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Revised Concept for the Waste Isolation Pilot Plant

Albert W. Dennis, John A. Milloy, Leo W. Scully, Henry C. Shefelbine
Robert E. Stinebaugh, William E. Wowak

Sandia Laboratories

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REVISED CONCEPT FOR THE WASTE ISOLATION PILOT PLANT

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ILLUSTRATIONS

/

ILLUSTRATIONS (continued)

A. Executive Summary

The quantities of remotely-handled (RH) wastes that must be handled at the Waste Isolation Pilot Plant (WIPP) have been significantly reduced from the estimates used as a basis for the Conceptual Design Report published in June 1977.

A revised concept of the WIPP has been prepared by Sandia Laboratories which will meet the following criteria:

- Provide facilities for the geologic disposal of transuranic waste.
- Provide facilities in which to perform R&D with other waste materials in salt.
- Provide a facility design which does not prevent or preclude a future decision to establish a high-level defense waste repository at this site.

This report describes only significant impacts on the original conceptual design. Portions of the facility that will be unchanged or only slightly modified have not been discussed here.

A comparison of the capacities and costs for the original and the revised concepts is contained in Table I.

Table I Facility Capacity and Facility Cost Comparison

Item	Original Design	Revised Design
Contact-Handled Waste Capacity	1.2×10^6 ft^3/yr	Unchanged
Remote-Handled Waste Capacity	250×10^3 ft^3/yr	$10 \times 10^3 ft^3/yr$
Experimental Waste	300 canisters	Unchanged
Capital Cost Inflated to midpoint of Const.* (millions of dollars)	534	428

The reduction in the quantity of remote-handled waste has resulted in the following changes in the facility design.

- The extent of the remote-handled storage area (the lower horizon in the underground development) has been substantially reduced. This horizon will be used to perform experiments with high-level waste and to store the remotely-handled defense TRU waste. This development of the lower horizon would in no way jeopardize the use of this horizon at a later date for full-scale, high-level waste disposal area.

*From DOE budget presentation on June 12, 1978.

- The separate surface facility and its associated shaft for receiving remote-handled waste have been eliminated. A capability to handle the reduced quantities of remote-handled waste has been added to what was the contact-handled waste building, now called the Waste Handling Building. The remote-handled waste would be placed in shielded transfer casks and then be lowered to the underground storage area by the hoist used for contact-handled waste transport.

- Because of the reduced ventilation requirements, separate shafts for the construction air exhaust and the waste storage air exhaust have been eliminated; thus, the revised design of the WIPP has only two shafts instead of the five in the original concept.

- Separate buildings for the waste storage air filter facility, the suspect waste treatment facility, and the hoist house have been eliminated and their functions have been incorporated into the Waste Handling Building.

If DOE should decide to exercise its option to construct a high-level waste repository concurrently with the construction of the revised design, with both facilities scheduled to begin receiving waste in 1985, the combined cost would be approximately $580,000,000 or about 9% more than the original conceptual design cost. It is unlikely that significant quantities of high-level waste in a form suitable for geologic disposal will be available until after 1990; therefore the high-level waste facility, if required at WIPP, would not be needed before that time.

B. Waste Quantities and Characteristics

The estimated backlog and production quantities of contact-handled waste and remote-handled waste are given in Tables II and III. Wastes that require remote-handling include the experiment canisters, and a small fraction of the retrievably stored TRU waste. The figures for the remote-handled TRU waste are maximum quantities. For the purposes of this report, it is assumed that the fraction of the buried TRU and the decontamination and

Table II Contact-Handled Waste Possibly Destined for the WIPP

Description	Backlog (1-1-85) (millions of ft^3)	Yearly Production (millions of ft^3/yr)
Retrievably stored TRU		
Defense	3.7	0.25
Commercial	0.1	0.01
Total	3.8	0.26
Buried TRU		
Defense	13	0[a]
D&D		
Defense (low est.)	5	-b
Defense (high est.)	95	-b

Table III Remote-Handled Waste Possibly Destined for the WIPP

Description	Backlog (1-1-85) (thousands of ft^3)	Yearly Production (thousands of ft^3/yr)
Retrievably stored TRU		
Defense	90	7.2
Buried TRU Defense	300	0a
D&D		
Defense(low est.)	100	-b
Defense(high est.)	2300	-b
Experiments		
Defense/commercial	less than 300 canisters	Not applicable

a. Under current regulations all TRU waste must be retrievably stored.

b. The quantity of D&D may increase with time as more facilities become obsolete, but no estimates are available as to how fast this increase will be.

decommissioning wastes (D&D) requiring remote-handling is the same as the fraction for the retrievably stored TRU.

The quantities of remote-handled waste (RHW) listed in Table III would require an RH throughput capacity of between 400 (one-shift operation) and 900 (three-shift operation) canisters per year, or between one and two canisters per shift. (This assumes that the RH TRU waste is placed in 2-foot diameter by 15-foot long canisters each holding 35 ft^3.) Using the CH hoist to transport the RH canisters in a shielded transfer cask would reduce by about 10% the number of hoist trips available for CH operations. However, the throughput capacity of the CH operation would not be reduced because the decrease in hoist trips would be more than offset by the increased payload of the hoist.

The CH throughputs for the revised design are the same as those in the original concept for the WIPP. Table IV gives the length of time that would be required to dispose of various TRU backlog alternatives. These times include a three-year startup period when only the current production of TRU waste plus a major fraction of the HLW experiments are handled. The revised facility is capable of handling, in a timely manner, backlog alternatives up to and including the alternative that calls for the disposal of all the retrievably stored TRU, the buried TRU and five million ft^3 of D&D TRU. If, however, the quantity of D&D TRU does approach the high estimate of 95 million ft^3, it would be necessary to triple or quadruple the CH throughput.

Table IV Length of Time to Dispose of TRU Backlog

Backlog Alternative	Backlog Quantity on 1/1/85 (millions of ft^3)	Time to Dispose of Backlog (years)	
Retrievably stored TRU plus current production	3.8	one-shift operation	19
		two-shift operation	9
		three-shift operation	7
Retrievably stored TRU plus buried TRU plus low estimate of D&D plus current production	22	three-shift operation	26
Retrievably stored TRU plus buried TRU plus high estimate of D&D plus current production	112	three-shift operation	122

The waste characteristic that is of major importance in the development of the modified design is the dose rate of the RHW. Unlike the original concept of the WIPP, the RHW will be transported down the waste shaft in a shielded cask. The dose rate of the waste determines the weight of the cask and, hence, the payload of the waste hoist. Preliminary shielding calculations indicate that a cask for RH TRU (100 R/hr typical dose rate) with an internal diameter of 26 inches will weigh approximately 15 tons. The HLW (2 x 10^5 R/hr for ten-year old waste) would require a 25-ton cask with a 16-inch internal diameter. The weights of these transfer casks would exceed the 12.5-ton capacity of the CH hoist called for in the original conceptual design of the WIPP. However, the hoist capacity can be increased to 30 tons without adding significantly to the cost of the facility.

C. Facility Description

1. General: The principal modifications to the original WIPP concept are: 1) the lower horizon has been scaled back to two areas of approximately 20 acres each: one for RH TRU storage and the other for high-level waste experimentation; 2) two shafts instead of five are used to provide access to the underground areas; 3) a single surface facility is used for the preparation and handling of all categories of waste (see Figures 1 and 2).

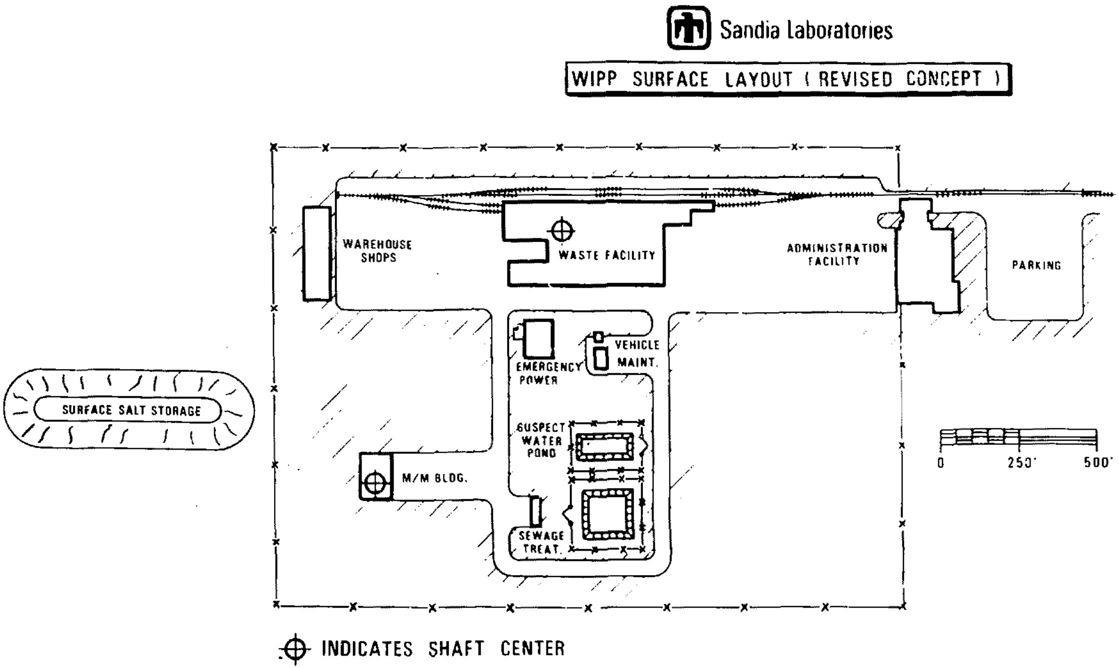
Sandia Laboratories
WIPP SURFACE LAYOUT (REVISED CONCEPT)
WAREHOUSE SHOPS
WASTE FACILITY
ADMINISTRATION FACILITY
PARKING
SURFACE SALT STORAGE
EMERGENCY POWER
VEHICLE MAINT.
SUSPECT WATER POND
M/M BLDG.
SEWAGE TREAT.
0
250'
500'
INDICATES SHAFT CENTER

FIG. 1

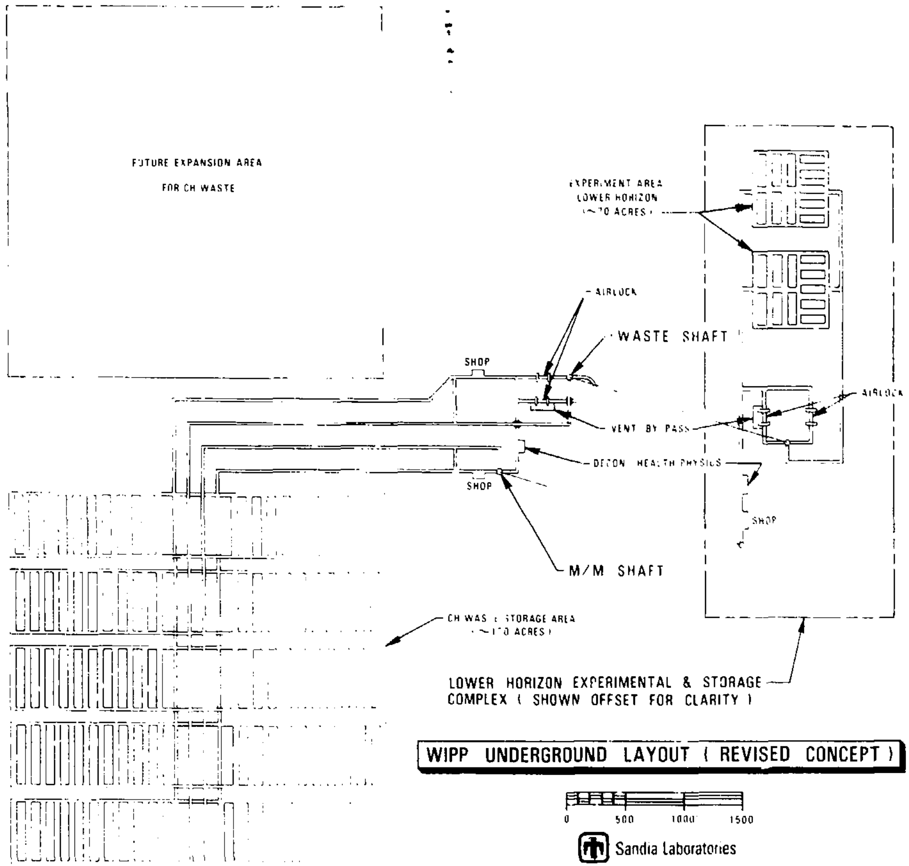
FUTURE EXPANSION AREA
FOR CH WASTE
EXPERIMENT AREA
LOWER HORIZON
(~70 ACRES)
AIRLOCK
WASTE SHAFT
SHOP
VENT BY PASS
AIRLOCK
DECON HEALTH PHYSICS
SHOP
SHOP
M/M SHAFT
CH WASTE STORAGE AREA
(~170 ACRES)
LOWER HORIZON EXPERIMENTAL & STORAGE
COMPLEX (SHOWN OFFSET FOR CLARITY)
WIPP UNDERGROUND LAYOUT (REVISED CONCEPT)
0
500
1000
1500
Sandia Laboratories

FIG. 2

2. Waste Handling System

a. Surface Facility - The number and size of the surface facilities have been substantially reduced. The design functions of the following facilities (from the original design) have been combined and/or modified into a single structure - the Waste Handling Building:

CH Building

RH Building

Mine Storage Filter Building

RH/CH Hoist House

Suspect Waste/Laundry Building

A simplified floor plan of the Waste Handling Building is shown in Figure 3. Some additional details are given in Figure 4, Waste Handling Building Section AA and Figure 5, Hot Cell Floor Plan.

The CH waste throughput capacity, defined by the Conceptual Design Report, would be maintained by carrying more CH waste on each hoist cycle. This is possible because the hoist capacity would be increased from 12.5 tons to approximately 30 tons. The hoist cage would be redesigned to accommodate the RH transfer casks and associated hardware.

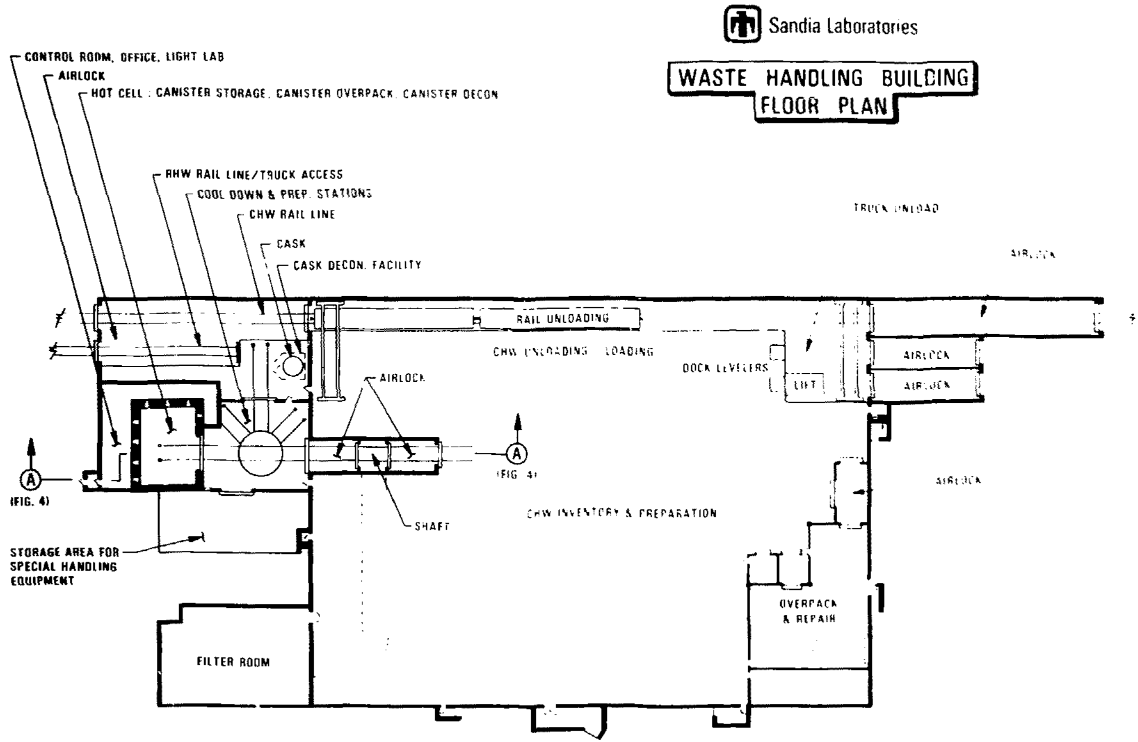
Sandia Laboratories
WASTE HANDLING BUILDING
FLOOR PLAN
CONTROL ROOM, OFFICE, LIGHT LAB
AIRLOCK
HOT CELL : CANISTER STORAGE, CANISTER OVERPACK, CANISTER DECON
RHW RAIL LINE/TRUCK ACCESS
COOL DOWN & PREP. STATIONS
CHW RAIL LINE
CASK
CASK DECON. FACILITY
TRUCK UNLOAD
AIRLOCK
RAIL UNLOADING
CHW UNLOADING LOADING
DOCK LEVELERS
AIRLOCK
AIRLOCK
LIFT
AIRLOCK
AIRLOCK
A
(FIG. 4)
A
(FIG. 4)
AIRLOCK
SHAFT
CHW INVENTORY & PREPARATION
STORAGE AREA FOR
SPECIAL HANDLING
EQUIPMENT
OVERPACK
& REPAIR
FILTER ROOM

FIG. 3

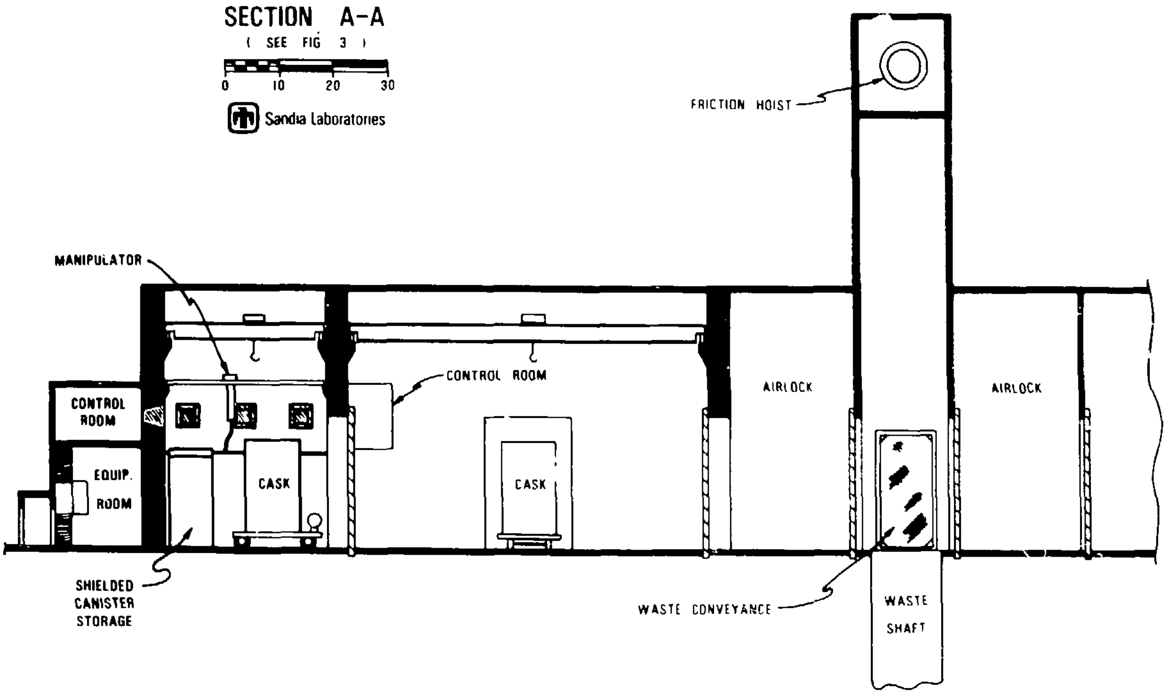
SECTION A-A
(SEE FIG 3)
0
10
20
30
Sandia Laboratories
FRICTION HOIST
MANIPULATOR
CONTROL ROOM
CONTROL ROOM
EQUIP. ROOM
CASK
CASK
AIRLOCK
AIRLOCK
SHIELDED CANISTER STORAGE
WASTE CONVEYANCE
WASTE SHAFT

FIG. 4

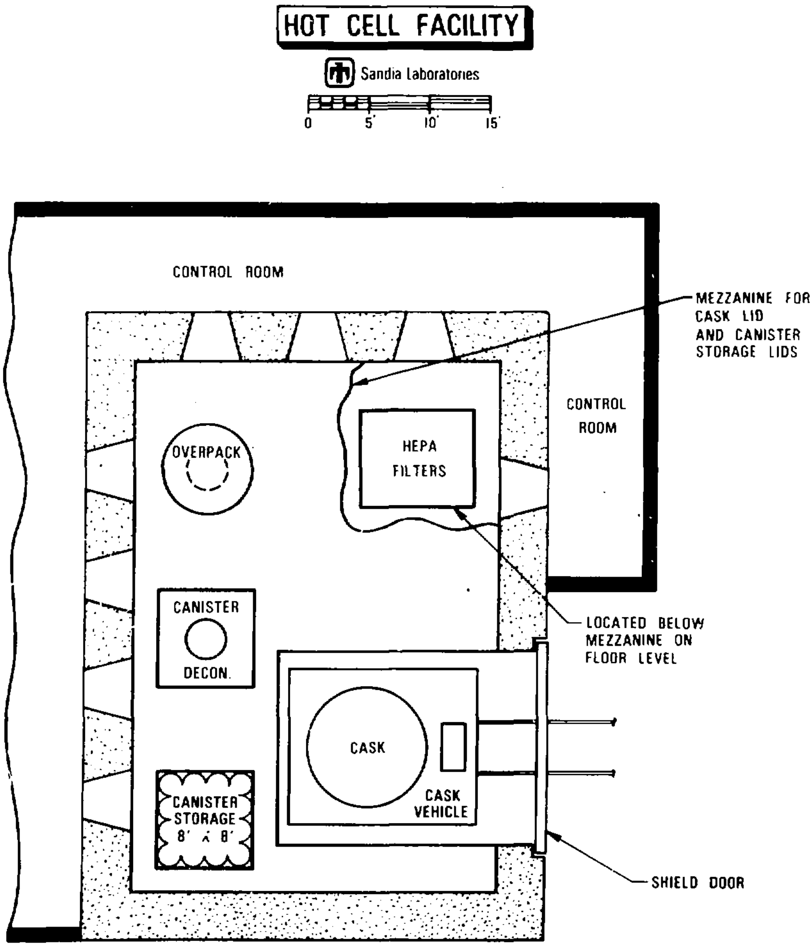
HOT CELL FACILITY
Sandia Laboratories
0
5'
10'
15'
CONTROL ROOM
MEZZANINE FOR
CASK LID
AND CANISTER
STORAGE LIDS
CONTROL
ROOM
HEPA
FILTERS
OVERPACK
CANISTER
DECON.
LOCATED BELOW
MEZZANINE ON
FLOOR LEVEL
CASK
CASK
VEHICLE
CANISTER
STORAGE
8' x 8'
SHIELD DOOR

FIG. 5

The RH building would be eliminated as a separate structure and a capability to handle RH waste would be added to the new Waste Handling Building. The RH waste would be moved to the storage horizon in a transfer cask via the same waste shaft used for contact-handled waste. The material flow diagram for RH waste is shown in Figure 6. Figure 7 is a simplified cross section through the surface and underground RH waste handling facility and supplements the flow diagram.

The mine storage filter building has been eliminated and a smaller filter facility added to the Waste Handling Building. The reduced filter capacity is a result of the reduction in ventilation requirement for the RH storage operations. (Section C.3.b Ventilation, describes the system in more detail.)

The RH TRU hoist house has been deleted. The new concept includes friction hoists mounted on the head frame of the waste shaft. Detailed economic trade-offs would be completed to determine if this selection is justified. If not, the drum hoist would be reintroduced.

The radioactive wastes generated by operations in the Waste Handling Building, underground storage, and experimental areas would be processed by a rad-waste system located in the mechanical equipment area of the Waste Handling

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RH WASTE MATERIAL FLOW DIAGRAM

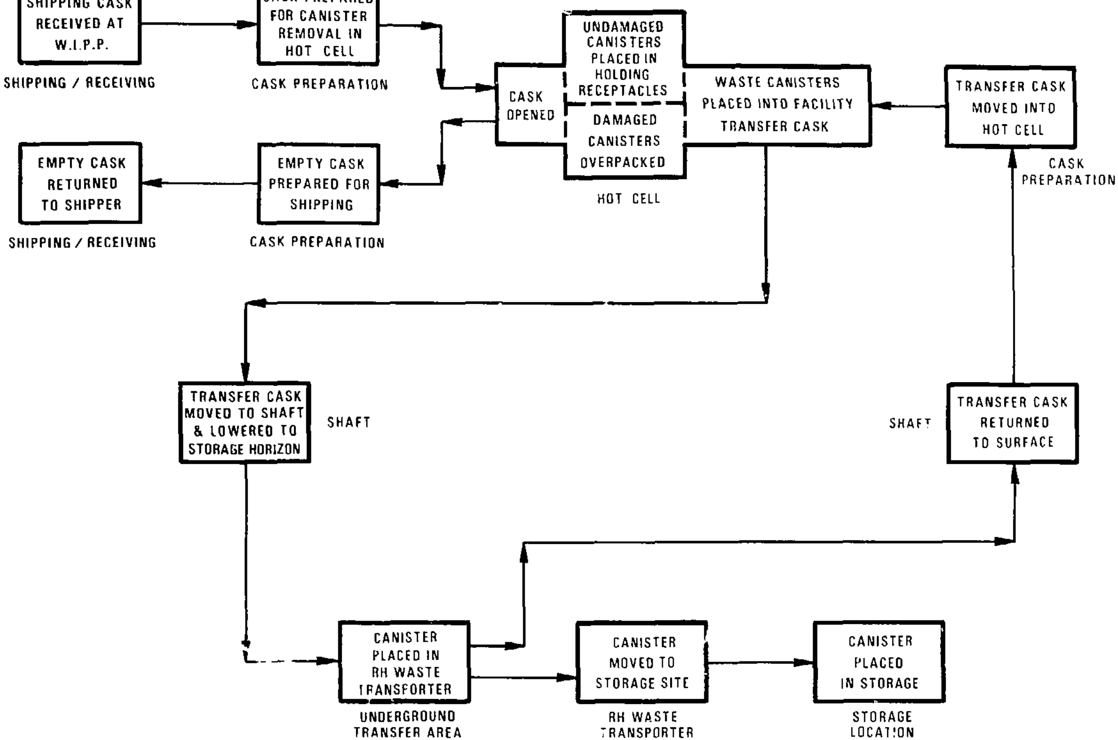

FIG. 6

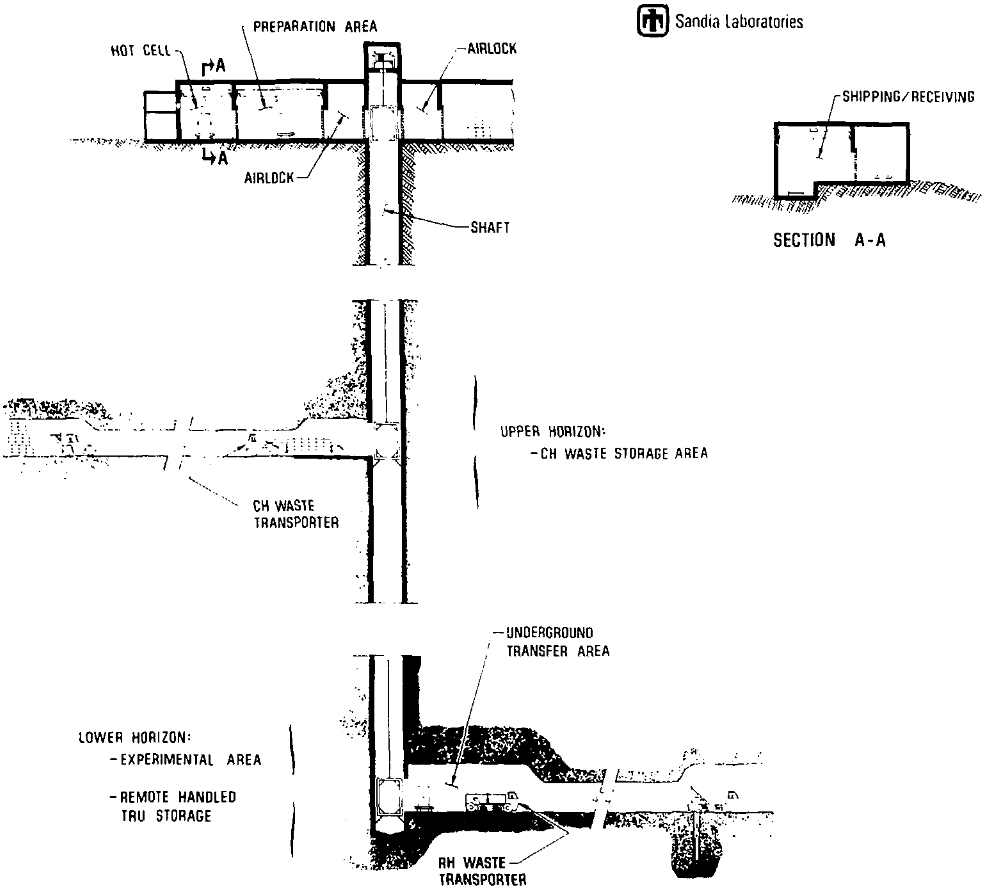
Sandia Laboratories
PREPARATION AREA
HOT CELL
A
A
AIRLOCK
AIRLOCK
SHAFT
SHIPPING/RECEIVING
SECTION A-A
UPPER HORIZON:
-CH WASTE STORAGE AREA
CH WASTE
TRANSPORTER
UNDERGROUND
TRANSFER AREA
LOWER HORIZON:
-EXPERIMENTAL AREA
-REMOTE HANDLED
TRU STORAGE
RH WASTE
TRANSPORTER

FIG. 7

Building. The consolidation of these functions into a single area would eliminate the requirement for interconnecting piping between buildings as well as some of the intermediate surge storage tanks.

b. Waste Shaft/Hoist Facility

This new WIPP concept would utilize a single hoist for the movement of all radioactive waste to the underground facilities. This hoist would be a friction type hoist mounted in the head frame of the waste shaft. The payload of the hoist would be 30 tons so that it can safely handle the shielded transfer casks planned for movement of RH waste. The conveyence of this hoist would be of sufficient size to accommodate those contact-handled waste groups specified in the original WIPP design.

The hoist station on the upper level would provide for off-loading contact-handled waste. The lower level hoist station would provide for off-loading the shielded RH waste transfer cask.

c. Underground Facility

The revised WIPP design utilizes two underground working horizons. The upper horizon is essentially the same as the contact-handled waste storage horizon shown in the WIPP Conceptual Design Report.

The lower horizon consists of two areas each of approximately 20 acres. One would be used for remotely-handled TRU waste storage. The second area would be used for the high-level waste experiments.

Support Facilities

a. Other Changes to the Facility Designs

In addition to the changes described above, the following reductions have also been made:

The man/material hoist house will be eliminated if it is more economical to use friction hoists instead of drum hoists. (Note: Figure 1 shows the site plan without the hoist house.)

The size of the emergency power building will be reduced by approximately 30%.

The number of continuous mining machines required has been reduced from five to two.

The salt from the storage horizon(s) would be stored in a single pile.

b. Ventilation Systems

The same design requirements for separation of mining and storage operations, filtration of potentially contaminated exhaust, and location of personnel upstream from potentially contaminated areas whenever possible have been included in the revised WIPP. However, the ventilation schematic for the revised facility design would be simpler than the original design since there would be only one major storage horizon. The reduction in size of the second storage horizon and the reduction in air flow requirements would permit the elimination of the construction exhaust and the storage area exhaust shafts (see Figures 8 and 9).

Fresh air for the underground operations would be delivered through one side of the partitioned man/material shaft. This air supply would be split to furnish approximately 100,000 cfm to the mining operation and approximately 200,000 cfm to the storage and experimental operations. The exhaust from the mining operation would be returned to the man/material shaft and exhausted through the mined salt hoisting portion of this shaft (see Figure 10). The air that is supplied for the storage and experimental operations would be distributed as necessary to these areas, and then would be exhausted through the waste shaft to the waste handling building on the surface. The exhaust air from this building would be passed through a HEPA

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UNDERGROUND VENTILATION FLOW-DIAGRAM

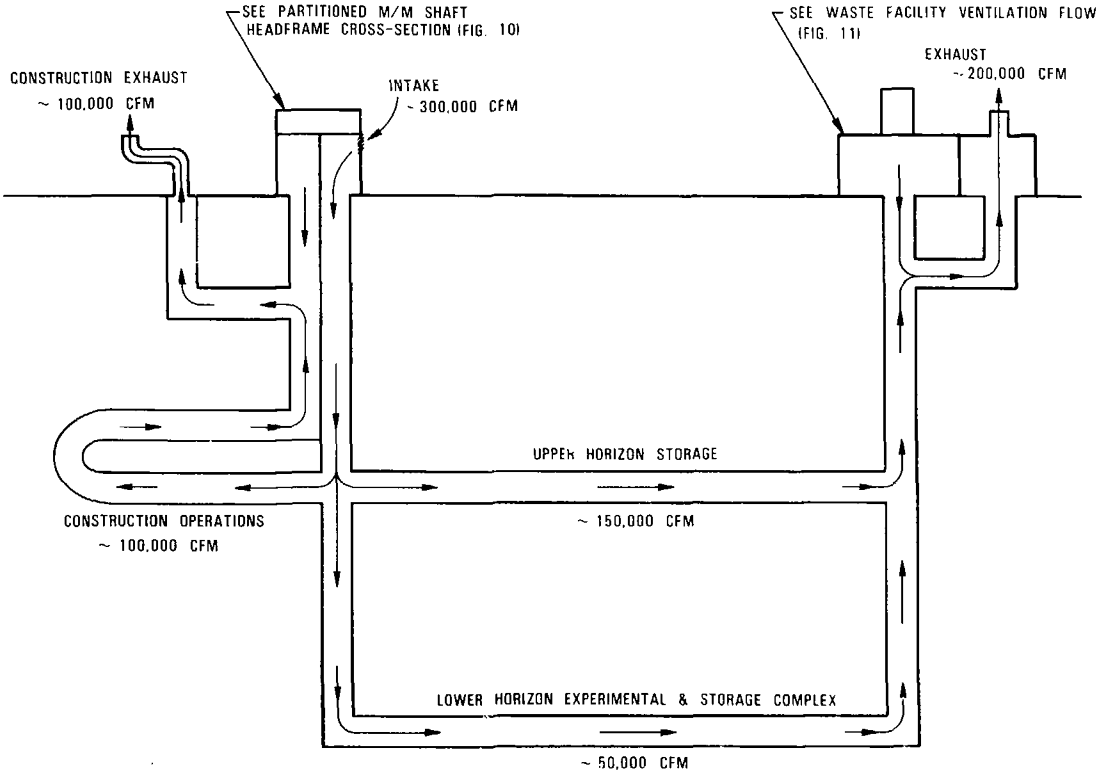

FIG. 8

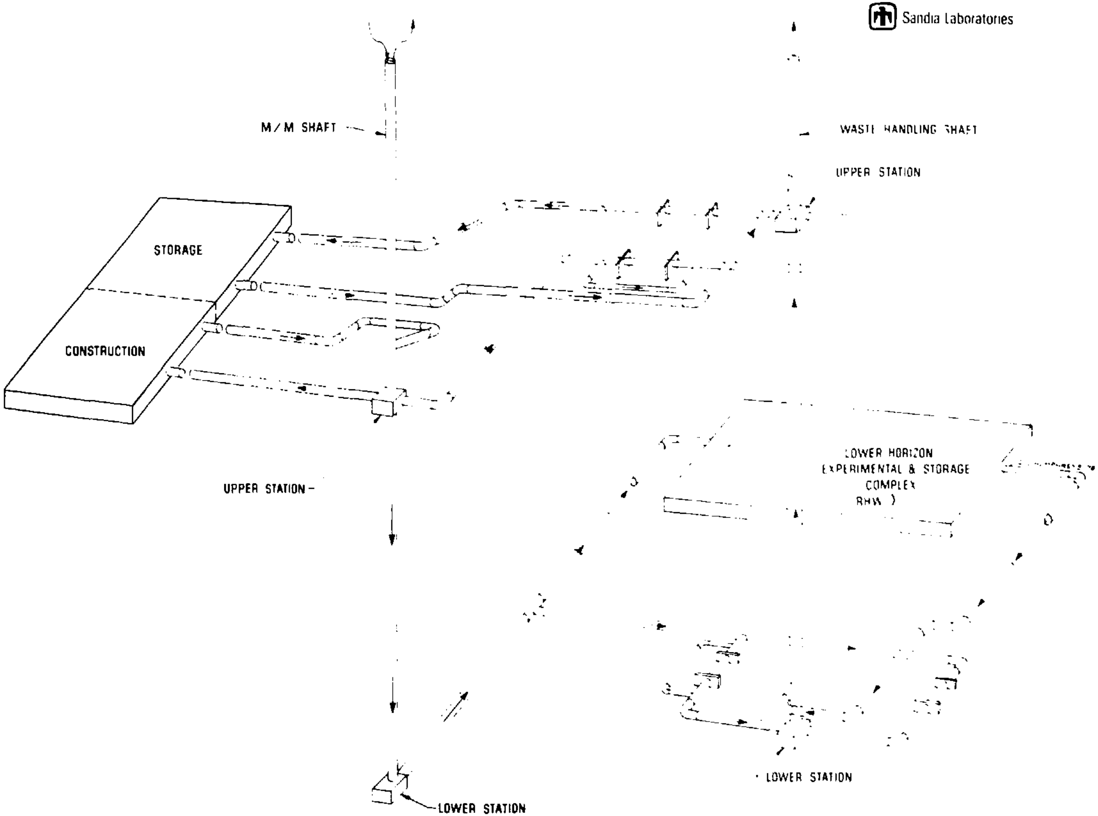
Sandia Laboratories
M/M SHAFT
WASTE HANDLING SHAFT
UPPER STATION
STORAGE
CONSTRUCTION
LOWER HORIZON
EXPERIMENTAL & STORAGE
COMPLEX
UPPER STATION
LOWER STATION
LOWER STATION

FIG. 9

PARTITIONED M/M SHAFT HEADFRAME CROSS-SECTION

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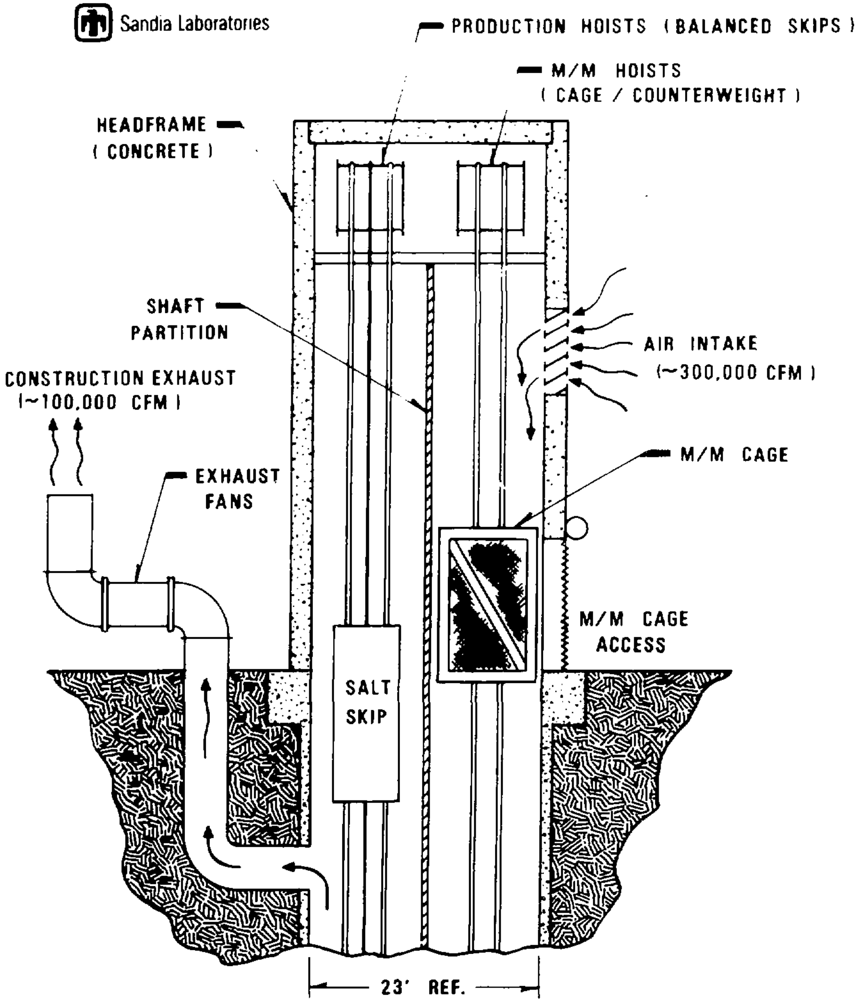


FIG. 10

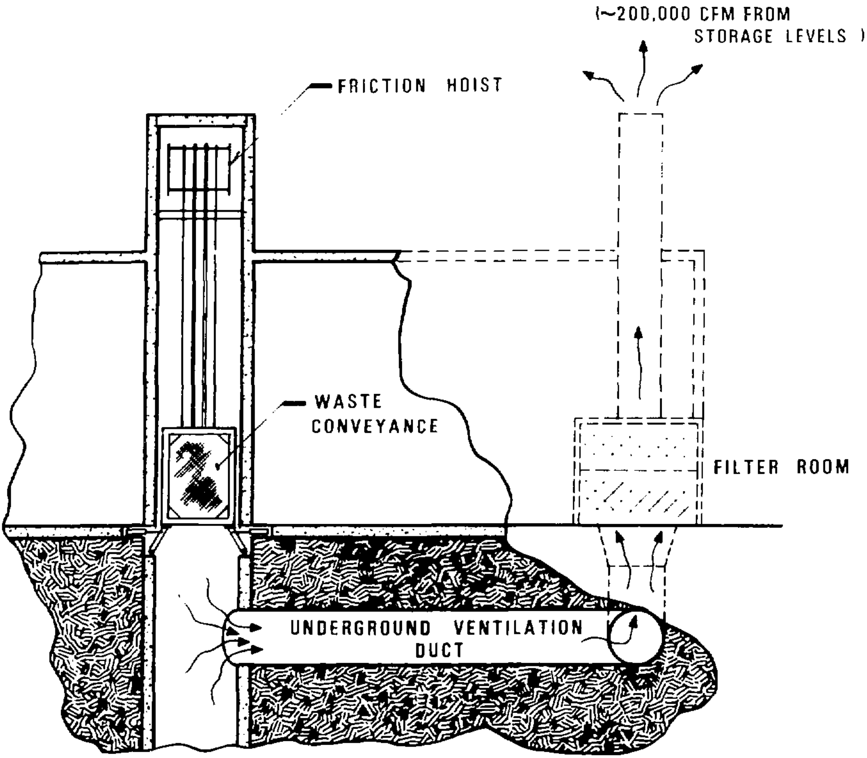
filter bank prior to release (see Figure 11). (Note: Any special filter systems required by the experimental areas, would be installed at the exhaust from that area.) All potentially contaminated air, whether from the Waste Handling Building or the storage horizon, is filtered and released by the exhaust systems located in the Waste Handling Building. This consolidation of filter systems would reduce the effluent release points from three to one and would reduce costs of common systems such as exhaust stacks and effluent monitors.

c. Security

A number of the physical security measures included in the original design have been eliminated in the modified design. This is in line with the current thinking that the physical characteristics of the waste in conjunction with normal industrial security provide adequate protection. This approach appears to be compatible with the present NRC guidance.

d. Retrievability

As in the original charter for the WIPP, the modified charter requires that all waste placed in the repository will be retrievable during the pilot plant phase. The retrieval techniques for the CH TRU, the RH TRU, and the



UNDERGROUND STORAGE EXHAUST

Sandia Laboratories

FIG. 11

experiments with HLW in the modified WIPP design are the same as in the original design. The period of retrieval for the CH TRU and RH TRU will be approximately five years and the experiments will be retrievable throughout their life.

e. Impact on Accident Consequences

The modified design can affect the accident consequences in the following areas:

- Combining several functions into one Waste Handling Building increases the risk that an accident in one portion of the building would have adverse impacts on other operations in the building.

- Elimination of three shafts reduces the number of escape routes available in the event of an accident underground.

- Transporting the waste down the shaft in a shielded cask reduces the consequences in either the event of a cage hanging up in the shaft, or of a cage fall.

Although the necessary detailed analyses have not been performed, it appears that the adverse impacts can be controlled by proper design.

4. Expansion Capabilities

The upper horizon of the revised WIPP can be expanded laterally to utilize all of the area of the WIPP zoned for waste disposal; consequently, considerable latitude exists in terms of waste capacity for this horizon. Ultimately approximately 70 x 10^6 ft^3 of waste could be stored on the upper horizon.

The capability of eventually using the lower horizon as a repository for RH waste is not precluded or jeopardized by the revised WIPP design. The surface layout modified to accommodate this expansion is shown on Figure 12. An example of how the lower level could be developed for use as an RH waste repository is shown on Figure 13. Actual waste volumes that could be accommodated on the lower horizon would depend on the heat generation rates of the waste and allowable thermal loadings. Based on current estimates of high-level waste volume and heat production rates as well as allowable thermal loadings, it is reasonable to expect that all DOE HL waste could be stored on the lower horizon.

D. Impacts on Cost and Schedule

1. Impacts on Cost

To establish the potential economic impact of the revised design we have compared the cost estimates for the original conceptual

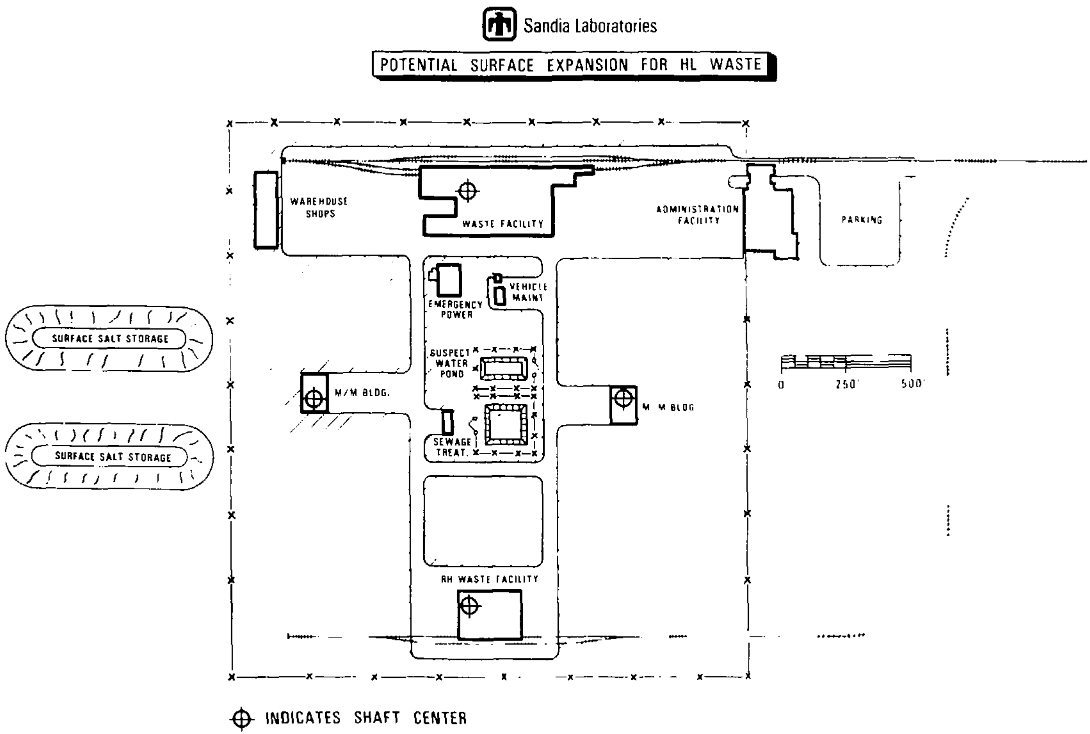
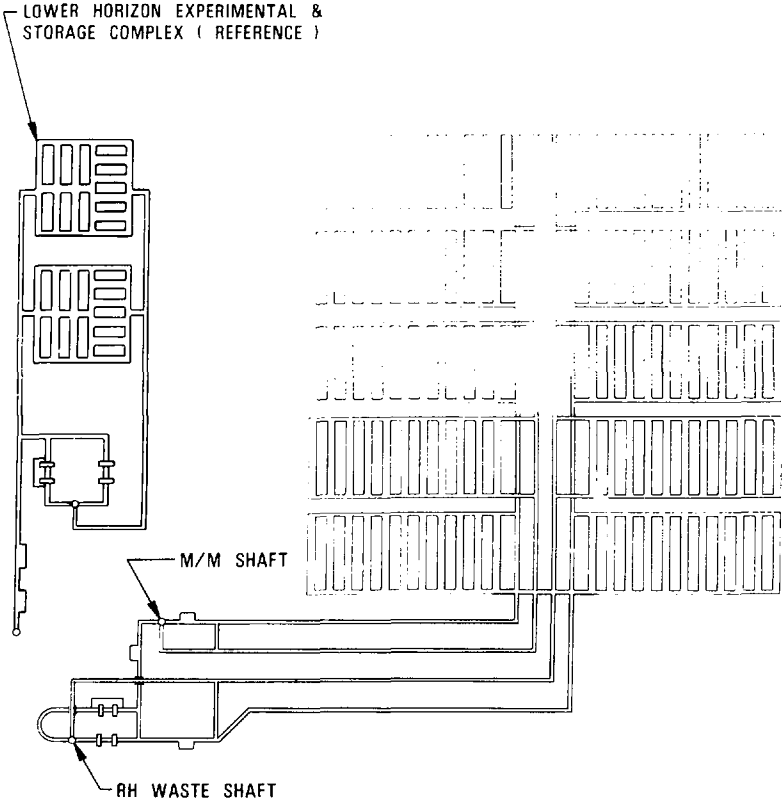

Sandia Laboratories
POTENTIAL SURFACE EXPANSION FOR HL WASTE
WAREHOUSE SHOPS
WASTE FACILITY
ADMINISTRATION FACILITY
PARKING
EMERGENCY POWER
VEHICLE MAINT
SURFACE SALT STORAGE
SUSPECT WATER POND
M/M BLDG.
M M BLDG
SURFACE SALT STORAGE
SEWAGE TREAT.
0
250'
500'
RH WASTE FACILITY
INDICATES SHAFT CENTER

FIG. 12



POTENTIAL DEVELOPMENT ON LOWER HORIZON FOR HL WASTE

0 500' 1000' 1500'

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FIG. 13

design and the revised conceptual design in the following paragraphs. The escalated costs for each case are shown in Table V.

As would be expected, the reduced scope of the revised design will result in a cost lower than the original conceptual design.

If a decision to store DOE HL waste in the WIPP were made today and a parallel effort were initiated to design and build the separate DOE HL waste facility to be operational by 1985, the total costs (revised design plus HL waste facility) would be approximately 9% higher than the original design. However, there is no need to make this decision now since the DOE HL waste probably would not be available for shipment to a repository in 1985.

2. Impacts on Schedule

The decision to change the course of the Title I design effort at Bechtel would delay completion of the Title I effort and submission of the PSAR to the NRC. Bechtel has indicated that approximately 12 months will be needed to complete Title I and the PSAR after redirection of the effort. Thus if the decision had been made on May 1, 1978, a two-month delay would already be introduced. Additional delay beyond May 1, 1978 will probably result in a month-for-month delay in completion of Title I and the PSAR.

Table V

Capital Costs

($ in millions; costs inflated to mid-points of construction of each major item)

	Original*** Design	Revised *** Design	DOE HL Waste Facility (on line in 1985)*
Eng. Design and Inspection	$ 44	$ 39	$ 20
Land and Land Rights	33	33	-
Construction	174	133	100
Tech. Support Contractor and Prototype Equip.	55	55	-**
Construction Mgmt.	15	12	-**
Escalation	130	89	120
Contingency	83	67	40
	$534	$428	$160

* Inflated capital costs will increase by approximately 8%/year for each year delay beyond 1985
** Construction management is included in costs for revised design. If constructed later, the operating contractor will provide construction management services.
***From DOE budget presentation of June 12, 1978.

The delay in submission of the PSAR would carry through the schedule to the start of construction. The period of construction for the revised facility would be shorter than the 42 months presently scheduled for the original facility design. The exact amount of the time saved has not been estimated in detail, but it is at least equal to the four months' delay that might be experienced in start of construction. The brief review of the construction schedule showed that if a decision is made by July 1, 1978, it may be possible to meet the scheduled completion date of mid-1985.

E. Additional Studies Required

1. Design Trade-offs: The concept described in this report is a significant change from the design described in the original Conceptual Design Report. Several areas require considerably more engineering work to validate the concepts presented in this report. The following paragraphs outline the more significant areas requiring further investigation.

Two-Shaft Concept: The concept of using only two shafts with one being partitioned for proper ventilation control appears to be sound. However, a cost trade-off study to explore the use of three shafts rather than construct the partition is in order. Using the two shafts for personnel escape routes should be adequate; however, the benefit to safety from three shafts should not be ignored.

Combined Surface Facilities: The advantages of combining several waste handling facilities into a single structure are many. Combining the waste treatment facility into the building where the waste is generated eliminates the potential spill from ruptured pipe lines, etc. However, there are also some disadvantages. Care must be taken so that a rather minor problem could not shut down all waste handling operations. More work is needed to assure a good design.

Mining Technique and Salt Handling: With the reduced quantities of salt to be mined and transported to the surface, a relook at the type and quantity of mining equipment is in order. With the small quantity of salt to be handled from the lower horizon, a single salt storage pile with a separate section for each horizon may be the best solution.

Site Energy Study: The reduced power demands from the mining equipment would indicate a new site energy study will be required.

Hoists: The relative advantages and disadvantages of friction hoists should be explored as opposed to drum type hoists.

2. Second Experimental Area: The need for a second experimental area in a salt zone with more impurities than the salt on the lower horizon has been suggested. The options considered for meeting this requirement were:

- Add an experimental area on the upper horizon. This would require modifications to the shaft station on the upper horizon and the underground ventilation system and procurement of additional waste handling equipment.

- Ramp from the lower horizon (either up or down) to a salt bed that has the desired properties. This option would probably require fewer facility modifications if the second layer were reasonably close to the lower horizon.

Neither of these options were considered in greater detail at this time.

Future work will concentrate on the need for a second experiment area and the nature of the information to be gained and facility requirements.