that may result from locating a repository at Yucca Mountain. The topics discussed include possible impacts to the geologic and hydrologic environments, land use, ecosystems, air quality, noise levels, aesthetics, archaeological, cultural, and historical resources, and background radiation levels. Where necessary, the discussion of potential effects is categorized by repository period (i.e., construction, operations, decommissioning and closure). Effects that would occur during the caretaker phase of the operations period are not discussed because the effects are small compared with effects that occur during other repository phases. The effects discussed are based on the design contained in the two-stage repository concepts report (MacDougall, 1985). This design, however, is undergoing revision (see the introduction to Chapter 5), and some impacts could change. A definitive analysis of potential repository impacts will be presented in the final environmental impact statement prepared in compliance with the Nuclear Waste Policy Act of 1982 (NWPA, 1983).

5.2.1 GEOLOGIC IMPACTS

Locating a repository at Yucca Mountain is expected to have minimal impact on the geologic environment. Excavation of the repository represents an insignificant disturbance to the overall competence of the rock units at Yucca Mountain. Studies by Dravo (1984a,b) and Hustrulid (1984) indicate that a repository can be built in the welded tuff of the Topopah Spring Member at Yucca Mountain using standard construction techniques (Section 6.3.3.2). Access drifts and underground openings can be supported by conventional rockbolts, wire mesh, and shotcrete. Intersections of fault zones and drifts could be supported, if necessary, by steel or by concrete. Experience in tunnels indicates that additional support would not be necessary. Heat and radiation, which would be introduced into the rocks by decay of radioactive material in the repository, would affect only a small volume of rock and would not affect the rock's isolation capability, competence, or structural stability (sections 6.3.1.2, 6.3.1.3, and 6.3.3.2). Furthermore, there are no indications that the retrieval of wastes, if required, would be hampered because of the effects of heat and radiation on the rock. Calculations predict that only minor thermally induced fractures extending less than 10 centimeters (4 inches) into the rock may occur around the waste-emplacement boreholes. Any possible difficulty in retrieving the wastes due to thermally induced fracturing could be either reduced or avoided by using steel sleeves in the waste-emplacement boreholes.

Future exploration and development of any local mineral or energy resources would be prohibited on approximately 10,000 hectares (24,710 acres) of Federal land. Literature review and field resource surveys (Bell and Larson, 1982; Quade and Tingley, 1983), field exploration and geologic mapping (Christiansen and Lipman, 1965; Lipman and McKay, 1965; Scott and Bonk, 1984), and geochemical analysis of exploratory borehole cuttings have shown that the potential for mineral and energy development at Yucca Mountain is low. Future exploration and development is not anticipated.

5.2.2 HYDROLOGIC IMPACTS

Locating a repository at Yucca Mountain is expected to have minimal impact on the hydrologic environment. Potential impacts include the following: the exclusion of any future exploitation of ground water in the area immediately surrounding the repository; regional drawdown effects from ground-water withdrawals at Yucca Mountain; release of radionuclides into the ground water; flash flooding at the repository; the diverted flood-water effects on the surrounding environment; and surface-water effects. The secondary effects on municipal water systems from population increases caused by locating a repository at Yucca Mountain are discussed in Section 5.4.3.

Development of a repository at Yucca Mountain would result in a controlled area within which ground-water exploitation would be prohibited. However, the character of the land is such that ground-water exploitation would not be expected. An estimate of ground-water potential by Sinnock and Fernandez (1982) indicates that future generations are more likely to drill for water in Jackass Flats to the east and Crater Flat to the west of Yucca Mountain than on the mountain itself, primarily because of the greater depth to ground water beneath Yucca Mountain (see also Section 6.3.1.8). Thus, no significant impact on ground-water exploitation is expected.

The regional effects of withdrawing ground water for a repository at Yucca Mountain are expected to be negligible. It has been estimated that the water requirements for a repository at Yucca Mountain would average about 432,000 cubic meters (350 acre-feet) per year over a 32-year period that includes the construction period and the emplacement phase assuming vertical emplacement, (Morales, 1985). Although this water can be adequately supplied by existing wells, primarily Well J-13 located on the Nevada Test Site (Figure 4-2), present plans call for the construction of new wells and storage provisions to be located at the proposed main surface facilities complex (Morales 1985). Thordarson (1983) reports that the water level in Well J-13 has remained essentially constant after long periods of pumping between 1962 and 1980. The large volume of water produced from this well (approximately 488,000 cubic meters (400 acre-feet) per year), along with the minor drawdown during pumping tests (Young, 1972), suggests the aquifers underlying Yucca Mountain can produce an abundant quantity of ground water for long periods of time without lowering the regional ground-water table (sections 6.3.1.1 and 6.3.3.3).

Both preliminary assessments of the long-term performance of a repository at Yucca Mountain (Sinnock et al., 1984; Thompson et al., 1984) and preliminary performance analyses described in sections 6.3.2 and 6.4.2 of this environmental assessment indicate that a repository at Yucca Mountain would meet the U.S. Environmental Protection Agency standards for radionuclide releases to the accessible environment (40 CFR Part 191, 1985). The analyses indicate that the natural barriers to radionuclide migration at Yucca Mountain, which are inherent attributes of the geologic and hydrologic setting, would adequately limit exposure to the accessible ground water and to the public for the required period of 10,000 years. Furthermore, there is no evidence to suggest that during the next 10,000 years the water table will rise to a level that could flood the repository. The details in Section 6.3.1.4 support this conclusion.

Part of the area being considered for construction of the surface facilities at Yucca Mountain could be inundated by the 500-year and regional maximum floods along Fortymile Wash (Squires and Young, 1984). During construction of the surface facilities, a combination of surface grading and construction of both flood barriers and diversion channels would be used to prevent such flooding (Section 6.3.3.3). The drainage control measures could result in locally increased erosion, but the overall impact is not expected to be significant.

The repository would be designed to be in compliance with Federal and State laws concerning liquid effluents. A packaged trickling-filter sewage treatment system is being considered for use at the repository. The effluent will conform to the requirements established by the Nevada State Board of Health for secondary treatment. Current plans for offsite sanitary sewage-disposal measures include septic tanks with seepage pits, absorption trenches, or seepage beds. A hypalon-lined evaporative pond would be used for mine waste-water effluents. These structures would be located beyond the repository geologic block. Outside the surface complex, runoff from precipitation would be channeled into the natural drainage system on Yucca Mountain. Inside the complex, runoff would be collected and drained into evaporation ponds. Runoff and possible leachates from the rock-storage pile would be retained by the hypalon liner and storage-pile berm. The water used for dust control during the construction of the access road and railroad would not be applied in large enough quantities to cause runoff or ponding.

5.2.3 LAND USE

A total of 10,000 hectares (24,710 acres) of land would be controlled by the U.S. Department of Energy (DOE) for repository uses (see Table 5-9.). This land is currently administered by the DOE, the Department of the Air Force, and the Bureau of Land Management. The DOE portion is currently used for nuclear research and development purposes. The Nellis Air Force Range (NAFR) is used for military weapons testing and personnel training. The portion of the range in the immediate vicinity of Yucca Mountain is reserved for overflights and provides air access to the bombing and gunnery areas located north and west of Yucca Mountain. Transfer of this land is not expected to adversely affect its current use of providing access to Air Force training areas. The Nevada Test Site (NTS) and the NAFR have been withdrawn from public use for more than 30 years. Continued restriction of public access is not expected to affect either the current or the future economic and recreational requirements of the people in this region.

In addition to use of NTS and NAFR land, about 2,100 hectares (5,000 acres) of public land administered by the Bureau of Land Management (BLM), U.S. Department of Interior, may be withdrawn from public use. Because Yucca Mountain is not a prime location for other uses, withdrawing this land should have essentially no effect on land use in the area. Construction of the rail line would require obtaining a right-of-way on BLM land (See Figure 5-2). Assuming that access to lands north of the proposed rail line is neither restricted nor reduced, adverse impacts are not expected to occur to users of these areas. The proposed new access road would be located on the NTS with the exception of a small segment on BLM land between the NTS and U.S. Highway 95.

5.2.4 ECOSYSTEMS

This section describes the effects that locating a repository at Yucca Mountain may have on terrestrial and aquatic vegetation and wildlife. Possible adverse effects are greatest for the construction period and are a result of removing vegetation and increasing transportation in the vicinity of the site.

The primary ecological effect of repository construction would be the permanent removal of about 680 hectares (1,680 acres) of vegetation. Table 5-9 itemizes the acreage that would be disturbed. Clearing this land is not expected to be ecologically significant because the affected areas are very small compared with surrounding undisturbed areas that have similar vegetation.

The ecological effects that may result from construction depend on the nature, size, location, and duration of the disturbance. If the disturbance is restricted to the surface without removing the soil, then revegetation from an existing seed source or from root stock could occur within 10 to 20 years (Wallace et al., 1980). If the disturbance includes removing the soil, then natural revegetation may require hundreds of years (Wallace et al., 1980). The development of new vegetation is usually inhibited by the very low precipitation in the area and is also influenced by soil characteristics and animal feeding habits.

A secondary ecological effect of removing the vegetation is the alteration of the habitats for wildlife. The vegetation provides wildlife with food, with structures for nesting, and with shelter from predators and climatic extremes. When the vegetation of an area is destroyed, the wildlife that is dependent on that area is destroyed or displaced into the surrounding, undisturbed areas. Most displaced wildlife will die, however, due to competition with wildlife that inhabit the adjacent undisturbed areas. However, the net potential effect would probably not be significant because the areas that would be disturbed are not ecologically unusual and because the potentially affected biota represents only a very small percentage of the surrounding, undisturbed biota in this region.

Indirect ecological effects of construction may also be caused by combustion emissions, fugitive dust, sedimentation, and noise. The projected concentrations of the combustion emissions, which are described in Section 5.2.5, are not considered high enough to cause any significant adverse effects to the plants and animals in the region. However, fugitive dust deposition on the leaves of desert shrubs can increase the loss of leaves (Beatley, 1965). Over several years, deposition of dust could result in the death of shrubby vegetation near disturbed areas. Levels of fugitive dust would be minimized to the extent possible by mitigative measures such as wetting the surface of the disturbed areas. Also, erosion of disturbed areas and sedimentation both during and after storms could bury the vegetation surrounding the disturbed areas. However, erosion of the disturbed areas would be controlled to the extent possible by maintaining moderate slopes and by applying soil stabilizers, if necessary. Construction noise may affect some animal communities; potential noise impacts are discussed in Section 5.2.6.

Although there are no federally listed threatened or endangered species in the vicinity of Yucca Mountain, two species that occur in the area are being reviewed for inclusion on the Federal list (O'Farrell and Collins, 1983). These species are the Mojave fishhook cactus (Sclerocactus polyancistrus) and the desert tortoise (Gopherus agassizi). The desert tortoise is also a State-protected species and is designated as a rare species. The distribution of these species is described in Section 3.4.2. Impacts on the Mojave fishhook cactus during construction are not expected because the surface facilities are to be constructed to the east of Yucca Mountain where the species does not occur (O'Farrell and Collins, 1983). The effects of construction on the desert tortoise would depend directly on the number of tortoises found in the construction zones. If a tortoise is encountered and if no other mitigation is possible, then it may be moved to a safe area. Further study of this mitigation method is planned prior to any relocation. The density of desert tortoise in the project area (less than 8 per square kilometer or 20 per square mile) is lower than in other parts of its range (O'Farrell and Collins, 1983).

Riparian habitats do not exist on Yucca Mountain or in Fortymile Wash because of the absence of perennial surface water. Therefore, impacts to aquatic ecosystems are not expected. Ash Meadows, which is located about 40 kilometers (25 miles) south of Yucca Mountain, contains approximately 30 springs that have populations of rare fish as well as the habitats of many unusual plants (Section 3.4.2.4). Ground-water withdrawals for the repository are not expected to have any impact on maintenance of the water levels in the Ash Meadows area because Ash Meadows and Yucca Mountain are in a different ground-water basin (Section 3.3.2), and impacts to the ecosystems of the area are not expected (Section 3.3.2).

During operations, the transportation of workers, materials, equipment, and waste to the repository would result in an increased number of animals killed on the road. The secondary effects of repository operations are similar to those discussed for construction and include the loss of some plants and animals from combustion emissions, noise, fugitive dust, and sedimentation.

During decommissioning and closure, the potential effects are expected to be similar to the effects experienced during repository construction; however, the magnitude of the effects should be lower during the decommissioning and closure period.

The long-term ecological effects of the repository project will be mitigated to some extent by efforts to restore and revegetate disturbed areas to approximately their original condition. For some areas, habitat restoration could commence upon completion of the construction period. After decommissioning, efforts to restore surface facility areas would begin. A restoration technique that would be similar to those outlined in Section 4.1.1.4 would be used. However, the results of habitat restoration efforts undertaken in conjunction with site characterization studies are expected to yield information on the best techniques for restoring disturbed habitat in the vicinity of Yucca Mountain.

Heat generated by the wastes would gradually increase the temperature of the ground at the surface. The maximum increase is expected to be less than 1°C (2°F) approximately 3,000 years after waste emplacement (Johnstone et al., 1984), and the heat would dissipate slowly thereafter. The surface area that would be affected by the 1°C isotherm would probably be generally circular and will encompass approximately 800 hectares (2,000 acres), which includes the areal extent of the repository. The ecological consequences of increasing the surface and near-surface temperatures over the repository cannot be quantified with the information currently available. However, significant ecological impacts would not be expected because of the relatively small temperature increase and size of the affected area.

5.2.5 AIR QUALITY

The development of Yucca Mountain as a repository would result in emissions of several substances into the atmosphere. This section discusses the applicable regulations as well as the impacts associated with emissions from construction, operations, and subsequent decommissioning of the repository and the relationship of these impacts to applicable regulations. Only nonradiological emissions are considered in this section. Section 5.2.9 discusses the potential for radiological emissions.

5.2.5.1 Ambient air-quality regulations

Both the State of Nevada and the U.S. Environmental Protection Agency (EPA) have promulgated regulations designed to protect the air quality of Nevada; the regulations are expressed as ambient air-quality standards. The standards that apply to the development of Yucca Mountain are outlined on Table 5-10. Before construction can begin, the State of Nevada may require a registration certificate that outlines limits on, and controls of, the emissions from facilities. After operations begin, an operating permit is required to verify that the source is operating within the limits of its registration certificate.

Particulate emissions are expected to be of the most concern in development of Yucca Mountain as a repository. The State of Nevada's regulatory intent concerning fugitive particulate emissions is that "no person shall cause or permit the handling, transporting, or storing of any material in a manner which allows, or may allow, controllable particulate matter to become airborne" (State of Nevada, 1983). Compliance with this mandate would be incorporated into the registration certificate. However, because of the preliminary stage of the repository concept at Yucca Mountain, only uncontrolled or minimally controlled (i.e., worst-case) particulate emissions have been assumed in this analyses.

In addition to these regulatory requirements, the project could be subject to review under the Prevention of Significant Deterioration (PSD)

Table 5-10. Ambient air-quality standards[a]

Pollutant	Time period	Ambient air-quality standard, micrograms per cubic meter (ppb)[b] Nevada standard	Federal primary standard	Federal secondary standard
Sulfur dioxide	3 hours	1,300 (500)	NS[c]	1,300 (500)
	24 hours	365 (140)	365 (140)	NS
	Annual arithmetic mean	80 (30)	80 (30)	80 (30)
Total suspended particulates	24 hours	150	260	150
	Annual geometric mean	75	75	60
Oxidant (ozone)	1 hour	235 (120)	235 (120)	235 (120)
Nitrogen dioxide	Annual arithmetic mean	100 (50)	100 (50)	100 (50)
Carbon monoxide	1 hour	40,000 (35,000)	40,000 (35,000)	40,000 (35,000)
	8 hours	10,000[d] (9,000)	10,000 (9,000)	10,000 (9,000)

[a]Data from 40 CFR Part 50 (1983); State of Nevada (1983).
[b]ppb = parts per billion.
[c]NS = no standard.
[d]At or below 5,000 feet mean sea level

provisions of the Clean Air Act Amendments of 1977. Three classes of areas were established under the Clean Air Act to maintain specified levels of air quality. The classes allow for some industrial development by specifying incremental increases in ambient pollutant levels. These increments are small percentages of the National Ambient Air Quality Standards (NAAQS) and

Table 5-11. Maximum allowable pollutant increments assuming Prevention of Significant Deterioration requirements

Pollutant	Time period	Increments[a] (micrograms per cubic meter) Class I	Class II	Class III
Sulfur dioxide	3 hours	25	512	700
	24 hours	5	91	182
	1 year	2	20	40
Particulates	24 hours	10	37	75
	1 year	5	19	37

[a]For any period other than annual, increase may be exceeded not more than one day per year at any one location (State of Nevada, 1983).

are outlined on Table 5-11. Class I areas are to remain pristine and allow only limited development, such as for national parks and wilderness areas. All other parts of the country that are subject to PSD regulations, including the Yucca Mountain site, were initially designated as Class II areas, which allows for moderate industrial development. Class III areas are allowed to reach, but not to exceed, the NAAQS. At present, it is not clear whether or not the repository would be subject to PSD review. The applicability of PSD requirements is based on significant emission levels below which PSD review is not required. When specific details of repository emissions are known, the State of Nevada would be required to make a determination of applicability of PSD requirements. If review is required, it would entail a control technology review and could require either air-quality or meteorological monitoring.

5.2.5.2 Construction

A preliminary assessment of the emissions and ambient air-quality impacts of construction of the Yucca Mountain repository has been made by Bowen and Egami (1983). They determined that emissions may result from site preparation, repository construction, movement of excavated rock to storage piles, wind erosion of stored material, concrete preparation, and combustion of fossil fuels. Bowen and Egami (1983) assumed a 7-year construction period and two 8-hour shifts working 260 days per year; estimates presented in Table 5-12 are based upon a 5-year construction period and three 8-hour shifts, working 250 days per year. The estimates for the 5-year construction period were calculated to determine the potential impacts of constructing a single-stage repository at Yucca Mountain (see Section 5.1 of the draft Environmental Assessment). The results of the 5-year construction analysis can be

Table 5-12. Estimated total particulate emissions from repository construction[a]

Source	Total emissions over 5 years (metric tons)[b]	Emission rate (grams per second)[c]
Surface facilities[d]	1296	86.5
Mine construction[e]		
Shaft drilling/blasting	58	0.54
Subsurface drilling/blasting[f]	4.4	0.04
Rock-moving		
Loading	13	0.12
Dumping	0.68	0.006
Surface rock transport		
Loading	1500	13.9
Hauling	2700	25.0
Dumping	77	0.7
Wind erosion	1000	6.5
Concrete		
Batching	20	0.19
Sand and gravel processing	17	0.15
Transportation related[g]	7.0	0.06

[a]Data from Bowen and Egami (1983).
[b]1 metric ton = 2.205×10^3 pounds.
[c]1 gram per second = 2.205×10^{-3} pounds per second.
[d]Total emissions and emission rate for one-year assumed duration of this activity; uses emission factors of 2.7 metric tons per hectare per month (1.2 tons per acre per month) with an assumed area of 40 hectare (100 acres).
[e]Conventional drill/blast/muck-removal techniques have been assumed.
[f]Emissions calculated assuming conventional subsurface controls.
[g]Includes diesel fuel use.

Table 5-13. Estimated total potential gaseous emissions during repository construction[a,b]

Pollutant	Total emissions over 5 years (metric tons)	Emission rate (grams per second)[c]
Carbon monoxide	22.0	0.20
Hydrocarbons	8.0	0.07
Nitrogen oxides	114.4	1.06
Sulfur dioxide	7.2	0.07

[a]Calculated using methods from Bowen and Egami (1983) and diesel fuel estimates from McBrien and Jones (1984).
[b]From diesel combustion engines.
[c]1 gram per second = 2.205×10^{-3} pounds per second.

considered to overstate the impacts of a 7-year construction period and are presented in this Section as a bounding analysis. Gaseous emissions resulting from construction are presented in Table 5-13. These estimates are modified from Bowen and Egami (1983) by removal of all transportation-related emissions (e.g., commuting, material shipments).

Bowen and Egami (1983) attempted to quantify the ambient impact of project related emissions by applying the air-quality simulation model known as Valley. Valley is approved by the U.S. Environmental Protection Agency and is a complex-terrain model that is most frequently used as a screening-level model for 24-hour periods. A screening-level model is typically used to determine whether the use of a more sophisticated model is necessary. Many physical parameters are not well known, such as exact emission rates and locations, plume rise and velocity, and onsite meteorology. For this reason, assumptions are made that result in worst-case ambient concentrations.

For modeling purposes, short-term worst-case meteorological conditions are defined as a very stable atmosphere and a constant wind speed of 2.5 meters per second (8.2 feet per second) in one of 16 compass directions for six of 24 hours. These conditions would most likely occur during late evening and early morning, and they do not necessarily correspond to peak working hours at the repository. In fact, emissions during this stable period could be at a minimum.

Two possible locations for the repository have been modeled: one is along the ridge of Yucca Mountain and the other is on the eastern slope of Yucca Mountain. For modeling purposes, the repository was assumed to be a square area of 280 hectares (700 acres) with a uniform emission rate over the entire area. Because the Valley model was developed for evaluating the impacts from a single, elevated-point source, this assumption is not entirely appropriate; however, it provides a screening-level assessment.

In the Valley model, ambient concentrations are directly proportional to emission rates. Thus, the modeled concentrations that had been obtained by assuming a 7-year construction period (Bowen and Egami, 1983) could be scaled to a 5-year construction period. The Valley-predicted maximum 24-hour concentrations are shown on Table 5-14. The worst-case emission scenario, in which all activities indicated in tables 5-12 and 5-13 occur simultaneously, is also shown in Table 5-14.

A comparison can be made of the predicted construction impacts (Table 5-14) with the ambient air-quality standards presented earlier (Table 5-11). Such a comparison indicates that none of the predicted pollutant concentrations would violate applicable standards.

If the project were subject to PSD requirements, these impacts would also have to be evaluated against applicable pollutant increment levels. Because of the uncertainties involved in many of the emission estimates and modeling assumptions, evaluation of PSD-related impacts have not been addressed.

In addition, the analyses described in the preceding section have assumed that fugitive dust control measures would not be used. However, such measures are available and could be used to further reduce emissions. For example, watering exposed surfaces twice daily would reduce emissions by about 50 percent, and the addition of chemical suppressants can further reduce emissions by 80 percent on completed cuts and fills (Jutze and Axetell, 1973). In general, by using proper techniques, emissions during construction of the repository could be reduced to a level less than one-half of that assumed in this conservative analysis.

Emissions from dirt roads can be reduced by traffic control. They can also be reduced 85 percent by paving, 50 percent by treating the surface with penetrating chemicals, and 50 percent by working soil-stabilization chemicals into the road bed (Bowen and Egami, 1983). Storage piles of waste rock could be treated with chemicals to inhibit resuspension, and the waste pile area could be revegetated.

In addition to potential impacts on ambient air quality, a potential health hazard to miners may exist because of the existence of zeolite mineral types that contain crystal forms similar to those of asbestos. The potential for health effects from exposure to minerals would be investigated further during site characterization.

5.2.5.3 Operations

Nonradiological emissions associated with operation of the repository include both dust from surface handling of mined materials and combustion products from burning diesel fuel. Emissions would also occur from commuter traffic to and from the site.

Dust emissions from surface handling of mined materials are discussed in Section 5.2.5.2 and are presented in Table 5-12. Wind erosion from waste-rock storage piles would cause resuspension of some particles. Also, unpaved roads at the site would be a source of fugitive dust emissions during

Table 5-14. Estimated maximum 24-hour concentrations of pollutants from repository construction[a,b]

Pollutant	Emission rate (grams per second)[c]	Predicted impact (micrograms per cubic meter)	
		Ridge location[d]	Valley location[e]
Total suspended particulate	133.7[f]	130	132
Carbon monoxide	0.2	0.2	0.2
Hydrocarbons	0.1	0.1	0.1
Nitrogen oxides	1.1	1.1	1.1
Sulfur dioxide	0.1	0.1	0.1

[a]Data from Bowen and Egami (1983).
[b]Modeled year includes surface facility construction that would not last the duration of the 5-year period.
[c]1 gram per second = 2.205×10^{-3} pounds per second.
[d]Maximum concentration occurred 1.5 kilometers (1 mile) south-southwest of the repository location.
[e]Maximum concentration occurred 1.0 kilometer (0.6 mile) east-northeast of the repository location.
[f]Sum of emission rates in Table 5-12.

repository operation. The amount of fugitive dust that could be generated depends upon the extent of such roads and the control measures to be employed; neither factor is known at this time.

Estimates of diesel fuel use cited in the draft EA were much higher than those cited in Table 5-6 of this document. Based upon the higher estimates of diesel fuel use (Table 5-9 of the Draft EA) and emission factors (URS, 1977), the total emissions from construction, operations, and decommissioning are shown on Table 5-15. Use of diesel fuel estimates contained in the draft EA did not result in violations of air quality standards. Consequently, the lower estimates of diesel fuel use for the two-stage repository (Table 5-6) are not expected to violate air quality standards. Furthermore, part of the diesel emissions would be underground and would be filtered before being released to the atmosphere; this would slightly reduce both the amount and the rate of particulate emissions from that listed in Table 5-15.

Total emissions from commuter traffic have been estimated on the basis of gasoline usage estimated in a report by United Research Services (URS, 1977) for a 35-year emission duration, and they are shown in Table 5-16. Considering the diverse area over which emissions would occur and the long duration of the emissions, these emission levels should have no significant impact on ambient air quality.

Table 5-15. Estimated emissions during 60 years of repository construction, operation, retrievability, and decommissioning phases based upon diesel fuel use[a]

Years and phase	Pollutant[b]				
	CO	HC	NO_x	SO_2	Particulates
1-5: Construction					
Total (metric tons)[c]	22.0	8.0	114.4	7.2	7.0
Emission rate[d] (grams per second)[e]	0.20	0.07	1.06	0.07	0.06
6-35: Operations					
Total (metric tons)	214.5	78.3	1114.2	70.4	67.9
Emission rate (grams per second)	0.33	0.12	1.72	0.11	0.10
36-55: Retrievability					
Total (metric tons)	7.8	2.8	40.4	2.6	2.5
Emission rate (grams per second)	0.02	0.0	0.09	0.01	0.01
56-60: Decommissioning					
Total (metric tons)	8.1	3.0	42.3	2.7	2.6
Emission rate[f] (grams per second)	0.11	0.0	0.60	0.04	0.04

[a] Calculated using methods from Bowen and Egami (1983) and diesel fuel estimates from McBrien and Jones (1984).

[b] CO = carbon monoxide; HC = hydrocarbons; NO_x = nitrogen oxides; SO_2 = sulfur dioxide.

[c] 1 metric ton = 2.205×10^3 pounds.

[d] Assuming three 8-hour shifts, 250 days per year.

[e] 1 gram per second = 2.205×10^{-3} pound per second.

[f] Assuming two 8-hour shifts, 250 days per year.

Table 5-16. Estimated total emissions, over 35 years, from commuter traffic[a]

Pollutant	Total emissions (metric tons)[b]
Carbon monoxide	27,075
Hydrocarbons	946
Nitrogen oxides	804
Sulfur dioxides	36
Total suspended particulates	50

[a]Based on data from URS (1977).
[b]1 metric ton = 2.205×10^3 pounds.

Transportation of radioactive wastes to the repository would result in emissions from trucks and trains. Because the amount of waste to be transported by each mode is not known at this time, it was assumed that emissions would be generated either 100 percent by rail or 100 percent by truck. Using estimates of diesel fuel consumption (Table 5-9 of the draft EA) and related emission factors (URS, 1977; EPA, 1977), emission estimates from transportation of waste to the site were calculated and are shown in Table 5-17. The estimated emissions, when distributed over total shipping distances during the life of the project, should have a negligible effect on ambient air quality.

Table 5-17. Estimated emissions, over 30 years, from transportation of radioactive wastes[a]

Pollutant	100% rail transport (metric tons)[b]	100% truck transport (metric tons)
Carbon monoxide	3,290	8,630
Hydrocarbons	2,390	3,130
Nitrogen oxides	9,370	44,800
Sulfur oxides	1,440	2,830
Total suspended particulates	630	2,730

[a]Based on data from URS (1977).
[b]1 metric ton = 2.205×10^3 pounds.

5.2.5.4 Decommissioning and Closure

The decommissioning and closure period could consist of partially back-filling the mined shafts and drifts with material from the storage piles, similar to its original topography. This would cause fugitive dust emissions from loading, hauling, dumping, and surface restoration. Gaseous and particulate emissions would occur from construction equipment and commuter traffic (Bowen and Egami, 1983). No particulate emission rate other than for diesel fuel combustion (Table 5-15) can be determined at this time. In any case, the extent of these activities would be limited in comparison to construction activities, and they are not expected to create significant ambient impacts when spread over 8 years.

5.2.6 NOISE

Investigators studying incremental noise levels that affect humans have concluded that an annual increment of 5 dBA should be considered significant (EPA, 1974). Assuming that small towns in the vicinity of Yucca Mountain experience an annual average noise level of 50 dBA, this increment would increase the annual level to 55 dBA for the small towns characterized in Chapter 3. A composite annual day/night noise level (L_{dn}) of 55 dBA has been declared to be the level that will protect public health and welfare (EPA, 1974). Therefore, this analysis will use an annual L_{dn} of 55 dBA as the level above which people in residential areas may begin to experience some annoyance.

Other than repository workers, who are protected by worker safety regulations, wildlife is the only sensitive noise receptor in the vicinity of Yucca Mountain. The effects of noise on wildlife are speculative. Laboratory and field experiments have shown both permanent and temporary physical and behavioral effects at levels in the 75 dBA to 95 dBA range (EPA, 1971; Ames, 1978; Brattstrom and Bondello, 1983). For purposes of this analysis, 75 dBA noise was assumed to be the level at which wildlife would be affected.

5.2.6.1 Construction

Construction noise sources include the use of construction equipment, blasting, and the transportation of workers and materials to the site. Construction activities that would produce noise include building the surface facilities, rail line, bridge over Fortymile Wash, access road, transmission line, and mining the repository shafts. All six of these activities are expected to occur simultaneously during the first 2 years of repository construction.

Since construction techniques have not yet been specified, it is assumed that the equipment would be similar to that required in the construction of other large facilities. Maximum noise levels attributed to each piece of construction equipment postulated are listed in Table 5-18. Table 5-19 lists the area that could be affected, sensitive receptors, and the expected composite noise levels at 150 meters (500 feet) from the focal point of construction activities.

Table 5-18. Noise sources during repository construction

Equipment	Maximum Noise level at 15.2 meters (50 feet) (dBA)	Construction activity and number of equipment units					
		Surface facilities	Each shaft	Access road	Rail spur	Rail spur bridge	Transmission line[a]
Air compressors	81[b]	1	1	0	0	0	0
Backhoes	85[b]	1	1	0	0	0	0
Boring machines	98[b]	1	1	0	0	1	1
Bulldozers	80[c]	1	1	5	5	5	0
Concrete mixers	85[b]	1	1	5	5	2	0
Cranes	83[b]	1	1	2	5	2	1
Drill rigs	101[c]	1	1	0	0	0	0
Dump trucks	88[c]	6	1	5	5	5	0
Earthmovers	78[c]	6	1	5	5	5	0
Front-end loaders	76[c]	6	1	5	5	5	0
Graders	88[c]	0	0	5	5	2	0
Grader/scrapers	88[c]	1	1	0	0	0	0
Gravel elevators	88[b]	1	1	0	0	0	0
Pile drivers	101[b]	0	0	0	0	3	0
Rollers	80[b]	0	0	5	5	0	0
Service vehicles	88[b]	30	5	10	10	5	2
Shovels	82[b]	1	1	2	5	5	0
Steam rollers	75[c]	1	1	0	0	0	0
Truck handling conveyors	88[b]	1	1	0	0	0	0

[a]Assumes that the transmission line is placed along the right-of-way for the rail line and that construction follows clearing for the rail line.

[b]Data estimated from EPA (1974).

[c]Data estimated from Henningson, Durham and Richardson Sciences (1980).

Table 5-19. Summary of maximum noise impacts from construction activities[a]

Location of activity	Expected maximum noise level at 150 meters[b] (dBA)	Radius of impact zone for humans (kilometers)[b]	Radius of impact zone for wildlife (kilometers)	Area affected	Receptor affected
Repository					
Surface facilities	85	NA[c]	0.5	desert	wildlife
Shafts	84	NA	0.4	desert	wildlife
Access road	82	1.4	0.3	desert	wildlife
				Town of Amargosa Valley	humans
Rail spur	82	1.4	0.3	desert	wildlife
				Indian Springs, Mercury	humans
Rail spur bridge	86	NA	0.5	desert	wildlife
Transmission line	79	1.3	0.2	desert	wildlife
				Indian Springs, Mercury	humans

[a] Methods for all calculations can be found in Chanlett (1973).
[b] 1 meter = 3.28 feet; 1 kilometer = 0.621 mile. Impacts were assumed at noise level above an annual day/night noise level of 55 dBA for humans and 75 dBA for wildlife.
[c] NA = Not applicable.

Because the noise levels expected at 150 meters (500 feet) have been developed assuming the maximum noise level of each piece of equipment is sustained throughout the construction day, the analysis is conservative. Furthermore, the analysis assumes that geometric divergence of the sound waves provides the only attenuation. Again, this represents a conservative analysis because it excludes possible attenuation due to absorption and barrier effects. Table 5-19 summarizes the noise levels from construction and indicates the radial distance required to attenuate the construction noise to below 75 dBA (the level assumed to affect wildlife) or 55 dBA (the level assumed to affect humans). In developing the radial distance required to achieve an annual day/night noise level (L_{dn}) of 55 dBA, it was assumed that construction would last 10 hours per day, 250 days per year, for all construction away from the surface facilities complex. Repository-related construction activities at the surface facilities complex are assumed to continue 24 hours per day, 250 days per year. Blasting noise associated with mining of the shafts would be similar to the blast noise considered in Section 4.2.1.4. As was found in Section 4.2.1.4, no significant noise impacts from blasting are expected.

The radial distances associated with reaching an annual L_{dn} level of 55 dBA suggests that impacts may occur. The access road is expected to pass within 0.8 kilometer (0.5 mile) of the Town of Amargosa Valley. The radial distance of 1.4 kilometers (0.9 mile) for the access road suggests that some residents may experience noise-related annoyance while construction operations are within 1.4 kilometers (0.9 mile) of town. Construction of the rail line also carries a 1.4 kilometers (0.9 mile) impact radius. This would affect residents in Indian Springs. People in Mercury and users of Floyd R. Lamb (formerly Tule Springs) State Park should not be affected by noise because the rail line will probably not pass within 1.4 kilometers (0.9 mile) of Mercury or the park. Impacts to wildlife should be limited to the immediate vicinity of the construction site.

Noise would also occur during transportation of workers to and from the site and from transportation of materials to the site. Worker transport during the day shift would have the greatest noise impact because of the number of workers and construction trucks using U.S. Highway 95. Incremental noise has been estimated and is based on the following:

1. Existing or baseline noise, which uses the 1996 projected traffic flows.

2. The average speed of vehicles is 80 kilometers per hour (50 miles per hour).

3. Nevada Test Site traffic patterns would persist.

Based upon these assumptions, incremental noise is calculated to be approximately 4 dBA, using methods found in Henningson, Durham, and Richardson Sciences (1980). It is generally accepted that 4 dBA is just over the value at which people begin to perceive a noise change and below the significant level of 5 dBA established by the U.S. Environmental Protection Agency. Therefore, no significant noise problems due to worker transport are anticipated at either the Town of Amargosa Valley or at Indian Springs. It is estimated that wildlife within 325 meters (1,070 feet) of the road would experience noise levels in excess of 75 dBA during periods of high traffic flow; therefore, they may be affected.

5.2.6.2 Operations

During repository operations, major noise sources would include rock-handling equipment, rail and truck waste transportation, and worker transport. Table 5-20 lists the type and number of vehicles expected to be used at Yucca Mountain during operations, the equipment noise levels, the area affected, the sensitive receptors, and the resultant noise levels at 150 meters (500 feet). Assuming a maximum resultant composite noise level of 82 dBA at 150 meters (500 feet), wildlife could be affected up to approximately 3,000 meters (1,120 feet) from the repository surface facilities complex.

Table 5-20. Maximum noise levels from operation of the repository

Equipment	Maximum noise level at 15.2 meters (50 feet) (dBA)	Number of vehicles
Bulldozers	80[a]	2
Earthmovers	78[a]	5
Front-end loaders	76[a]	5
Rock elevators	88[b]	2
Service vehicles	88[b]	25

Maximum estimated noise level at 150 meters (500 feet): 82 dBA
Area affected: uninhabited desert
Receptors affected: wildlife

[a]Henningson, Durham and Richardson Sciences (1980).
[b]EPA (1974).

Rail transport would consist of a locomotive and up to ten cars carrying radioactive waste and construction material. Maximum noise levels at 30 meters (100 feet) have been established by the U.S. Environmental Protection Agency (EPA) as 90 dBA for moving locomotives and 93 dBA for rail cars exceeding 72 kilometers per hour (45 miles per hour) (40 CFR Part 201, 1983). For a train with one locomotive and ten cars, the noise level at a distance of 150 meters (500 feet) would be approximately 89 dBA. This would result in maximum levels of approximately 69 dBA at Indian Springs, Floyd R. Lamb State Park, and Mercury. The level would begin to mask outdoor human communication where people were more than 1 meter (3 feet) apart (EPA, 1974). Human indoor activities should not be disturbed by the resultant levels; however, if rail shipments occur at night when people are most sensitive to intrusive noise, more severe problems should be anticipated in nearby communities. The resultant radius at which there would be no impacts to wildlife would be approximately 844 meters (2,580 feet).

During the operations period, combined worker and material transport would be less than it would be during construction. Furthermore, background, or existing, traffic is expected to increase with regional growth. Therefore, increased noise due to an incremental traffic increase would be less than that predicted for the construction period. As with the construction period, however, no significant impacts are expected either for the communities of the Town of Amergosa Valley or Indian Springs. The resultant radius to avoid impacts to wildlife along the access road is 47 meters (150 feet) assuming a truck noise level of 85 dBA at 15 meters (50 feet).

5.2.6.3 Decommissioning and closure

Decommissioning and closure operations would result in elevated noise levels from operation of construction equipment and from worker transport. The postclosure period would not contribute to noise.

Construction equipment that could be used during this phase is listed in Table 5-21. This table also indicates the location and number of construction vehicles, noise levels of the equipment, resultant noise levels at 150 meters (500 feet), and the areas and the sensitive receptors that could be affected. Based upon these values, the resultant impact radius is 300 meters (1000 feet) for decommissioning and closure of surface facilities and 150 meters (500 feet) for decommissioning of shafts.

Worker and material transport during this phase will be approximately one third of that previously analyzed for construction activities. Based on that analyses (Section 5.2.6.1), no impacts on the human population are predicted. Wildlife may experience noise levels above 75 dBA within about 47 meters (150 feet) of the road when trucks with a noise level of 85 dBA at 15 meters (50 feet) are passing by.

5.2.7 AESTHETIC RESOURCES

The construction and operation of a repository and its supporting facilities would have an impact on the visual aesthetics of the area. However, this impact is not expected to be either significant or controversial.

During the construction of the railway and access road, equipment and construction crews would be visible along U.S. Highway 95. When they are in place, the rail line, the transmission lines, and the paved access road would be visible to travelers along U.S. Highway 95. Most of the construction crews and equipment at Dike Siding would be far from population centers. In addition, the repository surface facilities would be constructed in a limited-access area and would probably not be visible from U.S. Highway 95. Overall, aesthetic impacts would be minimal.

Table 5-21. Noise levels from decommissioning operations[a]

Equipment	Maximum noise level at 15.2 meters (50 feet) (dBA)	Number and location of vehicles anticipated	
		Surface facilities	Each shaft
Bulldozers	80[b]	6	1
Concrete mixers	85[c]	[illegible]	1
Earth movers	78[b]	1	1
Graders	88[c]	1	1
Dump trucks	88[b]	4	1
Cranes	83[c]	1	1
Front-end loaders	76[b]	1	1
Shovels	82[c]	1	1
Service vehicles	88[c]	12	2

Maximum estimated noise level at 150 meters (500 feet):
Surface facilities: 81 dBA
Each shaft location: 75 dBA
Areas affected: uninhabited desert
Receptors affected: wildlife

[a]Methods for all calculations are given in Chanlett (1973).
[b]Data from Henningson, Durham and Richardson Sciences (1980).
[c]Data from EPA (1974).

5.2.8 ARCHAEOLOGICAL, CULTURAL, AND HISTORICAL RESOURCES

The development of Yucca Mountain as a repository for high-level radioactive waste may have both direct and indirect effects on significant cultural resources in the region. Destruction, vandalism, and unauthorized excavation of sites are examples of direct and indirect effects that may occur. Direct effects may result from scheduled activities, such as the construction of roads, drill pads, borrow pits, and railways, that are related directly to the construction, operations, caretaking, and decommissioning phases of the repository. Indirect effects might result from increased activity due to repository development and operation, but that is neither scheduled nor planned to contribute to repository development or operation. Whether or not these potential effects become adverse impacts to significant cultural resources depends on the specific cultural resources involved, the nature of the particular disturbance processes, and the procedures followed to identify and mitigate those potential impacts.

The identification and mitigation of potential direct impacts to significant cultural resources in the Yucca Mountain area are straightforward. Construction activities are planned, scheduled, and approved by the Nevada

Test Site Support Office (NTSO) before any land disturbance. The NTSO consults with a qualified archaeologist who conducts a preconstruction survey, if necessary, and determines if a potential exists for adversely affecting significant cultural resources. Much of the area surrounding Yucca Mountain has been systematically surveyed and cultural resources in the area have been identified and evaluated as to their significance and potential for adverse impact (Pippin et al., 1982; Pippin 1984). Archaeological activities are reviewed in consultation with the Nevada State Historic Preservation Officer (SHPO).

A Programmatic Memorandum of Agreement will be developed between the U.S. Department of Energy (DOE), Nevada SHPO, and National Advisory Council on Historic Preservation to provide for reviewing cultural impacts and determining appropriate mitigation strategies. If at all possible, mitigation of adverse impacts during repository construction would be accomplished by avoiding all identified significant cultural resources. This avoidance would be enhanced by including at least a 50-meter (164-foot) buffer zone around significant archaeological sites and having a professional archaeologist monitor all construction near sensitive locations. If complete avoidance of significant cultural resources is not possible, then adverse impacts would be avoided by the scientific study of that cultural resource prior to its disturbance.

As currently planned, the construction of the repository may directly affect 12 cultural resources. Site 505184RR6 is located in the area planned for surface facilities and muck handling. It is unlikely that this site could be avoided, because of its large size (9.1 square kilometers) (3.5 square miles); however, adverse impacts to this site would be mitigated by the scientific study of an approximate 10 percent sample. Direct impacts to sites 26Ny2969 and 26Ny2970, located near the currently proposed men-and-materials shaft entry, have been mitigated under cultural resources management procedures described in Section 4.2.1.6. However, nine small rockshelters, sites 26Ny3008, 26Ny3009, 26Ny3016, 26Ny3017, 26Ny3018, 26Ny3019, 26Ny3020, 26Ny3021, and 26Ny3022, occur directly across from the proposed men-and-materials shaft entry and could be adversely impacted by activities in this area. Finally, construction of the railway, power lines, and access roads could directly impact a series of cultural resources located adjacent to Fortymile Wash.

The identification and mitigation of potential indirect effects to significant cultural resources are more difficult than for direct impacts. Because these effects are due to activities that are neither planned nor scheduled by the DOE, it is not possible to mitigate them on a case-by-case basis as with the construction activities. Although it may be safely assumed that indirect impacts to significant cultural resources within the Yucca Mountain Project area will be minimal during site characterization activities, if Yucca Mountain is selected as the repository location, these indirect impacts can no longer be assumed to be minimal. Therefore, if selected for repository development, indirect impacts to significant cultural resources within the project area will be avoided by a systematic program of data recovery that focuses on an adequate, representative sample of classes of cultural resources. Because this program would treat the project area as a whole rather than a series of unrelated activities, it would ensure that a representative sample of all cultural resources is preserved and, thereby, would mitigate any adverse impacts regardless of their nature.

Areas around Yucca Mountain that are made more accessible during repository characterization and development (such as the lower reaches of Fortymile Canyon) will be subjected to a sample reconnaissance so that the nature of cultural resources in those areas can be assessed and ongoing impacts can be evaluated. If it should be determined that significant adverse impacts are occurring to important cultural resources in those outlying areas, measures will be taken to mitigate or otherwise prevent those impacts.

Potentially adverse impacts to significant archaeological and historic sites outside of the Nevada Test Site (NTS) by Project personnel can not be completely evaluated or avoided. These cultural resources, most of which have not been identified through cultural resources surveys, are also accessible to residents of communities around the NTS who would not be affiliated with the repository. Consequently, it would be impossible to differentiate the impacts due to repository personnel from those due to local, long-term residents; but it is reasonable to assume that the population influx associated with the repository would result in a greater potential for adverse impact. To mitigate possible adverse impacts, employees of the repository will be informed of legislation (Archaeological Resources Protection Act of 1979) and the penalities regarding unauthorized collection and excavation at these sites.

5.2.9 RADIOLOGICAL EFFECTS

This section discusses the possible radiological effects from repository construction and operation. Since much of the following discussion focuses on radiological effects, a brief review of the relevant terminology is in order.

A <u>curie</u> (Ci) is a unit used to describe the number of atoms undergoing radioactive decay per unit time. One Ci is equal to 3.7×10^{10} disintegrations per second. The mass of a 1-Ci amount of radioactive material can vary dramatically depending on the half-life (i.e., the time it takes for one-half of the atoms initially present to decay) of the material. For example, 1 Ci of cobalt-60 is equal to less than 1 milligram, 1 Ci of radium-226 is 1 gram, and 1 Ci of uranium-238 is about 3,000 kilograms (6,600 pounds). The activity of a unit mass of a radioactive material is referred to as <u>specific activity</u>, and the unit of specific activity is curie per gram.

Absorbed radiation dose is a measure of the amount of ionizing radiation that is deposited in a given mass of absorbing medium. The unit of absorbed radiation dose is the <u>rad</u>; 1 rad is equal to 100 ergs per gram.

Since the biological damage inflicted by different types of radiation can vary, the <u>quality factor</u> (Q) is used as a measure of the relative biological effectiveness of a given type of radiation. The quality factor is directly related to the <u>linear energy transfer</u> (LET) of the radiation, which is the energy deposited per unit of path length. The unit of LET is thousands of electron volts (keV) per micron. Densely ionizing (high-LET) particles, such as protons, neutrons, and alpha particles, are assigned quality factors of 10 to 20, while sparsely ionizing (low-LET) radiation, such as beta particles, X-rays, and gamma rays, are assigned a quality factor of 1. In essence, this means that densely ionizing radiation is approximately 10 to 20 times as effective at inflicting biological damage per rad as sparsely ionizing radiation.

The concept of dose equivalent is used to describe the effectiveness of a given unit of absorbed radiation dose. The unit of dose equivalent is the rem; 1 rem is the product of 1 rad and the quality factor for the radiation in question. Thus, an absorbed dose of 1 rad of gamma rays is equal to a dose equivalent of 1 rem, and a dose of 1 rad of alpha particles is equal to a dose equivalent of 20 rem. If radioactive material is taken into the body (e.g., by inhalation or ingestion), some fraction will be deposited in various organs or tissues depending on the chemical and physical nature of that material. The amount of deposited material will be reduced by a combination of physical and biological mechanisms, and the time required to eliminate half of the deposited material is called the effective half-life. Effective half-lives may range from a few days (e.g., soluble forms of tritium (H-3)) to many years (e.g., insoluble forms of uranium or plutonium isotopes). The cumulative radiation dose equivalent that an individual receives as a result of intake and subsequent deposition is referred to as the dose commitment. The unit of dose commitment is the rem, and the period of time over which the dose commitment is integrated is usually 50 years.

Two additional concepts often applied in radiological assessments are those of population dose and maximum individual dose. The population dose, which is sometimes refered to as collective dose, is simply a summation of the doses received by individuals in an exposed population. The unit of population dose is man-rem or person-rem. For example, if each member of a population of 1,000 individuals received a dose of 0.1 rem, the population dose would be 100 man-rem. The maximum individual dose is a dose received by a hypothetical individual whose location and habits are such that the dose received is the maximum expected to result from some given operation or accident. For example, the maximum (or maximally exposed) individual in an atmospheric radionuclide release accident scenario would be a person situated at the downwind location who would be expected to receive the highest level of radiation exposure as a result of the accident.

5.2.9.1 Construction

When the underground parts of the repository are mined, the breaking and crushing of rock will release some radioactive material that exists naturally in the rock. Two families of radioactive heavy elements (the uranium and thorium series) are found in most rocks and soils, and they account for about one-third of the natural background radiation to which humans are exposed. For example, the concentration of uranium in rocks ranges from more than 300 parts per million in phosphatic rocks in South Carolina, to from 1 to 4 parts per million in other sedimentary rocks. Some of the radioactive decay products of these heavy elements are gaseous. Normally, they escape from the rock only through fractures and pores. The breaking and crushing of rocks, such as that which occurs in mining operations, may release these gaseous

Yucca Mountain to arrive at the Yucca Mountain site construction doses cited above. By comparison, the estimated regional population of 19,908 people within an 80-kilometer (50-mile) radius of Yucca Mountain (Jackson et al., 1984) will receive an annual dose of about 1,790 man-rem from natural background radiation calculated on the basis of the 400 man-rem received by a population of 4,600 people (Patzer et al., 1984). The collective dose to the construction work force, which is also estimated on the basis of the DOE EIS, would be about 1,500 man-rem for vertical emplacement and 450 man-rem for horizontal emplacement. The 19,908 people residing within 80 kilometers (50 miles) of the proposed repository was conservatively estimated by identifying the counties within that radius and dividing the 1980 county population by the county area to obtain the population density. Once county population densities were determined, the county area within the 80-kilometer (50-mile) radius was multiplied by that county's density to estimate population. The results for each county were then summed. If population centers (i.e., cities or unincorporated places) are accounted for, the population within 80 kilometers (50 miles) of the proposed repository is estimated to be 11,674 (Morales, 1985).

5.2.9.2 Operation

During the 28-year emplacement phase, workers would be exposed to radiation from receiving, handling and packaging, and emplacing of wastes. The permissible dose equivalent limit for worker exposure is 3 rem per quarter, not to exceed 5(N-18) rem where N is the age of the individual in years (10 CFR Part 20, 1983). The facilities would be designed with the objective of reducing the annual exposure to individual workers and to the total repository work force to the lowest levels reasonably achievable.

For purposes of this analysis, two principal types of high-level wastes are assumed to be shipped to the Yucca Mountain repository: spent reactor fuel and defense high-level waste (DHLW). The repository is being designed to accept the equivalent of 70,000 metric tons of heavy metal. The occupational exposures that have been calculated and reported in the following paragraphs are for an assumed waste composition of 50 percent spent fuel and 50 percent commercial high-level waste. These dose estimates will not change substantially if other waste compositions (e.g., 89 percent spent fuel and 11 percent DHLW) are assumed.

5.2.9.2.1 Worker exposure during normal operation

Specific operations were identified, individual tasks were listed, and operation times were allocated so that estimates could be made of the radiation explosure to workers at the repository during the receipt, handling, and emplacing of high-level wastes (Dennis et al., 1984). The number of individual workers assigned to crew positions was estimated from the annual waste receipts and expected facility operation time. The annual worker exposure for each task and each individual was calculated from the expected operation time, the estimated worker exposure times for each task, the radiation field

8 0 0 0 8 0 3 9 4

products to the atmosphere in much larger quantities than those that escape naturally.

The quantities of these decay products that would be released annually to the atmosphere because of the mining of the repository are estimated in Table 5-22. The quantity released is directly proportional to the volume of rock that is mined annually. In the vertical waste-emplacement repository design, approximately 9 times as much rock is mined as in the horizontal waste-emplacement design. Values in Table 5-22 were estimated from those given for a repository constructed in granite (DOE, 1980), which has approximately the same uranium and thorium content as Yucca Mountain rocks, by scaling with the ratio of total mined volume.

Table 5-22. Estimated annual releases of naturally occurring radionuclides to the atmosphere from repository construction

Radionuclide	Releases (curies per year)	
	Horizontal emplacement	Vertical emplacement
Radon-220	1.8	5.9
Radon-222	1.7	5.6
Lead-210	1.4×10^{-4}	4.7×10^{-4}
Lead-212	2.7×10^{-3}	8.8×10^{-3}
Lead-214	1.7	5.6
Bismuth-210	1.7	5.6

The enhanced releases of naturally occurring radionuclides are estimated to result in maximum whole-body dose commitments of 0.09 man-rem to the regional population for the horizontal waste-emplacement design and 0.3 man-rem for the vertical waste-emplacement design. These estimates are determined using the method described in the U.S. Department of Energy (DOE) final environmental impact statement (EIS) on the management of commercially generated radioactive waste (DOE, 1980). This method involves the use of a reference site for purposes of radiological impact assessment. The reference site method used in the DOE EIS is extremely conservative in that the resultant doses are much higher than those that would be expected around Yucca Mountain. This is due to the assumption of an agricultural land use setting and a high regional population density (2,000,000 people within a radius of 80 kilometers (50 miles) from the site) for the reference site. The population doses estimated in the DOE EIS were scaled by the differences in excavated volume and population density between the reference site and in which the operation was performed, and the annual receipt and handling rates of spent fuel and commercial high-level waste (CHLW).

Gamma-ray and neutron source intensities were calculated using the isotope generation and depletion code ORIGEN2. Shipping cask designs were used in conjunction with the three-dimensional radiation-transport code, PATH, to develop dose rate maps around spent fuel and CHLW shipping casks. The results of these analyses are presented in Table 5-23.

Table 5-23. Summary of expected occupational exposures from repository operation[a,b]

Operation	Number of workers	Average worker dose (rem per year)	Collective worker dose (man-rem per year)
Receiving	35	1.28	44.8
Handling and packaging	16	0.43	6.9
Surface storage to emplacement horizon	14	0.43	6.0
Emplacement			
Vertical	18	0.69	12.4
Horizontal	7	1.25	8.7

[a]Data from Dennis et al. (1984).
[b]See text for assumptions.

The total annual worker population dose at the repository is estimated to be about 70 man-rem during receipt, handling, and emplacing of high-level radioactive wastes. Over the 28-year life of the repository, the estimated collective worker radiation dose is about 2,000 man-rem.

5.2.9.2.2 Public exposure during normal operation

The two principal pathways by which the offsite population may be potentially exposed from normal (nonaccident) repository operation are external exposure to direct radiation during receipt, handling, and emplacing nuclear waste and exposure to airborne effluents. The former pathway would result in insignificant public exposures both because of the shielding and packaging measures that would be taken to reduce occupational exposures and because of the large distance (several miles) that separates the waste from the public. Exposure to airborne effluents is not significant because of the negligible quantities of these emissions coupled with the dilution of effluent concentrations over the transport distance. In light of these facts, a quantitative estimate of public exposures resulting from normal repository operation was not made.

5.2.9.2.3 Accidental exposure during operation

The probability of accidental radionuclide releases that can result in radiation exposure of the general public and of repository operations personnel is a function of the following: (1) the probability that an accident will occur and (2) the probability that there will be a release if an accident were to occur. Accidental releases can be divided into three categories: natural phenomena, external man-made events, and operational accidents (Tables 5-24 and 5-25). Under natural phenomena, three scenarios are postulated that could cause radionuclide releases: flooding, tornadoes, and earthquakes. The external man-made events that could cause a release are aircraft impact and underground nuclear weapons testing, which could cause severe ground motion at the repository surface facility complex (Jackson et al., 1984). The five operational accidents considered to be potential sources of radionuclide release are (1) a fuel assembly drop in a hot cell; (2) a transportation accident and fire outside the loading dock involving spent fuel; (3) a transportation accident outside the loading dock involving commercial high-level waste; (4) a transportation accident and fire on the waste-handling ramp; and (5) a transportation accident and fire in an emplacement drift.

The principal exposure pathway for the accident scenarios analyzed is atmospheric transport. Immersion in contaminated flood water is an exposure mechanism only for workers in the flooding scenarios. No significant water ingestion pathway was identified. Ingestion of meat, milk, and crops grown on land contaminated by radionuclides is considered to be a minor exposure pathway for the general public because of the low level of agricultural activity in the surrounding area. Fifty-year dose commitments were calculated for the maximally exposed individual, for the general public, and for operations personnel for each of the 10 accident scenarios. The maximally exposed individual is a member of the public whose location and habits tend to maximize the radiation dose he receives from a postulated accident. In this analysis, this individual is located 4 kilometers (2.5 miles) directly west of the proposed repository surface facility complex.

The results of the accident analysis (Jackson et al., 1984) are presented in Tables 5-24 and 5-25. All exposures to the maximally exposed individual and to the general public are less than the radiation exposure limit set (0.5 rem per accident for defining systems important to safety) by the Nuclear Regulatory Commission (10 CFR Part 60, 1983). The most severe exposure to the maximally exposed individual is 0.328 rem from the postulated aircraft impact scenario. These accidental exposure analyses do not reflect the most recent (two-stage repository) design information. However, because the maximum waste receipt rate has not changed, these results are not expected to change substantially.

Table 5-24. Preliminary population dose commitments from postulated accidents[a]

Scenario[b]	Probability of occurrence (events per year)	Maximally exposed individual[c] Whole-body equivalent dose (rem)	General population Population exposed (number)	General population Whole-body equivalent dose (man-rem)
Natural phenomena				
Flood	1.0×10^{-2}	2.8×10^{-11}	96[d]	1.2×10^{-9}
Earthquake	$<1.3 \times 10^{-3}$	2.4×10^{-4}	19,908	3.1×10^{-3}
Tornado	$<9.1 \times 10^{-11}$	2.4×10^{-4}	19,908	3.1×10^{-3}
Man-made external events				
Underground nuclear explosives test	1.0×10^{-3}	2.4×10^{-4}	19,908	3.1×10^{-3}
Aircraft impact	$<2.0 \times 10^{-10}$	6.8×10^{-2}	19,908	1.1×10^{2}
Operational accidents				
Fuel assembly drop in hot cell	$<1.0 \times 10^{-1}$	5.3×10^{-6}	19,908	8.0×10^{-5}
Transportation accident and fire at loading dock				
Spent fuel	$<1.0 \times 10^{-7}$	2.1×10^{-2}	19,908	6.8×10^{-3}
CHLW[e]	$<1.0 \times 10^{-7}$	3.6×10^{-3}	19,908	9.2×10^{-4}
Transportation accident and fire on waste handling ramp	$<1.0 \times 10^{-7}$	1.8×10^{-7}	19,908	4.8×10^{-7}
Transportation accident and fire in repository emplacement drift	$<1.0 \times 10^{-7}$	1.8×10^{-7}	19,908	4.8×10^{-7}

[a]Data from Jackson et al. (1984).

[b]Except for the transportation accident outside facility where both spent fuel and commercial high-level waste are evaluated, all scenarios are based on spent fuel.

[c]Radiation safety levels in 10 CFR Part 60 (1983): 0.5 rem whole-body dose per accident for defining systems important to safety.

[d]Only population in the zone directly south of Drillhole Wash is exposed.

[e]Commercial high-level waste.

Table 5-25. Preliminary worker dose commitments from postulated accidents[a]

Scenario[b]	Single worker whole-body equivalent dose[c] (rem)
Natural phenomena	
Flood	[d] 5.0×10^{-10}
Earthquake	[d] 3.7×10^{-1}
Tornado	[d] 3.7×10^{-1}
Man-made external events	
Underground nuclear explosives test	[d] 3.7×10^{-1}
Aircraft impact	[e] 5.5×10^{0}
Operational accidents	
Fuel assembly drop in hot cell	[f] 8.1×10^{-3}
Transportation accident and fire at loading dock	
Spent fuel	[g] 3.5×10^{0} [g] 8.9×10^{-3}
Commercial high-level waste	[g] 6.0×10^{-1} [g] 1.5×10^{-3}
Transportation accident and fire and fire on waste handling ramp	[h] 6.4×10^{1} [i,j] 4.7×10^{1} [i,j] 1.2×10^{1} [i] 3.8×10^{-8}
Transportation accident and fire in repository emplacement drift	[j,k] 1.8×10^{2} [j,k] 1.5×10^{1} [k] 3.8×10^{-8}

[a] Data from Jackson et al. (1984).

[b] Except for the transportation accident and fire at the loading dock where both spent fuel and commercial high-level waste are evaluated, all scenarios involve spent fuel.

[c] Worker normal operational exposure limit in 10 CFR Part 20: 5.0 rem per year; 3 rem per quarter.

[d] Only waste-handling facility workers are assumed to be exposed.

[e] All surface waste-handling facility workers are assumed to be killed by the crash; therefore, doses for the workers are not calculated. Other surface and subsurface personnel are assumed to be exposed as a consequence of the accident.

[f] All surface and subsurface personnel are assumed to be exposed equally as a consequence of the accident.

[g] Workers at the waste-handling facility loading dock receive the maximum dose; remaining personnel receive the smaller dose.

[h] Workers in the waste-handling ramp area receive the maximum dose.

[i] Waste emplacement workers receive a smaller dose than workers in the ramp area. Remaining personnel above ground receive the smallest dose.

[j] Horizontal emplacement of waste canisters requires an estimated 40 subsurface workers; vertical emplacement requires an estimated 60 subsurface workers.

[k] Waste emplacement workers receive a greater dose than aboveground operations personnel.

5.3 EXPECTED EFFECTS OF TRANSPORTATION ACTIVITIES

The two major subdivisions of this section discuss effects from two sources: (1) use of the transportation network to move people and materials to and from the proposed Yucca Mountain repository site (Section 5.3.1) and (2) use of the transportation network to move radioactive waste through the State to the site (Section 5.3.2). This section discusses the expected effects of these two activities during repository construction, operations, and decommissioning periods as described in Section 5.1.

5.3.1 TRANSPORTATION OF PEOPLE AND MATERIALS

The impacts of increased traffic volumes on highway and railroad transportation networks during the construction, operations, and decommissioning phases are discussed in the following sections.

5.3.1.1 Highway impacts

5.3.1.1.1 Construction

During the construction period, two peak highway traffic conditions may occur. The first peak condition would occur in 1995 when the greatest number of truck deliveries would occur. The second would occur in 1998 when the greatest number of workers would travel to and from the site. Both conditions are analyzed in this section assuming

1. The waste would be emplaced in the vertical mode.

2. The distribution of day-shift workers by category would be miners, one-third of Table 5-5 estimates; emplacement, one-half of Table 5-5 estimates; and all others three-fourths of Table 5-5 estimates.

3. Truck deliveries would be evenly distributed over 8-hour days for 250 days per year.

4. The access road and rail line would be constructed over the first 2 years of construction.

5. Construction equipment would be uniformly delivered for 6 months to coincide with the most intensive period of truck deliveries in 1995.

6. Each truck carrying nuclear waste would be accompanied by an escort vehicle.

Based on these assumptions and the information presented in Section 5.1, the following conditions would result:

1. In 1995, 840 day-shift employees would travel to and from the site. Eight trucks per hour would travel in each direction. (To be conservative, the analysis uses ten trucks per hour in each direction.)

2. In 1998, 1,237 day-shift employees would travel to and from the site. One-half truck would travel per hour in each direction as well as two escort vehicles per day. (To be conservative the analysis uses one truck per hour in each direction.)

The projected travel patterns of these day-shift workers are derived from recent Nevada Test Site employee residence patterns as shown in Table 5-26. Figure 5-8 indicates that U.S. Highway 95 between the junction with the site access road and Las Vegas would be the most heavily used road in the region by repository related traffic. This highway would carry up to 98 percent of the day-shift employees. Seventy-six percent of the work force would terminate their trip in Las Vegas, and another 6 percent would travel beyond Las Vegas.

It is assumed that travel by these workers would occur during the evening rush hour thereby producing worst-case conditions. For trucks, it is assumed that all repository-related traffic will travel along U.S. Highway 95 between Las Vegas and the site.

The projected repository traffic must be evaluated against likely conditions in 1995 and 1998. As noted in Section 3.5, evening peak-hour traffic flow is of critical importance. Tables 5-27 and 5-28 compare 1995 and 1998 traffic patterns on U.S. Highway 95 with and without the repository during the evening peak hour. In developing these tables, several of the highway segments shown on Figure 5-8 were subdivided. This was done to account for traffic volumes that were not related to the repository and to account for varying road conditions, both of which would affect the level of service. (The level of service categories are discussed in Section 3.5.)

Tables 5-27 and 5-28 indicate that the level of service would decline beginning at State Route 160. The decline between State Route 160 and the Mercury interchange (segment E) approaches undesirable conditions. (See Table 3-9 for definitions of service levels). Baseline traffic for segment E has the lowest level of service for 1995 and 1998 along any of the evaluated segments of U.S. Highway 95. Furthermore, the incremental traffic due to the repository would not be as great for this segment as for segments B and C. This suggests that baseline traffic volumes and road conditions are prime factors contributing to a low service level. This two-lane road segment has very poor passing capabilities. There will also be a slight reduction in the level of service in 1998 between the Mercury interchange and Las Vegas as noted in Table 5-28.

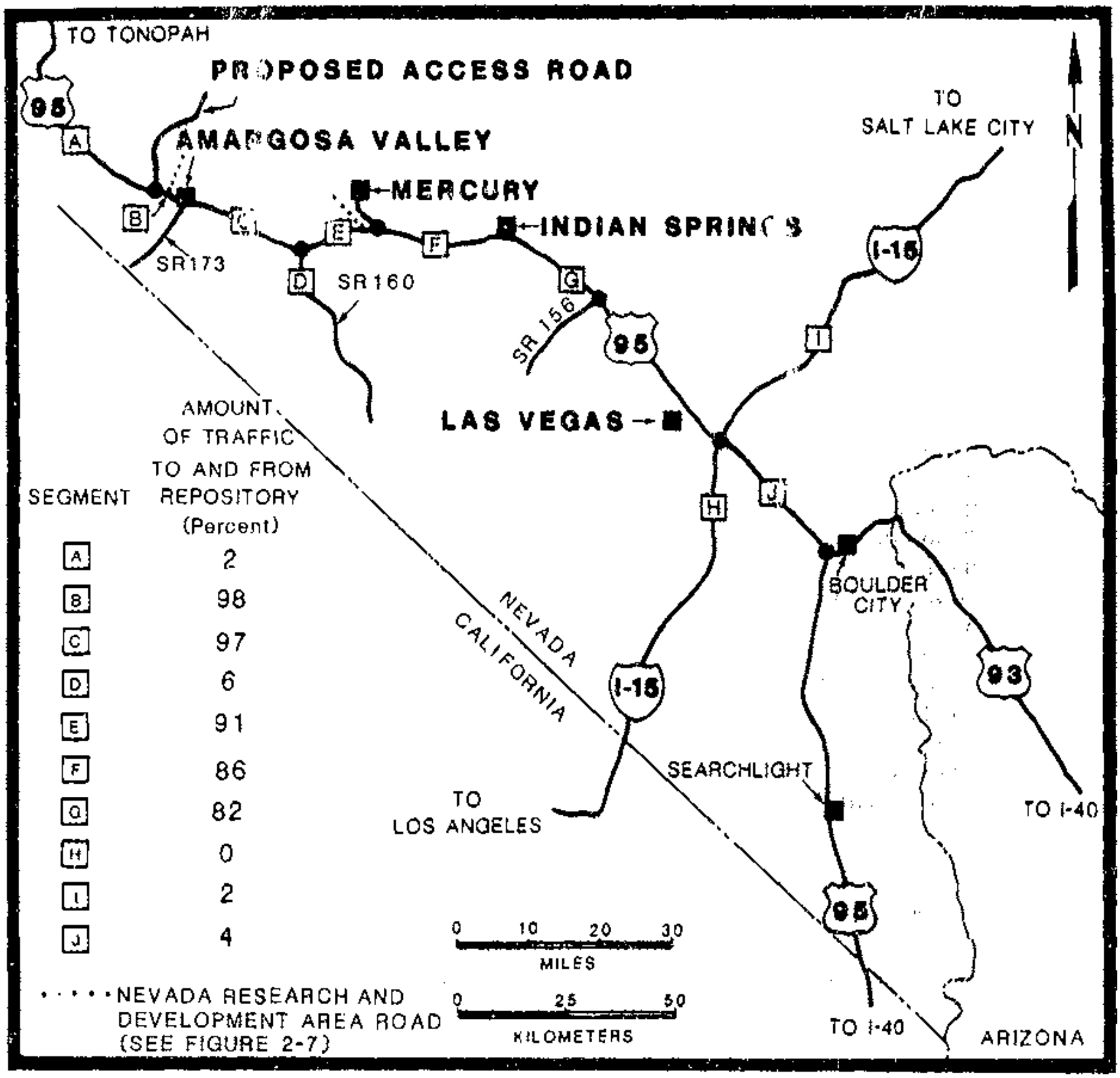

Figure 5-8. Employee travel patterns for the Yucca Mountain repository.

Table 5-26. Settlement patterns of Nevada Test Site employees[a]

Location	Percentage of employees reporting ZIP codes in these locations[b]
Unincorporated urban Clark County and Las Vegas	65.6
North Las Vegas	10.0
Indian Springs	4.1
Henderson	3.1
Boulder City	0.4
Other Clark County	0.4
Pahrump	6.1
Mercury[c]	4.6
Tonopah	1.9
Beatty	0.1
Town of Amargosa Valley	0.3
Alamo	0.6
Other Lincoln County	0.7
Other Nevada Counties[d]	0.2
California	0.7
Utah	0.6
Arizona	0.4
Other States	0.5

[a]Data based on ZIP codes of NTS contractors, 1984.
[b]Totals may not add to one hundred percent due to rounding.
[c]There are no permanent residents at Mercury.
[d]Includes Douglas, Lander, Lyon, and White Pine counties, and Carson City, a consolidated municipality.

As can be seen from the preceding discussion, repository construction traffic would have its greatest impact on U.S. Highway 95 between the site access road and Las Vegas. Predicted accidents for 1995 and 1998 along U.S. Highway 95 both with and without repository-related traffic are shown in tables 5-29 and 5-30. These predictions were calculated by assuming a linear relationship between vehicle-miles traveled and number of accidents (Pradere, 1983). These tables show that under predicted conditions approximately nine additional accidents per year may be expected due to peak construction-related traffic. These additional accidents could result in five additional injuries. Two additional deaths may occur in 1995. The accident rates suggest that the most likely place for accidents is segment E, which is between State Route 160 and the Mercury interchange. This projection is consistent with the results shown on tables 5-27 and 5-28,

Table 5-27. Projected traffic patterns on U.S. Highway 95 during evening peak hour (5-6 p.m.), 1995

	Highway segment[b] (see Figure 5-8)	Without repository (baseline)[a]			With repository		
		Number of cars	Number of trucks	Service level obtained[c]	Number of cars	Number of trucks	Service level obtained[c]
B	Site access road to the Town of Amargosa Valley	115	24	B	280	62	B
C	Town of Amargosa Valley to 5 miles east of the Town of Amargosa Valley	148	28	B	311	67	B
C	5 miles east of the Town of Amargosa Valley to S.R. 160	148	28	B	311	67	B
E	S.R. 160 to NRDA Road	152	29	B/C	305	66	D
E	NRDA Road to Mercury interchange	181	22	B/C	334	60	D
F	Mercury interchange to Indian Springs	308	79	B	453	105	B
G	Indian Springs to S.R. 156	325	83	B	463	109	B
G	S.R. 156 to northern city limits of Las Vegas	365	93	B	503	119	B

[a] Data from Pradere (1983).
[b] S.R. = State Route; NRDA = Nevada Research and Development Area road (see Figure 2-7).
[c] See Table 3-9 for definition of service levels.

Table 5-28. Projected traffic patterns on U.S. Highway 95 during evening peak hour (5-6 p.m.), 1998

	Highway segment[b] (see Figure 5-8)	Without repository (baseline)[a] Number of cars	Without repository (baseline)[a] Number of trucks	Without repository (baseline)[a] Service level obtained[c]	With repository Number of cars	With repository Number of trucks	With repository Service level obtained[c]
B	Site access road to the Town of Amargosa Valley	125	26	B	368	55	B
C	Town of Amargosa Valley to 5 miles east of the Town of Amargosa Valley	163	31	B	404	60	B
C	5 miles east of the Town of Amargosa Valley to S.R. 160	163	31	B	404	60	B
E	S.R. 160 to NRDA Road	166	32	C	392	59	D
E	NRDA Road to Mercury interchange	200	25	C	425	52	D
F	Mercury interchange to Indian Springs	339	87	B	552	112	B/C
G	Indian Springs to S.R. 156	357	92	B	560	115	B/C
G	S.R. 156 to northern city limits of Las Vegas	399	102	B	602	126	C

[a] Data from Pradere (1983).
[b] S.R. = State Route; NRDA Road = Nevada Research and Development Area Road (see Figure 2-7).
[c] See Table 3-9 for definition of service levels.

Table 5-29. Projected annual accidents on U.S. Highway 95, 1995

Highway segment[b] (see Figure 5-8)		Without repository (baseline)[a]				With repository			
		Thousands of vehicle miles	Accidents	Injuries	Fatalities	Thousands of vehicle miles	Accidents	Injuries	Fatalities
B	Site access road to the Town of Amargosa Valley	429	0	0	0	495	0	0	0
C	The Town of Amargosa Valley to 5 miles east of the Town of Amargosa Valley	5,467	4	3	1	6,121	5	3	1
C	5 miles east of the Town of Amargosa Valley to S.R. 160	12,684	10	6	3	14,200	11	7	3
E	S.R. 160 to NRDA Road	5,361	9	5	5	5,961	10	5	6
E	NRDA Road to Mercury interchange	3,658	6	3	1	4,021	6	3	1
F	Mercury interchange to Indian Springs	33,212	32	16	1	35,415	34	17	1
G	Indian Springs to S.R. 156	25,090	22	17	2	26,618	23	18	3
G	S.R. 156 to northern city limits of Las Vegas	29,420	29	17	2	31,018	30	18	2
TOTAL			112	67	15		119	71	17

[a] Data from Pradere (1982).
[b] S.R. = State Route; NRDA Road = Nevada Research and Development Area Road (see Figure 2-7).

Table 5-30. Projected annual accidents on U.S. Highway 95, 1998

Highway segment[b] (see Figure 5-8)		Without repository (baseline)[a] Thousands of vehicle miles	Accidents	Injuries	Fatalities	With repository Thousands of vehicle miles	Accidents	Injuries	Fatalities
B	Site access road to the Town of Amargosa Valley	467	0	0	0	537	1	0	0
C	The Town of Amargosa Valley to 5 miles east of the Town of Amargosa Valley	6,019	5	3	1	6,706	5	3	1
C	5 miles east of the Town of Amargosa Valley to S.R. 160	13,965	11	7	3	15,559	12	8	3
E	S.R. 160 to NRDA Road	5,876	10	5	6	6,496	11	6	6
E	NRDA Road to Mercury interchange	4,023	6	3	1	4,398	7	3	1
F	Mercury interchange to Indian Springs	36,529	35	17	1	38,768	37	18	1
G	Indian Springs to S.R. 156	27,536	24	19	3	29,067	26	20	3
G	S.R. 156 to northern city limits of Las Vegas	32,170	32	19	3	33,771	33	20	3
TOTAL			123	73	18		132	78	18

[a]Data from Pradere (1983).
[b]S.R. = State Route; NRDA Road = Nevada Research and Development Area Road (see Figure 2-7).

which indicate that this segment has the lowest level of service either with or without the repository. For this segment, peak repository-related construction traffic would be expected to cause an additional two accidents, which would include one injury during 1998 and one additional death during 1995.

5.3.1.1.2 Operations

During operations, the most intensive use of U.S. Highway 95 would occur in 2003 when both the number of workers and trucks would peak. Using the same assumptions previously noted for construction (Section 5.3.1.1.1) and by assuming all nuclear waste is shipped directly to the repository, the following conditions are expected to occur in 2003: 1,102 day-shift employees would travel to and from the site. Approximately two and one-half trucks per hour would travel in each direction as well as nineteen escort vehicles per day. (To be conservative the analysis uses four trucks per hour in each direction.)

Table 5-31 projects evening traffic for 2003, both with and without repository-related traffic. Values in this table indicate that incremental traffic due to operations of the repository would cause a drop in the level of service achieved for segment E (between State Route 160 and the Mercury interchange). This segment would drop to service level D, as is expected during peak construction activities. There would also be a slight degradation in the level of service from the Mercury interchange to Las Vegas. As repository-related traffic remains constant over the 28-year emplacement period of the repository, the regional traffic along the segment would grow. Therefore, the incremental traffic impacts due to repository operations would diminish over time, which would make this first year of full operations a worst-case for the operations stage.

Traffic accidents for this first year of full repository operations are projected in Table 5-32. The incremental repository traffic is estimated to cause an additional eight accidents including six injuries and two deaths over this one-year period. As noted previously, these incremental traffic effects would become relatively smaller during the operations stage of the facility.

5.3.1.1.3 Decommissioning

Decommissioning of the repository would involve fewer workers and truck shipments than previously analyzed. Traffic along U.S. Highway 95 will have increased because of regional growth. The increment of this work force on the regional highway network is not expected to create any significant effects as this increment is only one-fifth of that which was previously analyzed for construction activities in 1998.

Table 5-31. Projected traffic patterns on U.S. Highway 95 during evening peak hour (5-6 p.m.), 2003

	Highway segment[b] (see Figure 5-8)	Without repository (baseline)[a]			With repository		
		Number of cars	Number of trucks	Service level obtained[c]	Number of cars	Number of trucks	Service level obtained[c]
B	Site access road to the Town of Amargosa Valley	142	29	B	360	67	B
C	The Town of Amargosa Valley to 5 miles east of the Town of Amargosa Valley	188	36	B	404	73	B
C	5 miles east of the Town of Amargosa Valley to S.R. 160	188	36	B	404	73	B
E	S.R. 160 to NRDA Road	191	36	C	393	72	D
E	NRDA Road to Mercury interchange	230	28	C	432	64	D
F	Mercury interchanges to Indian Springs	390	100	B	581	130	C
G	Indian Springs to S.R. 156	410	105	B	592	134	C
G	S.R. 156 to northern city limits Las Vegas	456	117	B	637	145	C

[a] Data from Pradere (1983).
[b] S.R. = State Route; NRDA road = Nevada Research and Development Area Road (see Figure 2-7).
[c] See Table 3-9 for definition of service levels.

Table 5-32. Projected annual accidents on U.S. Highway 95, 2003

Highway segment[a] (see Figure 5-8)		Without repository (baseline)				With repository			
		Thousands of vehicle miles[b]	Accidents	Injuries	Fatalities	Thousands of vehicle miles[b]	Accidents	Injuries	Fatalities
B	Site access road to the Town of Amargosa Valley	531	1	0	0	602	1	0	0
C	The Town of Amargosa Valley to 5 miles east of the Town of Amargosa Valley	6,940	6	3	1	7,650	6	4	2
C	5 miles east of the Town of Amargosa Valley to S.R. 160	16,100	13	8	3	17,747	14	9	4
E	S.R. 160 to NRDA Road	6,735	11	6	7	7,381	12	6	7
E	NRDA Road to Mercury interchange	4,632	7	3	1	5,022	8	4	1
F	Mercury interchange to Indian Springs	42,059	40	20	2	44,406	42	21	2
G	Indian Springs to S.R. 156	31,619	28	22	3	33,228	29	23	3
G	S.R. 156 to northern city limits of Las Vegas	36,759	36	21	3	38,442	38	22	3
TOTAL			142	83	20		150	89	22

[a] SR = State Route; NRDA Road = Nevada Research and Development Road (see Figure 2-7).
[b] Data from Pradere (1983).

5.3.1.2 Railroad impacts

Maximum use of the rail line during construction is expected to occur in 1996, when the rail line is completed to the site. Projections of future Union Pacific rail use without the repository are unavailable. The incremental rail use due to repository requirements is evaluated against the maximum Union Pacific rail use over the past 6 years. During 1996 it is estimated that six rail cars per day would be required to supply the site with material (assuming vertical emplacement, see Section 5.1). As before, 250 delivery days per year have been assumed. In 1981 the Union Pacific line carried an average of 19.2 freight trains per day with an average of 66 cars per freight train (Section 3.5.2), or 1,257 rail cars per day. The increment of 6 rail cars per day is an increase of less than 0.5 percent of that use. Since the incremental traffic is so small, no impacts are predicted.

During the years of repository operations, the railroad may be used to transport both construction materials and nuclear waste. The maximum number of shipments of construction material is estimated to be approximately 1 rail car per day (Section 5.1).

The number of rail cars carrying nuclear waste will vary depending upon whether a monitored retrievable storage (MRS) facility is part of the waste-management system. Assuming all nuclear waste is shipped by rail and that the defense sites and West Valley always ship directly to the repository (a decision to ship defense and West Valley high-level waste through a MRS facility has not yet been made), the number of rail cars per day is estimated to be

1. 1.6 cars of consolidated spent fuel and secondary waste (assuming MRS casks of 100-ton capacity with overpack, resulting in the most shipments). Secondary waste is byproduct material produced during spent fuel consolidation (see Appendix A for more detail). Although no decision has been made to include such by-products in the repository, they are considered here so that potential impacts are not underestimated.

2. 0.6 cars of defense and West Valley waste.

3. 1.4 cars of spent fuel being shipped directly from the reactors.

Either with or without a MRS facility, the rail line will experience about the same amount of use. The resultant number of rail cars per day is slightly less than that which is expected during construction. No impacts due to the incremental rail traffic are expected.

During decommissioning, railroad use is expected to drop to less than one railcar per day (Section 5.1). At that level, no impacts are predicted.

5.3.2 TRANSPORTATION OF NUCLEAR WASTES

This section addresses the radiological, nonradiological, and cost impacts of transporting spent fuel, defense high-level waste, and West Valley high-level waste from their point of origin to the repository. Both national and regional risk impacts are assessed, while transportation costs are assessed only on a national basis. Descriptions of the key elements pertaining to nuclear waste transportation are presented in Appendix A. These include cask design, transportation cost and risk assessment methodology, regulations, routing, liability, emergency response, and others. This section provides a synopsis of the information contained in Appendix A as it relates to the Yucca Mountain site, and presents the methods and results of a detailed risk analysis of nuclear waste transportation occurring within the State of Nevada.

Because of the early developmental stage of the program, several in-state routing options and shipment scenarios are presented in the following sections in an attempt to realistically but conservatively describe the possible risk due to nuclear waste transportation.

5.3.2.1 Shipment and routing of nuclear waste shipments

Assumed conditions about the number and types of shipments from each waste origin point to interim and final destinations play an important role in the risk and cost assessment. This subsection describes the shipment and routing assumptions underlying the cost and risk assessments on both national and regional scales.

5.3.2.1.1 National shipment and routing

Specific routing requirements apply to packages containing quantities of radioactive material that are designated as a highway route controlled quantity. These requirements (49 CFR Part 177, 1983) would apply if the wastes are shipped by truck to Yucca Mountain. Federal regulations specify driver training requirements (49 CFR 177.825) and require that a written route plan be submitted that lists specifics such as planned stops, estimated departure and arrival times, and telephone numbers for emergency assistance in each state. Variations from the route plan are allowed only under certain circumstances, and must be reported as soon as possible within 30 days following the deviation. Appendix A describes these regulations in more detail.

The rationale underlying routing regulations and the role of State and local governments in selecting a route that maximizes safety are explained in a notice in the Federal Register (DOT, 1981) and in Appendix A. The overall goal is to reduce risk by reducing the amount of time the radioactive material is in transit. Therefore, interstate highways have been selected as preferred routes for truck transport. In addition to reducing the amount of the time in transit, interstate highways in general have lower accident rates than do other routes. However, State routing agencies as defined in 49 CFR 171.8 (1983), may designate alternate preferred routes. A State-designated alternate preferred route is one that is selected in accordance with the Department of Transportation (DOT) guidelines (DOT, 1984) or an equivalent routing analysis that adequately considers overall risk to the public. Designation must have been preceded by substantive consultation with affected local jurisdictions and with any other affected states to ensure consideration of all impacts and continuity of designated routes. The DOT guidelines require State routing agencies to consider all categories of risk and not simply the high-consequence, low-probability categories. For example, travel through population centers should be considered if it can be demonstrated that the risks in the area are lower than travel through less populated areas. Appendix A describes the routing guidelines which were used in postulating routes from origin points to Yucca Mountain.

For the national assessment, several different shipping scenarios involving various combinations of waste origin, interim destination, and shipping mode were considered. Two general cases of shipment on a national scale were considered. One case assumed no monitored retrievable storage (MRS) facility, with all nuclear waste generators shipping directly to the repository by either truck or rail. The second case assumes the existence of a MRS facility as an interim destination for spent fuel. The shipping scenarios for these cases are as follows:

<u>Without MRS</u>

1. All reactors would ship spent fuel directly to the repository by truck. Legal weight casks having a capacity of pressurized-water-reactor (PWR) or 5 boiling-water-reactor (BWR) spent fuel assemblies would be used.

2. All reactors would ship spent fuel directly to the repository by rail, with casks having a capacity for 14 PWR or 36 BWR spent fuel assemblies.

<u>Eastern Reactors To MRS</u>

3. All western reactors (those west of 100° longitude) would ship spent fuel to the repository by truck; eastern reactors ship spent fuel to the MRS facility by truck. Cask capacities would be the same as scenario 1 above.

4. All western reactors (those west of 100° longitude) would ship spent fuel to the repository by rail; eastern reactors ship spent fuel to the MRS facility by rail. Cask capacities would be the same as scenario 2 above.

<u>All Reactors to MRS</u>

5. All reactors would ship spent fuel to the MRS facility by truck. Cask capacities would be the same as scenario 1 above.

6. All reactors would ship spent fuel to the MRS facility by rail. Cask capacities would be the same as scenario 2 above.

Defense and West Valley Waste

7. All defense high-level waste (DHLW) and West Valley high-level waste (WVHLW) would be shipped directly to the repository by truck. Truck shipments would contain one canister per truck. Railcars would carry 5 canisters of DHLW or 7 canisters of WVHLW.

8. All DHLW and WVHLW would be shipped directly to the repository by rail. Shipment capacities would be the same as scenario 7 above.

Consolidated Fuel From MRS

9. All consolidated spent fuel and secondary waste would be shipped from the MRS facility to the repository by rail. Secondary waste consists of material generated or discarded during the spent-fuel consolidation process as described in Appendix A. Casks would weigh 100 tons with overpack, carrying either 18 PWR or 42 BWR consolidated spent fuel assemblies.

The expected number of shipments for each scenario is presented in Table 5-33. The assumptions used in estimating the number of shipments for these scenarios are described in Appendix A.

5.3.2.1.2 Regional shipment and routing

In Nevada, the State routing agency (as described in 49 CFR 171.8, 1983) is composed of three members who are all elected public officials. They include the Governor, the Attorney General, and the State Comptroller. To date, the State Routing Agency has designated U.S. Highway 95 between Las Vegas and Beatty, Nevada, as a preferred route. No other routes or entry points into the State have been so designated by the State of Nevada. However, examination of the locations of waste origination and information regarding the current network of regional and interstate highways and mainline rail systems indicates the principal candidate routes into the areas.

Two routing scenarios were postulated in which nuclear waste shipments would enter the State and travel to the repository on one of several candidate routes. Six postulated truck routes and two rail routes were evaluated for these scenarios. Descriptions of the postulated truck routes are as follows:

1. Interstate 15 southbound - Waste shipments would enter Nevada at Mesquite and travel southbound on Interstate 15 for 130 kilometers (81 miles) to the intersection of U.S. Highway 95 in Las Vegas. The postulated route would then take U.S. Highway 95 northbound for a distance of 135 kilometers (84 miles) to the intersection of the repository access road, located 0.8 kilometer (0.5 mile) north of the Town of Amargosa Valley. Travel would then be northwest on the U.S. Department of Energy (DOE) access road for a distance of 26 kilometers (16 miles) to the repository.

Table 5-33. Summary of national nuclear waste shipments

Origin/Destination	Number of shipments (scenario)[a] Truck	Rail
All reactors/repository	70,553 (1)	9,927 (2)
Western reactors[b]/repository	5,612 (3)	770 (4)
All reactors/MRS[c]	70,568 (5)	9,934 (6)
Eastern reactors/MRS[c]	65,297 (3)	9,183 (4)
HLW[d] generators/repository	(7)	(8)
Hanford, Washington	2,250	450
Idaho Falls, Idaho	9,000	1,800
Savannah River, South Carolina	11,600	2,320
West Valley, New York	800	115
Total HLW generators/repository	23,650	4,685
MRS/Repository		(9)[e]
Spent fuel from all reactors (CSF)	NA	8,050
Spent fuel from eastern reactors (CSF)	NA	7,536[f]
SW from all reactors	NA	2,793
SW from eastern reactors	NA	2,615[f]

[a]See definition of scenarios in Section 5.3.2.1.1.
[b]Western reactors are defined as those reactors west of 100 degrees longitude.
[c]MRS = monitored retrievable storage.
CSF = consolidated spent fuel.
SW = secondary waste. Secondary waste is consolidation by products consisting of hardware, high activity and transuranic (TRU) waste as described in Appendix A.
NA = not applicable.
[d]HLW = Defense and West Valley High-Level Wastes.
[e]Assumes use of 100-ton cask.
[f]Exact shipment numbers not available; estimates are based on the ratio of radiological risk of consolidated fuel shipments from the MRS facility to Yucca Mountain for eastern reactor case to all reactor case.

2. Interstate 15 northbound - Waste shipments would enter Nevada from California 18 kilometers (11 miles) south of the town of Jean, Nevada. Travel would be northbound on Interstate 15 for a distance of 66 kilometers (41 miles) to the intersection of U.S. Highway 95 in Las Vegas, Nevada. The postulated route would then take U.S. Highway 95 northbound for a distance of 135 kilometers (84 miles) to the intersection of the repository access road, located 0.8 kilometer (0.5 mile) north of the Town of Amargosa Valley. Travel would then be northwest on the DOE access road for a distance of 26 kilometers (16 miles) to the repository.

3. U.S. Highway 93 northbound - Waste shipments would enter Nevada at Hoover Dam. Travel would be northbound on U.S. Highway 93 for a distance of 60 kilometers (37 miles) to the intersection of U.S. Highway 95 in Las Vegas. The postulated route will then take U.S Highway 95 northbound for a distance of 135 kilometers (84 miles) to the intersection of the repository access road, located 0.8 kilometer (0.5 mile) north of the Town of Amargosa Valley. Travel would then be northwest on the DOE access road for a distance of 26 kilometers (16 miles) to the repository.

4. Interstate 80 eastbound - Waste shipments would enter Nevada at Verdi proceeding east on Interstate 80. The postulated route would continue east on Interstate 80 for a distance of 61 kilometers (38 miles) to the intersection with U.S. Highway 50 Alternate. Travel would continue eastbound on U.S. Highway 50 Alternate for 47 kilometers (29 miles) to the junction of U.S. Highway 95 south in Fallon. The route would travel south on U.S. Highway 95 a distance of 218 kilometers (135 miles) to the town of Coaldale. In Coaldale, U.S. Highway 95 south merges with U.S. Highway 6 east. Travel would continue on this route for 66 kilometers (41 miles) until U.S. Highway 95 separates from U.S. Highway 6 in Tonopah. At this point, the projected route would continue southbound on U.S. Highway 95 for a distance of 197 kilometers (122 miles) to the intersection of the access road located 0.8 kilometer (0.5 mile) north of the Town of Amargosa Valley. Travel would continue for a distance of 26 kilometers (16 miles) on the DOE access road to the repository.

5. U.S. Highway 95 southbound - Waste shipments would enter Nevada at McDermitt and proceed southbound on U.S. Highway 95 for a distance of 118 kilometers (73 miles) to the junction of Interstate 80 in Winnemucca. The postulated route then would travel eastbound on Interstate 80 for a distance of 87 kilometers (54 miles) to the intersection of State Route 305. Travel would continue southbound on State Route 305 for a distance of 144 kilometers (89 miles) to the intersection of U.S. Highway 50 in Austin. The route would proceed eastbound on U.S. Highway 50 for 19 kilometers (12 miles) to the junction of State Route 376. Travel would continue southbound on State Route 376 for 161 kilometers (100 miles) to the junction of U.S. Highway 6. The route then would proceed westbound for 10 kilometers (6 miles) to the intersection of U.S. Highway 95 in Tonopah. Travel would continue southbound on U.S. Highway 95 for 197 kilometers (122 miles) to the intersection of the DOE

access road, located 0.8 kilometer (0.5 mile) north of the Town of Amargosa Valley on U.S. Highway 95. Travel would then proceed north and west on the DOE access road for a distance of 26 kilometers (16 miles) to the DOE repository.

6. State Route 373 northbound - Waste shipments would enter Nevada 11 kilometers (7 miles) north of Death Valley Junction, California. Travel would be northbound along State Route 373 for a distance of 26 kilometers (16 miles) to the intersection of U.S. Highway 95 in Amargosa Valley. The route would continue for 0.8 kilometer (0.5 mile) northbound on U.S. Highway 95 to the intersection of the access road. Travel would continue north and west on the DOE access road for a distance of 26 kilometers (16 miles) to the repository.

Only the Union Pacific is postulated as the main line railroad that would carry nuclear waste into and within the State. Descriptions of the westbound and eastbound Union Pacific line routes are as follows:

1. Union Pacific westbound - Waste shipments would enter Nevada from Utah in Lincoln County near State Route 319. The tracks follow Clover Creek south and west for 61 kilometers (38 miles) to Caliente. The tracks are accessible from unimproved roads for part of this route. From Caliente, the tracks run south and southwest through Meadow Valley Wash for 102 kilometers (63 miles) to a junction at Moapa. State Route 317 follows the same route and is paved, turning into unimproved road as it goes south. The tracks enter Clark County 19 kilometers (12 miles) north of Moapa. At Moapa, a spur splits to the southeast. The main line continues southwest for 23 kilometers (14 miles) to Crystal where it meets Interstate 15. The line then essentially parallels Interstate 15 for 32 kilometers (20 miles) southwest to Dike Siding where a spur to the site would be built. From this point, the train route would travel along the proposed spur line to the repository.

2. Union Pacific eastbound - Waste shipments would enter Nevada from California on the Union Pacific lines in Clark County near Interstate 15. The tracks run north-northeast along Interstate 15 for 61 kilometers (38 miles) to Arden. The main line continues 6 kilometers (4 miles) northeast to metropolitan Las Vegas. The line continues for 13 kilometers (8 miles) through incorporated cities and then 11 kilometers (7 miles) through unincorporated land to Dike Siding where a spur to the site would be built. From this point, the train route would travel along the proposed spur line to the repository.

As in the national assessment, two general cases of shipment were considered. One case assumed no monitored retrievable storage (MRS) facility, with all nuclear waste generators shipping directly to the repository by either truck or rail. The second case assumes the existence of a MRS facility, with all eastern reactors shipping spent fuel to the MRS facility, while spent fuel from western reactors, as well as defense high-level waste and West Valley high-level waste is shipped directly to the repository. Each of these cases has two routing scenarios (called Scenario I and Scenario II) as described below.

The postulated truck and rail routes assigned to scenarios I and II respectively are illustrated in figures 5-9 and 5-10. For truck shipments, Scenario I includes all six postulated routes described above. For Scenario II, only the Interstate 15 and U.S. Highway 93 routes were considered. For reactor to repository rail shipments scenarios I and II are the same, assuming all waste is shipped directly to the repository with shipments assigned to the Union Pacific westbound or Union Pacific eastbound routes depending on their point of origin. For shipment from a MRS facility, it was assumed that spent fuel in 100-ton casks with overpack (which maximizes the number of shipments) enters the State on Union Pacific westbound route. All scenarios are summarized in Table 5-34, with the number of rail and truck shipments postulated. Table 5-35 divides the shipment numbers onto the postulated routes comprising the respective scenarios.

5.3.2.2 Radiological impacts

This section addresses the radiological impacts associated with the transportation of nuclear waste on both a national and regional scale. The nuclear waste mixture for which these impacts are assessed consists of spent fuel that has been out of reactors for a 5-year period if shipped directly from reactors and 10 years if shipped from a monitored retrievable storage (MRS) facility, wastes generated by the West Valley Plant, New York, and defense wastes from the Savannah River, South Carolina; Idaho Falls, Idaho; and Hanford, Washington sites.

The bounding scenarios assessed herein assume that the repository would receive 73,825 metric tons uranium (MTU) of waste consisting mainly of spent fuel with lesser amounts of West Valley high-level waste (WVHLW) and defense high-level waste (DHLW), and that the waste is shipped according to the various scenarios previously described. This volume of waste is slightly higher than the assumed 70,000 MTU capacity of the repository, and is used here to assure that the shipping scenarios underlying the impact analyses are conservative in nature.

Under accident-free operating circumstances, no radioactive material would be released from the shipping containers during transport. Nevertheless, because a small fraction of the radiation emitted by certain components of the radioactive wastes penetrates the cast shielding, people in the vicinity of the shipping containers would be exposed to low levels of radiation. Since the maximum level of radiation allowed by transportation regulations is 10 millirem per hour at a distance of 2 meters (6.6 feet) from the waste vehicle, this level of radiation was assumed for the purpose of analysis. In the actual case, however, radiation levels around waste vehicles could be significantly lower, and this analysis is conservative in this respect.

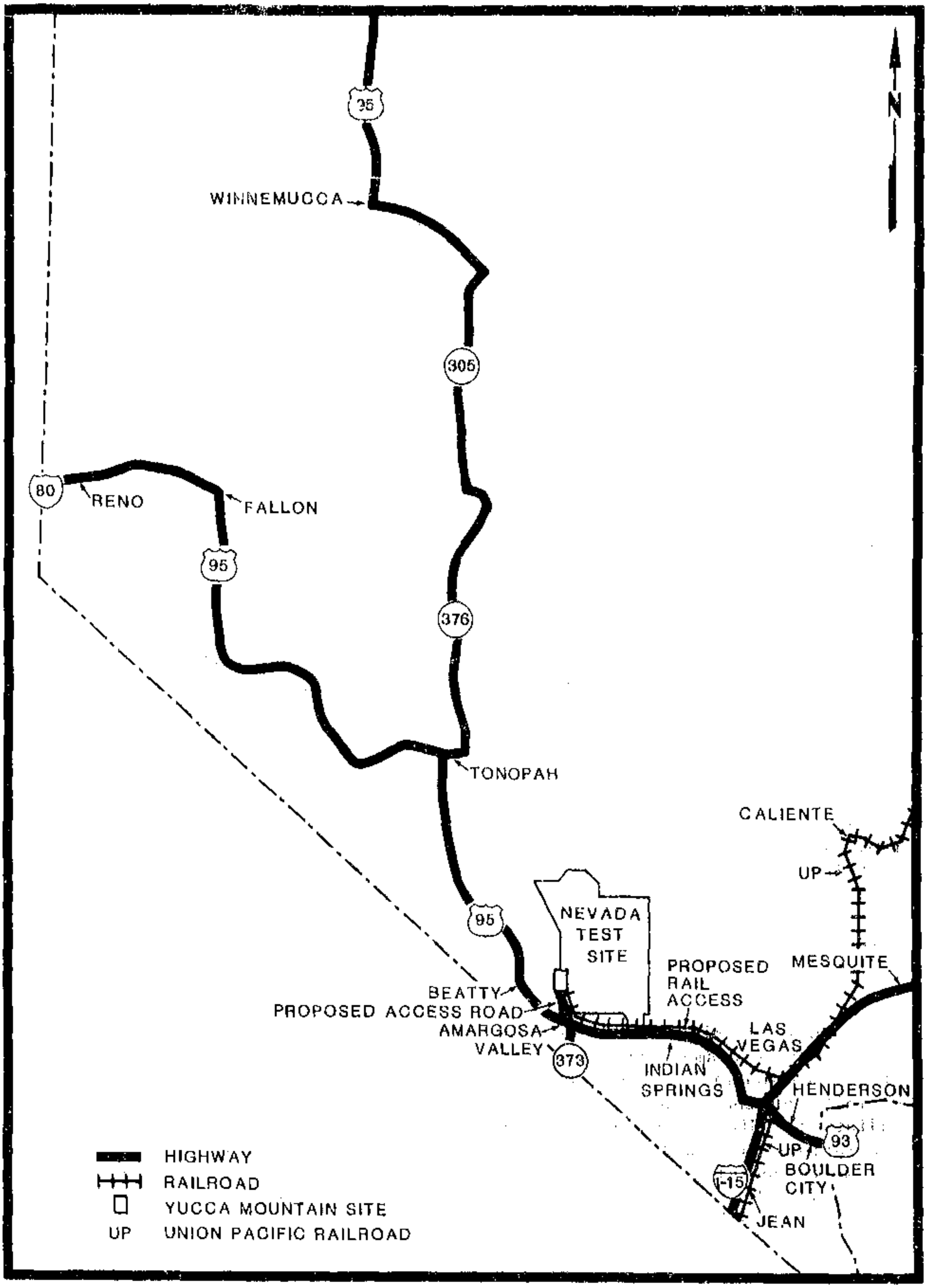

Figure 5-9. Regional routing scenario I.

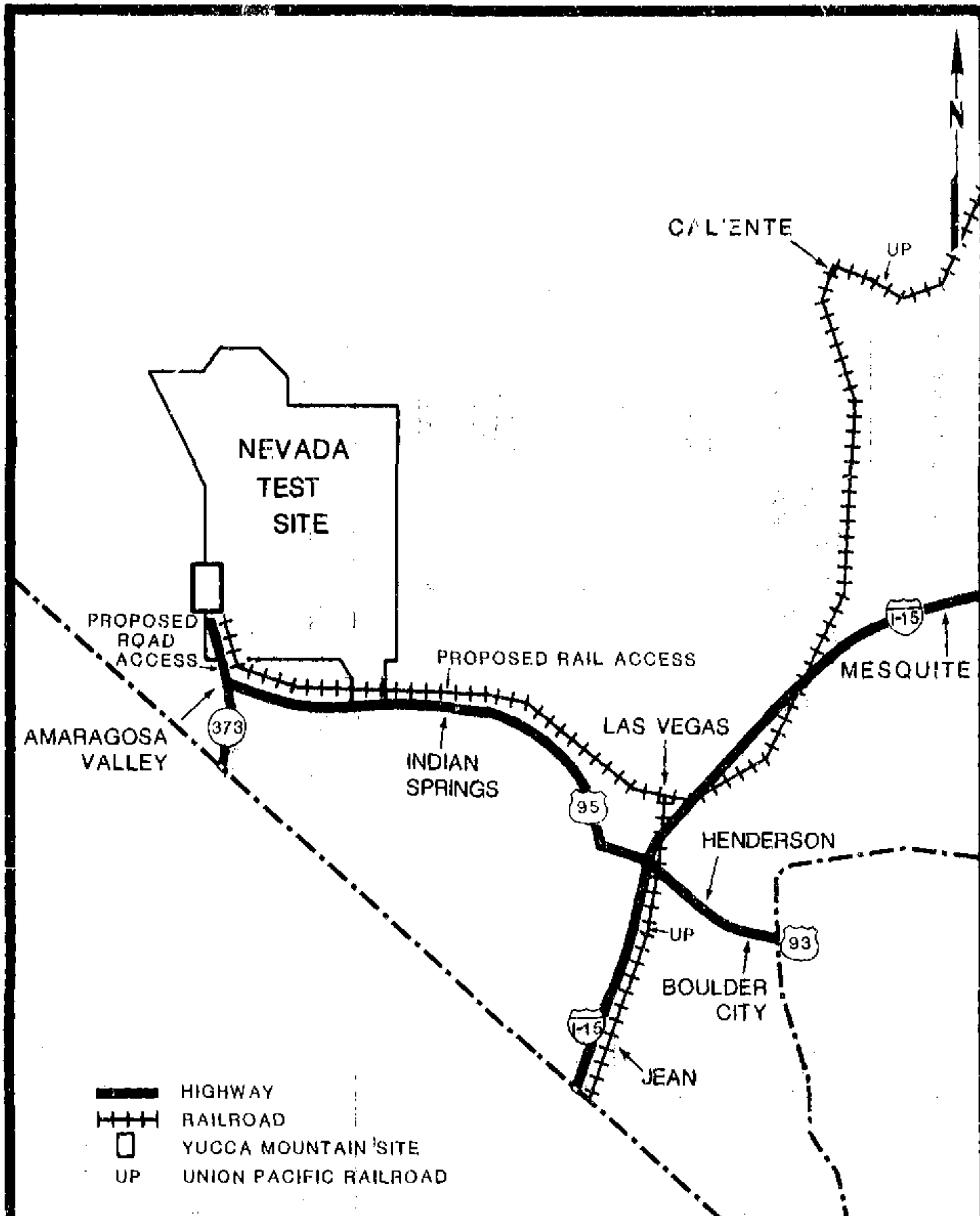

Figure 5-10. Regional routing scenario II.

Table 5-34. Summary of regional shipment and routing scenarios

	Number of Cask Shipments					
	Without MRS[a]		With MRS			
			From MRS		Direct to Repository	
Routing scenarios	100% Truck	100% Rail	All Spent Fuel	Eastern Spent Fuel	100% Truck	100% Rail
Scenario I[c]					Western	Western
	Spent Fuel	Spent Fuel			Spent Fuel	Spent Fuel
	70,553	9,927	N/A	N/A	5,612	770
	HLW[b]	HLW	N/A	N/A	HLW	HLW
	23,650	4,685	N/A	N/A	23,650	4,685
Scenario II[d]					Western	Western
	Spent Fuel	Spent Fuel			Spent Fuel	Spent Fuel
	70,553	9,927	N/A	N/A	5,612	770
	HLW	HLW	N/A	N/A	HLW	HLW
	23,650	4,685			23,650	4,685
Route from MRS	NA[a]	NA	Spent Fuel 8,050	Spent Fuel 7,536	N/A	N/A
			Secondary Waste	Secondary Waste		
Union Pacific westbound	NA	NA	2,793	2,615		

[a]MRS = monitored retrievable storage; NA = not applicable.
[b]HLW = defense and West Valley high-level waste.
[c]Scenario I = 6 highway routes; 2 rail routes.
[d]Scenario II = 3 highway routes; 2 rail routes.

Table 5-35. Summary of waste routing scenarios used for regional impact analysis

Without monitored retrievable storage — Number of shipments

Highway[a] Route	100% TRUCK Scenario I Spent fuel	HLW[b]	Scenario II Spent fuel	HLW
I-15S	36,583	9,800	38,574	12,050
I-15N	7,544	0	9,722	0
U.S. 93N	22,257	11,600	22,257	11,600
I-80E	807	0	0	0
U.S. 95S	1,991	2,250	0	0
S.R. 373N	1,371	0	0	0
TOTAL	70,553	23,650	70,553	23,650

Rail route[d]	100% RAIL Scenario I Spent fuel	HLW	Scenario II Spent fuel	HLW
UPW	7,298	4,685	7,298	4,685
UPE	2,629	0	2,629	0
TOTAL	9,927	4,685	9,927	4,685

With monitored retreivable storage

Highway[a] route	100% TRUCK Scenario I Spent fuel	HLW	Scenario II Spent fuel	HLW
I-15S	0	9,800	1,991	12,050
I-15N	1,443	0	3,621	0
U.S. 93N	0	11,600	0	11,600
I-80E	807	0	0	0
U.S. 95S	1,991	2,250	0	0
S.R. 373N	1,371	0	0	0
TOTAL	5,612	23,650	5,612	23,650

Rail route[d]	100% RAIL Scenario I Spent Fuel	HLW	Scenario II Spent Fuel	HLW
UPW 235	4,685	235	4,685	
UPE 535	0	535	0	
UPW-CSF	8,050	-	8,050	-
UPW-SW	2,793	-	2,793	-
TOTAL	11,613	4,685	11,613	4,685

[a] I = Interstate Highway; US = U.S. Highway; S.R. = State Route
[b] HLW = Defense and West Valley high-level waste
[c] Last letter in route designation denotes direction of travel.
[d] UP = Union Pacific; CSF = consolidated and overpacked spent fuel; SW = secondary waste.

Transportation accidents severe enough to release radioactive materials from a shipping container are extremely unlikely. However, because there is a small probability that some releases may occur that would expose people to radiation, the analysis in this section includes the radiological impacts of transportation accidents.

Potential radiation doses from transporting nuclear waste are presented for each of the following categories: (1) transportation workers, (2) the general population along the transportation route, (3) various categories of individuals in the public referred to as maximally exposed individuals, and (4) workers responding to a radiological accident. The nonoccupational maximally exposed individuals include various categories of people who, because of their occupation or the location of their residence, are considered to receive the maximum potential radiation exposure.

5.3.2.2.1 National impacts

To assess radiological impacts on a national scale, the RADTRAN-II computer program (Taylor and Daniel, 1982) was applied to the shipment scenarios described above. Details of the assumptions and methods used by the RADTRAN-II program are presented in Appendix A. The general method used to calculate radiological risk from the transportation of nuclear waste through a populated zone can be summarized as follows:

risk = unit risk factor x number of shipments x kilometers per shipment

The unit risk factor is calculated by the RADTRAN-II computer code and is a measure of the risk to the reference population for each kilometer of transport. Unit risk factors will vary depending on transport mode (truck or rail), population zone (urban, suburban, or rural), and waste type (spent fuel, defense high-level waste (DHLW), or West Valley high-level waste (WVHLW)); they are calculated for both workers and the general population. In addition, unit risk factors are calculated for both normal transport conditions and accidents. The unit risk factors used for the national assessment are presented in Appendix A.

The results of the national impact analyses are presented in Table 5-36. These results indicate that, in the option not including a monitored retrievable storage (MRS) facility, the shipment of spent fuel by truck results in a greater radiological risk than does shipment by rail. Highway shipment of spent fuel from all reactors directly to the repository results in an estimated population dose of 46,000 man-rem, while the shipment of the same amount of spent fuel by rail results in a population dose of about 1,200 man-rem. Using the assumption that 2×10^{-4} latent cancer and genetic effects are produced per man-rem, hereafter referred to as fatalities, these doses, which are for the entire 28-year shipping period, would be expected to result in a maximum of about 9 fatalities for truck shipment or less than 1 fatality for rail shipment. In the case involving a MRS facility, the associated transportation impacts are less. For example, if spent fuel from

Table 5-36. Summary of national radiological impacts of nuclear waste transportation[a]

Transportation Mode and Waste Type	Population dose (man-rem)		Total fatalities[b]	
WITHOUT MONITORED RETRIEVABLE STORAGE				
100% Truck				
Spent fuel	46,000		9.2	
Defense and West Valley high-level waste	11,000		2.1	
TOTAL	57,000		11.3	
100% Rail				
Spent Fuel	1,200		0.22	
Defense and West Valley high-level waste	400		0.08	
TOTAL	1,600		0.32	
WITH MONITORED RETRIEVABLE STORAGE				
100% Truck	(c)	(d)	(c)	(d)
Spent fuel	18,000	(15,400)	3.6	(3.1)
Defense and West Valley high-level waste	11,000	(11,000)	2.1	(2.1)
TOTAL	29,000	(26,400)	5.7	(5.2)
100% Rail				
Spent fuel	700	(643)	0.14	(0.13)
Defense and West Valley high-level waste	400	(400)	0.08	(0.08)
TOTAL	1,100	(1,043)	0.22	(0.21)
Rail from monitored retrievable storage[e]				
Spent fuel	296	(220)	0.05	(0.04)
Secondary waste	183	(135)	0.03	(0.03)
TOTAL	479	(355)	0.08	(0.07)
Total from origin				
Truck	29,500	(26,800)	5.7	(5.3)
Rail	1,600	(1,400)	0.30	(0.28)

[a]Includes occupational and nonoccupational exposure from normal and accident conditions (see Appendix A for more detail).

[b]Includes genetic effects to future generations.

[c]Results in this column assume all reactors ship spent fuel to the MRS facility.

[d]Results in parentheses assume western reactors ship spent fuel direct to repository; eastern reactors ship spent fuel to the MRS facility.

[e]Assumes 10-car dedicated train with 100-ton casks.

all reactors is shipped to the MRS facility by truck, consolidated and overpacked at the MRS facility, and shipped to the repository in 100-ton casks on dedicated trains, the resultant population dose would be about 18,500 man-rem (about 4 fatalities). If rail is used for the shipment of spent fuel from all reactors to the MRS facility and then to the repository, the resultant dose would be about 1,100 man-rem (less than 1 fatality). The shipment of DHLW from Hanford, Washington; Idaho Falls, Idaho; Savannah River, South Carolina; and WVHLW from West Valley, New York directly to the repository (regardless of the existence of a MRS facility) would result in a population dose of about 11,000 man-rem (about 2 fatalities) by truck or about 400 man-rem (less than 1 fatality) by rail. From these results, it is evident that the radiological impacts associated with truck shipment are much greater than those for rail, and that the use of a MRS facility would reduce the total radiological impact of transporting nuclear wastes, especially if rail is used as a shipping mode between the waste generation point and the MRS facility.

It is also notable that the radiological risks associated with accidents are much lower than the radiological risks associated with incident-free transport. This is because it is very unlikely that an accident resulting in a release of radioactive material would occur and because experimental evidence suggests that the consequences would not be great should such an accident occur (Wilmot et al., 1981; Sandoval and Newton, 1982). Nevertheless, because it is important to bound the consequences of a credible accident scenario, an assessment has been performed on a postulated accident in which radionuclides are dispersed to the surrounding environment. The basis for this accident assessment is described in Appendix A along with the results.

5.3.2.2.2 Regional impacts

For the regional impact analysis, the unit risk factors were modified to make them more appropriate for assessing risk on transportation routes within the State of Nevada. Specifically, this involved replacing the national average population density values used by RADTRAN-II with route-specific population density data. These data were determined as follows:

Each route was broken down into segments, with a segment defined as the length of a given route over which the conditions do not change significantly. For example, changes in population zone or county are conditions which would delineate route segments. Table 5-37 illustrates this delineation method by presenting a listing of the segments comprising the Interstate 15 northbound route. Once each route was broken down into segments, population densities were determined for each segment according to the method described below. The reader should note that the terms urban, suburban, and rural are used to specify differences in population density and do not correspond to definitions used by the U.S. Bureau of the Census.

Table 5-37. Identification of highway segments used in transport risk assessment

Segment No.	Description	Highway[a]	Population zone[b]	County	Segment length (km)[c]
1	California Border to Las Vegas	I-15	R	Clark	48
2	Las Vegas	I-15 U.S. 95	U	Clark	42
3	Las Vegas to Indian Springs	U.S. 95	R	Clark	43
4	Indian Springs	U.S. 95	S	Clark	3
5	Indian Springs to Nye County Line	U.S. 95	R	Clark	16
6	Nye County Line to access road	U.S. 95	R	Nye	39
7	U.S. 95 to repository	Access road	R	Nye	24

[a] I-15 = Interstate 15; U.S. 95 = U.S. Highway 95
[b] R = rural, S = suburban, U = urban
[c] 1 kilometer (km) = 0.6214 mile

1. Urban Population Density - Only Las Vegas and Reno, Nevada, are considered urbanized areas for the purpose of risk analysis. Population figures for these areas were obtained from the U.S. Department of Commerce (DOC, 1982). Population density was determined by dividing the population by the area of the Las Vegas or Reno Urbanized Area, which was also obtained from the U.S. Department of Commerce (DOC, 1981).

2. Suburban Population Density - All towns for which population data were available were considered suburban population zones. Two sources were used to obtain population data: (1) DOC (1982), and (2) CACI (1984). The areas of towns were determined from State of Nevada, Department of Transportation (ca. 1984).

3. Rural Population Density - It would not be appropriate to use rural population density values based on total county area. This is because most counties in Nevada contain large uninhabited areas. Therefore, the assumption was made that all rural residents of a given county are distributed within 1.6 kilometers (1 mile) on either side of major highways. Rural populations for each county were determined by obtaining county populations from DOC (1982), and subtracting the populations of urbanized areas and towns.

The population distribution pattern along rail routes was assumed to follow that determined for highway routes. That is, for a given population zone within a given county, the same population density was assumed for rail and truck routes.

The radiological unit risk factors used for the national assessment are presented in Appendix A while those used for the regional analyses are presented in Table 5-38.

Table 5-38. Radiological risk factors for transportation of nuclear waste within Nevada

	Fatalities per 100,000 shipments[a]			
Route[b]	CSF[c]	SW[d]	SF[e]	HLW[f]
Truck				
I-15S	NA[g]	NA	1.10	0.99
I-15N	NA	NA	0.89	0.79
U.S. 93N	NA	NA	0.84	0.75
I-80E	NA	NA	2.20	1.90
U.S. 95S	NA	NA	2.60	2.30
S.R. 373N	NA	NA	0.17	0.15
Rail				
UPW	0.40	0.252	0.40	0.37
UPE	NA	NA	1.30	1.07

[a]Includes latent cancer fatalities to occupational and nonoccupational exposures from normal transportation and accidents; assumes 2.0×10^{-4} cancer fatalities per man-rem. See Appendix A for more detail.

[b]I = Interstate Highway; U.S. = U.S. Highway; S.R. = State Route; UP = Union Pacific (last letter of acronym indicates direction).

[c]CSF = Consolidated and overpacked spent fuel.

[d]SW = Secondary waste.

[e]SF = Spent fuel.

[f]HLW = Defense and West Valley high-level waste.

[g]NA = not applicable.

These risk factors are presented in terms of radiological-related fatalities per shipment of a given waste type on a given route. For example, the greatest radiological risk per shipment of spent fuel by truck is incurred along the U.S. Highway 95 southbound route (the longest route), while for rail shipments, the Union Pacific eastbound route has the highest risk on a per shipment basis, because of the population density along that route.

The results of the assessment of radiological risk from nuclear waste transportation within the State of Nevada are presented in Table 5-39. The following conclusions can be drawn from these results. First, for the case involving no monitored retrievable storage (MRS) facility, the total radiological risk resulting from nuclear waste transportation within Nevada is very low, and there is little difference in the magnitude of the risk between routing scenarios I and II. In either scenario, about one cancer fatality would be expected from the population dose associated with truck shipments. The largest single component of radiological risk in either scenario is the truck shipment of wastes on the Interstate 15 southbound route. This route not only has a relatively high risk per shipment because the population density is higher than on other postulated routes but also has the largest number of shipments. Also, as in the case of national impact, it is evident that radiological risk from truck shipment is significantly greater than for rail shipment.

For the case assuming the existence of a MRS facility, there is also a low total radiological risk, with little difference between scenarios. For example, the total population dose assuming truck shipment from waste origin to a MRS facility or the repository is about 1,800 man-rem for Scenario I and 1,400 man-rem for Scenario II. These dose levels are well below that which would be expected to produce one cancer fatality. When rail shipment from waste origin to a MRS facility or repository is assumed, the doses are very low: about 500 man-rem for Scenario I and Scenario II. From the above, it can be concluded that the radiological risk associated with transportation of nuclear waste within the State of Nevada is very low and fairly constant for all postulated cases of routing and interim destinations.

Although the radiological risk from accidents is small, it should be noted that the risks may be overstated for the Nevada region for rail. That is, the rail accident rates used in the RADTRAN-II modeling may be greater than that experienced in Nevada by the Union Pacific railroad. For example, RADTRAN-II used railroad accident rates ranging between 1.0×10^{-7} and 1.5×10^{-5} accidents per rail car per kilometer depending upon whether the location was rural or urban. The suburban accident rate used in RADTRAN-II was 1.9×10^{-6}. In Nevada, the Union Pacific line had an accident rate of 6.88×10^{-8} accidents per rail car per kilometer over the period 1978 through 1983 (this does not include 1982 for which rail car per kilometer data was not available) for which rail equipment damage exceeded certain monetary limits (DOT, 1985b). This accident rate is one sixty-ninth of the lowest accident rate used in RADTRAN-II. Furthermore, the Union Pacific rail system overall had a lower than average accident rate for Class I main line railroads in the United States during 1984, with an accident rate equal to 78 percent of the average (DOT, 1985a).

Table 5-39. Summary of regional radiological impacts[a] of nuclear waste transportation

TOTAL FATALITIES		
Route	Scenario I	Scenario II
WITHOUT MONITORED RETREIVABLE STORAGE		
Truck[b]		
I-15S	0.50	0.55
I-15N	0.07	0.09
U.S. 93N	0.27	0.27
I-80E	0.02	0.00
U.S. 95S	0.11	0.00
S.R. 373N	0.00	0.00
TOTAL	0.97	0.91
Rail[c]		
UPW	0.05	0.05
UPE	0.03	0.03
TOTAL	0.08	0.08
WITH MONITORED RETREIVABLE STORAGE[d]		
Truck[b]		
I-15S	0.10	0.13
I-15N	0.01	0.03
U.S. 93N	0.09	0.09
I-80E	0.02	0.00
U.S. 95S	0.11	0.00
S.R. 373N	0.00	0.00
TOTAL	0.33	0.25
Rail[c]		
UPW (1)		
Spent fuel & high-level waste	0.02	0.02
Consolidated and overpacked spent fuel and secondary waste	0.04	0.04
UPE	0.01	0.01
TOTAL		
Case I[e]	0.37	0.29
Case II[f]	0.07	0.07

[a]Includes occupational and nonoccupational exposure due to normal and accident conditions (See Appendix A for more detail).

[b]I = Interstate highway; U.S = U.S. Highway; S.R. = State Route. Last letter in route designation denotes direction of travel.

[c]UP = Union Pacific.

[d]Assumes western reactors ship directly to the repository.

[e]Assumes 100% truck transport of western reactors and high-level waste from defense and West Valley sites to repository.

[f]Assumes 100% rail transport of western reactors and HLW from defense and West Valley sites to repository.

For transportation via truck, the opposite condition may exist. That is, RADTRAN-II may understate vehicle accident conditions in Nevada. This tentative conclusion is based on overall death rates (deaths per one hundred million vehicle miles for all vehicles) which indicates that Nevada was 40 percent above the national average in 1983 (National Safety Council, 1984). Actual accident rates for the types of vehicles of interest are not published. During site characterization such rates will be determined.

5.3.2.2.3 Maximally exposed individual impacts

The estimated doses to the various categories of maximally exposed individuals from normal nuclear waste transportation are presented in Appendix A. These results indicate that, in general, truck or train servicing personnel have the highest potential for exposure.

5.3.2.3 Nonradiological Impacts

Aside from the radiological risks described above, certain nonradiological risks are inherent in any large-scale transportation program, regardless of whether nuclear materials are involved or not. Nonradiological effects include the potential induction of cancer by nonradioactive pollutants emitted by the truck or train and the fatalities or injuries resulting from truck or railcar accidents. Nonradiological risks are expressed in terms of latent cancer fatalities per kilometer of incident-free travel and fatalities and injuries expected from accidents per kilometer of travel.

5.3.2.3.1 National impacts

The factors used to estimate nonradiological risk on a national basis are calculated as described in Appendix A. The origin of the data utilized to determine the factors is also identified in Appendix A via the reference cited therein.

The nonradiological impacts associated with truck and rail transport on a national scale are presented in Table 5-40. These results follow the same general pattern as that of radiological impacts for the direct to repository scenario in that truck shipments represent a greater risk than do rail shipments. This fact becomes obvious when one considers that accidents are the dominant causes of nonradiological impacts. In the direct-to-repository case, truck shipments would result in about 36 fatalities and 463 injuries, whereas rail shipments would produce about 3 fatalities and 29 injuries. In the case where all reactors ship spent fuel by truck to a MRS facility for consolidation, overpack, and shipment by train to Yucca Mountain, the total nonradiological impact is estimated at 42 fatalities and 483 injuries. If rail is used as a shipping mode for the reactor-to-MRS component of this scenario, about 27 fatalities and 287 injuries would be expected.

Table 5-40. Summary of national nonradiological impacts of nuclear waste transportation

	Total fatalities[a]		Total injuries	
WITHOUT MONITORED RETRIEVABLE STORAGE				
100% Truck				
Spent Fuel	29		370	
Defense and West Valley high-level waste	7.4		93	
TOTAL	36.4		463	
100% Rail				
Spent fuel	2.4		23	
Defense and West Valley high-level waste	0.6		6.4	
TOTAL	3.0		29.4	
WITH MONITORED RETRIEVABLE STORAGE				
	(b)	(c)	(b)	(c)
100% Truck from origin				
Spent fuel	9.1	(8.5)	124	(110)
Defense and West Valley high-level waste	7.4	(7.4)	93	(93)
TOTAL	16.5	15.9	217	(203)
100% Rail from origin				
Spent fuel	0.9	(0.87)	8.4	(7.8)
Defense and West Valley high-level waste	0.8	(0.84)	8.3	(8.3)
TOTAL	1.8	1.6	16.7	(16.1)
Rail from MRS[d]	25	(24)	270	(250)
Total from origin				
Truck	42	(39)	480	(440)
Rail	27	(25)	289	(270)

[a]Fatalities resulting from accidents and potential induction of cancer by nonradioactive pollutants emitted by the train or truck.

[b]Results in this column assume all reactors ship spent fuel to a MRS facility.

[c]Results in parentheses assume western reactors ship spent fuel directly to repository and eastern reactors ship spent fuel to a MRS facility.

[d]Assumes 10-car dedicated train with 100-ton casks.

5.3.2.3.2 Regional impacts

As in the case of radiological impact analysis, nonradiological unit risk factors were modified to make them more appropriate for the regional analysis. This was done by applying route-specific population density data to the formula used to calculate the risk factors as previously described. The regional-specific nonradiological risk factors generated in this manner are presented in Table 5-41.

Using the route-specific population densities and the routing scenarios previously described, results of the regional assessment were obtained and are presented in Table 5-42.

For the regional case involving no monitored retrievable storage (MRS) facility, the following conclusions are drawn:

1. The total nonradiological risk is low and there is not much difference in risk between scenarios I and II.

2. The nonradiological risk associated with truck shipments is greater than that for train shipments.

3. The largest fraction of the risk for truck shipments is incurred on the Interstate 15 southbound route.

If a MRS facility is assumed, the following conclusions are drawn:

1. The total nonradiological risk is low, and the risk for Scenario I (truck only) is slightly higher than for Scenario II, because the trip distance within the State is longer.

2. The nonradiological risk associated with train shipments is greater than that for truck shipments.

3. The largest fraction of the truck-related risk is incurred on the U.S. Highway 95 southbound route for Scenario I and the Interstate 15 southbound route for Scenario II, because of trip length. For train shipments, almost all of the risk is incurred on the Union Pacific westbound line, upon which most of the rail shipments would be transported.

5.3.2.4 Risk summary

5.3.2.4.1 National risk summary

This section summarizes total risk as a function of the number of shipments made and whether a monitored retrievable storage (MRS) facility is used in the waste-management system. In all cases, nonradiological fatalities and injuries far exceed those due to the radiological nature of the cargo.

Table 5-41. Nonradiological risk factors for transportation[a] of nuclear waste within Nevada

Route	CSF & SW[c]	SF[d]	HLW[e]
	FATALITIES PER 100,000 SHIPMENTS		
Truck[b]			
I-15S	NA[f]	1.62	1.62
I-15N	NA	1.27	1.27
U.S. 93N	NA	1.05	1.05
I-80E	NA	4.07	4.07
U.S. 95S	NA	5.19	5.19
S.R. 373N	NA	0.35	0.35
Rail[g]			
UPW	71.6	1.02	1.02
UPE	NA	17.3	17.3
	INJURIES PER 100,000 SHIPMENTS		
Truck[b]			
I-15S	NA	18.2	18.2
I-15N	NA	12.1	12.1
U.S. 93N	NA	13.0	13.0
I-80E	NA	50.4	50.4
U.S. 95S	NA	63.6	63.6
S.R. 373N	NA	4.3	4.3
Rail[g]			
UPW	76.1	10.8	10.8
UPE	NA	7.1	7.1

[a]Includes occupational and nonoccupational exposure due to accident and normal conditons. (See Appendix A for more detail.)

[b]I = Interstate highway; U.S. = U.S. Highway; S.R. = State Route (last letter of acronym indicate direction).

[c]CSF = Consolidated and overpacked spent fuel; SW = Secondary Waste.

[d]SF = Spent fuel.

[e]HLW = Defense and West Valley high-level waste.

[f]NA = Not applicable.

[g]UP = Union Pacific (last letter of acronym indicates direction).

Table 5-42. Summary of regional nonradiological impacts[a] of nuclear waste transportation

	Total Fatalities		Total Injuries	
Route	Scenario I	Scenario II	Scenario I	Scenario II
	WITHOUT MONITORED RETRIEVABLE STORAGE			
Truck[b]				
I-15S	0.75	0.82	8.45	9.22
I-15N	0.10	0.12	0.91	1.18
U.S. 93N	0.36	0.36	4.41	4.41
I-80E	0.03	0.00	0.41	0.00
U.S. 95S	0.22	0.00	2.69	0.00
S.R. 373N	0.00	0.00	0.06	0.00
TOTAL	1.46	1.30	16.92	14.81
Rail[c]				
UPW	0.12	0.12	1.28	1.28
UPE	0.45	0.45	0.19	0.19
TOTAL	0.57	0.57	1.47	1.47
	WITH MONITORED RETRIEVABLE STORAGE			
Truck[b]				
I-15S	0.16	0.29	1.78	2.55
I-15N	0.02	0.05	0.18	0.44
U.S. 93N	0.12	0.12	1.51	1.51
I-80E	0.03	0.00	0.41	0.00
U.S. 95S	0.40	0.00	2.69	0.00
S.R. 373N	0.00	0.00	0.06	0.00
TOTAL[d]	0.73	0.46	6.63	4.50
Rail[c]				
UPW (1)				
Spent fuel & high-level waste	0.05	0.05	0.53	0.53
Consolidated spent fuel & secondary waste	1.15	1.15	12.19	12.19
UPE	0.09	0.09	0.04	0.04
TOTAL				
Case I	1.88	1.61	18.82	16.69
Case II	1.29	1.29	12.76	12.76

[a]Includes occupational and nonoccupational exposure due to accident and normal conditions (see Appendix A for more detail).

[b]I = Interstate highway; U.S. = U.S. Highway; S.R. = State Route. Last letter of route designation indicates direction of travel.

[c]UP = Union Pacific. Last letter of route designation indicates direction of travel.

[d]Western reactors plus defense and West Valley high-level waste.

Over the 28 years during which nuclear waste will be transported, approximately 47 fatalities and 463 injuries are predicted nationally if all nuclear waste is transported by truck. If rail is used, the fatalities drop to about 4 and the injuries to 29. Inclusion of a MRS facility in the system slightly increases risk over the direct-to-repository by truck scenario to 48 fatalities and 483 injuries if all spent fuel is transported to the MRS facility by truck. If rail is used to transport the spent fuel to a MRS facility, the fatalities drop to 27 and the injuries to 287.

5.3.2.4.2 Regional risk summary

From a regional standpoint the safest scenario is direct transport from origin to Yucca Mountain by rail. The highest risk is associated with direct transport of western fuel from origin to Yucca Mountain by truck with eastern fuel being transported from the monitored retrievable storage facility by dedicated rail. However, as previously noted, all scenarios produce extremely low risk within the State of Nevada.

5.3.2.5 Costs of nuclear waste transportation

This section assesses the total costs associated with the transportation of nuclear waste over the life of the repository. The cost results presented here are based on the methods and data presented in Appendix A.

The total transportation cost associated with spent fuel, defense high level waste, and West Valley high level waste is the sum of costs incurred for each of the following items:

1. Capital costs, which are the costs of the transportation packaging and associated trailer or rail car.

2. Maintenance costs, which are costs associated with maintenance and licensing activities.

3. Shipping costs, which are based on studies of published tariffs or conservative estimates of actual shipping rates.

The results of this cost analysis are presented in Table 5-43. These results indicate that the total transportation cost would be about $1.54 billion for 100 percent truck shipments or $1.35 billion for 100 percent rail shipments if a monitored retrievable storage (MRS) facility is not considered. In the MRS facility case, the total transportation cost would be about $1.83 billion if origin-to-MRS truck shipment is assumed or 1.89 billion if origin-to-MRS rail shipment is assumed. These costs are for a repositoryof 70,000 metric tons uranium capacity at Yucca Mountain and are expressed as 1985 dollars.

Table 5-43. Summary of total transportation costs

Transportation Mode and Waste Type	Total Transportation Cost (millions of dollars)	
WITHOUT MONITORED RETRIEVABLE STORAGE		
100% Truck		
Spent fuel		1286
Defense high-level waste		237
West Valley high-level waste		15
TOTAL		1538
100% Rail		
Spent fuel		1024
Defense high-level waste		308
West Valley high-level waste		12
TOTAL		1345
WITH MONITORED RETRIEVABLE STORAGE		
	(a)	(b)
100% Truck from origin		
Spent Fuel	600	(533)
Defense high-level waste	237	(237)
West Valley high-level waste	15	(15)
100% Rail from origin		
Spent Fuel	593	(551)
Defense high-level waste	308	(308)
West Valley high-level waste	12	12
100-ton Rail cask from MRS		
Spent Fuel (overpacked)	800	(725)
Secondary Waste	174	(163)
Total from origin		
Truck	1828	(1674)
Rail	1889	(1760)

[a]Results without parenthesis assume all reactors ship spent fuel to a monitored retrievable storage (MRS) facility.

[b]Results in parenthesis assume western reactors ship spent fuel direct to repository and eastern reactors ship spent fuel to a MRS facility.

One additional cost element that warrants assessment is the cost incurred for the control and cleanup of an uncontrolled release of radioactivity. The likelihood that such an accident will occur is very low, but it is useful to assess the cost of such an event. The basis for and results of this cost estimate are provided in Appendix A.

5.3.2.6 Emergency response

Traditionally, it has been the responsibility of State and local government to respond to transportation accidents; the role of the Federal Government in the event of accidents during the transportation of civilian radioactive waste is usually one of supporting the State's lead role. In Nevada, the State Health Division is designated by law (Nevada Revised Statute 459, 1981) as the State radiation control agency. The Nevada Division of Emergency Management (DEM) is responsible for coordinating all disaster and emergency response activity. The DEM has a Memorandum of Understanding for hazardous materials that delineates responsibilities of State and Federal agencies in responding to radiological accidents. The DEM is also responsible for preparing the State Emergency Operations Plan, which includes response to a radiological accident. The DEM also provides radiological monitor training for state and local emergency response personnel. Assistance is available, as needed, from other government agencies and is coordinated by the U.S. Department of Energy (DOE). A State Radiological Emergency Plan is currently in effect (State of Nevada, Department of Human Resources, 1983).

The Department of Energy Nevada Operations Office has a unique capability in the area of radiological response. The DOE maintains a 24-hour manned emergency telephone station in Las Vegas that serves as the initial notification contact for emergencies and response coordination for radiological assistance. Under a Memorandum of Understanding with the State of Nevada (revised, 1984), the Department of Energy Nevada Operations Office will immediately notify the Health Division and the DEM of any emergency and will respond until State personnel take action (DOE/NVO, 1985). In southern Nevada, a Radiological Assistance Team, with a 24-hour rotating duty officer and a specially equipped vehicle, can be called upon immediately. In northern Nevada, the State of Nevada Emergency Response Team, composed of qualified State and university personnel, is available. In addition, first-on-the-scene training courses have been developed and conducted for ambulance operators, fire departments, and Nevada State law enforcement personnel by the Reynolds Electrical and Engineering Co. Inc., Environmental Sciences Department. Civil defense radiation monitoring kits have been given to each State highway patrolman who completes the course, and the kits are regularly maintained.

5.4 EXPECTED EFFECTS ON SOCIOECONOMIC CONDITIONS

This section describes the potential economic, demographic, community service, and social impacts of locating a repository at Yucca Mountain. Factors that are considered in the assessment of potential social and economic effects are discussed in this section. These factors include the local availability of workers, the extent of inmigration, worker settlement patterns, expenditures in the local area, and the public's perceptions and attitudes about the safety of high-level radioactive waste transportation and disposal. Radiological safety is a major consideration of the preclosure guidelines and is discussed in Sections 6.2.1.2, 6.4.3, and 6.2.2.1. However, for this analysis, it has been assumed that safety questions about transportation and disposal would be resolved before a repository would be constructed.

The analysis of these potential impacts is limited to the bicounty area (i.e. Nye and Clark counties) identified in Section 3.6 As discussed in that section, because of the similar geographic location and similar worker skills, historical settlement patterns of workers (as measured by reported ZIP codes) at the Nevada Test Site (NTS) provide a reasonable indication of where repository workers and their families would settle. In the absence of detailed information about worker skill mix, a worst-case analysis of demographic effects assumes that all project workers would come from outside the bicounty area of Clark and Nye counties. This assumption has been modified in the economic conditions section, which provides a preliminary evaluation of local labor availability.

Although fiscal impacts have not yet been quantified, preliminary estimates of the potential effects on community services do suggest the magnitude of potential fiscal effects. Section 5.4.5 presents a discussion of the Federal Government's commitments to provide financial and technical assistance for impact mitigation under the Nuclear Waste Policy Act of 1982 (NWPA, 1983). Other types of impact mitigation, such as mitigation by avoidance, would be identified as part of the ongoing studies. Factors that affect socioeconomic impact estimates would be the subject of more detailed analyses as part of studies carried out in the preparation of an environmental impact statement.

5.4.1 ECONOMIC CONDITIONS

The potential economic impacts that relate to labor, materials, income, land use, and tourism are described in this section. Only private sector activity will be considered here (public sector implications are discussed in sections 5.4.3 and 5.4.5). This analysis is based both on preliminary estimates of the demand for project labor and materials and on preliminary studies of future baseline market conditions. It is expected that repository construction would begin in September of 1993, and as a result, the bicounty area would begin to experience significant increases in demand for mine workers, construction workers, other skilled workers, and materials.

5.4.1.1 Labor

As shown in Figure 5-7a for vertical emplacement, the demand for direct workers would peak in 1998 and decline sharply at four points in the 63-year project schedule. Those points are (1) near the end of construction in 1999;

(2) at the phase down and completion of mining between 2018 and 2020; (3) between the phase down of emplacement in 2024 and the beginning of the caretaker phase in 2026; and (4) at the end of the decommissioning period in 2055. Figure 5-7b shows that the number of workers for horizontal emplacement would peak in 1997 and also decline at four points in the 58-year project schedule. Those points are (1) near the end of construction in 1999; (2) at the phase down and completion of mining between 2010 and 2012; (3) between the phase down of emplacement in 2024 and the beginning of the caretaker phase in 2026; and (4) at the end of the decommissioning period in 2050. Unless southern Nevada were experiencing rapid growth during these years, these periods would probably resemble similar periods of slower economic growth that the bicounty area has experienced during previous fluctuations in the mining and construction industries.

Tables 5-5a and 5-5b present preliminary estimates of the project's labor requirements by skill for vertical and horizontal emplacement, respectively. Assuming vertical emplacement, the projections in Table 5-5a suggest that the repository would employ about 250 direct workers in the first year of construction, 1993. This number would increase to a peak of about 1,900 direct workers in 1998. Mining employment would increase from a 1993 level of approximately 105 to a peak of about 630 direct workers in 1995 and 1996. Near the end of construction in 1999, direct repository workers would decline to 1,636. This number includes 235 construction workers (including construction managers) and 402 mining workers. The number of mining workers would be maintained at this level throughout most of the remainder of the emplacement phase of the operations period (i.e. through 2018). Near the end of the emplacement phase, after 2024, the work force would be reduced from 1,398 to 162 for the caretaker phase, which would begin in 2026. Near the end of the caretaker phase, employment would be increased to 412 for the start of the decommissioning period, and finally drop to 209 workers for the last year of decommissioning in 2055. No workers would remain at the site on a regular basis after 2055. A similar pattern is shown in Table 5-5b for horizontal emplacement.

Local purchases of repository materials, and expenditures by repository workers would result in increased demands for local goods and services. Indirect employment is defined as the increase in trade, service, and other employment that can be attributed to the increased demand for goods and services. The project's total employment effect is the sum of the direct repository workers and indirect project employment. Tables 5-5a and 5-5b provide estimates of the indirect employment effect based on the assumption that 1.54 indirect jobs would be created for each direct job (White et al., 1975; see also McBrien and Jones, 1984). The indirect employment multiplier of 1.54 was estimated, using data presented in White et al., as the average ratio of nonbasic (indirect) to basic (direct) employment in the Clark County area between 1961 and 1974. The annual ratio was fairly constant over that time interval. Basic employment was defined as the combined total employment of the resort industry, the Nevada Test Site, Nellis Air Force Base, and part of the manufacturing industry. Nonbasic employment was defined as total employment in the Las Vegas Standard Metropolitan Statistical Area minus basic employment (White et al., 1975). It should be noted that White et al. (1975) calculated a total employment multiplier of 2.54 rather than an indirect employment multiplier of 1.54 using the ratio of total employment to basic employment. The same total employment change results, however, whether indirect employment is estimated using the indirect employment multiplier and is then added to direct employment, (as shown in the analyses presented in this chapter); or the total employment change is calculated directly by applying the total employment multiplier to the change in direct employment. A total employment multiplier of this size has been applied in several past studies of Las Vegas and Clark County economies. The method discussed above results in a multiplier (either indirect or total) that is downward-biased to the extent that Nevada Test Site (NTS) employees reside in Nye County and to the extent that the resort industry serves the local population (i.e. is not totally a basic industry).

Total employment (i.e., direct and indirect) induced by the project would increase and decline over time in relation to the size of the direct project work force. The total annual employment would reach a peak of about 4,800 jobs in 1998. Near the end of the construction period in 1999, this number would decline to about 4,150. The average level of total employment would be about 4,260 for the next 25 years, through 2024. Although not reflected in tables 5-5a and 5-5b, the project also would employ direct workers during the operations period for traffic escort and control, emergency preparedness, road and rail maintenance, and operation of locomotives, trucks, and other vehicles. Estimates of employment levels for these activities are not yet available.

Recent settlement patterns (as measured by reported ZIP codes) of NTS employees are shown in Table 5-26. These data suggest that about 79 percent of the repository work force would reside in the Las Vegas metropolitan area, and about 14 percent of the work force would locate in the smaller communities of Indian Springs, Pahrump, Tonopah, Amargosa Valley, Beatty, and other southern Nevada communities. The settlement patterns of NTS employees also indicate that workers have been drawn from a labor market that includes residents of Clark, Nye, and other Nevada counties, as well as from California, Arizona, and Utah.

Potential labor market implications of the project would include inmigration of workers having mining and construction skills. There might be an increase of wages and salaries to induce these workers to relocate to the area. Labor market impacts would depend upon the local and regional availability of workers at various periods of the project, especially during the construction period (from 1993 through 2000) when direct work force requirements would reach their peak. Using actual 1983 wage and salary employment (State of Nevada, ESD, 1984; State of Nevada, OCS, 1985) and estimated 1983 population (Ryan, 1984), employment to population ratios for Clark and Nye counties can be calculated. Applying these to projected 1998 baseline population for each county (calculated from tables 3-15 and 3-16 using linear interpolation), and summing, results in an estimate of about 661,000 for the 1998 bicounty baseline total wage and salary employment. The peak number of direct repository workers (Table 5-5a for vertical emplacement) in 1998 would be less than one percent of this estimated baseline bicounty wage and salary employment in that year.

Estimates of project labor requirements indicate that a significant demand would exist for construction and mining workers. The peak requirement for construction workers (including construction managers) would be about 700 for vertical emplacement, as shown in Table 5-5a. This represents about a

3 percent increase over 1995 baseline construction employment levels projected for the bicounty area. The peak requirement for mining workers for vertical emplacement would be about 630 and would represent nearly a 40 percent increase over the projected 1995 Nye County baseline employment in that industry. (Baseline employment for 1995 is interpolated from 1990 and 2000 employment projections shown in tables 3-12 and 3-13.) Declining to about 400 in 1998, this level of mining employment would be maintained for the next 20 years and represents about a 23 percent increase over mining employment projected for Nye County for the year 2000. As noted in Section 3.6.1.2, employment projections for Clark County's small mining sector are not available. This projection indicates that the development of a repository at Yucca Mountain (assuming vertical emplacement) would place significant demands on the local mining sector and moderate demands on the local construction sector. Although the horizontal emplacement method would generate only about 80 percent as many mining jobs, the construction work force requirement would be about the same as for vertical emplacement. Many mining and construction workers would come from outside the bicounty area. The extent to which this would occur depends upon the presence in the area of other large projects in the early 1990s, the state of the national economy at that time, and the unemployment rates in these skill areas.

5.4.1.2 Materials and resources

The average annual requirements for some construction materials and resources are shown in Table 5-6. In addition to electrical power, a preliminary analysis of materials supplies in southern Nevada indicates that it is reasonable to assume that concrete and fuel would be purchased in the area (McBrien and Jones, 1984). However, many of the materials that eventually would be required may not be available in southern Nevada. The caretaker phase would generate only a small requirement for power and fuel. During the decommissioning period, the project would require heavy equipment and materials, both to seal the shafts and tunnels and to dismantle surface facilities.

5.4.1.3 Cost

Preliminary cost estimates for the construction, operation, and decommissioning of a repository at Yucca Mountain are summarized in Table 5-44. The cost estimates in Table 5-44 are preliminary and are useful for this analysis, but they are not appropriate for budget projections. Conceptual cost estimates cannot be completed until engineering designs have been developed further and until construction, operating, and decommissioning requirements have been assessed in greater detail. All costs are shown in 1984 dollars. Estimates shown include allowances for engineering, design, and inspection; contingency; construction management; and quality assurance.

The cost estimates are based on the emplacement of single spent fuel waste disposal containers in vertical holes in the floor of the emplacement drifts. For horizontal emplacement, the costs for underground workings and rock handling would be less; other costs would be about the same as for vertical emplacement. However, the total savings that could be realized have

Table 5-44. Preliminary cost estimates for the Yucca Mountain repository assuming vertical emplacement[a]

Category	Cost estimates (millions of 1984 dollars)			
	Engineering and construction	Operation	Decommissioning	Total
Waste preparation	395	1546	38	1979
Repository system				
Site	182	0	0	182
Waste handling and emplacement	134	1138	1	1273
Underground workings and rock handling	198	425	2	625
Ventilation	88	298	3	389
Support/utilities	134	2433	0	2567
TOTALS	1131	5840	44	7015

[a]Data from MacDougall (1985), Appendix A, tables 2.16A through 2.16E.

not yet been determined for horizontal emplacement. Facility operations costs are based upon receiving a total of 70,000 metric tons of heavy metal (MTHM) as spent fuel during a 28-year emplacement phase. It has been assumed that the maximum annual receipt rate would be 3,000 MTHM per year.

5.4.1.4 Income

Increases in the U.S. Department of Energy (DOE) spending on labor and materials during the construction and operation of a repository at Yucca Mountain would contribute to growth in the region. Labor and materials suppliers would experience a direct increase in demand for their resources. Also, increased DOE spending would generate growth in support sectors, such as the trade and services industries.

Table 5-45 shows the total increase in wages that might result from project employment, assuming vertical emplacement of the waste. The same information is shown in Table 5-46 for horizontal waste emplacement. These

Table 5-45. Potential annual wage expenditures associated with vertical emplacement (millions of 1983 dollars).

					[-----OPERATIONS PERIOD											
					[-----Emplacement Phase								[-Caretaker Phase----]			
	[-----CONSTRUCTION PERIOD						-----]									
	[--Phase 1 Construction--]														[--DECOMMIS-SIONING PERIOD--]	
	[-----Phase 2 Construction						-----]									
Category	1993	1994	1995 thru 1996	1997	1998	1999	2000	2001	2002 thru 2018	2019	2020 thru 2024	2025	2026 thru 2046	2047	2048 thru 2054	2055
Direct repository workers[a]	8.91	35.51	53.21	65.78	68.96	59.22	60.35	60.35	63.90	57.27	50.61	28.27	5.86	10.50	14.91	7.57
Indirect workers[b]	5.31	21.15	31.70	39.17	41.08	35.27	35.94	35.94	38.05	34.10	30.14	16.84	3.49	6.26	8.88	4.51
TOTAL	14.22	56.66	84.91	104.95	110.04	94.49	96.29	96.29	101.95	91.37	80.75	45.11	9.35	16.76	23.79	12.08

[a]Assumes an average annual wage of $36,200 (McBrien and Jones, 1984).
[b]Assumes an average annual salary of $14,000, the average annual wage of persons in the trade industry in southern Nevada (McBrien and Jones, 1984).

Table 5-46. Potential annual wage expenditures associated with horizontal emplacement (millions of 1983 dollars)

[------OPERATIONS PERIOD------]
[------Emplacement Phase------][--Caretaker Phase---]
[------CONSTRUCTION PERIOD------]
[--DECOMMISSIONING PERIOD--]
[--Phase 1 Construction--]
[------Phase 2 Construction------]

Category	1993	1994	1995 thru 1996	1997	1998	1999	2000	2001	2002 thru 2018	2019	2020 thru 2024	2025	2026 thru 2046	2047	2048 thru 2049	2050
Direct repository workers[a]	7.93	31.71	47.60	59.77	57.92	45.87	47.10	47.10	50.82	49.60	48.36	26.86	5.29	10.72	15.96	8.07
Indirect workers[b]	4.72	18.87	28.35	35.6	34.50	27.31	28.06	28.06	30.27	29.5	28.80	16.00	3.15	6.38	9.51	4.80
TOTAL	12.65	50.58	75.95	95.37	92.42	73.18	75.16	75.16	81.09	79.10	77.16	42.86	8.44	17.10	25.47	12.87

[a]Assumes an average annual wage of $36,200 (McBrien and Jones, 1984).
[b]Assumes an average annual salary of $14,000, the average annual wage of persons in the trade industry in southern Nevada (McBrien and Jones, 1984).

projections are based on preliminary studies that estimate an annual wage of $36,200 for direct repository workers and $14,000 for indirect workers in 1983 dollars (McBrien and Jones, 1984). The peak annual direct economic stimulus of repository spending on wages alone would be $110.04 million in 1998 under vertical emplacement and $95.37 million in 1997 under horizontal emplacement.

5.4.1.5 Land use

Land-use requirements for a repository at Yucca Mountain would involve the withdrawal of public land along with the associated surface and subsurface rights. It is unlikely that land in the Yucca Mountain area would be used for grazing even if it were not withdrawn for a repository. Range lands in the area are from low to medium grade, on which 250 hectares (630 acres) are required to support one head of cattle for one year (Collins et al., 1982). The area immediately surrounding the site has very limited, if any, potential for energy and mineral resource development (Bell and Larson, 1982). Withdrawing mineral rights is not expected to result in loss of significant resources (Section 3.2.4).

5.4.1.6 Tourism

Because of the importance of the tourism industry to the State and local economies, even small changes in tourism levels could have a significant economic impact. Public comments indicate a concern that the potential for adverse public perception of a repository and its associated waste transportation could adversely affect the tourism industry. The importance of public perception lies in the attractiveness of the image of Las Vegas to potential visitors. Concerns have been expressed that this image could be affected by the visibility of the repository and waste shipments and by safety concerns regarding the high-level radioactive waste-disposal program, particularly when accompanied by extensive media attention. Preliminary research to date concerning the potential effect of a repository on tourism is inconclusive; therefore further studies will be conducted. This section discusses the expected visibility of a repository and waste transportation, as well as the approach taken in a preliminary study of the relationship of tourism and nuclear-related and nonnuclear-related safety concerns.

Although the Yucca Mountain repository would be visible from parts of Amargosa Valley and U.S. Highway 95, the site is far from major population centers (Section 3.6.2.3). The repository itself would not be visible from metropolitan Clark County or its tourist areas. Construction of the proposed rail line from Dike Siding to Yucca Mountain would be visible from highways, residences, and Floyd Lamb State Park. High-level nuclear waste transportation shipments, which would be placarded, would be visible while in transit through the bicounty area. Actual transportation routes have not been identified; however, some of the postulated routes discussed in Section 5.3.2.1.2 pass through Las Vegas. None of those postulated routes include the Las Vegas "Strip".

A preliminary study performed for the U.S. Department of Energy (DOE) (SAIC, 1985) examined a variety of cases which exhibited elements analogous to the Yucca Mountain site: nuclear-related activites; perceived safety concerns, particularly when accompanied by broad media attention; and a local tourism industry. First, examples of published case studies examining the effect of nuclear facilities on tourism were reviewed. Second, other cases were examined where considerable media attention was given to an actual or perceived safety hazard and where tourism was a sufficiently important or observable part of the economy that data on changing tourism levels were available. For these cases, data on a variety of indicators of tourism were collected and analyzed. For example, the effect of the accident at Three Mile Island was examined by an analysis of data on convention attendance in the Harrisburg area and data on attendance at Hersheypark, which is near Three Mile Island. Analysis of the effect of the fires at the Las Vegas MGM Grand and Hilton hotels included both a qualitative review of comments regarding the potential for effects on hotel-casino stock prices in general, and a quantitative analysis of actual changes in specific stock prices. The latter included analysis of changes in stock prices of MGM Grand Hotels, Inc.; stock prices of seven other corporations with substantial Las Vegas hotel-casino holdings; and the New York Stock Exchange Composite Indicator. Finally, the effect of activities at the Nevada Test Site was examined, using a time series econometric analysis of the relationship among Clark County gaming revenues, U.S. economic activity, and the number of weapons tests each year from 1955 through 1982.

The cases examined included a variety of indicators of tourism, perceived and actual hazards, and facilities. The findings of these cases were mixed, with regard to short-term impacts on tourism. In some cases, short-term impacts were noticeable, although it was not always possible to attribute effects on tourism solely to the presence of a nuclear facility or a perceived or actual safety threat. In other instances, short-term impacts could not be discerned. Long-term impacts on tourism were not apparent in any of the cases examined, although there was variability in the time periods covered by these cases.

However, the evidence from this preliminary review and analysis of analogous cases examined to date does not deny the possiblity of adverse effects on tourism. The DOE recognizes public concerns regarding safety and potential impacts on tourism, the importance of the tourism sector to the local and State economies, and the preliminary nature of this analysis. For these reasons, further investigations will be undertaken.

5.4.2 POPULATION DENSITY AND DISTRIBUTION

Table 5-47 shows a preliminary forecast of the maximum population increase that would be associated with locating a repository at Yucca Mountain, assuming vertical waste emplacement. Table 5-48 summarizes the maximum population increase expected under horizontal emplacement. This

Table 5-47. Maximum population increase for vertical emplacement[a] and bicounty population forecast with and without the repository

Period, Phase, and Year

[—OPERATIONS PERIOD—] [—Emplacement Phase—] [—Caretaker Phase—]

[—CONSTRUCTION PERIOD—] [—Phase 1 Construction—] [—Phase 2 Construction—]

[—DECOMMISSIONING PERIOD—]

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002 thru 2018	2019	2020 thru 2024	2025	2026 thru 2046	2047	2048 thru 2054	2055
MAXIMUM POPULATION INCREASE																	
Direct project workers	246	981	1470	1470	1817	1905	1636	1667	1667	1765	1582	1398	781	162	290	412	209
Direct project workers dependents	315	1256	1882	1882	2326	4705	4041	4118	4118	4360	3908	3453	1929	400	716	527	268
Indirect workers	379	1511	2264	2264	2798	2934	2519	2567	2567	2718	2436	2153	1203	249	447	634	322
Indirect workers' dependents	936	3732	5592	5592	6911	7247	6222	6341	6341	6713	6017	5318	2971	615	1104	1566	795
Maximum population increase of project	1876	7480	11,208	11,208	13,852	16,791	14,418	14,693	14,693	15,556	13,943	12,322	6884	1426	2557	3139	1594
NYE AND CLARK COUNTIES[b]																	
Total population forecast with project	768,847	797,746	824,844	848,362	874,419	900,758	921,999	945,782		Following completion of construction, population growth with the project would vary between 2.5 and 1.0 percent annually. Without the project, growth would vary between 2.5 and 1.1 percent.[e]							
Annual growth rate, %[c]	3.4[d]	3.8	3.4	2.9	3.1	3.0	2.4	2.6									
Baseline population forecast without project	767,046	790,565	814,084	837,602	861,121	884,639	908,158	931,677									
Annual growth rate, %[c]	3.2[d]	3.1	3.0	2.9	2.8	2.7	2.7	2.6									

[a]Assumptions: 1. 2.47 dependents per operations period direct and all indirect workers; 1.28 dependents per all other direct workers; (DOE, 1979);
2. 1.54 indirect jobs generated by each direct job (Section 5.4.1.1);
3. All workers come from outside the area;
4. Construction begins in 1993.

[b]Assumes that 13 and 83 percent of immigrants would settle in Nye and Clark counties, respectively (see Table 5-26).
[c]Percent change over population in previous years.
[d]Projected 1992 population without repository is 743,528.
[e]Based on linear extrapolation of population forecasts presented in Tables 3-15 and 3-16.

Table 5-48. Maximum population increase for horizontal emplacement[a] and bicounty population forecast with and without the repository

Period, Phase, and Year

[--OPERATIONS PERIOD--] (2002 thru 2047)
[--Emplacement Phase--] (2002 thru 2025) [-Caretaker Phase---] (2026 thru 2047)
[--CONSTRUCTION PERIOD--] (1993 thru 2001)
[--Phase 1 Construction--] (1993 thru 1996)
[--Phase 2 Construction--] (1993 thru 2001)
[--DECOMMISSIONING PERIOD--] (2048 thru 2050)

MAXIMUM POPULATION INCREASE

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002 thru 2018	2019	2020 thru 2024	2025	2026 thru 2046	2047	2048 thru 2049	2050
Direct project workers	219	876	1,315	1,315	1,651	1,600	1,267	1,301	1,301	1,404	1,370	1,336	742	146	296	441	223
Direct project workers' dependents	280	1,121	1,683	1,683	2,113	3,952	3,130	3,214	3,214	3,468	3,384	3,300	1,833	361	731	565	285
Indirect workers	337	1,349	2,025	2,025	2,543	2,464	1,951	2,004	2,004	2,162	2,110	2,057	1,143	225	456	679	343
Indirect workers' dependents	832	3,332	5,002	5,002	6,281	6,086	4,819	4,950	4,950	5,340	5,212	5,081	2,823	556	1,126	1,677	847
Maximum population increase of project	1,668	6,678	10,025	10,025	12,588	14,102	11,167	11,469	11,469	12,374	12,076	11,774	6,541	1,288	2,609	3,362	1,698

NYE AND CLARK COUNTIES[b]

	1993	1994	1995	1996	1997	1998	1999	2000
Total population forecast with project[c]	768,647	796,976	823,708	847,226	873,205	898,177	918,878	942,687
Annual growth rate, %[c]	3.4[d]	3.7	3.4	2.9	3.1	2.9	2.3	2.6
Baseline population forecast without project[c]	767,046	790,565	814,084	837,602	861,121	884,639	908,158	931,677
Annual growth rate, %[c]	3.2[d]	3.1	3.0	2.9	2.8	2.7	2.7	2.6

Following completion of contruction, population growth with the project would vary between 2.5 and 1.1 percent annually. Without the project, growth would vary between 2.5 and 1.1 percent.[e]

[a]Assumptions: 1. 2.67 dependents per operations period direct and all indirect workers; 1.28 dependents per all other direct workers; (DOE, 1979);
2. 1.55 indirect jobs generated by each direct job (Section 5.4.1.1);
3. All workers come from outside the area;
4. Construction begins in 1993.

[b]Assumes that 13 and 83 percent of immigrants would settle in Nye and Clark Counties, respectively (see Table 5-26).

[c]Percent change over population in previous year.

[d]Projected 1992 population without repository is 743,528.

[e]Based on linear extrapolation of popolation forecasts presented in Tables 3-15 and 3-16.

forecast is based on the conservative assumption that all workers would come from and return to areas other than Nye and Clark counties and that each household has only one labor market participant. Thus, it overstates the likely upward (or downward) responses of bicounty population to changes in project labor requirements. These conservative assumptions are used in Section 5.4.3 to estimate the worst-case impacts on community services.

During peak employment for vertical emplacement, in 1998, the repository project could cause a maximum population increase of 16,791 (Table 5-47). Ninety-six percent of this population increase is expected to settle in the bicounty area. This 96 percent (16,119) represents an increase of about 2 percent over the baseline population forecast without the project, for 1998, shown in Table 5-47. If direct and indirect workers follow the settlement patterns of workers recently employed by the U.S. Department of Energy and its contractors at the Nevada Test Site, Clark County would receive 83 percent of the maximum annual project-related population increase or a maximum of about 13,940 people. Nye County, which would receive about 13 percent of the total, would experience a maximum influx of about 2,180 people. Assuming vertical waste emplacement, between 1999 and 2024, the annual bicounty project-related population increment would average about 14,170 people: about 12,250 would reside in Clark County and about 1,920 would reside in Nye County. The maximum annual population growth rate with the repository would occur between 1993 and 1994 and would be about 3.7 percent for Clark County, and about 4.0 percent for Nye County. Without the repository, the population growth rates between these two years are forecast to be about 3.1 percent for Clark County and about 2.1 percent for Nye County; this forecast is based on linear interpolation of forecasts shown in tables 3-16 and 3-15. Annual population growth rates forecast for the bicounty area, with and without the repository, are shown in the lower portions of tables 5-47 and 5-48 for vertical and horizontal emplacement, respectively.

The percentages of Nevada Test Site (NTS) workers reporting ZIP codes in other Nevada counties (as summarized in Table 5-26) can be applied to the maximum repository-related population increase for vertical emplacment shown in Table 5-47 to estimate the repository-related population expected to settle in those counties. Using baseline population forecasts (and linear interpolations therefrom) prepared by the University of Nevada, Reno for those counties (Ryan, 1984), the population growth rates with the repository are not expected to be significantly different than baseline growth rates without the repository for Douglas, Lander, Lyon, and White Pine counties and for Carson City, a consolidated municipality. If approximately 1.3 percent of the repository-related population were to settle in Lincoln County (as shown in Table 5-26) the population growth rate between 1993 and 1994 (i.e. the maximum annual rate) with the repository would be about 3.1 percent, and is forecast to be about 2.1 percent without the repository in this same period. The potential repository-related maximum population growth rates are not significantly different than expected baseline growth rates in five other counties or county-equivalents for which recent NTS workers reported their ZIP codes. While population growth rates for Lincoln County are expected to be greater with the repository than under baseline forecasts, the maximum annual growth rate expected with the repository (i.e. 3.1 percent) is less than expected for the bicounty area (i.e. 3.8 percent shown in Table 5-47). For these reasons, the potential repository-related community service and social impacts in these other counties would be expected to be negligible or less than those expected in the bicounty area, and are not discussed in the following sections.

5.4.3 COMMUNITY SERVICES

Increased population growth typically results in an increase in the demand for local, state, and regional public services. These increases are of particular concern to public planners either because of a corresponding requirement for new facilities or because existing capacity must be expanded earlier than anticipated. This section discusses county-level impacts for Nye and Clark counties. Generally, community services in the unincorporated towns in Nye and Clark counties that are nearest to Yucca Mountain are not provided by town governments. As discussed in Section 3.6.3, services are provided by the Nye and Clark County Commissions, county-wide agencies, local special purpose districts, and volunteer organizations. Therefore, potential impacts would be mainly on county-wide service providers that are more likely to have resources for managing growth. However, available information on the current adequacy of community services (See Section 3.6.3) indicates that repository related population growth in the sparsely populated areas of Nye and Clark counties could contribute to existing community service supply problems in some communities. Repository related population growth impacts on community services would likely be small in urban areas of Clark County.

The preliminary analysis of potential impacts on community services discussed in this section consisted of both quantitative and qualitative approaches. The quantitative approach recognized that population growth rates are manifested in increases in certain readily quantifiable measures of services demand, such as the number of police officers and millions of gallons of drinking water per day. The qualitative approach consisted of using the information presented in Section 3.6.3 to identify potentially significant community services issues and drawing preliminary conclusions as to their significance in the face of repository-related population growth.

Per capita service ratios were calculated for each type of service in Nye and Clark counties. These ratios, along with the references upon which they are based, are summarized in Table 5-49. It was also assumed that existing service ratios would be valid in future years; that is, that service providers, such as police departments and school districts, would increase their services in proportion to the population increases in their service areas. No assumptions were made as to the timing of the service expansion, except that the necessary number of facilities and personnel would be available during each period. Incremental service requirements were calculated by multiplying per capita service ratios by the forecast increments in the population of Nye and Clark counties that would be induced by the repository; this calculation provides a set of service requirements that would be over and above those that are due to projected baseline population growth.

This analysis assumes that 100 percent of the jobs created by the repository would be filled by inmigrating workers. This extreme assumption permits the identification of maximum impacts on all community services in the region.

8 0 0 0 8 0 4 5 0

Table 5-49. Per capita ratios used to forecast community service requirements

Type of service	Clark County			Nye County		
	Ratio[a]	Base year	Source[b]	Ratio[a]	Base year	Source[b]
Elementary schools	0.151	1982	1	0.710	1983	8
Secondary schools	0.064	1982	1	0.258	1983	8
Teachers and staff	9.194	1982	1	10.200	1983	9
Police officers	1.669	1983	3	3.529	1982	2
Police vehicles	0.804	1983	4	ND[c]	ND	ND
Volunteer firefighters	0.423	1982	4	8.558	1982	2
Paid firefighters	1.019	1982	4	1.051	1982	2
Fire equipment pieces	0.204	1982	4	2.703	1982	2
Physicians	1.313	1982	4	0.450	1982	5
Hospital beds	5.848	1982	5	3.453	1982	6
Water (million gallons per day)	0.469	1982	6	0.648	(d)	(e)
Library books (1000)	1.057	1983	7	ND	ND	ND
Library staff	0.191	1983	7	ND	ND	ND

[a]Number per 1,000 residents. Population values for calculating ratios were obtained from Ryan (1984).

[b]Data from:
1. McBrien and Jones (1984) from the 1982-1983 Clark County School District Budget
2. State of Nevada, OCS (1982)
3. LVMPD (1984); Fay (1984); McBrien and Jones (1984)
4. McBrien and Jones (1984)
5. State of Nevada, OHPR (1983)
6. Nevada Development Authority (1984)
7. Nevada Library Directory and Statistics 1984 (State of Nevada, NSL, 1984)
8. Research and Educational Planning Center (1984)
9. M. Johnson (1984).

[c]ND = no data on which to compute a ratio.

[d]Service ratio based on data from 1980-1984.

[e]Based upon ratio between reported use and number of people served by public and private water systems (see Table 3-20).

The size and probable community settlement patterns of the inmigrant population are uncertain; thus, the impact on community services is also uncertain. The following discussion summarizes service impacts under the assumption that 83 percent of the inmigrating repository-related population would settle in Clark County and that 13 percent would settle in Nye County (Table 5-26). Projections of the maximum one-year repository-related service demand during each of the three repository periods, and the overlap of the construction and operations period, are shown in tables 5-50 and 5-51, for vertical and horizontal emplacement, respectively.

The service requirements shown in tables 5-50 and 5-51 apply to the incremental repository-related population (i.e., the population over and above the projected baseline) expected to reside in each county. Once a service is provided, it is assumed to be available to help satisfy service requirements for subsequent years. For example, the maximum of two elementary schools required for Clark County during construction would also be available to help meet the maximum projected demand during the operations period.

Except for the last 8 years of the project (i.e. the decommissioning period), service requirements in Nye County would be greater for vertical emplacement. The maximum service requirements increase over those projected for the future baseline would be about 5 percent in 1998. During most of the project, service requirements would be less than 4 percent higher than the projected baseline levels. These incremental percentages are higher than those for Clark County, mainly because the projected inmigrating population represents a higher percentage of the projected baseline population.

It is not expected that the requirements for increased services in Clark County would exceed forecast baseline service levels by more than 1.7 percent during the period of greatest impact, which is the combined construction-operations period from 1998 to 2000. In other periods, the incremental service requirements associated with the repository in Clark County would range from about 0.1 to 1.4 percent over those expected due to projected baseline growth.

The following discussion describes some of the potential impacts on community services that could result from the repository project, given the estimated population increases described in Section 5.4.2. Impacts that, in light of currently available information, do not appear to be of concern will not be discussed. For example, both Nye and Clark counties appear to have ample near- and long-term future capacity to accommodate disposal of an increased volume of solid waste.

5.4.3.1 Housing

Housing impacts are qualitatively different from other community services impacts because housing services typically are provided by the private sector. Therefore, the issue is whether the market would be able to accommodate increased housing demand. Ample land for expansion of housing is

Table 5-50. Maximum service requirements associated with the location of a repository at Yucca Mountain during any one year in each period (vertical emplacement)[a]

Service	Incremental service requirements							
	Clark County				Nye County			
	Construction only	Construction and operations	Operations only	Decommissioning	Construction only	Construction and operations	Operations only	Decommissioning
Education								
Schools								
Elementary	2	2	2	0	1	2	1	0
Secondary	1	1	1	0	0	1	1	0
Teachers and staff	106	128	119	24	18	22	21	4
Police								
Officers	19	23	22	4	6	8	7	1
Vehicles	9	11	10	2	NC[b]	NC	NC	NC
Fire								
Volunteer fire fighters	5	6	5	1	15	19	17	3
Paid fire fighters	12	14	13	3	2	2	2	0
Trucks and other equipment	2	3	3	1	5	6	5	1
Medical services								
Doctors	15	18	17	3	1	1	1	0
Hospital beds	67	82	76	15	6	8	7	1
Water (millions of gallons per day)	5	7	6	1	1	1	1	0
Library services								
Books (thousands)	12	15	14	3	NC	NC	NC	NC
Staff	2	3	2	1	NC	NC	NC	NC

[a]Construction is assumed to begin in 1993, construction continues and operations begin in 1998, operations only in 2001, and decommissioning in 2048.

[b]NC = Not calculated because service ratio was unavailable.

Table 5-51. Maximum service requirements associated with the location of a repository at Yucca Mountain during any one year in each period (horizontal emplacement)[a]

Service	Incremental service requirements							
	Clark County				Nye County			
	Construction only	Construction and operations	Operations only	Decommissioning	Construction	Construction and operations	Operations only	Decommissioning
Education								
Schools								
Elementary	2	2	2	0	1	1	1	0
Secondary	1	1	1	0	0	0	0	0
Teachers and staff	96	108	94	26	17	19	16	4
Police								
Officers	17	20	17	5	6	6	6	2
Vehicles	8	9	8	2	NC[b]	NC	NC	NC
Fire								
Volunteer fire fighters	4	5	4	1	14	16	14	4
Paid fire fighters	11	12	10	3	2	2	2	0
Trucks and other equipment	2	2	2	1	4	5	4	1
Medical services								
Doctors	14	15	13	4	1	1	1	0
Hospital beds	61	68	60	16	6	6	6	2
Water (millions of gallons per day)	5	5	5	1	1	1	1	0
Library services								
Books (thousands)	11	12	11	3	NC	NC	NC	NC
Staff	2	2	2	1	NC	NC	NC	NC

[a]Construction is assumed to begin in 1993, construction and operations in 1998, operations only in 2001, and decommissioning in 2048.
[b]NC = Not calculated because service ratio was unavailable.

available in the rural towns closest to the repository site. Future baseline housing demand in Clark and Nye counties is shown in Table 5-52; it was assumed that the average ratio of population to housing units would remain constant. Repository-related impacts on projected housing demand in the area would follow forecast population changes associated with the project. During the initial construction period, housing demand would increase with the influx of workers and dependents. Potential outmigration of workers as construction is completed could produce a slight decline in housing demand. During the decommissioning period, the incremental impact would be small enough to allow the forecast housing units to easily absorb the additional repository-related population.

This qualitative analysis reflects preliminary assessments of effects on the housing market, which are related directly to the growth or decline of population and to the overall level of economic activity in the study region. The current uncertainty as to the location, type, price, and quality of available housing and the locational and other preferences of individuals who might inmigrate make estimates of housing effects uncertain. As this uncertainty becomes resolved, mitigative measures, such as temporary housing during the construction period, may be identified that would avoid potentially significant housing effects.

5.4.3.2 Education

Under vertical emplacement, a maximum of 3 additional schools and 22 additional teachers would be required by the repository-related population expected to settle in Nye County. Under the same emplacement scenario, a maximum of 3 schools and 128 teachers would be required in Clark County. The extent of impacts on local schools in rural areas would depend on the timely allocation of resources by the Nye and Clark County school districts during the first few years of the project, although enough time will be available before the start of construction to enable these service providers to plan for the additional requirements. In general, the effect on Clark County educational services could be small. If no teachers above the baseline forecast requirements were to be hired, then an average of 0.4 student per class could be added to existing classrooms.

5.4.3.3 Water supply

At present, the size of municipal and private utility systems in most Nye County communities near Yucca Mountain appears adequate for current and future population levels, although some water systems need to be expanded. The main problems presently associated with the expansion of existing water systems are identifying additional potable-water sources and obtaining adequate development capital. Impacts on water supply services in Beatty will depend upon how many inmigrants settle there and on the extent to which a new high-quality water source may be found and utilized. As was discussed in Section 3.6.3.3, the principal effect of an increase in population in Pahrump due to the project would be a shortening of the time before which the maximum sustainable rate of pumping from the valley-fill aquifer would once

Table 5-52. Projected future baseline (without repository) housing demand in Clark and Nye counties, 1980-2000[a,b]

Type of housing	Housing units							
	Clark County				Nye County			
	1980	1985	1990	2000	1980	1985	1990	2000
Single family units	114,315	140,003	163,343	219,520	1,916	4,275	7,367	8,980
Multiple family units	54,815	67,133	78,325	105,262	393	877	1,511	1,842
Mobile homes	20,730	25,388	29,621	39,808	1,893	4,224	7,279	8,872
TOTAL	189,860	232,524	271,289	364,590	4,202	9,376	16,157	19,694

[a]1980 Data from McBrien and Jones (1984).
[b]Housing demand for other years was calculated by scaling the 1980 demand to the population projections presented in tables 3-16 and 3-15.

again be reached. Although a basin-wide decline in usable storage would not likely occur until well into the next century, local effects, such as land subsidence and well interference, could result from sustained development (Harrill, 1982). In summary, water supply impacts due to project-related population growth would be significant only if (1) Beatty were unable to expand its supply of high-quality water and (2) inmigrants to Pahrump increased the total population beyond about 17,000 residents.

As discussed in Section 3.6.3.3, the total sustained yield of aquifiers in the Amargosa Desert ground-water basin has been estimated to be about 33×10^6 cubic meters (26,800 acre-feet) per year, of which agricultural and domestic uses currently consume 12×10^6 cubic meters (9,523 acre-feet). The repository is estimated to require 432,000 cubic meters (350 acre-feet) per year. Thus, the project would increase water use in the basin by about 3.7 percent. Potential physical effects on wells of other water users in the basin appear, on the basis of available information, to be insignificant.

According to an investigation sponsored by the State of Nevada, Department of Conservation and Natural Resources (State of Nevada NDCNR, 1982), if present rates of water use continue, there are both legal and technical uncertainties as to the ability of existing sources to provide additional capacity to meet increased water demands in the Las Vegas valley beyond the year 2020, or when the population would reach about 1 million people. Several recommendations have been made to extend and increase the water supply. These include increased conservation, reliance upon ground water for peak demand, and the use of aquifers for storage of temporary surface water surpluses.

5.4.3.4 Waste-water treatment

Additional treatment facilities may be necessary in the smaller communities to accommodate the increased water use associated with repository-related population increases. In Nye County, sewage is either disposed of through private septic tanks and package plants or discharged from sewage-collection systems to evaporation pits in the desert. The capacity for wastewater treatment is not likely to be affected more severely than that of water-supply systems. However, extensive settlement close to the repository site in Nye County could increase the need for additional facilities. Waste-water treatment systems in Clark County probably would be adequate for the increased demand resulting from repository-related population growth.

5.4.3.5 Public safety services

Special training and other assistance would be necessary to prepare local police and fire departments to respond to potential accidents involving high-level radioactive waste transportation. However, the quality of law enforcement and fire protection would not be affected significantly by the population increase associated with construction of a repository. Increased police and fire service requirements are likely to be accommodated by normal expansion plans that are commensurate with anticipated growth. However, as noted in Section 3.6.3.7, present police facilities in many Clark County rural communities are inadequate. Additional personnel may be required if the project work force were responsible either for committing greater numbers or different types of crimes than those usually accompanying similar growth in the existing population. During both the operations-only and decommissioning periods of the project, the demand for services would be less than that expected in the construction/operations period (see tables 5-50 and 5-51).

5.4.3.6 Medical services

A small increase in the demand for health-care facilities and personnel would result from repository construction, operation, and decommissioning. Under vertical emplacement, the additional population expected to settle in Nye County would require approximately one additional doctor and up to 8 additional hospital beds. The incremental population expected to settle in Clark County would require from 3 to 18 more doctors and from 15 to 81 additional hospital beds (Table 5-50.) This projection assumes that the mix of health care needs of the repository workers and their dependents would be similar to those of the present residents. The significance of these demand increases would probably be greatest in smaller communities in which relatively few medical facilities are available. As noted in Section 3.6.3.8, many of the rural communities have been ranked as high priority health-manpower-shortage areas.

5.4.3.7 Transportation

Major improvements to existing highway systems are planned for U.S. Highway 95 through metropolitan Las Vegas. This highway will be rebuilt completely from Railroad Pass to Interstate 15 and will become Interstate 515 along one section. The new freeway was scheduled to be completed to Russell Road by 1992; the entire freeway was planned to be completed to Railroad Pass by the year 2000. That schedule has been moved up as actual construction is taking place. Despite improvements, it is projected that a number of streets, including sections of Interstate 15 and U.S. Highway 95, would be either at or over capacity during peak-hour use for the baseline population levels expected by the year 2000 (Clark County Transportation Study Policy Committee, 1980).

To estimate the effects of repository-related traffic in Las Vegas, the annual average daily traffic levels for the in-town portions of U.S. Highway 95 and Interstate 15 have been compared both with and without the repository, for 1998, the peak year for direct employment.

Baseline traffic levels were estimated by multiplying 1982 traffic counts (Pradere, 1983) by the ratio between the estimated 1998 Las Vegas Valley population and the estimated 1982 population of the same area. The area generating this traffic was assumed to comprise the cities of Las Vegas, North Las Vegas, and Henderson, and unincorporated urban Clark County. The combined population of those communities in 1980 represented about 96 percent of Clark County's 1980 population (Section 3.6.2.3). For purposes of this analysis, it was assumed that this percentage would remain constant. To estimate the Las Vegas Valley population in 1982 and 1998, this percentage was applied to Clark County's estimated 1982 and 1998 populations, which were obtained, respectively, from Ryan (1984) and linear interpolation of the population forecasts presented in Table 3-16. Baseline (i.e., without repository) traffic projections for U.S. Highway 95 and Interstate 15 in the Las Vegas Valley are shown in tables 5-53 and 5-54, respectively.

To estimate the number of vehicles in 1998 expected with the repository, the incremental repository-related population expected to settle in the Las Vegas Valley was added to the projected 1998 baseline population. The total population increase in 1998 under vertical emplacement was estimated to be 16,791 (Table 5-47). Data on recent settlement patterns of NTS workers (Table 5-26) were used to estimate the percentage of repository-related inmigrants that would settle in the Las Vegas Valley. The 1982 traffic counts were multiplied by the ratio of total repository-related population (project baseline plus inmigrants) to projected baseline population in 1998 to obtain the "with repository" values in tables 5-53 and 5-54.

These projections indicate a 1.6 percent increase due to repository-related population growth. This increment is not considered significant. Rail capacity would be adequate to meet additional demands for service caused by baseline and project-related growth.

5.4.4 SOCIAL CONDITIONS

The following is a preliminary assessment of potential social effects that may be expected to occur in the bicounty area. The assessment is preliminary because of the limited data base (Chapter 3) and because of uncertainty about the number and location of expected inmigrants and the actual transportation mode and routing of high-level radioactive waste.

A distinction is made between standard and special effects that may accompany nuclear projects (Hebert et al., 1978; see also Murdock and Leistritz, 1983). Standard effects result from the influx of population that typically accompanies the construction of large projects in rural areas. Special effects stem from concerns about radioactive material. Because high-level radioactive materials would be transported through the region, these special effects may occur in both rural and urban areas. The concerns include the following: (1) the effects on health and safety; (2) the fairness of the site selection process; (3) the institutional issues related to security, handling, and transportation; and (4) public participation and monitoring (Hebert et al., 1978; see also Murdock and Leistritz, 1983).

Table 5-53. Projected annual average daily traffic on U.S. Highway 95 in Las Vegas, 1998

Highway segment	Without repository (baseline)			With repository		
	Number of cars	Number of trucks	Total vehicles	Number of cars	Number of trucks	Total vehicles
Decatur to Valley View	71,233	2,204	73,437	72,397	2,240	74,637
Valley View to Rancho	82,151	2,541	84,462	83,494	2,583	86,077
Rancho to Highland	96,135	2,974	99,109	97,707	3,022	100,729
Highland to I-15 Interchange	107,847	3,336	111,183	109,610	3,390	113,000
I-15 Interchange to Casino Center Blvd.	78,189	1,596	79,785	79,467	1,622	81,089
Casino Center Blvd. to Down Town Exp.	36,285	741	37,026	36,878	753	37,631
Down Town Exp. to Las Vegas Blvd.	37,409	763	38,172	38,020	776	38,796
Las Vegas Blvd. to Charleston	34,960	714	35,674	35,531	726	36,257
Charleston to Sahara	66,109	2,045	68,154	67,189	2,078	69,267
Sahara to Lamb	65,791	2,035	67,826	66,866	2,068	68,934
Lamb to Flamingo	66,521	2,058	68,579	67,609	2,091	69,700
Flamingo to Nellis	66,521	2,058	68,579	67,609	2,091	69,700
Nellis to Tropicana	49,422	1,529	50,951	50,230	1,554	51,784
Tropicana to Las Vegas NLV[a]	51,965	1,607	53,572	52,815	1,633	54,448
Las Vegas NLV to NUL[b] Henderson	48,692	1,506	50,198	49,488	1,530	51,018
NUL Henderson to Sunset Rd.	48,692	1,506	50,198	49,488	1,530	51,018
Sunset Rd. to S.R. 146[c]	58,232	2,426	60,658	59,183	2,466	61,649
S.R. 146 to Henderson	34,162	2,181	36,343	34,720	2,216	36,936

[a]NLV = North Las Vegas.
[b]NUL = Northern Urban Limits.
[c]S.R. = State Route.

Table 5-54. Projected annual average daily traffic on Interstate 15 in Las Vegas, 1998

Highway segment	Without repository (baseline) Number of cars	Number of trucks	Total vehicles	With repository Number of cars	Number of trucks	Total vehicles
Craig to northern city limits of Las Vegas	8,432	2,241	10,673	8,570	2,278	10,848
Craig to Cheyenne	18,827	3,322	22,149	19,135	3,377	22,512
Cheyenne to Lake Mead	35,328	3,925	39,253	35,906	3,990	39,896
Lake Mead to D and Washington	64,577	5,616	70,193	65,632	5,708	71,340
D & Washington to Down Town Exp.	70,185	6,103	76,288	71,332	6,202	77,534
Down Town Exp. to Charleston	124,224	7,929	132,153	126,254	8,059	134,313
Charleston to Sahara	132,509	8,459	140,968	134,675	8,597	143,272
Sahara to Spring Mountain	120,798	7,710	128,508	122,773	7,836	130,609
Spring Mountain to Dunes Flamingo	92,095	6,932	99,027	93,601	7,045	100,646
Dunes Flamingo to Tropicana	59,485	5,883	65,368	60,457	5,979	66,436
Tropicana to Las Vegas Blvd.	18,238	4,559	22,797	18,536	4,634	23,170

5.4.4.1 Social structure and social organization

The early studies cited in Section 3.6.4.1 have noted standard effects on social structure and organization in rural areas that may include conflicts between inmigrating workers and existing residents; changes from an informal, neighborly lifestyle to a more formal bureaucratic mode; and social disruption during the transition. Special effects may be evident in the mobilization (that is, commitment of resources) and formation of opposing and supporting groups.

5.4.4.1.1 Standard effects on social structure and social organization

If recent Nevada Test Site settlement patterns are followed, most of the population influx would be absorbed by urban Clark County. In light of the small size of the increment relative to the projected baseline population and the complex nature of the existing social structure in urban Clark County, the overall effects are not expected to be significant. Further study is required to assess whether there could be impacts on particular communities.

Nye County is a rural area in which previous experience indicates that significant standard effects could occur. However, preliminary assessment suggests that inmigrating construction workers could become assimilated within the existing county structure. Relevant factors in this assessment include the compatibility between inmigrating workers and the communities of Nye County and the long lead-time that permits adequate planning.

Certain characteristics of the existing rural structure, which would reduce the possibility of conflict between existing and inmigrating groups, appear to be compatible with inmigration (see Section 3.6.4.1.1). Residents in Indian Springs and in Nye County communities include employees from the Nevada Test Site (NTS). Historically, Nye County communities have also had large percentages of miners and mining continues to be important in the area. A recent trend in Pahrump has been an increase in construction and mining work relative to agricultural employment. Some residents of the town of Amargosa Valley depend on employment outside of the immediate area to supplement their farm income. In addition, separate employee housing complexes, such as temporary housing available at Mercury for Nevada Test Site (NTS) workers and the American Borate housing complex, appear to be accepted features of the existing social structure.

Increasingly formal relationships, which may occur as rural communities grow, may be particularly likely if growth is concentrated in any one rural community. The possibility that growth may be accompanied by an increase in social problems is a valid concern in a region that has had negative effects from rapid growth cycles. Local institutions may be especially strained if the long project lead-time causes persons, motivated by expectations of well-paid employment, to inmigrate in advance of the actual construction period. However, the possibility of social problems may be reduced because the long lead-time, combined with an impact mitigation process, should allow adequate time to plan for initial population increases and for changes that may occur over the entire repository lifecycle. Moreover, it is likely that repository construction and operation would provide employment stability. As noted in Section 3.6.4.1.1, at least one rural Nye County community appears to seek expansion. The degree to which each community is prepared for and willing to adapt to immigration and growth is a factor in influencing project effects (Murdock and Leistritz, 1983; Branch et al., 1984; Cortese, 1979).

5.4.4.1.2 Special effects on social structure and social organization

Concerns about radioactive material provide the basis for possible changes in existing social structure and social organization. Special effects may include the mobilization and formation of groups that either oppose or support the repository. As noted by the National Research Council in a recent report, a possible major adverse effect could be community conflict during the site selection and planning stage rather than the more conventional effects that could occur during construction and operation (National Research Council, 1984). These effects have been occurring since the State of Nevada was notified of the potential siting of the repository and public hearings were held (DOE/NVO, 1983). Opposition groups have formed, and several area organizations have made public statements either supporting or opposing the repository. Networks exist through which mobilization of groups could occur, such as those formed to oppose siting the MX Missile System in Nevada and Utah (Albrecht, 1983).

5.4.4.2 Culture and lifestyle

Because of the diversity of the existing cultural environment (see Section 3.6.4.2), immigrating workers would be able to select a compatible cultural environment and are likely to be readily assimilated into the community. Those construction workers who continue to be employed during the operations period would be the most completely assimilated. However, it is possible that repository activities could affect certain cultures in the area. As discussed in Section 3.6.4.2, American Indian reservations are unlikely to be affected by immigrating workers because of their distance from Yucca Mountain. However, both Paiute reservations in Clark County are near postulated transportation routes discussed in Section 5.3.2.1.2. Native Americans could interpret threats to their land as threats to their cultural identity if actual transportation routes traverse their communities (for a related discussion, see Knack, 1980; Stoffle et al., 1982). Therefore, further assessment of potential impacts would be required following identification of actual routes within the State.

5.4.4.3 Attitudes and perceptions

Attitudes and perceptions are an integral part of the social impact process and are factors in the social group mobilization that was previously discussed. The formation of attitudes toward the repository can be understood in the context of the way that an individual selects and integrates new information in light of current beliefs, values, preferences, and goals (Otway et al., 1978; Mitchell, 1984). The following preliminary assessment identifies conditions that are unique to southern Nevada and that may interact with the specific concerns outlined in sections 3.6.4.3 and 3.6.4.4 to affect the development of attitudes on the repository issue. These conditions include past experience, the salience of the issue to an individual or to a group, and the issue's relationship to other issues about which an attitude has already been formed.

Several experiences may be particularly relevant to the formation of attitudes on the repository issue. The MX siting process and the publicity surrounding the Beatty low-level waste site have sensitized southern Nevada residents to the subjects of radioactive waste transportation and disposal as well as to Federal Governmental procedure. In addition, the legal action and the publicity from early atmospheric testing may either introduce or reinforce apprehension of both civilian and military uses of nuclear material. Conversely, the identification of familiar and voluntarily accepted activities are important elements in the perception of risk and, by extension, of nuclear risk (Slovic, 1976; Slovic et al., 1984; Douglas and Wildavsky, 1982; Crouch and Wilson, 1982). For citizens who have lived alongside the Nevada Test Site for many years, nuclear technology may be viewed as more familiar and be more likely to be accepted.

Economic considerations and the potential for changes in lifestyle also contribute to the formation of public attitudes (for further discussion, see Section 3.6.4.3). Preliminary analysis suggests that the repository could be considered more economically beneficial by Nye County communities than by Clark County communities; however, there may be varied reactions within either county. Towns such as Amargosa Valley and Pahrump could welcome the potential for growth and increased employment, particularly for the skilled workers and young persons who might otherwise leave the area. Note, however, that indications of Nye County support should be tempered by the survey findings, cited in Section 3.6.4.3, that demonstrate a desire for growth without social disruption. This support may depend on the extent to which Nye County residents are convinced that growth can be managed and that problems can be mitigated.

In contrast, urban Clark County residents could view the repository, especially high-level radioactive waste transportation, as negatively affecting the tourism image on which the economy is based. Moreover, it is possible that repository-related traffic (other than waste) could be perceived as aggravating the transportation problems that have been cited already by residents (State of Nevada, Governor's Commission on the Future of Nevada, 1980; Frey, 1981). Las Vegas newspapers and the 1984 University of Nevada, Las Vegas, survey (UNLV, 1984) suggest that many Clark County residents may oppose locating a repository at Yucca Mountain.

The following issues may also be related to the formation of public attitudes about the repository: (1) resentment of the high percentage of federally controlled land, which was symbolized by the Sagebrush Rebellion (Brodhead, 1980); (2) the belief, which is evident in the public hearings, that Nevadans have "done their share" by giving land for Nevada Test Site activities and should not have to accept waste from other states when Nevada produces none; (3) distrust of the Federal Government, which is also evident in the hearings and is reinforced by the perception of a dual role played by the government in managing both the development of nuclear power and the disposal of high-level radioactive waste. This last issue may be particularly important because of the role that credibility plays in the formation of attitudes.

5.4.5 FISCAL CONDITIONS AND GOVERNMENT STRUCTURE

The location of a repository at Yucca Mountain would increase both the revenues and the expenditures of State and local government entities in the affected area. Although no quantitative estimates of potential net fiscal effects are presently available, this section describes some of the qualitative revenue and expenditure implications. All demographic, economic, community services, and social impacts described in Sections 5.4.1 through 5.4.4 could have fiscal implications and thus would be the subject of future, more detailed investigations, the results of which would appear in an environmental impact statement. A description of key fiscal impact mitigation provisions of the Nuclear Waste Policy Act (the Act) is also provided.

State, county and local governments already have incurred repository-related expenses for the increased planning activities to enable affected government entities to prepare for and participate in a decision to locate a repository at Yucca Mountain. In order to offset the costs of this planning effort, the U.S. Department of Energy (DOE) has given grant funds to the State, which has in turn passed funding along to several local government entities. At the onset of construction in 1993, an influx of workers from outside the area would increase the demand for community services, as described in Section 5.4.3. During repository operation, additional outlays would be associated with road maintenance, traffic escort and control, and emergency preparedness. These would be offset, at least partially, by increases in government revenues at the State level through increased sales and use taxes, motor fuels taxes, and other highway use and general fund revenues; and they would be offset at the local level through increased sales, property and other tax revenues, and user fees.

In addition, to ensure mitigation of any potentially adverse fiscal effects of a repository, the Act explicitly provides a number of different ways for State and local governments and Indian Tribes to obtain financial assistance. The Act recognizes the fiscal implications of preconstruction planning activities, as well as the fiscal effects of the physical presence of the repository and its related work force. Under the Act, the Secretary of Energy must make grants to a State that has been notified that a repository may be located within its boundaries so that the State can participate in the review of assessments of the economic, social, public health and safety, and environmental implications of a repository (Section 116, NWPA, 1983). Similar provisions for financial assistance to affected Indian Tribes appear in Section 118. Provisions of Section 116(c)(1)(B) (NWPA, 1983) relating to purposes for which grants may be made to states have been paraphrased below:

1. To review activities undertaken with regard to repository siting to assess potential economic, social, public health and safety, and environmental impacts.

2. To develop a request for impact assistance associated with the development of a repository.

3. To engage in any monitoring, testing, or evaluation activities with respect to site characterization programs.

4. To provide information to residents about activities concerning the potential repository.

5. To request information from and to make comments and recommendations to the Secretary of Energy regarding the siting of a repository.

Section 116(c)(2)(A) of the Act provides for financial and technical assistance to the state in which repository construction is authorized for purposes of mitigating the impacts of repository development (NWPA, 1983). In addition to this financial assistance, the Act (Section 116(c)(3) requires that the Federal Government make grants equal to taxes to the State and units of general local government in whose jurisdictions a repository site has been chosen for site characterization. These payments must be equal to the amount the State and units of general local government would receive if they were authorized to tax site-characterization development and operation as they would tax any other real property and industrial activities occurring in their jurisdictions.

In addition, Section 117(c)(5) requires that, pursuant to a Consultation and Cooperation Agreement negotiated with States selected for characterization, DOE is to assist both the State and units of general local government in resolving a number of offsite concerns, such as State liability arising from accidents; necessary road upgrading and access to the site; ongoing emergency preparedness and emergency response; monitoring of transportation of high-level waste and spent nuclear fuel through the State; the conduct of baseline health studies of inhabitants in neighboring communities near the repository site, and reasonable periodic monitoring thereafter; and monitoring of the repository site upon decommissioning and closure (NWPA, 1983).

The repository could also have fiscal impacts through increased demands on community service providers. The significance of these impacts would depend on the extent to which workers would inmigrate from outside southern Nevada, the community settlement patterns of these workers, and the capabilities of service providers to handle increased service requirements. The assessment of community services impacts in Section 5.4.3 suggests that community-service-related fiscal effects might be observable yet insignificant for the urban areas of Clark County. Although service requirements in unincorporated towns near the repository site could increase at rates proportional to repository-related population growth, the potential impacts on fiscal conditions would generally be at the level of county-wide service providers which would likely have more resources for dealing with growth than town governments. It is possible, that as some small communities grow as a result of repository related inmigration, their form of governmental organization could change. Further information on inmigration and settlement patterns will be required to accurately quantify these impacts for purposes of identifying a detailed approach to fiscal and governmental impact mitigation.

5.5 SUMMARY OF ENVIRONMENTAL EFFECTS

Table 5-55 summarizes the environmental effects associated with locating a repository at Yucca Mountain. The table lists the activities associated with the construction, operation, and decommissioning periods of the repository and the potential effects of these activities. The table also outlines standard operating practices that could be used to minimize environmental effects and presents preliminary evaluations of the extent of any residual environmental impact remaining after standard operating practices have been implemented.

Land-surface disturbance would result in the most widespread and lasting impact on the physical environment since vegetation would be removed from approximately 680 hectares (1,680 acres). Locating the repository at Yucca Mountain is also expected to result in geologic, hydrologic, ecologic, aesthetic, and transportation impacts, but none of these impacts is considered extensive or severe enough to be judged as significant.

Inmigration of workers could contribute to existing water supply problems in Beatty.

All radiological exposures to the public are expected to be below the exposure limits specified by the Nuclear Regulatory Commission and the U.S. Environmental Protection Agency, but under extremely unlikely accident scenarios, radiological releases could result in significant doses to individual workers. Although all possible effects of locating a repository at Yucca Mountain will be subject to further study should the site be selected for site characterization, Table 5-55 indicates that not enough is presently known about six possible effects to evaluate their potential significance. These six are (1) the effect of the inhalation of zeolite mineral dust on miners, (2) the effect of train noise on residents in Indian Springs, visitors to Floyd R. Lamb State Park, and people in Mercury, (3) effects of population increases on demand for housing in the bicounty area, increased demand for educational services in Nye County, and on rural communities' waste-waster treatment capacity (4) the effect on culturea and lifestyles, (5) the potential for public concerns regarding high-level radioactive waste disposal to result in community controversy, and (6) the effect on the revenues and expenditures of State and local governments.

Table 5-55. Summary of environmental effects associated with the construction, operations, and decommissioning periods of the repository

Impact category	Activity and effects	Standard operating practice	Residual impacts of significance
Geology	Repository excavation slightly disturbs overall competence of rock units.	Use standard construction and mining support techniques and equipment, including rockbolts, wire mesh, and concrete sprayed on walls.	None.
	Repository development would exclude future exploration and development of local mineral or energy resources on approximately 42 hectares (104 acres) Federal land.	None.	None; there is no evidence of significant resources on these lands.
Hydrology	Ground water withdrawn during the construction, operation, and decommissioning periods may cause regional draw down although water table appears able to supply adequate water with negligible effects.	Monitor ground water for regional effects on the water table.	None.
	Radionuclide release during the operation and decommissioning periods may cause contamination of ground waters.	Use natural and engineered barriers to prevent and subseqently retard radionuclide migration; implement radiological monitoring of local and regional ground-water supplies.	None.

Table 5-55. Summary of environmental effects associated with the construction, operations, and decommissioning periods of the repository (continued)

Impact category	Activity and effects	Standard operating practice	Residual impacts of significance
Hydrology (continued)	Heavy precipitation may cause flash flooding of surface facilities at Yucca Mountain.	Use engineered surface grading to construct standard drainage system and diversion channels (see Ecosystems).	None.
Land use	Withdrawal of public land (approximately 5,000 acres) administered by the Bureau of Land Management.	Apply for and complete proper legal procedures for land withdrawal.	None; Yucca Mountain is not a prime location for other uses.
Ecosystems	Permanent removal of over 639 hectares (1,680 acres) of vegetation to construct surface facilities.	Stockpiling topsoil when possible.	None; affected areas are very small compared with similar surrounding undisturbed areas.
	Alteration of wildlife habitats through removal of vegetation for construction purposes.	Implement habitat restoration program following decommissioning.	None; habitat will be lost for more than 60 years, but areas disturbed are not ecologically unusual and surrounding areas provide similar habitats.
	Combustion emissions may indirectly affect biota near surface facilities.	None.	None.

Table 5-55. Summary of environmental effects associated with the construction, operations, and decommissioning periods of the repository (continued)

Impact category	Activity and effects	Standard operating practice	Residual impacts of significance
Ecosystems (continued)	Fugitive dust deposition on the leaves of desert shrubs near the surface facilities may indirectly cause death of individual plants.	Minimize dust when possible by wetting surfaces of the disturbed areas.	None; although some individual plants may be damaged or destroyed in areas if dust is not controlled.
	Increased erosion and sedimentation, during and after storms, as a result of grading operations may indirectly affect plant communities.	Control erosion by maintaining moderate slopes and applying soil stabilizers if necessary.	None.
	Construction noise in the area may affect individual animals or animal communities.	None.	None; the effects of noise on wildlife are speculative (Section 5.2.6). Also, wildlife is expected to be displaced from most noise sources during clearing operations.
	Clearing activities for construction could affect individual Mojave fishhook cactus plants (candidate for Federal listing as a threatened or endangered species).	Relocation of individual plants encountered.	None; although relocated plants may be traumatized.

Table 5-55. Summary of environmental effects associated with the construction, operations, and decommissioning periods of the repository (continued)

Impact category	Activity and effects	Standard operating practice	Residual impacts of significance
Ecosystems (continued)	Clearing activities for construction could affect individual desert tortoises (candidate for Federal listing as a threatened species).	Possibly relocate to a safe area. Further study of this practice is necessary.	None.
	Increased numbers of transportation, service, and personnel vehicles could cause increased animal kills on roads.	Avoid animals in road when possible and when safety of transportation is not jeopardized.	None.
Air quality	Construction activities (such as site preparation, mine construction, movement of mined rock, wind erosion, and concrete preparation) and operation activities (such as vehicle traffic and wind erosion of stored rock piles) could result in increased suspended particulates and fugitive dust emissions, which could affect ambient air quality.	Water exposed surfaces using chemical suppressants on cuts and fills, control traffic on dirt roads, pave roads using soil stabilization chemicals on road beds, and revegetate exposed surfaces.	None; none of the predicted pollutant concentrations is expected to violate applicable standards.
	Zeolite mineral dust from mining operations could pose a possible health hazard to miners from inhalation.	The possible hazard will be further studied during site characterization and if deemed hazardous, filtering or dust suppressant techniques will be used.	May be significant; subject to further study.

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Table 5-55. Summary of environmental effects associated with the construction, operations, and decommissioning periods of the repository (continued)

Impact category	Activity and effects	Standard operating practice	Residual impacts of significance
Air quality (continued)	Construction and operation activities, such as heavy equipment use; commuter worker and service traffic; and nuclear waste transportation by trucks or trains could possibly affect ambient air quality (combustion products from burning fossil fuels).	Filter diesel emissions where necessary (underground).	None; comparisons and studies indicate that combustion product emissions will have a negligible effect on ambient air-quality standards.
Noise	Construction noise could affect residents of the Town of Amargosa Valley (access road) and Indian Springs (rail line construction).	None.	May be significant when levels are greater than 55 dBA and receptor is within affected radius (Section 5.2.6.1).
	Noise could affect wildlife in the immediate vicinity of construction sites and passing trains and trucks.	None.	May be significant when levels are greater than 75 dBA and receptor is within affected radius (Section 5.2.6.1), although the effects of noise on wildlife are speculative.

Table 5-55. Summary of environmental effects associated with the construction, operations, and decommissioning periods of the repository (continued)

Impact category	Activity and effects	Standard operating practice	Residual impacts of significance
Noise (continued)	Noise from trains (if rail transportation is used) could affect residents in Indian Springs, visitors to Floyd R. Lamb State Park, and people in Mercury.	None.	May be significant (Section 5.2.6.2). Subject to further study.
Aesthetic resources	Construction and operation of a repository would be visible from the Nevada Test Site and may be visible from portions of U.S. Highway 95 and the Town of Amargosa Valley. Construction and use of the rail line and access road would be visible to the public along U.S. Highway 95.	None.	None.
Archaeological, cultural, and historical resources	Repository construction, operation, and decommissioning could potentially destroy archaeological sites.	Avoid or preserve significant cultural resources that would be affected.	None.
	Unauthorized individuals could potentially collect or destroy artifacts.	Restrict off-road travel and make employees aware of the importance of archaeological sites and the penalties resulting from disturbing such sites.	None.

Table 5-55. Summary of environmental effects associated with the construction, operations, and decommissioning periods of the repository (continued)

Impact category	Activity and effects	Standard operating practice	Residual impacts of significance
Radiological effects	Handling, packaging, and emplacing waste during repository operations may expose workers to radioactivity.	Provide radiological monitoring to warn of amounts exceeding permissible levels; use appropriately engineered shielding and packaging measures; provide protective clothing; and provide ventilation and filter systems.	None.
	Receiving, handling, and emplacing waste during normal operations could result in radiation exposure to the public.	Use appropriate engineered shielding and packaging measures. Filter gaseous effluents and keep liquid effluents onsite to evaporate. Monitor for radiological releases.	None; in addition to the protection provided by the standard operating practices, several miles separate the general public from facilities.
	Operational accidents during handling, packaging, and emplacing waste may cause radionuclide releases to general public and workers (Section 5.2.9.2 and Tables 5-24 and 5-25).	Use appropriately engineered shielding and packaging measures, use approved standard and and emergency operating procedures, establish facility and surrounding area evacuation plans, and monitor for radiological releases.	Significant doses to individual workers could occur under some unlikely accident scenarios (see Table 5-25). All exposures to the public are below Nuclear Regulatory Commission standard (see Table 5-27).

Table 5-55. Summary of environmental effects associated with the construction, operations, and decommissioning periods of the repository (continued)

Impact category	Activity and effects	Standard operating practice	Residual impacts of significance
Transportation	Constructing, operating, and decommissioning a repository at Yucca Mountain would increase traffic volume causing a slight increase in the number of highway accidents.	None.	None.
	Constructing, operating, and decommissioning a repository would increase the number of freight cars and trains on the existing line.	None.	None.
	Nuclear waste transport would expose people near the cask to radiation.	Use licensed shipping casks: follow all applicable regulations; perform radiation surveys (See Appendix A).	A maximum of 11 fatalities nationally over 28-year operating lifetime.
Transportation (continued)	A transportation accident might result in a release of radioactive material, although it is highly unlikely that an accident severe enough to cause a release would occur (See Appendix A).	Use licensed shipping casks; comply with DOT routing, inspection, driver training, and other applicable guidelines; establish emergency preparedness programs. (See Appendix A.)	A maximum of 22 fatalities should such a highly unlikely event occur (See Appendix A).
	Nuclear waste transport would result in nonradiological deaths or injuries (e.g., caused by collisions or exhaust emissions.	Comply with DOT inspection and driver training guidelines, and routing requirements for avoiding dangerous routes. (See Appendix A.)	A maximum of 42 fatalities nationally and 480 injuries over 28-year operating lifetime.

Table 5-55. Summary of environmental effects associated with the construction, operations, and decommissioning periods of the repository (continued)

Impact category	Activity and effects	Standard operating practice	Residual impacts of significance
Transportation (continued)	People and material transport to Yucca Mountain results in more congestion along U.S. 95 Highway between Las Vegas and the the Town of Amaragosa Valley.	None.	A maximum of 8 additional traffic accidents resulting in 2 deaths and 6 injuries during the peak year of 2003.
Socioeconomics	Repository construction would increase the demand for construction and mining workers in the bicounty area.	Recruit personnel from local area job market when possible.	Local employment in these sectors would increase; miners and construction workers could immigrate.
	Constructing, operating, and decommissioning the repository would increase the demand for some materials and resources.	Purchase materials in local area economy where possible.	Increases in Department of Energy spending on labor and materials during construction and operation of the repository would contribute to income and growth in the region.

Table 5-55. Summary of environmental effects associated with the construction, operations, and decommissioning periods of the repository (continued)

Impact category	Activity and effects	Standard operating practice	Residual impacts of significance
Socioeconomics (continued)	Locating a repository at Yucca Mountain could possibly affect the local tourism industry.	None.	None; Nevada Test Site activities do not appear to have affected the tourism industry, nevertheless, research on the subject to date is inconclusive and will be continued.
	Construction worker inmigration would increase demand for housing in Nye and Clark counties.	None.	Subject to further study.
	Construction worker inmigration would result in increased demand for educational services (i.e., new schools and teachers) in Nye County.	None.	Subject to further study.
	Inmigration of workers would result in an increased demand on water supply systems in Beatty and Pahrump.	None.	Potentially significant in Beatty if water supply systems are not upgraded or expanded.
	Inmigration of workers could result in increased demand on waste-water treatment facilities in the smaller communities.	None.	Subject to further study.

Table 5-55. Summary of environmental effects associated with the construction, operations, and decommissioning periods of the repository (continued)

Impact category	Activity and effects	Standard operating practice	Residual impacts of significance
	The potential for accidents involving nuclear waste transportation would result in increased demand for public safety services.	Prepare personnel for identified scenarios through special training and other assistance.	None.
	Repository construction could result in small increase in demand for medical services.	None.	None; although smaller communities may require additional facilities.
	Worker inmigration may affect the social structure and organization in urban Clark County.	None.	None; complex social structures exist in the baseline population.
	Worker inmigration may affect the social structure and organization in rural communities of Nye and Clark County.	None.	Potentially significant, if growth is concentrated in any one community; although inmigrants are likely to be compatible with existing social structure.
	Repository activities may affect certain cultures and lifestyles in the area (e.g. Native Americans may interpret threats to their land as threatening their cultural identity).	None.	Subject to further study.

Table 5-55. Summary of environmental effects associated with the construction, operations, and decommissioning periods of the repository (continued)

Impact category	Activity and effects	Standard operating practice	Residual impacts of significance
	Public concerns regarding waste disposal and transportation could result in community controversy.	None.	Potentially significant; subject to further study.
	Locating a repository at Yucca Mountain may increase revenues and expenditures of State and local governments in the affected area.	None.	Subject to further study.

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