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TUMULUS DISPOSAL DEMONSTRATION FACILITY FOR THE OAK RIDGE RESERVATION*

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1.0 INTRODUCTION

The acquisition of a broad range of experience in the design, construction, operation, closure, and monitoring of low-level radioactive waste facilities is a major goal of the waste disposal program at the Oak Ridge Reservation. The disposal concept presented here is based on the Tumulus design developed by the French at the La Manche facility. The word "Tumulus" comes from the Latin for stack or pile. In the disposal technique discussed here, waste units are stacked above-grade on a concrete pad. The Tumulus Disposal Demonstration Facility currently under development at the Oak Ridge National Laboratory (ORNL) involves sealing waste in concrete vaults, placing the vaults on a grade level concrete pad, and covering the pad and vaults with a soil cover after vault emplacement is complete. Construction of the facility began in October 1986 and emplacement of wastes on the pad will begin in June 1987. Emplacement is expected to continue for 12 to 18 months until the facility exhausts its approximate 800 m^3 (28,000 ft^3) capacity. The Tumulus Disposal

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Demonstration Facility incorporates three features intended to reduce the likelihood of groundwater contamination: (1) engineered barriers to radionuclide migration; (2) a monitoring system to ensure barrier performance; and (3) a newly developed set of Demonstration Waste Acceptance Criteria. The above-grade disposal technology represented by the Tumulus concept offers significant potential for overcoming the weaknesses of shallow land burial which are radionuclide confinement, monitoring, and problem remediation.

2.0 FUNCTIONAL DESCRIPTION

A. Design Basis

The Tumulus concept is particularly advantageous for two reasons. First, the waste containment over the period of institutional control is important because past experience at Solid Waste Storage Area 6 (SWSA-6) at ORNL has shown that leached radionuclides can be transported in the groundwater. This is so because the soils are comprised mostly of saprolitic shales with extensive small-scale fractures providing conduits for lateral transport.

Second, space in SWSA-6 for other disposal methods is restricted. Shallow land burial which was stopped in 1986, and below-grade greater confinement disposal units (typically concrete lined "silos"); require depths of 5 to 6.5 meters (16 to 21 ft) to the water table. With this restriction only about half of the 28 ha (68 acre) area in SWSA-6 could be utilized. However, the Tumulus with its "cut-off" floor that collects and redirects all leachate to a monitoring station can be built in places where the depth of the water table is relatively shallow.

The main advantage of the facility relative to past practices of shallow land burial is that the performance goal of total containment within the waste vaults will avoid environmental risks associated with groundwater transport. Furthermore, the Tumulus pad which provides continuous monitoring capability serves as a stable platform so that the unit can be sited in areas where the groundwater elevation is relatively high. These sites would be unsuitable for conventional shallow land burial or for engineered, subsurface disposal units. Also, the monitoring of all the leachate will allow detailed analysis of the facility performance.

B. Waste Stream

Before elaborating on the physical aspects of the facility, it is worthwhile to consider the waste streams to be disposed and the role of the waste acceptance criteria (WAC). Two types of waste will be disposed. Dry-solids in compacted and noncompacted form will comprise approximately 60% of the disposal volume, and solidified waste made from the supernate of the liquid contained in storage tanks in nearby Melton Valley will comprise the remainder. The latter type introduces complexities to the system due to its high activity and the nitrate and chloride concentrations that pose a potential risk of corrosion for the concrete. The solidified waste will be fixed in a cement matrix in a cylindrical mild steel container or liner (1.8 m diameter x 1.8 m, or 6 ft x 6 ft). The radiation field at the liner surface will be 2 rem/hr requiring remote handling for loading. The preferred disposal option is to place the liners in cylindrical vaults designed to shield the material to <200 mrem/hr. Production of the solidified waste will start in October 1987, and approximately 50 to 60 vaults will be placed in the center of the Tumulus stack by the end of 1987.

The development of the WAC is a key element in the overall strategy for disposing of future wastes to be generated at the Reservation. The WAC are based primarily on pathway analysis, that is to say, mathematical analysis that predicts potential doses to the public (off-site) and to the inadvertent intruder (on-site after institutional control ceases). For this demonstration project, the candidate variables for the analysis are 10 mrem/year dosage to the public during the institutional control period and 300-year institutional control. These parameters may be modified from demonstration to demonstration before the strategy gains regulatory acceptance.

As to the intruder, for this demonstration no barriers to intrusion after institutional control are planned, thus protection is derived from radionuclide decay combined with limitations to the radionuclide inventory through the WAC. Consequently, with respect to environmental protection, the use of pathway analysis leads to acceptance of relatively large concentrations of short half-life isotopes and small concentrations of long half-life or environmentally mobile isotopes. In turn, the engineered barriers to leaching and transport of radionuclides are designed to maintain total containment for the period of institutional control at which time radioactive decay will result in a residual waste "below regulatory concern." As one might expect, not all wastes produced at the Reservation can be disposed in this manner. Wastes containing high concentrations of long half-life isotopes and/or very high activity must be treated and disposed of by alternative technologies.

The WAC derived from the pathway analysis are not yet finalized, however, additional waste acceptance criteria are also being developed by Operations Division, ORNL, which are intended to limit radiation exposure for workers or to address other regulatory concerns. Draft criteria developed to date include:

- for solid-dry waste, contact radiation at the surface of the waste containers before placement in the concrete vaults will be <200 mrem/hr;
- for solidified waste, the liner surface radiation will be <2 rem/hr;
- waste will be contained in sealed 55 gal drums, 4 ft x 4 ft x 6 ft boxes or cylindrical liners prior to placement in disposal vaults;

- all waste will be certified to be free of Resource Conservation and Recovery Act (RCRA) materials; and
- waste will contain <100 nCi/g of transuranic materials.

C. Design Features

In designing the Tumulus demonstration, the chief goals were to provide multiple, engineered barriers to isolate radionuclides and to provide for complete leachate monitoring. The barriers are provided by the vaults and the concrete pad. The design criteria for the Tumulus pad are as follows:

- the lifetime should be approximately 300 years;
- the pad should be constructed to support 3 to 5 meters (10 to 16 ft) of waste contained in concrete vaults, soil overburden of 1.2 to 1.6 meters (4 to 6 ft), concrete cover of up to 0.6 meters (2 ft), and earth moving equipment;
- the pad should be constructed with a curbed perimeter and a drainage system to accommodate collection of rainwater during loading operations and collection of leachate after closure; and
- the pad should be sized to hold approximately one year's supply of waste generation.

The most difficult task is to meet the 300 year performance lifetime because there are no authoritative guidelines in this area. The approach taken was to use high strength concrete (6000 psi) with additional reinforcing steel to minimize the potential for cracking. The steel reinforcing is provided by two layers of 3/4" deformed bars with epoxy coating to minimize corrosion. The bars are spaced on approximate 15.2 cm (6 in) centers as opposed to conventional construction where the grid spacing interval is typically larger.

The concrete pad varies in thickness from 20.3 cm (8 in) in the center to 40.6 cm (16 in) at the thickened footer along the sides. A 15.2 cm

(6 in) curb is included along the entire perimeter of the pad. As indicated in Fig. 1, the pad is sloped to the west side (approximately 1% slope) to a gutter with two floor drains. The drains empty through 10.1 cm (4 in) pipes which join into a single 15.2 cm (6 in) line connected to the monitoring station.

As indicated in Fig. 2, a complex pad foundation was built in order to assure collection of leachate should the concrete pad fail. The main feature of the under-pad area is the 0.7 mm (30 mil) plastic liner and associated protective sand layers. This liner is placed under the pad and sealed to the pad sides, completely isolating the area under the pad. The liner is sloped to a single drain on the west side of the pad, and the drain directs flows through a 7.6 cm (3 in) pipe to the monitoring station.

The construction started in late October 1986, with site preparation. Wet weather and cold temperatures delayed activities, and the grade had to be reduced by 15 cm (6 in) due to wet conditions and poor drainage. The gravel base was increased by a similar amount to keep the pad at the design evaluation. The pad was poured in one continuous operation over a 8 hr. period on January 15, 1987. A total of 29 truckloads of concrete were delivered, but four loads were rejected because samples failed to meet the 2.5 cm (1 in) slump test. Detailed construction notes related individual concrete deliveries to sections of the poured pad. For quality control, at least 3 samples were collected from each truck for 7 day and 28 day strength tests. All but one sample met the 6000 psi requirement at 7 days, and all samples met the requirement at the 28 day test. The key lesson learned in construction is to avoid building such a structure in the wintertime when conditions are wet.

A small monitoring station will be constructed to the southwest of the pad. The station will receive flows from the 15.2 cm (6 in) pad surface drain (designed to monitor for leaching of the waste) and the 7.6 cm (3 in) under pad drain (designed to monitor for leakage through

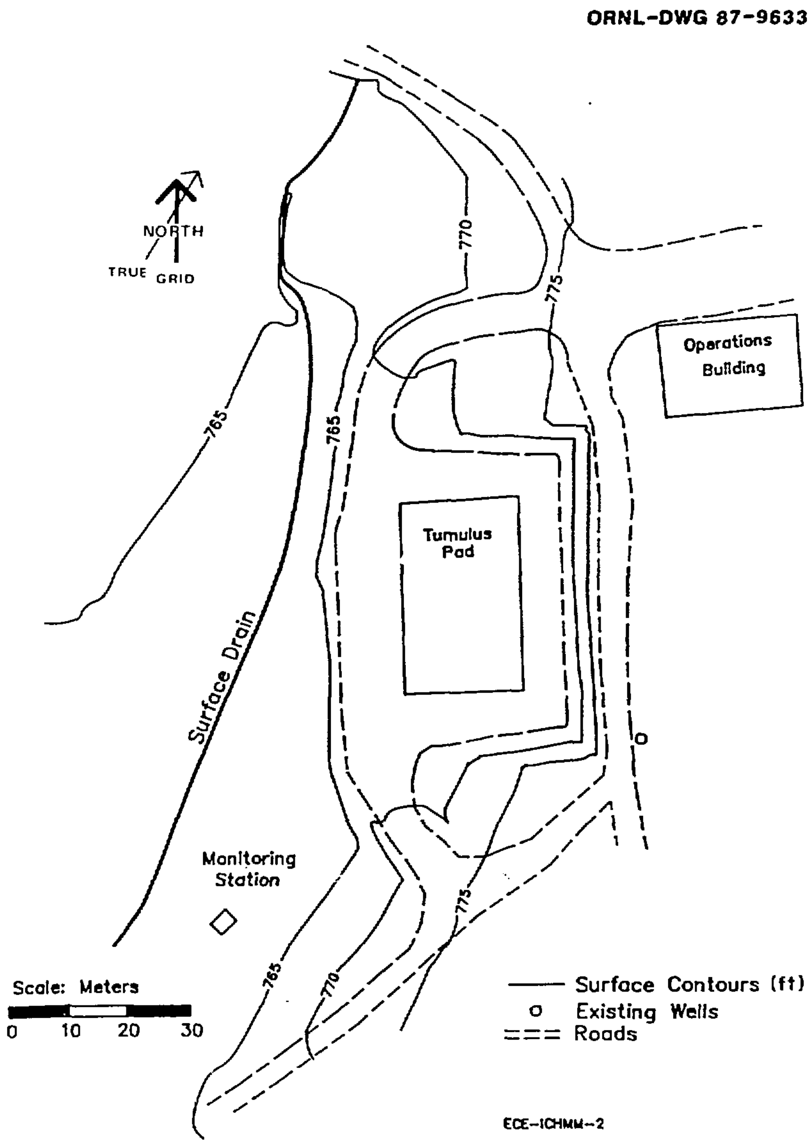

Figure 1. Tumulus location in Solid Waste Storage Area 6.

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TUMULUS PAD DRAINAGE FLOWS

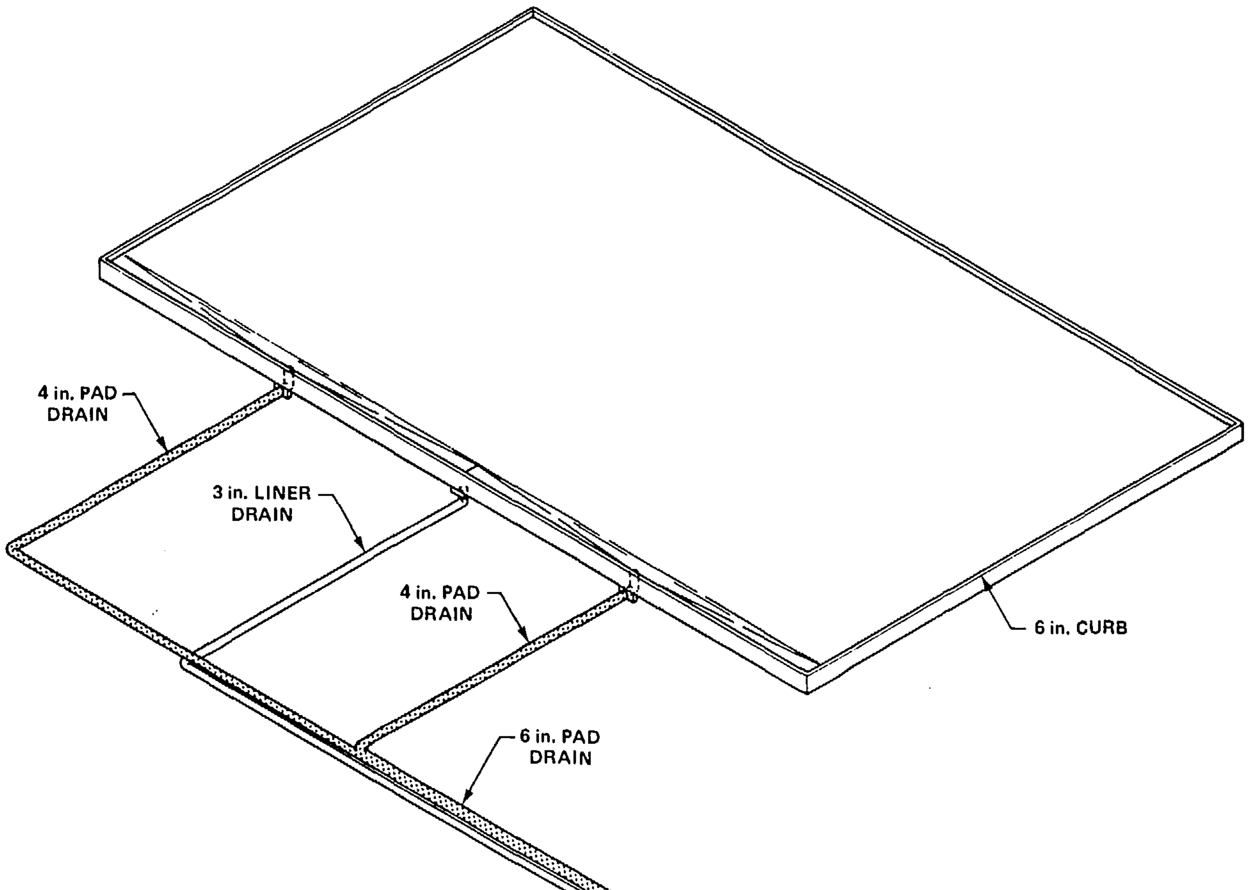

Figure 2. Drainage system for the pad and under-pad liner.

the pad). The pad drainline and the monitoring equipment were sized to accommodate the flows during the period when the pad and waste are uncovered. A 5-minute storm intensity with a return period of 2 years, which corresponds to a depth of 1.1 cm (0.43 in), was used for design purposes. The flow rate will be measured and recorded electronically, and a composite flow sample will be collected automatically. Flow from the underpad drain will be collected in a sump where it can be measured, sampled and relased. In addition, the proposed environmental monitoring plan includes 5 or 6 shallow wells to be installed for the purposes of determining groundwater flow direction and groundwater quality.

The cover for the facility has not yet been designed; however, the plan calls for the development of three conceptual designs varying from a simple earthen cap to a multilayered cap with enhanced drainage features. Based on projected performance, cost, and ease of construction, one design will be selected and detailed plans will be developed. In a parallel activity, the post-cover environmental monitoring plan will be developed. Items such as monitoring wells that penetrate the cap must be planned in concert with the development of the cover design. Key environmental attributes to be studied in the post-cover stage are the hydrologic performance of the cap, slope stability, and soil erosion, as well as water quality of the pad and under-pad drainage.

3.0 LAYOUT

A. General Site Layout

The major site selection criterion was the requirement that the demonstration unit be located within an existing active waste disposal site so that it could be operated with "hot" waste. Solid Waste Storage Area 6 (SWSA-6) at ORNL was selected as the candidate burial area.

Within SWSA-6, the following criteria were utilized in selecting the site of the demonstration:

- must be located above the 500 year flood elevation;
- must have at least 2 ft depth to the highest recorded groundwater elevation;
- may not be located on top of old disposal areas;
- may not be located in areas suitable for below-grade disposal;
- land area should be large enough to accommodate earthen cover 6 ft thick with 4:1 slope to sides;
- should be located in a level area (e.g., slope <10%);
- may not be constructed on a fill area;
- must be accessible by fork lift and crane from the staging area to be built near the existing operations building;
- should be located as far as possible from surface drainage features; and
- location should be compatible with the overall SWSA-6 surface monitoring scheme.

Based on these criteria, a site adjacent to the west side of the operations building was selected for the demonstration unit (Fig. 3).

B. Disposal Unit

Two types of disposal units will be utilized for the two types of waste to be handled: dry-solid waste and solidified liquid waste. A concrete disposal vault was designed for the dry solids in the Tumulus Demonstration. The vault is sized to accept a standard 4 ft x 4 ft x 6 ft box, with approximately 7.62 cm (3 in) clearance on all sides. The void space will be filled with grout before the vault lid is sealed in place. The vault will be constructed from steel reinforced concrete. The concrete is designed for 6000 psi strength and contains a waterproofing additive. Epoxy coated reinforcing steel will be used to minimize corrosion potential. The vaults are intended to be moved by forklift.

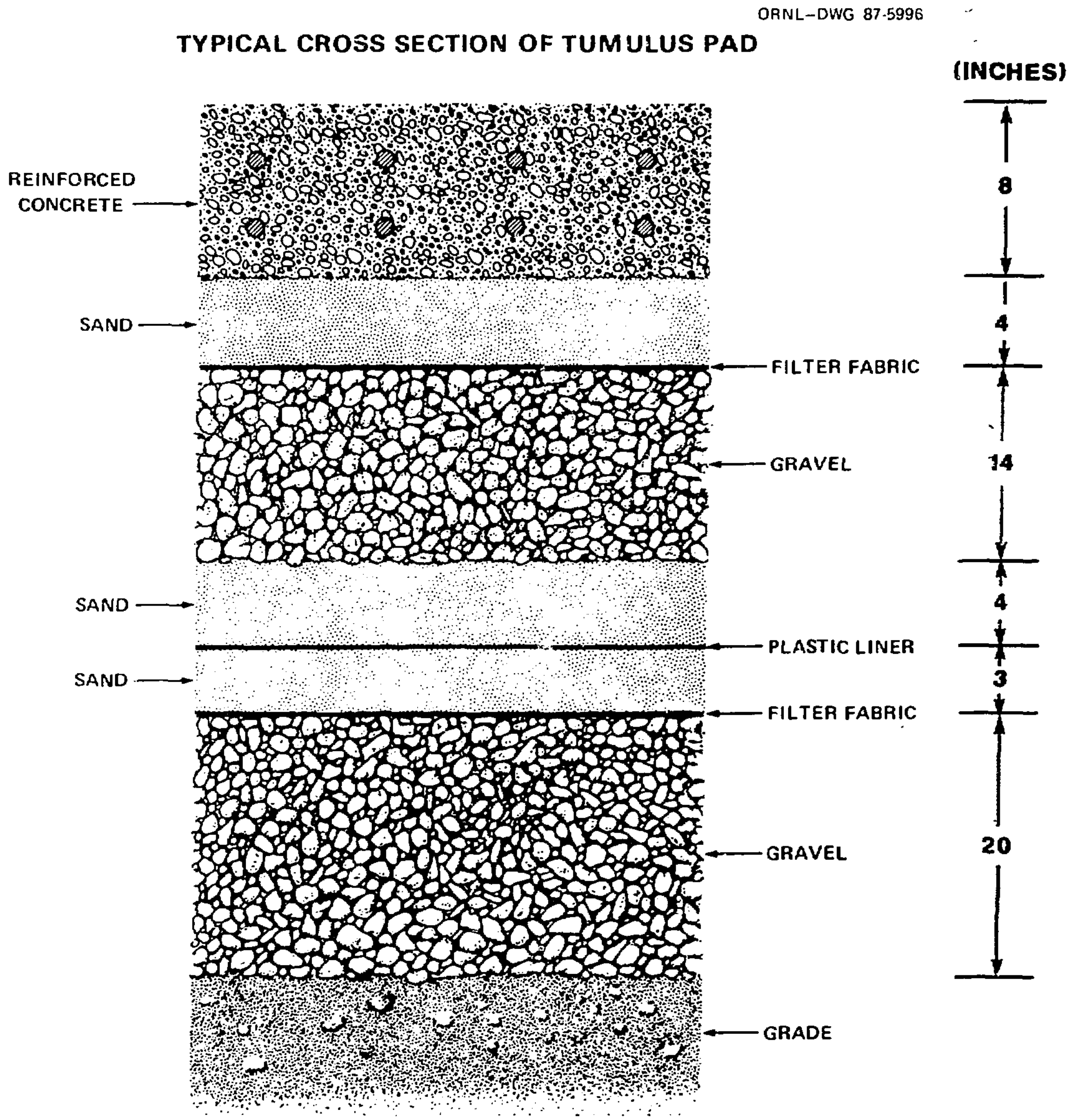

Figure 3. Cross section showing the pad and the plastic liner. Near the edges of the pat the thickness of the concrete is greater than shown. The filter fabric and sand layers are intended to decrease the likelihood of tearing the liner during construction.

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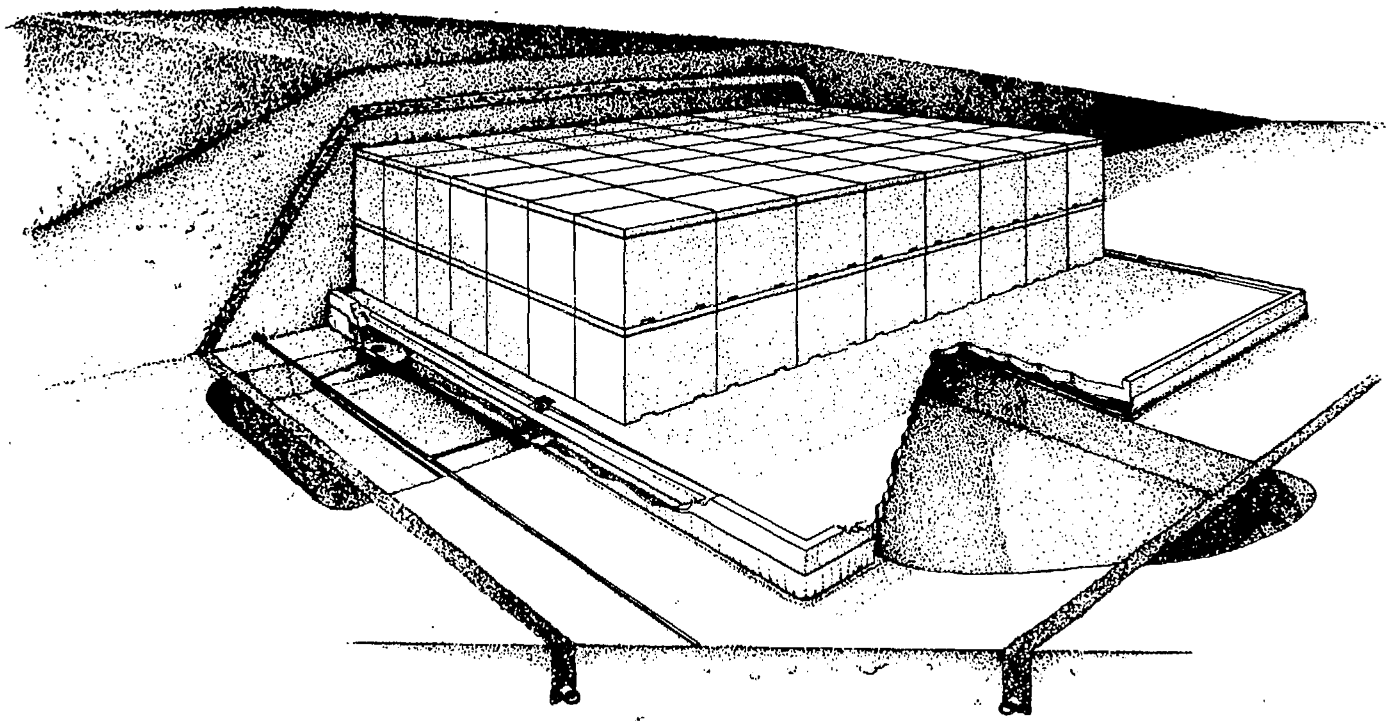

Figure 4. Tumulus Disposal Demonstration Facility.

For the liners containing solidified waste, several options are being considered. The preferred method has the cylindrical vaults placed first on the pad, the unshielded liner placed in the vault, then a concrete cap placed on the vault. The cylindrical vaults will occupy the interior, lower part of the stack.

B. Worker Safety

Occupational exposure is another major area of investigation planned for the Tumulus Demonstration. Each of the unit operations associated with the Tumulus will be evaluated in detail to characterize the potential for worker exposures. In addition, overall worker exposures will be compared with experience from below-grade operations to determine if additional exposure potentials are associated with the Tumulus. Detailed plans for the environmental and radiation safety monitoring programs are currently being developed.

5.0 SUMMARY

The Tumulus Waste Disposal Demonstration Project will provide disposal capacity for solid low-level waste for a period of 12 to 18 months. The primary advantage of this technique is that containing the waste within vaults avoids the environmental risks associated with groundwater transport. The demonstration is being conducted to develop experience and information which will help in evaluating the suitability of this technology for the management of low-level wastes. Information will also be collected and developed on environmental and health, operational, and construction aspects of the technology.

Performance assessment for the facility is in progress. The analysis has been complicated by uncertainties related to emplacement of the high activity solidified wastes from the Melton Valley storage tanks and to the fact that the earthen cap has not yet been designed.

Because the facility is a demonstration with numerous features that may not be incorporated in an operational Tumulus, the actual costs are not considered to be reflective of future above-grade facilities of similar design at ORNL. Presently, we are making estimates of costs for future Tumulus-like facilities.

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DISCLAIMER