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TECHNICAL SUPPORT FOR GEIS: RADIOACTIVE WASTE ISOLATION IN GEOLOGIC FORMATIONS

MASTER

Volume 16

Repository Preconceptual Design Studies: BPNL Waste Forms in Salt

April 1978

Prepared By

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One Penn Plaza
250 West 34th Street
New York, New York 10001

UNION CARBIDE

OFFICE OF WASTE ISOLATION
OAK RIDGE, TENNESSEE

prepared for the U.S. DEPARTMENT OF ENERGY *under*
U.S. GOVERNMENT *Contract W-7405 eng 26*

This report was prepared by Parsons Brinckerhoff Quade & Douglas, Inc., under Subcontract 62Y-45702 with Union Carbide Corporation, Nuclear Division. The subcontract was administered by the Office of Waste Isolation.

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RADIOACTIVE WASTE ISOLATION
IN GEOLOGIC FORMATIONS

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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
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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 16, "Repository Preconceptual Design Studies: BPNL Waste Forms in Salt," is one of a 23 volume series, "Technical Support for GEIS: Radioactive Waste Isolation in Geologic Form ations," 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 salt. The waste forms assumed to arrive at the repository were supplied by Battelle Pacific Northwest Laboratories (BPNL). 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-36/17, "Drawings for Repository Preconceptual Design Studies: BPNL Waste Forms in Salt."

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 reprocessing) or from either of two fuel cycles that include reprocessing--the cycle with uranium and plutonium cycle 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: BPNL Waste Forms in Salt," 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. The final section of the Volume (Section 7.0) compares the design for BPNL waste forms with that for OWI waste forms.

1.0 INTRODUCTION

1.1 Scope of the Generic Repository

Preconceptual design studies have been prepared for an underground nuclear repository in salt that stores nuclear wastes generated from commercial power plants. These wastes are classified, packaged, and received in accordance with an expanded Office of Waste Isolation (OWI) data package developed by Battelle Pacific Northwest Laboratories, Inc. (BPNL). Previous studies were completed for a repository in salt receiving wastes in accordance with different waste classification, packaging and receipt criteria.[1]

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 or trucks
- o transfer of waste containers to inspection stations
- o decontamination of waste containers, if required
- o overpacking when needed
- o preparation of waste for descent to the storage level.

The design includes two basic process lines developed to handle the wastes in this manner:

1) Waste packages shipped in shielded casks are remotely handled in hot cell facilities with high attenuation shielding. This procedure is performed in the Canistered Waste Receiving Building.

2) Waste packages shipped in containers other than shielded casks are mechanically handled with low attenuation shielding. This procedure is performed in the Low-Level Waste Receiving Building.

In addition to the surface facilities required for processing the wastes, additional support installations. such as an administration building, clinic, cafeteria, utility systems, and radwate 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 high-level 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 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

Once the waste has been lowered down the shaft it would be transported to the storage rooms. Initially, the repository is assumed to operate in retrievable mode for a short period of time to validate repository operations and safety. During this period when the retrievability option is maintained, 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 to the mine would be plugged and sealed.

1.2 Alternative Fuel Cycles

Three alternative fuel cycles for light water reactors (LWRs) have been identified for analysis.[2] Because of the different thermal loadings associated with each fuel cycle, repository design parameters may vary according to cycle. The cycles include:

Cycle I: Total Recycle -- Spent fuel is reprocessed to extract and recover uranium (U) and plutonium (Pu). The reprocessing 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 6.5 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 be approximately five years old upon arrival at the repository.

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 would receive: (1) intact spent LWR fuel assemblies; and (2) low-level waste.

Assemblies from PWR and BWR reactors differ from each other in size and heat generation, and would therefore be handled separately. For the purposes of this study, it is assumed that the spent fuel assemblies are aged a minimum of 5.5 years after removal from the reactor, prior to delivery to the repository. Low-level wastes could also be stored, although none were specifically included in the BPNL waste package data. Low-level wastes are assumed to be 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 and the plutonium is discarded in solid form with the HLW. In addition, the repository will receive cladding waste, intermediate-level transuranic waste, and low-level transuranic waste as in Cycle I. Similarly, the HLW is assumed to be 6.5 years old and all other wastes are assumed to be five years old upon arrival at the repository.

1.3 Waste Package Receipt Considerations

For purpose 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.

1.3.1 Waste Characteristics

Nine types of waste are expected to be received for Cycles I and III and three for Cycle II. Waste receipt criteria for all cycles are shown in Table 1-1.

The subsurface portion of the repository is divided into three areas, designated "A", "B", and "C". In Cycles I and III, Storage Area "A" would be used to store HLW canisters only. Area "B" would be used for storage of CW, IL-1, IL-2, IL-3, and IL-4 wastes. Both types of low-level wastes, LL-1 and LL-2, along with IL-5, would be stored in Area "C".

For Cycle II, PWR spent fuel canisters would be stored in Area "A", BWR in Area "B", and LLW in Area "C".

1.3.2 Shipping Containers

All waste packages are assumed to arrive at the repository in various shipping containers. The shipping containers are influenced by waste dimensions, waste heat generation, and required radiation shielding. A large number of variations in the design and dimensions of these shipping containers would create great complexity and duplication in handling equipment and facilities. Therefore, it is assumed that the following types of shipping containers would be used:

- C1 - Cask carrying nine 12.75 in. dia. by 10 ft. long canisters containing high-level waste.
- C2 - Cask carrying three 30 in. dia. by 10 ft. long canisters containing cladding waste (CW) or intermediate level waste (IL-3, IL-4).
- C3 - Cask carrying six or fourteen DOT Type 17c drums containing intermediate level waste (IL-1, IL-2). The change in the capacity of the cask is due to variable shielding requirements.
- C4 - Cask carrying seven 9.5 in. square by 16 ft. long canisters containing PWR spent fuel assemblies or eighteen 6.5 in. square by 16 ft. long canisters containing BWR spent fuel assemblies.
- Shielded Vans - carrying palletized DOT Type 17C drums (IL-5). These vans must be designed for unloading by shielded forklift vehicles.
- "Supertigers" carrying palletized DOT Type 17C drums (LL-1, LL-2).

For the development of a reference facility, the basic characteristics of these shipping casks must be standardized for each category of waste with respect to overall dimensions, details of bolting of outer and inner lids, methods of lifting and provisions for sealing against port openings in the transfer cells.

The following overall dimensions are assumed for the various casks:

C1 - 10 ft. dia. by 16 ft. long

C2 - 7 ft. 4 in. dia. by 12 ft. 10 in. long

C3 - 8 ft. dia. by 9 ft. long

C4 - 10 ft. dia. by 20 ft. long

The shipping cask atmosphere is anticipated to be dry. i.e., containing no water or other liquid. Air or inert atmosphere in the shipping casks would be acceptable at the repository. The casks would be provided with external connections to the interior cavity for testing the internal atmosphere. Similar connections would be provided for cooling if that should be required.

1.3.3 Canisters

The waste containers are assumed to be fabricated of stainless steel, type 304-L or carbon steel with a minimum wall thickness of 1/4 in. and equipped with a standard device for lifting and handling.

1.3.4 Drums

All drums to be received at the repository are assumed to be standard size 55 gal. drums DOT Type 17C.

1.3.5 Overpacks

The repository will accept overpacks for canisters or drums that are slightly larger than the basic containers. Lifting and handling devices on the overpacks must be of the same type as for the basic waste containers.

1.4 Waste Receiving Rates

Annual and accummulated receiving rates for the various waste types are tabulated in Tables 1-2 through 1-8 for Cycles I and III, and in Tables 1-9 and 1-10 for Cycle II.

1.5 Geotechnical Factors That Influence Design[3]

Because of geological characteristics and the general stratigraphic setting of in-situ salt, many of the design and layout features of the surface and subsurface facilities as well as the amount of waste that can be stored will be influenced. These geotechnical characteristics include:

- o effects of heat on rock strength
- o rock movement
- o rock stability and closure
- o groundwater movement.

1.5.1 Effects of Heat on Rock Strength

At high temperatures the strength of rock is diminished as the rock structure begins to break down. In salt, decrepitation begins to occur in the range between 250°C and 400°C. 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 the large volumes of rock immediately adjacent to the canisters.

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

1.5.2 Rock Movement

The mined excavation and thermal loadings from the waste materials would create stresses which would cause the rock surrounding and overlying the repository to react or move. 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.

1.5.3 Rock Stability and Closure

Salt is a relatively pliable material with low to moderate strength and pronounced creep behavior, particularly at high temperatures. It undergoes large amounts of deformation without rupturing. Because of these properties, additional considerations must be given to establishing the mine layout, room geometry, and allowable thermal loadings in a repositiory in salt. Not only must the overall stability of the room and pillars be maintained, but the room closure during the operational phase of the facilities must be limited to acceptable amounts.

1.5.3.1 Room and Pillar Stability

For the generic repository in bedded salt, the room and pillar stability was evaluated using information from experimental and analytical studies. The experimental work centered around the project Salt Vault demonstration. Based on these studies, it is expected that the overall salt mass will remain intact and maintain almost all of its strength throughout the operational phase of the repository. Although movements of the roof and pillar walls are expected, support would not be required except in isolated cases.

1.5.3.2 Room Closure

Amounts of room closure have been estimated from the studies described in the foregoing paragraphs. The relative closure rates are affected not only by the thermal loading but by the mine geometry. For example, room closure is reduced significantly when barrier (buttress) pillars are used.

Room dimensions were established taking into account the amount of closure expected to occur during the developmental and operational phases of the repository. That is, if the roof and floor in a particular room were expected to converge two feet during the time period of interest, the room height was increased by two ft. plus an additional amount for a margin of safety.

1.5.4 Groundwater Movement

The shafts sunk to the repository level would most likely encounter water bearing aquifers as indicated in the generic stratigraphic section shown in Dwg. 22 in TM-36/9. Theoretical calculations show that water would flow from the unsealed acquifers into the shafts at rates of between a few hundred gallons per minute (gpm) and a few thousand gpm.[4] (The extreme variation in the calculated inflow rates reflects the wide range of aquifer permeabilities found in nature. More exact estimates of water inflow can be established only after the specific site of the repository has been studied and tested.) Unless the aquifers are properly sealed, the shafts would provide potential conduits for water to enter the repository. For this reason, special care must be used in the design and construction of the acquifer seals.

The repository would be constructed entirely within the salt layer. Therefore, no inflow into the repository would occur, assuming the design and layout of the facilities would eliminate the possibility of major shearing or rupturing of the rock to adjacent water-bearing strata.[5]

1.6 Repository Personnel

At times of peak mining and waste handling, the repository labor force is projected to be about 1,500 to 2,000 total employees. Waste placement operations are assumed to be three 8-hour shifts, 250 days per year while all other operations are performed on a two 8-hour shift, 300-day per year basis. Personnel assignment schedules for Cycles I, II, and III are given in Tables 1-11, 1-12, and 1-13, respectively. For a Job Classification Breakdown Summary the reader is referred to Appendix B.

1.7 Mining Methodology

Continuous mining units would be used to mine the rooms and corridors in the salt repository. These machines are finding increasing applicaton in mine layouts having relatively long rooms (1,000 ft. in length or greater).

Because of the high productivity and very long distances involved, an elaborate conveyor system would be used to transport excavated material underground. An extendible conveyor would be used to load mined salt from directly behind the mining unit onto the branch corridor conveyor. The material would then be conveyed through the branch corridor and automatically be discharged onto the main corridor conveyor which empties into a surge bin. The surge bin feeds a loading pocket and the material is then loaded into a skip for removal to the surface.

1. REFERENCES

1. Office of Waste Isolation/Union Carbide Corporation, Nuclear Division, Repository Preconceptual Design Studies: Salt, Y/OWI/TM-36/8, Oak Ridge, Tennessee, April 1978.

2. Office of Waste Isolation/Union Carbide Corporation, Nuclear Division, Commercial Waste Forms, Packaging and Projections for Preconceptual Repository Design Studies, Y/OWI/TM-36/2, Oak Ridge, Tennessee, April 1978. Part II.

3. ________________, Baseline Rock Properties Salt, Y/OWI/TM-36/4, Oak Ridge, Tennessee, April 1978. Chapters 2 and 7.

4. ________________, Stratigraphies of Salt, Granite, Shale, and Basalt, Y/OWI/TM-36/3, Oak Ridge, Tennesse, April 1978. Chapter 2.

5. ________________, Ground Water Movement and Nuclide Transport Y/OWI/TM-36/21, Oak Ridge, Tennesse, 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, would be required to accommodate the surface facilities. The relation of this surface area to the subsurface area is shown on the inset of Dwgs. 100, 200, and 300.[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. Railroad trackage is located between the agricultural fence and the fenced-in high security area to handle excavated material for disposal and coal for the boilers.

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 and double security fencing 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 are assumed to 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 Facilitiy

2.2.2.1 Building Function

The Canistered Waste Receiving Building would provide facilities and equipment necessary to receive and handle those wastes that, because of their radioactivity, require remote handling and a high degree of attenuation shielding when removed from their shielded shipping casks.

2.2.2.2 Building Description for Cycle II

The Canistered Waste Receiving Building, shown in Dwgs. 201, 202, 204 and 205, would be a two-story reinforced concrete structure: one story above grade and one below grade. The building would be designed according to criteria specified in 10 CFR Part 50, Appendix A.

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

The ground floor, shown in Dwg. 201, would contain 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 Electrical Equipment Room. Additional space for support functions and activities associated with canister handling including a lab, counting room (for counting surface dose rates), health physics office, security personnel checks, reception station, change rooms, briefing room, shift foreman's office, and service and maintenance area would be provided.

The basement floor, shown in Dwg. 202, would contain 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. 202 in all sets, adjoins the Canistered Waste Shaft and contains two (2) Shaft Transfer Rooms.

2.2.2.2.1 <u>Major Equipment for Cycle II</u>

Major equipment items in the facility would include:

A. Overhead bridge cranes:
- o Two - 10 ton 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 - 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

2.2.2.2.2 Detailed Sequence of Operation for Cycle II

The sequence of handling the canistered waste, shown in Dwg. 205 would be as follows:

1. Pull in one or two railroad cars, with a single shipping cask aboard each, into the Cask Preparation and Washdown Shed. Test the car for any surface contamination. Decontaminate the car, if indicated, by a washdown. Remove the cask tiedowns.
2. Using a switch engine or a track-mobile, move a railroad car through one of three confinement chambers and into one of the three Cask Unloading Stations.
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 the cask for surface contamination and sample the cask atmosphere by purging and testing. Using an automatic machine, unbolt the cask lid, without removing the lid itself. (All cask inspection, testing and unbolting would 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 a crane and lower it 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 described in 4a above.

c. If the sampling of the cask atmosphere indicates canister leaks within the cask - move and lower 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. Utilizing a moving and lifting mechanism, lift the cask, 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 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, use master slave manipulators 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 and compare the temperature of the surface and radioactivity level at the surface are to the repository acceptance criteria. (Tests for canister leaks are performed 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 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 vision of the operators. Proceed as in paragraph 7a above.

   c. If leaks or physical damage to the canister are indicated - place the canister back into shipping casks, 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 (using the automatic machine), retest the surface of the cask and decontaminate if so indicated. (Note: All openings in the floor of the cell have removable plugs to prevent contamination of adjacent areas. The plugs would be removed and reinstalled as required by the process.)

9. Return the cask to the railroad car and place it in a shipping position (using overhead crane) and move it to the Cask Preparation and Washdown Shed. After the final test of the car (and decontamination, if needed), tie the cask down and ship it back to 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 for 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. Using a cell crane lower the damaged canister 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. After removing all canisters, decontaminate the cell after each overpacking operation, as required.

11. Laterally move the processed canisters, which were lowered into a tracked carrier in the Canister Storage and Feed Room (paragraph 7a above), to the reach of one of the two 25-ton overhead bridge cranes. Pick up the canisters one at a time, and nest 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 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 it into a shielded cage in the Canistered Waste Shaft and lower it to the mine.
13. At the subsurface receiving station roll out the basket from the cage and, by use of overhead cranes, bring it to the 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. Track back the empty basket to the cage, bring it up to the Shaft Transfer Room and then to the Canister Storage and Feed Room for further use.

2.2.2.3 Building Description for Cycles I and III

The Canistered Waste Receiving Building for Cycles I and III shown in Dwgs. 101 through 105 will also be a two story reinforced concrete structure: one story above grade and one below grade. The building would be designated according to criteria specified in 10 CFR Part 50, Appendix A.

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

The ground floor contains four receiving and cask preparation bays. One of these bays is assigned to receive the canistered wastes either by rail or by truck. Two separate lines of cask transfer galleries, transfer cells and overpack facilities allow the processing of the two types of canisters (30 in. and 12 in. diameters). Three of the bays are assigned to receive drummed waste arriving by truck in casks. In each bay one line of cask transfer gallery, transfer cell and overpack facilities allows the processing of the drums.

The processed waste containers from all lines would be transported to the shaft transfer room in the waste container feed room by overhead bridge cranes.

Additional space in this building would be provided for support functions and activities including Electrical and Mechanical rooms, health physics room, laboratory, and other personnel and maintenance facilities.

2.2.2.3.1 Major Equipment (Cycles I and III)

Major Equipment items in the facility would include:

A. Overhead Bridge Cranes

- o One-150 ton capacity for casks with canisters
- o Three-100 ton capacity for casks with drums
- o Five-10 ton capacity in transfer cells
- o Five - 2 ton capacity for empty overpack handling
- o Two - 25 ton capacity in waste container feed room
- o 1 - 5 ton capacity, in the mechanical room

B. Transfer Mechanisms

- o Five - lateral cask transfer carriages
- o Five - cask lifting mechanisms

- o Five - overpack transfer carriages and lift table
- o Five - processed waste transfer mechanisms
- o Two - processed waste shaft feed mechanisms

C. Miscellaneous equipment

- o Five - ganghead socket wrenches for unbolting outer lids of casks
- o Five - ganghead socket wrenches for unbolting inner lids of casks
- o Five - inner lid removal rigs
- o Five - overpack lid handing rigs
- o Five - overpack welders
- o One - canister leak test well for 12 in. dia. canisters
- o One - canister leak test wells for 30 in. dia. canister
- o One - canister decontamination mechanism for 12 in. dia. canisters
- o One - canister decontamination mechanism for 30 in. dia. canisters
- o Six - drum decontamination mechanisms

2.2.2.3.2 Detailed Sequence of Operations (Cycles I and III)

The sequence of handling the canistered waste is similar to the method described in paragraph 2.2.2.2.2 for Cycle II except for the following:

- o Because of the small number of daily railroad car arrivals no separate shed is provided for cask preparation
- o One test cell is provided for each of the two types of canister
- o Each test cell provides overpacking facilities for its canister type

The sequence of handling the drums, described as a series of instructions, would be as follows:

1. Drive a truck with one cask containing drums through

an airlock into the cask preparation and unloading area. Remove the cask tie downs.

2. Using an overhead bridge crane lift the cask from the truck and transfer it to a cask inspection station.
3. Inspect the cask identification mark and compare them to shipping documents for accounting purposes. Check the cask for surface contamination and sample its internal atmosphere. Using an automatic ganghead socket wrench, unbolt and remove the outer lid. Wash down the exterior if necessary.
4. Using a overhead crane pick up the cask and lower it onto the cask transfer carrier in the cask transfer gallery.
5. Transfer the cask laterally to position under port in floor of transfer cell and lift it to the seal shoulder of cask against the port opening.
6. Using a ganghead socket wrench, unbolt and remove the inner lid of cask.
7. Using an overhead bridge crane extract drums from the cask and move them to the test stand.
8. Technicians working in the Operating Galleries, besides remote controlling the crane in the transfer cell, would use master-slave manipulators to test, inspect and process the drums in the cell. Read and compare the drum identification mark with the shipping documents. Test them for surface contamination and, if necessary, decontaminate in a special decontamination well.
9. Overpack all drums passing through this building - - three at a time - in an overpack cylinder of outside dimension and detail comparable to the 30 in. dia. by 10 ft. long canister. Lower the drums into the overpack cylinder, lock or weld the cylinder lid locked and bring it to the exit port in the same manner as the canisters.

(This canister, complete with three drums, is referred to as a "drum pack". See Dwg. 119). The rationale for overpacking all drum in cylinders is described below in paragraph 2.2.2.3.3.

10. Lower the overpack cylinders containing the drums through the exit port of the transfer cell into a carrier. The carrier transfers them laterally to the reach of one of two overhead bridge cranes.
11. Using the bridge crane pick up the carrier and move it laterally and longitudinally to one of two shaft transfer cells. If an overflow should occur, the carrier can be temporarily stored in storage wells.
12. Lower the carrier into the shaft transfer cell and transfer it laterally into one of two shielded hoist cages and lower it to a subsurface receiving station.
13. At the subsurface receiving station move the carrier laterally to a position below a port where a shielded transporter will extract the overpack cylinder from the carrier and transport it to a storage room for emplacement.
14. Track the empty carrier back to the hoist cage, bring it up to the shaft transfer room and then return it for further use.

2.2.2.3.3 <u>Overpack Cylinders For Drummed Waste</u>

The use of overpack cylinders, called "drum packs", for overpacking three drums of high surface dose rate at one time is suggested for the following reasons:

- o The ability to use common handling equipment and techniques for drum packs as for the 30 in. diameter canisters
- o Same shielded transporters as for the 30 in. dia. canisters
- o Same method of placement

- o Ease of retrievability
- o Protection from corrosion
- o Reduction in number of items to be handled and thereby increase in equipment availability.

The overpack cylinders would arrive by truck in the cask preparation areas, crated in baskets so that the overhead bridge cranes handling the casks could also handle these crates and deposit them near the overpack feed port. A small auxiliary crane would lift one cylinder at a time out of the crate and lower it into an overpack carrier. The carrier would move laterally to a position underneath an overpack entry port in the floor of the transfer cell. The carrier would be lifted to seal against the entry port with the cylinder projecting into the transfer cell. Here, a special rig would remove the lid of the cylinder and replace it after three drums have been loaded into the cylinder. A lid welding machine would seal the lid. A second hoist in tandem with the drum handling hoist would then move the completed drum pack to the exit port of the transfer cell.

2.2.3 Low-Level Waste Handling Facilities

2.2.3.1 Building Function

The Low-Level Waste Receiving Building will provide facilities and equipment necessary to receive and handle waste materials that require less attenuation shielding than waste assigned to the Canistered Waste Receiving Building or in the case of Cycle II can be contact handled.

The following waste types would be accepted.

- o For Cycle II--LLW arriving in drums on pallets in vans or "supertigers" by truck.
- o For Cycles I and III--(IL-5) arriving in drums on pallets in vans; (LL-1) arriving in drums on pallets in "supertigers" by truck; (LL-2) arriving in steel boxes in "supertigers" by truck.

2.2.3.2 Building Description

The Low-Level Waste Receiving Building for Cycles I and III, shown in Dwgs. 107 through 109, is a one story reinforced concrete building designed according to criteria specified in 10 CFR Part 50, Appendix A. The same building configuration and arrangement can serve both Cycle II and Cycles I and III with the only difference being the reduction of shielding requirements for Cycle II.

The building would provide for two confinement chambers for incoming trucks, unloading docks, an area for maneuvering pallets by forklift trucks, two test cells, one decontamination and over-pack cell, empty overpack storage, confinement chamber access to the Low-Level Waste Shaft and a battery charging room. Additional areas are provided for a mechanical equipment room (housing fans and filters), an electrical switchgear room, and personnel facilities.

2.2.3.2.1 Major Equipment

Major equipment item in the facility include:

- Forklift trucks (standard construction for Cycle II and shielded for Cycles I and III)
- Clamp trucks for handling individual drums
- One-overhead bridge crane for handling individual drums
- One-overhead bridge crane for handling overpack drums
- One-drum decontamination station
- One-drum overpack lid closing rig
- Manipulators in test cells

2.2.3.2.2 Detailed Sequence of Operation

It is assumed that all drums will arrive in rear opening vans or supertigers on pallets measuring 4 ft. by 6 ft. containing 6 drums. The sequence of handling the low-level waste, described below as a series of operating instructions, would be as follows:

1. Trucks will arrive through either one of two confinement chambers and back up against the dock.

2. Before opening the truck doors check the interior atmosphere.
3. Open the truck doors and using forklift trucks (shielded for Cycles I and III), remove the pallets and transport them to either one of two test cells.
4. In case of self-unloading or top loading, vans should be used with non palletized drums. An overhead bridge crane is provided that can handle individual drums. However, these must be palletized for later handling.
5. From behind shielded walls, check the drums in the test cell for identification, surface contamination and damage.
6. If the surface contamination falls within acceptable limits, remove the pallet with drums from the test cell using the shielded fork lift truck and take it through an air-lock into the hoist cage for lowering to the mine level.
7. If some drums are found to require decontamination or overpacking, use the forklift truck to move the entire pallet from the test cell to the Decon/overpack room. Otherwise, use an overhead crane to transfer the single drums in the same path.
8. Store empty overpacks next to the Decon/overpack room and handle them by the same overhead crane.
9. Place the drums into the overpack drum and seal the cover. (The Decon/overpack room will have equipment to wash down the drums.)

2.2.4 Radwaste Management and Facilities[2]

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. 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.

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 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.

2.2.4.3.2 Liquid Radwaste Treatment Process

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 compacting 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 contaimination 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 incineration 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 towers operating from 85 F to 105° 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 capabilities 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.

2.2.4.4 Gaseous Waste Treatment

Each of the four critical buildings, the Low-Level Waste Receiving Building, Canistered 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 phathalate (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 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

The building will house the exhaust fans and filters for the continuous filtering of the exhaust air from the canistered waste placement operations in the storage areas as well as the exhaust fans associated with the mining and drilling 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.

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:

- 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.
- A communication room
- A guard room
- A mechanical room for services for this building
- A switchgear room for control of the equipment in the Exhaust and Supply Ventilation Buildings
- A garage for security personnel use
- 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 waste building, the low level waste building, and the placing 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 pumps 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

The 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 communications 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 rail 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, mailroom, 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:

- 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.
- 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.
- 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.
- 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: Salt, Y/OWI/TM-36/9, 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 the local electric utility company. It is expected that a facility total demand load would vary between 20 and 30 MVA depending on the fuel cycle (See Table 31.). 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 Dwgs. 112 and 212. 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 of TM-36/8. 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 would be designed to be installed in underground conduits and manholes. 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 and Material Shaft. In the mine, exposed insulated cables would 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 a discussion on 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

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

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 of TM-36/8, 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 SALT

4.1 General Description

In these designs, five distinct shaft structures would be sunk using conventional techniques. These shafts are the Canistered Waste Shaft, the Low-Level Waste (LLW) 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 Dwgs. A32, B31, C32, D31, and E34 of TM-36/9. Shaft descriptions for these repository designs are shown in Table 4-1 of TM-36/8.

In the study being considered, five shafts are to be excavated from the surface to the repository horizon. Because the placement schedule would be delayed if the underground initial development had to wait until the permanent Men and Materials Shaft was operational. Efforts were directed toward developing a construction plan that would promptly provide a temporary shaft facility with: (1) an excavated material hoisting capacity of 2,000 TPD; (2) capability of lowering a maximum load of 20,000 pounds; and (3) sufficient space to deliver 100,000 cfm of fresh air. The plan selected to satisfy these requirements is to sink one of the shafts using the "Blind Hole Drilling Method," which is faster than conventional shaft sinking. (See Section 4.4.) The shaft to be bored would be the LLW shaft which, because of its small diameter, can be bored the fastest. The four remaining shafts are to be excavated using conventional drilling and blasting techniques. Basic shaft information is contained in Table 4-2 of TM-36/8.

4.2 Shaft Descriptions

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 receiving 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 Dwgs. A34, B33, C34, D33, and E36 of TM-36/9. The Canistered Waste Shaft will accommodate high-level and intermediate-level waste (except IL-5) in both canister and drum-pack form for Cycles I and III, and PWR/BWR spent fuel canisters for the Cycle II repository.

In a repository for reprocessed waste (Cycles I and III), the shaft access to Storage Area "A" is at one elevation and the access to Storage Area "B" is at another elevation. From shielded receiving stations at these two elevations, the canisters may be transferred to shielded transporter vehicles for relocation to the subterranean storage site. Both high-and intermediate-level-waste would travel to the Canistered Waste Shaft in a canistered waste cage. Loading and unloading of the waste canisters into and from the canistered waste cage would be performed by remote control systems at each respective station. Since HLW and ILW canisters differ in physical properties, remote handling facilities must be tailored to meet the individual requirements at the separate receiving levels.

In a SURF repository, the shaft would provide access to PWR fuel assembly storage area (Area "A") at one elevation and to the BWR fuel assembly storage area (Area "B") at a higher 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 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.

4.2.2 Low-Level Waste Shaft

The Low-Level Waste (LLW) Shaft has an inside diameter of 10 ft. and is lined with a special steel hydrostatic liner over its entire length. The special liner is required because of the "blind hole drilling method" used only for construction of this shaft. In Cycles I and III, both types of low-level waste (LL-1 & LL-2), along with IL-5, would travel in the shaft. Shielded subsurface handling would provide special fork lift vehicles operating from a Low-Level Subsurface Receiving Station enclosed by concrete. The receiving station is shown in Dwg. 121.

For Cycle II, the BPNL waste package data do not specify any low-level waste. However, the assumption has been made that low-level waste comparable to the original OWI study, could possibly be received in reduced quantity. Under the study criteria, LLW for Cycle II could be handled with fewer precautions than for other Cycles. Thus, an elaborate subsurface receiving station would not be necessary. The Low-Level Waste Shaft would also be used as a secondary point of egress during emergency situations.

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 will 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 placement crews would use different levels so that task crews remain separate. The compartment also is large enough to permit the lowering and raising of large pieces of equipment either in assembled or partly disassembled form.

4.2.4 Ventilation Supply Shaft

Ventilation air for the underground areas would be received through this shaft. 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.

4.2.5 Ventilation Exhaust Shaft

Vitiated air from the subsurface areas would be exhausted through this shaft into filtration systems located in the Exhaust Ventilation Building. The shaft is concrete-lined and divided so that under nominal operating conditions, mining and placement exhaust air can be processed separately. The division is made in relative proportion to the aniticipated air flows corresponding to peak rates of waste placement and mining operations. The inside diameter of the exhuast shaft for all three cycles is 26 ft.

4.3 Conventional Shaft Sinking Techniques

Once the construction contract has been awarded and clearing of the construction site completed, mobilization of the shaft sinking contractor's equipment can begin. In the conventionally excavated shafts, the bottom of each shaft would be advanced using a bench 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. Alternate halves of the shaft are drilled and blasted to advance the entire shaft bottom.

The broken rock would be 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.

Prior to sinking into the aquifer, a grouting station would be excavated at the bottom, outside the perimeter of the shaft. From this station, vertical holes would be drilled to intersect the water-bearing zones. As these zones are intersected, a cement or chemical grout would be pumped from the surface into the water-bearing formation. In this manner, a grout curtain would be formed around the perimeter of the shaft. This would prevent excessive amounts of formation water from entering the shaft excavation so that the sinking can proceed safely and expediently.

Depending upon the stability of the shaft walls, 40 ft. to 60 ft. of shaft would be advanced before lining with concrete. Concrete will 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.

While sinking through the water-bearing zones, the diameter of the excavation is enlarged and a "preliminary" 12-inch thick concrete lining would be poured-in-place. Once the excavation has fully penetrated the aquifer a concrete bearing ring and steel wedge ring will be installed at the bottom of the water-bearing zone. Working from the steel wedge ring upward to the top of the aquifer, a permanent steel lined concrete hydrostatic liner would be installed and grouted in place to make the shaft watertight.

After the shaft has been excavated to its final depth, the final grouting of any water leaks in the lining would be accomplished. This procedure, called drywalling, ensures that the lining is competent and watertight.

4.4 Shaft Boring Techniques - Blind Hole Drilling Method[2]

As mentioned previously, it was decided to bore the LLW shaft from surface to its final depth - 2,000 ft. - in order to allow initial development to start at an earlier date than would be possible using conventional sinking techniques.

Both the equipment and method used for drilling shafts are highly specialized. Shaft drilling differs from ordinary rotary drilling in the manner in which force is applied to the bit and in the technique used to remove the cuttings.

In order for a rotary bit to cut a hole, the required bit force must vary directly with the square of the hole diameter in order to maintain drilling pressure. Thus such as a shaft requires large downward forces. Drilling pressure is maintained by adding heavy "parasite" weights to the drill string immediately above the bit. These parasite weights are cast iron "donut-shaped" sections that fit around the drill string. These sections can be added or removed as required.

Drill cuttings are removed by a method called "reverse circulation air lift". Using this method, the drilling fluid is added to the annular space and the cuttings are removed up the inside of the drill string (reverse of ordinary rotary drilling).

The selection of correct drilling muds and the amount to be used is a specialized field of engineering which has been developed in the oil well drilling industry. While drilling the LLW Shaft, the drilling mud would initially consist of sodium bentonite clay. From the anticipated flow of water, it has been estimated that mixtures up to 11 pounds of bentonite per gallon of water would be required. Once salt is encountered, the mud composition would be changed by the addition of Attapulgite clay. This would prevent the bentonite clay from losing its swelling characteristics which occurs when it comes in contact with a salt brine.

Upon completion of the drilled hole, the drill rods, weights and bit would be removed from the hole which is left full of drilling mud.

The next step consits of installing the steel liner. The liner provided is a hydrostatic liner designed to resist the total static head of water at all depths in the shaft. The shaft liner is prefabricated in 10 ft. high sections consisting of an outer shell of cold rolled mild steel strip plate of varying thickness from 3/8 in. to 1-1/4 in. and an inner lining of concrete 12 in. thick and varying in strength from 3500 psi to 6000 psi.

Following installation of the lining, the permanent headframe and hoist would be constructed. Initially, the shaft would be equipped to permit hoisting a 10-ton skip in balance with a counterweight. A solid brattice wall would divide the shaft allowing it to be used for fresh air and exhaust air. These arrangements would be used to permit mining from the LLW shaft until the M&M shaft has been excavated and equipped to permit its use for mining. At that time, the LLW shaft would be converted to its final use. This would involve removing the 10-ton skip, counterweight and brattice wall, re-arranging the guides and installing the LLW cage.

4.5 Lining

Since one of the requirements of a salt mine is that the shaft be completely dry, and, since it will be desirable at some time in the future to abandon and decomission the underground facility, it must be protected in such a manner that there is no possibility of contaminating the ground water. Therefore, the shaft linings are designed in the aquifers to be completely watertight and capable of withstanding a full hydrostatic head with a safety factor of 2.5.

In the excavated shafts the lining consists of a "construction" lining of 3500 psi concrete 12 in. thick, placed while sinking through the aquifer. Any water made by this liner is collected in water rings and directed through vertical piping, cast into the concrete liner, to the shaft bottom. From there it would be pumped or hoisted to surface in the sinking buckets. Once the shafts have been sunk through an aquifer, the permanent lining, consisting of an inner and outer shell of steel filled with concrete, would be constructed inside the "construction" lining.

The bored shaft is to be lined with a steel liner for its entire length. The liner consists of cold rolled mild steel plate from 3/8 in. to 1-1/4 in. thick and inner lining of 12 in. thick concrete, having a compressive strength of 3500 psi to 6000 psi.

Specifications for the hydrostatic liners in the different aquifers are given in Table 4-3.

4.6 Water Control Techniques

As mentioned previously, the principal difficulty to be overcome when excavating the shafts is the heavy water flows expected to be encountered in water-bearing aquifers. In order to overcome these problems, the following techniques would be used.

4.6.1 Pregrouting

Prior to excavating through the aquifers, a grout station would be excavated at the bottom of the shaft. Vertical holes are drilled and cement or chemical grout injected into the water-bearing formations to form a grout curtain around the area to be excavated.

4.6.1.1 Lining

In the excavated shafts doublewall steel and concrete hydrostatic lining would be placed through the entire depth of each aquifer. This liner includes a pikotage to prevent water migration along the liner.

The bored shaft would have a steel hydrostatic liner throughout its entire length. A 12 in. thick concrete liner would be poured on the inside face of the steel liner.

4.6.1.2 Drywalling

Following excavation of the entire shaft, time has been allotted to permit grouting any water seepage that may occur through the liner.

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 4.1.2.1.

2. Ibid, Section 4.1.2.2.

5.0 MINING AND WASTE PLACEMENT OPERATIONS IN SALT

5.1 Design Criteria

Several criteria must be considered when developing a layout for the subsurface portion of the repository. The following are of prime concern:

- In order to avoid special machinery as well as to be compatible with the proposed waste placement scheme, the size of the room opening must be compatible with the mining equipment to be used. Room sizes must also be designed with consideration of the clearance requirements of the waste transporter.
- The pillar size must ensure adequate heat dissipation into the geologic medium and must also ensure overall mine stability.
- The mining schedule must make storage rooms available for waste placement by early 1985 (1986 for HLW). This requirement affects excavation of the rooms, drilling of holes, and installation of canister sleeves. Subsequent storage rooms must be completed in time to permit receipt of incoming waste.
- Mine and waste placement operations must be kept separate from each for reasons of safety. This necessitates allowing entries for waste placement that are isolated from those used for mining, and the sequencing for each of the operations to avoid cross-overs.
- The extent of underground development must not exceed 2000 acres. (See Section 2.1)
- All shafts must be located in a central area for reasons of security. Also, the shafts must be in the same relative positions for each cycle in order to make possible the use of similar surface layouts for each of the cycles.

5.2 Mine Layouts

Room dimensions and configurations were determined, based on the above criteria, for each of the fuel cycles. The Mine Master Plans are shown in Dwgs.115, 215, and 315 for each of the respective fuel cycles. Extraction ratios are shown in Fig. 5. Room and corridor details are shown in Dwgs. 118 and 218. Table 5-1 summarizes the repository characteristics for each cycle.

Two basic configurations are presented for the storage room layout in Cycle I. In the first, used for storage of ILW, CW and LLW (Storage Areas "B" & "C"), the storage rooms connect directly to the main corridors at right angles. (See Dwg. 115). They are grouped into panels of four rooms per panel and vary in length from 640 ft. to 3295 ft. The first panel of Area "B" is shorter than the remaining panels in that storage area so that it can be completed in time to receive the wastes in 1985. This is also true of the first two panels of Storage Area "C". The rooms within a panel are separated by a yield pillar 30 ft. wide. Successive panels are separated by a more massive buttress pillar 78 ft. wide. The room openings are 36 ft. wide by 20 ft. high, resulting in an extraction ratio of 46%. (See Dwg. 118). This "long room" system provides for relative ease of operation and high mining efficiency. Also, the yield and buttress pillar sequence increases the overall mine stability and decreases the susceptibility of the rooms to shear failure, while significantly reducing the room closure rate.

The second scheme, which would be used for HLW storage, (Storage Area "A"), provides for a number of "branch corridors" perpendicular to the main corridors. Storage rooms, each 560 ft. long, 18 ft. wide and 20 ft. high, extend from the branch corridor at right angles. (See Dwg. 118). A branch corridor and its adjacent rooms constitute one panel. Each panel has 42 rooms, except the first two, which have 9 and 26 rooms respectively. Mining this "short room" system is more difficult and less efficient than the long rooms. However, the short rooms permit a greater flexibility of waste placement and increased control over the dissipation of heat as required by the special nature of the high-level waste canister.

The 20 ft. room height will easily accommodate the waste transporter, which is about 16 ft. high. Room closure due to creep is assumed to reduce the ceiling height by two ft., leaving an additional two ft. of clearance.

Both configurations allow for the separation of the mining exhaust air from the canister placement exhaust air. In the designs, the mining exhaust air in the short room system is taken back to the branch corridor (separated from the supply air by a line brattice) then ducted to the closest completed room in the same panel. It then travels from the end of the room to the main corridor system by way of the branch exhaust corridor. (See Dwg. 111.) Similarly, in the long room system, mining exhaust air is directed back to the main corridor and finally to the exhaust shaft. In both systems, air from the placement operation is designed to be directed outward to a perimeter exhaust corridor and back to the exhaust shaft.

The layout for Cycle II utilizes the long room system for both PWR and BWR spent fuel (Storage Areas "A" & "B") as well as for LLW (Area "C"). (See Dwg. 215.) Because of the heat generated by the spent fuel canisters, a lower extraction ratio (25%) was used as compared to the ILW in Cycle I. The yield pillars are 45 ft. wide and buttress pillars are 80 ft. Room openings are 18 ft. wide by 22 ft. high (see Dwg. 218). The 22 ft. high ceiling is required in order to allow for a 19 ft. high transporter, 2 ft. of creep and one ft. additional clearance.

The Cycle III layout uses the same combination of long- and short-room systems as Cycle I. There are slight differences in the number and size of panels reflecting differences in the waste receipt schedules and in the required spacing of the HLW canisters (See Dwg. 315). The room and corridor openings and the extraction ratios are identical with Cycle I.

The layouts for Cycles I and III satisfy the requirement of 150 KW per acre maximum allowable local areal thermal loadings. Spent fuel heat generation in the Cycle II layout must not exceed 170 KW per acre. Actual thermal loadings are shown in Table 5-2. The thermal loading for BWR spent fuel canisters (Cycle II) is significantly less than the maximum allowable because of physical restraints excluding canister spacing of less than 6 ft. on centers. Also shown are the assumed heat generation rates for the various waste types at the time of arrival at the repository. All areal thermal loadings are based upon these initial canister heat generation rates.

5.3 Mining Operations

Drill and blast mining methods are sometimes chosen over continuous mining machines for mining in thick salt deposits for reasons of cost and productivity. Salt is abrasive to continuous mining units and therefore maintenance costs may be high. However, conventional drilling and blasting would not be employed for mining operations in the storage areas because of possible blasting damage to the facility. No blasting would be required after the proposed starting date of the repository operation, and only a limited amount would be required prior to the receipt of waste units.

The mining operations would be performed using electrically powered continuous mining units that cut an opening 11 ft. high by 18 ft. wide.[1] If the mining machine cuts a second pass beside an initial entry, a room with dimensions 11 ft. high by 36 ft. wide would be created. If two passes in the floor are made later, the room produced would have dimensions of 36 ft. by 20 ft., suitable for IL-TRU and CW storage. Thus, a total of 4 machine passes would be required. For these 20 ft. high rooms, the floor cutting would involve unbalanced pressures on the mining machine rotors and increased maintenance costs. For the 18 ft. wide rooms, two passes would be required, resulting in 20 ft. high ceilings (HLW) or 22 ft. high ceilings (spent fuel). If the spent fuel waste transporter is 20 ft. high instead of the 19 ft. high assumed, an additional one ft. would have to be mined out from the storage rooms, resulting in a room cross-section of 18 ft. by 23 ft. The extra mining pass would reduce the mining production rate and increase costs significantly.

In order to achieve efficient mining, at least three development entries or "corridors" would be needed. Four main corridors would be used in each repository--one waste placement corridor and three Men & Material (M&M) corridors. The M&M corridors serve the following functions: to accommodate the mined salt conveyor; to serve as a travelway for mining equipment, trucks and personnel; and to carry exhaust air from the mining operation. The main conveyor is assumed to be suspended from the ceiling, thus allowing additional mining equipment to travel through this corridor. Supply air would flow through all corridors except the exhaust air corridor.

Extendible conveyor systems that receive the mined salt directly behind the mining machine and transport the material without secondary handling are strongly preferred in many mining applications because of high productivity and low operating cost. Such a mining scheme would be used for the long room systems of each cycle. The extendible conveyors in each room would transfer the salt to roof-suspended main line conveyor systems that transport the salt to a 6500-ton underground bin. A reclaim conveyor beneath the storage bins would be fed by vibratory feeders that are automatically controlled. The salt would be held in a surge bin before being conveyed to loading pockets for hoisting to the surface. (See Dwg. 117).

In the short room system, however, the constraints on mine geometry require that the loader and truck method, which is more flexible, would be used for the mining operation. Trucks would transport the mined salt from the rear of the continuous mining machine to the branch corridor conveyors which would be frequently extended so that truck haulage distances are kept as short as possible. The branch corridor conveyors would then transfer the salt to the main line conveyor.

Electrically-operated trucks could be used in the rooms, but the haulage distances are fairly long for trailing cables, and trolley wire systems are not practical for continuous mining systems. Therefore, diesel trucks would be used for this operation. Normally, two trucks operate behind one mining unit, but often in restricted areas, only one truck can operate efficiently. On very long hauls three or more trucks may be used.

Support facilities for mining operations would be located in a central area near the M&M Shaft. Access to all mining areas would be provided from the central service area, which would include a communications center, a warehouse, large mechanical and electrical shops, a parking area, and a tool room. This location is most suitable to provide efficient service for all mine areas and would have the least effect from heat originating from the storage areas.

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. During this time a number of operations must be completed, including the sinking of all shafts, excavation of a service area for assembly, maintenance and repair of mining equipment, and the installation of the main conveyor system. In addition, a mined material handling system, consisting of a 6500 ton storage bin, a 1000 ton surge bin, and conveyors which would transport the material to the M&M Shaft, needs to be installed to ensure efficient mining production. Lastly, at least one panel in each of the waste type areas would be mined and ready to receive the incoming waste units.

In order to initiate mining as soon as possible, the first 1.5 years of mining operations would be directed through the LLW shaft since this shaft can be completed in about half the time required for the M&M Shaft. A temporary hoisting system would be installed in the LLW Shaft and a salt handling system developed at the base of the shaft for use during this period. The temporary hoisting system would have a capacity of about 2000 tons per day. This corresponds to two machines each mining 1000 tons per day. During this time air for ventilation would be ducted back through the LLW shaft. When the M&M Shaft is completed, mining operations would gradually switch to this shaft. Mining and hoisting capacities would then increase significantly. The following is a tentative schedule for the initial development stage of the repository. The schedule is roughly the same for all 3 cycles. The start of construction is taken as time 0.0.

Year	
0.0	All shaft construction commences.
1.5	LLW Shaft completed; temporary hoisting and salt handling system installed in LLW Shaft.
1.5-3.2	Two mining machines in operation, approximately 2000 ton/day total; mining service area completed; mined material handling system installed; main line conveyor system completed; Ventilation Supply Shaft and Ventilation Exhaust Shaft completed.
3.2	Men and Material Shaft completed.
3.2-5.0	Four mining machines in operation, approximately 6000 tons/day total; canistered waste shaft completed; all corridors in the central area mined; approximately 30% of exhaust corridors mined; one panel in each of the 3 waste storage areas mined; holes drilled and sleeves installed in the completed panels.

5.5 Excavation of Rooms

As mining continues past the initial development stage, production rates peak and remain fairly constant throughout the life of the repository. In the spent fuel (Cycle II) repository, a maximum of 4 mining machines would be operated simultaneously. Each machine mines approximately 2000 tons per day, yielding a total output of 8000 tons per day.

For Cycles I and III, where the short room system is utilized (Areas "A"), peak production per machine is 1560 tons per day. In Areas "B" & "C", where long rooms are used, peak production per machine is 2000 tons per day. A maximum of four machines operate simulataneously in the repository, resulting in a daily mined output of 7120 tons. Peak mining production figures are summarized in Table 5-3.

Mining production rates were computed assuming 2 working shifts per day and 300 working days per year. If production should fall behind schedule, a third shift could be initiated. Also, for each 4 mining machines in operation an additional one would be required as a spare so that major overhauls can be routinely performed on each machine in turn. It is probable that one or two mining machines would need replacements after the first ten years.

The panel numbers shown in each of the Mine Master Plans (Dwgs. 115, 215 and 315) signify the sequence in which the panels are mined for each storage area. Generally, it was assumed that drilling of the canister storage holes in a panel commences after completion of the mining in that panel. The only exception occurs during the initial development stage, when the two operations may be concurrent within a panel because of time constraints. In many cases there is an interval between the mining and drilling phases in a panel in order to minimize the number of drilling crews required to work simultaneously. In all cases, drilling of the storage holes in a panel must be completed before waste canisters can be placed in that panel. Drawings 113, 114, 213, 214, 313, and 314 show the approximate time periods allocated to each operation for each panel. Note that in panels that require the installation of canister sleeves, this operation is included in the time allowed for the drilling operation.

Equipment and personnel associated with the mining, drilling and sleeve placement operations would travel through the middle two M&M corridors. Transporters carrying the waste canisters would travel through the main corridor closest to the Canistered Waste Shaft. Placement of waste canisters would follow the same panel sequence as the mining operation. The sequence of panels is such that the canister placement operation need not cross any of the other operations. There would be a period between 2 months and 4 years between the time of panel completion (holes drilled or sleeves installed) and placement of the waste canisters. It is more efficient to have a steady mining rate, which results in these time gaps, than to adjust the mining rate to the waste receiving schedule. Table 5-4 shows a breakdown of the mining tonnages for each cycle.

5.6 Drilling

Following the excavation of the rooms, storage holes would be drilled into the floor of Storage Areas "A" & "B" for all 3 cycles, using electrically-powered drills. As the hole depth exceeds or nearly exceeds the room height, the drilling would be done in a multistage operation, using a two-piece drill bit. The drillings would be handled by front end loaders or large scooptrams which would carry the material to the main conveyor.

The spacing of storage holes differs between waste types. Spent fuel canisters are stored in holes arranged 2 rows per room. PWR canisters are spaced 7 ft. longitudinally, and BWR canisters 6 ft. In Cycles I and III - Storage Area "B", since the local areal thermal loading is not a consideration, holes are spaced as closely as the integrity of the salt would allow. This distance was estimated to be 7.5 ft. center to center for the diameter of hole used in Area B (See Dwg. 118).

The spacing of storage holes in Area "A" of Cycle I and III (HLW) varies from panel to panel because the initial heat generation rates per canister for HLW increases with time. Thus, in order to maintain the same 150 KW per acre areal heat loading, the canister spacing must increase with successive panels. The table in Dwg. 118 shows that the spacing for HLW canisters varies from 8 ft. to 12 ft. for Cycle I and from 9 ft. to 12 ft. for Cycle III. All HLW canisters would be placed in single rows per room.

Storage holes for spent fuel canisters are 25 ft. deep. If no sleeves are required, the hole diameters are 22 in. for PWR and 18 in. for BWR. For holes with protective sleeves, 2 in. are added to the above hole diameters. HLW canisters are stored in holes 20 ft. deep. The diameter when a sleeve is used is 22 in. and 20 in. when no sleeve is used. Canisters stored in Area B of the Cycle I or III repository would require holes 20 ft. deep. The diameter without sleeve would be 37 in. and 39 in. with a sleeve.

Table 5-3 shows the maximum number of drilling crew-shifts per day.

5.7 Sleeve Placement

The purpose of the sleeve is to maintain retrievability by maintaining the integrity of the hole from creep and to help protect the canister from corrosive influences. In salt, a 3/8 in. thick sleeve of mild steel would be placed into the hole prior to waste placement. The sleeve size corresponds to the dimensions of the canister. The sleeve outside diameter is 16 in. for HLW, 33 in. for CW & ILW (Area "B"), 18 in. for PWR and 14 in. for BWR. The length of the sleeve is approximately 18-1/2 ft. for wastes in Cycles I and III and approximately 23-1/2 ft. for wastes in Cycle II. The sleeves would be lowered through the Men and Material Shaft in sections of two and positioned into the drilled hole. At the top of the sleeve a segmental flange would be used to support the concrete plug. A small amount of backfill may be required between the sleeve and the drilled hole to ensure that the canister would remain plumb during the placement process and throughout the retrieval period. Sleeve placement would be provided only during the retrievability period (assumed in these studies to be five years).

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 level -- serve separate functions in the material flow process.

HLW canisters would first arrive at the lower level in baskets of up to four units each. Drum packs and ILW canisters would be received at a separate receiving station. 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 port in the ceiling above. The port would open and allow a moveable bridge crane to hoist 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 would thus act 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 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 would accommodate the final stage in the subsurface receiving operations before the waste is taken to a storage room. This level would provide two independent loading areas for the transport vehicles and vehicle queuing space. Each loading area has a remotely operated port opening to the intermediate level below.

Canisters placed by the moveable crane would be removed from the basket into the transporter shielded container 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 the port, open the port, lower independently operated hoisting devices down from within the shielded chamber and lift two HLW canisters (one at a time) or one ILW canister or drum pack (depending on receiving station) from the basket below. In the case of the HLW waste, the remaining two would be taken by the next transporter. Once the canister is within the shielded loading chamber of the transporter, the chamber and 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 transit to the storage room. A cutaway perspective of this operation appears in Fig. 4. The PWR and BWR canisters would be treated in a manner similar to that for the HLW mentioned above

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

The hoist would then be disengaged and retracted. The placing of the second canister would be similar. A possible configuration for retrievable canister storage in salt is shown in Dwgs. 119 and 219.

During the five year retrievability period, the transporter would be equipped to emplace a concrete plug; alternately an auxiliary vehicle would insert the plug; otherwise, the floor opening will be backfilled with excavated material using a support vehicle. These vehicles will be in constant communication during the placement process. After placement, the transporter returns to the subsurface receiving station to recommence the placement cycle.

An estimate has been made of the number of transporters required during the peak year as well as at five year intervals starting with 1985. To make this estimate, the average speed of the vehicle was taken as 5 mph. This is the conceptual operating speed of the vehicle; it may in fact be as high as 10 mph. The 5 mph figure was introduced to include an allowance for delays due to turning , brief breakdowns, etc. For each year, the approximate location of storage for the waste units was determined and the distance from the shaft to this point was found. Using this distance and the average speed of 5 mph, the time required for the transporter to travel from the shaft to the storage hole was determined; the total cycle time was taken as twice this time plus 30 minutes, which accounts for receiving and depositing of the waste canister. This cycle time was used to calculate the number of transporters required assuming 6.5 work hours per shift, 3 shifts/day and 250 working days/year.

Note that two types of transporters are required for the remote placement operations for Cycles I and III. One type would carry HLW 12 in. diameter canisters, two at a time, while another type would carry 30 in. diameter canisters or drum packs, one at a time. It is estimated that three transporters would be required for the 30 in. diameter canisters and drums packs and one for the

12 in. diameter canisters of Cycles I and III. A total of five vehicles appears necessary for Cycle II. Additional vehicles would be needed as back-ups. In a final design, the underground storage procedure would have to be simulated in detail using queueing theory to ensure that the requisite number of vehicles could be accommodated.

In the handling of LLW, a cage would lower pallets of drums or metal boxes to the subsurface facility. Shielded forklifts for Cycles I and III, would be used to remove the pallet from the cage and transport it to the storage room. At the storage room the forklift vehicle would place the pallet or box in its final storage position. Each pallet measures 4 ft. wide by 6 ft. long by 3.5 ft. high, and contains 6 drums. The pallets would be stacked against each wall of the room in Cycles I and III, leaving a center aisle 24 ft. wide. In Cycle II, where the rooms are 18 ft. wide, pallets would be stacked against one wall, leaving a 14 ft. wide corridor (See Dwg. 120.)

5.9 Backfilling

Upon a decision to cease retrievable storage (assumed to be after the fifth year of repository operation), the storage rooms filled with waste would begin to be backfilled. From that point on, rooms would be backfilled as soon as they are filled with canisters. Also, sleeves would not be required for emplacement of subsequent waste canisters.

Material for backfill would initially be provided by freshly mined salt from storage rooms being excavated concurrently. The salt would be transported by conveyor. Since the waste placement operation would occur in a panel between the panel being backfilled and the panel being mined, a crossover would necessarily result. This problem is solved by installing a conveyor which would traverse the waste placement corridor through the ceiling, a common mining practice. Thus, the waste placement operation would not be impinged by the backfilling operation. Mined salt that is not needed for backfilling would continue along the main corridor to the M&M shaft.

After the excavation of rooms has ceased, salt for backfill would be taken back down the M&M Shaft and, by conveyor, to the room being backfilled. The hoisting and conveyor systems would have features enabling them to accommodate such a reversal of operation. Prior to decommissioning, all corridors would also be backfilled.

Approximately 60% of the mined salt would be returned as backfill. This figure results from the assumption that the rooms can be backfilled up to a height 2 ft. below the ceiling and that the unit weight of loose salt is 89 pounds per cubic foot. (Salt in place is 135 pounds per cubic foot.) The mined salt not used for backfill must be dealt with in some manner. Table 5-4 summarizes the mining and backfill tonnages. The on-site storage tonnage is assumed to be 60% of the material mined from the rooms associated with the first five years of waste placement.

5.10 Decommissioning of Underground Facilities

After all wastes have been emplaced or retrieved, and decommissioning of the facility has been directed, backfilling of all remaining subsurface openings (including 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 returned to the subterranean openings via the excavated material hoist in the M&M shaft. Mining equipment deemed to be useful would be removed, dismantled, crated where required, and transfered 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 5.2.

6.0 VENTILATION SYSTEMS FOR FACILITIES

6.1 Subterranean Ventilation Systems

6.1.1 Ventilation Requirements and Criteria

The ventilation of the mining operations and of the subterranean waste storage rooms 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 Section 6.1.4 and 6.1.5.

Adequate supply of fresh air is required to satsify 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 statutes of the U.S. Bureau of Mines, Mining Enforcement and Safety Administration (MESA) or the strictest state regulations, and will include:

- Minimum of 200 cubic feet per minute (cfm) of fresh air for each man underground;
- Minimum of 125 cfm per brake horsepower of diesel-powered equipment;
- Minimum of 50 cfm per square ft. of headings (or 50 linear ft. per minute of air velocity in entries);
- 40,000 cfm of fresh air per mining machine (based on existing practice in potash mines).

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. 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, six centrifugal fans in parallel, each with a nominal capacity of 215,000 cfm, would supply a total of 1,3000,000 for (Cycles I and III) or 1,250,000 for (Cycle II) ventilation air underground. Two additional fans of the same capacity would be provided as back-up units to facilitate maintenance and/or repair without interruption of the air supply. The supply fans would 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 would be maintained at minimum 40^{o}F by heating coils located in the air intake plenum. Motorized shut-off dampers would be provided in the discharge of each supply fan. The subsurface supply air would be monitored by a flow switch which would 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 would travel down the concrete-lined air supply shaft. At the base of the Ventilation Supply Shaft, the airflow would be divided into separate supply air systems by a controlling dampers. A throttle in each of the main supply branches would permit the ventilation air supply to be shut off in case of fire. The distribution of the supply air would be as follows:

- 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.
- 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.
- 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 stations).
- The remaining, major portion of supply air would be used to satisfy ventilation requirements of the mining operations such as boring, drilling of waste placement holes, sleeve placement and backfilling. At the peak of the mining and placement operations this portion of the ventilation supply air would be approximately 955,000 cfm for Cycles I & III, and 905,000 cfm for a Cycle II repository.

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. Conceptual layout of the subterranean ventilation system is shown on Dwgs. 111 and 211.

All corridors and rooms would be mined by continuous mining machines in multiple passes. During the mining of the first pass, effective dust removal from the working face of the mining machine would be ensured by locating the exhaust tube inlet of the portable ventilating fan as close to the cutting head of the machine as possible. The fan would exhaust the dusty air through the reinforced flexible tubing and discharge it into the main corridor serving exclusively as a mine exhaust air corridor. Additional lengths of ducting would be added as required by the advancing mining machine.

During the second pass in mining of a storage room, the exhaust air need not be returned through the same room as described above, but could be allowed to travel past the working face to the perimeter exhaust corridor and exhausted by an auxiliary fan through the adjacent, already mined, storage room. In this manner, if the ventilating fan is installed in the already mined room, the repeated extension of the exhaust tubing is not necessary. In order to avoid mining into an active exhaust corridor, in some areas an auxilary perimeter corridor would be provided.

Drilling of holes and placement of sleeves for the canistered waste would be ventilated the same way as described above for the second passing mining operation, i.e. supply air would flow through the entire room where the work is in progress, and would be exhausted through the adjacent unoccupied storage room into the mining air exhaust corridor.

The storage rooms would be backfilled after the 5-year retrievability period. Since the backfilling would start at the end of the storage room adjacent to the periphery ventilation airway and proceed in a retreating manner toward the main corridors, ventilation would be provided the same way as during the first pass of mining of the storage room, described earlier in this section. Through redirection by a system of bulkheads, air from the mining operation will 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 would be separated from the supply air carrying M&M corridors by well-sealed stoppings. Air lock type access would 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 would pass above the M&M corridor through an aerodynamically shaped overcast. The exhaust air corridor would be connected to the mining exhaust compartment of the Ventilation Exhaust Shaft, through which the air would travel to the surface and will be exhausted to the atmosphere as described in Section 6.1.5.

6.1.4 Ventilation of Placement Operations

Ventilation flow rates 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 in Storage Areas "A" and "B" the governing criterion is the air requirement for the diesel engine powered waste transporters, resulting in approximately 40,000 cfm of fresh air per transporter. For low-level waste placement operations (Storage Area "C"), where forklift-type vehicles would be used to place the palletized drum and boxes, ventilation would be determined by the minimum air velocity required in the occupied corridor or storage room. In a 36 ft. x 20 ft. Cycle I low-level waste storage room, this amounts to 36,000 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 would be exhausted through the periphery ventilation duct system. (See Dwgs. 111 and 211.) 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 would 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 would 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 would 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 will 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 contaimination while the backfill and mining air will be treated only when contamination is detected. The 26 ft. diameter shaft would 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.

An analysis of ventilation in the event of a mine fire is described in Appendix B.

6.1.5 Exhaust Ventilation Building

The Ventilation Exhaust Shaft would terminate in the plenum chamber of the Exhaust Ventilation Building. This building, the final component in the underground ventilation system, would house the exhaust fans and the central filtering station. A schematic flow diagram of the exhaust air filtering system is shown on Dwg. No. 110.

Exhaust air from the placement compartment of the upcast shaft would 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 would handle 250,000 cfm; a duplicate fan-filter train would 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 would 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 three 550,000 cfm nominal capacity centrifugal fans serving the mining operations only, and discharged directly to the atmosphere through an evase stack. The three fans would be connected in parallel. Normally two of the three mining operations exhaust fans would be in operation while the third may be serviced or used as a standby. Alternate electrical power would be provided to operate any one of the three fans in the event the normal power fails.

Monitors would 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 would 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 to which the placement compartment of the upcast shaft is connected. From this chamber four additional filter-fan trains, identical to the two units serving the placement exhaust, would 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 would operate in case of emergency only, under normal circumstances they can serve as additional back-up units for the placement exhaust filtering system.

Differential pressure gauges would be installed on each side of each filter bank and would indicate when filter replacement is necessary. Each fan would 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 resistence. Connections would be provided for in-place DOP testing of individual HEPA filter banks. Special quick-closing blast dampers would be provided in the fan discharge to the stack to protect the upstream HEPA filters from tornado damage. These dampers would 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.

For the ventilation airflows required in salt, 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 would be maintained at a negative pressure. To achieve the desired distribution of the supply air and assure confinement of mine air within the mine, a system of manually and automatically activated dampers and controls would be incorporated into the ventilation system. Supply fan inlet vane controls and dampers in the supply air distribution system would operate in conjunction with dampers and regulators located in the exhaust air stream to control the air flow and pressure in the high-level and low-level waste storage areas. These fan and damper controls associated with the supply and exhaust systems would 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 and Low-Level Waste Receiving Stations at the base of the waste shafts must be ventilated to ensure confinement of any radioactive contamination as well as provide for safe and comfortable working environment.

The subterranean waste receiving stations would 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, Workmen Area, Waste Receiving and Transporter Loading Areas. Ventilation flow rates will provide six air changes per hour for the Observation and Control Rooms of the Canistered Waste Receiving Station and the Control Room, Foreman's Office and Workmen Area of the Low-Level Waste Receiving Station, and a minimum of 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 would be maintained under negative pressure relative to the mine atmosphere. Upon loss of normal power the supply fans would automatically shut down and the exhaust fans would automatically operate at half speed.

6.1.9 Ventilation During Retrieval

It is assumed that all other mining and placement operations would halt during the retrievable period, if retrieval of the emplaced nuclear waste would be required. 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 room would 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 the 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 an 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 would 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 would depend on the geographic location of the repository. Summer inside design conditions would be 78°F dry bulb (db) with 50% relative humidity in air-conditioned spaces, unless otherwise required for special equipment environment. In spaces that are not air-conditioned, temperatures would be limited to 105°F. Winter inside design conditions would 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:

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

Each confinement zone would 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 would be permitted if filtered through high efficiency particulate air (HEPA) filters.

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

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

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

Exhaust systems for Zones I and II would 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 would 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 would automatically shut down, and the confinement zone exhaust fans would automatically operate at half speed.

All supply and exhaust systems where HEPA filters are required would 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 would 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 would be distributed through underground utility tunnels. In small and remotely located surface buildings, electrical cabinet heaters would 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 the 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 Mechanical Equipment Room. 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 6-4.

6.2.2.1 Descripton of Heating, Ventilating and Air-Conditioning System

The schematic air flow diagram for the Canistered Waste Receiving Building is shown on Dwgs. 106 and 206. 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 and testing areas. A back-up supply fan/air-conditioning unit would be provided for operational reliability. A room thermostat from one of the operating galleries would 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 and Testing Rooms by filter/air-conditioning units. These approximately 15 ton capacity units would 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 and Testing space. Room thermostats in each Cask Unloading and Testing Room would modulate the cooling coil control valve of the respective supplementary unit.

Part of the return air from the Cask Unloading and Testing 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 below.

In the Transfer Cells and the Canister Storage & Feed Room, fan-coil units would 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 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 combined exhaust air flow rates from the primary secondary confinement zones for the Canistered Waste Receiving Building are estimated to be 81,000 cfm for Cycles 1 and III, and 1,000 cfm for Cycle II repository designs.

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.

Ventilation for the Mechanical Equipment Room and the Exhaust Filter Room would be provided from the supply units serving the non-restricted (Zone III) areas and the secondary confinement zones, respectively. 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 unit serving the secondary confinement zone rooms.

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

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 would modulate the cooling and heating coil control valves in the air-conditioning unit. Air would be exhausted to the atmosphere after filtration 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 would have a spark-proof wheel and explosion-proof motor construction.

Supply air for the Mechanical Equipment Room and the Exhaust Filter Room would be provided from the supply units serving the non-restricted zone (Zone III) and the secondary confinement zone, respectively. 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 would 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 atmospher after filtration 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. 109. Outside air for the ventilation of the Low-Level Waste 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 entries 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 would be provided for operational reliability, and the exhaust fans would be linked to the emergency power distribution system. Upon loss of normal power, the confinement zone ventilation supply system would automatically shut down and the exhaust fan would automatically operate at half speed. Exhaust air flow rates from the secondary confinement zones are estimated to be 32,000 cfm in repository designs for all three fuel cycles.

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 would not have auxiliary back-up capabilities, nor would 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 would provide a minimum of ten (10) air changes per hour. Potentially contaminated roon would be maintained under negative pressure relative to the atmosphere, and an overpressure condition will 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 would be provided with an independent climate control system.

6.2.5 Other Surface Structures

The Administration Building and the Mine Operations Building would be provided with year-round central air-conditioning. The system would be designed to recirculate air from the office spaces, drawing only the minimum required outside air. During heating season supplementary heat would be provided by fir 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 would 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 would be provided in the Control Room, and both the normally operating units and the back-up units would be connected to the emergency power network. The switchgear area would 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 would be provided with a heating and ventilating unit. For supplementary heating, cabinet heaters and unit heaters would be used.

Exhaust Ventilation Building: Separate ventilating systems will be provided for the subgrade mechanical fan rooms and Computer Room and for the at-grade Filter Change area. Supply and exhaust control dampers would 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 would be provided as required to maintain indoor temperature at 50°F.

Cafeteria Building: The dining area would be served by an air-conditioning unit supplying 100% outside air. Return air from the dining area would 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 would also serve the kitchen areas. Exhaust fan and ductwork from the kitchen areas would be designed to meet requirements of the application. Heating would be provided by fin tube convectors, unit heaters and cabinet heaters as required.

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

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

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

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

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

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

7.0 BPNL ALTERNATE WASTE DATA IMPACT ON REPOSITORY FACILITY

7.1 General

Battelle Pacific Northwest Laboratories, Inc. (BPNL) has prepared projections for the receipt of nuclear wastes to be stored in a Federal subterranean repository. Similar projections have been made by the Office of Waste Isolation (OWI) for their pre-conceptual study of a repository in salt as reported in Y/OWI/TM-36/7.

The purpose of this chapter is to compare BPNL data with those of OWI and to evaluate their impact on the design and operation of the repository. The basis of comparison will be a subterranean area of 2000 acres in bedded salt of the same stratigraphical characteristics described in TM-36/8. The comparison will be made for the three fuel cycles under consideration, that is:

Cycle I - Total Recycle (U+Pu)

Cycle II - Spent Unreprocessed Fuel

Cycle III - U Recycle Only

7.2 Comparison of Waste Projections

7.2.1 Projected Installed Nuclear Generation Capacity

Figure 6 is a comparative graphical representation of BPNL and OWI projections of the U.S. installed nuclear power generating capacity in gigawatts (GWe) and the accumulated nuclear energy generation in GWe-years through the year 2010. As seen in the table, OWI has assumed a peak installed capacity of approximately 480 GWe, while BPNL has predicted a peak of 400 GWe. Both OWI and BPNL have assumed the peak to occur in the year 2000. The projections for the other years from 1980 to 2010 differ between the two estimates by about the same proportion--OWI's projections being roughly 20% greater than BPNL's.

7.2.2 Waste Types and Packaging

7.2.2.1 Cycles I and III

With the exception of high-level waste (HLW), OWI and BPNL differ in the classification and packaging of wastes resulting from the reprocessing cycles (I & III). HLW continues to be solidified in glass and packaged in steel canisters measuring 12 in. in diameter and 10 ft. in length. Cladding waste (CW), consisting of hulls and hardware from the fuel assemblies packaged in 12 in. diameter canisters for the OWI study, comes packaged in a 30 in. diameter by 10 ft. long canister in BPNL.

Intermediate-level wastes (ILW), consisting of various combustible and non-combustible failed equipment and trash, are divided into five groups. These groups are shown in Table 1-1 where the wastes are designated IL-1 through IL-5 based on the differences between their surface dose rate and packaging. IL-1, IL-2, and IL-5 are packaged in 55 gal. drums (DOT type 17C); IL-3 and IL-4 are packaged in canisters 30 in. in diameter by 10 ft. in length. OWI data contains no such distinction between the ILW types; all ILW is packaged in 12 in. diameter canisters 10 ft. long.

Low-level wastes (LLW) in the BPNL study are divided into two categories, LL-1 and LL-2 (See Table 1-1). LL-1 waste is packaged in 55 gal. drums (DOT Type 17C) and LL-2 waste is packaged in steel boxes (DOT Type 7A), measuring 4 ft. by 6 ft. by 6 ft. OWI waste projections consider all LLW packaged in 55 gal. drums.

7.2.2.2 Cycle II

Both OWI and BPNL data separate the receipts of pressurized water reactor and boiling water reactor spent fuel assemblies. This is done because the assemblies differ in size, heat generation and radioactivity. OWI provides 14 in. diameter canisters for the PWR assemblies and 10 in. diameter canisters for the BWR assemblies. BPNL uses 9.5 in. square canisters for PWR and 6.5 in.

square for BWR. All spent fuel canisters in both studies are 16 ft. long.

OWI projects a relatively small amount of LLW associated with the SURF cycle. This waste is packaged in 55 gal. drums. BPNL does not specify any LLW in this cycle. However, for the purposes of this study a receipt schedule for LLW prorated with respect to the variance of projected installed nuclear generating capacities was used.

7.2.3 Shipping Containers

7.2.3.1 Cycles I and III

BPNL differentiates between the following 5 shipping container types:

- o Cask C-1 for 12" dia. x 10' canisters (HLW)
- o Cask C-2 for 30" dia. x 10' canisters (CW, IL-3 and IL-4)
- o Cask C-3 for 55 gal. drums (IL-1 and IL-2)
- o 8' x 8' x 20' supertigers for drums and boxes (LL-1 and LL-2)
- o Shielded van for drums (IL-5)

OWI identifies the following:

- o Cask for all canistered waste (HLW, CW and ILW)
- o Supertigers for all drums (LLW)

7.2.3.2 Cycle II

Both BPNL and OWI assume the same shipping containers. They are:

- o Casks for all canistered waste (PWR and BWR spent fuel assemblies)
- o Supertigers for all LLW drums

Table 1-1 summaries these shipping containers.

7.2.4 Shipping Carriers

7.2.4.1 Cycles I and III

- o BPNL assumes that only HLW and CW would arrive by rail. All drums would arrive by truck, regardless of shipping container--cask, shielded van, or supertiger.
- o OWI assumes all waste to arrive by rail.

7.2.4.2 Cycle II

- o Both BPNL and OWI assume that all spent fuel canisters will arrive by rail.
- o BPNL assumes low-level waste arrives by truck while OWI assumes rail shipment of these wastes.

7.2.5 Waste Receipts

Tables 7-1, 7-2, and 7-3 give comparative data for BPNL and OWI receipts for the three cycles as follows:

- o Assignments of the various waste packages to either the Canistered Waste Receiving Building or the Low-Level Waste Receiving Building.
- o Maximum daily receipts.
- o Accumulated receipts to the year when the 2000 acre repositories are filled and cannot accept additional wastes.

7.2.5.1 Cycles I and III.

A difference in assignment of the waste to either of the receiving buildings is attributable to a difference in packaging and shipping containers. For OWI data, all intermediate-level waste is packaged, shipped and buried by the same methods as HLW and CW-- that is, packaged in small diameter canisters, shipped in casks and emplaced in drilled holes. This implies that all these wastes are received in the Canistered Waste Receiving Building. BPNL, on the other hand, assumes certain intermediate-level wastes (IL-5) to arrive in shielded vans requiring handling and disposal methods similar to the low-level wastes. (LL-1, LL-2). For this reason they are received by the Low-Level Waste Receiving Building. The impact of this difference is described in Section 7.3

7.2.5.2 Cycle II

The receipts for BPNL are less than those encountered in the OWI study. This reflects the difference in projected generating capacity between the data.

7.2.6 Age of Wastes

In order to develop the waste receipt projections, an assumption must be made about the age of the waste upon receipt at the repository. For HLW, BPNL has estimated a 6.5 year interval between discharge from the reactor and receipt at the repository, with reprocessing occuring 1.5 years after discharge. OWI assumes a 10 year interval. For spent fuel, BPNL envisages a 5.5 year interval between discharge and receipt; OWI uses a 10 year interval. All other waste types - CW, ILW and LLW - are assumed by BPNL and OWI to arrive at the repository approximately 5 years after discharge.

The age of the waste has a bearing not only on the waste receipt projections but also on the heat generation rate per canister. This in turn affects the allowable spacing of the stored canisters as discussed below in Section 7.5.2.

7.3 Impact of BPNL Alternate Waste Packaging

7.3.1 Site

7.3.1.1 Cycles I and III

Because of the reduced number of rail shipments and a corresponding increase in truck shipments, the railroad trackage serving the waste receiving building would be greatly reduced, while roadways and truck maneuvering and parking areas would be increased.

7.3.1.2 Cycle II

The railroad spur to the Low-Level Waste Receiving Building will be replaced with truck facilities.

7.3.2 Canistered Waste Receiving Building

7.3.2.1 Cycles I and III

The alternate packaging of the waste to be received in this facility required the following revisions:

a. Because of the small number of rail shipments, the cask preparation shed is eliminated. This function would be performed in the single bay assigned to receive canistered waste.

b. Three receiving bays would be assigned to receive truck shipments of drummed waste (IL-1, IL-2) in casks.

c. In the OWI study, because of the uniformity of waste and shipping containers, six similar parallel lines served the functions of cask handling, canister extraction, testing and decontamination. One additional line provides overpack facilities. In the BPNL choice of waste packaging and shipping, the handling facilities are varied. For the two sizes of canisters (12 in. and 30 in.) separate handling lines have to be assigned to cask handling, canister extraction, testing, decontamination and overpacking as the equipment for these operations are of appreciably different size.

BPNL data require the Canistered Waste Receiving Building to handle drums arriving in casks in addition to canisters. Three parallel lines have been assigned to processing these drums. There may be several options for this operation but in this preconceptual study it is assumed that all drums processed through the canistered waste building will be overpacked in thin-walled metal cylinders, three drums per cylinder, of dimensions similar to the 30 in. dia. canisters. This method of handling the large number of drums has the following advantages:

a. The equipment used for handling the cylinder in the process line from the test cells to the mine hoist cages can be the same as that used for handling the 30 in. diameter canisters.
b. The number and size of the mine hoists need not be increased.
c. Handling equipment at the subsurface receiving station can accommodate both the cylinders and the 30 in. canisters.
d. The same type of transporter can handle the 30 in. dia. canisters and the overpack cylinders for the drums.
e. Invert storage of the cylinders is identical with that of the 30 in. canisters.
f. The overpack cylinder will increase protection of the drums from corrosion.

7.3.2.2 Cycle II

No basic changes are required in the Canistered Waste Receiving Building as the BPNL and OWI projections are similar.

7.3.3 Low-Level Waste Receiving Building

7.3.3.1 Cycles I and III

The major changes affecting the design and operation of the Low-Level Waste Receiving Building are as follows:

a. In the BPNL study, some ILW (IL-5), in addition to the LLW, is handled. In addition, a portion of the LLW (LL-2) is packaged in metal boxes. In the OWI study, the Low-Level Waste Receiving Building accepts only wastes classified as LLW in drums.

b. Because of the higher surface dose rate of the IL-5 waste, some shielding would be required for BPNL. The OWI facility would not require shielding. To avoid duplication of equipment, all wastes received by the Low-Level Waste Receiving Building in the BPNL study (LL-1, LL-2 and IL-5) would be handled with shielded equipment. Forklift trucks and processing facilities would require adequate biological shielding and critical areas of this building will be designed for Classification I.

c. BPNL shipments would arrive by truck while OWI shipments would arrive by railroad. This eliminates the transfer of the "supertigers" from railroad car to an unloading area. Trucks can enter directly through a confinement chamber unloading would be performed by forklift truck.

d. For Cycle I, the maximum daily BPNL receipt of LLW is less than in the OWI study. This would allow a reduction in manpower required. For Cycle III, OWI projections are less than BPNL; a greater number of personnel are thus required to accommodate the BPNL data.

7.3.3.2 Cycle II

LLW drums in the BPNL study would be shipped by truck instead of by rail. A waste handling arrangement similar to that described for Cycle I can therefore be utilized, except that contact handling can be allowed. Manpower requirements are much less in Cycle II because there are considerably fewer LLW receipts for the spent fuel cycle in both the OWI and BPNL projections, as compared with Cycle I.

7.3.4 Mine Layouts

7.3.4.1 Cycles I and III

The mine layouts developed for the BPNL alternate waste packaging differ primarily because of variations in the waste receiving schedules and storage logistics. In Cycles I and III a larger amount of the 2000 acre repository is taken up by low-level waste storage, partly because of the need to accommodate a portion of the intermediate-level waste (IL-5). The IL-5 waste can be stored more economically with the low-level waste rather with the canistered waste.

Another deviation from earlier repository design criteria deals with HLW canister heat generation rates and the resulting invert storage spacing. In the study based on OWI data, HLW was assumed to have an initial KW per canister (upon receipt at the repository) equal to canisters arriving in later years. Thus, the spacing of canisters remains unchanged throughout the life of the repository. BPNL's packaging methodology results in an initial canister heat loading that increases over time. The spacing of the canisters must then be increased for successive storage panels. This means that a more sophisticated drilling program is required by BPNL data.

7.3.4.2 Cycle II

As stated earlier, BPNL has assumed a lower peak nuclear generating capacity than OWI. However, because of the shorter aging period of the spent fuel canisters that BPNL has assumed, the total number of canisters to be received at the repository by a given year is greater in the BPNL projections than in those of OWI. This tends to reduce the operating life of the repository for the BPNL study.

The shorter aging period also results in a greater initial thermal power (KW) per canister in the BPNL study (0.85 vs. 0.55 for

PWR; 0.25 vs. 0.18 for BWR). The higher canister thermal power, although mitigated by a greater allowable areal loading (180 KW per acre vs. 150 KW per acre), results in an increase in the PWR canister spacing for BPNL--from 6 ft. to 7 ft. on centers. The BWR canisters spacing is unchanged at 6 feet, because at this minimum allowable hole spacing (based on the integrity of the geology), the areal thermal loading remains below the allowable. The greater PWR spacing in the BPNL study reduces the storage capacity of the repository and thus further reduces the operating life (see Table 7-2).

7.3.5 Mining Operations

Basic mining operations for repositories evaluated using BPNL data parallels those selected for the OWI preconceptual design studies. Here again, continuous mining machines would excavate the various rooms and corridors by performing successive advances in the salt stratum. In long rooms (rooms approximately 3000 ft. long), mined materials would be transported away from the heading by branch conveyors to a roof-supported mainline conveyor which would bring the cuttings to a central surge bin. The mined materials would then be transferred into loading pockets and finally into skips for removal to the surface. The excavation of short rooms (rooms 560 ft. long) is similar, except that trucks would be substituted for branch conveyors at the headings. As in the OWI study, blasting is restricted to the initial phase of repository development (before the arrival of waste).

7.3.6 Initial Development

7.3.6.1 Cycles I and III

As in the OWI study the assumption is made that approximately five years will expire between the commencement of construction and waste placement operations. Differences in the anticipated rates of receipt are reflected in this initial development phase as subtle proportionate changes of storage area development. The initial LLW storage area for Cycles I and III (accommodating the first five years of waste) stores the waste more efficiently than previously. This is accomplished by consolidation of the palletized and box waste storage pattern in the rooms. High-level waste receipt in the BPNL data would not begin until one year later than in the OWI data. Thus, the initial mining efforts can be scheduled more flexibly.

7.3.6.2 Cycle II

Cycle II preliminary mine development is similar to the OWI version. Differences in storage are absorbed within the rooms and are not reflected in the number of preliminary panels constructed.

7.3.7 Excavation of Rooms

Rooms are excavated alike in both studies. The overall interaction of various excavation operations for BPNL data is shown in the "Mining and Placement Schedules", Dwgs. 113-114, 213-214 and 313-314. For schedules based on OWI data see Dwgs. B-23 and B-24 in TM-36/8.

7.3.8 Drilling

7.3.8.1 Cycles I and III

Generally, invert storage holes are drilled immediately following the individual room excavation. As with the OWI data, low-level waste is stored directly on the floor. Hence no drilling is required in these rooms. Drilling does occur for all other waste types.

Unlike in OWI, the BPNL Cycle I and III holes are subdivided into two groups: one ft. 8 in. diameter holes for high-level waste canisters and 3 ft. diameter holes for intermediate-level and cladding wastes. The addition of a 3 ft. diameter hole is a direct result of BPNL alternative canister definition. A more elaborate waste handling system is now introduced to accommodate 30 in. diameter canisters as well as "drum packs" (a drum pack comprises 3 drums encapsulated in a steel cylinder intended for invert storage). See Dwg. 119.

HLW canisters in the OWI study utilize an invert storage spacing that is constant throughout the storage area. The spacing is based on a heat generation rate of 2.8 and 2.6 KW per canister for Cycles I and III, respectively. Hole spacing for BPNL is calculated on the basis of a variable canister heat load. Since it would be impractical to uniquely locate every hole, spacing has been standardized in sub-groups consisting of several rooms. For Cycles I and III the range of spacing varies from 8 ft. to 12 ft. with corrresponding heat loads of 2.31 and 3.47 kilowatts per canister.

7.3.8.2 Cycle II

As discussed above, fewer storage holes for spent fuel need to be drilled because of the younger spent fuel being stored in the BPNL study. This however, does not produce any cost savings per canister since the mine storage capacity is reduced accordingly. (See Dwg. 219.)

7.3.9 Sleeve Emplacement

To maintain the stability of holes drilled for invert storage and to protect canister integrity in the 5-year retrievable repository, mild steel sleeves 3/8 in. thick are inserted into each hole, as with the OWI data. In the OWI data sizes of these sleeves were 16 in. in diameter for Cycles I and III and 18 in. and 14 in. in diameter for Cycle II. In the BPNL data an additional sleeve 33 in. in diameter is used for intermediate waste in Cycles I and III; the sleeves for Cycle II remain unchanged despite the different canister cross-section (square vs. round) because of the greatest outside dimensions of the canisters are approximately equal.

7.3.10 Subsurface Waste Receiving and Placement Operations

7.3.10.1 Cycles I and III

Variance in canister size and handling requirements are the contributing factors to changes in subsurface receiving and placement operations. In the OWI study, high-level and intermediate-level waste were delivered to the repository in canisters of comparable physical properties. In BPNL data, Cycle I and III intermediate-level waste is packaged in 30 in. diameter canisters rather than 12 in. diameter as the high-level waste. Using the BPNL data high and intermediate-level waste, subsurface receiving would still be carried out at two subterranean levels via the Canistered Waste Shaft. However, modifications would be required at the intermediate-level waste receiving station to permit remote handling of 30 in. diameter canisters and drum pack units for the intermediate-level waste. The differentiation of canister packages requires two types of transporters in placement service for remotely handled waste.

Low-level waste of the BPNL study has a higher average radioactivity (largely because of the IL-5 waste being handled) and, therefore, requires shielded handling equipment and facilities. To meet this requirement a subsurface receiving station devoted to low-level waste management has been created. In TM-36/17, a subterranean area was provided for receiving low-level waste, but it was not a structural entity. (See Dwg. 121.) Unlike previous low-level waste which came only as palletized drums, the BPNL study low-level waste may also be received at the storage level in metal storage boxes. Forklift vehicles used in the underground transit operations must be additionally shielded, sufficiently flexible to deal with either mode of packaging and rugged enough for reliable service in the underground environment.

7.3.10.2 Cycle II

In Cycle II there is a change in the cross-sectional properties of the spent fuel canister, but this does not appear to have more than a minor impact on the subsurface receiving or placement operations. For the BPNL study low-level waste is similar to the earlier OWI study except that the receipt schedule has been adjusted downward to reflect a lower projected nuclear power generating capacity of 400 Gwe vs. 480 Gwe for the OWI studies.

7.4 Comparison of Ventilation Requirements

7.4.1 Surface Facilities

7.4.1.1 Canistered Waste Receiving Building - Cycles I and III

Basic ventilation concepts for the receiving and handling of high-level, canistered waste packages in Cycles I and III are the same in both the BPNL and the OWI study. Thus, the ventilation systems, described in TM-36/8 under Section 6.2, remain unchanged for the BPNL study.

There is some difference however, in the numerical values of the ventilation air quantities, for the following reasons. In the OWI study where all waste was assumed to arrive via railroad cars, the waste receiving and unloading area consisted of three rail shipment receiving bays. The BPNL data however projects just a small number of rail shipments for Cycles I and III, with most of the waste shipments arriving by trucks. Accordingly, the facility for Cycles I and III was redesigned to include three truck shipment receiving bays and only one rail shipment receiving bay. But since the average size of a truck shipment receiving bay is smaller than a rail shipment receiving bay, the sum of airflow rates for the receiving bays in the BPNL study does not differ much from that computed for the three rail shipment receiving bays in the OWI study (76,000 cfm vs. 78,876 cfm in the OWI study).

The total combined exhaust airflow from the primary and secondary confinement zones for Cycles I and III high-level waste receiving and handling facilities, however, show a larger difference: 81,000 cfm in the BPNL study as compared to 91,000 cfm in the OWI study. This difference is in line with the approximately 11% decrease in overall volume of the BPNL Cycles I and III Canistered Waste Receiving Building as compared to the same facility in the OWI study.

7.4.1.2 Canistered Waste Receiving Building - Cycle II

For Cycle II neither the ventilation concepts nor the ventilation airflow rates require basic changes since the preconceptual layout and operation of the Canistered Waste Receiving Building in the BPNL study is similar to the one developed in the OWI study.

7.4.1.3 Low-Level Waste Receiving Building - Cycles I, II and III

The changes affecting the layout of the low-level waste receiving and handling facilities developed for the OWI and BPNL studies are discussed in Section 7.3.3. The differences that have the greatest impact on the ventilation requirements for the facility in the BPNL study are the elimination of the Cargo Carrier Unloading and Storage Area and the provisions for the bridge crane and the simulataneous unloading of two trucks in the Waste Unloading Area.

The size of the Unloading Area has increased significantly, from approximately 2,700 ft. square total floor area for the Unloading and Palletizing Areas in the OWI study to approx. 6,700 sq. ft. in the BPNL study. This area increase, coupled with the higher headroom required to accommodate the bridge crane in the BPNL study, is the principal reason for the increase in the total exhaust airflow of the secondary confinement zone areas from 12,300 cfm in the BPNL study.

Ventilation requirements for the unrestricted support facilities (Offices, Health Physics, Toilets, Lockers, etc.) do not differ in any significant degree between the BPNL and OWI low-level waste receiving and handling facility designs.

7.4.2 Mine Ventilation

7.4.2.1 Cycles I and III

Mining and waste placement operations for repositories in the BPNL study are similar to those selected for the OWI preconceptual design studies. As in the OWI study, the mining of corridors and storage rooms would be done by continuous mining machines. The methods employed for the excavation of rooms, the drilling of invert storage holes, placement of sleeves and the placement of waste are similar in the two studies. The basic ventilation requirements and methods therefore, are also similar in the BPNL and OWI studies. For Cycles I and III the following minor differences can be identified:

Maximum ventilation air demand for the mining and placement operation for Cycles I and III is 1,100,000 cfm in the BPNL study, 150,000 cfm less than the 1,250,000 cfm required for the same Cycles in the OWI study. The reason for this 12% decrease in peak air flow rates is found in the mining schedules developed for the two studies. In the BPNL study, the required mining rate, as determined by the waste receiving schedules, can be met by 4 continuous mining machines, while in the OWI study 5 machines would be required. Providing ventilation air for one less mining machine means an estimated 40,000 cfm reduction in the ventilation requirements.

Further reduction in peak ventilation airflow rates is realized from the fact that in the BPNL study there are fewer rooms in which drilling of large diameter storage holes would be in progress simultaneously. This was achieved by adjusting the storage hole drilling schedule so as to minimize the number of storage panels requiring drilling at the same time. For example, in Area B (BPNL study) drilling is required in one panel at any one time, while in the ILW and CW storage areas (OWI study) the schedule indicates drilling in two, or sometimes even three panels during the years of peak operation.

Low-level waste of the BPNL study requires shielded handling equipment and facilities. To meet this requirement, the subterranean waste receiving area provided in the OWI study has been modified to include concrete structures for a Control Room, Foreman's Office and Workmen Area. The additional ventilation air requirements for these rooms, however, are negligible when compared to the total airflow (20,000 cfm) estimated for the Low-Level Waste Receiving Station.

7.4.2.2 Cycle II

In Cycle II the peak ventilation air requirements are essentially the same for both the BPNL and the OWI repository design.

7.5 Comparison of Electrical Requirements

7.5.1 Surface Facilities

7.5.1.1 Canistered Waste Receiving Building - Cycles I & III

Due to the redesign of the layout of the Canistered Waste Receiving Building to accommodate most of the waste being shipped by truck and a small amount by rail the BPNL study project a nominal increase in electrical load over that projected in the OWI study by an amount of 40 operational KVA. Of this additional amount 16 KVA is attributed to interior lighting, 10 KVA to miscellaneous power and 19 KVA to waste handling equipment. With regard to the mechanical ventilation system there is a decrease of 5 KVA in the BPNL study.

7.5.1.2 Canistered Waste Receiving Building - Cycle II

While no basic changes were required in the Canistered Waste Receiving Building due to similarity in the BPNL and OWI projections, the BPNL study projects a higher electric load over the OWI study by an amount of approximately 70 operating KVA. This increase is principally attributed to an increase in the overall building area of approximately 12% in the BPNL study resulting from a redesign necessitated by waste shipments arriving by truck instead of rail as in the OWI study. Of this increased amount 31 KVA is attributed to interior lighting, 11 KVA to miscellaneous power and 28 KVA to mechanical ventilation. There are no load changes in the waste handling equipment.

7.5.1.3 Low-Level Waste Receiving Building - Cycles I, II and III

The BPNL study reflects a higher electrical load than the OWI study by the amount of approximately 44 operating KVA. While this amount is considered to be a nominal increase, the major part of it is attributed to the increase in ventilation required by an increase in the classification II area in the BPNL study.

7.5.2 Subterranean Facilities - Underground Service Area, Transfer Stations and Mine Lighting

7.5.2.1 Underground Service Area, Transfer Stations and Mining Lighting - Cycle I

The BPNL study projects a lower electrical load than the OWI study by the amount of approximately 99 operating KVA. This reduction in load is principally attributed to the smaller cummulative lengths of main corrdiors, branch corridors and chambers resulting in less lighting requirements for the BPNL mine laylout.

7.5.2.2 Cycle II

For the same reasons mentioned for Cycle I above, the BPNL study projects a lower electrical load than the OWI study by the amount of approximately 100 operating KVA.

7.5.2.3 Cycle III

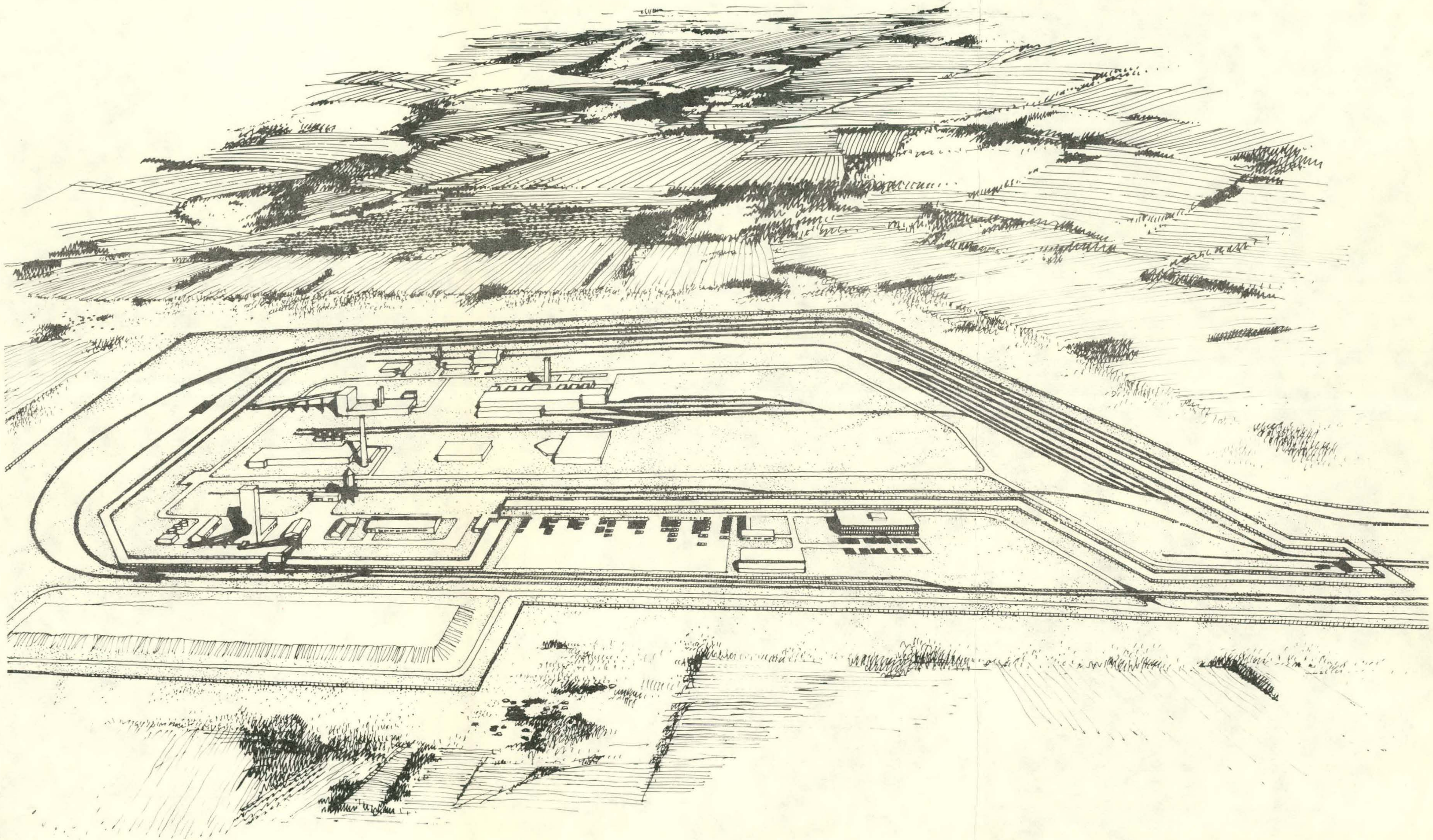
Similarly, as above for Cycles I and II, the BPNL study reflects a lower electrical load than the OWI study by the amount of approximately 202 operating KVA.

7.5.3 Mining Operations

In the mining operations the BPNL study projects a lower connected electrical load than the OWI study by approximately 4344 KVA. The reason is that the individual mining substations must accomodate larger transient loads due to logistical differences in the mining schedules.

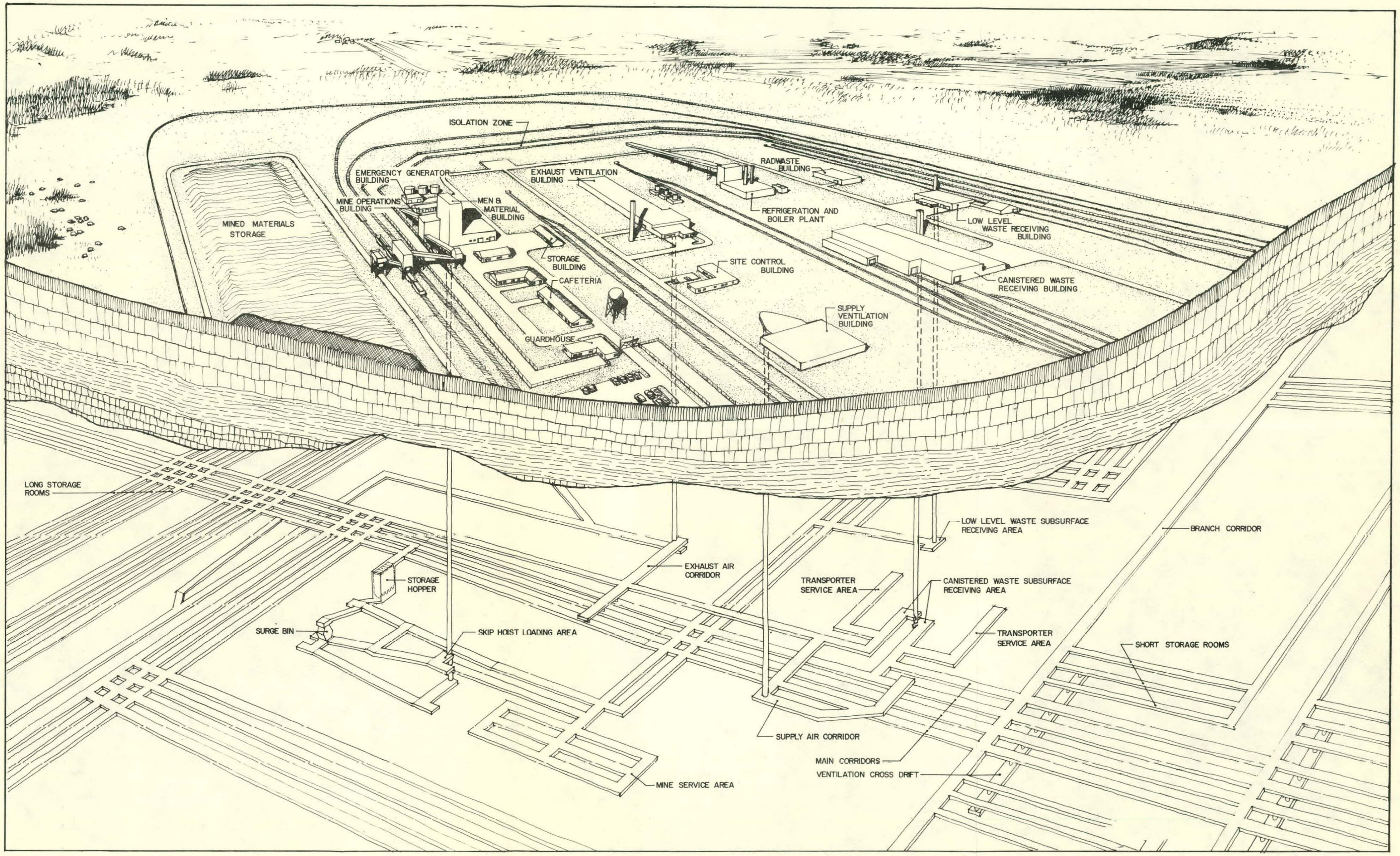
7.5.4 Overall Facility Load Comparison

The estimated total facility electrical loads for the BPNL and OWI studies for Cycles I, II, and III are given in Table 7-4.



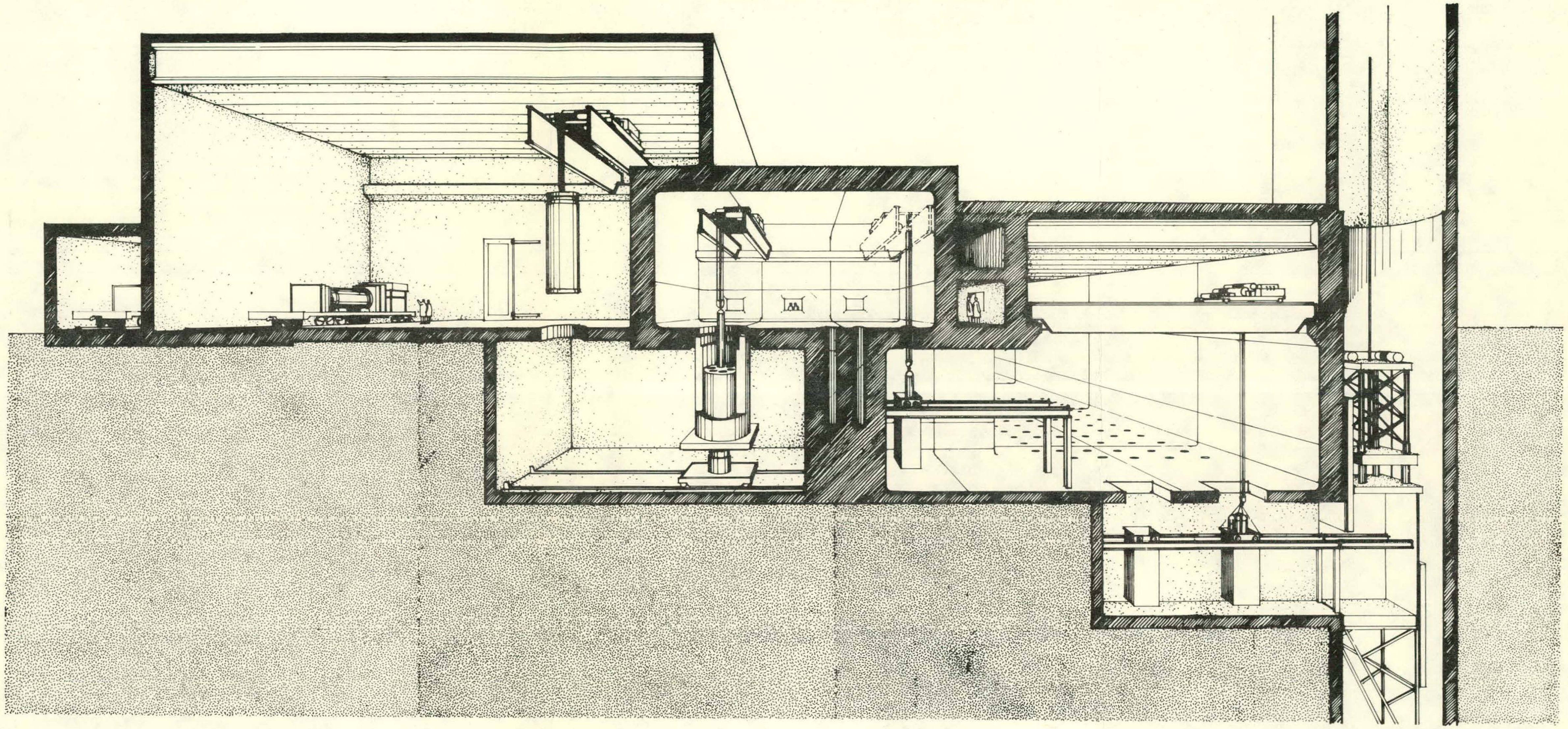
SURFACE FACILITIES

FIG. 1



WASTE ISOLATION FACILITY

FIG. 2



CANISTERED WASTE BLDG. CUTAWAY PERSPECTIVE

FIG. 3

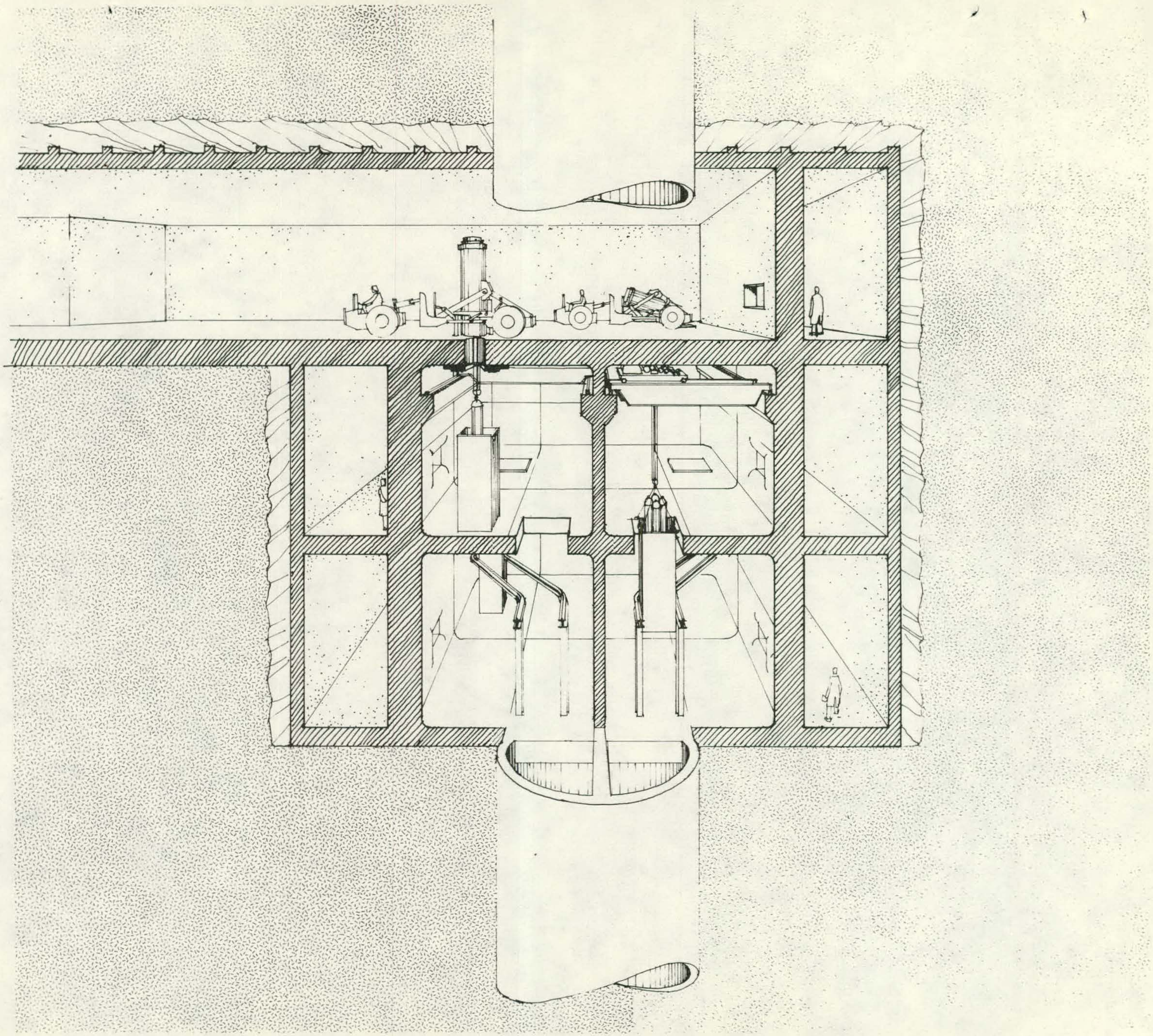
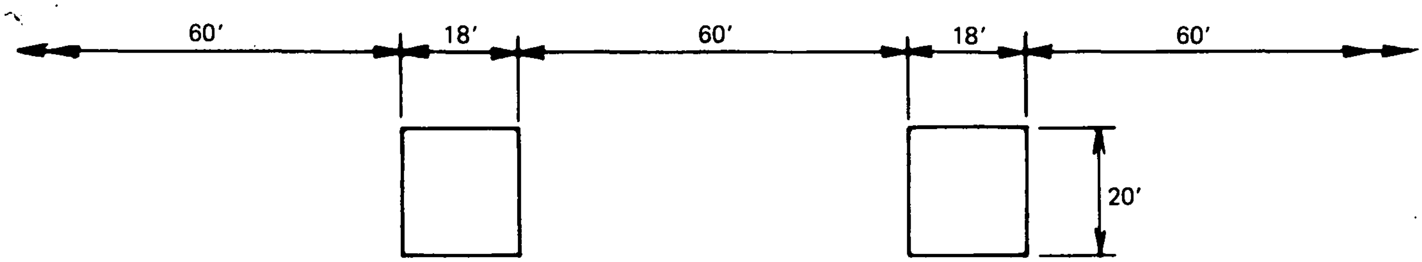


FIG. 4

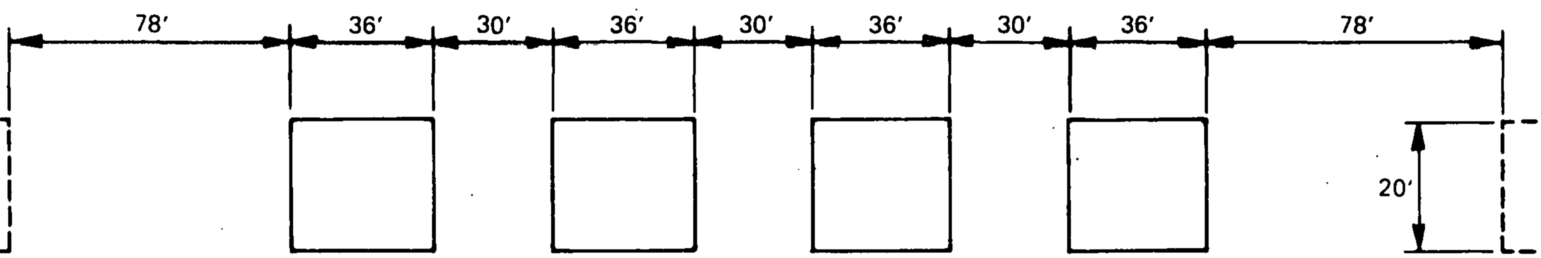
WASTE RECEIVING OPERATIONS CUTAWAY PERSPECTIVE

Salt

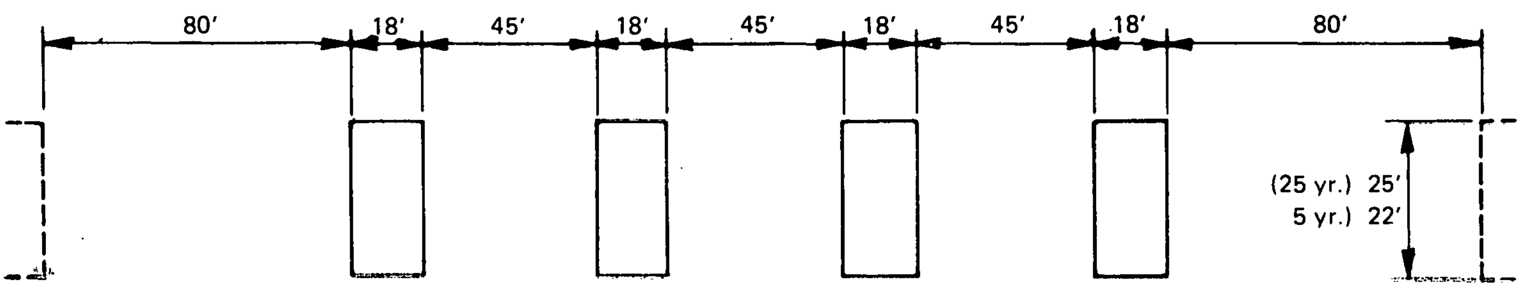
CYCLE I
HLW: Extraction Ration = 23%



ILW & CW: Extraction Ratio = 46%



CYCLE II
PWR/BWR: Extraction Ratio = 25%



CYCLE III: Same as CYCLE I

EXTRACTION RATIO CHART

FIG. 5

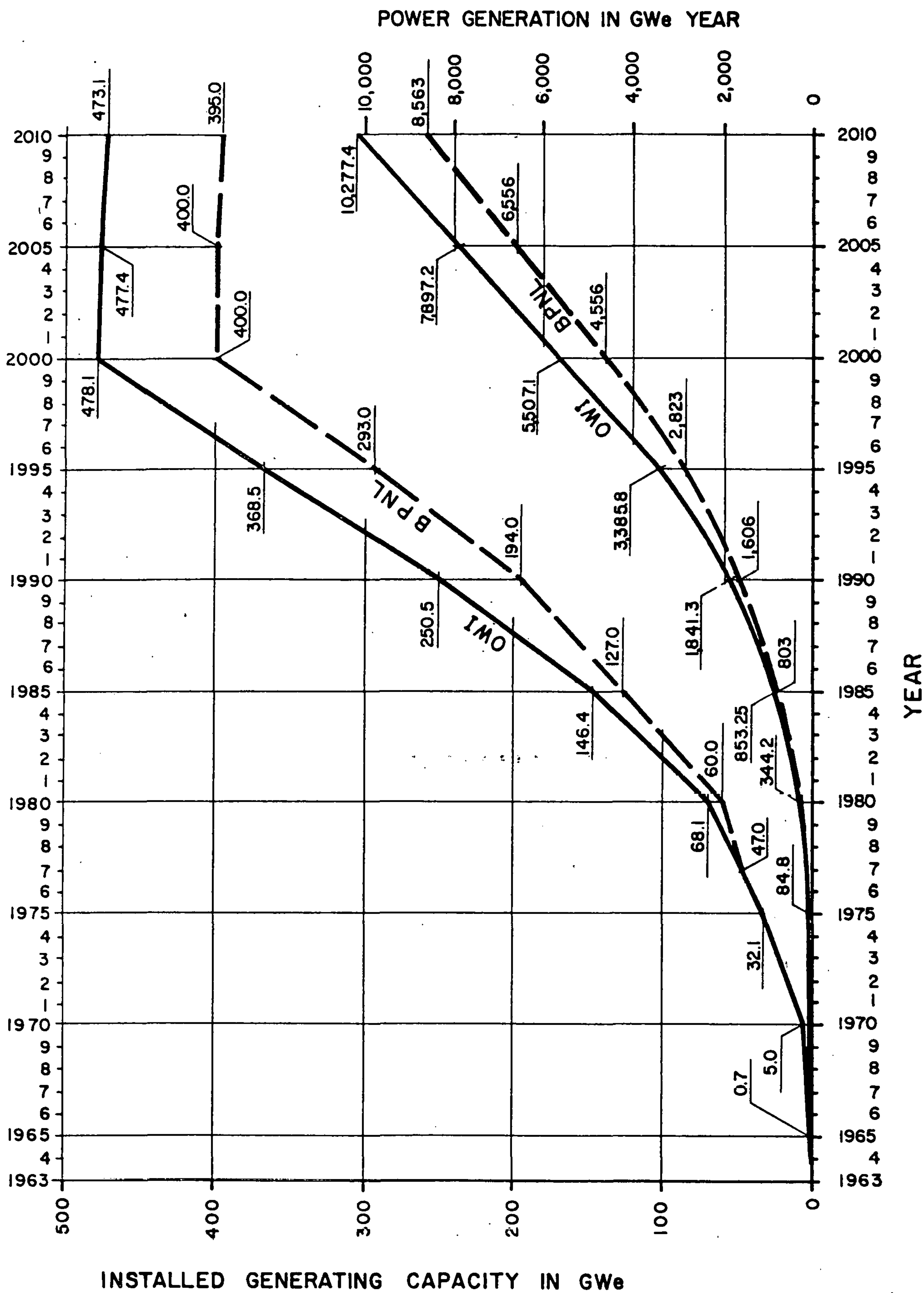

POWER GENERATION IN GWe YEAR
0
2,000
4,000
6,000
8,000
10,000
8,563
YEAR
1963
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
OWI
BPNL
473.1
395.0
400.0
477.4
400.0
478.1
293.0
368.5
194.0
250.5
127.0
146.4
60.0
68.1
47.0
32.1
5.0
0.7
84.8
344.2
853.25
803
1841.3
1,606
3,385.8
2,823
5,507.1
4,556
7,897.2
6,556
10,277.4
500
400
300
200
100
0
INSTALLED GENERATING CAPACITY IN GWe

FIGURE 6

TABLE 1-1

WASTE PACKAGING AND SHIPPING CHARACTERISTICS

	Fuel Cycle	Surface Dose R/Hr	Waste Type	Waste Containers*	Shipping Containers	Shipping Carrier	No. Waste Containers Per Shipping Container
BPNL DATA	I & III	>10.0	HLW	12.75" dia. x 10' Canisters	Casks C-1	Rail	9
			CW	30" dia. x 10' Canisters	Casks C-2	Rail	3
			IL-1	DOT Type 17C Drums	Casks C-3	Truck	6
		1.0 – 10.0	IL-2	DOT Type 17C Drums	Casks C-3	Truck	14
			IL-3	30" Dia. x 10' Canisters	Casks C-2	Truck	3
		0.2 – 1.0	IL-4	30" dia. x 10' Canisters	Casks C-2	Truck	3
			IL-5	DOT Type 17C Drums	Shielded Vans	Truck	36
		<0.2	LL-1	DOT Type 17C Drums	"Supertigers"	Truck	36
			LL-2	DOT Type 7A Boxes	"Supertigers"	Truck	3
	II	N.A.	PWR	9.5' Sq. x 16' Canisters	Casks C-4	Rail	7
			BWR	6.5' Sq. x 16' Canisters	Casks C-4	Rail	17
		N.A.	LLW	DOT Type 17C Drums	"Supertigers"	Truck	42
OWI DATA	I & III	N.A.	HLW	12.75" dia. x 10' Canisters	Cask	Rail	8
			CW	12.75" dia. x 12' Canisters	Cask	Rail	8
			ILW	12.75" dia. x 12' Canisters	Cask	Rail	8
			LLW	DOT Type 17C Drums	"Supertigers"	Rail	42
	II	N.A.	PWR	14" dia. x 16' Canisters	Cask	Rail	7
			BWR	10.75" dia. x 16' Canisters	Cask	Rail	12
			LLW	DOT Type 17C Drums	"Supertigers"	Rail	42

N.A. = Not Available

*All sizes are given in overall dimensions.

Table 1-2

HIGH-LEVEL WASTE (HLW) RECEIVING RATES[a] (CYCLE I)

Year	Canisters[b] Annual	Canisters[b] Accumulated
1985	0	0
1986	164	164
1987	329	493
1988	493	986
1989	493	1479
1990	712	2191
1991	931	3122
1992	1150	4272
1993	1150	5422
1994	1150	6572
1995	1150	7722
1996	1150	8872
1997	1150	10022
1998	1369	11391
1999	1588	12979
2000	1807	14786
2001	1807	16593
2002	1807	18400
2003	2026	20426
2004	2245	22671
2005	2464	25135
2006	2464	27599
2007	2464	30063
2008	2683	32746
2009	2902	35648
2010	3121	38769
2011	3121	41890
2012	3121	45011
2013	3121	48132
2014[c]	3176	51308
2015	3244	54552
2016	2752	57304
2017	3004	60308
2018	3260	63568
2019	3518	67086
2020	2835	69921
2021	2841	72762
2022	2847	75609
2023	2852	78461
2024	2858	81319
2025	3042	84361

[a] Based on projections prepared by BPNL (November-1977). Assumes 400 GWe by the year 2000.

[b] Reference HLW canister is 10 ft. long by 12 in. diameter.

[c] Number of canisters received between the year 2014 and 2025 has been adjusted to reflect the maximum allowable heat load per canister in salt after the 5 year retrievable period. This value has been determined to be 3.8 kw/canister.

Table 1-3

HLW RECEIVING RATES (CYCLE III)

Year	Canisters[b] Annual	Canisters[b] Accumulated
1985	0	0
1986	164	164
1987	329	493
1988	493	986
1989	493	1479
1990	712	2191
1991	931	3122
1992	1150	4272
1993	1150	5422
1994	1150	6572
1995	1150	7722
1996	1150	8872
1997	1150	10022
1998	1369	11391
1999	1588	12979
2000	1807	14786
2001	1807	16593
2002	1807	18400
2003	2026	20426
2004	2245	22671
2005	2464	25135
2006	2464	27599
2007	2464	30063
2008	2683	32746
2009	2902	35648
2010	3121	38769
2011	3121	41890
2012	3121	45011
2013	3121	48132
2014	3121	51253
2015	3121	54374
2016	2628	57002
2017	2847	59849
2018	3066	62915
2019	3285	66200
2020	2628	68828
2021	2628	71456
2022	2628	74084
2023	2628	76712
2024	2628	79340
2025	2792	82132

[a]Based on projections prepared by BPNL (November-1977). Assumes 400 Gwe installed nuclear capacity by the year 2000.

[b]HLW canisters are 12 inches in diameter and 10 feet long.

Table 1-4

CLADDING WASTE (CW) RECEIVING RATES[a] (CYCLES I AND III)

Year	Canisters[b] Annual	Accumulated
1985[c]	520	520
1986	896	1416
1987	1056	2472
1988	1056	3528
1989	1056	4584
1990	1056	5640
1991	840	6480
1992	840	7320
1993	1000	8320
1994	1160	9480
1995	1320	10800
1996	1320	12120
1997	1320	13440
1998	1480	14920
1999	1640	16560
2000	1800	18360
2001	1800	20160
2002	1800	21960
2003	1960	23920
2004	2120	26040
2005	2280	28320
2006	2280	30600
2007	2280	32880
2008	2280	35160
2009	2280	37440
2010	2280	39720
2011	1920	41640
2012	2080	43720
2013	2240	45960
2014	2400	48360
2015	1920	50280
2016	1920	52200
2017	1920	54120
2018	1920	56040
2019	1920	57960
2020	2040	60000
2021	2160	62160
2022	2400	64560
2023	1920	66480
2024	1920	68400
2025	1920	70320

[a]Based on projections prepared by BPNL (November-1977). Assumes 400 GWe by the year 2000.

[b]Reference canisters are 10 feet long with a 30 inch diameter containing cladding hulls and assembly hardware.

[c]Backlog of 1080 canisters prior to 1985 is evenly distributed in projections for 1986-1990.

Table 1-5

INTERMEDIATE - LEVEL WASTE (ILW) DRUM RECEIVING RATES[a,b]
(CYCLES I AND III)

Year	IL-5 (0.2-1 R/hr)[c]		IL-2 (1-10 R/hr)[c]		IL-1 (>10 R/hr)[c]	
	Annual	Accumulated	Annual	Accumulated	Annual	Accumulated
1985[d]	2114	2114	2130	2130	4627	4627
1986	3642	5756	3669	5800	7969	12596
1987	4292	10048	4326	10126	9394	21990
1988	4292	14340	4326	14452	9394	31384
1989	4292	18632	4326	18778	9394	40778
1990	4292	22924	4326	23104	9394	50172
1991	3414	26338	3441	26545	7473	57645
1992	3414	29752	3441	29986	7473	65118
1993	4065	33817	4096	34082	8897	74015
1994	4715	38532	4751	38833	10318	84333
1995	5365	43897	5407	44240	11743	96076
1996	5365	49262	5407	49647	11743	107819
1997	5365	54627	5407	55054	11743	119562
1998	6016	60643	6062	61116	13167	132729
1999	6666	67309	6717	67833	14588	147317
2000	7316	74625	7373	75206	16013	163330
2001	7316	81941	7373	82579	16013	179343
2002	7316	89257	7373	89952	16013	195356
2003	7967	97224	8028	97980	17437	212793
2004	8617	105841	8683	106663	18858	231651
2005	9267	115108	9338	116001	20283	251934
2006	9267	124375	9338	125339	20283	272217
2007	9267	133642	9338	134677	20283	292500
2008	9267	142909	9338	144015	20283	312783
2009	9267	152176	9338	153353	20283	333066
2010	9267	161443	9338	162691	20283	353349
2011	7804	169247	7864	170555	17080	370429
2012	8455	177702	8520	179075	18504	388933
2013	9104	186806	9174	188249	19926	408853
2014	9755	196561	9830	198079	21350	430209
2015	7804	204365	7864	205943	17080	447283
2016	7804	212169	7864	213807	17080	464369
2017	7804	219973	7864	221671	17080	481449
2018	7804	227777	7864	229535	17080	498529
2019	7804	235581	7864	237399	17080	515609
2020	8292	243873	8356	245755	18148	533757
2021	8780	252653	8847	245602	19215	552972
2022	9755	262408	9830	264432	21350	574322
2023	7804	270212	7864	272296	17080	591402
2024	7804	278016	7864	280160	17080	608482
2025	7804	282820	7864	288024	17080	625562

[a] Based on projections prepared by BPNL (November-1977). Assumes 400 GWe by the year 2000.

[b] Reference drum is a DOT type 17C (or 17H), 55 gallon drum.

[c] Surface does rate.

[d] Backlogs of 4390, .2-1 R/hr drums, 4424, 1-10 R/hr drums and 9607, >10 R/hr drums prior to year 1985 are evenly distributed into projections for the years 1986-1990.

Table 1-6

INTERMEDIATE - LEVEL WASTE (ILW) CANISTER RECEIVING RATES[a,b]
(CYCLES I AND III)

	IL-4 (0.2-1R/hr[c])		IL-3 (1-10 R/hr[c])	
Year	Annual	Accumulated	Annual	Accumulated
1985[d]	73	73	4	4
1986	125	198	8	12
1987	147	345	8	20
1988	147	492	9	29
1989	147	639	9	38
1990	147	786	9	47
1991	117	903	7	54
1992	117	1020	7	61
1993	140	1160	8	69
1994	162	1322	10	79
1995	184	1506	11	90
1996	184	1690	11	101
1997	184	1874	11	112
1998	207	2081	12	124
1999	229	2310	14	138
2000	251	2561	15	153
2001	251	2812	15	168
2002	251	3063	15	183
2003	274	3337	16	199
2004	296	3633	18	217
2005	318	3951	19	236
2006	318	4269	19	255
2007	318	4587	19	274
2008	318	4905	19	293
2009	318	5223	19	312
2010	318	5541	19	331
2011	268	5809	16	347
2012	290	6099	17	364
2013	313	6412	19	383
2014	335	6747	20	403
2015	268	7015	16	419
2016	268	7283	16	435
2017	268	7551	16	451
2018	268	7819	16	467
2019	268	8087	16	483
2020	285	8372	17	500
2021	302	8674	18	518
2022	335	9009	20	538
2023	268	9277	16	554
2024	268	9545	16	570
2025	268	9813	16	586

[a] Based on projections prepared by BPNL (November-1977). Assumes 400 GWe by 2000.
[b] Reference canisters are 10 feet long with a 30 inch diameter.
[c] Canister surface dose rate.
[d] Backlogs of 150, 0.2-1R/hr canisters and 9, 1-10 R/hr canisters prior to 1985 are evenly distributed in projections for 1986-1990.

Table 1-7

LOW-LEVEL WASTE (LLW) RECEIVING RATES[a] (CYCLE I)

	IL-1 (Drums)[b,d]		LL-2 (Boxes)[c,d]	
Year	Annual	Accumulated	Annual	Accumulated
1985[e]	5182	5182	85	85
1986	9047	14229	148	233
1987	10762	24990	175	408
1988	11238	36228	179	587
1989	11462	47680	181	768
1990	11694	59374	183	951
1991	9772	69146	150	1101
1992	9946	79092	151	1252
1993	11520	90612	177	1429
1994	13564	104176	207	1639
1995	15649	119825	238	1874
1996	16172	135997	243	2117
1997	16042	152039	241	2358
1998	17374	169413	265	2623
1999	19250	188661	294	2917
2000	21262	209925	324	3241
2001	21931	231856	330	3571
2002	22077	253933	331	3902
2003	23487	277420	353	4257
2004	25403	302823	384	4641
2005	27358	330181	414	5055
2006	28123	358301	421	5476
2007	28437	386738	423	5899
2008	28612	415350	425	6324
2009	28814	444164	427	6751
2010	28876	473040	427	7178
2011	25841	498881	373	7551
2012	26352	525233	390	7941
2013	28525	553758	421	8362
2014	30779	584537	453	8815
2015	26740	611277	381	9195
2016	25059	636336	366	9561
2017	24941	661277	365	9926
2018	24902	686179	365	10291
2019	24992	711171	366	10657
2020	25856	737027	382	11039
2021	27484	764511	406	11448
2022	29385	793896	441	11885
2023	25678	819674	372	12258
2024	23722	843296	355	12613
2025	23424	866720	352	12956

[a]Based on projections prepared by BPNL (November-1977). Assumes 400 GWe by the year 2000.

[b]Reference drum is DOT type 17C (or 17H), 55 gallon drum.

[c]Reference box is DOT spec 7A carbon steel box with dimensions 4'x6'x6'.

[d]Surface dose rate of >0.2 R/hr.

[e]Backlogs of 10533 drums and 174 boxes prior to 1985 are evenly distributed into projections for 1986-1990.

Table 1-8

LOW-LEVEL WASTE (LLW) RECEIVING RATES[a] (CYCLE III)

Year	LL-1 (Drums)[b,d] Annual	LL-1 (Drums)[b,d] Accumulated	LL-2 (Boxes)[c,d] Annual	LL-2 (Boxes)[c,d] Accumulated
1985	2883	2883	54	54
1986	4966	7849	94	148
1987	5854	13703	110	258
1988	5854	19557	110	368
1989	5854	25411	111	479
1990	5856	31267	111	590
1991	4657	35924	88	678
1992	4657	40581	88	766
1993	5544	46125	104	870
1994	6430	52555	121	991
1995	7318	59873	138	1129
1996	7318	67191	138	1267
1997	7318	74509	138	1405
1998	8205	82714	154	1559
1999	9091	91805	171	1730
2000	9979	101784	188	1918
2001	9979	111763	188	2106
2002	9979	121742	188	2294
2003	10866	132608	204	2498
2004	11752	144360	221	2719
2005	12640	157000	238	2957
2006	12640	169640	238	3195
2007	12640	182280	238	3433
2008	12640	194920	238	3671
2009	12640	207560	238	3909
2010	12640	220200	238	4147
2011	10644	230844	200	4347
2012	11531	242376	217	4564
2013	12418	254793	233	4797
2014	13305	268098	250	5047
2015	10644	278742	200	5247
2016	10644	289386	200	5447
2017	10644	300030	200	5647
2018	10644	310674	200	5847
2019	10644	321318	200	6047
2020	11309	332627	213	6260
2021	11975	344602	225	6485
2022	13305	357907	250	6735
2023	10644	368551	200	6935
2024	10644	379195	200	7135
2025	10644	389839	200	7335

[a] Based on projections prepared by BPNL (November-1977). Assumes 400 GWe by the year 2000.

[b] Reference drum is DOT type 17C (or 17H), 55 gallon drum.

[c] Reference box is DOT spec. 7A carbon steel box with dimensions 4'x6'x6'.

[d] Surface dose rate of >0.2R/hr.

[e] Backlogs of 5987 drums and 113 boxes prior to 1985 are evenly distributed into projections for 1986-1990.

Table 1-9

SPENT FUEL RECEIVING RATES[a] (CYCLE II)

Year	PWR Assemblies[b] Annual	PWR Assemblies[b] Accumulated	BWR Assemblies[c] Annual	BWR Assemblies[c] Accumulated
1985	2100	2100	3150	3150
1986	2100	4200	3150	6300
1987	2100	6300	3150	9450
1988	2100	8400	3150	12600
1989	2100	10500	3150	15750
1990	2300	12800	3450	19200
1991	2600	15400	3900	23100
1992	3200	18600	4800	27900
1993	3500	22100	5300	33200
1994	4100	26200	6200	39400
1995	4600	30800	6800	46200
1996	5100	35900	7600	53800
1997	5300	41200	7900	61700
1998	5700	46900	8500	70200
1999	6400	53300	9600	79800
2000	6800	60100	10200	90000
2001	7300	67400	11000	101000
2002	8100	75500	12100	113100
2003	8800	84300	13200	126300
2004	9300	93600	13900	140200
2005	10200	103800	15300	155500
2006	10700	114500	16000	171500
2007	11500	126000	17200	188700
2008	12100	138100	18100	206800
2009	12700	150800	19000	225800
2010	12400	163200	18600	244400
2011	12300	175500	18500	262900

[a]Based on projections prepared by BPNL (September-1977). Assumes 400 GWe nuclear capacity by the year 2000.

[b]Reference PWR canister is 9.5 inches square by 16 feet long (contains 1 PWR assembly).

[c]Reference BWR canister is 6.5 inches square by 16 feet long (contains 1 BWR assembly).

Table 1-10

SPENT FUEL - LLW RECEIVING RATES[a,c] (CYCLE II)

Year	Number of LLW-Drums[b] Annual	Accumulated
1985	180	180
1986	790	970
1987	900	1870
1988	1000	2870
1989	1120	3990
1990	1160	5150
1991	1910	7060
1992	2030	9090
1993	2150	11240
1994	2280	13520
1995	2450	15970
1996	1990	17960
1997	2110	20070
1998	2230	22300
1999	2350	24650
2000	2530	27180
2001	2640	29820
2002	2640	32460
2003	2640	35100
2004	2640	37740
2005	2640	40380
2006	2640	43020
2007	2640	45660
2008	2640	48300
2009	2640	50940
2010	2640	53580

[a]Based on data prepared by OWI (Y/OWI/TM-34). Adjusted from projections for 480 GWe installed nuclear capacity by year 2000 to reflect 400 GWe installed capacity by the same year.
[b]Reference drum is DOT type 17c, 55 gallon drum (.208m^3).
[c]Assumes 13.7 m^3 LLW per GWe-yr. generating capacity. Waste compacted by a factor of 10 during packaging.

Table 1-11
Personnel Assignment Schedule
BPNL - Cycle I

Year	Waste Storage Operation	Mining Operation *	Drilling Operation	Sleeve Placement Operation	Backfill Operation	Total
1980	58	-	-	-	-	58
1981	64	70	-	-	-	134
1982	77	140	-	-	-	217
1983	85	372	-	-	-	457
1984	93	373	43	14	-	523
1985	557	342	142	29	-	1070
1986	742	342	142	29	-	1255
1987	817	342	142	29	-	1330
1988	828	350	145	-	-	1312
1989	827	350	145	-	-	2634
1990	831	350	145	-	37	1363
1991	742	350	145	-	37	1274
1992	742	350	145	-	37	1274
1993	814	350	145	-	37	1346
1994	881	350	145	-	37	1413
1995	966	350	145	-	37	1498
1996	966	350	145	-	37	1498
1997	974	350	145	-	37	1506
1998	1046	350	145	-	37	1578
1999	1118	230	93	-	24	1535
2000	1189	230	93	-	24	1536
2001	1189	230	93	-	24	1536
2002	1188	230	93	-	24	1535
2003	1259	322	134	-	35	1750
2004	1330	322	134	-	35	1821
2005	1407	322	134	-	35	1898
2006	1407	322	134	-	35	1898
2007	1404	254	106	-	27	1791
2008**	1405	-	106	-	125	1635
2009	220	-	-	-	107	327
2010	146	-	-	-	107	253
2011	110	-	-	-	107	217
2012	73	-	-	-	89	169
2013	37	-	-	-	71	108

*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 1-12
Personnel Assignment Schedule
BPNL - Cycle II

Year	Waste Storage Operation	Mining Operation *	Drilling Operation	Sleeve Placement Operation	Backfill Operation	Total
1980	58	-	-	-	-	58
1981	64	62	-	-	-	126
1982	77	124	-	-	-	201
1983	85	371	14	-	-	470
1984	93	372	43	29	-	537
1985	428	200	87	24	-	739
1986	442	200	87	24	-	753
1987	451	200	87	23	-	761
1988	460	200	87	12	-	759
1989	459	200	87	-	-	746
1990	472	200	87	-	15	774
1991	493	200	87	-	15	795
1992	519	308	135	-	23	985
1993	533	308	135	-	23	999
1994	562	308	135	-	24	1029
1995	590	308	135	-	24	1057
1996	612	308	135	-	24	1079
1997	629	308	135	-	24	1096
1998	646	308	135	-	24	1113
1999	677	309	135	-	24	1145
2000	692	309	135	-	24	1160
2001	714	437	191	-	33	1375
2002	748	219	96	-	17	1080
2003	778	219	96	-	17	1110
2004	800	219	96	-	17	1132
2005	844	109	96	-	17	1066
2006	866	-	96	-	134	1096
2007**	898	-	48	-	124	1070
2008	220	-	-	-	116	336
2009	146	-	-	-	116	262
2010	110	-	-	-	116	226
2011	73	-	-	-	116	189
2012	37	-	-	-	116	153

*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 2007.

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 1-13
Personnel Assignment Schedule
BPNL - Cycle III

Year	Waste Storage Operation	Mining Operation *	Drilling Operation	Sleeve Placement Operation	Backfill Operation	Total
1980	58	-	-	-	-	58
1981	64	70	-	-	-	134
1982	77	140	-	-	-	217
1983	85	326	-	-	-	411
1984	93	396	159	16	-	664
1985	499	350	119	63	-	1031
1986	642	224	77	32	-	975
1987	701	224	77	16	-	1018
1988	711	224	77	-	-	1012
1989	710	224	77	-	-	1011
1990	714	224	77	-	20	1035
1991	648	224	77	-	20	969
1992	648	224	77	-	20	969
1993	703	350	119	-	31	1203
1994	760	344	117	-	30	1251
1995	820	322	110	-	28	1280
1996	820	447	153	-	40	1460
1997	828	447	153	-	40	1468
1998	882	447	153	-	39	1521
1999	937	447	153	-	39	1576
2000	989	447	153	-	39	1628
2001	989	447	153	-	39	1628
2002	988	447	153	-	39	1627
2003	1041	435	148	-	38	1662
2004	1096	322	148	-	28	1594
2005	1154	292	149	-	26	1621
2006	1154	49	149	-	79	1431
2007	1151	-	149	-	75	1375
2008**	1152	-	100	-	75	1327
2009	220	-	-	-	106	326
2010	146	-	-	-	106	252
2011	110	-	-	-	106	216
2012	73	-	-	-	106	179
2013	37	-	-	-	106	143

*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 - BPNL

	Salt - Cycle I BPNL Waste Packages			Salt - Cycle II BPNL Waste Packages			Salt - Cycle III BPNL Waste Packages		
	Conn. KVA	Oper. KVA	Emerg. KVA	Conn. KVA	Oper. KVA	Emerg. KVA	Conn. KVA	Oper. KVA	Emerg. KVA
Adm. Bldg.	211	168	9	211	168	9	211	168	9
Clinic	136	92	24	136	92	24	136	92	24
Whse. & Veh. Maint.	88	67	3	88	67	3	88	67	3
Gd. House Psnl.	29	23	20	29	23	20	29	23	20
Gd. House RR chk.	20	17	6	20	17	6	20	17	6
Cafeteria	177	129	5	177	129	5	177	129	5
Laundry	130	86	3	130	86	3	130	86	3
Firehouse	59	47	15	59	47	15	59	47	15
M & M Buldg.	437	290	56	437	290	56	437	290	56
Mine Oper. Bldg.	36	28	3	36	28	3	36	28	3
Fuel Oil Dpt. & Gen. Bldg.	102	81	62	102	81	62	102	81	62
Storage Bldg.	63	51	2	63	51	2	63	51	2
Water Tower	92	65	42	92	65	42	92	65	42
Exhst. Vent. Bldg. # 1	4800	3788	423	4771	3764	423	4800	3788	423
Exhst. Vent. Bldg. # 2	-	-	-	-	-	-	-	-	-
Supply Vent Bldg.	2242	1701	10	2242	1701	10	2242	1701	10
Boiler Plant	1120	892	228	1120	892	228	1120	892	228
Refrigeration Bldg.	393	314	25	393	314	25	393	314	25
HLW Bldg.	2059	966	700	2054	995	709	2059	966	700
LLW Bldg.	272	186	89	272	186	89	272	186	89
Radwaste Bldg.	169	109	11	169	109	11	169	109	11
Alarm Comm. Ctr	130	107	70	130	107	70	130	107	70
Roadway Lighting	96	96	78	96	96	78	96	96	78
Security Lighting	17	17	17	17	17	17	17	17	17
M & M Cage Hoist	675	675	675	675	675	675	675	675	675
Aux. M & M Hoist	136	136	-	136	136	-	136	136	-
M & M Skip Hoist	2952	2952	-	2952	2952	-	2952	2952	-
HLW Hoist No. 1	429	429	-	429	429	-	429	429	-
HLW Hoist No. 2	429	429	-	429	429	-	429	429	-
LLW Hoist	843	843	-	843	843	-	843	843	-
Undergrd. Serv. Transfer Sta., & Mine Lighting	4049	2179	208	4543	2498	240	5158	2748	265
Mining Substation No. 1	4176	3132	-	5403	4052	-	4176	3132	-
Mining Substation No. 2	1692	1269	-	2813	2110	-	1735	1301	-
Mining Substation No. 3	2934	2200	-	3535	2651	-	2934	2200	-
TOTALS	31193	23564	2784	34602	26100	2825	32345	24165	2841

Table 5-1

BPNL REPOSITORY SUMMARY

Cycle/ Year Repository Filled	Waste Type	Capacity*	Storage Mode	Storage Area	Approximate Area (Acres)	Total No. Of Rooms	Total No. Of Panels	Rows Per Room	Longitudinal Spacing Ea. Row (Ft.)	Room Opening WxH (Ft.)	Panel No.	Rooms Per Panel	Room Length (Ft.)	Waste Units Per Room**
	HLW	33,240[c]	Canisters in holes	A	920	707	18	1	8-12	18x20	1	9	560	64
											2	26	560	64
											3-18	42	560	43-61
	CW	35,182[c]	Canisters in holes	B	696	124	31	4	7.5	36x20	1	4	1645	860
	IL-1	312,990[d]	Drum-packs of 3 in holes								2-24	4	3295	1740
I	IL-2	144,111[d]	"								25-31	4	1990	1044
	IL-3	294[c]	Canisters in holes											
2008	IL-4	4909[c]	"											
	IL-5	143,665[d]	Pallets of 6 on floor	C	61	24	6	-	-	36x20	1-2	4	640	800
	LL-1	417,486[d]	"								3-5	4	1600	3120
	LL-2	6357[b]	Boxes on floor											
II	PWR	129,736[c]	Canisters in holes	A	808	148	37	2	7	18x22	1-9	4	1900	530
											10-37	4	3500	988
	BWR	190,816[c]	"	B	994	172	43	2	6	18x22	1-34	4	3500	1150
2007											35-43	4	2910	956
	LLW	56,000[d]	Pallets of 6 on floor	C	33	20	5	-	-	18x22	1-5	4	774	2800
	HLW	32,299[c]	Canisters in holes	A	925	727	18	1	9-12	18x20	1	18	560	57
											2	21	560	55-57
											3-18	43	560	43-55
III	CW	35,180[c]	"	B	700	120	30	4	7.5	36x20	1	4	1690	880
	IL-1	312,966[d]	Drum-packs of 3 in holes								2-22	4	3414	1800
2008	IL-2	144,099[d]	"								23-30	4	2260	1188
	IL-3	293[c]	Canisters in holes											
	IL-4	4908[c]	"											
	IL-5	142,914[d]	Pallets of 6 on floor	C	38	20	5	-	-	36x20	1	4	280	320.5
	LL-1	194,922[d]	"								2	4	580	717
	LL-2	3,671[b]	Boxes on floor								3-5	4	1200	2323

* b = Boxes
c = Canisters
d = Drums

** 3 Drums = 1 Unit for IL-1, IL-2
12 Drums = 1 Unit for IL-5, LL-1.

Table 5-2

LOCAL AREAL THERMAL LOADINGS

Cycle	Waste Type	Age of Waste Upon Receipt**	Average KW/Can*	Allow. Areal Thermal Loading (Kw/Acre)	Design Areal Thermal Loading (Kw/Acre)
I	HLW (glass)	6.5	2.31-3.47	150	148-149
II	PWR	5.5	0.853	170	167
	BWR	5.5	0.247	170	56
III	HLW + Pu (glass)	6.5	2.61-3.44	150	147-150

*upon receipt at repository

**years after discharge from reactor

Table 5-3

MINING PRODUCTION SUMMARY

Cycle	Max. Mining Machines Working Simultaneously	Max. Prod. Rate: Tons/Day/ Machine	Max. Tons Mined/Yr.	Max. Tons Mined/Day	Drilling: Max. Crew-Shifts/Day	Sleeve Placement: Max. Crew Shifts/ Day
I	4	1560/2000*	2.14×10^6	7120	33	33
II	4	2000	2.40×10^6	8000	30	16
III	4	1560/2000*	2.14×10^6	7120	33	33

*Area "A"/Area "B"

Table 5-4

REPOSITORY TONNAGE SUMMARY

Cycle	Tonnage Mined (x 10^6)	Room Backfill Tonnage (x 10^6)	Total Backfill Tonnage (x 10^6)[a]	Off-Site Removal Tonnage (x 10^6)	On-Site Storage Tonnage (x 10^6)[b]
I	41.1	17.1	23.4	17.7	2.1
II	35.5	16.9	20.5	15.0	1.4
III	40.3	17.1	22.9	17.4	1.8

a. Total backfill is the tonnage mined less the tonnage associated with the drilled holes all multiplied by the backfill tonnage factor (0.60).

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.

b. 60% of material excavated from rooms for 5-year capacity.

TABLE 6-1

TYPICAL SUBSURFACE VENTILATING FAN SPECIFICATIONS

TYPE	NOMINAL CAPACITY (CFM) PER FAN	EST. TOTAL PRESSURE (INCHES OF WATER)	MOTOR (HP)
Main Supply Fans (Cycles I, II and III)	215,000	4	250
Placement Operation Exhaust Fan	250,000	14	900
Mining Operation Exhaust Fans			
Normal Operations	550,000	4	500
Emergency Filtering	250,000	14	900

TABLE 6-2

ESTIMATED UNDERGROUND VENTILATION REQUIREMENTS
AT PEAK OF MINING AND PLACEMENT OPERATIONS

WASTE REPOSITORY TYPE	MINING OPERATION EXHAUST (cfm)	PLACEMENT OPERATION EXHAUST (cfm)	TOTAL EXHAUST (cfm)	EXHAUST SHAFT DIAMETER/AIR VELOCITY* (FPM)
Salt-BPNL Alternate Waste Packaging				
Fuel Cycle I	1,100,000	250,000	1,350,000	26 ft/2638
Fuel Cycle II	1,050,000	250,000	1,300,000	26 ft/2540
Fuel Cycle III	1,100,000	250,000	1,350,000	26 ft/2638

* Average velocity for mining and placement compartments.

TABLE 6-3

SUBSURFACE AIR VELOCITIES

Type of Airway	Air Velocity (fpm)
Ventilation Shafts (Concrete lined, smooth surface)	2540-2855
Main supply Air Corridors	
Cycle I & III,	250- 350
Cycle II	250- 300
Branch Corridors, carrying air for:	
Mining Operation	150- 250
Storage hole drilling	400
Backfilling	200
Storage Rooms, with	
Mining in progress	50- 350
Waste placement in progress	Min. 50
Mining Air Exhaust Corridor	500- 650
Placement Air Exhaust Airways	
Branch airways	200- 400
Main airways	300- 600

TABLE 6-4

Canistered Waste Receiving Building - Confinement Zone Classifications and Ventilation Design Requirements

Room	Confinement Zone**	Room Pressure (Inches of water gage)	Ventilation Criteria: Air Changes per Hour	Ventilation Criteria: Outside Air %
Waste Container 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
Control Room	II	-0.10	10	100
Cask Unloading & Testing	II	-0.10	6*	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 & Lobby	III	-0.10	10	100
Offices	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	-
Locker Rooms	III	-0.10	10	100

*For Fuel Cycle II only, the 6 air changes per hour applies to the lower 25 ft. high portion of the Cask Unloading & Testing bays. The overall ventilation rate for the total volume of these bays is about 3.25 air 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	Confinement Zone*	Room Pressure (Inches of water gage)	Ventilation Criteria: Air Changes per Hour	Ventilation Criteria: Outside Air %
Unloading and Parking	II	-0.50	10	100
Decon & Overpack Room	II	-0.50	10	100
Test Cells	II	-0.50	10	100
Exhaust Fan Filter Room	II	-0.50	2	100
Hoist House	II	-0.10	10	100
Mechanical Equip. Room	III	-0.10	6	100
Electrical Equip. Room	III	+0.10	6	100
Battery Room	III	-0.10	15	100
Health Physics	III	-0.10	10	100
Counting Room	III	-0.10	10	100
Chemical & Supervisor's Rm.	III	-0.10	10	100
Lobby & Guard Room	III	-0.10	10	100
Toilet Rooms	III	-0.10	10	-
Locker Rooms	III	-0.10	10	100

*For a definition of Confinement Zone see Section 6.2.1.2.

TABLE 7-1

COMPARISON OF WASTE RECEIPTS

CYCLE I - TOTAL RECYCLE

Year of Completion of Storage Capacity				OWI 2006	BPNL 2008
Total Energy Generation to Year of Completion in GWe-Years				8370	7760
		Maximum Daily Receipts		Accumulated Receipts to Year of Completion	
		OWI	BPNL	OWI	BPNL
CANISTERED WASTE RECVG. BLDG.					
Small Dia. Canisters	HLW	16.2	10.8	41340	33240
	CW	17.3	-	57055	-
	ILW	83.1	-	274485	-
Subtotal		116.6	10.8	352860	33240
Large Dia. Canisters	CW	-	9.1	-	35182
	IL-3	-	.1	-	294
	IL-4	-	1.3	-	4909
Subtotal		-	10.5	-	40385
Drums	IL-1	-	81.2	-	312990
	IL-2	-	37.4	-	144110
Subtotal		-	118.6	-	457100
Total Number of Units		116.6	139.9	352860	530726
LOW-LEVEL WASTE RECVG. BLDG.					
Drums	IL-5	-	37.1	-	143665
	LL-1	275	114.5	571200	417486
Subtotal		275	151.6	571200	561151
Boxes	LL-2	-	1.7	-	6857

TABLE 7-2

COMPARISON OF WASTE RECEIPTS

CYCLE II - THROWAWAY CYCLE

			OWI	BPNL
Year of Completion of Storage Capacity			2008	2007
Total Energy Generation to Year of Completion in GWe-Years			9325	7360
	Maximum Daily Receipts		Accumulated Receipts to Year of Completion	
	OWI	BPNL	OWI	BPNL
CANISTERED WASTE RECVG. BLDG.				
PWR Canisters	50.6	46.0	134648	129736
BWR Canisters	75.8	68.8	200015	190816
Total	126.4	114.8	334663	320552
LOW-LEVEL WASTE RECVG. BLDG.				
Drums	12.6	10.6	60192	56000

TABLE 7-3

COMPARISON OF WASTE RECEIPTS

CYCLE III - U ONLY RECYCLE

				OWI	BPNL
Year of Completion of Storage Capacity				2007	2008
Total Energy Generation to Year of Completion in GWe-Yrs.				8850	7760
		Maximum Daily Receipts		Accumulated Receipts to Year of Completion	
		OWI	BPNL	OWI	BPNL
CANISTERED WASTE RECVG. BLDG.					
Small Dia. Canisters	HLW	17.2	10.8	44460	33299
	CW	17.3	-	60260	-
	ILW	60.7	-	246780	-
Subtotal		95.2	10.8	351500	33299
Large Dia. Canisters	CW	-	9.1	-	35180
	IL-3	-	.1	-	293
	IL-4	-	1.3	-	4908
Subtotal		-	10.5	-	40381
Drums	IL-1	-	81.2	-	312966
	IL-2	-	37.4	-	144099
Subtotal		-	118.6	-	457065
Total Number of Units		95.2	139.9	351500	530745
LOW-LEVEL WASTE RECVG. BLDG.					
Drums	IL-5	-	37.1	-	142914
	LL-1	21.2	50.6	81600	194922
Subtotal		21.2	87.7	81600	337836
Boxes	LL-2	-	1.0	-	3671

Table 7-4

Comparison of Electrical Loads (KVA)

LOAD DESIGNATION	CYCLE I		CYCLE II		CYCLE III	
	BPNL Study	OWI Study	BPNL Study	OWI Study	BPNL Study	OWI Study
Connected Load	31193	38731	34602	34673	32345	37009
Operating Load	23564	28810	26100	26103	24165	27591
Emergency Load	2784	2853	2825	2798	2841	2831

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.

S.C. - Self-Cooled
F.V. - Force Ventilated
L.C. - Locked Coil
F.S. - Flat Stranded

1. M & M Shaft

a. Skip Hoist

No:	1
Type:	Friction
Mounting:	Tower
Wheel Dia.:	11'-0"
No. Ropes:	4
Rope Size:	1 5/16" L.C.
RMS H.P.:	3,500 (S.C.)
RMS H.P.:	2,836 (F.V.)

b. Cage Hoist

No:	1
Type:	Friction
Mounting:	Tower
Wheel Dia.:	11'-0"
No. Ropes:	4
Rope Size:	1 5/16" L.C.
RMS H.P.:	781 (S.C.)

c. Auxiliary Cage Hoist

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

2. LLW Shaft

a. Cage Hoist

No:	1
Type:	Drum
Mounting:	Ground
Drum Dia.:	10'-0"
No. Ropes:	1
Rope Size:	1 1/2" F.S.
RMS H.P.:	1,000 (S.C.)

3. Canistered Waste Shaft

a. Cage Hoist

No:	2
Type:	Friction
Mounting:	Tower
Wheel Dia.:	16'-0"
No. Ropes:	5
Rope Size:	1 7/8" L.C.
RMS H.P.:	1710 (F.V.)
No. Tail Ropes:	None

B. The LLW Shaft

The LLW Shaft hoisting system is designed for two different conditions:

1. Preliminary mining to be executed from the LLW Shaft requires the hoist to be capable of hoisting 2,000 TPD and lower a maximum load of 20,000 lbs.
2. Permanent use of this shaft requires the hoist to be designed to handle low-level pallets and waste containers with a maximum weight of 10,000 lbs.

During preliminary mining, ground mounted single drum hoist would be roped with two 1 1/2 in. flattened strand cables. An 11-ton capacity skip with a removable cage would be hoisted in balance with a counterweight. Hoisting speed is 1,200 FPM.

Once the M & M Shaft is completed, mining from the LLW Shaft will cease. At this time, the skip and counterweight would be removed, the guides arranged for the permanent cage and the permanent cage installed.

C. The Canistered Waste Shaft

The Canistered Waste Shaft hoisting system is designed to handle HLW, IL-TRU and CW from Cycles I and III and PWR/BWR canisters from Cycle II. The shaft will have two hoisting systems operating independently. Four canisters can be lowered by the cage of each hoist. The canisters are to be lowered in a specially designed cage having two in. thick stainless steel walls, a five in. thick lead core and a 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. 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 crder to ensure safe operation of this facility, the shaft would be equipped with buntons at four ft. centers and the cages guided by elevator type guide rails. The cages would also be equipped with an 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 over the M & M Shaft.

Broken rock will be hoisted out of the mine at a rate of up to 12,000 TPD in two 16-ton capacity skips operating in balance. The hoist is a friction type with a wheel diameter of 11 ft. and a hoisting speed of 2,100 FPM.

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

1. Capacity to sling 26-ton gear box (heaviest piece) of mechanical miner.
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 2,000 FPM. The wheel diameter is 11 f 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 salt and the placement of radioactive waste material. Four of the shafts are to be excavated using conventional drill and blasting shaft sinking techniques. The fifth shaft would be bored using a surface mounted drilling rig. The bored shaft is to be completed first allowing preliminary mining in the repository to begin at an early date.

Construction of all five shafts would begin at the same time. An estimate of the time required to complete each shaft is shown in Table A-1 and Table A-2.

Table A-1 Excavated Shafts - Time in Weeks

Item	27'Ø M&M	26'Ø SuA	26'Ø ExA	14'Ø Can. Waste
1. Contractor's Mobilization	6	6	6	6
2. Collar & Headframe	39	24	24	36
3. Shaft Sinking, Station Cutting, Lateral Development	49	42	48	68
4. Grout Curtains, Drywall Steel Lining	49	45	45	41
5. Equip Shaft	9	3	5	7
6. Install Permanent Hoisting Equipment in Shaft	17	12	21	19
TOTAL	166	132	149	177

Table A-2 Bored Shaft - Time in Weeks

Item	10'Ø LLW
1. Contractor's Mobilization	6
2. Contractor's Setup, Foundations and Install Coping	4
3. Shaft Drilling, Lining and Grouting	40
4. Construct Permanent Headframe, Equip Shaft	18
5. Miscellaneous Excavation and Prepare for Development	20
TOTAL	88

APPENDIX B

JOB CLASSIFICATION BREAKDOWN SUMMARY

BPNL - SALT CYCLE II

	Symbol	Number
Supervisory and Clerical	A	101
Administrative and Management	B	175
Professionals	C	24
Skilled Labor	D	910
Miners	E	36
Semi-skilled Labor	F	236
Technicians	T	31
		1,513

The above figures correspond to the peak average daily man-shift requirements occurring in the year 2001 for the BPNL-Salt 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 classifications 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 mining machine operators, cable tenders, and task foremen. 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 2001 with the values shown in the tables 1-2, 1-3, and 1-4 of the BPNL - Salt Technical Report.

JOB CLASSIFICATION BREAKDOWN

BPNL - SALT CYCLE II

	Man-Shifts Per Day	Job* Classification
I - Waste Storage Operation		
Underground Storage		
a) LLW		
Shaft Crew	3	D
Forklift Drivers	4	D
Room Laborers	4	F
Equipment Maintenance	2	D
b) PWR/BWR		
Shaft Crew	13	D
Transporter Operators	21	D
Transporter Maintenance	8	D
Room Laborers	12	F
Crusher Crew	6	F
Maintenance Crews	6	D
Above Ground Storage		
a) Canistered Waste Bldg.		
Cask Washdown Crews	12	F
Bay Crane Operator	8	D
Bay Laborers	18	F
Bay Inspectors and Monitors	12	D
Transfer Cell Monitors	6	D
Transfer Cell Operators	48	D
Crane Operators	8	D
Hoist Operators	8	D
Lab Personnel	10	T
Mechanical and Electrical Services	10	D
Supervisors and Clerical	12	A
b) Low-Level Waste Bldg.		
Crane Operator	1	D
Transfer Cell Laborers	3	D
Fork Lift Drivers	3	D
Inspectors and Testers	3	D
Lab Personnel	3	T
Maintenance	2	D
Supervisors and Clerical	3	A
c) Control Room		
Monitoring and Scheduling Personnel	22	B
d) Railroad Operations		
Operations Personnel	24	D
Equipment Maintenance	17	D

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

JOB CLASSIFICATION BREAKDOWN

BPNL - SALT CYCLE II

	Man-Shifts Per Day	Job* Classification
e) Shipment Inspections Handling and Warehouse Operations	14	F
f) Liquid Rad Waste		
Crane Operators	3	D
Lab Personnel	5	T
Mechanical and Electrical Service	2	D
Supervisors and Clerical	2	A
Support Activities		
a) Ventilation Maintenance	9	D
b) Boiler, Refrigeration, Coal Handling Labor and Maintenance	16	F
c) Motor Pool and Fuel Depot Operations Personnel and Maint.	6	F
d) Maintenance		
Roads and 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		
Lanundy	8	F
Cafeteria	9	F
Change House	10	F
Fire Protection	22	D
Radiation Safety	23	D
Administration and Management	126	B
Total of Waste Storage Operation	714	

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

JOB CLASSIFICATION BREAKDOWN

BPNL - SALT CYCLE II

II - Mining Operation

Section	Type	Man-Shifts Per Day	Job* Classification
Mining @ Face	Foreman	12	E
	Machine Operators	12	E
	Cable Tenders	12	E
	Machine Maintenance	24	D
Underground Haulage	Truck Drivers & Conveyor Tenders	54	D
	Loader Operators	12	D
Hoisting	Shaft Superintendent	3	D
	Bin Tenders	6	D
	Conveyor Operators	12	D
	Skip Tenders	3	D
	Hoistmen	3	D
	Cage Tenders	3	D
	Signal Men	9	D
	Helpers	12	F
Disposal	Equipment Operators	30	D
Support	Roadway Maintenance and Equipment Repair	8	D
	Ventilation Maintenance and Repair	23	D
	Electricians	31	D
	Mining Equipment Maintenance	12	D
	Truck Maintenance	18	D
	Hoist Maintenance	9	D
	Machine Bit Maintenance	17	D
	Utility Maintenance	10	D
	Roof Support	1	D
	General Labor	45	F
	Supervisors and Clerks	56	A
	Total of Mining Operation	437	

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

III - Drilling

Section	Type	Man-Shifts Per Day	Job* Classification
Drilling	Foreman	15	D
	Drill Operators	46	D
	Helpers	30	F
	Machine Repair and Maintenance	100	D
	Total of Drilling Operation	191	

IV - Backfill

Section	Type	Man-Shifts Per Day	Job* Classification
Backfill	Conveyor Tenders	27	D
	Dozer Operators	6	D
	Total of Backfill Operation	33	

ɔr Job Classification definitions see "Job Classification Breakdown Summary"

JOB CLASSIFICATION BREAKDOWN

	Man-Shifts Per Day	Job* Classification
V - Mining Production Management Group		
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 and Service Mgr.	1	B
Budget Director	1	B
Services Coordinator	1	B
Warehouse Supervisor	1	A
and Workers	10	F
Public Coordinator	1	B
Material Buyers	2	B
Data Processing Coordinator	1	B
Data Processing Supervisor	1	B
Programming Supervisor	1	B
Computer Operators and Programmers	5	D
Accounting Supervisor	1	B
Cost Accountant	2	B
Payroll Accountant	1	B
Clerks	11	A
Typist	2	A
C) Employee Relations Dept.		
Manager	1	B
Security Officer	1	B
Guards	8	D

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

JOB CLASSIFICATION BREAKDOWN

	Man-Shifts Per Day	Job* Classification
C) Employee Relations Dept. (cont'd.)		
Safety Director	1	B
Engineers	3	C
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	A
Receptionist	1	B
Typists	2	A
D) Miscellaneous		
Legal Advisor	1	C
Planning Coordinator	1	B
Public and Government Manager	1	B
Public Relations	2	B
Typists	3	A
Total of Mining Production Management Group	138	

for Job Classification definitions see "Job Classification Breakdown Summary"

APPENDIX C

MINE FIRE ANALYSIS

INTRODUCTION

The occurrence of a fire involving combustible waste located in a storage room of the repository potentially could lead to the contamination of other areas of the mine due to the dispersion of radioactive airborne particulates. This dispersion, which is directly attributable to the combined thermal buoyant effects of the fire and the ventilating air through the storage room, was investigated for three idealized cases in the present analysis utilizing the Subway Environment Simulation (SES) computer program developed by Parsons Brinckerhoff (Ref. 1).

The analysis considered a fire located in the center of an intermediate level storage room of the BPNL repository design in salt. The fire was assumed to occur during the placement operation, at which time the repository ventilation system provides 40,000 CFM supply air to the room. The fire was further assumed to correspond to the combustion of three intermediate level waste drums which are completely opened and burning freely. The fire heat generation rate (81,000 BTU/min.), the duration of the fire (22 min.), and the generation rate of airborne particulate and its composition (Ash: .45 lbs./hr., Fission Products: 4.2×10^{-3} Ci/hr., Actinides: 60×10^{-4} Ci/hr., Activation Products: 2.37×10^{-5} Ci/hr.) were derived from information presented in Ref. 2 for one burning drum.

Three simulations were performed in which the time dependent ventilation rate to the storage room was parameterized to reflect alternative ventilation procedures that might be implemented during the fire emergency to control the direction of smoke flow and limit the spread of contamination. Although the specific operational characteristics of the ventilation system necessary to implement these specific air flow rates are not specified at the time, they do represent a reasonable approach to increasing the ventilation rate through the room.

Simulation 1 represents the base case, in which the ventilation rate corresponds to the normal airflow rate through the storage room during placement (40,000 CFM). The ventilation rate remained constant throughout and after the duration of the fire.

Simulation 2 represents the case in which airflow through an adjacent room where placement is occurring simultaneously is diverted to the room in question by closing off its entranceway. This was assumed to result in a doubling of the airflow rate to the fire from 40,000 to 80,000 CFM. It was assumed that 7.5 minutes would elapse after the start of the fire before this procedure could be implemented.

Simulation 3 represents the case wherein the airflow through the storage room is increased to 120,000 CFM. This would be accomplished by having central control activate an additional supply and exhaust fan (250,000 CFM each) and close the appropriate dampers. It was estimated that at least 2/3 of this additional capacity could be directed to the main corridor serving the storage room in question. Since placement is assumed to be occurring in two adjacent storage rooms, each storage room would experience an increase of one half of the additional available flow. It was assumed that 15 minutes would elapse after the start of the fire before this additional flow would be experienced in the room.

METHODOLOGY

Documented reports of tunnel fires (Ref. 3, 4) show the behavior of the fire and associated tunnel air flows to differ significantly from more familiar fire situations outside the confines of a tunnel. The most noteworthy distinction is the thermal buoyant effect, which tends to create a layer of hot smoke and gases flowing away from the fire near the crown of the tunnel, while air supporting combustion moves toward the fire and beneath the smoke layer. In a horizontal (0% grade), unventilated tunnel with the fire near the longitudinal midpoint, the thermal buoyancy will establish a symmetrical circulation pattern with the hot, smoky air leaving both ends of the tunnel and air outside the tunnel drawn beneath it. (See Figure 1.)

A longitudinal ventilation system forcing air to flow through the tunnel will shift the balance of heated air in the direction of the forced flow. If such flow is of sufficiently high capacity, it will cause all of the heated air to flow towards the downstream direction. If the ventilation is weak, the upper layer of heated air may flow in a direction contrary to the forced ventilation (a phenomena called "back layering;" see Figure 2). Whether back layering occurs depends upon the location and intensity of the fire, the grade of the tunnel and the velocity of the ventilating airstreams.

Since the SES model is basically one-dimensional, the storage room was represented in this analysis as two separate parallel flow paths (over/under) with frequent interconnections in order to evaluate such thermal buoyant effects as back layering. This approach, which has been applied in other fire study analyses (Ref. 3, 4) also drew upon the findings of other research and field experimentation (Ref. 5, 6, 7).

The release of particulate matter in the fire zone and its subsequent dilution was simulated with the SES model by using those portions of the program that normally make humidity computations. The ambient humidity levels and normal latent sources are suppressed in this scheme and a special "humidity" source is located in the fire zone. Computed levels of the resulting "specific humidity" throughout the storage room are analagous to the movement and dilution of airborne particulates resulting from fan-induced flows and/or thermal buoyant effects. The resulting humidities were converted to particulate concentrations through the use of a formulation reflecting the relationship among the magnitude of the latent source in the fire zone, the particulate release rates, and the density of the ventilation air stream.

The SES estimates are more than qualitative appraisals. They provide a means of quantifying the potential for back layering under a variety of circumstances and they afford a view of the time-dependent events occurring during the course of the fire emergency. Comparisons of SES predictions with available data on tunnel fires show general agreement, but it must be recognized that at present there exists no documentation for full verification of the methodology employed.

However, because of the assumptions required and the basic characteristics of the SES program, the SES estimates of air temperature, velocity and particulate concentrations should not be taken as precise quantitative estimates. Among these assumptions and characteristics are the following:

1. The storage room wall surface temperature remains fixed during the simulation, causing an over-estimation of the convective heat flow to the sink at elevated air temperatures. This overestimate is in the order of 20% or less for simulated high intensity fires of less than one hour duration and is at least partially offset by radiation from the hot, smoke laden air to the walls.
2. The SES does not fully consider the change in air density with increasing temperature. As a consequence, the predicted velocity of the heated air is lower than the actual velocity by the density ratio; the pressure losses are similarly affected. All air flow rates are reported in equivalent ambient flow rates at 0.0768 pounds per cubic foot density.

3. The predicted air flows, particularly on the back layering conditions, are affected by the fractional areas assigned to the over/under storage room arrangement. These areas were calculated on the basis of a series of relationships presented in Ref. 5, which are founded on the results of limited field measurements.
4. An approximation is used to represent the shear stresses and turbulence between the upper and lower flow layers. These shear stresses are important in controlling relatively thin, low temperature smoke layers. Inclusion of turbulence effects would further reduce the sharp vertical gradients in temperature and humidity (or particulate) concentrations that are currently predicted by the model.

DISCUSSION OF RESULTS

The results of the simulations indicate that back layering will occur in all three cases studied but in no instance does it extend into the main corridors of the repository. However, the fact that back layering does occur in all cases indicates that the ventilation rate through the room during placement is not sufficient to control the fire and prevent the spread of contamination to the main corridors entirely. If the fire were located within 1200 feet of the room entrance, contamination of the main corridor could occur to some degree, depending on the closeness of the fire to the room entrance.

The results of simulations 1, 2, and 3 are shown in figures 3, 4 and 5, respectively, at four locations in the storage room. Depicted is the percentage of airborne particulates that would be generated over the entire duration of the fire (10-1300 seconds) that pass these locations in the direction away from the fire, as a function of time. The quantity of airborne particulates in the storage room segments between these locations is simply the difference in their percentages.

The results of simulation 1 (which is the baseline case, i.e., 40,000 CFM of constant ventilation) indicate that back layering will occur beyond location A (250 feet upstream of the fire). The degree of contamination upstream of this point, however, never exceeds 8% of the total generated airborne particulate. As time elapses beyond the duration of the fire, the ventilating airstream reverses the direction of this particulate flow, with the percentage of generated particulate upstream of this location again approaching zero. If the room were capable of being isolated within 2400 seconds of the start of the fire, almost half of the airborne particulates would be trapped in the room.

The results of simulations 2 and 3 indicate the effects of implementing procedures to increase the ventilation rate through the room in question. The results of simulation 2 show the effects of increasing the ventilation rate from 40 to 80 KCFM at 7.5 minutes after the start of the fire (time = 460 seconds). The results indicate that the degree of back layering beyond location A is reduced approximately in half compared to simulation 1. The results also show that almost 95% of the airborne particulates will be exhausted from the room within 2600 seconds after the start of the fire. The results of simulation 3 which reflect an increase in the ventilation rate from 40 to 120KCFM 15 minutes after the start of the fire (time = 910 seconds) indicate that the delay in increasing the ventilation rate offsets the beneficial effects of additional ventilation compared to simulation 2. The degree of back layering beyond location A is not shown to be reduced compared to simulation 2.

REVIEW OF CONTAINMENT MEASURES

At the preconceptual design stage, it is not possible to specify precisely the operational characteristics of the control mechanism for fire-related dispersal of radioactive particulate matter in the underground storage facility. However, it is possible to postulate various technologically feasible courses of action that would prevent or minimize undesirable impacts of the fire outside of the immediate room in which it occurs.

1. Locally increased ventilation: There are various ways in which the local ventilation can be enhanced. These are discussed in the foregoing sections of this appendix.

   Advantages: The primary advantage of this option is that increased ventilation increases the opportunities for control of the fire, since firefighting teams on the upstream side of the ventilation flow can approach and control the fire. Also, if it is desired to purge the room, a faster rate of air flow accelerates this process.

   Disadvantages: If it is desired to isolate the contamination entirely in the room, then increased air flow would work against this objective.

2. Confinement doors on the rooms: There is the option of installing specially designed confinement doors at one or both ends of the rooms. These doors could be either manually or remotely operated.

Advantages: This would theoretically permit isolation of the fire in a confined area, preventing the contamination of the downstream ventilation system.

Disadvantages: It would be necessary to completely evacuate all personnel before this option could be employed. It effectively prohibits any direct firefighting measures, and it might prohibit further use of the room or the equipment in the room.

EFFECTS OF FIRE ON MINE OPERATION

Operator Doses

Since the operator is normally enclosed, and therefore shielded, by the fork-lift cab, it is expected that the doses to the operator would be negligible. However, for calculational purposes, it is assumed that the operator is out of the cab and in the vicinity of the fire during the first 10 minutes of the emergency. From Table 4-10 of Reference 2, the total radioactive release to the room from 3 drums in 10 minutes would be:

$$R = 3 \times (7.0 \times 10^{-2} + 1.0 \times 10^{-2} + 4.0 \times 10^{-4}) \frac{Ci}{hi} \times \frac{10}{60} hr = 4 \times 10^{-2} Ci$$

Averaging this release over the 10 minute period yields an average radioactive release of 2×10^{-2} Ci. It is also assumed that the radioactivity is dispersed into the room volume (180,000 ft^3) between the fire and point B which is located 250 ft. downstream. Using a factor of 10 for conservatism yields an average radioactive concentration of:

$$C = \frac{2 \times 10^{-2} Ci}{180,000 \; ft^3} \times 10 = 1.11 \times 10^{-7} \frac{Ci}{ft^3}$$

$$C = 0.1 \times 11 \frac{uCi}{ft^3} = 3.92 \times 10^{-6} \frac{uCi}{ml}$$

Using a breathing rate of $8000 m^3/yr$ ($255. \frac{ml}{sec}$) and a whole body dose conversion (for Cs-137) of 5.35×10^{-5} mrem/(pCi inhaled) from Regulatory Guide 1.109 "Calculation of Annual Doses to Man from Routine Releases from Nuclear Power Plants," the operator dose can be estimated:

$$D = \left(\frac{3.92 \times 10^{-6} \mu Ci}{ml}\right) \left(255 \frac{ml}{sec} \times 600 \; sec\right) \left(5.35 \times 10^{-5} \frac{mrem}{10^{-6} \mu Ci}\right)$$

$$D = 32 \; mrem$$

This dose rate is orders of magnitude lower than the allowable accident dose of 25 rem and therefore should not be cause for concern.

Room Contamination

The results of the mine fire simulations indicate that the ventilating air will remove virtually all of the airborne particulate from the room within one hour after the fire ends. Because of the large room volume and the small amounts of airborne radioactivity, room contamination is not expected to be significant and routine decontamination procedures could be employed, if desired, to decontaminate the room for further disposal operations.

Effects on Ventilation System

The largest effect on the ventilating system is expected to be the impact of ash on the ventilating system pre-filters. However, because of the small quantity of ash (.17 lb) released to the ventilating system, this quantity of ash can be accomodated in future design calculations if the preconceptual design is shown to be inadequate.

Off-site Release

The off-site release will be mitigated further by the ventilation system HEPA filters. The magnitude of the release has been estimated in Section 4.2.8 of Reference 2 and the results indicate that the release is orders of magnitude below allowable release limits.

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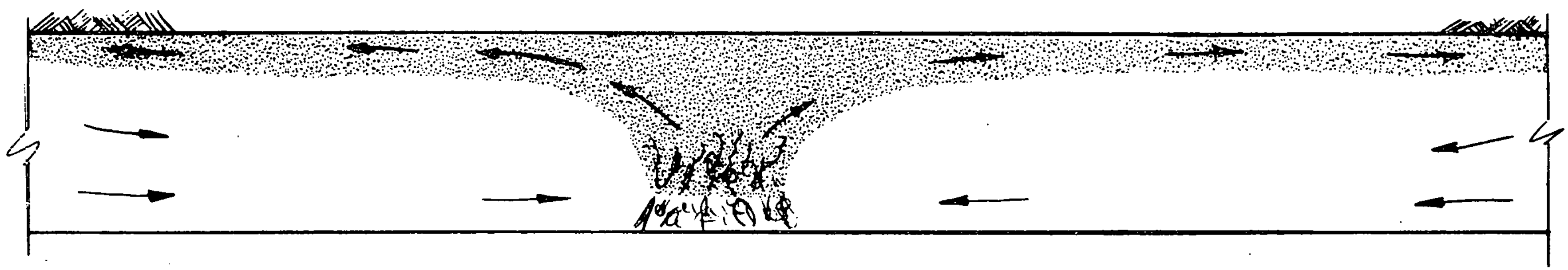

Figure 1. Fully Developed Fire Without Ventilation

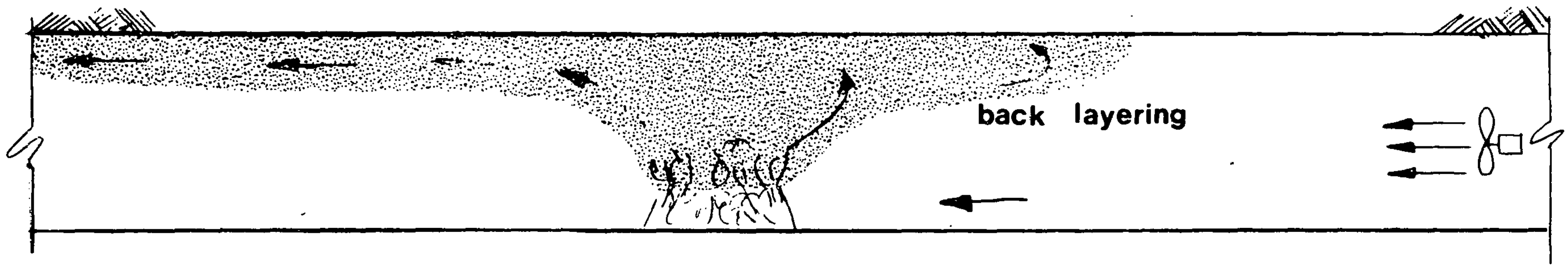

Figure 2. Fully Developed Fire With Back Layering

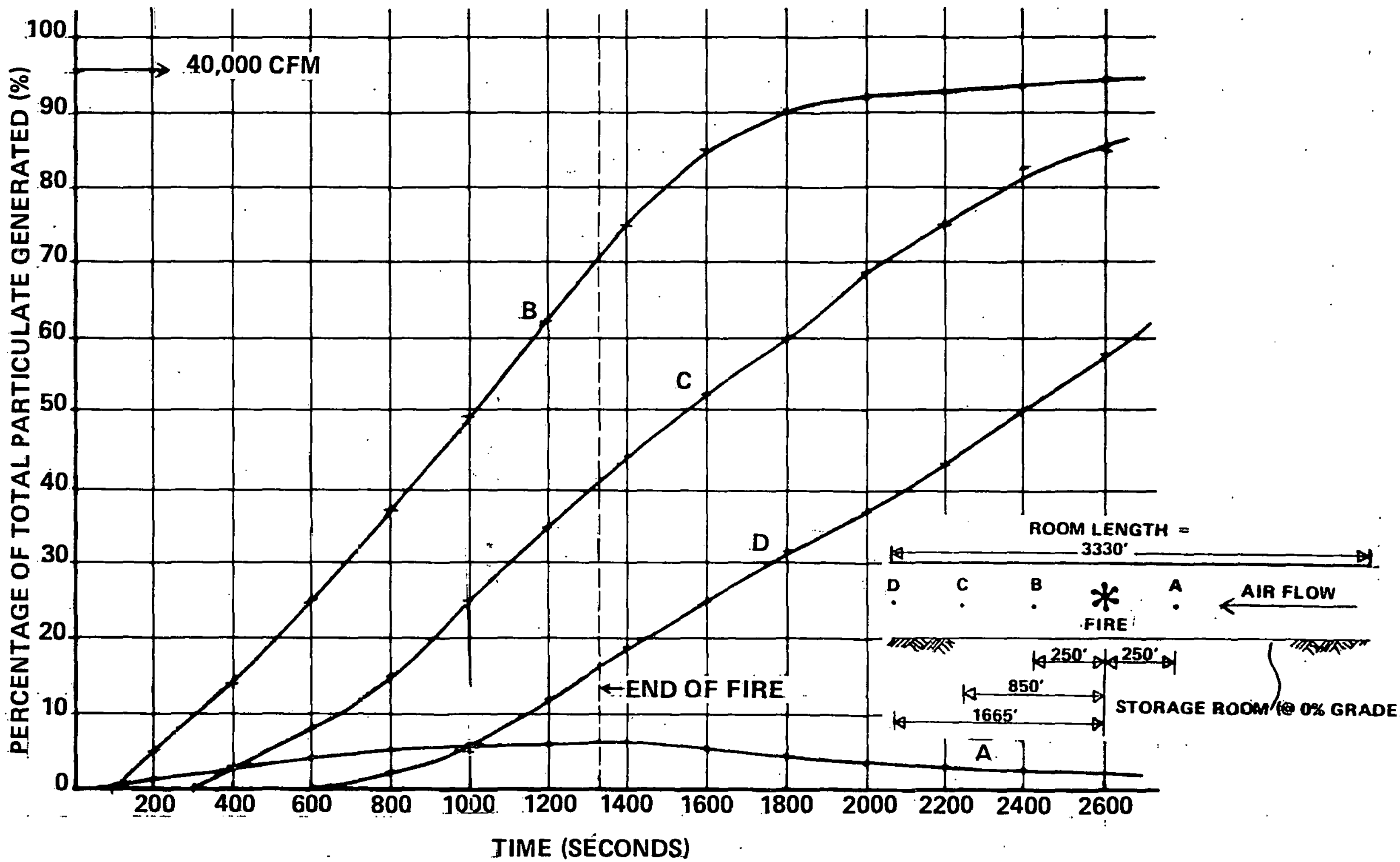

FIGURE 3. TRANSIENT FLOW OF PARTICULATE AWAY FROM FIRE – SIMULATION 1

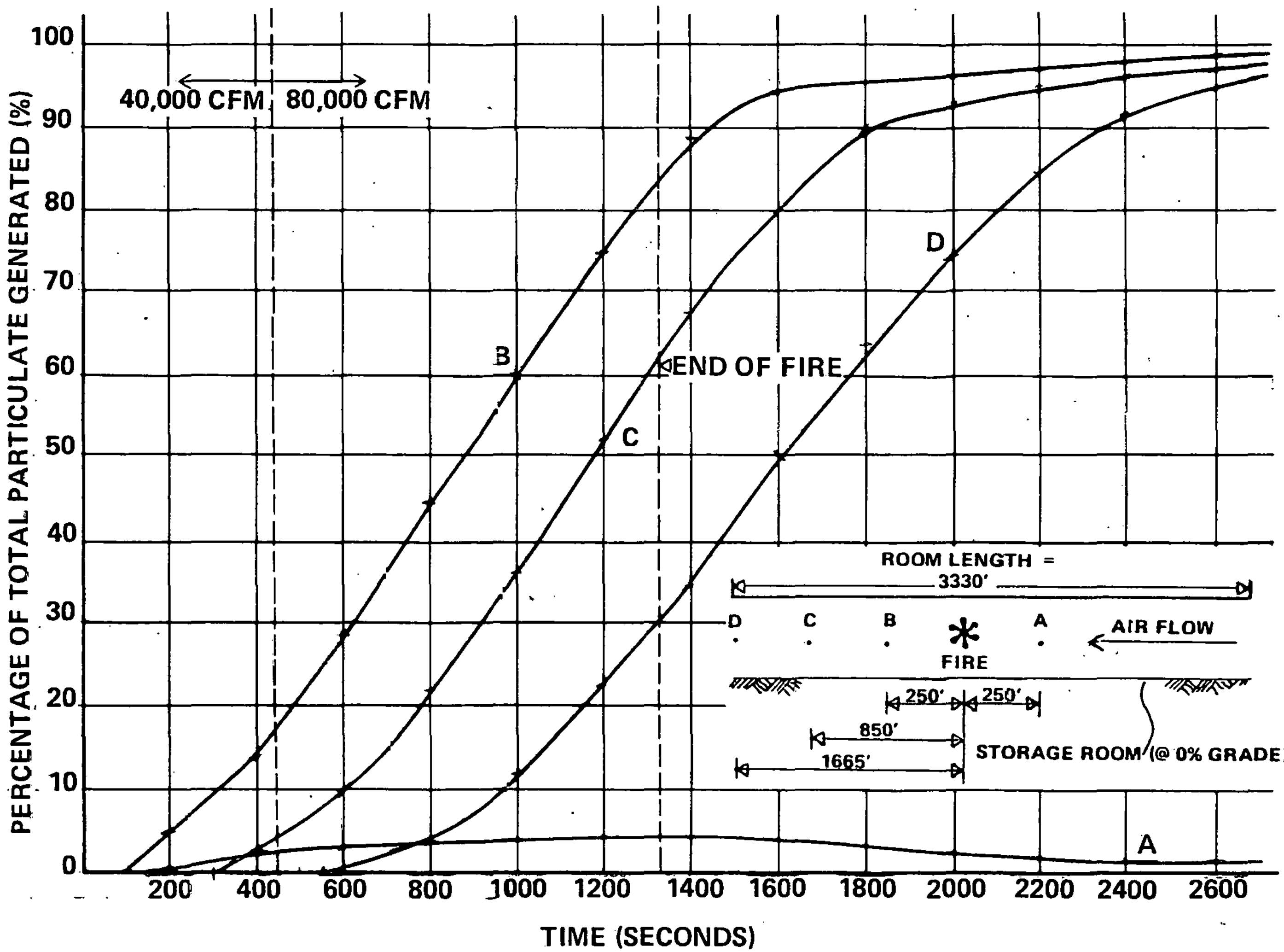

FIGURE 4. TRANSIENT FLOW OF PARTICULATE AWAY FROM FIRE – SIMULATION 2

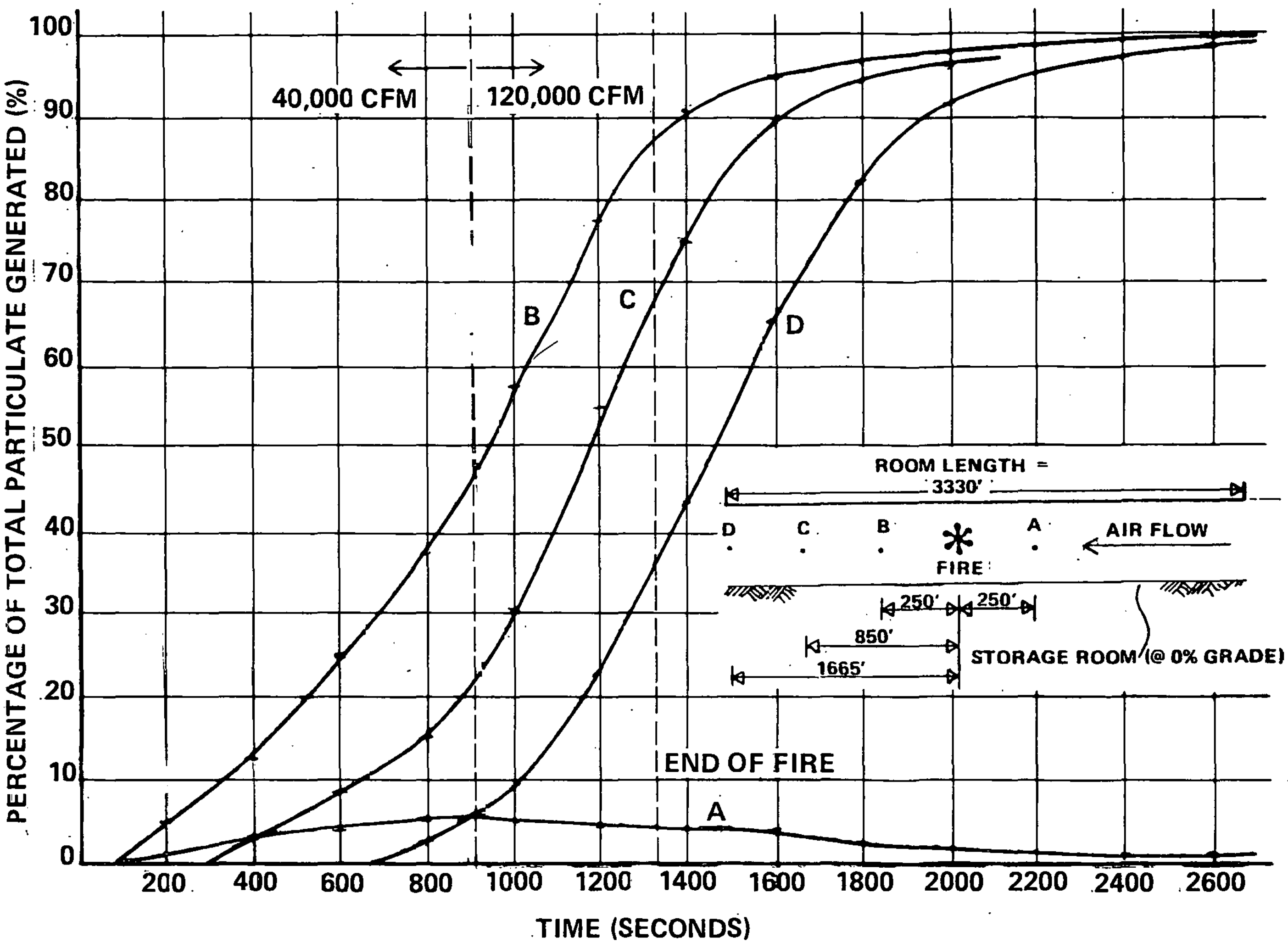

FIGURE 5. TRANSIENT FLOW OF PARTICULATE AWAY FROM FIRE – SIMULATION 3