ESTIMATES OF SECONDARY WASTE PRODUCTION

FROM OPERATIONS AT A PROSPECTIVE GEOLOGIC REPOSITORY IN TUFF[a]

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ABSTRACT

In this paper, a method is outlined for estimating the volumes of solid and liquid radioactive wastes produced during the operation of a repository in tuff. Volume estimates were also developed based on a preliminary conceptual facility design. Based on a disposal rate of 3,000 MTU/yr of commercial.spent fuel, the waste estimates ranged from 793 to 2,464 m^3/yr of uncompacted solids and from 80,431 to 128,690 L/yr of liquids, depending on the specific set of facility features assumed. The estimates of waste quantities were most dependent on variations in the ratio of truck to rail cask shipments received. The quantities of waste generated on site decreased as this ratio decreased. Although there are large uncertainties in the current estimates caused by the preliminary nature of the facility designs and the limited amount of engineering detail completed, the methodology can be used to refine estimates as the repository design progresses.

INTRODUCTION

The Department of Energy (DOE) has determined that the safest and most feasible method currently known for the disposal of commercially generated high-level radioactive waste is to emplace it in mined geologic repositories. As part of the Nevada Nuclear Waste Storage Investigations (NNWSI) Project,

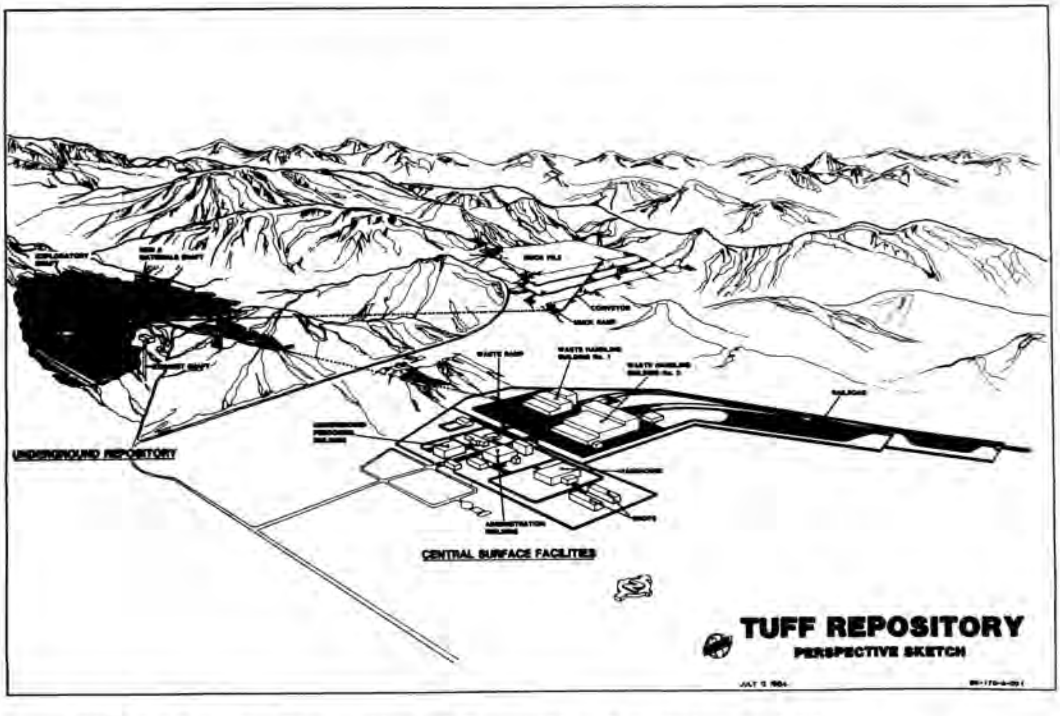

Fig. 1. Artist's Perspective of Prospective Repository in Tuff[1].

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the DOE's Nevada Operations Office (NVO) is studying the possibility of siting a geologic repository in tuff at Yucca Mountain near the southwestern corner of the Nevada Test Site (NTS).

As a participant in the NNWSI Project, Sandia National Laboratories is responsible for the conceptual design of the surface and underground facilities at the repository. Bechtel National, Inc., under contract to Sandia, is the architect/engineer for the surface facilities. An artist's perspective of the preliminary conceptual design as of July 1984 is shown in Figure 1. Further details can be found in Reference 1.

Before the high-level wastes are permanently emplaced in the underground disposal facility, they are received, handled, packaged, inspected, and stored on the surface. Handling these materials in the surface facilities generates secondary radioactive wastes that require disposal. Although secondary wastes are not expected to contain more than 100 nCi of transuranic radionuclides per gram of waste (and would therefore be classified as low-level waste suitable for surface burial), current plans call for emplacement of the secondary waste in the underground disposal area.

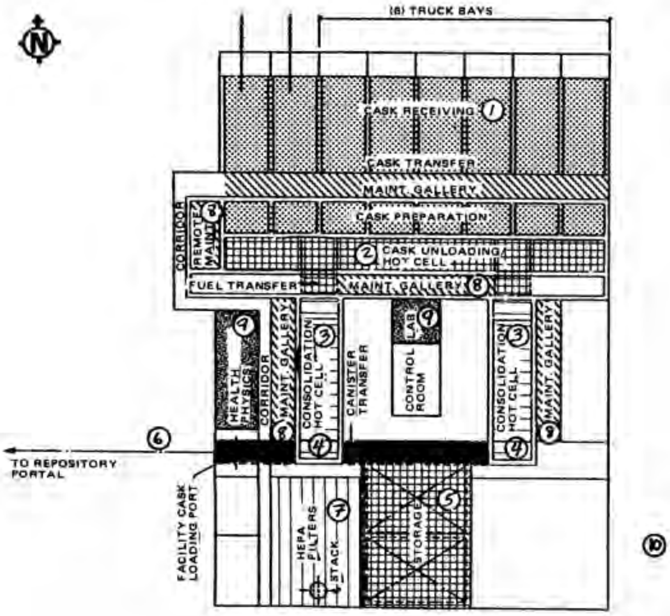
Estimates of the amounts of secondary waste and its characteristics are needed so that the size and types of equipment and systems needed for treatment of these wastes can be determined. Because there are no operating geologic repositories disposing of spent fuel or high level wastes anywhere in the world, operations data are not directly available to guide the development of initial design requirements for secondary waste treatment facilities. The amounts and characteristics of secondary liquid and solid wastes at the Yucca Mountain repository were developed from literature dealing with operating systems in nuclear power plants, from information and experience with storage facilities for spent fuel, and from engineering judgment.

These design bases were developed using a three-step estimating methodology. This paper outlines the methodology and major assumptions used to develop estimates of secondary solid and liquid waste volumes based on preliminary designs.

METHODOLOGY

A three-step approach was used to develop estimates of secondary solid and liquid waste types and quantities. First, the repository site represented in Figure 1 was divided into ten discrete areas (operation zones). These zones are areas known or anticipated to create major quantities of secondary wastes and are based on the anticipated repository operations. Each zone was studied in sufficient detail to identify the major activities and/or equipment required to carry out its functional requirements. In the final step, all of the activities that generate secondary solid and liquid wastes within a zone were examined individually so that estimates of the secondary waste quantities could be developed. Where insufficient facility design information existed and when available literature or industry experience was inadequate, engineering judgment was used. The total volume of waste was then estimated by tabulating the results for each zone.

The ten zones used for identifying and estimating secondary wastes were based primarily on the major functions of the repository and the major operations that generate secondary radioactive waste streams. Nearly all the secondary wastes at the repository are generated in the waste-handling building. Figure 2 illustrates the ten zones and is derived from a preliminary sketch of the main waste-handling building (Reference 1) at the site. The ten zones include (1) shipping cask receiving/handling, (2) waste receiving/handling, (3) spent fuel consolidation, (4) spent fuel packaging/inspection, (5) surface waste storage, (6) underground waste emplacement, (7) ventilation system maintenance,



UNIT OPERATIONAL ZONES

1. Shipping cask receiving/handling
2. Waste receiving/handling
3. Spent fuel consolidation
4. Spent fuel packaging/inspection
5. Surface waste storage
6. Underground waste emplacement
7. Ventilation system maintenance
8. Contaminated equipment maintenance
9. Hot analytical laboratories
10. General support facilities

WASTE HANDLING BUILDING
PLAN

Fig. 2. Illustration of Unit Operation Zones Defined to Estimate Secondary Wastes.

(8) maintenance of contaminated equipment, (9) hot analytical laboratories, and (10) general support facilities. The general support facilities include secondary waste treatment facilities, laundries for contaminated clothing and special decontamination facilities for equipment and personnel. The other zones can be interpreted from their titles and the preliminary facility layouts.

Each zone was examined to identify activities and equipment associated with its functional requirements. Wherever possible, preliminary facility reference designs, such as those summarized in Reference 1, were used as the basis for examination. If no designs were available, preliminary designs were developed and activities were identified from experience with other design studies of nuclear fuel cycle facilities, especially fuel-handling facilities. To facilitate the estimation of the types and quantities of waste, all activities associated with each zone were assigned to one of five categories: (1) normal operations, (2) decontamination operations, (3) housekeeping, (4) preventive and corrective maintenance, and (5) health physics.

Normal operations were defined as those daily activities performed to keep the facility operating safely and efficiently. Normal operations include cask receiving, cask handling, cask unloading, fuel consolidation, waste packaging, waste storage, and waste emplacement operations.

Decontamination activities are those in which radioactivity is removed from canisters, surfaces, floors, walls, ceilings, equipment, tools, etc. Operations associated with the hot cells, fuel consolidation equipment, and other hot cell components were judged to generate the largest quantity of site-generated solid decontamination wastes. Decontamination of the exterior and flushing of loose contamination in the interior of shipping casks were included in the decontamination activities.

Preventive maintenance activities are performed to keep equipment operating at design levels. These activities include lubrication, seal and filter replacement, and instrument calibration. Corrective maintenance is performed to repair or replace malfunctioning equipment, repair leaks, adjust instruments, etc. It is anticipated that ventilation system filter changes in the waste-handling building will generate the largest quantity of waste in the category of preventive maintenance. However at this stage of the design, wastes due to filter changes have been assigned to the normal operations activities.

Housekeeping activities are those activities generally performed on a daily basis to keep all repository facilities free of dirt and trash. The large quantities of trash generated in areas that contain radioactive materials are assigned to this category. These wastes require either radiological surveys or treatment as contaminated waste. Health physics surveys are performed routinely to ensure that repository personnel and the public are protected from excessive exposure to radioactivity.

Once the operational zones and the corresponding waste-producing activities had been identified, the types of solid and/or liquid wastes generated, the rates at which the wastes are produced, and the quantity of waste produced per unit event were assessed by estimating the quantity of waste produced per cask shipment received, per fuel assembly handled, and/or per MTU handled. For cases such as filter changeouts and scheduled maintenance events, waste quantities were assessed per unit of time. Because the level of engineering detail available was limited and no data base for wastes from operating repository facilities exists, many of the estimates were based on engineering judgment and perceived equipment and operational procedures. However, a previous study pertaining to operating experience with secondary waste generation at existing spent-fuel-handling facilities (Reference 3), served as a valuable guide for estimating the quantities of solid waste that would be produced in the ten zones of the repository.

MAJOR ASSUMPTIONS

It was assumed that the Yucca Mountain repository receives, processes as necessary, and disposes of commercial spent fuel equivalent to 3,000 metric tons uranium (MTU)/yr. It was assumed that any other wastes received at the repository do not affect these estimates, and other wastes were not considered in the initial estimates of secondary waste quantities.

Spent fuel will be received at the repository in both truck and rail shipping casks. Current shipping casks are designed to contain 7 PWR or 18 BWR assemblies for rail transport and 1 PWR or 2 BWR assemblies for truck transport. New designs will permit these numbers to be increased to 12/32 for rail and 2/5 for truck (Reference 2). To bound the amount of site-generated waste, the larger rail cask and the smaller truck cask were considered to produce the minimum and maximum estimates of waste.

The truck/rail shipping cask ratio and, therefore, the total number of casks to be received have not yet been determined. Because secondary waste volume depends strongly on the number of shipping casks received (Reference 3), four different ratios or shipment scenarios were examined to evaluate secondary waste generation. The specific shipment scenarios evaluated included receipt of 100% truck casks, 70% truck/30% rail, 20% truck/80% rail and 100% rail cask shipment.

It was assumed that dry, as opposed to wet, methods are used for all shipping cask operations (receiving/unloading, spent fuel handling, processing and storage). These methods generate air filters (HEPA, roughing, and cartridge filters) as secondary waste rather than the ion exchange resins which are generated at facilities that use pool or wet methods.

RESULTS

SOLID WASTE ESTIMATES

Solid wastes can be either compactible or noncompactible. Typically, compactible wastes include cloth, paper, plastics, absorbent materials, and filters. Noncompactible wastes include failed equipment, discarded tools, glass, metal, filter frames, and other contaminated metal components. For a repository in tuff, the methodology described in this paper and the reference design summarized in Reference 1 yielded the volume estimates of annual solid waste for each of the scenarios shown in Table 1.

Table I

Scenario	Compactible (m^3/y)	Noncompactible (m^3/y)
100% truck	2,464	38
80% truck/20% rail	1,954	30
20% truck/80% rail	1,133	17
100% rail	793	11

Table II summarizes the estimates for the 100% truck scenario in terms of the waste generating activities and the operation zones. Assignments of wastes to specific operation zones and activities will change as engineering details are developed in future design activities, but the total volumes are anticipated to remain nearly the same. Thus, the focus of Table II should be on the subtotals and total waste volumes rather than any specific matrix position within Table II.

As shown in Table II, suspect or potentially contaminated clothing, paper and plastics from normal operations resulted in ~72% of the total solid waste volume estimated. Potentially contaminated trash from facility housekeeping operations constituted ~21% and decontamination operations contributed ~5% to the total volume estimated. Spent HEPA filters and prefilters proposed for the conceptual design of the waste handling building (Reference 1) amount to 2% of the total solid waste volume. At this state of facility design, other wastes associated with maintenance and health physics have been shown in the estimates of Table II for normal operations and decontamination operations. As the facility design evolves, estimates for these two specific types of facility waste generating activities will be refined.

It was estimated that failed or retired equipment and small tools were the main components of noncompactible wastes. Spent filter frames also contributed to the total volume of noncompactible solid waste.

LIQUID WASTE ESTIMATES

The same methodology and procedures used for estimating solid wastes were used to determine volumes of liquid wastes. For design purposes, liquid wastes were further subclassified as shipping cask washdowns, decontamination solutions, effluent from laboratory drains, and floor drains.

Liquid wastes are generated in washing down shipping casks and by other decontamination operations. Waste from washing the exterior walls of shipping casks includes detergents, oils, road salts, and road dirt. Washdown equipment can be designed to recycle effluents by incorporating secondary cleanup

TABLE II

Summary of Annual Solid and Liquid Waste Volume Estimates by Waste Generating Activity and Unit Operation Zone for Scenario of 100% Truck Shipments

	Waste Generating Activity									
	Normal Operations		Decon Operations		Housekeeping		Maintenance		Health Physics[i]	
Unit Operation Zone	Solids[(b)] (m^3)	Liquids (L)	Solids[(b)] (m^3)	Liquids (L)	Solids[(b)] (m^3)	Liquids (L)	Solids[(a)] (m^3)	Liquids (L)	Solids[(b)] (m^3)	Liquids (L)
1) Shipping Cask Receiving/Handling	1,453	52,839	73	-	-	-	31[a]	-	3	291
2) Waste Receiving/Handling	264	-	4	-	-	-	1[a]	-	-	76
3) Spent Fuel Consolidation	e	-	4	2,500	-	-	2[a]	-	-	-
4) Spent Fuel Packaging/Inspection	39	-	-	-	-	-	-	-	-	-
5) Surface Waste Storage	-	-	-	-	-	-	-	-	-	-
6) Underground Waste Emplacement	-	-	-	-	-	-	-	-	-	-
7) Ventilation System Maintenance	43[h]	-	-	-	-	-	-	-	-	-
8) Contaminated Equipment Maintenance	-	-	11	52,042	-	-	2[a]	-	-	-
9) Hot Analytical Laboratories	1	14,194	-	-	-	-	-	-	-	-
10) General Support Facilities	-	-	55	7,437	520[d]	-	2[a]	-	-	-
SUBTOTALS[c]	1,800	67,033	147	61,979	520	-	38[a]	g	3[f]	367

Footnotes:
a noncompactible solids
b compactible solids
c The total compactible solids are 2,470 m^3, total noncompactible solids are 38 m^3 and total liquids are 129,379 L.
d This volume is total from all ten zones
e Volume of fuel disassembly hardware is not included in these estimates
f Additional solid waste volumes have been included in normal and decontamination operations
g Liquid volumes have been included in normal and decontamination operations
h Filter changes can be considered as maintenance activities but are shown here as normal operation.
i Most wastes from health physics activities have been included in the normal and decontamination operations.

components such as filters, ion exchangers and possibly evaporators to minimize liquid waste volumes and to conserve water. The interior of the shipping casks may also be flushed to remove loose contamination particulates. Interior washdowns can result in liquid waste that contains significant quantities of radioactive deposits dislodged from exterior surfaces of spent fuel assemblies.

Decontamination solutions are generated in hot cells and special decontamination areas as the result of using water, detergents, or chemical solutions to remove radioactivity contamination from equipment, cell surfaces, tools, and casks.

Liquid waste from laboratory drains include chemical wastes and other solutions that contain varying amounts of soluble constituents, insoluble solids, detergents, and some organic compounds.

Liquid wastes from floor drains include liquids collected from washdowns and cleaning of equipment and areas that are contaminated or potentially contaminated. These liquids contain varying concentrations of insoluble solids (dirt and dust), detergents, and chemicals.

The estimates of annual liquid waste volume are shown in Table III.

Table III

Estimates of Annual Liquid Waste Volume

Scenario	Liquid Wastes (L/Year)
100% truck	128,690
80% truck/20% rail	115,064
20% truck/70% rail	96,461
100% rail	80,431

As shown in Table III, for the specific case of 100% truck shipments, the 128,690 L of liquid wastes was estimated to consist of approximately equal amounts due to normal operations and decontamination operations. Less than 20% of the total volume was estimated for the remaining three activities. Of the 128,690 L, the wastes were further subclassifed for design purposes as 41% cask washdowns, 41% decontamination solutions, 10% laboratory drains and 8% floor drains.

SUMMARY

The methodology outlined in this paper was used to estimate the volumes and types of solid and liquid secondary radioactive wastes produced during the handling of radioactive materials at a geologic repository. The results can be used as design bases for equipment and facilities required for treatment of secondary radioactive wastes.

Because of the uncertainty in the number of truck and rail shipments, estimates were developed for four different shipping scenarios based on an annual throughput of 3,000 MTU/yr of spent fuel. A nearly linear relationship was found between estimated waste volumes and the number of cask shipments received. The results are plotted in Figure 3. Because a rail cask contains more spent fuel per cask than a truck cask, both solid and liquid secondary wastes decreased as the number of rail shipments increased and the truck shipments decreased. It was found that compactible solid waste volumes were approximately two times more sensitive than liquid waste volumes to the ratio of truck to rail shipping casks.

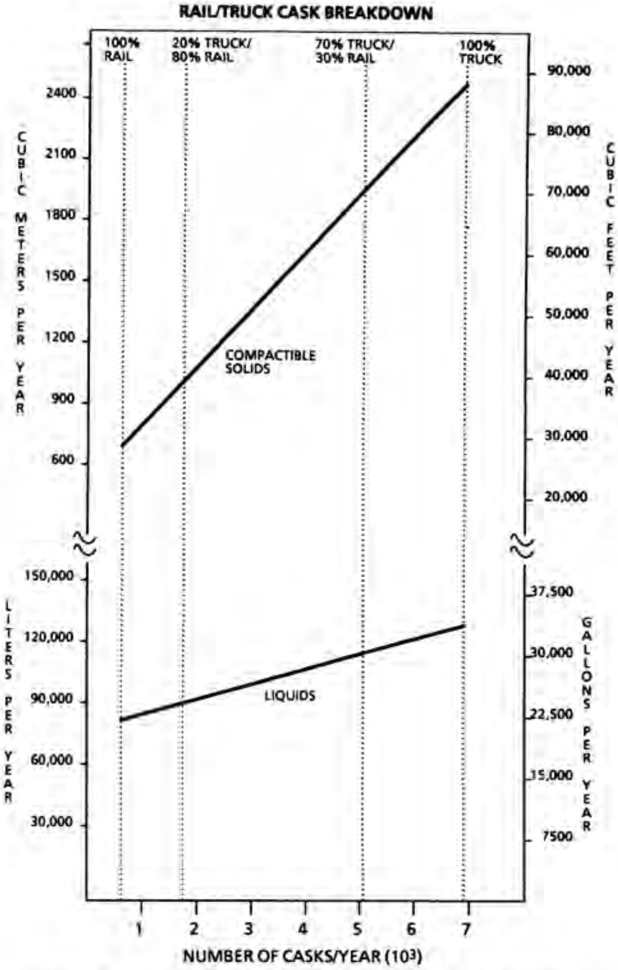


Fig. 3. Estimates of annual secondary waste quantities as a function of the number of shipping casks received each year at the repository.

The estimated volumes were based on a preliminary design for a repository in tuff described in Reference 1. As the design evolves and more engineering detail becomes available, it will be necessary to revise the estimates of solid and liquid waste volumes to reflect more detailed design concepts. The estimates provided in this paper should be regarded as preliminary, but they provide an adequate basis for sizing and selecting waste treatment facilities.

References

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