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TITLE: SHALLOW LAND BURIAL: EXPERIENCE AND DEVELOPMENTS
AT OAK RIDGE AND LOS ALAMOS
~~LOS ALAMOS EXPERIENCE AND DEVELOPMENTS~~

Per Pm

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University of California

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Shallow Land Burial: Experience and Developments at Oak Ridge and Los Alamos

Los Alamos Experience and Developments

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Shallow Land Burial: Experience and Developments at Oak Ridge and Los Alamos

Los Alamos Experience and Developments

ABSTRACT

Since the mid-1940's, in excess of 250,000 m^3 of low- and intermediate-level radioactive solid waste, generated in operations at the Los Alamos Scientific Laboratory (LASL), has been disposed of by on- site shallow land burial and retrievable storage in dry volcanic tuff. Guidelines have been developed at LASL which regulate the construction of waste disposal facilities, burial and storage operations, disposal site maintenance and restoration, and documentation of all waste disposal activities. Monitoring programs at the past and current solid waste disposal sites have continued to show that, with the exception of low levels of tritium, no migration of contaminants away from their disposal location has been detected.

INTRODUCTION

The Los Alamos Scientific Laboratory (LASL), operated under contract to the US Department of Energy, has used on-site shallow land burial as the means to dispose of most low- and intermediate-level solid radioactive wastes generated at LASL since the beginning of operations in the mid-1940's. The LASL, situated in the semi-arid southwestern region of the United States, has very favorable climatological and geological conditions for disposal of solid radioactive wastes in this manner. To date, over 250,000 m^3 of solid radioactive waste has been buried in on-site locations. Additionally, since 1971, 1800 m^3 of transuranic (TRU) waste has been retrievably stored. Through December 31, 1977, the radioactive content of buried waste was an estimated 205 600 Ci (decay corrected), 94.6% of which was tritium. Stored wastes contain 76 300 Ci of TRU alpha activity.

All investigations of the solid waste disposal sites have indicated that, with the exception of relatively small quantities of tritium, no migration of radionuclides has been detectable. This paper describes waste disposal facilities, procedures, experience and developments at LASL which contribute to this successful program.

ENVIRONMENTAL SETTING

General Site Environment

The LASL is located in north central New Mexico on the Pajarito Plateau, a topographical high, approximately 600 m above the Rio Grande (Fig. 1). The plateau is cut by numerous steep sided canyons that open into the Rio Grande drainage at intervals of one to several kilometers. The Laboratories' past and present disposal sites are located on the tops of the resulting finger-like mesas. The plateau is composed of moderate-to-densely welded rhyolytic tuffs that were deposited about 1.4 million years ago. The tuff is broken by numerous near-vertical joints at intervals of 1 to 2 m. The regional water table is located in sediments of the Rio Grande basin at depths of 200 to 300 m below the plateau surface. Soil cover is typically <1 m thick, and waste disposal facilities are dug through the soil into the underlying tuff.[1] The Los Alamos area has an average annual precipitation which varies with elevation from 300 to 500 mm; the potential evapotranspiration is ~ 600 mm in the area.[2] The tuff has a relatively low hydraulic conductivity when saturated, and this decreases rapidly with reduced moisture content. The combined effect of the precipitation/evaporation ratio and the relative impermeability of the tuff restricts moisture penetration to the upper few meters of the tuff. Data obtained through analyses of tuff removed in coring, and through neutron moisture logging, show that the moisture content of the tuff is generally 5% or less, by volume, at depths >4 m.[3-4]

Active Disposal Site

The major current LASL disposal site, identified as Area G (Fig. 2) has been in operation since 1957. Area G is located on an approximately 3.2 km long mesa which is relatively narrow, ranging in width from about 90 to 400 m. The fenced portion of the site covers 250,000 m^2 of the estimated 360,000 m^2 available. To date, approximately 135,000 m^2 has been utilized. Soil cover on the mesa is 0.3 to 0.6 m thick, and erosion is slow because of the small drainage area. Height of the mesa above the adjacent canyon floors ranges from 24 to 30 m.[5]

WASTE FORM AND PACKAGING

Characteristics of Buried Waste

Over the period 1971-1978, the LASL has buried annually an average of 6735 m^3 of radioactive solid waste. Actual annual volumes have ranged from 3610 m^3 to 13075 m^3 over this period. The types and relative quantities of the LASL wastes are listed in Table I. The distribution of radioactive contaminants found in these wastes is identified in Table II. Over the period 1975-1978, 70.8% (23113.5 m^3) of the waste buried has originated from facility decommissioning and area decontamination operations, while only 29.2% (9528.5 m^3) has originated from laboratory operations. The burial volume of routine laboratory waste has been reduced significantly as a result of employee education programs, improved materials handling, written procedures, and waste treatment prior to burial.

Waste Compaction

Since April 1977, a 45,500 kg press compactor-baler has been used to reduce the volume of trash-type wastes prior to burial (Fig. 3). Approximately 1000 m^3 of wastes annually are reduced to a burial volume of <200 m^3. Bales generated are 0.4 m^3 in volume and weigh 200 to 250 kg. Advantages of compaction include a reduction in fire hazard associated with placing the combustible trash wastes directly into a burial pit, and a considerable saving of pit space due both to the direct reduction in waste volume and to a resultant reduction of backfill material required to cover this smaller waste volume.

Buried Waste Packaging

Waste packaging in most instances serves to meet requirements of safe, on-site handling and transport. Typical packagings include plastic wrap and bags, cardboard boxes, metal or fiber drums, and wooden crates. Large equipment items and much of the decontamination/decommissioning wastes are not packaged, but are delivered to the burial site in covered or enclosed transport vehicles. Following burial, the dry site environment contains the waste and its radioactive contamination.

Tritium Waste

A noteable exception to the above packaging and containment requirements is tritium contaminated waste. Tritium is highly mobile even under dry burial site conditions. Found in waste principally as tritiated water, tritium is as capable of migration as the water which exists in the tuff. LASL research efforts in 1970 identified asphalt as being effective in containing tritium contamination.[6] Consequently, all wastes having >mCi levels of tritium require containment in metal drums having an internal asphalt coating. Waste containing tritium in excess of a few 10's of Curies requires containment in a metal drum that is completely encased by several centimeters of asphalt within a second larger drum.

Transuranic (TRU) Waste

In March 1970 the US Federal Government issued a requirement that all waste contaminated with long-lived TRU alpha emitters at an activity concentration greater than 10 nCi/g must be stored retrievably in a contamination free manner for a 20-year period. These TRU wastes comprise 10 to 15% of LASL's annual waste generation. Wastes include essentially all materials listed in Table I; TRU contaminants at LASL include primarily ^{238,239}Pu, ^{241}Am, and ^{233}U.

Transuranic wastes receive special handling and are packaged only in containers meeting strict quality control requirements. These packagings include 210-ℓ drums and fiberglass-reinforced polyester coated wooden crates of varying size. All packages include inner plastic liners, ranging in thickness from 0.13 mm for dry wastes to a 2.3 mm high density crosslinked polyethylene liner for potentially corrosive wastes.

DISPOSAL FACILITY CONSTRUCTION AND USE

Criteria

In 1974, LASL Waste Management and Environmental scientists significantly expanded criteria, developed in 1965 by the US Geological Survey, to insure adequate containment of buried radioactive waste at LASL sites. The criteria apply controls to conditions relating to possible pathways of release of contamination from buried wastes. Major release pathways are through infiltration of water into wastes, and erosion, both from the surface and from the mesa sides. The criteria describe disposal facility sites, orientation, construction, approval, use, documentation, maintenance, and site conditioning requirements following use.

Burial Pit Construction

The bulk of LASL waste is buried in large pits (Fig. 4). Except for pit depth, pit dimensions generally are not restricted, and have ranged in size from 120 to 180 m long by 8 to 30 m wide. To prevent possible association between buried waste and perched water which exists in alluvial material in the floors of adjacent canyons, no burial facilities may be deeper than the adjacent canyon floor. To date the deepest pit excavation has been ~ 14 m, this being controlled primarily by the stability of the pit walls. Pits are oriented with the long dimension as parallel as possible to the area surface contours. Pits are dug no closer than 15 m to a canyon wall, and pit sidewalls must be at least 4.5 m apart at the surface. All topsoil is removed and stockpiled for future site revegetation.

For stability, pit walls are excavated with approximately a 1:4 slope. The ends are dug with slopes ranging from 2:1 to 4:1 to allow access by vehicles and equipment. As a final step in the excavation, tuff is ground and compacted in the pit bottom to a depth of 0.15 to 0.30 m. This provides a seal for fractures in the pit bottom, and an absorption medium for precipitation that enters the pit prior to waste burial. All burial facilities are surveyed and recorded on permanent LASL drawings. LASL environmental scientists map all fractures in pit walls, and all open fractures in excess of 5 cm wide are filled with materials such as cement, bentonite clay, or crushed tuff. Final approval of a pit for use by a LASL geologist is required.

Pit Burial Operations

Waste is buried in pits in layers, with a minimum of 0.15 m of backfill compacted between layers. Excavated tuff is used for all backfill operations. Waste considered to be combustible, wind dispersable, or which has a potential for contamination release must be covered on the day of delivery. Routinely, waste is covered twice weekly. Pits are filled to a level 1 m below the "spill point," defined as the lowest point on the pit rim, thus insuring complete containment of waste by undisturbed tuff. Based on conservative estimates of rates of surface and mesa wall erosion, times to expose buried wastes from the top and sides are estimated to be 50 000 and 150 000 years, respectively.[1] In recent years the waste volume buried in a pit has ranged from 18 to 42%, with the average being 31% of the total pit volume.

Final Cover and Site Rehabilitation

Excavated tuff is used to refill the pit to the original land contour. Additional mounding with tuff up to 1 m or more at the center of the pit, and extending to 1 m beyond the edges of the pit is accomplished if required for surface drainage modification.

Following the final use of an area, revegetation is required. Topsoil is spread to a depth of 10 to 15 cm, followed by application of seed, fertilizer, and straw (to maintain soil moisture). To meet the semi-arid growing conditions at Los Alamos a seed mixture comprised of approximately equal proportions of the seven varieties listed in Table III are used. Special watering is not required.

Burial Shaft Construction and Use

To provide for better isolation following burial and/or to increase worker safety, certain LASL wastes are buried in deep shafts (Fig. 5). These wastes and specific reasons for shaft burial are listed in Table IV. Burial shafts are augered vertically into the tuff, most are unlined (a few were constructed with a 0.3 m concrete liner), and measure 0.3 to 1.8 m in diameter by up to 20 m deep. All applicable disposal facility siting and construction criteria described for burial pits apply to shafts.

To assure criticality safety, shafts are limited to 500 g total fissile material. Shafts may be filled to within ~ 1.5 m of the surface. Sufficient excavated tuff then is added to cover all waste in the shaft, and a final 1 m concrete plug is poured.

TRANSURANIC WASTE STORAGE

Transuranic wastes are stored in facilities designed from modification of burial pits and shafts. The bulk of the LASL transuranic waste currently is stored in a modified pit (Fig. 6) measuring 122 m long, 9 m wide and 8 m deep. Pit modifications include the near vertical excavation of one end, pavement of the pit floor with asphalt road material, and construction of two 1.2 m diameter, 3 m deep asphalt lined sumps for collection and monitoring of precipitation.

Waste packages (drums and crates) are stacked on the pavement, beginning at the vertical end, to a height of 6 to 7 m. As the stack progresses down the pit, the top is covered with 19 mm thick plywood, and the entire stack is encased with 0.5 mm nylon reinforced vinyl sheeting. The stack is covered and mounded with tuff in the same manner as a burial pit.

Three different storage modes are utilized for other special transuranic wastes; these wastes and storage modes are identified in Table V.

WASTE RECORDS AND FACILITY IDENTIFICATION

Permanent records for all wastes buried and stored since 1971 are contained in a computer records system. Fig. 9 is the data input form used. Item 5 - WASTE CODE - is a code used to identify the waste matrix (e.g. combustible trash, sludge, building rubble, etc.). DISPOSAL/STORAGE LOCATION - item 14 -includes entries for the location of waste within a pit. POST(S) refers to sequentially numbered markers at 3 m intervals along the pit side, Pit LAYER is numbered sequentially bottom to top, and POS. (Position) denotes the side or center portion of the pit.

When filled, and following revegetation of the area, permanent brass cap markers are set in concrete monuments at two corners of each pit. Markers identify the pit and pit corners, dates of use, and major contaminants. Similar brass markers are set in the concrete cap sealing each burial shaft.

SITE MONITORING

Routine Monitoring

The overall Laboratory site environmental surveillance program at LASL is not sufficiently sensitive, with the possible exception of atmospheric tritium, to distinguish a burial ground release from normal site releases. Collection of water samples from unsaturated tuff is difficult to impossible, and consequently samples of tuff with their contained water are analyzed. Water samples obtained from nearby supply wells are analyzed for radionuclides.

Soil moisture content and movement is determined to depths of 40 m in undisturbed tuff and in and below filled burial/storage pits. Meteorlogic data collected at a burial site facility provides additional information on the rates of water movement into and out of the tuff. From these data an upper limit for the rate of possible radionuclide migration from water movement is being determined.

Low levels of TRU, fission product, and tritium contamination have been detected in analyses of surface soil samples collected at two old LASL burial sites. While this contamination, with the possible exception of tritium, is believed to be the result of operational "spills" while the sites were active, additional sampling and investigation is planned.

Coring

In 1976, five horizontal core holes were drilled beneath Pit 3 in a fan-shaped array. (See Fig. 2; Pit 3 received waste 1963-1966.).[7] The holes angled slightly downward, and depths ranged from zero to seven meters beneath the pit. Cores were analyzed for gross-α, gross-β, ^{90}Sr, ^{137}Cs, total uranium, ^{238,239}Pu, and ^{241}Am. No statistically significant variations of activities were observed between these cores and samples collected in the same geologic strata at other locations.[8] Tritium was not analyzed for because air had been used as a cuttings carrier during coring, and thus would have removed an unknown amount of water vapor containing tritium. No radionuclides were detected in the cores that could be attributed to migration from the overlying waste.

Tritium Migration

Tritium migration was detected in 1970, and the use of asphalt was initiated then to achieve better containment. Monitoring of tritium disposals through 1975, however, showed that asphalt, as it was being applied to shaft walls and as an inner drum coating, was ineffective in enhancing containment.[9] Results from two burial locations showed that <1% of the buried tritium was migrating, and that the migration was restricted to relatively small areas immediately around the disposal locations. Further, it was shown that the tritium, as tritiated water, was moving with water vapor through joints and porous zones, rather than with liquid moisture flow. No other radionuclides present in LASL waste can migrate in this fashion. Since 1975, procedures have been established to assure containment of tritium using asphalt. Burial of tritium waste has been accomplished in a new portion of the burial site in a shaft surrounded by nine sampling holes. This shaft will be sealed in mid-1979, and sampling for tritium and soil moisture will be initiated shortly thereafter.

SUMMARY

Over 30 years of experience show that shallow land burial of low- and intermediate-level solid radioactive waste can be safely accomplished in an environmentally acceptable manner. Future LASL Waste Management operations will strongly emphasize development and implementation of improved technologies in the fields of waste volume reduction, arid-site monitoring, and overall shallow-land burial procedures.

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TABLE I

LASL Buried Wastes (1971-1978)

Waste Category	Volume m^3	Volume %
Laboratory Trash	13910	25.8
Failed Equipment	2715	5.0
Building Rubble	10625	19.7
Sludge	1235	2.3
Cement Paste	2755	5.1
Soil	19105	35.5
Oil	120	0.2
Uranium and Residues	260	0.5
Filter Media	115	0.2
Hot Cell Waste	40	0.1
Graphite	535	1.0
Animal Tissue	30	0.1
Chemical Wastes	210	0.4
Other	2225	4.1
Total	53880	100.0%

TABLE II

LASL Waste Radioactive Contaminants (1971-1978)

Radionuclide	Volume m^3	Volume %
Transuranics (^{238}Pu, ^{239}Pu, ^{241}Am, ^{233}U)	35155	65.3
Uranium (depleted, normal, enriched)	14190	26.3
Fission Product/Induced Activity	3675	6.8
Tritium	460	0.9
Other	400	0.7
Total	53880	100%

TABLE III

Revegetation Seed Mixture for Semi-Arid New Mexico

Indian Rice	(Oryzopeis hymenoides)
Little Blue-stem	(Andropagan scoparius)
Western Wheatgrass	(Agropyron Smithii)
Side Oats Grama	(Boutelana curtipendula)
Yellow Blossom Clover	(Melilotus oficinalis)
Buffalo Sharps	(Buchloe dactyliodes)
Perennial Rye	(Lelium perenne)

TABLE IV

LASL Burial Shaft Usage

Wastes	Reason for shaft use
1. High Activity ^3H, (>mCi•quantities)	Greater protection of packaging; ease of monitoring.
2. Beta-gamma hot cell waste (intermediate level)	Direct disposal from bottom loading, truck-mounted cask; personnel protection.
3. High-activity accelerator waste	Personnel protection.
4. Contaminated chemical wastes	Greater protection of packaging; improved isolation from other reactive wastes.
5. Animal tissue	Isolation from meat eating animals.
6. Cement paste	Ease of operation; paste is pumped directly into shaft from adjacent liquid waste treatment facility (Note: This operaton is not at Area G).

TABLE V

Transuranic Waste Storage Modes

Waste	Storage Mode
^{238}Pu contaminated trash, residues, small equipment; >1 g ^{238}Pu per drum.	110-ℓ steel drums, 2 each sealed in buried concrete cask (Fig. 7).
Highly beta-gamma active hot-cell wastes; up to several 1000's R/hr per 4- package, unshielded.	12 packages sealed in 0.6 m diameter, 4.5 m long corrugated metal pipe/concrete cask set in 0.9 m diameter, 4.5 m deep shaft (Fig. 5).
^{239}Pu - ^{241}Am cement paste.	Paste solidified in 0.75 m diameter, 20 m long corrugated metal pipe having 0.3 m thick uncontaminated concrete plug at the bottom. Pipe filled to within 0.3 m of top, then sealed with uncontaminated concrete. Pipes stand vertically in 6 m deep pit; backfilled with 1 m tuff (Fig. 8).

LIST OF FIGURES

Fig. 1. Geologic Cross Section, Los Alamos, New Mexico

LOS ALAMOS, NM

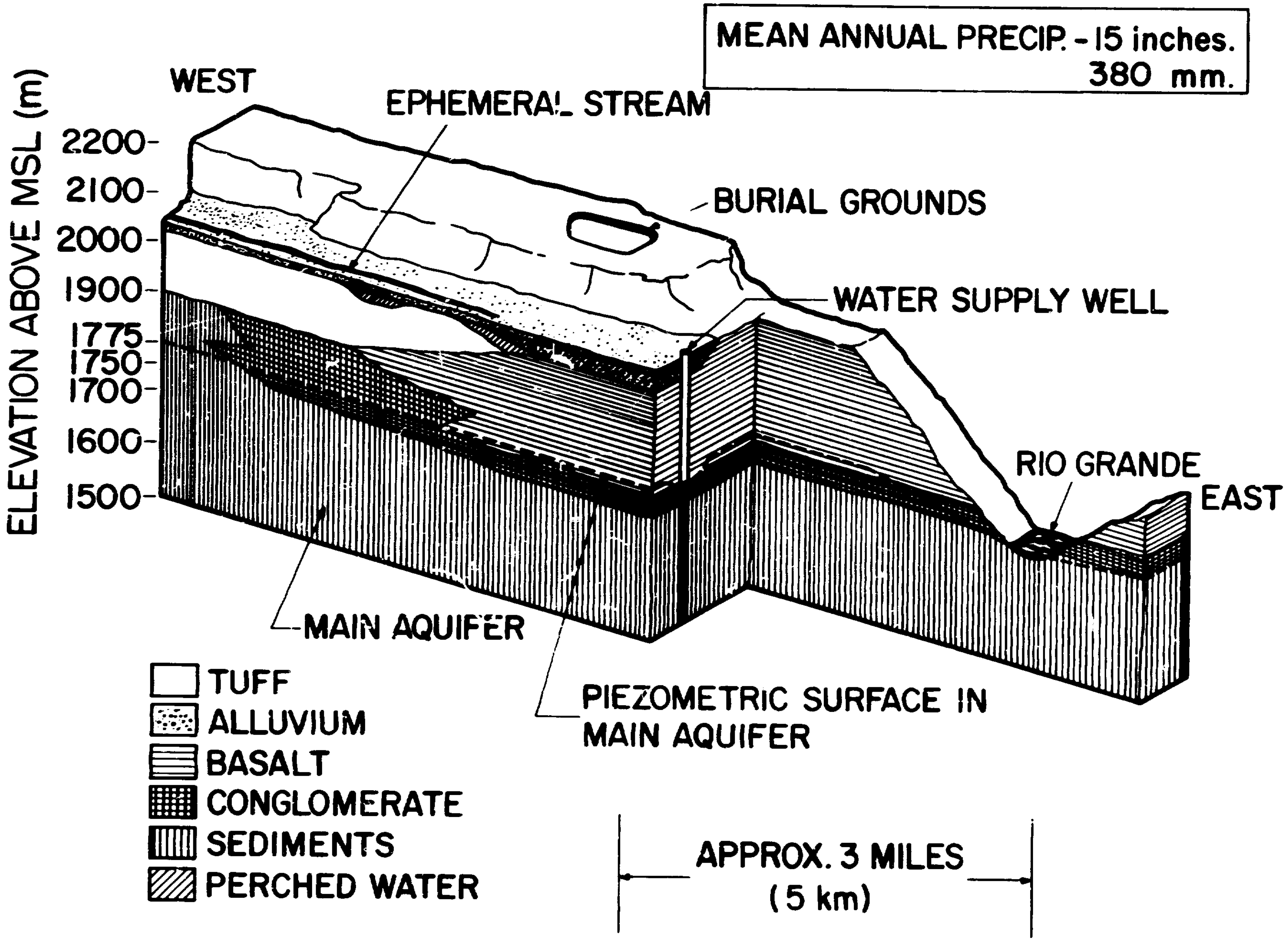
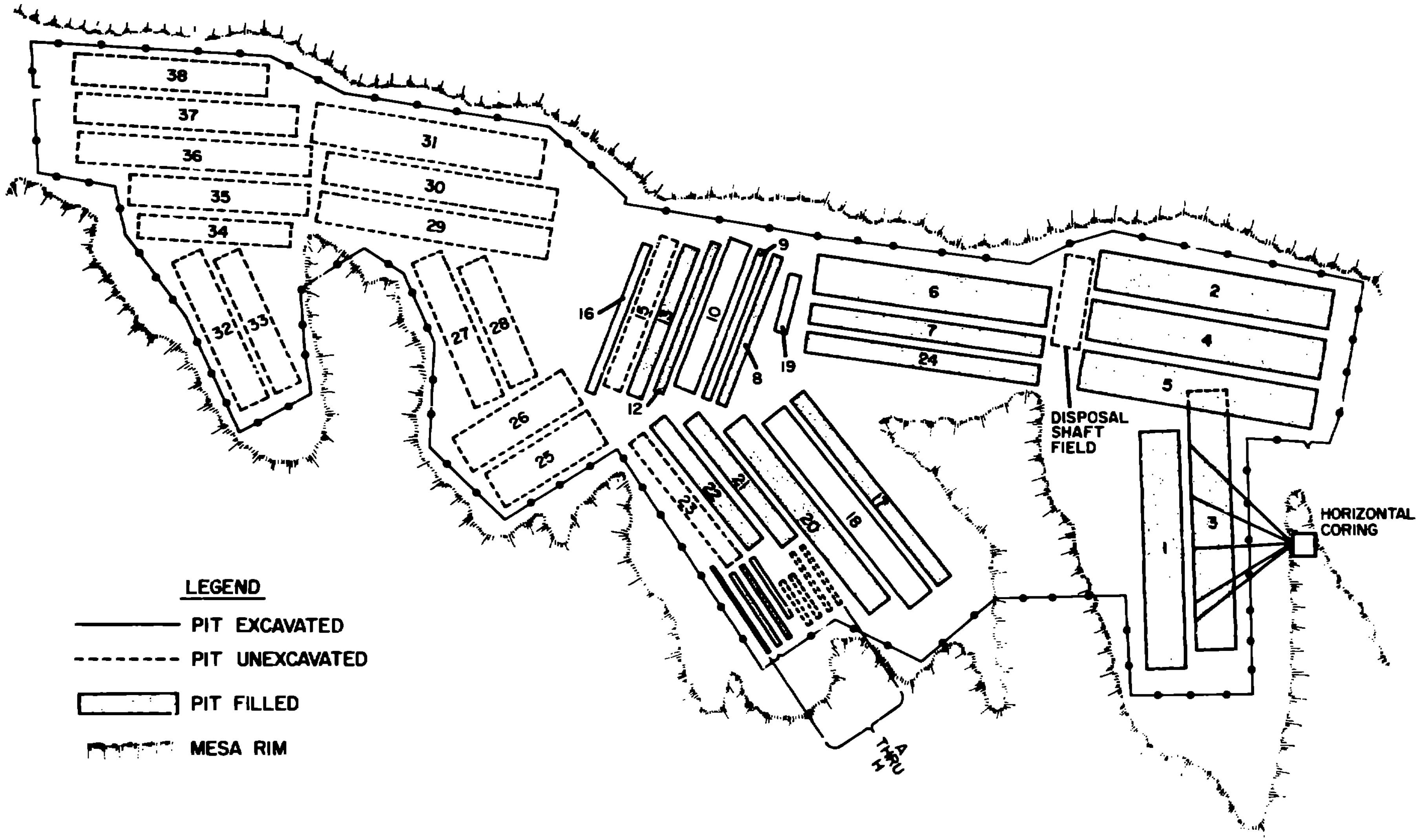


Fig. 2. Layout of Area G Disposal/Storage Site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DISPOSAL SHAFT FIELD
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HORIZONTAL CORING
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LEGEND
PIT EXCAVATED
PIT UNEXCAVATED
PIT FILLED
MESA RIM

Fig. 3. Waste Compactor-Baler at Area G

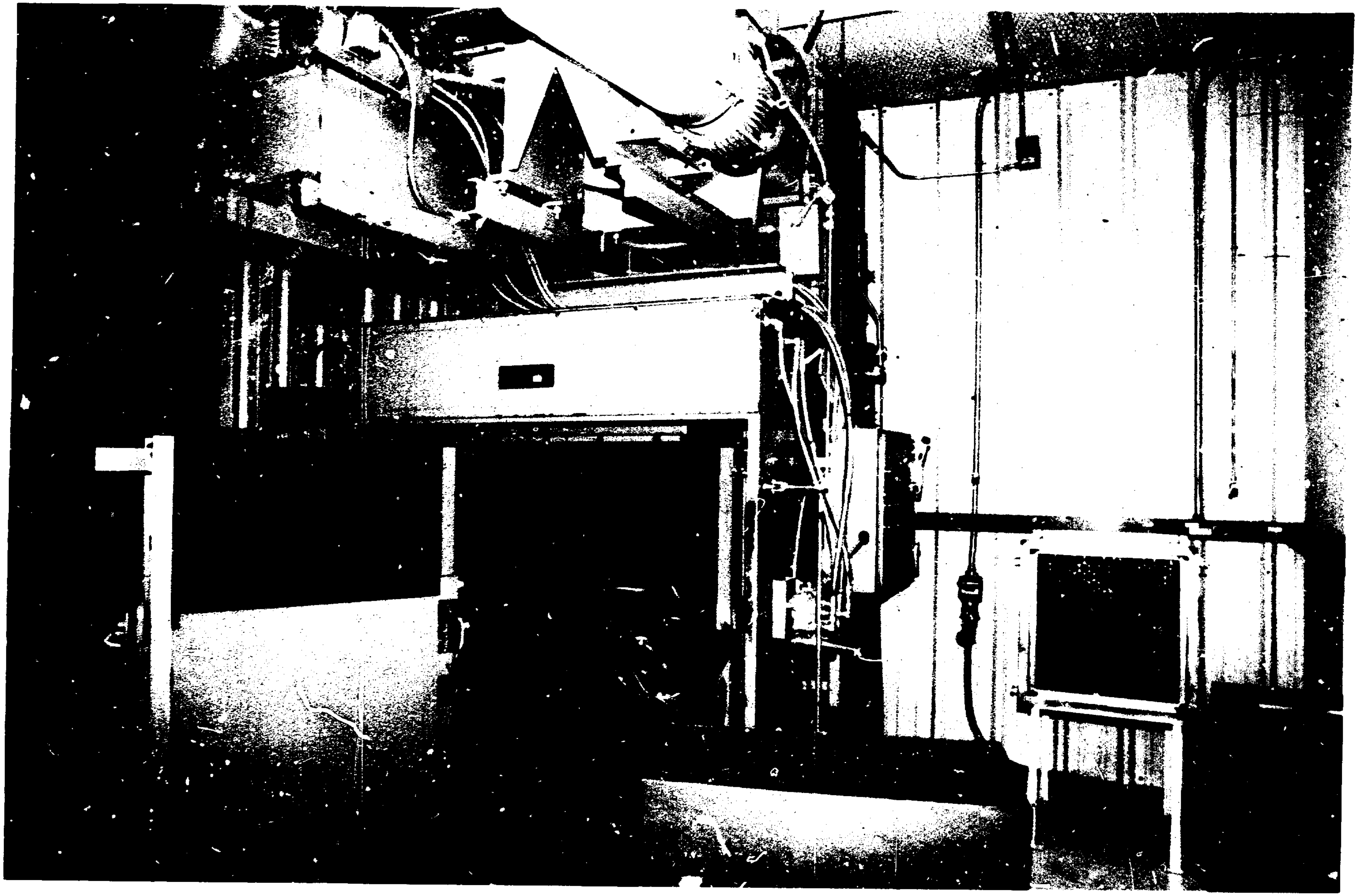

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Fig. 4. Waste Burial Pit Measuring 180 m long, 15 m wide, 8 m deep

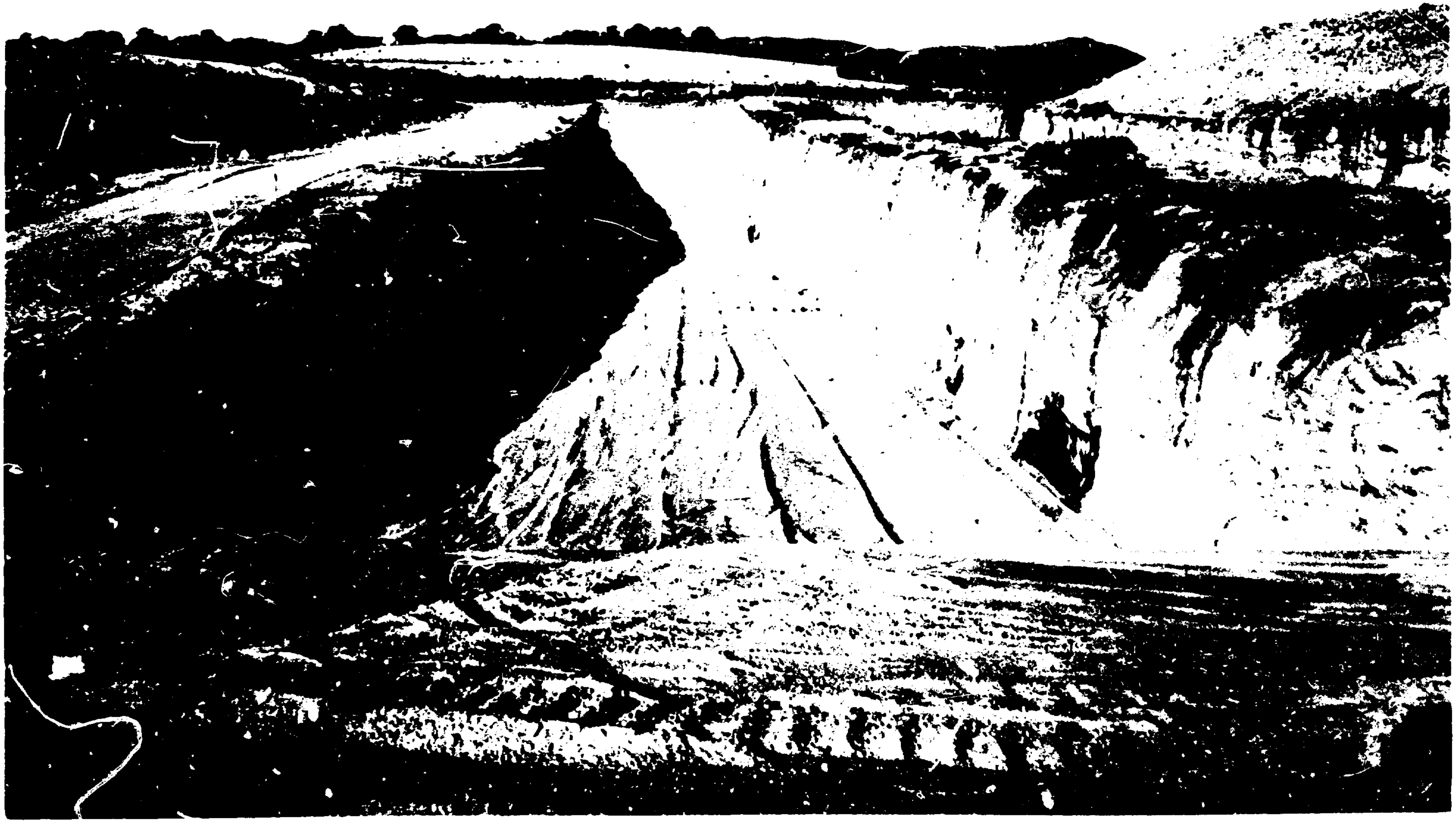
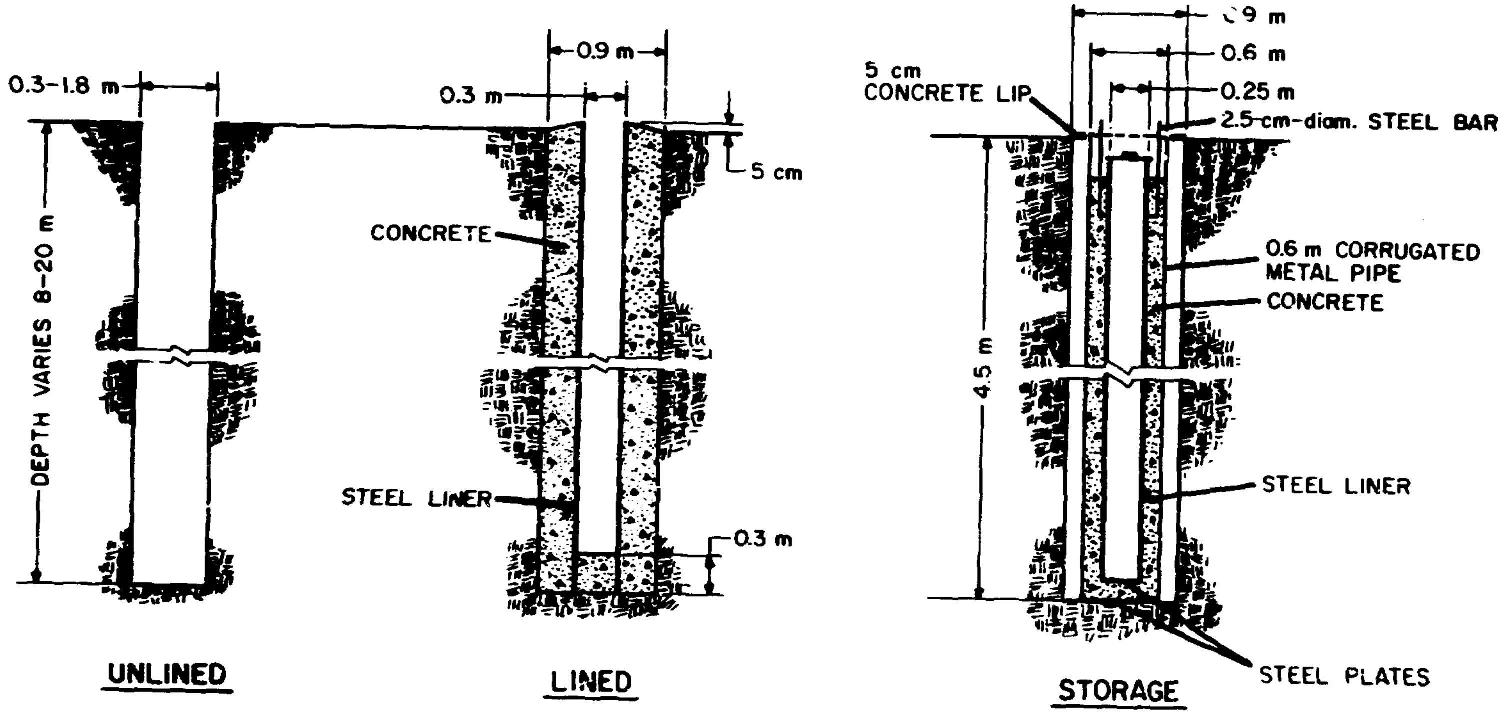


Fig. 5. LASL Burial/Storage Shafts



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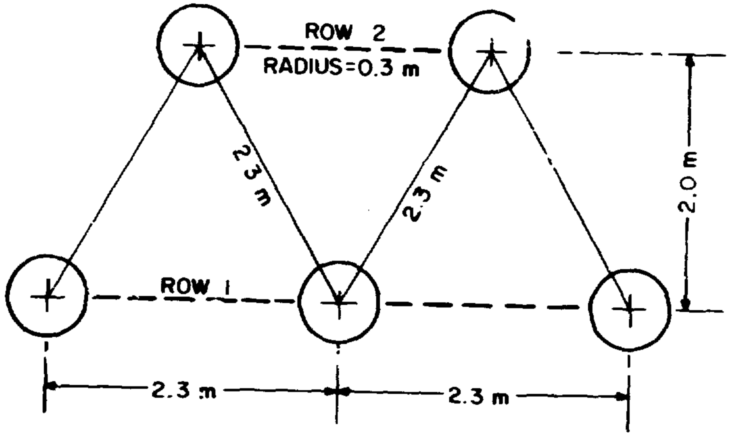
STORAGE

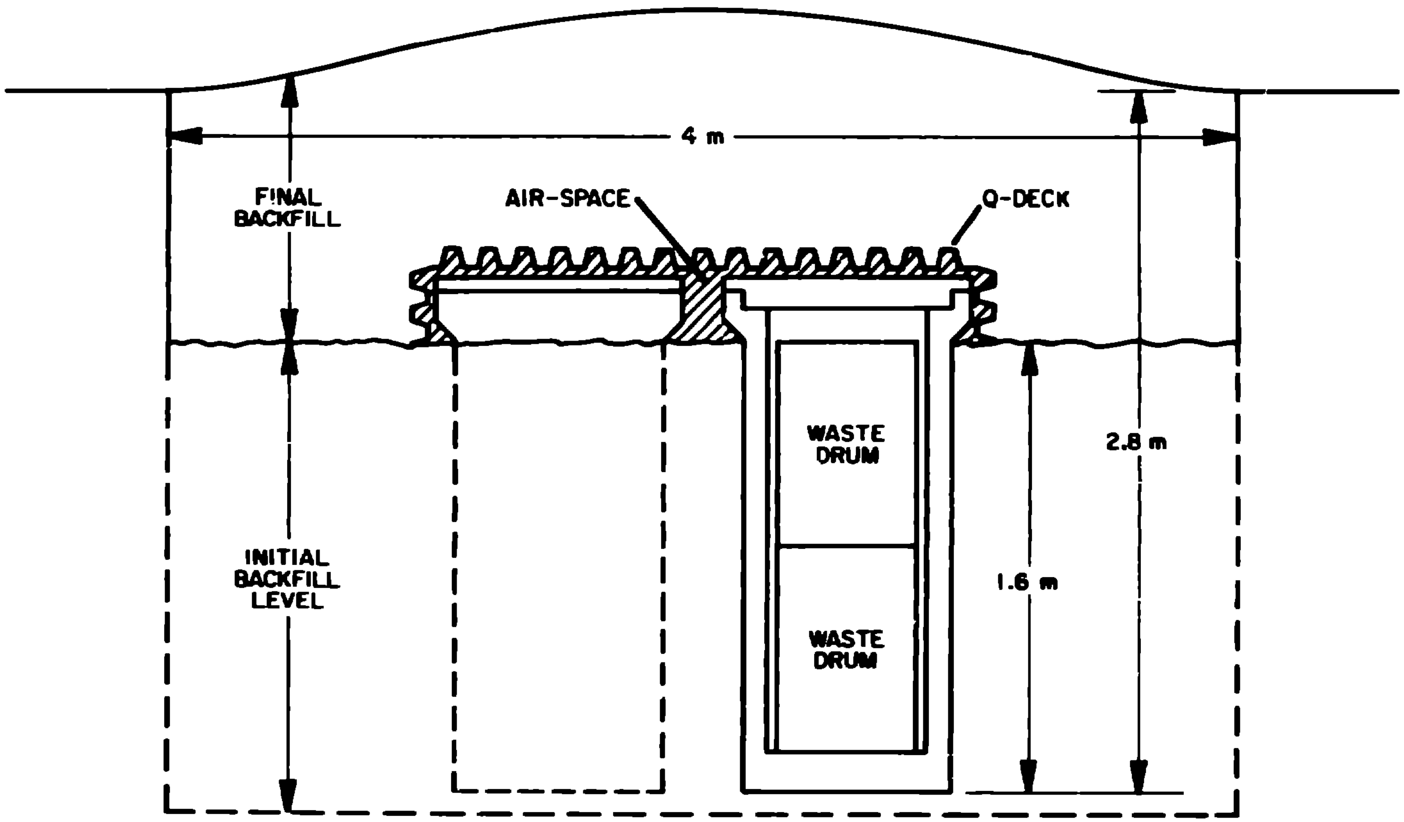
TYPICAL SHAFT DIAGRAM



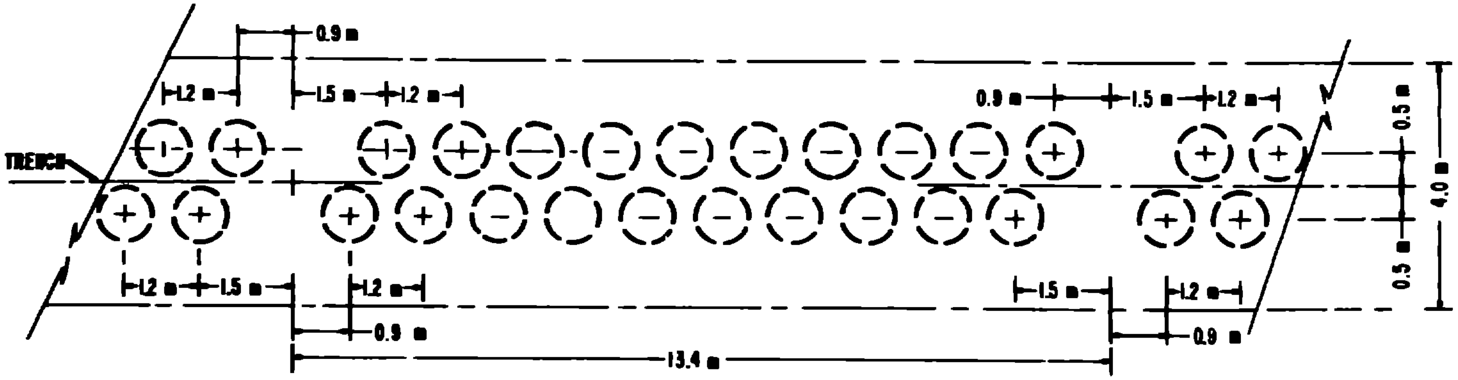
TYPICAL ORIENTATION FOR 0.3-0.9-m-DIAMETER SHAFTS

Fig. 6. TRU-Waste Storage Pit

Fig. 7. Concrete Storage Cask Usage



TYPICAL CASK BURIAL



CASK LAYOUT DETAIL

Fig. 8. Corrugated Metal Pipe for Storage of Cement Paste

Fig. 9. LASL Radioactive Solid Waste Disposal Form

1. FORM NUMBER

8,7,9,3811

PLEASE READ INSTRUCTIONS ON BACK CAREFULLY

H-7 Waste Management
Ext 6095 MS-592

LASL RADIOACTIVE SOLID WASTE DISPOSAL RECORD FORM

		2. DATE	3. RETRIEVABLE SERIAL NO.	4. ORIGIN OF WASTE GROUP	TA	BLDG.	WING	ROOM	5. WASTE CODE
		M M D D Y Y							
1	▨								
1	2 - 8	9 – 14	15 – 20	21 – 25	26 27	28 – 32	33	34 – 37	38 – 40

6. WASTE DESCRIPTION

41 – 80

M = METER³
F = FEET³
G = GALLON

		7. NUMBERS OF WASTE PACKAGES PLASTIC BAGS	CARD-BOARD BOXES	DRUMS NO.	DRUMS GAL.	WOODEN CRATES NO.	WOODEN CRATES VOLUME - ft³	8. GROSS VOLUME	UNITS	9. PACKAGE RADIATION AT: SURFACE MR/HR	1 METER MR/HR
2	▨										
1	2 - 8	9 – 11	12 – 14	15 – 17	18 19	20 21	22 – 26	27 – 30	31	32 – 36	37 – 41

K = KILOGRAM
P = POUND
T = TON

10. GROSS WEIGHT	UNITS	11. ADDITIONAL DESCRIPTION OF PACKAGING AND PACKAGING MATERIALS
42 – 45	46	47 – 80

C = CURIE
M = GRAM

AMOUNT DETERMINED BY:
A = ANALYSIS
M = MEASUREMENT
E = ESTIMATE

		12. RADIONUCLIDE CONTENT NUCLIDE	AMOUNT		±	UNITS	ERROR ON AMOUNT		±		SS MATERIALS WRITEOFF ACCOUNT	PROJECT CODE
3	▨			E				E				
3	▨			E				E				
3	▨			E				E				
3	▨			E				E				
1	2 - 8	9 – 13	14 – 20			21	22 – 28			29		

WASTE GENERATOR
Signature certifies that waste is in accordance with all applicable disposal requirements.

H-1 AREA REPRESENTATIVE
Signature certifies that waste package or shipment is safe to handle and transport.

GROUP LEADER (AS NECESSARY)

		13. DATE DISPOSED	14. DISPOSAL/STORAGE LOCATION AREA	SHAFT	PIT	POST(S)	LAYER	POS.	15. SHAFT SURFACE DOSE MR/HR
		M M D D Y Y							
4	▨								
1	2 - 8	9 – 14	15 16	17 – 19	20 21	22 – 26	25 27	28	29 – 32

H-7 WASTE MANAGEMENT REPRESENTATIVE ______________________