MASTER

TECHNICAL SUPPORT FOR GEIS: RADIOACTIVE WASTE ISOLATION IN GEOLOGIC FORMATIONS

Volume 14

Repository Preconceptual Design Studies: Basalt

April 1978

Prepared By

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UNION
CARBIDE

OFFICE OF WASTE ISOLATION
OAK RIDGE, TENNESSEE

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Volume No.	Volume Title	Prepared by*
TM-36/1	Executive Summary	SAI
TM-36/2	Commercial Waste Forms, Packaging and Projections for Preconceptual Repository Design Studies	SAI
TM-36/3	Stratigraphies of Salt, Granite, Shale, and Basalt	D&M
TM-36/4	Baseline Rock Properties-Salt	D&M
TM-36/5	Baseline Rock Properties-Granite	D&M
TM-36/6	Baseline Rock Properties-Shale	D&M
TM-36/7	Baseline Rock Properties-Basalt	D&M
TM-36/8	Repository Preconceptual Design Studies: Salt	PBQD
TM-36/9	Drawings for Repository Preconceptual Design Studies: Salt	PBQD
TM-36/10	Repository Preconceptual Design Studies: Granite	PBQD
TM-36/11	Drawings for Repository Preconceptual Design Studies: Granite	PBQD
TM-36/12	Repository Preconceptual Design Studies: Shale	PBQD
TM-36/13	Drawings for Repository Preconceptual Design Studies: Shale	PBQD
TM-36/14	Repository Preconceptual Design Studies: Basalt	PBQD
TM-36/15	Drawings for Repository Preconceptual Design Studies: Basalt	PBQD
TM-36/16	Repository Preconceptual Design Studies: BPNL Waste Forms in Salt	PBQD
TM-36/17	Drawings for Repository Preconceptual Design Studies: BPNL Waste Forms in Salt	PBQD
TM-36/18	Facility Construction Feasibility and Costs by Rock Type	PBQD
TM-36/19	Thermal Analyses	SAI
TM-36/20	Thermomechanical Stress Analysis and Development of Thermal Loading Guidelines	D&M
TM-36/21	Ground Water Movement and Nuclide Transport	D&M
TM-36/22	Nuclear Considerations for Repository Design	SAI
TM-36/23	Environmental Effluent Analyses	SAI

*These documents were prepared by Science Applications, Inc. (SAI), 800 Oak Ridge Turnpike, Oak Ridge, Tennessee 37830; Dames & Moore (D&M), 20 Haarlem Avenue, White Plains, New York 10603; and Parsons Brinckerhoff Quade & Douglas, Inc. (PBQD), One Penn Plaza, New York, New York 10001.

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ABSTRACT

This volume, Volume 14 "Repository Preconceptual Design Studies: Basalt," is one of a 23-volume series, "Technical Support for GEIS: Radioactive Waste Isolation in Geologic Formations," Y/OWI/TM-36, which supplements the "Contribution to Draft Generic Environmental Impact Statement on Commercial Waste Management: Radioactive Waste Isolation in Geologic Formations," Y/OWI/TM-44. The series provides a more complete technical basis for the preconceptual designs, resource requirements, and environmental source terms associated with isolating commercial LWR wastes in underground repositories in salt, granite, shale and basalt. Wastes are considered from three fuel cycles: uranium and plutonium recycling, no recycling of spent fuel and uranium-only recycling.

This document describes a preconceptual design for a nuclear waste storage facility in basalt. The facility design consists of several chambers excavated deep within a geologic formation together with access shafts and supportive surface structures. The facility design provides for: receiving and unloading waste containers; lowering them down shafts to the mine level; transporting them to the proper storage area and emplacing them in mined storage rooms. Drawings of the facility design are contained in TM-36/15, "Drawings for Repository Preconceptual Design Studies: Basalt."

PREFACE

Project Background

One of the major problems related to the production of electricity by light-water nuclear reactors is the management of radioactive wastes generated by the use of nuclear fuel. However, the subject is considered amenable to a rational solution, and the technology involved is considered to be well within the capabilities of our present-day technological base.

An important step toward the realization of an effective waste management program is the preparation of the generic environmental impact statement for commercial waste management. A pivotal issue in waste management is the means of providing long-term, permanent storage of these wastes in a manner that best assures their isolation from the biosphere. Analyses spanning two decades have generated the widely supported concept for providing final isolation of these nuclear wastes in deep geologic formations. Therefore, the Office of Waste Isolation* was assigned the responsibility for preparation of the sections of this generic statement that deal with deep geologic waste isolation.

The original concept for deep geologic disposal was first advanced in 1957 when a National Research Council Advisory Committee of the National Academy of Sciences suggested the burial of solid radioactive wastes in salt deposits. To date, the majority of the research, development, and demonstration (RD&D) activities have been in salt. The current United States Department of Energy (DOE) National Waste Terminal Storage (NWTs) program calls for the selection of two sites overlying suitable salt formations by 1979, followed by the construction and start-up in 1985 of one

*Operated by Union Carbide Corporation Nuclear Division for the Department of Energy.

NRC-licensed repository designed for the permanent disposal/isolation of commercial nuclear wastes in a salt formation at one of these two sites. In addition to this activity in salt, vigorous RD&D programs have been initiated to determine the appropriateness of various hard rocks as host media for a repository.

The deep geologic isolation portion of the generic statement considers repositories located in salt, granite, shale, and basalt. The repositories are designed to handle wastes from the nuclear fuel cycle in which the spent fuel is considered a waste (no re-processing) or from either of two fuel cycles that include re-processing--the cycle with uranium and plutonium recycle and that with only uranium recycle. To prepare this contribution, the Office of Waste Isolation contracted with Dames & Moore, Parsons Brinckerhoff Quade & Douglas, Inc. and Science Applications, Inc. In order to prepare this description, generic sites were defined, preconceptual repository designs completed, and resource requirements and effluents from the repositories identified. The preconceptual repository designs for the salt host formation were based on more than two decades of analysis and in-situ experimentation. The data base upon which the repository designs for the non-salt host formations were based is much more sparse since repository-oriented analyses of these formations have been proceeding only for the last couple of years. For each of the host rocks additional analyses were performed during the conduct of these studies. Details of this additional technical work are described within the twenty-three volumes of this report.

For an overview of these preconceptual repository design studies, the study objectives and scope, and the major study assumptions, the reader is referred to Volume 1 of this series, the Executive Summary (Y/OWI/TM-36/1).

Volume Summary

This volume, "Repository Preconceptual Design Studies: Basalt," describes the scope of the generic repository and various design

assumptions (Section 1.0). Sections 2.0 and 3.0 outline the surface facilities and utilities of the repository. Mine-operating and waste receiving shafts are treated in Section 4.0 and mining and waste placement operations are discussed in Section 5.0. Section 6.0 examines the ventilation systems for the facilities of the repository.

1.0 INTRODUCTION

1.1 Scope of the Generic Repository

Preconceptual design studies have been prepared for an underground nuclear repository in basalt that stores nuclear wastes generated from commercial power plants. The overall design of the repository may be divided, for purposes of analysis, into three major components: (1) surface facilities; (2) shafts; and (3) underground storage rooms.

1.1.1 Surface Facilities

The surface facilities, which occupy approximately 200 acres of land, are designed to serve all functions associated with handling the waste on the surface. These functions include:

- o receipt and unloading of wastes in specially designed containers from rail cars
- o transfer of waste containers to inspection stations
- o decontamination of waste containers, if required
- o canister overpacking, when needed
- o preparation of waste for descent to the storage level

The repository design includes two basic waste handling streams: one for wastes that require shielding and hot-cell facilities (canistered waste), and one for wastes that do not (low-level waste).

In addition to the surface facilities required for processing the wastes, additional support installations, such as an administration building, clinic, cafeteria, utility systems, and radwaste management facilities are provided. An artist's conception of a typical federal repository is shown in Figs. 1 and 2.

1.1.2 Shafts

Five shafts have been provided for the repository. These are:

- o Canistered Waste Shaft--for transporting canisters of waste to the storage level
- o Low-Level Waste Shaft--for transporting pallets containing drums of low-level waste to the storage level
- o Men and Material Shaft--for transporting personnel and equipment to and from the storage level as well as for transporting excavated material to the surface
- o Ventilation Supply Shaft--for supplying fresh air for personnel and equipment requirements
- o Ventilation Exhaust Shaft--for removing exhaust air from mining, backfilling and waste placing operations.

1.1.3 Underground Storage Rooms

After the waste containers have been inspected and recorded they would be lowered through a shaft to the storage level. Upon arrival at the storage level the waste would be transported to the storage rooms and emplaced. Initially, the repository is assumed to operate in a retrievable mode so that repository operations and safety can be validated. During this period when the retrievability option is maintained, provisions are made so that all waste can be removed from the repository at about the same rate and with about the same effort as storage placement, should this be desired. After the repository has satisfactorily operated for a certain period of time (currently assumed to be five years), operations performed to maintain retrievability would be terminated and the storage rooms would be backfilled. Once the storage rooms are backfilled, the surface facilities would be decommissioned and dismantled, and all shafts would be plugged and sealed.

1.2 Alternative Fuel Cycles

Three alternative fuel cycles for light water reactors (LWRs) have been identified for analysis.¹ Because of the different thermal loadings associated with each fuel cycle, capacities for the repository design vary according to each cycle. The cycles are:

Cycle I: Total Recycle -- Spent fuel is reprocessed to extract and recover uranium (U) and plutonium (Pu). The reprocessed waste consists of: (1) high-level waste (HLW) containing fission products, actinides and other radioactive isotopes; (2) cladding waste (CW) and other intermediate-level transuranic (IL-TRU) waste; and (3) low-level transuranic (LL-TRU) waste. The high-level waste is assumed to arrive at the repository ten years after the fuel assemblies from which the HLW was generated were discharged from reactors. All other wastes from this fuel cycle are assumed to arrive at the repository, five years after discharge from the reactor.

Cycle II: Spent Unreprocessed Fuel (SURF) Cycle -- Spent fuel assemblies are not reprocessed but are directly disposed of as waste. In this alternative, the repository will receive intact spent LWR fuel assemblies and low-level waste.

For the purposes of this study, it is assumed that Pressurized Water Reactor (PWR) and Boiling Water Reactor (BWR) spent fuel assemblies are aged a minimum of ten years after removal from the reactor, prior to delivery to the repository and low-level wastes are one year old when they arrive at the repository.

Cycle III: U Only Recycle (with Pu in HLW) -- Spent fuel is reprocessed but only the uranium is removed from the waste. In partial reprocessing operations, the uranium is recovered for reactor recycle but the plutonium is not. In addition, the repository will receive cladding waste, intermediate-level waste, and low-level transuranic waste, as in Fuel Cycle I. Similarly, the HLW is assumed to be ten years old and all other wastes are assumed to be five years old upon arrival at the repository.

1.3 Canister Design Assumptions

For purposes of the design of a reference repository, certain assumptions have been made concerning the form in which the wastes will be received at the repository.² The assumed waste containers

are summarized in Table 1-1. All high-level wastes from Cycles I and III, both PWR and BWR spent fuel assemblies from Cycle II, and intermediate-level transuranic waste and cladding waste from Cycles I and III are anticipated to arrive at the repository in sealed steel canisters. Depending upon waste type, the outside diameter of these canisters may range from 8-5/8 in. to 14 in. and the overall length may range from 10 ft. to 16 ft. Although the specific dimensions of the canisters vary with waste type, all canisters, regardless of fuel cycle, are handled remotely and require shielding for radiation attenuation.

Physical similarities among the canisters for high-level, intermediate-level, cladding and spent fuel wastes, enabled a single receiving facility and common handling procedures to be developed for all canistered wastes, scaled as appropriate for respective fuel cycles. All low-level wastes will be received at the repository in 55 gal. drums and will be handled without shielding in a receiving building separate from the canistered wastes.

1.4 Geotechnical Factors That Influence Design³

Because of the geological characteristics and general stratigraphic setting of in-situ basalt, the choice of basalt for a repository will influence many of the design and layout features of the surface and subsurface facilities as well as the amount of waste that can be stored.

Basalt, like granite, is an igneous rock. The failure of basalt is abrupt and is preceded by little warning of imminent collapse. Because of the commonalities between the in situ properties of the rocks, guidelines for basalt closely parallel those outlined for granite. Like granite, the basis for design decisions in basalt are underlain by the objective to keep the total of all stress components significantly below the threshold value required for the occurrence of an initial failure mechanism. The characteristics that would significantly impact the design of the waste storage facility include:

- o Effects of heat on rock strength
- o Rock movement and faulting
- o Room and pillar stability
- o Ground water movement
- o Rock hardness.

1.4.1 Effects of Heat on Rock Strength

At high temperatures, the strength of rock is diminished as the rock crystalline structures begin to break down. In basalt, major losses of strength are expected to occur at around 450⁰ C to 500⁰C. To prevent weakening of the rock adjacent to the waste packages and the concomitant problems it would pose to retrievability, the thermal loading should be adjusted so that temperatures do not exceed critical values in large volumes of rock in the immediate vicinity of the canisters.

To maintain room safety and to reduce the possibility of progressive spalling failures, the temperature of the rock surfaces in the room walls and roof should also be held below the values that cause excessive strength loss.

1.4.2 Rock Movement

The rock surrounding and overlying the repository would react or move in response to the stresses imposed by the mined excavation and by thermal loading from the implanted waste materials. Mining activities would cause the surrounding rock to subside or move into and towards the mined opening. In contrast, the thermal loading would expand the rock and cause heaving to occur.

The repository layout and geometry and the allowable thermal loading should be designed to minimize rock movements so that the safety or integrity of the shafts is not adversely affected. Movements at the ground surface should be less than that which would cause distress in any structure. In addition, rock movement should not cause disruption or shearing of any aquifers in the vicinity of the repository.

1.4.3 Room and Pillar Stability

When basalt is overstressed, it will fail quickly with comparatively little warning. Accordingly, the main philosophy used in establishing design guidelines for waste facilities was to limit stresses to a value well below the level required for initial failure.

1.4.3.1 Room Stability

The repository layout and geometry and thermal loading limits were chosen such that the ratio of rock strength to rock stress within any rock cube with one face exposed in the wall of the room and with dimensions equal to 20% of the mean tunnel diameter was two or greater. Rock strength is defined as the mean compressive strength of the rock mass, considering the confining pressures, the offsets of fractures and joints, and temperatures. Rock stress is the mean compressive stress including a combination of the virgin stresses, stresses developed by the opening, and thermal stresses.

Analytical studies indicate that the room stability guidelines were met for the generic repository in basalt at the proposed 2,000 ft. (660m) depth. Therefore, additional support (rock bolting) would be necessary only in localized areas where loose rock is observed.

1.4.3.2 Pillar Stability

The repository layout was designed such that the ratio of pillar strength to pillar stress remains greater than two. This ratio is defined as the mean compressive strength of the pillar at mid-height. To protect against blast damage, the pillars were designed with a minimum width of 20 ft. In all cases the pillar width was designed to be at least equal to the height of the room.

1.4.4 Groundwater Movement

The generic basalt in which the repository would be placed is relatively impermeable. During shaft sinking, it is estimated that no more than a few gallons per minute (gpm) would

flow into the shaft.⁴ This flow could be sealed off by conventional grouting procedures. The total inflows into the repository can reach 265 gpm (227 gpm downflow/38 gpm upflow) during the later years of operation.

The question of groundwater flow into the repository during operation and after decommissioning, together with recommended water control technology, is discussed in Sections 4.0 and 6.0 of Groundwater Movement and Nuclide Transport.

If any major water-bearing fracture zones are encountered during development of the waste storage facilities they should be sealed by grouting.

1.4.5 Rock Hardness

Basalt as an igneous rock is relatively hard in comparison with other geologic formations. This limits the selection of construction methods and in general slows down shaft sinking operations and the advance rate of underground development. The storage room layout is designed to compensate for this problem.

1.5 Repository Personnel

At times of peak mining and waste handling, the repository labor force is projected to be about 1,500 to 2,500 employees, working in three 8-hour shifts per day, 260 days per year. Personnel assignment schedules for Cycles I, II, and III are given in Tables 1-2, 1-3, and 1-4, respectively. For a Job Classification Breakdown Summary the reader is referred to Appendix B.

1.6 Mining Methodology

For this underground nuclear waste storage facility, the hardness of basalt dictates that conventional drill and blast techniques be used for mining. Broken rock would be hauled by trucks to chutes located at the entry to each storage panel. There the material would be broken further, sent down a chute to rail cars located on a lower level, transported to a crusher, conveyed to skip loading pockets, and finally hoisted to the surface for disposal.

1. REFERENCES

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2. Ibid.
3. _____, Baseline Rock Properties - Basalt, Y/OWI/TM-36/7, Oak Ridge, Tennessee, April 1978. Chapters 2 and 9.
4. _____, Stratigraphies of Salt, Granite, Shale, and Basalt, Y/OWI/TM-36/3, Oak Ridge, Tennessee, April 1978 Chapter 5.
5. _____, Ground Water Movement and Nuclide Transport Y/OWI/TM-36/21, Oak Ridge, Tennessee, April 1978.

2.0 SURFACE FACILITIES

2.1 Site

An area of approximately 200 acres, roughly centered on the 2,000 acre subsurface repository area, is required to accommodate the surface facilities. The relation of this surface area to the subsurface area is shown on the inset of the Site and Plot Plan Drawing (Dwg. 1 in all sets).¹

This 200 acre area is enclosed first by an agricultural fence. A second double security fence with a 50 ft. unoccupied isolation zone provides a high security area for repository operations. The minimum distance between the agricultural fence and the double security fence is 75 ft.

The double security fencing is penetrated only by two guarded access points - one for personnel and motor vehicles and one for railroad tracks that serve the receipt of nuclear waste and miscellaneous material required for plant operation.

The buildings and facilities located inside the high security area are:

- o Canistered Waste Receiving Building
- o Low-Level Waste Receiving Building
- o Liquid Radwaste Treatment Building
- o Exhaust Ventilation Building
- o Supply Ventilation Building
- o Boiler and Refrigeration Building
- o Site Control Building
- o Men and Material Building
- o Mine Operations Building
- o Main Power Substation
- o Emergency Generator Building
- o Diesel Fuel Tanks
- o Storage Building

- o Cafeteria
- o Laundry
- o Fire House
- o Water Tank
- o Guardhouses

Between the agricultural fence and the double security fence are the following facilities:

- o Administration building
- o Warehouse and maintenance building
- o Clinic
- o Major parking area
- o Storage area and railroad car loading facilities for excavated material
- o Railroad car dump hopper for coal supply to the boiler house.

2.2 Buildings

2.2.1 Design Criteria

All surface buildings would be designed for standard construction, as required by local conditions and local codes except for specific critical buildings as described under the respective headings.

The various equipment and parts incorporated at the repository will be, to the greatest extent possible, manufacturer standards and off-the-shelf items. The design for the basic movement of all matter being handled either vertically or horizontally always considered equipment that would not require an engineering effort of a first time nature.

2.2.2 Canistered Waste Handling and Receiving Facility

2.2.2.1 Building Function

The Canistered Waste Receiving Building, shown in Dwgs. 2 through 4, in all sets, and in Fig. 3, would provide the facilities

and equipment necessary to receive and handle waste canisters arriving at the repository in shielded and sealed shipping casks via railroad cars.

Depending on the fuel cycle, several of the following types of canistered waste would be received at this facility:

- o High-level waste (HLW) in solidified glass or calcined form
- o Intermediate-level transuranic waste (IL-TRU)
- o Cladding waste (CW)
- o Spent Fuel assemblies from Pressurized Water Reactors (PWR)
- o Spent Fuel assemblies from Boiling Water Reactor (BWR)

2.2.2.2 Building Description

The Canistered Waste Receiving Building is a two-story reinforced concrete structure - one story above grade and one below grade. The building is designed according to criteria specified in 10 CFR Part 50, Appendix A.

All areas where the canisters would be outside of a shielded cask have adequate biological shielding of conventional reinforced concrete. All activities in these areas (Transfer Cells, Canister Storage and Feed Room and Shaft Transfer Room) are remotely monitored and controlled.

The ground floor, shown in Dwg. 2 in all sets, contains a Railroad Car Washdown and Cask Preparation Shed, three (3) independent bays for Cask Unloading with confinement chambers, six (6) Transfer Cells plus one (1) Overpack Transfer Cell, six (6) Operating Galleries, the upper part of the Canister Storage and Feed Room, and the Electrical Equipment Room. Additional space is provided for support functions and activities associated with canister handling, including a lab, counting room (for counting surface dose rates from swabs), health physics office, security personnel checks, reception station, change rooms, briefing room, shift foreman's office, and service and maintenance area.

The basement floor, shown in Dwg. 3 in all sets, contains six (6) Transfer Galleries plus one (1) Overpack Transfer Gallery, working in tandem with the Transfer Cells above, five (5) Service Galleries in conjunction with the Transfer Galleries, the lower part of the Canister Storage and Feed Room with an adjoining Operating Gallery, a Mechanical Equipment Room containing air intake and exhaust filters plus intake fans, and a maintenance and service area.

A small sub-basement, also shown in Dwg. 3 in all sets, adjoins the Canistered Waste Shaft and contains two (2) Shaft Transfer Rooms.

2.2.2.3 Major Equipment

Major equipment items in the facility include:

A. Overhead bridge cranes:

- o Two - 10 capacity, in the Cask Preparation Shed
- o Three - 150 ton capacity, in the Cask Unloading stations
- o Seven - 10 ton capacity, in the Transfer Cells
- o Two - 25 ton capacity, in the Canister Feed Room
- o One - 5 ton capacity, in the Mechanical Room
- o Four - 25 ton capacity, at the bottom of Canistered Waste Shaft

B. Transfer Mechanisms:

- o Seven - lateral cask transfer, in the Transfer Galleries
- o Seven - lifting, in the Transfer Galleries
- o Seven - lateral canister carrier movement, in the Canister Feed Room
- o Two - canister basket movement, in the Shaft Transfer Rooms
- o Two - track closures, (removable track extension) in the Shaft Transfer Rooms

- o Four - canister basket movement, in the bottom of Canistered Waste Shaft
 - o Four - track closures, in the bottom of Canistered Waste Shaft
 - o One - overpack canister transfer and lift table, in the Overpack Gallery.
- C. Miscellaneous Equipment:
- o Six - automatic cask lid unbolting and bolting machines, in the Cask Unloading Stations
 - o Six - cask washdown showers, in the Cask Unloading Stations
 - o Twenty-one - master slave manipulators, (remote mechanism for testing, inspecting and processing the canisters) between Operating Galleries and Transfer Cells
 - o Fourteen - canister washdown mechanisms, in the Transfer Cells
 - o One - automatic overpack canister lid welding machine, in the Overpack Transfer Cell
 - o Six - cask atmosphere purging and testing machines, in the Cask Unloading Station
 - o Fourteen - canister leak testing machines, in the Transfer Cells

2.2.2.4 Detailed Sequence of Operation

The sequence of handling the canistered wastes, shown in Dwg. 5 in all sets, is described below in the form of a list of instructions to permit the reader to understand more clearly the handling process:

1. Pull in one or two railroad cars, with a single shipping cask aboard each, into the Cask Preparation and Washdown Shed. Test each car for surface contamination. If indicated, decontaminate the car by a washdown. Remove the cask tiedowns.

2. Move a railroad car through one of three confinement chambers and into one of the three Cask Unloading Stations, using a switch engine or a trackmobile.
3. Using a 150-ton overhead bridge crane, raise the cask to a vertical position on the car. Lift the cask and transfer it to a Cask Inspection Station.
4. Inspect the cask identification mark and compare it to the shipping documents for accounting purposes. Check for surface contamination and sample the cask atmosphere by purging and testing. By use of an automatic machine, unbolt the cask lid, without removing the lid itself. (All cask inspection, testing and unbolting will be done remotely or behind a shielded screen.)
 - a. If the cask surface passes the acceptance criteria, and the sampling of its atmosphere indicates no canister leak - pick up the cask by crane and lower the cask into one of the Transfer Galleries (normal route).
 - b. If the surface of the cask is contaminated (but contains no canister leaks) - wash and decontaminate the cask and continue as 4a above.
 - c. If the sampling of the cask atmosphere indicates canister leaks within the cask - move and lower the cask into the Overpack Transfer Gallery, washing the cask first if surface contamination is also indicated. (Note: If a cask with a leaking canister is located in one of the two outer Cask Unloading Bays - move this cask to the central bay first, through the interconnecting doors, since only this bay has the Overpack Transfer Gallery.)
5. Move and position the cask in the Transfer Gallery to line it up with a cask port in the Transfer Cell above. Lift the cask, utilizing a moving and lifting mechanism, until its neck engages the seal in the port above. The operations in the Transfer Galleries can be monitored

from the adjoining Service Galleries. (For handling of a cask in the Overpack Transfer Gallery see paragraph 10 below.)

6. Using a remotely controlled (from the Operating Gallery) 10-ton overhead bridge crane in the Transfer Cell, remove the cask's lid (the bolts were removed previously) and lay it down on the floor of the cell. The same crane would remove one canister at a time and place it on a testing stand.
7. Technicians working in the Operating Galleries (at the side of the Transfer Cells), besides remotely controlling the crane in the cell, would use master slave manipulators and shielded viewing windows, to test, inspect and process the canisters in the cells. Read and compare the canister identification mark with the shipping documents. Weigh and take swabs of the canisters to test for surface contamination. Read the temperature of the surface and the radioactivity level at the surface and compare them to the repository acceptance criteria. Test for canister leaks in a special test well within the cell.
 - a. If the surface of the canister passes the acceptance criteria and there are no indications of leaks or damage - lower the canister, by use of the crane, through a small port in the floor into a carrier in the Canister Storage and Feed Room (main route.)
 - b. If the surface of the canister is contaminated (but contains no leaks or physical damage) - decontaminate the canister by use of steam in a special well located within the cell, ensuring no escape of steam into the cell which might cause fogging and impairment of the operators' vision; proceed according to paragraph 7a above.
 - c. If leaks or physical damage to the canister are indicated - place the canister back into the shipping

cask, put the lid back on and move it to the Overpack Transfer Gallery in the central bay. (Note: In case of canister surface contamination or leaks (paragraph 7b and 7c above) the Transfer Cell itself should be checked for surface contamination and, if so indicated, washed down.)

8. After removal of all canisters from the cask (paragraph 7a and 7b above) - put the cask lid on, and send it back to the test stand in the Cask Unloading Station. Rebolt the lid (use the automatic machine), retest the surface of cask and if so indicated, decontaminate. (Note: All openings in the floor of the cell have removable plugs to prevent contamination of adjacent areas. The plugs will be removed and reinstalled as required by the process.)
9. Return the cask to the railroad car and place it in a shipping position (use overhead crane) and move it to the Cask Preparation and Washdown Shed. After a final test of the car (and decontamination, if needed) - tie the cask down and ship back to the source.
10. The cask in the Overpack Transfer Gallery (see paragraph 4c above) and the canisters in the Overpack Transfer Cells (paragraph 7c above) are handled similarly to the cask and the canisters in the regular Transfer Galleries and Transfer Cells respectively (paragraphs 5, 6 and 7 above), except for additional steps of overpacking a leaking or damaged canister in the following manner:
 - a. Move and raise an empty overpack canister, which is stored in the Overpack Transfer Gallery, to be flush with a sealed opening in the floor of the Overpack Transfer Cell above. Lower the damaged canister (by use of cell crane) into the overpack canister. Using a remote control welding machine, seal the lid of the overpack canister.

- b. Decontaminate the overpacked canister and all the other canisters from the cask which contained the leaking canister. Decontaminate the cell, after removing all canisters after each overpacking operation as required.
- 11. Move the processed canisters that were lowered into a tracked carrier in the Canister Storage and Feed Room (paragraph 7a above) laterally to the reach of one of the two 25-ton overhead bridge cranes. Pick up the canisters, one at a time, and nest them into a four (4) canister transport basket. If a backlog occurs, temporarily store the canisters in holes in the floor of the Canister Storage and Feed Room and plug; later on, retrieve and load the canisters into the four canister transport basket as above. The whole operation in the Canister Storage and Feed Room is remotely controlled from an adjoining operation gallery.
- 12. Lower the filled transport basket through openings in the floor into the Shaft Transfer Room, track them into a shielded cage in the Canistered Waste Shaft, and lower them to the storage level.
- 13. At the Subsurface Receiving Station, roll out the basket from the cage and, by use of overhead cranes, bring it within reach of a shielded transporter. The transporter removes two canisters, one at a time, and transports them together to a Storage Room for emplacement.
- 14. The empty basket is tracked back to the cage, brought up to the Shaft Transfer Room and then to the Canister Storage and Feed Room for further use.

2.2.3 Low-Level Waste Handling and Receiving Facility

2.2.3.1 Building Function

The Low-Level Waste Receiving Building will provide the capabilities necessary to receive and handle all low-level waste shipped

to the repository in closed cargo carriers via railroad cars containing drums on pallets; in addition, the facility will receive and handle loose drums with low-level waste produced within the confines of the repository and trucked to the facility.

In all cases the drums containing low-level waste would be standard size, 55 gal., Department of Transportation (DOT) type 17C, steel drums and would be contact handleable. The basic difference between the low-level waste operations and operations for canistered waste is that low-level wastes are not anticipated to require remote or shielded handling. For a process flow diagram see Dwg. 8 in all sets.

2.2.3.2 Building Description

The Low-Level Waste Receiving Building, shown on Dwg. 7 in all sets, is a single story reinforced concrete building divided into two parts: a high bay and a low bay. The high bay contains the Cargo Carrier Unloading and Storage Area and is of conventional construction, i.e., with no special seismic, nuclear, or quality assurance requirements.

The low bay would be designed for seismic loads but no biological shielding is required because the radiation level at the drum surface does not exceed allowable exposure levels. The low bay contains a transfer vehicle confinement chamber, a parking area for the loaded transfer car, an unloading area for the forklifts, depalletizing and repalletizing areas for the drums, personnel and vehicle confinement chambers, a Low-Level Waste Shaft confinement chamber, testing room, operating gallery, decontamination and overpack room, a counting room, health physics and foreman offices, a forklift battery charge room, electrical and mechanical equipment room (housing fans, filters, and electrical switchgear), men and women change rooms, and a controlled entry.

2.2.3.3 Major Equipment

Major equipment items in the facility are as follows:

- o One overhead bridge crane, 50 ton capacity in the Cargo Carrier Unloading Area;
- o One overhead bridge crane, 5 ton capacity in the Mechanical Room;
- o One tracked Cargo Carrier Transfer Car;
- o One forklift truck for pallet handling;
- o One clamp truck for drum handling (two trucks for Fuel Cycle I only);
- o Two forklift trucks for pallet handling at the bottom of the Low-Level Waste Shaft and in the storage room (one each);
- o One flat bed truck for underground transport of pallets.

In addition spare forklift and clamp trucks are necessary to provide uninterrupted service during maintenance and repair.

2.2.3.4 Detailed Sequence of Operation

The sequence of handling the low-level waste, shown in Dwg. 8 in all sets, is described below in the form of a list of instructions to permit the reader to understand more clearly the handling process:

1. A flat railroad car arrives with two cargo carriers (similar to "Super Tiger" Type B cargo containers) aboard at the Low-Level Waste Receiving Building Cargo Carrier Unloading Area. Each carrier contains up to 42 drums on pallets. Test the car and the exterior of the carriers for surface contamination and sample the interior of the carriers. Decontaminate, if indicated, and wash down dirt and grime from the car and the carriers. Unstrap the carriers.
2. Using a 50-ton overhead bridge crane, lift one carrier and place it on the floor of the Cargo Carrier Unloading Area for temporary storage. Check the carrier identification mark and compare it to shipping documents for accounting purposes.

3. Move the transfer car (which is self-propelled) with the carrier aboard through the confinement chamber and into a parking spot in the Pallet Unloading Area.
4. Open the end doors of the carrier and, by means of a battery operated forklift truck, remove the pallets (one at a time) from the carrier and deposit them in the Depalletizing Area of the Transfer Room.
5. Meanwhile, the transfer car with the empty carrier is sent back to the Cargo Carrier Unloading Area. The empty carrier is picked up by the crane, loaded onto the waiting railroad car and strapped down. The full carrier is then lifted from the temporary storage on the floor, and loaded on the transfer car which is moved to the Pallet Unloading Area.
6. In the depalletizing area a clamp truck removes one drum at a time from the pallet ("depalletizing") and transfers it to the Testing Room.
7. In the Testing Room the drums are identified (compared with shipping documents), weighed and tested for surface contamination and leaks. The radioactivity level at the surface is measured and compared to the repository acceptance criteria.
 - a. Drums that have sufficiently low surface contamination are taken by the clamp truck to the Repalletizing Area where they are repalletized.
 - b. Drums that have excessive surface contamination or show an indication of leaks, are moved by the clamp truck to the Decontamination and Overpack Room, where they are decontaminated (the leaking drums are first overpacked) and then moved by the clamp truck to the Repalletizing Area for repalletizing as in paragraph 7a above.

8. The reassembled pallets are moved, one at a time, by a forklift truck to the Low-Level Waste Shaft where they are lowered to the storage level. The pallets are then taken to the Storage Room and stacked two high.

2.2.4 Radwaste Management and Facilities²

Radwastes that result from the operation of a waste isolation facility would take the form of solids, liquids and particulate matter in gases. The primary sources for these radwastes include:

Solids. Combustible items such as paper, rags, plastic sheeting, protective clothing, gloves, rubber shoes, wood and filter cartridges and noncombustible materials (concrete, mortar, etc.), small discarded equipment, metal filters and metal encased HEPA filters.

Liquids. Sources of liquid radwaste would be from railroad car and cask decontamination, laboratory drains, laundry drains, shower rooms, building and equipment decontamination, personnel decontamination facilities and chemical wastes from the chemical makeup area. A potential source of liquid radwaste would be the mine water inflow. In the unlikely event that this ground water, pumped from the mine, were to become contaminated by contacting waste containers, treatment of this water could be required before it met water quality standards for liquid discharges to the environment.

Gases. Fine suspended radioactive particulate matter in vent gases, building ventilation system and gases from the incineration process.

2.2.4.1 Solid Radwaste Treatment

Solid waste from all sources would be sorted at the points of origin and segregated as follows: Noncombustible materials would be collected and packaged for eventual size reduction by

compaction and disposal in drums; combustible wastes would be burned in an incinerator with the resulting waste ash collected in drums for disposal.

The compactor system would compress noncombustible material such as residue from the incinerator or used high efficiency particulate air (HEPA) filters directly into 55-gal. drums. The compaction/drumming process can be operated remotely from the control room. The required approximate capacity of the compaction system is estimated to be 150 drums/month.

2.2.4.2 Decontamination Procedures

The decontamination of rooms, casks and equipment would be accomplished by high pressure steam with remote and manual operation for the high and low radiation levels, respectively. Local decontamination of casks can be achieved by wiping. The resulting liquid waste in each building would then be collected locally in each building in a storage tank through pipe drains. Radwaste generated at the storage level as a result of clean-up operations for an accidental spill would be collected there in drums and transported to the surface through the Low-Level Waste Shaft. A 3,000 gal. tank in a concrete vault would be located adjacent to each of the following building facilities: the Low-Level Waste Receiving Building; Canistered Waste Receiving Building; Exhaust Ventilation Building; and the Liquid Radwaste Treatment Building. These tanks would receive the locally collected liquid radwaste and, depending on measured radioactivity, would feed one of four 10,000 gal. tanks in concrete vaults located outside the Liquid Radwaste Treatment Building. The contents of these four tanks would be sampled and monitored for effluent disposal or processing through the radwaste treatment system.

2.2.4.3 Liquid Radwaste Treatment and Facilities

2.2.4.3.1 Building Description

The Liquid Radwaste Treatment Building would contain all the

tanks and equipment necessary for collecting, storing, treating, and solidifying liquid radioactive waste generated on the site. The plan for this building provides separate rooms for the concentrator, ion exchange systems, solidification systems and access for trucks to bring in empty drums and chemicals and to carry filled drums on pallets to the Low-Level Waste Receiving Building for storage processing. Space is also provided for guarded check-in of personnel, change room, wash rooms, and supervision room. Arrangement of this building is the same for all fuel cycles.

A treatment system for removing radionuclides from the groundwater, if necessary, would consist of a sampling and holding pond, an optional pretreatment process to remove hardness, a cation exchanger and an anion exchanger. The building of this system would be larger than the one described for other liquid radwaste due to the larger flow volumes that could require treatment; however, the support facilities, such as drumming station, personnel areas and truck access areas, would be similar in size.

2.2.4.3.2 Liquid Radwaste Treatment Process

A schematic flow diagram of the liquid radwaste management system is shown in Dwg. 16 in all sets. Liquid radwaste would be generated in five major areas including: the Canistered Waste Receiving Building, the Low-Level Waste Receiving Building, the Exhaust Ventilation Building with its solid waste incineration and compaction facilities, the Liquid Radwaste Treatment Building, and in the subsurface storage areas.

To minimize the need for treatment of the liquid waste, an effort would be made to separate the drainage collection system into two areas: those where contamination is certain to occur and those where the chance of contamination is only slight.

The probability of high contamination would occur in those areas where unshielded waste materials are handled or decontaminated, namely, the Canistered Waste Receiving Building, the incin-

eration and compaction facility, and various areas of the Liquid Radwaste Treatment Building. In the remaining areas, the chance of contamination of house cleaning elements is much reduced and liquids would be collected merely as suspected waste.

The waste of known contamination and the suspect waste would be collected in each area in two separate tanks and from these tanks pumped in separate double contained pipelines with leak test capability to two 10,000 gal. tanks each for contaminated and suspect waste. The contamination of the liquid would be monitored. Contaminated waste would be pumped to the concentrator feed tank. Suspect waste would be pumped in one of three paths depending on the degree of contamination: if clean, into one of two clean water holding tanks; if only mildly contaminated, to an ion exchanger; if contaminated, to the concentrator feed tank.

The clean wastes can be disposed of in several ways: either reused for decontamination, discharged into an evaporation pond, or boiled off or fog sprayed into the exhaust stack of the Exhaust Ventilation Building.

The waste to be treated would be pumped into the concentrator system where the volume would be reduced. The vapors would be condensed, and the condensate cooled and further treated in ion exchangers. The residual matter from the concentrator would be pumped to a holding tank for solidification with cement. The ion exchange effluent would be monitored in catch tanks and either pumped to the clean water tanks or recirculated through the concentrator system. The spent resin would also be treated through the concentrator system.

All tanks and condensers would be vented under negative pressure by a steam jet into a condenser; the condensate is treated as contaminated waste, and the off vapor is heated, filtered through two HEPA filters, and exhausted to the atmosphere.

The following is recommended for the liquid radwaste treatment system for this facility:

System handling capacity approximately equal to 300 gal./hr.

Concentrator system and condenser to handle 900 gal/hr. for 8 hr./day

Steam supply = 3,000 #/hr. at 50 psig

Concentrator reduction factor = 25 to 1

Concentrator feed tank = 2,500 gal/ (7'-6" Dia x 8')

Condensate tank = 2000 gal.

Concentrate Tank = 500 gal.

2 - 18" Dia. by 6.0' ion exchangers at 7.5 gpm each

2 - 300 to 350 gpm cooling tower operating from 85⁰ F to 105⁰ F, size 14'-3" x 7'-3 1/2" x 8'-3" each

4 - 10,000 gal. waste tanks (14'-0" Dia x 10' each)

2 - 10,000 gal. clean effluent receiving tank (14'-0" Dia x 10').

The liquid radwaste solidification system would use cement as a solidification agent, and the solid radwaste would be packed in DOT type 17C, closed-top, 55-gal. drums with 4-in. diameter caps.

Components of the system are: (1) cement filling station, (2) holding tank, (3) drumming station, (4) bridge crane, (5) control console, and (6) drum inspection and labeling station. The system handling capacity would be about 12 gal./hr.

In operation, cement brought to the site would be unloaded into the cement storage silo. The silo and drum loading system would be a closed, dust-free system with its own bag-type dust collector. Empty drums from storage would be transported on a roller conveyor to the filling location. The radwaste material, in the form of a slurry, would be piped in double contained pipes with leak test capability to the holding tank where the liquids and solids would be properly proportioned for mixing with the cement. After the operator determines the proper mix, an automatic cycle would be started that would uncap the drum, then fill, mix, and recap it. This would be done on the safe side of the shielding wall.

The drum would then be moved by crane to the inspection station where it would be weighed and the radiation level measured prior to being transported to the Low-Level Waste Receiving Building.

2.2.4.3.3 Groundwater Treatment Process

Water pumped from the mine would be held in a surface pond and sampled for radioactivity. This holding pond would be equal in size to about four to six daily flow volumes. In the event the activity concentration in the water was above applicable water quality standards the water would pass through the treatment system. The first stage would be an optional pretreatment process to remove hardness in the form of Ca and Mg ions if they existed in sufficient quantities to hinder the operation of the ion exchange beds. The next two stages consist of cation and anion exchange beds which remove the radionuclides from the water. One stage of each type of ion exchange bed would be sufficient to obtain the recommended decontamination factor of 1×10^2 . A detailed description of the need for an operation of this system, up to the ion exchanger stages, can be found in Y/OWI/TM-36/21, Ground Water Movement and Nuclide Transport.

The remainder of the system would consist of a liquid solidification process and a drumming station similar to that described in Section 2.2.4.3.2 for the treatment of other liquid radwastes.

2.2.4.4 Gaseous Waste Treatment

Each of the four critical buildings, the Low-Level Waste Receiving Building, Canister Waste Receiving Building, the Liquid Radwaste Treatment Building, and the Exhaust Ventilation Building, has a separate vent system filtered by a multistage filtering system. The type of filters and their characteristics are determined by the potential radioactive content of the circulation route. Operation of the system would be within its specified operational limits of flow, pressure drop and other parameters at all times. The air would pass through three stages - pretreatment, prefiltration and high efficiency filtration - before being exhausted.

All exhaust air would pass through prefilters before it passes through the high efficiency filters. The prefiltration would remove large concentrations of particles (1 micron) and thus protect the more efficient, and therefore more easily plugged, HEPA filters downstream. The prefilters would be constructed of panels of vertically pleated fiberglass and encased in rigid cases similar to the HEPA filters described below. When dust loaded, the entire unit would be removed and replaced.

High efficiency filtration will be done with HEPA filters having an efficiency of 99.9% for 0.3 micron particles when tested with a monodispersed 0.3 micron thermally-generated, diotyle phthalate (DOP) aerosol. The maximum clean filter pressure drop would be 1.0 in. of water at rated flow capacity.

The filter would have a core of continuous web fiberglass pleated with aluminum separators; the rigid frame would be of corrosion resistant steel. All exhaust effluents would be passed through two HEPA filters in series before being released to the atmosphere. Used HEPA filters would be compacted and disposed of as noncombustible solid waste.

Testing would be done in-place, and the design includes ports for injection of testing agents and for extraction of samples. The design also includes access for testing personnel with radiation shielding, lighting and life support systems to adequately protect personnel and expedite the work. Individual testing of multiple filters in close proximity would be accomplished by built-in or temporary bypass ducts and shrouds.

The system with two HEPA filters in series would have a total decontamination factor (DF) of 1×10^6 . This would be verified by DOP or Freon Testing in accordance with ANSI N510.

2.2.4.5 Control of Radwaste Systems

The atmosphere in all rooms of the Liquid Radwaste Treatment Building would be monitored on a continuous basis. Substances to be monitored include alpha- and beta- emitting particulates and beta- emitting gases. Three ambient gamma-monitors with two of three alarm logics are assumed to be in operation at all times

in each room. This provides maximum monitoring, with assurances against false alarms. The incineration and compaction room of the Exhaust Ventilation Building has a similar system. In each of the two waste receiving buildings, duplicate beta- particulate and beta- gas monitors analyze the vent discharge air downstream of the filters at all times. Liquid waste in the storage tanks would be continuously monitored with gamma- and alpha- sensitive liquid monitors.

All controls for operation of the radwaste treatment systems are located in a control room with secured separate outside access. This control room is assumed to have an independent HVAC system. The entire system is designed to be equipped with a closed loop video system to provide the operator with views of all rooms and operations in the building. All remote handling and automatic cycling originates in the control room. Alphanumeric and graphic displays of all data from the radiation monitors are provided to the operator as well as transmitted to the central control station.

2.2.5 Exhaust Ventilation Building

Plans and sections of the Exhaust Ventilation Building are shown in Dwgs. 10, 11, and 12 in all sets.

The building will house the exhaust fans and filters required for the continuous filtering of the exhaust air from the canistered waste placement operations in the storage rooms as well as the exhaust fans associated with the mining and drilling (or trenching) operations. In addition, space is provided for incineration and/or compaction of site-generated solid radwaste.

Exhaust air from the filters would be discharged through a 100 ft. high stack. Handling of filters and fans would be accomplished by two overhead bridge cranes.

2.2.6 Supply Ventilation Building

This building will house the fans that supply ambient air for the mining and placing operations, heating coils for possible preheating of the mine supply air and filters for the intake air.

A layout of this building is shown for each respective cycle in Dwg. 14 in all sets.

2.2.7 Boiler and Refrigeration Building

The steam generating equipment and the refrigeration equipment will be housed in separate sections of the building. The boiler plant will be complete with coal-fired stoker furnaces, boilers, coal storage handling and weighing system, condensate handling, water treatment and feedwater systems, and effluent treatment systems.

Furnace flue gases will pass through a dust collector and a scrubber prior to discharge through the boiler stack to meet EPA regulations on dust and gaseous pollutant emissions. Ash from the dust collector and the stokers will be collected in the ash storage bin before final disposal.

The refrigeration plant includes water chillers, chilled water and condenser water pumps, cooling towers, chemical water treatment systems, and local motor control center area. Heating and ventilation are provided for the refrigeration plant to meet minimum summer and winter design conditions.

2.2.8 Central Site Control and Switchgear Building

This building will house the following facilities:

- o A central control room for remotely controlling and monitoring the ventilation equipment in the Exhaust and Supply Ventilation Buildings, monitoring all security instrumentation and monitoring radiological readouts for all critical areas.
- o A communication room
- o A guard room
- o A mechanical room for services for this building
- o A switchgear room for control of the equipment in the Exhaust and Supply Ventilation Buildings

- o A garage for security personnel use
- o Ancillary facilities such as offices, lounge, conference rooms, locker and shower rooms

The arrangement of this building is the same for all cycles.

2.2.9 Men and Material Building

This building provides separate personnel facilities such as locker rooms and showers for the mining crews and the placing crews, as well as briefing rooms, check-in, and control facilities. It will also provide covered access to the Men and Material Shaft Headhouse for personnel, equipment and materials.

2.2.10 Mine Operations Building

Adjacent to the Men and Material Building, a Mine Operations Building will be provided for use of the mining contractor.

2.2.11 Main Substation

The main power substation will be an outdoor installation (without shelter surrounding it).

2.2.12 Emergency Generator Building

This building will house the diesel turbine-driven emergency generators.

2.2.13 Diesel Fuel Tanks

Diesel fuel for the diesel driven emergency generators and the mining and placing operations will be stored in three below grade 15,000 gal. capacity storage tanks. A pump system will fill the day tank for the diesel turbines of the emergency generators. Fuel oil for the mining and placing operation will be lowered to the mine level either in drums or tanks on the men and material hoist.

2.2.14 Storage Building

This building will provide intermediate storage between the warehouse located outside the isolation fencing and short-term requirements of the plant operations. It is accessible by truck and railroad for shipments from outside.

2.2.15 Cafeteria

The cafeteria will be located within the high security area to obviate security checks of the personnel during lunch breaks. The cafeteria will be serviced by a local caterer and will operate for each shift.

2.2.16 Laundry

The laundry building will be equipped to clean work clothes of the mining personnel and personnel other than those engaged in areas where radiological contamination may occur, such as the Canistered Receiving Waste Building, the Low-Level Waste Receiving Building, and the plating operations. The clothing for these personnel will be of the disposable type and will be incinerated for emplacement as low level waste.

2.2.17 Fire House

The fire house will be equipped with pumpers and other fire fighting equipment.

2.2.18 Water Tank

An elevated water tank will provide storage of approximately 150,000 gal. capacity for fire fighting emergencies.

2.2.19 Guardhouses

A guardhouse is located at the entrance for personnel and motor vehicles. It will provide all facilities for checking, controlling, and monitoring all personnel, cars, and trucks entering the high security area. It will also contain an alarm and com-

munications system integrated with the security system of the central site control building.

A second guardhouse at the entrance of the railroad tracks would serve to monitor and control all railroad traffic into and out of the high security area.

2.2.20 Administration Building

The administration building, located outside the high security area, will house all administrative operations for the repository such as accounting, auditing, computer, contracts, insurance, mail-room, payrolls, and purchasing.

2.2.21 Warehouse and Maintenance Building

Materials will be received at the warehouse and maintenance building, also located outside the high security area, thereby allowing deliveries by truck or rail to enter and leave without elaborate security checks. Material required inside the high security area will be removed from its packaging as far as possible, checked and forwarded to the storage building inside. All refuse, cartons, or other packaging material will thus remain outside and can be disposed of through ordinary means. The maintenance building would be equipped with tools and machines for minor repairs and maintenance. Major repairs are expected to be performed by outside contractors.

2.2.22 Clinic

The clinic is located outside the high security area to permit outside ambulance service to operate without delay caused by security checking. First aid and emergency treatment will be performed in the clinic.

2.3 Major Parking Area

This area is also located outside the high security area to avoid having to check every car. It will have sufficient parking space for personnel for two shifts.

2.4 Railroads

The railroad track work is arranged so that nuclear waste material handling, excavated material disposal, and coal handling will be separated in their respective areas to minimize security checking of equipment and personnel. The design of the track work serves the following purposes:

- o Receipt of nuclear waste shipments, transfer to the Canistered Waste and Low-Level Waste Receiving Buildings and return of empty casks and shipping containers: Sufficient trackage is provided within the high security area for two days of shipments and outside this area for ten days of shipments. Transfer from over-the-road locomotive to plant switch engine is assumed to take place at the guarded entrance.
- o Receipt of shipments for warehouse and mine operations: Trackage is provided so that these shipments can be moved directly to a warehouse located outside the high security area without take-over by plant engines, or into the high security area by transfer to plant engines in a manner similar to the handling of nuclear waste shipments.
- o Disposal of excavated material: A railroad loop outside the high security area allows over-the-road locomotives to bring in trains of empty cars to the loading station and remove loaded trains to an offsite disposal area.
- o Receipt of coal shipments: A track parallel to the excavated material loop allows receipt of coal for the boiler plant.

All repairs to over-the-road railroad equipment will be performed by the carrier. Minor repairs to yard equipment will be performed on-site. Major repairs will be assigned to outside contractors.

2.5 Materials and Supplies - Receiving and Handling

Materials and supplies are assumed to be received either by railroad or trucks at the warehouse located outside the high security area where they may be stored, uncrated, and checked. They are then to be taken to the storage building inside the high security area by on-site trucks, as required. Alternatively, materials and supplies can be brought directly to the storage building and yard storage inside the high security area by truck or rail if appropriate security procedures are followed.

2. REFERENCES

1. Office of Waste Isolation/Union Carbide Corporation, Nuclear Division, Drawings for Repository Preconceptual Design Studies: Basalt, Y/OWI/TM-36/15, Oak Ridge, Tennessee, April 1978.
2. _____, Nuclear Considerations for Repository Design, Y/OWI/TM-36/21, Oak Ridge, Tennessee, April 1978. Section 5.0.

3.0 UTILITIES

3.1 Domestic Water

Potable water for the facility would be supplied to the site from two sources to minimize the chance of supply interruption. A storage tank would provide emergency water reserves on site.

3.2 Electric Power

3.2.1 Power Sources

The primary source of electric power for the facility is assumed to be from overhead medium voltage lines of a local electric utility company. It is expected that the facility total demand load would vary between 20 and 30 MVA depending on the fuel cycle (See Table 3-1). In the event of complete failure of the primary source, electric power would be supplied to critical equipment and loads by a secondary power source consisting of an on-site limited capacity generating plant. This generating plant would provide alternate power by diesel electric generators having their own fuel supply. During the interim period between loss of primary power and the availability of secondary power, uninterrupted power supply would be provided by motor generator sets with flywheel or battery powered converter-inverter systems.

3.2.2 Primary Electric Power

The primary electric power is assumed to be purchased from the utility company at a locally available medium voltage from 23,000 to 69,000 volts and transformed down to a distribution voltage of 13,800 volts. Primary power would supply interior and exterior lighting, ventilation equipment for mining and nuclear waste placement operations, surface waste handling and support facilities, motorized equipment for surface building HVAC requirements, radiation monitoring instrumentation, telephone and radio communications

systems, security and surveillance systems and alarms including closed circuit television, hoists, mining operations and conveyors, repository waste placement operations and maintenance and repair of equipment.

3.2.3 Electric Services

Two electric services would be provided, each normally supplying half of the total facility load as shown in Dwg. 20 in all sets. Each service voltage would be transformed to the distribution voltage by a dual rated transformer located in the main substation as shown in Dwg. 21 in all sets. Appropriate interconnecting high voltage switching would permit connection of both transformers to a remaining service in the event of failure of one of the services. Each of the main service transformers would be provided with sufficient redundant capacity through forced air cooling to permit supplying up to 93% of the facility load through one transformer.

3.2.4 Distribution

Each main service transformer secondary winding would connect to a sectionalized 15 KV switchgear bus through a main secondary power air circuit breaker. The sectionalized bus would be interconnected by a bus tie circuit breaker.

Several 15 KV feeders would connect to the sectionalized bus and supply various loads throughout the facility at a nominal voltage of 13,800 volts. Essential loads such as waste processing buildings and mine ventilation would be supplied by dual feeders terminating in double ended load centers. Other loads would be supplied by single feeders. Each of the dual feeders would have sufficient capacity to supply the total load of a double ended load center in the event of failure of one of the feeders. Similarly, transformers and primary and secondary circuit breakers of double ended load centers would have redundant capacity to supply the total load-center load.

3.2.5 Utilization Voltages

Utilization voltages would be 4,160 volts, 480 volts, 277 volts, and 120 volts. Motors rated at 450 hp and larger would be energized at 4,160 volts. Motors rated at 1/2 hp to 400 hp would be supplied at 480 volts. Building fluorescent lighting would generally be supplied at 277 volts. Incandescent lighting and convenience receptacles would be fed at 120 volts. Outdoor perimeter security lighting would be on a series 6.6-ampere circuit as would be the roadway lighting. Security lighting would be on an emergency circuit.

3.2.6 Underground Distribution

All wiring between origin and destination of different buildings is designed to be installed in underground conduits and man-holes. Three separate conduit systems would be used. One system would contain wiring for telephone communications, security and alarm wiring, fire alarm wiring and CCTV wiring and cables. The second system would contain power and control wiring originating at the emergency electric power generating plant. The third system would contain power, lighting and control wiring of the normal primary power source supply and distribution. Power to the mine for mining and placement operations would be supplied by exposed insulated 13.8 KV cables installed in the utility compartment of the Men & Material Shaft. In the mine, exposed insulated cables be suitably attached to the wall and, through skid-mounted mining-type power centers at predetermined locations, would supply power to mining equipment as well as placement, service, and repair equipment.

3.3 Sanitary Waste Disposal

The sanitary waste treatment and disposal system would collect and dispose of all non-contaminated waste and sewerage from the surface facilities in an on-site treatment system. (Refer to Section 2.2.4 for discussion of contaminated waste treatment).

3.4 Fuels

Coal and diesel oil would be the only fuels stored on the site. Coal would be used for the steam boilers and oil would be used for diesel operated trucks and for emergency electric power generators.

Daily diesel oil requirements for underground activities would be transported in approved portable tanks. The emergency diesel electric generators would have an oil supply that is separate from all other uses.

3.5 Steam

Steam at 200 PSIG is assumed to be generated by four coal burning boilers. Each boiler would have a capacity of 50,000 lbs./hr. for a total capacity of 200,000 lbs./hr. Steam would be routed through the utility tunnels to each building or area where service is required. At each building the steam pressure would be reduced to low pressure (under 15 PSIG) or as required for process service.

The steam is used for three major purposes: General Building Heating (35%); Process Usage (45%); and Underground Ventilation Supply Air Tempering (20%).

3.6 Refrigeration Plant

Five steam-driven chilled water refrigeration machines, with a capacity of 250 tons each, would serve the facility. Four refrigeration machines would operate and one chiller would serve as a standby. The machines would be either of the steam drive absorption type or the steam drive turbine open centrifugal type.

The refrigerant condensing water would be cooled by water towers. The chilled water would be routed to the various buildings through the utility tunnel.

3.7 Emergency Utility System

3.7.1 On-Site Power Generation

In the event of the failure of both primary electric services, on-site power generating capacity, as shown in Dwg. 21 in all sets,

would be provided to supply the requirements of essential loads. This includes power for: limited mine ventilation while evacuating mine personnel, radiation monitoring instruments, communications and security systems, maintaining essential underground and surface facility processes, fire alarm and protection systems and the Men and Material (M&M) hoist system serving the men working below ground.

Three or four units, each rated at 1000 KW, 1250 KVA, 0.8 power factor, would be provided depending on the ultimate requirements for essential load. Each of the several units would have the capability of being connected to one of two distribution busses. One bus would be exclusively connected to the M&M hoist during an emergency. The other bus would connect to the remaining essential emergency load. Once a generating unit is preselected and connected to the exclusive M&M hoist bus the other units would be permitted, though appropriate interlocks, to be connected only to the other bus serving the remaining essential load. One of the units would be a reserve unit in the event any other of the preselected units fails to start upon command.

3.7.2 Uninterruptable Power Supply

During the interim between the failure of the primary power source and the availability of the secondary generator power source there are currently only two requirements anticipated for uninterrupted power at the repository. The first is for sufficient lighting to aid personnel to exit from structures and for operating personnel to start alternate power equipment if manual starting is required. The second requirement is for sufficient power to maintain the continuity of operation of radiation monitoring equipment, communications, security operations, central control station, guard house operations and control instrumentation among all of the principal facilities of the repository.

Essential and critical equipment that requires power continuity would be supported by localized uninterruptable power supplies consisting of a rectifier, battery and inverter. Complete lighting

blackout would be precluded by the installation of self-contained battery powered emergency lighting units which would provide sufficient lighting for orderly egress from structures.

3.8 Communications

Normal communications between or within the various areas of the repository, both surface and subsurface facilities, are assumed to use commercial telephone lines. In addition, each guard or watchman on duty would have the capability of maintaining continuous communications with an individual in a continuously manned central alarm station. The secondary alarm station would be located at the guard house adjacent to the personnel portal. The primary communication link between a roving guard and the central and secondary alarm stations would be by dual-channel walkie-talkie. A secondary guard communication link would be by strategically located telephones with exclusive guard access and connected to the central alarm station by dedicated lines. This secondary link would serve a two-fold purpose as it would complement procedures for frequent status reporting and serve indirectly as a duress alarm to verify the safety of patrolling personnel.

The central alarm station would have the capability of calling for assistance from other guards or by prior arrangement from the local law enforcement authorities. Two-way radio and conventional telephone service would be provided for this capability. All communications equipment would remain operable after loss of primary power by automatically switching to an uninterruptable supply and then to the on-site alternate generator system.

4.0 MINE-OPERATING AND WASTE-RECEIVING SHAFTS IN BASALT

4.1 General Description

In these designs, five distinct shaft structures would be sunk using conventional techniques. These are the Canistered Waste Shaft, the Low-Level Waste Shaft, the Men and Material (M&M) Shaft, the Ventilation Supply Shaft, and the Ventilation Exhaust Shaft. The orientation of the shafts as well as their basic characteristics, such as size, method of construction and design, varies according to their purpose and the influence of constraints upon the mine and shaft network construction schedule. The shaft construction schedule is given in Dwg. 37 in all sets. Shaft descriptions for these repository designs are shown in Table 4-1.

4.2 Shaft Descriptions

All five shafts are to be excavated using conventional drill and blast techniques. Basic shaft information is presented in Table 4-2.

4.2.1 Canistered Waste Shaft

The Canistered Waste Shaft is designed to provide a means for transporting canisters from the Canistered Waste Receiving Building at the surface to the subterranean storage levels. This shaft has an inside diameter of 14 ft. and is lined with a minimum of one ft. of concrete except where aquifers are encountered. At such interfaces extra measures such as steel liners and grout would be used to control water inflow. The top of the shaft forms an integral part of the Canistered Waste Receiving Building. Both the surface and subsurface areas associated with this shaft and the shaft itself are divided by a wall to provide two identical but independent means of transporting canistered waste. The waste is lowered in the shaft with a Canistered Waste Cage. The Canistered Waste Shaft is shown in Dwg. 39 in all sets.

In a repository for reprocessed waste (Cycles I and III), the Canistered Waste Shaft would provide access to the intermediate and cladding waste storage area at one elevation and to the high-level waste storage area at another elevation. From shielded receiving stations at these two elevations, the canisters may be transferred to shielded transporter vehicles for transport to the storage sites. The loading and unloading of the waste canisters into and from the Canistered Waste Cage used in the Canistered Waste Shaft would be handled by remote control.

In a SURF (Cycle II) repository, the shaft would provide access to the PWR fuel assembly storage area at one elevation and to the BWR fuel assembly storage area at a lower elevation. Receiving stations and handling operations at each of these levels are anticipated to be similar to those for HLW in the reprocessed waste repository.

The desirability of using a shielded cage for moving the canistered waste between the surface and the subsurface facilities is problematical. Although a shielded cage would permit easier access in case of accidental derailment of the cage within the shaft, the shielding would increase the cage weight substantially. However, the total lifting load is considered to be within existing mine practice. In contrast, the alternative to a shielded cage would be to use an unshielded cage and provide for a means whereby a disabled cage could be assisted either by remote operation from one of the shaft entrances or by personnel using a specially designed shielded repair cage. These remote handling devices and special repair vehicles are unique; they would require research and development and involve a continuous modification program based on accident experience, whereas the shielded canister cage would not. The Canistered Waste Cage is shown in Dwg. 40 in all sets and the Canistered Waste Safety Mechanism is shown in Dwg. 41 in all sets.

4.2.2 Low-Level Waste Shaft

The Low-Level Waste Shaft would provide a means for transporting low-level waste pallets from the low-level waste surface facility to the low-level waste subterranean storage area. This shaft has an inside diameter of 10 ft. and is lined with a minimum of one ft. of concrete except in aquifer strata where extra measures will be incorporated, such as steel liners, grout, etc. (See Dwg. 42 in all sets).

4.2.3 Men and Material (M&M) Shaft

A Men and Material Shaft would handle mine and storage personnel and mined material removal. The shaft is designed to satisfy three requirements:

1. Provide access for personnel and equipment into and out of the subterranean storage areas.
2. Provide excavated material hoisting for the mining operation.
3. Serve as a utility access shaft and manway for emergency exit by all personnel.

To meet these requirements the M&M shaft is divided into three main compartments (personnel and equipment cage, excavated material hoisting skips, and a manway and utility access space) and two auxiliary compartments for skip counterweights. The shaft has an inside diameter of 27 ft. and a minimum of one ft. thick concrete liner except in water bearing strata where extra measures described above would be incorporated.

The personnel and equipment compartment for the shaft is designed to be sufficiently large to accommodate a double-deck cage with a capacity for 140 men. The mining and waste placement crews

would use different levels of this cage so that the task crews remain separated. The compartment also is large enough to permit the lowering and raising of large pieces of equipment either in assembled or partly disassembled form. The M&M Shaft is shown in Dwg. 38 in all sets.

4.2.4 Ventilation Supply Shaft

Ventilation air for the subterranean area would be received through this shaft. (See Dwg. 43 in all sets). Prior to receipt, the air is anticipated to be processed in conformance with air quality and temperature requirements. The shaft, as designed, is lined with a one ft. minimum layer of concrete. Ventilation Supply Shaft dimensions are given in Table 4-1.

4.2.5 Ventilation Exhaust Shaft

Ventilation air from the underground areas would be exhausted through this shaft into filtration systems located on the surface. The shaft is assumed to be concrete lined and divided so that mine and placement exhaust air can be processed separately if there is no evidence of contamination. Inside diameters of the exhaust shafts for various repository designs are shown in Table 4-1. The ventilation exhaust shaft is shown in Dwg. 44 in all sets.

4.3 Conventional Shaft Sinking Techniques¹

Once the construction contract has been awarded and clearing of the construction site has been completed, mobilization of the shaft sinking Contractor's equipment can begin.

In conventionally excavated shafts, the bottom of each shaft is advanced using the benching method. In this method, hand-held drills are used to drill holes over one half of the shaft area. The holes are loaded with explosives and the rock blasted. Alternative halves of the shaft are drilled and blasted to advance the entire shaft bottom.

The broken rock is then cleaned from the bottom using a cactus-grab mucker dumping into buckets. These buckets are hoisted to the surface and dumped at the headframe into a bin. On the surface, the broken rock is transported by truck from the headframe bin to a rock disposal area.

Depending upon the stability of the shaft walls, 40 ft. to 60 ft. of shaft would be advanced before lining with concrete. Concrete would be mixed on the surface and lowered to a receiving hopper on the sinking stage. From the receiving hopper, the concrete would be distributed to liner forms through large diameter hoses.

Once the shaft has been excavated to its final depth, the sinking stage would be modified to permit its use as an equipping stage during installation of the permanent shaft equipment.

Once the modification has been completed, the stage would be hoisted to the surface to begin shaft equipping. At this time, any water leaks in the lining would be grouted. This procedure, called drywalling, would reduce any water flows to an acceptable level.

Shaft equipping consists of installing the permanent shaft equipment such as the horizontal buntons, vertical guides, manways, brattice walls, electric cables, and pipelines. In order to align the shaft structural steel, plumb lines, fixed top and bottom, would be installed in the shaft. Upon completion of shaft equipping, the stage would be dismantled and hoisted to the surface. By this time the permanent hoists would have been installed, roped up and the permanent shaft conveyances installed. A description of the hoisting system is given in Appendix A.

The shaft would then be ready to begin operating for its intended purposes.

4.4 Lining

In the excavated shafts, the 12-inch thick lining consists of 3,500 psi poured-in-place concrete. Any water seeping through

this lining would be collected in water rings and directed through vertical piping to the shaft bottom. During sinking, this water would be handled with the sinking buckets. Once the shafts are completed, this water can be directed to the main pumps and pumped to the surface.

4.5 Water Control Techniques

Geological investigations indicate that although the rock strata above the basalt are not completely dry, there is not sufficient water to hamper shaft sinking. Consequently, the need for water control techniques such as grouting is minimal.

The sand and gravel overburden is reported as being water-bearing and will require treatment prior to excavating the shaft collars.

4.6 Lateral Development From Shafts

Some lateral development from each shaft is required at the repository level. This work would be completed either during shaft sinking or following sinking of a particular shaft. This lateral development is listed in Table 4-3.

4. REFERENCES

1. Office of Waste Isolation/Union Carbide Corporation, Nuclear Division, Facility Construction Feasibility and Costs by Rock Type, Y/OWI/TM-36/18, Oak Ridge, Tennessee, April 1978. Section 4.4.2.1.

5.0 MINING AND WASTE PLACEMENT OPERATIONS IN BASALT¹

5.1 Design Criteria

The Mine Master Plans for the repository designs in basalt for the 5-year retrievable cases in Cycles I, II, and III and the 25-year retrievable case in Cycle II are shown in Dwg. 25 in all sets. The following criteria were considered in the formulation of the Mine Master Plans:

- o The size of the room opening must be compatible with both the mining equipment to be used in order to avoid the use of special machinery as well as with the proposed waste placement scheme. Room sizes must also be designed with consideration of clearance requirements of the waste transporter.
- o The pillar size must ensure adequate heat dissipation into the geologic medium and must also ensure overall mine stability.
- o The mining schedule must make storage rooms available for waste placement by early 1985. This requirement includes excavation of the rooms, ventilation drifts and the panel backfill drift access. It also requires that sufficient trenching or drilling of holes and installation of canister sleeves be completed. Subsequent storage rooms must be completed in time to permit receipt of incoming waste.
- o Mining and waste placement operations must be kept separate from each other for reasons of safety. This necessitates allowing entries for waste placement that are isolated from those used for mining and the sequencing of each of the operations to avoid crossovers.
- o The total repository area must approximate 2000 acres. (See Section 2.1)

- o Shaft location is confined to a central area for reasons of security. Also, the shafts have been located in the same relative position for each cycle, thereby allowing use of similar surface layouts.

5.2 Mine Layouts

Figure 5 shows the room sizes employed for all repository designs in Cycle I, II, and III 5-year retrievability and Cycle II 25-year retrievability studied and the pillar sizes and extraction ratios required to ensure mine stability. It should be noted that because of the heat concentration of the HLW canisters, a 54 ft. pillar is required, whereas only a 27 ft. pillar is required for all other waste types. The indicated room heights of 20ft. and 25 ft. can easily accomodate the waste transporter which measures 16 ft. high in Cycles I and III and 19 ft. high in Cycle II.

In all mine layouts three development entries or main corridors are needed. These main corridors, are designed to be 30 ft. wide by 25 ft. high in all cycles. Note that in Cycles I and III the main corridor height exceeds the room height. This additional corridor height is necessary to reduce air velocities to acceptable levels. The first corridor (known as the placement or transporter corridor) is used for the waste placement activity and supplies fresh air for the placement operation. The center corridor (M & M corridor) serves as a travelway for mining equipment, trucks and personnel, in addition to carrying fresh air for their operation. The third corridor is used solely to carry exhaust air from the mining operation. (The placement exhaust air is carried through the perimeter exhaust system). All main corridors are separated by 30 ft. pillars.

A fourth corridor located some 70 ft. below the main corridor system would be mined to accommodate a train haulage line. This rail system would be used to collect and transport broken rock to a centrally located crusher and storage bin. (See Dwgs. 27, 29, and 30 in all sets.) The corridor will measure 13 ft. by 11

ft. in all 5-year retrievable cases and may be used to carry mining ventilation supply air during the peak ventilation demand if the velocity in the Man & Material Main Corridor proves excessive. In the 25-year retrievable case, where the peak ventilation requirements are larger (Table 6-2), the train haulage drift would be utilized to carry up to 250,000 cfm of the ventilation supply air. To restrict this flow to acceptable velocities, the train drift has been increased to 23 ft. by 11 ft. (See Section 6.3)

Storage rooms have been grouped to form a panel. Access to storage rooms in a given panel is through a branch corridor, perpendicular to the main corridor. The dimensions of the storage rooms are shown in Table 5-1. This layout permits flexibility and provides a number of working faces for the mining crew, allowing them to achieve maximum productivity. Rooms and corridors will have one percent slope to facilitate drainage. (See Dwgs. 45 and 46 in all sets.) Smaller panels are anticipated to be developed in the earlier years for two reasons: to allow development panels to be completed in time for initial waste placements, and to match room development to canister receiving. Initial panels will have rooms of length 280 ft. while rooms mined later on will measure 560 ft. The ends of each room are interconnected to a 20 ft. wide by 20 ft. high exhaust air corridor. These corridors are parallel to the branch corridors and connect to placement exhaust corridors located on the perimeter of the repository. Since these latter corridors feed to the placement exhaust compartment of the upcast air shaft they are designed to keep the exhaust air from the storage areas separate from the mining exhaust air.

A corridor located around the perimeter of the repository is provided in all 5-year retrievable cases for the backfilling process. (See Section 5.10)

The area allocated to each waste type is related to the waste receiving schedule, the heat content per canister and the allowable heat loading of the rock. (See Table 5-2)

A summary of the approximate area occupied by each waste type and general information from each cycle is given in Table 5-1. The date given indicates the last full year of waste that can be accommodated according to the waste receiving schedules given in Tables 5-4 through 5-9.

5.3 Mining Operations

In basalt, conventional drilling and blasting techniques would be used to mine all corridors, rooms, service areas and ventilation corridors. A mining "cycle" for a production "unit" in basalt would consist of drilling the drift face, loading the holes with explosives, blasting, and after allowing time for fumes to clear, muck removal. The drilling would be performed by three-boom jumbos equipped with electric hydraulic drills. The drilling crew would drill between 60 and 90, two inch diameter holes per face, depending on the size of each face. The hole length would be 11 ft. which would allow breaking of 10 ft. of ground. When the drilling of a face is completed, the drill crew would move to a second face and commence work while preparations for blasting are being made at the first face.

At the first face drilled, a blasting crew would load the holes with a round of explosives. At some designated time, the round would be blasted. While the fumes clear, the blasting crew would move on to another face that already has been drilled.

After the fumes have cleared, a mucking crew would begin removing the blasted rock. The mucking crew would employ a rubber-tired front-end loader equipped with a 6-yard rock bucket to load the broken rock into 35 ton or 22 yard dump-trucks before moving on to another blasted face.

Following the removal of the blasted rock, a fourth crew may be required for bolting and scaling. The bolting crew would use a mobile bolting platform to install rock bolts on the roof and in walls in a 4 ft. by 4 ft. pattern. Crews to install pipe lines and ventilation tubing, and to maintain the roadways will then follow the rock bolting crew. Upon finishing its task each crew would move on to another face, thereby allowing advances on a total of six faces. This process of multiple heading advance would only be applied during the full mining stages.

Advances for the openings encountered are approximately as follows: 41 ft./day for all waste rooms; 18 ft./day for all corridors; 24 ft./day for all ventilation corridors; and 42 ft./day for all trenches. All indicated advance rates are based on a 3-shift day.

The time interval required to mine a panel and the time interval in which a panel will receive waste can be approximated by referring to Dwgs. 23 and 24 in all sets. An approximate time interval between the end of the mining of a panel and the beginning of placement in the same panel can also be ascertained from Dwgs. 23 and 24 in all sets. Note that simultaneous mining and placing in a panel is never permitted.

The sequence of panel mining is indicated by the circled numbers in the Mine Master Plan. This sequences assure that no cross-over exists between the mining and placing activities.

5.4 Initial Development

An assumption of five years between the start of construction of the first shaft and the receiving of the first shipment of waste has been made for design purposes. All shafts are sunk simultaneously and have the relative positions given in Dwg. 26 in all sets and the diameters given in Table 4-1. The shaft sinking process would take approximately three years, leaving only two years remaining for the initial development. The shaft construction schedule for Cycles I, II, and III 5-year retrievable and Cycle II, 25-year retrievable is given in Dwg. 37 in all sets.

During the two year period following shaft construction, a number of operations must be completed. These include: interconnecting all of the shafts; developing a service area for the assembly, maintenance and repair of mining equipment; and excavating a ventilation circuit. In addition, a material handling system consisting of a rail haulage level 70 ft. below the main corridor levels, a crusher station, 3000-ton storage bins and interconnecting conveyor belt to the shaft loading pockets must be installed. Last, at least one panel in each of the waste type areas would be mined and ready to receive the incoming waste units by the beginning of 1985.

The mining of these areas would proceed as follows. Two crews would start development from the Men and Material Shaft. One crew, starting on the 1970 ft. level, which is the rail haulage level,

would develop a rail haulage system and then would excavate a crusher station, a surge bin, and a conveyor gallery from the surge bin to the skip loading pockets. All of the equipment --such as rail, locomotive, chutes, feeders, crusher, and belt conveyors -- would be installed once the openings have been excavated. The second crew would start development on the 1900 ft. level. Its objective is to connect the M&M shaft to the fresh air shaft and thus provide an initial ventilation circuit. Once these shafts have been connected, a third crew would be added. This crew will also start development on the 1900 ft. level. The two crews on the 1900 ft. level would interconnect all five shafts and thus complete the return ventilation circuit. All of the broken muck from this phase of development would be transported to the M&M Shaft and dumped through a grizzly into the loading pockets, where it would be loaded into the skips and hoisted to the surface. After the shafts have been interconnected and ventilation circuits established, mining of the panels can commence. One crew would initially be assigned to mine each of the waste panels for a total of three crews. By this time the crushing, conveying, and rail haulage systems should be operational and full scale mining can begin.

5.5 Excavation of Ventilation Drifts, Storage Rooms and Corridors

The mining of the drifts associated with the ventilation circuit, storage rooms and corridors would proceed using the drilling and blasting sequence described in the Mining Operations section. The broken rock is loaded into off-highway trucks and, in the case of mining the rooms, is sent down the branch corridor toward the main corridor system. A grizzly located at the end of the branch corridor, just off to the side of the main corridor, would reduce the size of the material by use of a hydraulic breaker. All the broken rock passing through the grizzly would be dropped through a vertical opening excavated in the rock, to a control chute. (See Dwg. 30 in all sets.) In the case of corridor and ventilation drift mining, the broken rock would be dropped into the nearest chute.

From the control chute, the broken rock would then be fed into rail cars and transported to a centrally located rock crusher. (Dwgs. 29 and 30 in all sets). The crushed rock (maximum 8 in. material) would be fed onto a conveyor located below the crusher discharge. The conveyor would then carry the crushed rock up an incline slope of 25% and discharge it into a 3000 ton capacity storage bin located near the M&M shaft, which would act as a surge control for hoisting operations. The broken rock would be fed onto two short conveyor belts located directly below the storage bin which, in turn, would feed the loading pocket in the Men and Material Shaft.

Room and branch corridor layouts (Dwg. 28 in all sets), provide a sufficient number of faces for maximum production. A number of production units could be working at one time to assure an adequate inventory of rooms. Dwgs. 23 and 24 in each set indicate the approximate time interval for the mining of the storage panels. Tables 5-10 through 5-13 indicate the peak number of mining units operating in a given year. Each production unit can produce a peak of about 1800 tons of excavation per day. It should be noted that in common practice, certain personnel and equipment are not confined to working in a specific area. In other words, the mining of rooms and corridors may share personnel and equipment. With this in mind, the information given in Tables 5-10 through 5-13 (except for drilling units) represents a relative or joint mining effort and not the effort of independent units. Tables 1-2, 1-3, and 1-4 give the average daily labor requirement for the mining operation.

As each room is completed, it would be interconnected at the back to the previously completed room. This would allow exhaust air to be drawn with fans through completed rooms and directed to the main exhaust corridor. In this manner, mining and placing air will remain completely separate.

Completion of all ventilation drifts precedes completion of the rooms and corridors by a minimum of nine months in order to ensure that adequate ventilation for mining and placement would be available.

Table 5-3 provides the total tonnage mined for each of the repositories. Cycle II, 5 and 25-year retrievable cases, require about 40% more tonnage to be mined than Cycles I and III. Since the Cycle II, 25-year case must be mined in approximately the same time as that required for Cycles I and III, it requires more mining units, as may be seen by comparing Table 5-13 with Tables 5-10 and 5-12. However, the 5-year Cycle II repository has a greater capacity per unit area than any of the others which permits the use of approximately the same number of mining units as that required for Cycles I and III even though its service life is longer.

5.6 Drilling and Trenching

Following the excavation of the rooms, storage trenches are excavated along the floor centerline for BWR, IL-TRU and cladding wastes, and holes are drilled for PWR and HLW canisters. The trench is selected for the BWR, IL-TRU and cladding waste because the calculation of the local heat loading allows a canister spacing much closer than the 6 ft. on-center drilling minimum. In the case of the PWR and HLW canisters, accommodating the local heat loading does not violate the minimum drilled spacing distance and therefore drilling can be used.

The trenches would be excavated using the same drill and blast cycle used in mining the rooms and corridors. The trench for the BWR waste will measure 5.5 ft. wide by 25 ft. deep and will have a length of approximately 230 ft. in the 280 ft. rooms and 510 ft. in the 560 ft. rooms. Mining would advance at a rate of 42 ft. per 3 shift day. For the IL-TRU and cladding wastes the trench will measure 5.5 ft. wide by 20 ft. deep and have a length of approximately 240 ft. in the 280 ft. rooms and 520 ft. in the 560 ft. rooms. Trenching for the IL-TRU and cladding waste would also advance at a rate of 42 ft. per day. The number of trenching production units associated with each of the wastes is a function of the canister receipt schedules (Table 5-4 through Table 5-8) and is given in Table 5-10 through Table 5-13.

The drill unit used for the PWR and high-level wastes would be electrically powered. The hole for the Cycle II PWR waste will measure 24 in. in diameter by 25 ft. deep and would advance at a rate of 54 ft. per 3-shift day. The hole spacing is a function of the areal heat loading and is given in Table 5-1 and Dwg. 28. The total number of drilled holes is equal to the total repository capacity for PWR waste and is listed in Table 5-1. The 5-year retrievable case required 50% more drilling units at its peak than the 25-year retrievable case requires. This is due to the accelerated receiving rate that the 5-year retrievable case experiences by going beyond the capacity year of the 25-year retrievable case.

The drilled hole used for HLW canister in Cycle I and III will be 22 in. in diameter by 20 ft. deep and will also advance at a rate of 54 ft. per 3-shift day. As with PWR waste, the HLW canister hole geometry is also influenced by the local areal thermal loading (Table 5-2) and is listed in Table 5-1. The total number of holes required is equal to the total repository capacity for the HLW waste and is given in Table 5-1. Tables 5-10 through 5-13 indicate the number of drilling units utilized in a given year. Cycle I and III are similar as can be seen by comparing the drilling unit totals for each.

The drilled hole diameters stated above can be reduced by 2 in. when no sleeve is used. The approximate time interval for the drilling and trenching tasks in each panel is given in Dwgs. 23 and 24 in all sets. The drilling or trenching operation is permitted to occur simultaneously with the mining operation within a given panel. However, at no time are these operations permitted simultaneously in the same room. Tables 1-2 through 1-4 lists the average daily labor requirements for these activities. Rooms designated for low-level wastes are not trenched or drilled.

5.7 Sleeve Emplacement

For all cycles studied in basalt, sleeves would be provided during the retrievability period. The sleeves will be of 3/8 in.

thick mild steel. Individual sleeves would be provided for the PWR and HLW canisters (Dwg. 33 in all sets), while a sleeve assembly arrangement will be provided for the BWR, IL-TRU and cladding canisters which are cooler (Dwgs. 34 and 35 in all sets). The sleeve diameter will be 16 in. for canisters in Cycles I and III, 18 in. for Cycle II PWR canisters, and 14 in. for Cycle II BWR canisters. The sleeve length is approximately 18-1/2 ft. for wastes in Cycles I and III and approximately 23-1/2 ft. for wastes in Cycle II.

In these repository designs, the sleeves for the HLW and PWR canisters are brought down the Men and Material Shaft in two sections of approximately equal length and placed in the drilled holes. For the BWR, IL-TRU and cladding canisters, an assembly holding 8 sleeves is designed to secure vertical placements of the canisters in the trench. Each canister sleeve assembly will measure approximately 5 ft. 6 in. by 7 ft. 6 in. in plan. The sleeve assembly is anticipated to be lowered down through the Men and Material Shaft in two sections, each measuring approximately 12 ft. All required bracing would be in place before the system is sent down the M&M Shaft.

For BWR, IL-TRU, and CW canisters beyond the retrievability period in Cycles I, II and III, a storage frame is designed to maintain the canisters in the vertical position in the trench. This frame (Dwg. 35) will measure approximately 4 ft. 9 in. by 8 ft. in plan and is 13 ft. deep for the BWR canisters and 8 ft. deep for the IL-TRU and Cladding canisters.

Labor requirements for the sleeve placement operation are given in Tables 1-2 through 1-4. The personnel required to place the frames have been included under "Drilling and Trench Preparation."

5.8 Subsurface Waste Receiving and Placement Operations

Subsurface receiving and placement operations originate at the Subsurface Canistered Waste Receiving Station, a tri-level underground facility capable of safely handling the material under shielded control conditions. The three distinct levels -- lower, intermediate and transporter -- serve separate functions in the material flow process. (See Dwgs. 31 and 32 in all sets).

The canistered waste would first arrive at the lower level in baskets of up to four units each. (See Dwg. 39, 40 and 41 in all sets). A section of moveable rail, part of an elevated rail, would bridge the gap to the canister waste cage. The basket would move out onto this rail until it aligns with a remotely operated bridge crane that hoists the basket up into the intermediate level. The port would then close, and an empty basket which is queueing on the elevated rail would be immediately loaded into the cage to return to the surface for refilling. The lower level thus acts as an exchange room for empty and full baskets of waste canisters.

After the full basket has entered the intermediate level, one of two procedures would be followed: The bridge crane may locate the basket directly below the loading port for transporter loading or it may transfer the basket off to the side for temporary surge storage. Thus the intermediate level provides isolation between the unloading of the cage and the loading of the transporter. The transporter level accommodates the final stage in the subsurface receiving operations before the waste is taken to a storage room. This level provides two independent loading areas for the transport vehicles and vehicle queueing space. Each loading area has a remotely operated port opening to the intermediate level below.

Canisters positioned in the intermediate level by the moveable crane will be removed from the basket into the transporter-shielded chamber by hoisting devices on the transporter. The transporter

operator would position the vehicle over the loading port in the floor of the transporter level, seal the space between the vehicle and port, open the port, lower independently operated hoisting devices down from within the shielded chamber and lift two canisters, one at a time, from the basket below. The remaining two would be taken by the next transporter. Once the canister is within the shielded chamber of the transporter the loading port would be closed, the seal removed and the transporter would reposition the shielded chamber to an inclined position (to lower the center of gravity) for transport to the storage room. A cutaway perspective of this operation appears as Fig. 4.

The transporter would then proceed through the isolation doors to a designated storage room at approximately 5 mph. Once in the room the vehicle is positioned over an empty storage hole, and the chamber is repositioned erect. Instrumentation on the transporter will permit the operator to adjust alignment of the chamber with the floor opening. The chamber door would slide open and a canister would be lowered down into the storage position. The hoist would then be disengaged and retracted. The placing of the second canister would follow the same procedure.

During the first five years (the retrievability period) of the repository the transporter would return equipped to emplace a concrete plug; otherwise, the floor opening would be backfilled with excavated material using a support vehicle. These vehicles would be in constant communication during the placement process. After placement, the transporter would return to the subsurface receiving station for another set of canisters.

The peak number of canister transporters required is a function of waste receipt schedule, transporter speed, the distance between the storage room and subsurface receiving station, the time required to load a transporter, and the time required to align the canister with the drilled hole (or trench). Because of the complex relationship among these factors, the maximum number of transporters required will not necessarily be proportional to peak year canister arrival rates. The peak transporter requirements are as follows: 5 in Cycle I; 6 in Cycle II - Five year retrievable; 5 in Cycle II - 25 year retrievable; and 5 in Cycle III.

In the handling of low-level waste, a cage would lower pallets of drums to the subsurface facility. A forklift vehicle would be used to remove the pallet from the cage and place it on a flat bed truck to be transported to the storage room. At the storage room the forklift type vehicle would place the pallet in its final storage position. The pallets measure 4 ft. wide by 6 ft. long by 7 ft. high, each containing 12 drums (2 levels of 6 drums). They would be stacked against each wall, leaving a center aisle. (See Dwg. 28 in all sets.) For the anticipated low receipt rates only two forklift vehicles are necessary: one in the storage room and one at the bottom of the shaft.

5.9 Backfill

In the 5-year retrievable case in each cycle, rooms would be backfilled commencing after the first 5 years of placement is completed. For this study it has been assumed that crushed basalt produced during the mining operation would be used.

Due to the configuration of the blasted rock, backfill can not be transported to the appropriate panel by conveyor. Therefore, a truck must be employed. If the trucks were to use the main corridor for access to the panel receiving backfill, a cross-over would exist with the placing activities going on in the panel situated between the panel being mined and the panel receiving backfill. To avoid this conflict, a perimeter corridor used solely for backfilling is provided in the 5 year retrievable cases in Cycles I, II, and III. (It is not provided in the Cycle II - 25 year retrievable case since no backfilling activity has been considered.) The perimeter corridor will be connected to the branch corridors at the end of each panel. Broken basalt (density 124 lbs./cu. ft) would be taken by truck to the end of the branch corridor servicing the rooms currently being mined and into the perimeter backfill corridor. From the perimeter corridor the backfill material would enter the appropriate panel through the branch corridor servicing the rooms to be backfilled. A front end loader would then be employed to fill the room to within 5 ft. of the ceiling. Material not being used as backfill would be directed

from the branch corridor servicing the panel being mined toward the main corridor system. From here the material will follow the route described in Section 5.5.

The percent of material returned to the repository in each cycle is given in Table 5-3 as the backfill tonnage factor. Also given in Table 5-3 are the tonnages associated with backfilling the entire repository, the tonnage involved in backfilling just the rooms, the amount of material that must be removed from the repository site, and the on-site storage tonnage. This last tonnage must be sufficient to backfill any rooms receiving waste prior to 1990 if the need arises.

Toward the end of the life of the repository, waste placing is ongoing while mining has ceased. Therefore, material for backfill must be taken back down the M&M Shaft. The hoisting system would have features enabling them to accommodate such a reversal of operation. It is estimated that approximately 7500 tons per day in Cycles I and III and 11,000 tons per day in Cycle II would be required at the peak for backfilling during this time period. These rates are required so that all backfilling will be completed within 5 years of the last waste receipt date. Prior to decommissioning, all corridors would also be backfilled.

5.10 Decommissioning of Underground Facilities

After all the wastes have been emplaced or retrieved, and decommissioning of the facility has been directed, backfilling of all remaining subsurface openings (corridors) would commence. Material for the final backfilling would come from surface storage to the extent possible. The excavation sequence would be reversed and material would be sent back into the mine via the excavated material hoist. Mining equipment deemed to be useful would be removed, dismantled, crated where required, and transferred to other sites. Shafts would be sealed in a manner to be determined by further studies.

5. REFERENCES

1. Office of Waste Isolation/Union Carbide Corporation, Nuclear Division, Facility Construction Feasibility and Costs by Rock Type, Y/OWI/TM-36/18, Oak Ridge, Tennessee, April 1978. Section 5.5.

6.0 VENTILATION SYSTEM FOR FACILITIES IN BASALT

6.1 Subterranean Ventilation Systems

6.1.1 Ventilation Requirements and Criteria

The ventilation of the mine and of the subterranean waste storage facilities represents a complex, challenging requirement. The changing amounts of ventilation required, as well as the gradual changeover of successive portions of the underground rooms from active excavation to long-term storage, means that the ventilation system demands a special flexibility not usually required either of simple mines or of conventional waste processing facilities.

The basic purpose of the mine ventilation system is to protect the mine personnel and the public from excessive exposure to radiation and mining dust and to provide an adequate supply of clean, fresh air for human needs and equipment requirements. Protection from excessive radiation exposure is ensured by arranging the ventilation system so that the airflows for mining activities and for waste placement are separated and by providing for filtration of all air that may have come in contact with the stored nuclear waste. The method of separation of airflows and the provisions for filtration of waste placement air are described in Sections 6.1.4 and 6.1.5.

Adequate supply of fresh air is required to satisfy breathing air supply needs and to control the chemical and physical quality of the mine atmospheric environment by providing for the removal of contaminants such as engine exhaust gases, dust, heat, moisture, and smoke generated by equipment and mining processes. Reversibility of fans would be provided if required by applicable federal and state regulations.

Ventilation criteria for this repository have been selected to provide for airflow ventilation that would comply with all existing statutes of the U.S. Bureau of Mines, Mining Enforcement and Safety Administration (MESA) or the strictest state regulations, and will include:

- o Minimum of 200 cubic feet per minute (cfm) of fresh air for each man underground;
- o Minimum of 125 cfm per brake horsepower of diesel-powered equipment;
- o Minimum of 50 cfm per square ft. of headings (or 50 linear ft. per minute of air velocity in entries);

The above criteria are considered to be sufficiently conservative and yet reasonable for the preliminary estimate of ventilation requirements for mining and placement operations.

6.1.2 Underground Ventilation Supply Air

Underground ventilation air would be provided by multiple supply fans located in the Supply Ventilation Building. Conceptual layout of the building is shown on Dwg. 14. The ventilation for the entire repository would be achieved in stages to correspond to the staged mining process. At the peak of the mining and storage activities, eight centrifugal fans in parallel, each with a nominal capacity of 250,000 cfm, will supply a total of 1,945,000 cfm of ventilation air underground. Two additional fans of the same capacity will be provided as back-up units to facilitate maintenance and/or repair without interruption of the air supply. (For Cycle II, 25-year retrievable repository only, the nominal capacity of each fan will be 285,000 cfm, supplying a total of 2,310,000 cfm ventilation air.) The supply fans will have inlet vane control for efficient volume control capability. Typical supply (and exhaust) fan specifications are presented in Table 6-1.

Outside air would be drawn into the Supply Ventilation building through air intake louvres (equipped with bird screen) and 30% NBS efficiency air filters. During cold weather, temperature of the supply air will be maintained at minimum 40°F by heating coils located in the air intake plenum. Motorized shut-off dampers

will be provided in the discharge of each supply fan. The sub-surface supply air would be monitored by a flow switch which will trigger an alarm if the air flow is reduced below a pre-set minimum due to fan failure or other causes.

Air discharged into the supply air plenum will travel down the concrete-lined air supply shaft. At the base of the ventilation shaft, the airflow would be divided into separate supply air systems by controlling dampers. A throttle in each of the main supply branches will permit the ventilation air supply to be shut off in case of fire. The distribution of the supply air will be as follows:

- o Approximately 100,000 cfm would be provided for ventilating the underground M&M station and the maintenance shop and for control of dust at the storage bins and loading pockets.
- o Approximately 200,000 cfm would be supplied into the canistered waste placement corridors and the low level waste placement corridor for the ventilation of placement operations.
- o An estimated 45,000 cfm would be required for ventilation of the subterranean waste receiving stations (25,000 cfm for the high level waste receiving stations and 20,000 cfm for the low level waste receiving and loading area).
- o The remaining, major portion of supply air will be used to satisfy ventilation requirements of the mining operations such as drilling and blasting, mucking, drilling of waste placement holes and sleeve placement, mining of trenches and backfilling. At the peak of the mining and placement activities this portion of the ventilation supply air would be approximately 1,600,000 cfm for all 5-year retrievable repository designs. Most of the supply air would be channelled to the work stations through the M&M corridors; but in order to limit air velocity in the supply air corridor to 1,000 feet per minute, approximately 100,000 cfm would be supplied through the haulageway which runs parallel to and below the M&M corridor.

Estimated total ventilation airflow requirements at the peak of mining and placement operations are shown in Table 6-2.

6.1.3 Ventilation of Mining Operations

Proper distribution of the ventilation air to the working areas would be accomplished through the use of stoppings, doors, air locks and crossings in the main airways, and line brattices and auxiliary fans at the working faces. A conceptual layout of the subterranean ventilation system is shown on Dwg. 19.

All corridors and rooms will be mined by conventional drill and blast methods. During the mining operations, effective ventilation at the work places would be ensured by locating the exhaust tube inlet of the portable ventilating fan as close to the mining face as possible. The fan will exhaust the vitiated air through the reinforced flexible tubing and discharge it through the adjacent already mined storage room into the panel vent drift of the periphery ventilation airway system. The panel vent drift will channel the air into the main corridor that serves exclusively as mine exhaust air corridor. Additional lengths of ducting will be added as required by the advancing mining operation.

Drilling of holes and placement of sleeves for HLW canisters and trench mining for IL-TRU and CW canisters would be ventilated by taking advantage of the fact that mining of the storage rooms is already completed. In this scheme the supply air would flow through the entire room where the work is in progress, and exhausted through the adjacent unoccupied storage room and the panel vent drift into the mining air exhaust corridor. Since mining operations and placing operations do not occur simultaneously in a given panel, this process of exhausting through the adjacent storage room does not result in a mixing of mining and placing air.

The storage rooms will be backfilled after the retrievability period, presently assumed to be 5 years. Since in basalt the backfilling would be done by trucking (as described in Section 4.8), a backfill haulage corridor system is provided parallel with the perimeter ventilation airways. Ventilation supply air would be

supplied through the panel branch corridor and the backfill haulage corridor to the storage room where the backfilling is in progress, and would be exhausted through the panel vent drift into the mining air exhaust corridor. Through redirection by a system of bulk-heads, mining operations would not interface with the air from the backfill operation until both are vitiated.

All exhaust from the various mining operations and from the maintenance shop area would be collected by the mining air exhaust corridor. The exhaust corridor will be separated from the supply air carrying M&M corridors by well-sealed stoppings. Airlock type access will be provided to the exhaust corridor at intervals required by mining regulations. At places where the exhaust air corridor crosses entryways used by men and equipment, the exhaust air will pass above the M&M corridor through an aerodynamically shaped overcast. The exhaust air corridor will be connected to the mining exhaust compartment of the Ventilation Exhaust Shaft, through which the air would travel to the surface and would be exhausted to the atmosphere as described in Section 6.1.5.

6.1.4 Ventilation of Placement Operations

Ventilation flow rate for placement corridors and storage rooms where the placement is in progress would be as determined by the ventilation criteria described in Section 6.1.1. For canistered waste placement operations the governing criteria is the air requirement for the diesel engine powered waste transporters, resulting in approximately 40,000 cfm fresh air per transporter. For low-level waste placement operations, where forklift type vehicles will be used to transport the palletized drums, ventilation would be determined by the minimum air velocity required in the occupied corridor or storage room. In a 18 ft. x 20 ft. low-level waste storage room this amounts to 18,000 cfm. Total volume of the ventilation air for the canistered and low-level waste placement operations is estimated to be 250,000 cfm, with four canistered waste transporters operating simultaneously (including exhaust air from the subterranean waste receiving stations).

Placement of the canistered or low-level waste would begin at the end of storage room adjacent to the periphery ventilation drifts and proceed in a retreating manner toward the placement corridor. The ventilation air, supplied through the placement corridor, would flow through the storage room and will be exhausted through the periphery ventilation duct system (See Dwg. 19.) This way, the placement would always be done in a fresh air stream, with the air flowing past the placement point. When placement is completed in a given storage room, the room will be temporarily sealed and the placement ventilation airflow would be directed into the next room.

When an entire panel has been filled, the branch corridor will be bulkheaded and sealed between the just completed and the next-to-be-placed panels. This is done to isolate the panel where placement is taking place from the already filled panels.

The layout of the subterranean ventilation system will provide for the separation of the potentially contaminated exhaust air of the waste placement operations from the mining operations exhaust air. As described earlier, the mining exhaust air would be collected through one of the main corridors. Placement operation exhaust air would be collected through the completely separate system of perimeter ventilation drifts. The two exhaust airflows would be brought to the surface in separate compartments of the divided Ventilation Exhaust Shaft. The air from the placement operation will be continuously treated for contamination while the backfill and mining air will be treated only when contamination is detected. The 28 ft. diameter shaft will be constructed of reinforced concrete with a smooth concrete lining, suitable for decontamination in case that ever becomes necessary. Precautions are required during construction to ensure that the shaft is free of cracks through which groundwater could seep into the shaft.

6.1.5 Exhaust Ventilation Building

The Ventilation Exhaust Shaft will terminate in the plenum chamber of the Exhaust Ventilation Building. This building, the

final component in the underground ventilation system, will house the exhaust fans and the central filtering station. A schematic flow diagram of the exhaust air filtering system is shown on Dwg. 13.

Exhaust air from the placement compartment of the upcast shaft will always be filtered by prefilters (30% and 90% NBS efficiency) and two sets of high efficiency particulate air (HEPA) filters arranged in series. The fan-filter arrangement will handle 250,000 cfm; a duplicate fan-filter train will serve as back-up unit to ensure continuity of placement exhaust when malfunction, maintenance or filter change necessitates shut-down of the first unit. Motorized isolating dampers will be provided before and after the filter trains and in the discharge of the exhaust fans. The filtered air would then be discharged through the 100 ft. high exhaust stack that is continuously monitored to detect any radioactivity in the air stream.

Under non-emergency operating conditions, exhaust air from the mining operations would not pass through HEPA filters. Instead, it would be drawn through a set of (normally open) dampers and 30% NBS efficiency filters, by four 600,000 cfm nominal capacity centrifugal fans serving the mining operations only, and discharged directly to the atmosphere through a stack. The four fans will be connected in parallel. Normally three of the four mining operations exhaust fans will be in operation while the fourth may be serviced or used as a standby. Alternate electrical power will be provided to operate any one of the four fans in the event the normal power fails.

Monitors will be located in the mining air compartment of the Ventilation Exhaust Shaft to indicate the presence of any radioactive contaminants. Under normal conditions there would be no radioactive particulates in the mining exhaust and only a minimal amount in the canister placement exhaust. In the event of an accident involving a canister leak or some other release of radioactive particles from a canister, only the placement exhaust air would become contaminated since the two air flows are separated. Although it is highly unlikely that the mining exhaust air would

also exhibit the presence of radioactive elements, the capability will be provided to filter this air also. In such an event, the dampers which are normally open would close and those which are normally closed would open. The mining exhaust air would thereby enter the same plenum chamber which the placement compartment of the upcast shaft is connected. From this chamber six additional filter-fan trains, identical to the two units serving the placement exhaust, will draw the mine exhaust air through 30% and 90% NBS efficiency prefilters and two sets of HEPA filters before discharge to the atmosphere through the exhaust stack. Since these additional filter-fan trains will operate in case of emergency only, under normal circumstances they can serve as additional back-up units for the placement exhaust filter system.

Differential pressure gauges will be installed on each side of each filter bank and will indicate when filter replacement is necessary. Each fan will have a nominal capacity of 250,000 cfm, and sufficient static pressure head to overcome friction losses in the mine, shaft, and stack, plus a reasonable buildup of filter resistance. Connections will be provided for in-place DOP testing of individual HEPA filter banks. Special quick-closing blast dampers will be provided in the fan discharge to the stack to protect the upstream HEPA filters from tornado damage. These dampers will be designed to withstand a 3 psi differential pressure (in the closed position) that may be imposed by a tornado.

6.1.6 Air Velocities in Subterranean Ventilation Airways

Air velocities in the ventilation airways are a function of the air flow and the size of the airway. Air flow is determined by the ventilation requirements for the mining and placement operations. In regard to the size of the airways, large airways would reduce pressure and power requirements and hence operating costs but would be expensive from the standpoint of investment or capital cost. In the final design of the airways, the system with the lowest overall cost is the goal.

For the ventilation airflows required in basalt, the airway sizes selected in this preconceptual study resulted in the typical air velocities given in Table 6-3.

6.1.7 Ventilation Systems Controls

Ventilation air from the mine would be exhausted through the mining and placement exhaust fans located in the Exhaust Ventilation Building, and the underground areas will be maintained at a negative pressure. To achieve the desired distribution of the supply air and insure confinement of mine air within the mine, a system of manually and automatically activated dampers and controls will be incorporated into the ventilation system. Supply fan inlet vane controls and dampers in the supply air distribution system will operate in conjunction with dampers and regulators located in the exhaust air stream to control the air flow and pressure in the high and low-level waste storage areas. These fan and damper controls associated with the supply and exhaust systems will provide assurance that all exhaust air that may have come in contact with waste storage areas would be filtered under controlled conditions prior to discharge to the atmosphere.

6.1.8 Ventilation of Subterranean Waste Receiving Stations

The Canistered Waste Receiving Station at the base of the Canistered Waste Shaft must be ventilated to ensure confinement of any radioactive contamination as well as provide for safe and comfortable working environments.

The subterranean waste receiving stations will be provided with separate supply and exhaust systems. Ventilation supply air would be drawn from the mine ventilation air at the base of the Ventilation Supply Shaft by a supply fan and ducted to the Observation and Control Rooms, Waste Receiving and Transporter Loading Areas. Ventilation flow rates would provide for six air changes per hour in the Observation and Control Rooms and minimum two air changes per hour in the Waste Receiving and Transporter Loading areas.

Exhaust air from the subterranean waste receiving stations would be filtered through 30% and 90% NBS efficiency prefilters and one set of HEPA filters by dual fan/filter units. Filtered air would be ducted to the Ventilation Exhaust Shaft and discharged into the placement exhaust compartment of the shaft.

All spaces of the subterranean waste receiving stations will be maintained under negative pressure relative to the mine atmosphere. Upon loss of normal power the supply fans will automatically shut down and the exhaust fans will automatically operate at half speed.

6.1.9 Ventilation During Retrieval

If retrieval of the emplaced nuclear waste is required during the retrievable period, it is assumed that all other mining and placement operations would halt. Ventilation capacity of the mine ventilating system would be used first to cool down the waste storage rooms where the retrieval is to take place and then to provide ventilation during the retrieval operations.

After the temporary seal is removed at the branch corridor end of a storage room, the heat built up in the previously sealed room will be removed by directing approximately 250,000 cfm supply air along the M&M corridor to the opened-up room and exhausting it through the room via the placement exhaust perimeter ventilation drift system. After the room is sufficiently cooled, the retrieval operation would be done with a lesser rate of ventilation, but sufficiently large to provide 100 fpm air velocity through the storage room. Retrieval would begin at the corridor end of the room, progressing toward the periphery ventilation drift. This way, the retrieval would always be done in the "fresh" air stream, and air flowing over the still emplaced canisters would be flowing away from the working points.

All exhaust air from the retrieval operations would be collected through the perimeter ventilation airway system and brought to the central filter room via the placement exhaust compartment of the Ventilation Exhaust Shaft. Filtration of the retrieval

operation exhaust air would be the same as that described for the placement exhaust air filtration in Section 6.1.5. If retrieval operation is initiated in more than one storage room at the same time, additional fan-filter trains (installed originally for filtering the mining air in emergency) can be started up to handle the increased volume of exhaust air. The filtered air would be discharged to the atmosphere through the 100 ft. high exhaust stack.

6.2 Heating, Ventilating and Air-Conditioning of Surface Structures

6.2.1 Introduction

Heating, ventilating and air-conditioning systems would be required to provide proper working environment for personnel and equipment, and to effectively confine any airborne contamination within the facilities.

6.2.1.1 Design Conditions

Design conditions for environmental control will be based on data published in the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Handbook of Fundamentals, latest edition. Summer and winter outside air design conditions will depend on the geographic location of the repository. Summer inside design conditions will be 78°F db with 50% relative humidity in air-conditioned spaces, unless otherwise required for special equipment environment. In non-air-conditioned spaces temperature will be limited to 105°F. Winter inside design conditions will be 70°F with no humidity control in air conditioned spaces and 50°F in equipment rooms and non-occupied spaces.

6.2.1.2 Air Distribution and Design Requirements

Three major zones of air distribution have been assumed in surface structures where nuclear waste material is being handled, including:

- o Zone I - Primary Confinement Zone: areas of high potential contamination;
- o Zone II - Secondary Confinement Zone: areas of low potential contamination;
- o Zone III - Unrestricted Zone: areas of no potential contamination under normal operating conditions.

Each confinement zone will be provided with supply and exhaust systems. Supply and exhaust control dampers will provide for successively greater negative pressures between areas of successively higher contamination potential. Recirculation of air from a lower potential contamination zone to a higher potential contamination zone will be permitted if filtered through high efficiency particulate air (HEPA) filters.

Supply systems for Zone I areas will be provided with two sets of HEPA filters, DOP testable in place.

Supply systems for Zone II areas will be provided with one set of HEPA filters, DOP testable in place.

Supply systems for Zone III areas will be provided with 30% NBS and 90% NBS efficiency filters arranged in series.

Exhaust systems for Zones I and II will be:

- o Provided with at least two sets of HEPA filters, separately DOP testable in place;
- o Provided with 100% back-up (standby) systems;
- o Connected to the emergency electric power system.

Exhaust systems serving Zone III areas will have at least one set of HEPA filters, but no back-up system or emergency power supply is required.

Upon loss of normal power, the outside air supply fans will automatically shut down, and the confinement zone exhaust fans will automatically operate at half speed.

All supply and exhaust systems where HEPA filters are required will also be provided with 30% NBS and 90% NBS efficiency filters,

arranged in series upstream of the HEPA filters. Conventional low-velocity duct systems design will be used for all supply and exhaust systems.

6.2.1.3 Heating and Cooling

Heating would be provided by hot water coils in the air-conditioning units, fan-coil units, unit heaters and cabinet heaters. Hot water will be circulated from the steam-to-water converters located in the mechanical equipment room of each building. Steam generated in the central boiler plant for the whole facility will be distributed through underground utility tunnels. In small and remotely located surface buildings electrical cabinet heaters will be used.

In general, cooling would be provided by the chilled water supplied to the air-conditioning units and fan-coil units from the central refrigeration plant. In small and remotely located buildings (such as railway guardhouse) unitary room air-conditioners will be utilized.

6.2.2 Canistered Waste Receiving Building HVAC Systems

Outside air for ventilation of the Canistered Waste Receiving Building would be provided by air-conditioning units located in the Mechanical Equipment Room. Confinement chambers will be provided to the restricted zones to maintain the confinement integrity of the nuclear waste handling areas. The air supply to, and the pressure within individual rooms would be regulated by static pressure regulators and automatic pressure and volume control dampers. Confinement zone classification of various rooms and specific ventilation design requirements are shown in Table 6-4.

6.2.2.1 Description of Heating, Ventilating and Air-Conditioning Systems

Schematic air flow diagram for the Canistered Waste Building is shown on Drawing 6. The outside air would be drawn through

prefilters (30% and 90% NBS efficiency) and HEPA filters, conditioned and then supplied to the operating galleries and cask unloading areas. A back-up supply fan/air-conditioning unit will be provided for operational reliability. A room thermostat from one of the operating galleries will modulate control valves of the heating or cooling coils in these air-conditioning units. To reduce the heating/cooling load on the outside air supply units, supplementary ventilation and cooling would be provided in each of the Cask Unloading Rooms by filter/air-conditioning units. These approximately 15 ton capacity units will draw air from the operating galleries, filter it through prefilters and two HEPA filters arranged in series, condition it and discharge into the Cask Unloading space. Room thermostats in each Cask Unloading Room will modulate the cooling coil control valve of the respective supplementary unit.

Part of the return air from the Cask Unloading Rooms would be supplied to the primary confinement zone area (comprising the Transfer Galleries, Transfer Cells and the Canister Storage and Feed Room), after it is filtered through prefilters and two sets of HEPA filters. Surplus return air not required for Zone I ventilation would be exhausted to the atmosphere after filtering as described in a latter part of this section.

In the Transfer Cells and the Canister Storage & Feed Room, fan-coil units will be provided (with back-up units, rated at 100% of required capacity) to prevent excessive room temperatures due to heat emitted by process equipment, lighting and the nuclear waste canisters.

Exhaust air from the primary confinement zone areas and excess return air from the secondary confinement zones would be processed through dual HEPA filter units with one operating and one on standby. The filtered air would be drawn through underground ducts to the dual exhaust fans located in the exhaust vent building, and discharged to the atmosphere through the 100 ft. high mine exhaust stack. The total exhaust air flow rates from the primary and secondary confinement zones are estimated to be 91,000 cfm in the repository designs for all three fuel cycles.

Exhaust from unrestricted support facility rooms and from the mechanical equipment room would be filtered through prefilters and two sets of HEPA filters before being discharged to the atmosphere from the exhaust fan located in the mechanical room of the Canistered Waste Building.

The Mechanical Equipment Room and the Exhaust Filter Room would be provided with a heating and ventilating unit. Outside air would be filtered as required for Zone II supply systems and discharged into the Mechanical Equipment Room. Exhaust air from this space would be supplied to the restricted (Zone II) Exhaust Filter Room. The exhaust system serving the Filter Room will have filters as required for Zone II systems, but no standby unit or emergency power connection will be provided.

The Electrical Equipment Room would be provided with a separate ventilating unit for summer ventilation. During the winter, room thermostat controlled unit heaters will maintain the minimum design temperature in the room.

The Hoist Machine Room would be provided with a separate air-conditioning unit using a combination of recirculated air and the minimum required rate of outside air to provide the desired room pressure, ventilation and summer-winter design temperature. A room thermostat will modulate the cooling and heating coil control valves in the air-conditioning unit. Air would be exhausted to the atmosphere after passing through prefilters (30% and 90% NBS efficiency) and two sets of HEPA filters.

The Battery Room would be ventilated by a continuously running exhaust fan to ensure a safe low level of hydrogen concentration in the room. The exhaust fan will have spark-proof wheel and explosion-proof motor construction.

Supply air for the Mechanical Equipment Room and the Exhaust Filter Room would be provided by a heating and ventilating unit. Outside air drawn by the fan would be filtered by 30% and 90% NBS efficiency filters. The duct thermostat downstream of the supply fan will modulate the heating coil control valve in the heating operation mode. Supplementary heating would be provided for the Mechanical Equipment Room by room thermostat controlled unit heaters

to maintain minimum 50°F in the room. Exhaust air from the Mechanical Equipment Room would be handled by the fan/filter unit serving the Zone III areas. Exhaust air from the Exhaust Filter Room would be filtered through the filter/fan unit serving the secondary confinement zone rooms.

The Electrical Equipment Room would be provided with a separate ventilating unit for summer ventilation. During the winter, unit heaters will maintain the minimum winter design room temperature, controlled by room thermostats.

The Hoist House would be provided with a separate air-conditioning unit using a combination of recirculated air and the minimum required rate of outside air to provide the desired space pressure, ventilation and summer-winter design temperature. A room thermostat would modulate the cooling and heating coil control valves in the air-conditioning unit. Air would be exhausted to the atmosphere after filtered through prefilters (30% and 90% NBS efficiency) and two sets of HEPA filters.

6.2.3 Low-Level Waste Receiving Facility HVAC Systems

The ventilation air flow diagram for the Low-Level Waste Receiving Building for all fuel cycles is shown on Dwg. 9. Outside air for the ventilation of Low-Level Waste Receiving Building would be provided by air-conditioning units located in the Mechanical Equipment Room. Independent supply and exhaust systems would serve the non-restricted and the secondary confinement zone areas. Confinement chambers would be provided to the restricted zones to maintain the confinement integrity of the nuclear waste handling areas. The air supply to and the pressure within individual rooms would be regulated by static pressure regulators and automatic pressure and volume control dampers. Confinement zone classification of various rooms and specific ventilation design requirements are shown in Table 6-5.

Supply air for the Zone II rooms would flow through prefilters (30% and 90% NBS efficiency) and one set of HEPA filters, heating and cooling coils and a backflow preventer before being

distributed to the rooms. Exhaust air from the confinement zones would be processed through prefilters and two HEPA filters in series, and then discharged to the atmosphere. A duplicate filter bank and exhaust fan installation will be provided for operational reliability, and the exhaust fans will be linked to the standby power distribution system. Upon loss of normal power, the confinement zone ventilation supply system will automatically shut down and the exhaust fan will automatically operate at half speed. Exhaust air flow rates from the secondary confinement zones are estimated to be 8200 cfm for Fuel Cycle II and III repository designs, and 12,300 cfm for Fuel Cycle I repository design.

Outside air for the non-restricted zone rooms would be filtered through a prefilter (30% NBS) and a main filter (90% NBS) and heated or cooled before distribution. The nonrestricted zone exhaust system will not have auxiliary back-up capabilities, nor will it be linked to the standby power network.

6.2.4 Liquid Radwaste Treatment Facility

The Liquid Radwaste Treatment Building would be provided with a separate, independent ventilation system. System capacity will provide a minimum of ten (10) air changes per hour. Potentially contaminated rooms will be maintained under negative pressure relative to the atmosphere, and an overpressure condition would automatically close all vents from a room.

Exhaust air filtering would include an 85% NBS efficiency prefilter and two HEPA filter banks in series. The control room for the liquid radwaste treatment operations will be provided with an independent climate control system.

6.2.5 Other Surface Structures

Administration Building and the Mine Operations Building would be provided with year-round central air-conditioning. The system

will be designed to recirculate air from the office spaces, drawing only the minimum required outside air. During heating seasons, supplementary heat will be provided by fin tube convectors, cabinet heaters, and unit heaters as determined by the function of spaces served.

Central Site Control and Switchgear Building: General office spaces would be air-conditioned by a central system with the same design features as described above for the Administration Building system. The Control Room and related control equipment spaces will be provided with packaged computer room air-conditioning units (to control space temperature and humidity as required for the equipment environment and human comfort). Emergency units will be provided in the Control Room, and both the normally operating units and the alternate units will be connected to the emergency power network. The switchgear area will be ventilated in the summer and heated in the winter to maintain design space conditions.

Supply Ventilation Building: The electrical switchgear room of this building would be provided with ventilation supply air fans and relief vent opening to limit the maximum summer space temperature to 105°F. Other ancillary spaces in the building will be provided with a heating and ventilating unit. For supplementary heating cabinet heaters and unit heaters will be used.

Exhaust Ventilation Building: Separate ventilating systems would be provided for the subgrade mechanical fan rooms and Compacter Room and for the at-grade Filter Change area. Supply and exhaust control dampers will maintain negative pressure relative to atmosphere. Exhaust air would be filtered as required for secondary confinement zone exhaust and discharged to atmosphere through the mine exhaust stack. Unit heaters will be provided as required to maintain indoor temperature at 50°F.

Cafeteria Building: The dining area will be served by an air conditioning unit supplying 100% outside air. Return air from the dining area will be filtered and supplied to the kitchen area by a transfer fan. To meet the total kitchen area ventilation requirements, a separate heating and ventilating unit will also serve the kitchen areas. The exhaust fan and ductwork from the

kitchen areas will be designed to meet requirements of the application. Heating would be provided by fin tube convectors, unit heaters and cabinet heaters as required.

Laundry Building will be provided with a heating and ventilating unit; exhaust fan and stainless steel or aluminum ductwork will be provided to discharge the air to the atmosphere.

Clinic Building will be air conditioned by a central unit; separate exhaust systems will be provided for general area exhaust and for the clinic rooms.

Men and Material Building: Locker rooms will be ventilated by a heating and ventilating unit. Briefing rooms and offices will be air-conditioned by self-contained air-conditioning units. Heating would be provided by cabinet and unit heaters.

Warehouse and Maintenance Building will be provided with a supply fan ventilation unit and relief air openings. Winter design space temperature will be maintained by steam unit heaters controlled by individual space thermostats.

Fire House will be ventilated in the summer to keep indoor temperature below design limits. Unit heaters will be provided for heating in the winter to maintain 50°F indoor temperature. The Fire Warden's office will be air conditioned by a self-contained air conditioning unit.

Guardhouses will be provided with self-contained air-conditioning units; heating would be provided by electric cabinet heaters.

6.3 Ventilation of 25-Year Retrievable Repository

In this alternative repository design the 25-year retrievability is achieved by reducing the allowable local thermal loading as compared to 5-year retrievable repository designs.

Mine ventilation criteria and the method of ventilating the mining and placement operations is the same as for 5-year retrievable repository, described in Section 6.1. Conceptual layout of the subterranean ventilation system is the same as shown on Dwg 19. The total ventilation airflow, however, shown in Table 6-2,

is about 20% higher than what is required for 5-year retrievable repositories. The reason for this increase lies in the accelerated rate of mining activity required for the 25-year repository design (See Dwgs. U23 and U24 and Tables 5-10 through 5-13), which more than offsets the ventilation reducing effect of not considering a backfill operation. A consequence of the increased ventilation airflows is that in order to limit the air velocity in the M&M corridors to 1,000 fpm, the 23 ft. x 11 ft. haulageway will be utilized to carry about 250,000 cfm supply air during years of peak demand. Air velocities in branch corridors and at the work stations would be as estimated for 5-year retrievable repository designs, shown in Table 6-3.

Under normal conditions, exhaust air from the mining operations will be exhausted by five 430,000 cfm nominal capacity centrifugal fans, with one additional fan of the same capacity as a standby. Capacity of these fans was determined so that the resulting estimated fan motor (900 HP, see Table 6-1) can be started up and operated by the emergency power generator in the event the normal power supply is interrupted.

Provisions for filtering the placement exhaust air and for emergency filtration of the mining exhaust air would be the same as described in Section 6.1.5 for 5-year retrievable repository designs.

SURFACE FACILITIES

FIG. 1

WASTE ISOLATION FACILITY

FIG. 2

CANISTERED WASTE BLDG. CUTAWAY PERSPECTIVE

FIG. 3

FIG. 4

WASTE RECEIVING OPERATIONS CUTAWAY PERSPECTIVE

Basalt

CYCLE I

HLW: Extraction Ratio = 25%

ILW & CW: Extraction Ratio = 40%

CYCLE II

PWR/BWR: Extraction Ratio = 40%

CYCLE III: Same as CYCLE I

EXTRACTION RATIO CHART

FIG. 5

Table 1-1

CANISTER RECEIPT CRITERIA RECOMMENDATIONS

Contents	Canister		Overpack		Age (Years)	Maximum Radiation Level (rem/hr)			
	Outside Diameter (inches)	Overall Length (feet)	Outside Diameter (inches)	Overall Length (feet)		At Surface		10' from Ctr. Line	
						gamma dose rate	neutron dose rate	gamma dose rate	neutron dose rate
HLW in Glass	12-3/4	10	14	11	10	2.0x10 ⁵	1.0x10 ²	1.0x10 ⁴	1.0x10 ¹
HLW in Calcine	8-5/8	10	10-3/4	11	10	5.0x10 ⁵	1.0x10 ²	5.0x10 ⁴	1.0x10 ¹
IL-TRU	12-3/4	10	14	11	5	1.0x10 ²	1.0x10 ⁻¹	1.0x10 ¹	5.0x10 ⁻³
Cladding	12-3/4	10	14	11	5	1.0x10 ³	1.0x10 ⁻¹	1.0x10 ¹	5.0x10 ⁻³
PWR	14	16	16	16-1/2	10	7.0x10 ⁴	1.0x10 ¹	3.5x10 ³	5.8x10 ⁻¹
BWR	10-3/4	16	12-3/4	16-1/2	10	5.0x10 ⁴	1.0x10 ¹	2.5x10 ³	5.8x10 ⁻¹

ADDITIONAL RECEIPT CRITERIA
(For All Canisters)

Max. Weight (incl. overpack) = 3000 lbs.

Max. outer surface contamination
with transferable radioisotopes:

beta-gamma radiation emitting nuclides: $10,000 \text{ dis/min/dm}^2$ (disintegration/minute/100 centimeters²)
alpha emitting nuclides: 300 dis/min/dm^2

Source: TM-36/2, Commercial Waste Forms, Packaging and Projections for Preconceptual Repository Design Studies

Table 1-2
Personnel Assignment Schedule
Basalt - Cycle I

Year	Waste Storage Operation	Mining Operation*	Drilling and Trench Preparation	Sleeve Placement Operation	Backfill Operation	Total
1980	58	-	-	-	-	58
1981	64	-	-	-	-	64
1982	77	-	-	-	-	77
1983	85	338	-	-	-	423
1984	93	508	39	4	-	644
1985	411	537	117	10	-	1075
1986	687	537	117	10	-	1351
1987	731	537	117	-	-	1385
1988	704	537	117	-	-	1358
1989	773	537	117	-	-	1427
1990	671	567	124	-	12	1374
1991	1126	616	134	-	13	1889
1992	1091	766	167	-	17	2041
1993	1126	766	167	-	17	2076
1994	1199	766	167	-	17	2149
1995	1239	766	167	-	17	2189
1996	934	766	167	-	17	1884
1997	1047	766	167	-	17	1997
1998	1082	766	167	-	17	2032
1999	1152	766	167	-	17	2102
2000	1220	791	173	-	17	2201
2001	1290	830	180	-	18	2318
2002	1394	830	180	-	18	2422
2003	1428	830	180	-	18	2456
2004	1534	700	180	-	15	2429
2005	1608	645	180	-	14	2447
2006	1678	23	180	-	145	2026
2007	1710	-	-	-	155	1865
2008**	1781	-	-	-	167	1948
2009	220	-	-	-	155	375
2010	146	-	-	-	155	301
2011	110	-	-	-	155	265
2012	73	-	-	-	132	205
2013	37	-	-	-	132	169

*The mining operation is monitored by a separate Mining Production Management Group which has a staff of 138 individuals.

**Capacity of mine expired after year 2008.

Not included:

1. Overall management and engineering
2. Contingencies
3. General Contractor's personnel for initial development (1980-1984)

Note: Above figures represent the average daily manning requirements during the indicated year based on 3 shift operation including surface and subsurface personnel for each category.

Table 1-3
Personnel Assignment Schedule
Basalt - Cycle II

Year	Waste Storage Operation	Mining Operation*	Drilling and Trench Preparation	Sleeve Placement Operation	Backfill Operation	Total
1980	58	-	-	-	-	58
1981	64	-	-	-	-	64
1982	77	-	-	-	-	77
1983	85	391	-	-	-	476
1984	93	560	38	4	-	695
1985	328	470	151	5	-	954
1986	359	483	155	5	-	1002
1987	386	483	155	5	-	1029
1988	411	499	160	5	-	1075
1989	422	499	160	-	-	1081
1990	437	508	163	-	4	1112
1991	463	508	163	-	4	1138
1992	473	508	163	-	4	1148
1993	489	508	163	-	4	1164
1994	513	508	163	-	4	1188
1995	544	508	163	-	8	1223
1996	559	508	163	-	8	1238
1997	592	508	163	-	8	1271
1998	619	659	211	-	8	1497
1999	647	781	250	-	8	1686
2000	674	804	258	-	13	1749
2001	704	804	258	-	13	1779
2002	732	804	258	-	13	1807
2003	761	805	258	-	13	1837
2004	792	826	265	-	13	1896
2005	828	841	270	-	28	1967
2006	860	841	270	-	28	1999
2007	887	841	270	-	28	2026
2008	918	841	270	-	28	2057
2009	945	841	270	-	28	2084
2010	971	784	251	-	46	2052
2011	965	784	251	-	46	2046
2012	966	784	251	-	46	2047
2013	961	629	202	-	46	1838
2014	956	629	202	-	46	1833
2015	956	18	6	-	230	1210
2016	959	-	-	-	230	1189
2017**	949	-	-	-	230	1179
2018	220	-	-	-	230	450
2019	146	-	-	-	230	376
2020	110	-	-	-	230	340
2021	73	-	-	-	219	292
2022	37	-	-	-	219	256

*The mining operation is monitored by a separate Mining Production Management Group which has a staff of 138 individuals.

**Capacity of mine expired after year 2017.

Not included:

1. Overall management and engineering
2. Contingencies
3. General Contractor's personnel for initial development (1980-1984)

Note: Above figures represent the average daily manning requirements during the indicated year based on 3 shift operation including surface and subsurface personnel for each category.

Table 1-4
Personnel Assignment Schedule
Basalt - Cycle III

Year	Waste Storage Operation	Mining Operation*	Drilling and Trench Preparation	Sleeve Placement Operation	Backfill Operation	Total
1980	58	-	-	-	-	58
1981	64	-	-	-	-	64
1982	77	-	-	-	-	77
1983	85	348	-	-	-	433
1984	93	474	40	4	-	611
1985	366	476	117	5	-	964
1986	511	476	117	5	-	1109
1987	538	476	117	5	-	1136
1988	528	476	117	5	-	1126
1989	563	543	133	-	-	1239
1990	514	584	143	-	6	1247
1991	747	684	167	-	6	1604
1992	712	655	160	-	6	1533
1993	746	656	161	-	7	1570
1994	766	686	168	-	7	1627
1995	789	657	161	-	12	1619
1996	619	657	161	-	12	1449
1997	662	657	161	-	12	1492
1998	680	686	168	-	12	1546
1999	697	686	168	-	12	1563
2000	730	686	168	-	22	1606
2001	748	686	168	-	22	1624
2002	764	686	168	-	22	1640
2003	798	686	168	-	22	1674
2004	816	781	191	-	22	1810
2005	838	573	140	-	29	1580
2006	856	68	17	-	30	971
2007	853	-	-	-	154	1007
2008**	854	-	-	-	154	1008
2009	220	-	-	-	154	374
2010	146	-	-	-	154	300
2011	110	-	-	-	155	265
2012	73	-	-	-	85	158
2013	37	-	-	-	85	122

*The mining operation is monitored by a separate Mining Production Management Group which has a staff of 138 individuals.

**Capacity of mine expired after year 2008.

Not included:

1. Overall management and engineering
2. Contingencies
3. General Contractor's personnel for initial development (1980-1984)

Note: Above figures represent the average daily manning requirements during the indicated year based on 3 shift operation including surface and subsurface personnel for each category.

Table 3-1

Summary of Electrical Loads - Basalt

	Basalt- Cycle I 5 Yr. Retrievable			Basalt - Cycle II 5 Yr. Retrievable			Basalt - Cycle II 25 Yr. Retrievable			Basalt - Cycle III 5 Yr. Retrievable		
	Conn. KVA	Oper. KVA	Emerg. KVA	Conn. KVA	Oper. KVA	Emerg. KVA	Conn. KVA	Oper. KVA	Emerg. KVA	Conn. KVA	Oper. KVA	Emerg. KVA
Admin. Bldg.	211	168	9	211	168	9	211	168	9	211	168	9
Clinic	136	92	24	136	92	24	136	92	24	136	92	24
Whse. & Veh. Maint.	88	67	3	88	67	3	88	67	3	88	67	3
Gd. House Psnl.	29	23	20	29	23	20	29	23	20	29	23	20
Gd. House RR chk.	20	17	6	20	17	6	20	17	6	20	17	6
Cafeteria	177	129	5	177	129	5	177	129	5	177	129	5
Laundry	130	86	3	130	86	3	130	86	3	130	86	3
Firehouse	59	47	15	59	47	15	59	47	15	59	47	15
M & M Bldg.	437	290	56	437	290	56	437	290	56	437	290	56
Mine Oper. Bldg.	36	28	3	36	28	3	36	28	3	36	28	3
Oil Dpt. & Gen. Bldg.	102	81	62	102	81	62	102	81	62	102	81	62
Storage Bldg.	63	51	2	63	51	2	63	51	2	63	51	2
Water Tower	92	65	42	92	65	42	92	65	42	92	65	42
Exhst. Vent. Bldg. #1	6481	5132	839	6481	5132	839	6481	5132	839	6481	5132	839
Exhst. Vent. Bldg. #2	--	--	--	--	--	--	--	--	--	--	--	--
Supply Vent Bldg.	3228	2490	10	3228	2490	10	3246	2504	10	3228	2490	10
Boiler Plant	1120	892	228	1120	892	228	1120	892	228	1120	892	228
Refrig. Bldg.	393	314	25	393	314	25	393	314	25	393	314	25
HLW Bldg.	1966	926	657	1966	926	657	1966	926	657	1966	926	657
LLW Bldg.	232	141	109	232	141	109	232	141	109	232	141	109
Radwaste Bldg.	169	109	11	169	109	11	169	109	11	169	109	11
Alarm Comm. Ctr	130	107	70	130	107	70	130	107	70	130	107	70
Roadway Lighting	96	96	78	96	96	78	96	96	78	96	96	78
Security Lighting	17	17	17	17	17	17	17	17	17	17	17	17
M & M Cage Hoist	649	649	649	649	649	649	649	649	649	649	649	649
Aux. M & M Hoist	136	136	-	136	136	-	136	136	-	136	136	-
M & M Skip Hoist	2932	2932	-	2932	2932	-	2932	2932	-	2932	2932	-
HLW Hoist No.1	1475	1475	-	1475	1475	-	1475	1475	-	1475	1475	-
HLW Hoist No.2	1475	1475	-	1475	1475	-	1475	1475	-	1475	1475	-
LLW Hoist	717	717	-	717	717	-	717	717	-	717	717	-
Undergrd. Serv. Transfer												
Sta., & Mine Lighting	4642	2373	228	5778	2996	291	5629	2909	282	4186	2174	208
Mining Substation No. 1	2401	1801	-	3388	2541	-	3388	2541	-	2302	1727	-
Mining Substation No. 2	1413	1060	-	1413	1060	-	1413	1060	-	1413	1060	-
Mining Substation No. 3	1196	897	-	1196	897	-	1196	897	-	1196	897	-
TOTALS	32448	24883	3171	34571	26246	3234	34440	26173	3225	31893	24610	3151

TABLE 4-1

BASALT

SHAFT DIAMETERS (Feet)

DESIGNATION	<u>5 Year Retrievable</u>			<u>25 Year Retrievable</u>
	CYCLE I	CYCLE II	CYCLE III	CYCLE II
MEN & MATERIAL SHAFT	27	27	27	27
LOW-LEVEL WASTE SHAFT	10	10	10	10
CANISTERED WASTE SHAFT	14	14	14	14
VENTILATION SUPPLY SHAFT	28	28	28	30
VENTILATION EXHAUST SHAFT	28	28	28	30

Table 4-2

Basic Shaft Information for Basalt

<u>Shaft Function</u>	<u>Diameter (Inside)</u>	<u>Depth</u>	<u>Excavation Method</u>
Men and Materials	27 ft.	2107 ft.	Conventional
Ventilation Supply	28 ft.	1970 ft.	Conventional
Ventilation Exhaust	28 ft.	1900 ft.	Conventional
Canistered Waste	14 ft.	1962 ft.	Conventional
Low-Level Waste	10 ft.	1986 ft.	Conventional

Table 4-3.

Lateral Development from Shafts in Basalt

<u>Shaft</u>	<u>Elevation</u>	<u>Description</u>
Men & Materials	1900	Drift, 40' l x 25' h x 30' w
	1970	Drift, 40' l x 14' h x 30' w Pocket, 44' h x 18' l x 19' w Drift, 30' l x 9' h x 18' w Raise, 21' l x 6' h x 6' w
	2100	Drift, 40' l x 14' h x 15' w
	1825	Transporter Room, approximately 19,000 cu. yds.
Canistered Waste	1900	Transporter Room, approximately 19,000 cu. yds.
Low-Level Waste	1900	Drift, 40' l x 25' h x 30' w
Ventilation Supply	1900	Drift, 40' l x 20' h x 20' w
	1970	Drift, 40' l x 20' h x 20' w
Ventilation Exhaust	1825	Drift, 40' l x 20' h x 20' w
	1900	Drift, 40' l x 20' h x 20' w

Table 5-1

BASALT REPOSITORY SUMMARY

Cycle (Date Filled)	Waste Type	Capacity (No. Con- tainers)	Room Length (feet)	Room Opening W x H (ft.)	Approx. ¹ Area (acres)	No. Rooms	Waste Units/ Room	Total No. Panels	No. Rooms per Panel/Panel Number	No. ² Rows	Long Spacing ea. Row	Storage Configuration
I-Total Recycle (2008)	HLW (Glass)	119,710	280 560	18 x 20	967	83 779	72 146	3 19	11/P #1 31/P #2 41/P #3 to 22	2	7 ft.	Can. in Holes
	IL-TRU CW	303,197 62,451	280 560	18 x 20	502 104	202 694	216 464	4 11	26/P #1 44/P #2 66/P #3 to 11 58/P #12 to 15	2	2 ft.	Can. in Trenches
	LL-TRU	731,520	280 560	18 x 20	131	24 152	2208 4464	2 7	12/P #1 to 5 29/P #6 to 9			Palletized Drums
II-Spent Unrepro- cessed Fuel (2017)	PWR	268,524	280 560	18 x 25	1155	255 1404	84 176	5 21	13/P #1 26/P #2 72/P #3 to 22 45/P #23 to 26	2	6 ft.	Can. in Holes
	BWR	393,480	280 560	18 x 25	637	275 720	216 464	6 10	18/P #1 29/P #2 42/P #3 and 4 72/P # 5 to 16	2	2 ft.	Can. in Trenches
	LLW	86,832	280 560	18 x 25	18	9 15	2208 4464	1 1	9/P #1 15/P #2			Palletized Drums
III- U Only Cycle (2008)	HLW (Glass)	119,710	280 560	18 x 20	967	83 779	72 146	3 19	11/P #1 31/P #2 41/P #3 to 22	2	7 ft.	Can. in Holes
	IL-TRU CW	263,943 65,049	280 560	18 x 20	440 109	202 615	216 464	4 10	26/P #1 44/P #2 66/P #3 to 11 51/P #12 to 14	2	2 ft.	Can. in Trenches
	LL-TRU	89,040	280 560	18 x 20	19	10 15	2208 4464	1 1	10/P #1 15/P #2			Palletized Drums

Table 5-1 (cont'd.)

REPOSITORY SUMMARY - CYCLE II
25-YEAR RETRIEVABLE CASE

Medium (Date Filled)	Waste Type	Capacity (No. Con- tainers)	Room Length (ft.)	Room Opening W x H (ft.)	Approx. ¹ Area (acres)	No. Rooms	Waste Units/ Room	Total No. Panels	No. Rooms per Panel/Panel Number	No. ² Rows	Long. Spacing ea. Row	Storage Configuration
Basalt (2008)	PWR	131,754	280	18 x 25	1063	113	42	3	10/P #1	1	6.5 ft.	Can. in Holes
			560			1512	84	22	31/P #2 72/P #3 to 22 48/P #23 to 25			
	BWR	199,808	280	18 x 25	556	121	128	3	19/P #1	2	2 ft.	Can. in Trench
			560			720	256	10	30/P #2 72/P #3 to 13			
	LLW	60,048	280	18 x 25	19	9	2208	1	9/P #1 & 2			Palletized Drums
			560			9	4464	1				

1) Approximate area is gross acreage associated with each storage section including main corridors; exhaust corridors and buttress pillars; it is not the net area used to calculate areal heat loads.

2) Refers to rows of canisters in each room.

Table 5-2

LOCAL AREAL THERMAL LOADINGBASALT

<u>Cycle</u>	<u>Waste Type</u>	<u>Average KW/can</u>	<u>Allow. Areal Thermal Loading</u>	<u>Design Areal Thermal Loading</u>
I	HLW	1.2	190	189
II	PWR	0.55	190	167*
	BWR	0.18	190	142*
II (25-Yr.)	PWR	0.55	80	79
	BWR	0.18	80	78
III	HLW + Pu (glass)	1.2	190	189

* Design Areal Thermal Loading could not be brought up to Allowable due to physical restrictions on spacing.

Table 5-3

REPOSITORY TONNAGE SUMMARY

	<u>Cycle</u>	<u>Tonnage Mined (x 10⁶)</u>	<u>Room Backfill Tonnage (x 10⁶)</u>	<u>Total Backfill Tonnage (x 10⁶)^a</u>	<u>Off-Site Removal Tonnage (x 10⁻⁶)</u>	<u>On-Site Storage Tonnage (x 10⁶)^c</u>	<u>Backfill Tonnage Factor^b</u>
Basalt:	I	61	18	28	33	1.1	.5
	II	93	33	47	46	.7	.5
	III	54	16	25	29	1.1	.5
	II (25-Yr.)	87	*	*	87	*	*

- a. Total backfill is the tonnage mined less the tonnage associated with the trenches and drilled holes all multiplied by the backfill tonnage factor.
- b. The backfill tonnage factor is the broken rock density divided by the inplace rock density times the percentage of room face area to be backfilled.
- c. 60% of material excavated from rooms for 5-year capacity.
- * Backfill for the 25-year retrievable repository is not considered in this study.

TABLE 5-4
HIGH-LEVEL WASTE RECEIVING RATES^{a,e} (CYCLES I and III)

Year	Glass Waste Canisters		Calcine Waste Canisters	
	Annual	Accumulated	Annual	Accumulated
1985 ^d	215	215	240	240
1986	859	1073	966	1206
1987	1141	2214	1283	2490
1988	1293	3507	1454	3943
1989	1461	4968	1643	5586
1990	1577	6545	1773	7359
1991	2126	8671	2389	9749
1992	2410	11081	2709	12458
1993	2702	13783	3038	15496
1994	3089	16872	3472	18968
1995	3640	20512	4090	23058
1996	3841	24353	4317	27375
1997	4368	28721	4909	32284
1998	4881	33602	5486	37770
1999	5434	39037	6109	43878
2000	6004	45040	6748	50626
2001	6543	51583	7355	57981
2002	7119	58702	8001	65982
2003	7698	66400	8652	74634
2004	8293	74692	9322	83956
2005	8888	83580	9989	93945
2006	9478	93058	10654	104599
2007	10033	103091	11277	115876
2008	10558	113650	11867	127743
2009	11069	124719	12441	140184
2010	11564	136283	12997	153181
2011	12012	148295	13498	166679
2012	11923	160218	13403	180082
2013	11809	172027	13274	193356
2014	11688	183715	13137	206493
2015	11599	195314	13036	219529
2016	11382	206696	12791	232320
2017	11209	217905	12600	244920
2018	11039	228944	12409	257329
2019	10862	239806	12208	269537
2020	10745	250551	12077	281614
2021	10565	261116	11874	293488
2022	10206	271322	11471	304959
2023	10197	281519	11459	316418
2024	10206	291725	11471	327889
2025	9784	301509	10995	338884

^aBased on projections prepared by OWI (June-1977). Assumes 480 GWe installed nuclear capacity by the year 2000 (10 year delay prior to burial).

^bAssuming waste density of 7.0 ft³/MTU and canister volume of 6.28 ft³ (0.178m³).

^cAssuming waste density of 3.5 ft³/MTU and canister volume of 2.79 ft³ (0.079m³).

^dA total backlog of 704 HLW-glass canisters or 791 HLW-calcine canisters built-up before 1985 is worked off between 1991-1995 at the rate of 140.8 glass or 158.2 calcine canisters per year.

^eWaste projections apply to all of the reprocessing cycles: U + Pu, U only with Pu in HLW.

TABLE 5-5

CLADDING WASTE RECEIVING RATES^{a,b} (CYCLES I and III)

<u>Year</u>	<u>Canisters^c</u>	
	<u>Annual</u>	<u>Accumulated</u>
1985 ^d	169	169
1986	674	843
1987	730	1573
1988	843	2416
1989	1011	3427
1990	1180	4607
1991	1966	6573
1992	2135	8708
1993	2303	11011
1994	2528	13539
1995	2753	16292
1996	2360	18652
1997	2585	21236
1998	2753	23989
1999	2978	26967
2000	3202	30169
2001	3427	33596
2002	3596	37192
2003	3820	41012
2004	3989	45001
2005	4157	49158
2006	4326	53484
2007	4270	57754
2008	4270	62024
2009	4213	66237
2010	4157	70394

^aCladding wastes for the U-recycle and U + Pu recycle cases.

^bBased on projections prepared by OWI (June-1977). Assumes a 480 GWe installed nuclear capacity by the year 2000 (5 year delay prior to burial).

^cReference canister is 10 feet long with a 1 foot diameter, containing 6.28 ft³ (.178m³) waste.

^dBacklog of 2809 containers in 1985 worked off during 1991-1995.

TABLE 5-6

ILW AND LLW RECEIVING RATES - U+Pu RECYCLE^a (CYCLE I)

<u>Year</u>	<u>ILW Canisters^b</u>		<u>LLW Drums^c</u>	
	<u>Annual</u>	<u>Accumulated</u>	<u>Annual</u>	<u>Accumulated</u>
1985 ^d	1404	1404	481	481
1986	5618	7022	1923	2404
1987	6180	13202	2404	4808
1988	5618	18820	3846	8654
1989	6742	25562	9135	17789
1990	5056	30618	6731	24520
1991	12191	42809	9808	34328
1992	11629	54438	11250	45578
1993	12191	66629	16058	61636
1994	13315	79944	16538	78174
1995	13876	93820	18462	96636
1996	8989	102809	21154	117790
1997	10674	113483	25000	142790
1998	11236	124719	28846	171636
1999	12360	137079	31731	203367
2000	13483	150562	37500	240867
2001	14607	165169	40865	281732
2002	16292	181461	46635	328367
2003	16854	198315	50000	378367
2004	18539	216854	57212	435579
2005	19663	236517	62500	498079
2006	20787	257304	68750	566829
2007	21348	278652	73558	640387
2008	22472	301124	80288	720675
2009	23034	324158	86538	807213
2010	23596	347754	88942	896155

^aBased on projections prepared by OWI (June-1977). Assumes 480 GWe installed nuclear capacity in year 2000 (5 year delay prior to burial).

^bILW Reference canister is 10 ft. long, 1 ft. diameter with an active volume of 6.28 ft³ (0.178m³).

^cLLW reference drum is a type 170,55 gallon (7.35 ft³ or 0.208 m³).

^dPrior to 1985 backlog of 30,056 ILW and 10,577 LLW canisters is accumulated. This backlog is worked off between 1991 and 1995.

TABLE 5-7

ILW AND LLW RECEIVING RATES^a - U RECYCLE (CYCLE III)

<u>Year</u>	<u>ILW Canisters^b</u>		<u>LLW Drums^c</u>	
	<u>Annual</u>	<u>Accumulated</u>	<u>Annual</u>	<u>Accumulated</u>
1985	1404	1404	481	481
1986	5618	7022	1923	2404
1987	6180	13202	2404	4808
1988	5618	18820	1923	6731
1989	6742	25562	2404	9135
1990	5056	30618	1923	11058
1991	12191	42809	4038	15091
1992	11067	53876	4038	19129
1993	12191	66067	4038	23167
1994	12753	78821	4519	27686
1995	13314	92135	4519	32205
1996	7865	100000	2885	35089
1997	8989	108989	2885	37974
1998	9551	118540	3365	41339
1999	10112	128652	3365	44704
2000	11236	139888	3846	48551
2001	11798	151686	3846	52397
2002	12360	164046	4327	56723
2003	13483	177529	4327	61050
2004	14045	191574	4808	65858
2005	14607	206181	4808	70666
2006	15169	221350	5288	75954
2007	15169	236519	5288	81242
2008	15169	251688	5288	86530
2009	15169	266857	5288	91818
2010	15169	282026	5288	97106

^aBased on projections prepared by OWI (June-1977). Assumes 480 GWe installed nuclear capacity in year 2000 (5 year delay prior to burial).

^bReference ILW canister is 10 ft. long, with 1 ft. diameter (6.28 ft³ or .178m³).

^cReference LLW container is a type 17C, 55 gallon drum (7.35 ft³ or .208m³).

^dBacklog of 30056 canisters ILW and 10575 drums LLW in 1985 to be worked off during 1991-1995.

TABLE 5-8

10-YR OLD SPENT FUEL RECEIVING RATES^a (CYCLE II)

Year	<u>PWR Canisters^b</u>		<u>BWR Canisters^c</u>	
	<u>Annual</u>	<u>Accumulated</u>	<u>Annual</u>	<u>Accumulated</u>
1985	139	139	454	454
1986	555	694	1814	2268
1987	979	1673	2124	4392
1988	1390	3063	2435	6827
1989	1657	4720	2524	9351
1990	1906	6626	2596	11947
1991	2336	8962	3723	15670
1992	2582	11545	4338	20008
1993	2953	14498	4814	24822
1994	3446	17945	5235	30057
1995	4045	21990	6021	36078
1996	4388	26378	6391	42469
1997	4976	31354	7520	49989
1998	5616	36970	8453	58442
1999	6270	43240	9422	67864
2000	6955	50195	10445	78309
2001	7637	57832	11436	89745
2002	8323	66155	12441	102186
2003	9026	75181	13498	115684
2004	9739	84920	14575	130259
2005	10506	95426	15734	145993
2006	11240	106666	16838	162831
2007	11953	118619	17903	180734
2008	12642	131261	18938	199672
2009	13301	144562	19910	219582
2010	13915	158477	20882	240464
2011	13939		20980	
2012	13932		20849	
2013	13932		20917	
2014	13932		20826	
2015	13932		20826	
2016	14043		20826	
2017	13877		20826	
2018	14008		20826	
2019	13812		21476	
2020	13928		20609	
2021	13951		21594	
2022	13951		21269	
2023	14261		21738	
2024	13728		21667	
2025	13428		21027	

^aBased on projections prepared by OWI (July-1977). Assumes 480 GWe by year 2000.

^bReference PWR canister contains 1 PWR assembly (0.461 MTHM).

^cReference BWR canister contains 1 BWR assembly (0.183 MTHM).

TABLE 5-9

SPENT FUEL - LLW RECEIVING RATES^a (CYCLE II)

<u>Year</u>	<u>Number of LLW Drums^b</u>	
	<u>Annual</u>	<u>Accumulated</u>
1985 ^c	208	208
1986	962	1170
1987	1093	2263
1988	1225	3488
1989	1363	4851
1990	1508	6359
1991	2438	8797
1992	2589	11386
1993	2741	14127
1994	2899	17026
1995	3056	20082
1996	2423	22505
1997	2575	25080
1998	2719	27799
1999	2866	30665
2000	3011	33676
2001	3147	36823
2002	3147	39970
2003	3147	43117
2004	3147	46264
2005	3147	49411
2006	3147	52558
2007	3147	55705
2008	3147	58852
2009	3147	61999
2010	3147	65146
2011	3114	
2012	3094	
2013	3081	
2014	3048	
2015	2995	
2016	2935	
2017	2057	
2018	2823	
2019	2782	
2020	2753	
2021	2700	
2022	2631	
2023	2553	
2024	2452	
2025	2315	

^aBased on projections prepared by OWI (June-1977). Assumes 480 GWe installed nuclear capacity by year 2000 and 13.7 m³ waste generated per GWe-yr. (With a compaction factor of 10).

^bReference drum is DOT type 17C 55 gal. drum containing 7.35 ft³ (0.208m³) of waste.

^cBacklog acquired before 1985 worked off between 1991-1995. Waste is shipped 1 year after generation - after the backlog is worked off.

TABLE 5-10

MINING PRODUCTION SUMMARY
PEAK REQUIREMENTS

CYCLE I

<u>Year</u>	<u>Room Mining Units</u>	<u>Corridor Mining Units</u>	<u>Vent. Mining Units</u>	<u>Trenching Units</u>	<u>Drilling Units</u>
1983	-	2	1	-	-
1984	3	2	1	1	4
1985	3	2	1	1	4
1986	3	2	1	1	4
1987	3	2	1	1	4
1988	3	2	1	1	4
1989	3	2	1	2	4
1990	3	2	1	2	4
1991	3	2	1	2	7
1992	5	2	1	2	7
1993	5	2	1	2	7
1994	5	2	1	2	7
1995	5	2	1	2	7
1996	5	2	1	2	10
1997	5	2	1	3	10
1998	5	2	1	2	10
1999	5	2	1	2	10
2000	5	2	1	2	10
2001	5	2	2	2	10
2002	5	2	2	2	10
2003	5	2	2	2	10
2004	5	2	2	2	10
2005	5	2	-	2	10
2006	-	-	-	-	10

TABLE 5-11

MINING PRODUCTION SUMMARY
PEAK REQUIREMENTS

CYCLE II

Year	Room Mining Units	Corridor Mining Units	Vent. Mining Units	Trenching Units	Drilling Units
1983	-	2	1	-	-
1984	3	2	1	1	5
1985	3	1	1	1	5
1986	3	1	1	1	5
1987	3	1	1	1	5
1987	3	1	1	1	5
1988	3	1	1	1	5
1989	3	1	1	1	5
1990	3	1	1	1	15
1991	3	1	1	1	15
1992	3	1	1	1	15
1993	3	1	1	1	15
1994	3	1	1	1	15
1995	3	1	1	1	15
1996	3	1	1	1	15
1997	3	1	1	1	15
1998	5	1	1	1	15
1999	5	2	1	1	15
2000	5	2	1	1	15
2001	5	2	1	1	15
2002	5	2	1	1	15
2003	5	2	1	1	20
2004	5	2	1	2	20
2005	5	2	1	2	20
2006	5	2	1	2	20
2007	5	2	1	2	20
2008	5	2	1	2	20
2009	5	2	1	2	20
2010	5	2	1	2	20
2011	5	2	-	2	20
2012	5	2	-	2	20
2013	5	-	-	2	20
2014	5	-	-	2	20
2015	-	-	-	-	20

TABLE 5-12

MINING PRODUCTION SUMMARY
PEAK REQUIREMENTS

CYCLE III

Year	Room Mining Units	Corridor Mining Units	Vent. Mining Units	Trenching Units	Drilling Units
1983	-	2	1	-	-
1984	3	2	1	1	4
1985	3	1	1	1	4
1986	3	1	1	1	4
1987	3	1	1	1	4
1988	3	1	1	1	4
1989	3	2	1	1	7
1990	3	2	1	2	7
1991	4	2	1	2	7
1992	4	2	1	1	7
1993	4	2	1	1	9
1994	4	2	1	2	9
1995	4	2	1	1	9
1996	4	2	1	1	9
1997	4	2	1	1	9
1998	4	2	1	2	9
1999	4	2	1	2	9
2000	4	2	1	2	9
2001	4	2	1	2	9
2002	4	2	1	2	9
2003	4	2	1	2	9
2004	5	2	1	2	9
2005	5	-	-	2	9
2006	-	-	-	2	9

TABLE 5-13

MINING PRODUCTION SUMMARY
PEAK REQUIREMENTS

CYCLE II - 25-YEAR

<u>Year</u>	<u>Room Mining Units</u>	<u>Corridor Mining Units</u>	<u>Vent. Mining Units</u>	<u>Trenching Units</u>	<u>Drilling Units</u>
1983	-	2	2	-	-
1984	4	2	2	1	4
1985	4	2	2	1	4
1986	4	2	2	1	6
1987	4	2	2	1	8
1988	4	2	2	2	10
1989	4	2	2	2	12
1990	7	2	2	2	12
1991	7	2	2	2	12
1992	7	2	2	2	12
1993	7	2	2	2	12
1994	7	2	2	2	12
1995	7	2	1	2	12
1996	7	2	1	2	14
1997	7	2	1	2	14
1998	7	2	1	2	14
1999	7	2	1	2	14
2000	7	2	1	2	14
2001	7	2	1	2	14
2002	7	-	1	2	14
2003	7	-	-	2	14
2004	7	-	-	1	14
2005	7	-	-	-	14

TABLE 6-1

TYPICAL SUBSURFACE VENTILATING FAN SPECIFICATIONS.

<u>Type</u>	<u>Nominal Capacity</u> <u>Per Fan (CFM)</u>	<u>Est. Total Pressure</u> <u>(inches of water)</u>	<u>Motor HP</u>
Main Supply Fans			
(Cycles I, II, III, 5 yr. retriev.)	250,000	7	400
(Cycles II, 25 yr. retriev.)	285,000	7	400
Placement Operations			
Exhaust Fans	250,000	15	900
Mining Exhaust Fans			
Normal Operations			
(Cycles I, II & III, 5 yr. retriev.)	600,000	8	900
(Cycles II, 25 yr. retriev.)	430,000	10	900
Emergency Operations			
(All cycles, 5 or 25 yr. retriev.)	250,000	15	900

Table 6-2

ESTIMATED UNDERGROUND VENTILATION REQUIREMENTS
AT PEAK OF MINING AND PLACEMENT OPERATIONS

<u>Waste Repository Type</u>	<u>Mining Operation Exhaust (cfm)</u>	<u>Placement Operation Exhaust (cfm)</u>	<u>Total Exhaust (cfm)</u>	<u>Exhaust Shaft Diameter/Air Velocity* (fpm)</u>
(5-Yr.):				
Fuel Cycle I	1,750,000	250,000	2,000,000	28 ft/3355
Fuel Cycle II	1,300,000	250,000	2,050,000	28 ft/3440
Fuel Cycle III	1,750,000	250,000	2,000,000	28 ft/3355
(25-Yr.):				
Fuel Cycle II	2,150,000	250,000	2,400,000	30 ft/3490

* Average velocity for mining and placement compartments.

TABLE 6-3.

SUBSURFACE AIR VELOCITIES

<u>Type of Airway</u>	<u>Air Velocity (FPM)</u>
Ventilation Shafts (Concrete lined, smooth surface)	3350
Main Supply Air Corridors	
Cycles I & III, HLW mine	1000
ILW mine	750 - 930
Cycles II, 5 & 25-yr, PWR mine	1000
BWR mine	750 to 1000
Branch Corridors	
Drill/blast & mucking	300 to 600
Waste canister drilling	200
Backfilling	100
Storage Rooms	
Mining	50 to 300
Placement	Min. 50
Mining Exhaust Corridor	750 to 1300
Placement Exhaust Airways	
Branch airways	100 to 300
Main airways	300 to 625

TABLE 6-4

Canistered Waste Receiving Building
Confinement Zone Classifications
and Ventilation Design Requirements

Room	Confine- ment Zone **	Room Pressure (Inches of water gage)	<u>Ventilation Criteria</u>	
			<u>Air Changes per Hour</u>	<u>Outside Air %</u>
Canister Storage and Feed Room	I	-1.00	2	-
Transfer Galleries	I	-1.00	6	-
Transfer Cells	I	-1.50	6	-
Operating Galleries	II	-0.10	6	100
Hoist Machine Room	II	-0.25	10	100
Service and Maintenance	II	-0.10	10	100
Cask Unloading	II	-0.10	3*	66
Exhaust Air Filter Room	II	-0.50	2	100
Mechanical Equipment Rm.	II	-0.10	6	100
Electrical Equipment Rm.	III	+0.10	6	100
Security Room	III	-0.10	10	100
Shift Foreman's Room	III	-0.10	10	100
Counting Room	III	-0.10	10	100
Chemical Lab.	III	-0.10	10	100
Health Physics Room	III	-0.10	10	100
Toilet Rooms	III	-0.10	10	-
Shower Rooms	III	-0.10	10	-
Locker Rooms	III	-0.10	10	100

*Overall ventilation rate for the total volume of Cask Unloading Rooms. Effective air change rate for the lower 25 ft. high portion of the room will be about six changes per hour.

**For a definition of Confinement Zone, see section 6.2.1.2

TABLE 6-5

Low-Level Waste Receiving Building
Confinement Zone Classifications
and Ventilation Design Requirements

Room	Confine- ment Zone *	Room Pressure (Inches of water gage)	Ventilation Criteria	
			Air Changes per Hour	Outside Air %
Unloading and Parking	II	-0.50	10	100
Palletizing and Depalletizing	II	-0.50	10	100
Counting	II	-0.25	10	100
Inspection Room	II	-0.25	10	100
Decon. and Overpack	II	-0.25	10	100
Exhaust Fan Filter Room	II	-0.50	2	100
Hoist House	II	-0.10	10	100
Foreman's Room	III	-0.10	10	100
Health Physics	III	-0.10	10	100
Mechanical Equipment Room	III	-0.10	6	100
Electrical Equip. Room	III	+0.10	6	100
Battery Room	III	-0.10	15	100
Toilet Rooms	III	-0.10	10	-
Locker Rooms	III	-0.10	10	100
Janitor Closet	III	-0.10	10	-

*For a definition of Confinement Zone, see section 6.2.1.2

APPENDIX A
HOISTING SYSTEMS

A. Introduction

A total of six hoists will be installed in three of the five shafts. Four will be tower-mounted friction hoists, one will be a tower-mounted drum hoist and one will be a ground-mounted drum hoist. A list of permanent hoists is given below.

1. M & M Shaft

a. Skip Hoist

No: 1
Type: Friction
Mounting: Tower
Wheel Dia.: 12'-0"
No. Ropes: 4
Rope Size: 1-3/8"
RMS H.P.: 3269 (F.V.)

S.C. - Self Cooled
F.V. - Forced Ventilation
L.C. - Locked Coil
F.S. - Flattened Strand

b. Cage Hoist

No: 1
Type: Friction
Mounting: Tower
Wheel Dia.: 8'-0"
No. Ropes: 4
Rope Size: 1-5/16"
RMS H.P.: 770 (S.C.)

c. Auxiliary Cage Hoist

No: 1
Type: Drum
Mounting: Tower
Wheel Dia.: 5'-0"
No. Ropes: 1
Rope Size: 3/4"
RMS H.P.: 160 (S.C.)

2. LLW Shaft

a. Cage Hoist

No: 1
Type: Drum
Mounting: Ground
Drum Dia.: 8'-0"
No. Ropes: 1
Rope Size: 1-1/4"
RMS H.P.: 850 (S.C.)

3. Canistered Waste Shaft

a. No: 2
Type: Friction
Mounting: Tower
Wheel Dia.: 15'-0"
No. Head Ropes: 6
Head Rope Size: 1-7/8"
RMS H.P.: 1725 (F.V.)

B. The LLW Shaft

The LLW Shaft hoisting system has been designed to handle low-level pallets and waste containers with a maximum weight of 10,000 lbs. These containers will be handled in a single cage travelling at a speed of 1200 FPM. A single drum, ground-mounted hoist, with a diameter of 8 ft. will be installed. Rope size is 1-1/4 in.

C. The Canistered Waste Shaft

The Canistered Waste Shaft hoisting system is designed to handle HLW, IL-TRU, CW, PWR and BWR canisters having a maximum size of 15 in. diameter by 16 ft. long and a maximum weight of 10,000 lbs. The canisters are to be lowered in a specially designed cage having 2 in. thick stainless steel walls, a 5 in. thick lead core and 1/4 in. steel plate liner retainer skin. The cage has a weight of 200,000 lbs. The cage will be hoisted in balance with a 200,000 lb. counterweight. Reliability of canister delivery to the repository will be ensured by providing dual cage counterweight systems. The Canistered Waste Shaft is divided into two sections, with a separate hoist in each half. The divider can be a concrete wall or a steel plate with intermittent doors to facilitate retrieval of malfunctioning equipment. Due to the heavy loads to be hoisted, friction type hoists were selected. These hoists are tower-mounted over the Canistered Waste Shaft. In order to ensure safe operation of this facility, the shaft will be equipped with buntons at 4-ft. centers and cages will be guided by elevator type guide rails. The cages will also be equipped with elevator type braking mechanism designed to stop the cage during an overspeed condition.

D. Men and Materials Shaft

The Men and Materials Shaft hoisting system has been designed to meet the requirements of excavating the repository. Three separate hoisting systems are to be installed in a tower above the M & M Shaft.

Broken rock will be hoisted out of the mine at a rate of up to 19,500 TPD in two 18-ton capacity skips operating in balance. The hoist is a friction type with a wheel diameter of 12 ft. and a hoisting speed of 2040 FPM.

Men and materials will be hoisted in a large cage designed to meet the following criteria:

1. Capacity to sling 26-ton load.
2. Capacity to raise and lower diesel powered vehicles (maximum width 8 ft.)
3. Capacity to hoist at least 140 men in one trip.

The cage hoist will operate at a speed of 2000 FPM. The wheel diameter is 8 ft. and is equipped with four 1-5/16 in. diameter cables. The cage will operate in balance with the counterweight.

An auxiliary cage will also be installed in the M & M Shaft. The purpose of this cage is to lower men and small items during the operating shift, thus allowing the large cage to be scheduled to optimum use. The auxiliary cage hoist will have a capacity of 3,000 pounds or six men. The hoist is single drum, having a diameter of 5 ft. and a single 3/4-in. diameter cable.

E. Schedules

For the purpose of this study, five shafts have been designed to accommodate the excavation of an underground repository in basalt and the placement of radioactive waste material. All of the shafts are to be excavated using conventional drill and blasting shaft sinking techniques. Preplacement development mining will be from the M & M Shaft.

Construction of all five shafts will begin at the same time. An estimate of the time required to complete each shaft is shown in Dwg 37 in all sets.

APPENDIX B

JOB CLASSIFICATION BREAKDOWN SUMMARY

BASALT CYCLE II

	<u>Symbol</u>	<u>Number</u>
Supervisory and Clerical	A	131
Administrative and Management	B	212
Professionals	C	24
Skilled Labor	D	1,221
Miners	E	235
Semi-skilled Labor	F	355
Technicians	T	44
		<u>2,222</u>

The above figures correspond to the peak average daily man-shift requirements occurring in the year 2009 for the Basalt Cycle II repository. Included in these figures are the personnel for the waste storage operation, mining operation, drilling operation, back-filling operation, and the mining production management group. Since the overall management and engineering requirements depend on the site selection, they are not included.

The Supervisory and Clerical category includes typists, secretaries, clerks and job supervisors. The accounting, employee relations, and public relations personnel are included under the Administrative and Management category.

The Professional classification is for other positions requiring advanced education. This includes lawyers, engineers, health care personnel and job specialists. Those persons requiring some post high school professional training, such as lab personnel are classified as technicians.

Since miners are considered to perform unique functions, they are listed separately. The mining category includes charge loading crews, blasting crews, and jumbo operators. The Skilled Labor section consists of those assigned to operate any other mechanical devices, such as trucks, transporters or cranes. The Semi-skilled category comprises building custodians, food and clean-up services, and helpers to the skilled laborers.

An approximate classification breakdown summary can be obtained for any given year regardless of the fuel cycle by prorating the information given in the subsequent pages for the year 2009 with the values shown in the tables 1-2, 1-3, and 1-4 of the Basalt Technical Report.

JOB CLASSIFICATION BREAKDOWN

BASALT CYCLE II

	<u>Man-Shifts Per Day</u>	<u>Job* Classification</u>
<u>I - Waste Storage Operation</u>		
Underground Storage		
a) LLW		
Shaft Crew	4	D
Forklift Drivers	5	D
Laborers (room)	5	F
Equipment Maintenance	3	D
b) PWR/BWR		
Shaft Crew	23	D
Transporter Operators	32	D
Transporter Maintenance	12	D
Room Laborers	23	F
Crusher Crew	11	F
Maintenance Crew	12	D
Above Ground Storage		
a) High Level Waste Bldg.		
Cask Washdown Crew	23	F
Bay Crane Operators	14	D
Bay Laborers	33	F
Bay Inspectors & Monitors	22	D
Transfer Cell Monitors	11	D
Transfer Cell Operators	70	D
Crane Operators	14	D
Hoist Operators	14	D
Lab Personnel	19	T
Mechanical & Electrical Services	19	D
Supervisors & Clerical	21	A
b) Low Level Waste Bldg.		
Crane Operators	2	D
Transfer Cell Laborers	4	D
Fork Lift Drivers	5	D
Inspectors & Testers	4	D
Lab Personnel	4	T
Maintenance	3	D
Supervisors & Clerical	4	A
c) Control Room		
Monitoring & Scheduling Personnel	35	B
d) Railroad Operations		
Operations Personnel	31	D
Equipment Maintenance	22	D

*for Job Classification definitions see "Job Classification Breakdown Summary"

JOB CLASSIFICATION BREAKDOWN

BASALT CYCLE II

	<u>Man-Shifts Per Day</u>	<u>Job* Classification</u>
e) Shipment Inspections Handling & Warehouse Operations	18	F
f) Liquid Rad Waste		
Crane Operators	4	D
Lab Personnel	8	T
Mechanical & Electrical Services	4	D
Supervisors & Clerical	5	A
Support Activities		
a) Ventilation Maintenance	9	D
b) Boiler, Refrigeration, Coal Handling Labor & Maintenance	16	F
c) Motor Pool and Fuel Depot Operations Personnel & Maint.	6	F
d) Maintenance		
Roads & Grounds	4	F
Building	4	F
Equipment	6	D
Electricians	8	D
Utilities	6	D
Instrument Repair	4	D
Custodial	12	F
e) Security		
Administration Building	8	D
Main Gate	8	D
Railroad Gate	4	D
Control Room	4	D
High Level Waste Building	4	D
Patrols	15	D
Underground	49	D
Badge Checkers	6	D
Security Chief	3	D
Clerical	2	A
f) Miscellaneous		
Laundry	8	F
Cafeteria	9	F
Change House	10	F
Fire Protection	22	D
Radiation Safety	25	D
Administration & Management	150	B

*for Job Classification definitions see "Job Classification Breakdown Summary"

JOB CLASSIFICATION BREAKDOWN

BASALT CYCLE II

II - Mining Operation

<u>Section</u>	<u>Type</u>	<u>Man-Shifts Per Day</u>	<u>Job* Classification</u>
Mining @ Face	Miners	226	E
	Equipment Operators	215	D
	Clerks	3	A
Underground Haulage	Grizzly Operators	21	D
	Train Crew	7	D
	Crusher Operators	3	D
	Conveyor Operators	3	D
	Helpers	6	F
Shaft Hoisting	Hoistmen	5	D
	Deckmen	3	D
	Cage Tenders	3	D
	Skip Operators	3	D
Surface Disposal	Equipment Operators	41	D
Support			
a) Underground	Mechanics	42	D
	Welders	11	D
	Helpers	33	F
b) Surface Maint.	Mechanics	26	D
	Machine Operators	12	D
	Welders	5	D
	Helpers	29	F
	Plant Operators	7	D
	Blacksmiths	2	D
	General Maint.	10	F
	Electricians	24	D
	Electrician Helpers	19	F
	Ventilation Maint.	12	D
c) General	Mining Supervisors	40	A
	Maint. Supervisors	24	A
	Surface Supervisors	6	A

III - Drilling

Drilling	Equipment Operators	132	D
	Maintenance Personnel	33	D
	Helpers	33	F
Frame Placing	Equipment Operators	20	D
	& Helpers	29	F
Trench Prep.	Equipment Operators	6	D
	Miners	9	E
	Service	8	D

IV - Backfill

Backfill	Equipment Operators (dozers & trucks)	28	D
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*for Job Classification definitions see "Job Classification Breakdown Summary"

JOB CLASSIFICATION BREAKDOWN

BASALT CYCLE II

	<u>Man-Shifts Per Day</u>	<u>Job* Classification</u>
<u>V - Mining Production Management Group</u>		
A) Engineering		
Chief Engineer	1	C
Industrial Engineer	1	C
Ventilation Engineer	1	C
Electrical/Mechanical Engineers	3	C
Mining Engineer	1	C
Junior Engineers	8	C
Technicians	13	T
Ventilation Instrument Men	4	D
Chief Planner	1	C
Chief Draftsman	1	D
Draftsmen	3	D
Chief Surveyor	1	D
Surveying Party Leaders	4	D
Surveying Instrument Men	4	D
Surveying Rod Men	4	F
Surveying Clerks	4	D
Typists	2	A
Secretary	1	A
B) Accounting		
Accounting & Service Mgr.	1	B
Budget Director	1	B
Services Coordinator	1	B
Warehouse Supervisor	1	A
& Workers	10	F
Public Coordinator	1	B
Material Buyers	2	B
Data Processing Coordinator	1	B
Data Processing Supervisor	1	R
Programming Supervisor	1	B
Computer Operators & Programmers	5	D
Accounting Supervisor	1	B
Cost Accountants	2	B
Payroll Accountant	1	B
Clerks	11	A
Typists	2	A
C) Employee Relations Dept.		
Manager	1	B
Security Officer	1	B
Guards	8	D
Safety Director	1	B
Engineers	3	C

*for Job Classification definitions see "Job Classification Breakdown Summary"

JOB CLASSIFICATION BREAKDOWN

BASALT CYCLE II

	<u>Man-Shifts Per Day</u>	<u>Job* Classification</u>
C) Employee Relations Dept. (cont'd.)		
Industrial Hygiene	1	C
Clerk	1	A
Training Director	1	B
Training Coordinator	1	B
Employee Relations Specialist	1	C
Employment Relations	3	B
Labor Relations Specialist	1	C
Benefits Specialist	1	C
Clerks	3	A
Secretary	1	B
Receptionist	1	B
Typists	2	A
D) Miscellaneous		
Legal Advisor	1	C
Planning Coordinator	1	B
Public & Government Mgr.	1	B
Public Relations	2	B
Typists	3	A

*for Job Classification definitions see "Job Classification Breakdown Summary"