ATTACHMENT II

CRWMS/M&O

Design Analysis Cover Sheet

Complete only applicable items.

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11. REMARKS

The following TBD/TBVs are identified for inputs to this analysis: TBD-1, TBV-228, TBV-459, TBV-428, TBV-457, TBV-458, TBV-460, TBV-404, TBV-289, TBV-291, TBV-292, TBV-295, TBV-298, TBV-300, and TBV-312. None of the identified TBVs are critical inputs to this analysis, and the TBVs do not impact the conclusions drawn by the analysis.

CRWMS/M&O

Design Analysis Revision Record

Complete only applicable items.

(1.)

2. DESIGN ANALYSIS TITLE

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TABLES

1. PURPOSE

The objective of this design analysis is to update the assessment of estimated annual secondary low-level waste (LLW) generation rates resulting from the repackaging of spent nuclear fuel (SNF) and high-level waste (HLW) for disposal at the Monitored Geologic Repository (MGR). This analysis supports the preparation of documentation necessary for license application (LA) for the MGR. For the purposes of this analysis, secondary LLW is defined, in brief terms, as LLW generated as a direct result of processing SNF/HLW through the receiving and repackaging operations. The current Waste Handling Building (WHB) design is based on the predominant movement of fuel assemblies through the wet handling lines within the WHB. Dry handling lines are also included in the current WHB design to accommodate canistered waste (i.e., SNF and/or HLW packages). Major input changes to this analysis in comparison to previous analyses include: 1) changes in the SNF/HLW arrival schedules; 2) changes to the WHB and the Waste Treatment Building (WTB) dimensions; and 3) changes in operational staff sizes within the WHB and WTB. The rates generated in this analysis can be utilized to define necessary waste processes, waste flow rates, and equipment sizes for the processing of secondary LLW for proper disposal.

This analysis is based on the present reference design, i.e., Viability Assessment (VA) design, and present projections on spent fuel delivery and processing. LLW generation rates, for both liquids and solids, are a direct function of square footages in radiological areas, and a direct function of spent fuel throughput. Future changes in the approved reference design or spent fuel throughput will directly impact the LLW generation rates defined in this analysis.

Small amounts of wastes other than LLW may be generated on a non-routine basis. These wastes may include transuranic (TRU), hazardous, and mixed wastes. Although the objective of this analysis is to define LLW waste generation rates, this analysis does establish bounding estimates on hazardous and mixed waste generation rates for these two waste forms.

2. QUALITY ASSURANCE

An activity evaluation, *Site-Generated Radiological Waste Systems and Facilities Design,* (Work Package 24012392M3) (Reference 5.1) has been performed in accordance with QAP-2-0, *Conduct of Activities,* and has determined that this analysis is subject to the requirements of the *Quality Assurance Requirements and Description (QARD)* (Reference 5.2). In addition, review of the classification of permanent items described in *Classification of the Preliminary MGDS Repository Design* (TBV-228), (Reference 5.3) prepared in accordance with QAP-2-3, *Classification of Permanent Items,* REV 01, has been performed, and indicates that for the SDDs SU02, SU04, SU05, SU09, SU10, SU12, SU13, and SU16 some of the items are "Q". Therefore, items addressed in this analysis are to be considered "Q" items (i.e., having a QA classification), and, as specified in NLP-3-18, this analysis is documented as being subject to QA controls. Table 2-1 presents the quality classification assignments for features and systems associated with secondary LLW for the WHB, the WTB, and the Carrier Preparation Building (CPB) (formerly named the Carrier Staging Shed).

Table 2-1. Secondary LLW Systems Quality Classification Assignment

SDD Number	System	QA Classification (Assumption 4.3.2)
SU02	Waste Handling Facility (WHF)[1] System	
	Facility Decontamination System	QA-3
SU04	Radiological Waste Treatment Facility System	
	Process Supply Systems	non-Q (TBV-459)
	Waste Treatment Building	QA-3 (TBV-459)
SU10	Assembly Transfer System	
	Cask Preparation System	
	Decontamination Equipment	QA-3 (TBV-459)
	Dry Handling System	
	DC Decontamination Manipulator	QA-3 (TBV-459)
	Decontamination Equipment	QA-3 (TBV-459)
SU12	Waste Package (WP) Remediation System	
	Decontamination and Survey System	QA-3 (TBV-459)
SU13	Disposal Container (DC) Handling System	
	DC Emplacement Preparation Systems	
	WP Decontamination Device	QA-3 (TBV-459)
	WP Decontamination Sample Pass Through	QA-3 (TBV-459)
	WP Decontamination/Inspection Manipulator	non-Q (TBV-459)
SU37	Site-Generated Radioactive Waste Handling System	
	Aqueous LLW Processing System	QA-3 (TBV-459)
	Chemical LLW System	QA-3 (TBV-459)
	Solid LLW Processing System	QA-3 (TBV-459)
SU47	Site Generated Hazardous and Non-Hazardous Waste Disposal Systems	
	Hazardous Waste Collection System	non-Q (TBV-228)

[1] The Waste Handling Facility is now called the Waste Handling Building (WHB).

3. METHOD

A WTB conceptual design was prepared in fiscal 1995, and the results presented in the *Waste Treatment Building Interim Design Study*, Reference 5.4. A follow-on analysis, *Secondary Waste Treatment Analysis,* Reference 5.5, was performed in 1997. In both of these efforts, assessment of waste volumes was built up from analysis of potential LLW production mechanisms within the WHB and support systems. As similar facilities do not currently exist, estimation of secondary LLW resulting from repository operations must utilize assumptions based on nuclear industry methods. This design analysis utilizes secondary LLW estimation techniques from the previous reports, and employs updated information regarding the WHB design to develop revised waste generation rates. As was done in the previous efforts, secondary LLW generation rates are built up from cask processing rates, cask physical dimensions, assumed frequency of contamination, operating area washdown frequency, and other predictable recurring secondary LLW producing operations.

4. DESIGN INPUT

Design inputs were screened in regard to TBV/TBD applicability. The results of this screening identified no newly generated TBV/TBDs to be tracked per the requirements of NLP-3-15. Inputs are annotated with the following classification codes to indicate their individual screening results:

1. The input is not data and does not affect the system's critical characteristics, nor is it directly relied upon to address safety and waste isolation issues; therefore, it should not be controlled as TBV/TBD (Classification Code 1).

2. The input is data, but does not affect the system's critical characteristics, nor is it directly relied upon to address safety and waste isolation issues; therefore, it should not be controlled as TBV/TBD (Classification Code 2).

Certain of the references used in the preparation of this analysis were prepared to support VA and contain preliminary data which is not tracked using the formal TBV/TBD process. Tracking is not required for inputs because changes to these inputs will not impact the conclusions reached within this analysis.

4.1 DESIGN PARAMETERS

The waste arrival and emplacement schedules used in the preparation of this design analysis are taken from the *Controlled Design Assumptions* (CDA) document, Key 001, Key 002, and Key 003, Reference 5.6. Additional Key Assumptions are also included as design parameters. The waste arrival and emplacement schedules in the CDA are derived from the *Waste Quantity, Mix and Throughput Study Report,* Reference 5.8.

Dimensions for incoming casks are taken from *Interface Control Document for the Transportation System and the Mined Geologic Disposal System Surface Repository Facilities and Systems for Mechanical and Envelope Interfaces Between the Surface Facility Operations and the Waste Acceptance Transportation Office,* A00000000-01717-8100-00008 REV 00, Reference 5.13.

DC/WP dimensions are taken from *Carrier/Cask Handling System Design Analysis,* Reference 5.15.

The following engineering and conversion factors were utilized in the preparation of this analysis:

INPUT	REFERENCE
1 in = 0.0254 meters = 25.4 mm	Table 1-7, Reference 5.14
π = 3.1415926536 (rounded to 3.14)	page 2-3, Reference 5.14
1 ft = 12 in	page 1-27, Reference 5.14

4.1.1 Cask Arrival Scenario (Key 001)

The transportation cask arrival schedule at the Monitored Geologic Repository (MGR) is indicated in the tables of Key Assumption 001. Table 3-1 (Key 001) provides the total number of transportation casks, by year, arriving at the repository by legal weight trucks. These casks do not contain canisters. Table 3-2 provides the total number of transportation casks, by year, arriving at the repository by train. These casks also do not contain canisters. Table 3-3 provides the total number of casks arriving, by year, at the repository by train. These casks contain non-disposable canisters. Table 3-4 provides the total number of casks arriving, by year, at the repository. The high level waste (HLW) and DOE Spent Nuclear Fuel (SNF) will have been loaded in disposable canisters before shipment to the repository, as indicated in Key Assumption 002 and 005. As discussed in Key Assumption 005, a very small amount of the DOE SNF may be received uncanistered in casks if it can be handled and processed in the same facilities as the commercial SNF. This small quantity is not distinguished in the waste stream.

Additional capacity must also be designed into the facility to create flexibility to accommodate waste stream unknowns.

Exception 1: The total number of transportation casks received in any single year could reach 820.
Exception 2: The number of large disposable canisters containing commercial SNF received in any

single year could reach 300[2].

Exception 3: Surges in commercial SNF shipments could reach 20% per month higher than the monthly average in the peak year for 4 consecutive months.

4.1.2 Waste Form Arrival Scenario (Key 002)

The assembly arrival schedule at the MGR is indicated in the tables of Key Assumption 002. Table 3-5 (Key 002) provides the total number of assemblies, by year, arriving at the repository by legal weight trucks. These assemblies are not contained in canisters. Table 3-6 provides the total number of assemblies, by year, arriving at the repository by train. These assemblies also are not contained in canisters. Table 3-7 provides the total number of canistered assemblies arriving at the repository by train in a given year. These assemblies are contained in non-disposable canisters. Table 3-8 provides the total number of commercial SNF assemblies (arriving in canisters or as bare assemblies) and high-level waste (HLW) and DOE SNF in disposable canisters arriving, by year, at the repository. As discussed in Key Assumption 005, a very small amount of the DOE SNF may be received uncanistered in casks if it can be handled and processed in the same facilities as the commercial SNF. This small quantity is not distinguished in the waste stream.

4.1.3 Waste Package Emplacement Scenario (Key 003)

The waste package emplacement scenario at the MGR is as indicated in Table 3-9 of Key Assumption 003. This emplacement scenario is consistent with the *Mined Geologic Disposal System Requirements Document* (MGDS-RD) Table 3-3, (Reference 5.7) which shows a steady state emplacement rate of commercial SNF of 3,000 MTU/year. The commercial SNF disposed of in this scenario totals 63,000 MTU. The HLW and DOE SNF total approximately 7,000 MTU equivalents combined (see Key Assumption 005).

4.1.4 Site Generated Wastes (Key 024)

Secondary site generated waste (low-level, hazardous, mixed, and municipal) will be transported to government-approved offsite facilities for disposal. Radioactive LLW will be processed (including volume reduction) and packaged for shipment to off-Yucca Mountain-Site disposal. Utilizing the Nevada Test Site (NTS) as designated in Key Assumption 082 will meet this requirement for off-site disposal, provided the NTS waste management complex is properly licensed with the NRC. LLW must be packaged in accordance with NRC requirements and in compliance with the waste

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[2] Table 3-3, Key 001 shows up to a total of 411 canisters arriving in year 2026. This exception is more restrictive in that Table 3-3 shows arrival of only approximately 115 of the larger canisters in year 2026.

acceptance criteria for that disposal site. Used dual-purpose canisters (DPCs) will be prepared for off-site recycling. Hazardous and mixed wastes will be collected and packaged for transport to Resource Conservation and Recovery Act (RCRA)-approved off-site treatment, storage and disposal facility. This activity will be limited to packaging required for transportation and acceptance of the hazardous and mixed waste at the treatment/disposal facility. Measures will be taken to maintain separation of the hazardous and low-level wastes during HLW processing to preclude formation of mixed waste. Temporary accumulations of site-generated wastes will be accommodated onsite to facilitate treatment of low-level waste and packaging of all wastes types prior to transport to designated facilities. Offsite disposal and recycling options are to be assessed.

4.1.5 Regional Servicing Contractor Interface (Key 080)

Regional Servicing Contractors (RSCs), under contract to the DOE, will be responsible for arranging and providing waste acceptance and transportation services to deliver the commercial SNF to a federal facility, which is the repository for the reference design case. This will include responsibility for providing, maintaining, and decontaminating the transportation casks in which the SNF will be received at the repository. The repository will not perform transportation cask maintenance and decontamination, except for the incidental maintenance and decontamination needed to return the casks to the RSC or ship the unloaded casks offsite to a Cask Maintenance Facility approved by the Nuclear Regulatory Commission (NRC) or Agreement State.

4.1.6 LLW Disposal at NTS (Key 082)

The DOE Nevada Test Site (NTS) LLW disposal facilities will be made available for MGR-generated LLW. This would be an off-Yucca Mountain Site compatible with KEY Assumption 024. The volume of LLW to be shipped to the disposal facility will be minimized through appropriate means at the MGR.

4.1.7 Decontamination Equipment and Space (DCS 008)

Necessary equipment and space required for decontamination will be provided in each building where contamination will be present.

4.1.8 Underground Waste Generation (DCS 011)

Significant quantities of secondary mixed or low-level radioactive wastes will not be generated by underground emplacement operations.

4.1.9 No HLW in Waste Treatment Building (DCS 012)

The Waste Treatment Building (WTB) will not process secondary transuranic (TRU) or high-level waste (HLW). If such waste materials are generated, they will be packaged at the point of generation and disposed in the underground emplacement area via the Waste Handling Building (WHB).

4.1.10 Waste Generated by Performance Confirmation Activities (DCS 013)

Waste quantities generated by the performance confirmation operations will be negligible in comparison to the waste generated during normal receiving, handling and repackaging of SNF and HLW for disposal. As a result, wastes generated in the performance confirmation operations will not impact the design of the Waste Treatment Building (WTB).

4.1.11 Transportation Cask Design Characteristics

A compilation of presently available data on transportation systems for the transport of SNF to the MGR is presented in *Interface Control Document for the Transportation System and the Mined Geologic Disposal System Surface Repository Facilities and Systems for Mechanical and Envelope Interfaces Between the Surface Facility Operations and the Waste Acceptance and Transportation Office,* Reference 5.13. This data is for presently licensed transportation systems and transportation systems proposed for licensing.

4.1.12 DC/WP Design Characteristics

Waste Package characteristics are presented in *Interface Control Document for Waste Packages and the Mined Geologic Disposal System Repository Subsurface Facilities and Systems for Mechanical and Envelope Interfaces Between Barrier System Operations and Waste Package Operations,* Reference 5.25, Figure 2. Additional parameters and design characteristics are provided in *Interface Control Document for the Waste Package/Disposal Containers and the Surface Repository Facilities and Systems for Mechanical, Envelope, and Functional Interfaces between Surface Facilities Operations and Waste Package Operations,* Reference 5.9.

4.2 CRITERIA

Design criteria for the handling, processing, and disposal of MGR site-generated radiological wastes are established in *Site-Generated Radiological Waste Handling System Description Document* (Reference 5.11). Additional criteria in regard to decontamination requirements are provided in *Assembly Transfer System Description Document* (Reference 5.10).

4.2.1 Low-Level Waste Disposal

If the design of the Repository Sector provides for the disposal of licensed low-level waste material into sanitary sewerage, the requirements of 10 CFR 20.2003 (Section 4.1.1.3) shall be met.

If the design of the Repository Segment provides for the treatment or disposal of licensed low-level waste material by incineration, only the amounts and forms specified in 10 CFR 20.2005 (Section 4.1.1.3), or specifically approved by the NRC pursuant to 10 CFR 20.2002, shall be allowed.

4.2.2 Transportation Protection

The Repository Segment shall be provided with the capability to comply with the requirements for packaging and transporting radioactive materials contained in 10 CFR 71 (Section 4.4.1.3) and 49 CFR 173 (Section 4.4.1.5) when shipping licensed radioactive material from the MGR.

4.2.3 Solid Waste Control

The management and disposal of any solid and hazardous wastes shall be conducted in accordance with the requirements of the Resource Conservation and Recovery Act, as amended (42 USC 6901 et. seq.) Which include the permitting for the hazardous wastes. The federal regulations that impact the design of the Repository are included in 40 CFR 261, 40 CFR 262, and 40 CFR 270 (Section 4.4.1.4).

4.2.4 Cask Maintenance

The repository waste handling facilities shall be capable, as a minimum, of supporting the following maintenance tasks (Reference 5.10, Section 1.1) for all transportation casks:

A. Testing the surfaces of incoming casks for contamination and radiation.

B. Decontaminating of cask exterior surfaces if required prior to admission into the processing and transfer facilities.

C. Cleaning the interior of the casks following unloading

D. If necessary, decontaminating to satisfy the cleanliness requirements for transportation and any agreements which may exist with the waste producers as identified in the Waste Acceptance System Requirements Document.

4.2.5 Site-Generated Waste Treatment

Radioactive waste treatment facilities shall be designed to process any radioactive waste generated at the Geologic Repository Operations Area (GROA) into a form suitable to permit safe disposal at the GROA or to permit safe transportation and conversion to a form suitable for disposal at an alternative site in accordance with any regulations that are applicable.

Facilities shall be provided to manage and dispose of site-generated solid and hazardous wastes (excluding radioactive wastes) in accordance with requirements of the Clean Water Act (CWA), unless arrangements are made for off-site disposal.

The Repository Segment facilities shall be designed to minimize the production of site-generated hazardous wastes.

4.2.6 Waste Handling Requirements

Waste handling facilities shall provide a contamination free waste package exterior surface prior to release to the underground (Reference 5.10, Section 1.1.14).

4.2.7 System Performance

The system description document (SDD) for the site-generated radiological waste handling system (Reference 5.11) identified radiological waste stream volumes in Sections 1.2.1.1, 1.2.1.2, and 1.2.1.3 of that SDD. These waste volumes estimated in the SDD carry TBV-428. This analysis updates the estimated volumes of radiological wastes to be generated at the MGR; the SDD will be updated as necessary.

4.3 ASSUMPTIONS

Development of the waste treatment system design will require estimating the annual quantity of secondary LLW. Since a facility has not yet been designed or operated which handles the type and throughput of waste proposed for the repository, technical data defining the quantity of liquid and solid secondary LLW generated or the specific types of decontamination operations which would be required is not available. As a substitute for this historic information, the waste generation estimate in this report is based on a number of engineering assumptions intended to yield a bounding estimate of the LLW generation rates likely to result from repository operations.

4.3.1 It is not anticipated that any hazardous wastes or mixed wastes will be generated through the direct activities within the WHB associated with receiving and repackaging of SNF/HLW for disposal at the MGR. It is also not anticipated that any hazardous wastes or mixed wastes will be generated through the processing of LLW within the WTB. Minor quantities of TRU waste may result through the inadvertent processing of damaged fuel assemblies.

Basis: It is presently envisioned that only two sources of chemical materials will be inputs associated with the processing of SNF/HLW through the WHB. These two sources are ion exchange resins (nuclear grade) and decontamination agents. Nuclear grade ion exchange resins are used for water treatment of radioactive waste streams and are not classified as hazardous materials. Although the actual decontamination solutions have not been defined, it is anticipated that nonhazardous decontamination agents, the nuclear industry norm, would be employed when required.

Used: Section 1.

[TBV: Classification Code 1]

4.3.2 It is assumed that the QA classifications identified in Section 2., Quality Assurance, have been correctly assigned.

Basis: This assumption is based on the work performed in *Classification of the Preliminary MGDS Repository Design* (Reference 5.3) which carries a TBV for these classifications (TBV-228, TBV-457, TBV-458, TBV-459, and TBV-460).

Used: Section 2.

[TBV: TBV-228, TBV-457, TBV-458, TBV-459, and TBV-460]

4.3.3 It is assumed that the liquid LLW treatment system which will receive the liquid waste streams identified in this analysis will be capable of processing two main subcategories of liquid LLW: 1) the generated liquid waste streams which contain chemicals unsuitable for recycling which will be grouted and disposed of as solid waste; and, 2) those liquid waste streams suitable for recycling which will be treated in a series of processing steps including filtration, evaporation, and ion-exchange, and are recycled for further use. This recycling of waste water represents a significant reduction in water demand by the repository facilities, as well as a major reduction in waste water disposal requirements.

Basis: This is based on analysis, *Secondary Waste Treatment Analysis*, Reference 5.5, page 14.

Used: Section 7.2.1.

[TBV: Classification Code 1]

4.3.4 The types of decontamination/washdown methods used and the type and quantity of waste generated from each are provided in Table 7.2-1. The quantities are expressed as a rate (gallons or pounds) per unit (items or square foot of surface area).

Basis: A thorough literature survey was performed to define "typical" waste quantities produced during cask and facility decontamination activities. No data was found. It is believed that the waste quantity rates presented in Table 7.2-1 provide a reasonable bounding basis for utilization in this analysis and that they are based on typical decontamination sequences.

Used: Section 7.2.1.

[TBV: Classification Code 2]

4.3.5 It is assumed that the receipt schedule for casks, DPCs, HLW and canisters, and the emplacement schedule for DCs are as shown in Table I-1, Attachment I.

Basis: This data was extracted from the *Controlled Design Assumptions* (CDA) (Reference 5.6. The CDA data is gathered from the *Waste Quantity, Mix and Throughput Study Report,* Reference 5.8.

Used: Section 7.2.1.

[TBV: Classification Code 2]

4.3.6 Potential transportation casks are identified in Reference 5.15 (See Section 4.1.15 of this analysis). The available transportation cask definition covers presently licensed casks, and casks proposed for licensing. There is no certain knowledge of which potential casks may be utilized for the transport of the various SNF assemblies. Because of the present uncertainty associated with potential casks which will be available for transporting SNF to the repository, the following casks dimensions (Table 4-1) are assumed to coincide with the SNF receipt schedule as defined in the CDA. Casks dimensions were utilized in assuming which cask would be utilized in the delivery of the various fuel types.

Table 4-1. Transportation Cask Dimensions

Waste Shipment	Transport Cask	Length (in)	Diameter (in)
UCF Trucked Waste			
9 BWR	GA-9	198.3	40.2
7 BWR	GA-9	198.3	40.2
4 PWR	GA-4	187.8	39.8
3 PWR	GA-4	187.8	39.8
HH 7 BWR	GA-9	198.3	40.2
HH 3 PWR	GA-4	187.8	39.8
UCF Rail Waste			
61 BWR	TranStor^{TM}	210	97.6
26 PWR	NAC-STC	193	99.0
24 BWR	NUHOMS^{TM} MP-187	201.5	92.5
12 PWR	Small MPC-(12P)	203.8	67.7
17 BWR	Small MPC-(24B)	203.8	67.7
HH 7 PWR	Small MPC-(12P)	203.8	67.7
ST 12 PWR	not available	233.2(1)	87.8(1)
Rail Canistered			
61 BWR	TranStor^{TM}	210	97.6
24 PWR	TranStor^{TM}	210	97.6
44 BWR	Large MPC-(44B)	205.2	87.8
21 PWR	Large MPC-(21P)	205.2	87.8
24 BWR	Small MPC-(24B)	203.8	67.7
12 PWR	Small MPC-(12P)	203.8	67.7
22 BP	not available	233.2(1)	87.8(1)
HLW & DSNF			
HLW	not available	233.2(1)	87.8(1)
DSNF	not available	225	90

(1)This dimensional data carries TBV-404.

Basis: The basis for the cask selection is the capacities and dimensional data as presented in Table 4.1-1 of *Carrier/Cask Handling System Design Analysis,* Reference 5.15, and

Reference 5.13. Although actual cask sizes cannot be specified for given fuel shipments, it is believed that assuming the indicated dimensions for a given fuel type presents a reasonable bounding basis for the calculation of surface areas to be decontaminated.

Used: Throughout Section 7.0 and in Attachment I.

[TBV: Classification Code 2, the use of the data in this analysis is not safety significant, although certain of the casks carry TBV-404]

4.3.7 DPC dimensions are assumed to equal the dimensions of casks used to transport the DPC.

Basis: Because of the uncertainty of the various sizes and combinations of DPCs and their overpack/cask systems, using the larger size of the cask for purposes of bounding the amount of waste generated in decontamination activities is believed reasonable for purposes of this analysis. Dimensions for incoming casks are taken from *Interface Control Document for the Transportation System and the Mined Geologic Disposal System Surface Repository Facilities and Systems for Mechanical and Envelope Interfaces Between the Surface Facility Operations and the Waste Acceptance Transportation Office,* A00000000-01717-8100-00008 REV 00, Reference 5.13.

Used: Section 7.2.1.

[TBV: Classification Code 2]

4.3.8 The assumed sizes of the disposal containers are as presented in Table 4-2. Long waste packages were used as bounding values.

Table 4-2. Assumed Disposal Container Dimensions

Waste Package	Length (in)	Diameter (in)
LG WP 44 BWR (TBV-312)	210.0	63.1
LG WP 21 PWR (TBV-292)	210.0	65.5
SM WP 12 PWR (TBV-291)	210.0	52.0
SM WP 24 BWR (TBV-300)	210.0	52.7
ST-WP 12 ST (TBV-298)	231.1	53.1
HLW & DSNF (TBV-295)	211.3	78.6
DSNF (TBV-289)	242.7	77.1

Where: LG – large
SM – small
ST – South Texas

Basis: Disposal container capacities and dimensions are taken from *Interface Control Document for Waste Packages and the Mined Geologic Disposal System Repository Subsurface Facilities and Systems for Mechanical and Envelope Interfaces between Engineered Barrier System Operations and Waste Package Operations,* Figure 2 of Reference 5.25. Dimensional data has been converted from mm to inches using the conversion factor of 1 in = 25.4 mm.

Used: Throughout Section 7.0 and in Attachment.

[TBV: Classification Code 2, although all disposal containers carry TBVs as indicated in Table 4-2.]

4.3.9 It is assumed that the majority of LLW generated by facility decontamination comes from decontamination of floor areas within the WHB and the WTB radiological areas. The waste generation rates are assumed proportional to floor areas. The assumed potentially contaminated floor areas within the WHB and WTB are provided in Table 7.2-2.

Basis: These floor areas are taken from *Surface Nuclear Facilities Space Program Analysis,* DI:BCBD00000-01717-0200-00012, REV 00, Section 7.2, 7.3, and specifically Table 7.2-3 (Reference 5.16).

Used: Section 7.2.1.

[TBV: Classification Code 2]

4.3.10 The estimated annual quantities of waste generated from individual decontamination and washdown operations are shown on Table I-2, Attachment I. This table also includes the basis for these quantities, including: decontamination frequency (months between floor washdowns or percentage of casks and equipment requiring decontamination); surface areas for casks, DCs, DPCs, operating areas, yokes, tooling and DC handling collars; percentage of each item or area that is decontaminated; and type of decontamination process used.

The following decontamination assumptions are utilized in the preparation of the estimate of waste generation quantities from decontamination/floor washdown used in Table I-2, Attachment I:

- It is assumed that year 2026, which has the highest total surface area of incoming casks represents a bounding case for design purposes of the generation of LLW.

- It is assumed that the solid LLW generation rate is 5 lb/100 ft^2 of surface area wiped during wipe decontamination. It is assumed that the solid LLW generation rate is 1 lb/100 ft^2 of surface area washed during wash decontamination.

- It is assumed that 5% of the SNF/HLW carriers will require decontamination, and that they have an average surface area of 400 ft^2. Of those carriers decontaminated, 80 percent will be decontaminated by wiping approximately 10 percent of the surface area, and 20 percent will be decontaminated by water washing 100 percent of the surface area.

- The following frequencies for floor washdown are assumed: Carrier Prep - 1/year; Assembly Transfer (Pool Areas - 1/month, Assembly Cell – 2/month, and DC Load/Decon – 2/year); Canister Transfer - 1/month; Disposal Container Handling - 2/year; Waste Package Remediation - 2/month; Primary Support Areas - 6/year; Pool Support Area - 2/year; and, WTB Process Area - 1/year. When these areas are washed down, they will be 100 percent washed with 60 percent being water washed and 40 percent being chemical/detergent washed.

- It is assumed that the outer surfaces of incoming casks will be contamination free when they enter the WHB, and therefore, no additional decontamination will be required.

- Overpacks, casks, DPCs, and handling equipment will be washed down with deionized and/or recycled water as these items are removed from the waste transfer pools. It is assumed that 100 percent of the casks are rinsed down with deionized water at a rate of 20 gal/100 ft^2 of surface area. This water enters the pools and is therefore not a liquid waste stream.

- It is assumed that all (100 percent) empty casks will require some form of decontamination.

  For casks used for uncanistered fuel, 100 percent will be washed down with demineralized water as they are removed from the waste transfer system pools. Five percent of these casks will require wipe decontamination over 5 percent of their surface area. Forty percent of these casks will require water wash over 100 percent of their surface area, and 20 percent will require chemical/detergent wash over 100 percent of their surface area.

For empty casks which originally contained canistered SNF/HLW, and therefore were processed through the dry transfer lines, 5 percent will require wiping over 10 percent of their surface area. Ninety percent of these casks will require water washing over 100 percent of their surface area, and 10 percent will require chemical/detergent wash over 100 percent of their surface area.

- Pool tooling and miscellaneous items leaving the waste transfer system pools will receive 100 percent washdown with demineralized water as they leave the pool. The assumed quantity is 200, with an assumed surface area of 200 ft^2/unit.

- Pool yokes leaving the waste transfer system pools will receive 100 percent washdown with demineralized water as they leave the pools. The assumed quantity is 40, with an assumed surface area of 400 ft^2/unit.

- The DC top, after fuel loading, but prior to welding, will be decontaminated by vacuuming. The assumed surface area is 50 ft^2/top.

- One hundred percent of the DCs will be decontaminated before transfer to subsurface. At the present time, the actual decontamination methods for DCs has not been established. To ensure that liquid waste volumes include waste from the decontamination of DCs this analysis assumes that eighty percent will receive water wash over their entire exterior surface area. Twenty percent will receive chemical decontamination over their entire exterior surface area

- Fixtures and miscellaneous items, used in the canister transfer lines, will require decontamination every 6 months, on the average. The assumed surface area is 400 ft^2/unit. Twenty percent of the fixtures will be wiped over 10 percent of their surface area. Sixty percent of the fixtures will be water washed over 100 percent of their surface area, and 40 percent will be chemical/detergent washed over 100 percent of their surface area.

- Ten percent of the DC Handling Collars will require decontamination annually over their assumed surface area of 200 ft^2/unit. Ninety percent of these collars will be water washed over 100 percent of their surface area, and 10 percent will be chemical/detergent washed over 100 percent of their surface area.

Basis: As identified in the introduction of Section 4.3, since a repository of this nature has never been operated, there is no data available on actual decontamination operations. These assumptions on decontamination rates and the waste generation associated with these decontaminations are believed reasonably bounding for the purposes of this analysis.

Used: Section 7.2.1.

[TBV: Classification Code 2]

4.3.11 After extensive literature review, it was determined that little published quantitative information exists relative to the quantity of solid LLW generated from cask and fuel handling operations. For the purpose of this analysis the following assumptions for solid LLW are employed:

- 20 ft^3 of rags, paper, and plastic are generated per transportation cask handling operation (per Reference 5.18, p.II.D.5-4).

- 100 ft^3/yr of rags, paper, and plastic are generated per waste handling operator and waste treatment technician.

- 70 percent of the compactible solid LLW waste is rags, paper, and plastic (Figure 2-1, page 2-10 of Reference 5.20).

- It is assumed that the waste generated due to a spill or other foreseeable accident is bounded by the waste volumes estimated for normal operations.

Basis: The references for the first and third bullet are identified within the assumption. For the second bullet, paper, plastic, PVC (polyvinylchloride), and cloth are considered compactible. Metal, rubber, wood, non-compactible, absorbent materials (e.g., clay), and filters are considered non-compactible. The assumed quantity of solid waste generated/yr per operator is believed reasonably bounding for the purposes of this analysis.

Used: Section 7.2.

[TBV: Classification Code 2]

4.3.12 It is assumed that compactible dry active waste (DAW) has a density of 6 lb/ft^3.

Basis: This is based on data from Reference 5.20, Figure 4-5, which shows a range of approximately 3 to 13 lb/ft^3, and an average of approximately 6 to 7 lb/ft^3 for the Turkey Point Nuclear Power Plant.

Used: Section 7.2.4.

[TBV: Classification Code 2]

4.3.13 For the purposes of this analysis, it is assumed that non-compactible dry active waste (DAW) represents 44 percent (mid-point between BWRs and PWRs) of the total DAW.

Basis: Historically, non-compactible waste at power plants has accounted for anywhere from 19 percent to 57 percent of the total DAW, with pressurized water reactors (PWRs) averaging 52 percent and boiling water reactors (BWRs) averaging 36 percent (Reference Tables 2-6 and 2-7 of *Identification of Radwaste Sources and Reduction Techniques,* EPRI, Reference 5.21).

Used: Section 7.2.4.

[TBV: Classification Code 2]

4.3.14 It is assumed that the ion exchange resin quantities generated by pool water treatment will be equivalent to the quantities generated at the average PWR. It is assumed that the cartridge filter volume is equal to the resin volume.

Basis: Because there is no available data on what the pool water or recycle water solids and dissolved solids characteristics might be, it is believed that using the PWR average provides a reasonable bounding quantity of resin for the purposes of this analysis. From Reference 5.21, Table 3-2A, page 3-46, the average resin volume from a PWR is 1,295 ft^3/yr.

Used: Section 7.2.3.

[TBV: Classification Code 2]

4.3.15 It is assumed that the inside surface of the DPC will be contaminated with some amount of spalled or scraped off fuel crud, but will not contain any significant quantities of TRU waste[3].

[3] In other words, the concentration of alpha emitting transuranic nuclides with a half-life greater than five years in the final waste form will be less than 100 nanocuries/gram per 10 CFR 61 (Section 4.4.4).

Basis: Fuel received from commercial reactors is not expected to have experienced significant cladding failures during loading, storage, or transit. The minor cladding imperfections on 1 to 2 percent of the fuel should not result in TRU leakage. Fuel which has undergone significant failure will result in the generation of TRU waste which is beyond the scope of this analysis. It is assumed that fuel with significant cladding failures will be canistered or containerized in external facilities.

Used: Section 7.2.4.

[TBV: Classification Code 1]

4.3.16 It is assumed that the DAW waste characteristics will be similar to those of DAW generated by a power reactor.

Basis: Although a repository like the MGR has never been operated, it is believed reasonable to assume that the DAW waste characteristics for the MGR will be similar to those for power reactors.
Used: Section 7.3.1.

[TBV: Classification Code 1]

4.3.17 It is assumed that the average liquid LLW generated will have the following radiological characteristics:

Dose Rates - 5 mR/hr (contact)

Specific Activity - ^{60}Co - 1 x 10^{-3} micro Ci/ml
^{137}Cs -1.5 x 10^{-3} micro Ci/ml

Basis: Although specific decontamination activities have not been defined, and therefore liquid LLW radiological characteristics cannot be predicted, it is believed that using a source term of approximately 5 times the source term recommended by ANSI/ANS 57.7, Appendix B, for storage basin water (Reference 4.4.2.1, Appendix B) provides a reasonable bounding definition of source term for the purposes of this analysis.

Used: Section 7.3.2.

[TBV: Classification Code 2]

4.3.18 For the purposes of establishing waste characterization properties and waste handling requirements, it is assumed that filter cartridges will be administratively controlled below 10 R/hr.

Basis: Because of the significant variations in fuel assembly crud characteristics and the adhesion characteristics of the crud, there is no way of predicting how much of this material may collect on a given filter cartridge before it would need to be changed out due to pressure drop across the cartridge. More importantly, there is no way of predicting what the radioactive isotopic content of the cartridge might be. Appendix B of ANSI/ANS 57.7 (Section 4.4.2.1) shows that typical waste filter cartridges from water purification systems have a contact reading in the 1×10^4 mR/hr, 10 R/hr, range. That is, if a filter cartridge does not load up with particulate material sufficient to require changeout due to pressure drop, the filter cartridge will be changed out as it approaches the 10 R/hr limit.

Used: Section 7.3.3

[TBV: Classification Code 2]

4.3.19 For the purposes of establishing waste characterization properties and waste handling requirements, it is assumed that ion exchange resins will be administratively controlled below 10 R/hr.

Basis: As with the fuel crud, there is no way of predicting how much radioactive material (primarily Cs isotopes) will be placed into the pool systems from the fuel being processed at any given time. Appendix B of ANSI/ANS 57.7 (Section 4.4.2.1) shows that typical waste ion exchange resin units cartridges from water purification systems have a contact reading in the 1×10^4 mR/hr, 10 R/hr, range. That is, if an ion exchange unit does not reach ionic breakthrough before 10 R/hr, the resin unit will be changed out as it approaches the 10 R/hr.

Used: Section 7.3.3.

[TBV: Classification Code 2]

4.3.20 It is recognized that the DAW rate from decontamination/floor washdown and other decontamination activities is taken from data for year 2026, while the DAW rate for cask handling operations is taken from year 2016. Since cask handling operations generates substantially more DAW than washdown, it is believed justifiable to use the maximum quantities (regardless of year generated) for this summation.

Basis: It is believed reasonable to use the larger DAW quantities for establishing bounding amount of DAW for the purposes of this analysis.

Used: Section 7.2.2

[TBV: Classification Code 2]

4.3.21 The assumed maximum quantities of mixed waste are 11 ft^3 of solid mixed waste and 32 gallons of liquid mixed waste (Assumption 4.3.21).

Basis: These numbers are taken from Section 1.2.1.2 of Reference 5.11.

Used: Section 7.2.7

[TBV: Classification Code 2, although the quantities carry TBV-428]

4.4 CODES AND STANDARDS

4.4.1 Code of Federal Regulations (CFR)

Resource Conservation and Recovery Act (RCRA) of 1976. (42 USC 6901 et. seq.)

Atomic Energy Act of 1954, as amended.

10 CFR, *Energy*

10 CFR 20, *Standards for Protection Against Radiation*, January 1, 1998.

10 CFR 61, *Licensing Requirements for Land Disposal of Radioactive Wastes*, January 1, 1998.

10 CFR 71, *Packaging and Transportation of Radioactive Materials*, January 1, 1998.

10 CFR 72, *Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste*, January 1, 1998.

40 CFR, *Protection of Environment*

40 CFR 191, *Environmental Radiation Protection Standards for Management and*

Disposal of Spent Nuclear Fuel, High-Level and Transuranic Wastes July 1, 1998.

40 CFR 261, *Identification and Listing of Hazardous Materials*, July 1, 1998.

40 CFR 262, *Standards Applicable to Generators of Hazardous Waste*, July 1, 1998.

40 CFR 270, *EPA Administered Permit Programs: The Hazardous Waste Permit Program*, July 1, 1998.

49 CFR, *Transportation*

49 CFR 173, *Shippers – General Requirements for Shipping and Packaging*, October 1, 1998.

4.4.2 U. S. Nuclear Regulatory Commission (NRC)

ANSI/ANS 57.7, *Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type),* 1988.

ANSI/ANS 55.1, *Solid Radioactive Waste Processing System for Light-Water-Cooled Reactor Plants,* 1992.

5. REFERENCES

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5.2 DOE (U.S. Department of Energy) 1998. *Quality Assurance Requirements and Description for the Civilian Radioactive Waste Management Program.* DOE/RW-0333P REV 8. Washington D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.19980601.0022.

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ACC: MOL.19960619.0126.

5.5 CRWMS M&O 1997. *Secondary Waste Treatment Analysis.* BCBD00000-01717-0200-00005 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971208.0201.

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5.7 DOE 1996. *Mined Geologic Disposal System Requirements Document.* DOE/RW-0404P REV 02, DCN 02. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.19990119.0319.

5.8 CRWMS M&O 1997. *Waste Quantity, Mix and Throughput Study Report.* B00000000-01717-5705-00059, REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971210.0628.

5.9 CRWMS M&O 1998. *Interface Control Document for the Waste Packages/Disposal Containers and the Surface Repository Facilities and Systems for Mechanical, Envelope and Functional Interfaces between Surface Facilities Operations and Waste Package Operations.* B00000000-01717-8100-00021 REV00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981229.0160.

5.10 CRWMS M&O 1998. *Assembly Transfer System Description Document.* BCB000000-01717-1705-00023 REV00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980812.0276.

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5.12 DOE, 1997. *Nevada Test Site Waste Acceptance Criteria,* DOE/NV-325 NTSWAC (Rev.1). Las Vegas, Nevada: U. S Department of Energy, Las Vegas Operations Office. ACC: MOL.19990318.0235.

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5.16 CRWMS M&O 1997. *Surface Nuclear Facilities Space Program Analysis.* BCBD00000-01717-0200-00012 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980204.0138.

5.17 CRWMS M&O 1998. *Site Gas/Liquid Systems Technical Report.* BCBC00000-01717-5705-00001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980415.0542.

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5.21 EPRI 1984. *Identification of Radwaste Sources and Reduction Techniques, Volume 1: Implementation Handbook.* NP-3370. Palo Alto, California: Author. TIC: 242200.

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5.26 CRWMS M&O 1997. *Repository Surface Design Engineering Files Report.* BCB000000-01717-5705-00009 REV 01. Las Vegas, Nevada: CRWMS M&O.
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6. USE OF COMPUTER SOFTWARE

EXCEL97™ was utilized in performing simple spreadsheet calculations in the attachments to this analysis. All numerical calculations were checked by performing hand calculations to verify the accuracy of the spreadsheet calculations.

7. DESIGN ANALYSIS

7.1 INTRODUCTION

7.1.1 Definition of Secondary Low-Level Waste

Secondary radioactive waste streams will be generated during the processes associated with receiving and packaging of commercial SNF, DOE SNF, and DOE HLW for disposal at the MGR. These secondary waste streams will be primarily LLW by definition; where LLW is defined in *Solid Radioactive Waste Processing System for Light-Water-Cooled Reactor Plants* (Section 4.4.1) as radioactive waste not classified as high-level radioactive waste, TRU waste, spent nuclear fuel or byproduct material as defined in section 11.e.(2) of the Atomic Energy Act (uranium or thorium tailings and waste). Where:

- HLW is defined as: (1) the highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and (2) other highly radioactive material that the Commission (NRC), consistent with existing law, determines by rule requires permanent isolation. (10 CFR 72, Section 72.3)

- TRU waste[4] is defined as: radioactive waste containing more than 100 nanocuries of alpha-emitting TRU isotopes, with half-lives greater than 20 years, per gram of waste, except for: (1) high-level radioactive wastes; (2) wastes that the Department (DOE) has determined, with the concurrence of the Administrator (EPA), do not need the degree of isolation required by this part; or (3) wastes that the Commission (NRC) has approved for disposal on a case-by-case basis in accordance with 10 CFR 61. (40 CFR 191, Section 191.02)

It is anticipated that secondary LLW will be processed prior to shipment for disposal to ensure that the waste attains the requirements of the NTS WAC (Reference 5.12)[5]:

- Liquid wastes will be solidified to ensure that free liquid is less than 1 percent of the volume of the waste, or 0.5 percent of the volume of the waste processed in stable form.

- Fine particulate wastes will be immobilized to ensure that a waste package contains no more than 1 weight percent of less-than-10-micrometer-diameter particles, or no more than 15 weight percent of less-than-200-micrometer-diameter particles.

- Structural stability of solid contaminated LLW will be enhanced through the use of techniques such as sorting, shredding, and compacting.

- Waste sorting and characterization will be performed to ensure that chemical stability of the waste can be demonstrated.

- Chelating or complexing agents used in decontamination activities will be processed and stabilized to ensure that unbound chelating or complexing agents are not greater than 1 percent by weight.

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[4] Per the requirements of the Nevada Test Site (NTS) Waste Acceptance Criteria (WAC) the following isotopes shall be considered when making the TRU waste determination: ^{236}Np, ^{237}Np, ^{238}Pu, ^{240}Pu, ^{242}Pu, ^{244}Pu, ^{241}Am, ^{242}Am, ^{243}Am, ^{243}Cm, ^{245}Cm, ^{246}Cm, ^{247}Cm, ^{248}Bk, ^{249}Cf, ^{251}CF (Reference 5.12)

[5] The LLW quantities identified in this analysis represent estimated quantities prior to any waste treatment necessary for waste minimization or acceptance criteria.

Due to the nature of operations performed in the processing of SNF for disposal, LLW generated should not have hazardous properties (as defined in Title 40 CFR) (Section 4.4.1.4), should not contain compressed gases (as defined in Title 49 CFR) (Section 4.4.1.5), should not contain etiologic agents (as defined in Title 49 CFR), should not contain polychlorinated biphynyls (PCBs), should not contain explosive or pyrophoric compounds, nor contain asbestos materials.

7.1.2 Secondary LLW Generating Activities

Secondary LLW will be generated primarily in the WHB, and lessor quantities of secondary LLW will generated from activities within the WTB. Due to the possibility of receiving a surface contaminated SNF/HLW shipment, the possibility exists for the generation of minor quantities of secondary LLW being generated in the Carrier Prep Building (CPB).

Secondary LLW will result from decontamination activities associated with processing SNF/HLW for disposal. Secondary LLW will also be generated from housekeeping and maintenance activities within the WHB and WTB. Additionally, secondary LLW will also be generated from the treatment of water for the waste transfer pool system.

Typical items to be decontaminated include:

- Arriving Truck/ Rail Carriages
- Loaded Casks
- Unloaded Casks
- Unloaded Dual-Purpose Canisters
- Facility Floors
- Disposal Containers
- Small Equipment & Tools
- Crane Hooks, Casks, Cask Lids, Vacuum Equipment, and other items exiting the Assembly Handling Pools

Secondary LLW streams will be primarily liquids and solids. Minor releases gaseous wastes will be processed through the WHB and WTB buildings high-efficiency particulate air (HEPA) filtration systems prior to discharge to the atmosphere. The quantities of gaseous wastes are not quantified in this analysis, but are addressed in the *Repository Surface Design Engineering Files Report* (Reference 5.26). It is anticipated that the following secondary LLW streams will be produced as a result of repository operations:

Liquid Streams

Recyclable Liquids - Aqueous streams suitable for treatment and recycling.

- Decontamination water
- Floor washdown water

Chemical Liquids - Aqueous streams unsuitable for treatment and recycling due to chemical content.

- Spent decontamination solution
- Floor washdown water used in conjunction with chemical cleaners

Solid Streams

Compactible solid LLW (rags, paper, plastic, etc.)
Non-compactible solid LLW (metal, wood, etc.)
Spent ion-exchange resin (slurry) and filter cartridges

The first task in this design analysis, documented in Section 7.2, develops a secondary LLW generation rate estimate based on available information on operations performed within the industry similar to those at the repository, and on the type, frequency, and anticipated rate of SNF/HLW materials to be processed for disposal at the repository.

7.1.3 Radiological Characteristics of Secondary Low-Level Waste

The majority of LLW will meet the criteria for Class A LLW (as defined in 10 CFR 61.55) (Section 4.4.1.3). A small portion of the LLW, e.g., filter cartridges and/or ion exchange media, may contain sufficient radioactive constituents to meet or exceed Class C designation. Section 7.3 discusses the anticipated radiological characteristics of the various solid and liquid secondary LLW streams.

7.2 SECONDARY LOW-LEVEL WASTE GENERATION RATE ESTIMATE

The maximum annual secondary LLW generation rate is determined from an examination of SNF/HLW receipt rates as well as the rate of repository waste package processing. Since a facility has not been built which processes the types and quantities of SNF/HLW proposed for the repository, detailed data supporting the rate of secondary LLW generation is not available. As a substitute for actual plant operating data, the rate estimate for the repository is established from a number of assumed or estimated parameters such as the rate of receipt of contaminated transportation casks, methods of decontamination to be employed and quantities of decontamination materials required, frequency and fluid volumes used for facility floor washdown, ion-exchange resin, HEPA filter and cartridge filter quantities and replacement intervals, and other supporting data. The objective in establishing the LLW rate estimate is to develop a reasonable basis for facility conceptual design. The assumptions used to support the rate estimate are defined in Section 4.3 of this analysis. This section of the analysis is divided into subsections that discuss the various sources and categories of anticipated generated LLW. Section 7.2.1 discusses the LLW generated by decontamination and washdown activities. Section 7.2.2 discusses dry active waste (DAW) generated by general operation and maintenance activities. Section 7.2.3 discusses the LLW that will be generated by treatment of the water in the assembly transfer pool system. Section 7.2.4 discusses the waste issues in regard to the disposal of used Dual-Purpose Canisters (DPCs) and their shield plugs.

It is assumed that LLW generated due to a spill or other foreseeable accident is bounded by the estimated waste quantities identified in this analysis (Assumption 4.3.11). Transuranic waste generated by an accident such as the dropping and rupturing of a fuel assembly is specifically excluded from this analysis.

7.2.1 Decontamination and Washdown Wastes

The primary generator of secondary liquid LLW is anticipated to be decontamination and washdown operations performed within the repository surface facilities in general and the WHB in particular. These decontamination activities are necessary to minimize the potential of allowing contamination to leave controlled areas, and to minimize exposure (ALARA) to operating personnel.

The primary decontamination processes envisioned for the processing of SNF/HLW for disposal at the MGR are:

- Minor spot decontamination of received SNF/HLW casks arriving at the Carrier Prep Building (CPB). It is anticipated that these wastes will be primarily dry wastes resulting from manual decontamination of casks exteriors performed by health physicists as the casks have crating and/or impact limiters removed prior to be transported to the WHB.

- Overpacks, casks, DPCs, and handling equipment will be washed down with deionized and/or recycled water as these items are removed from the waste transfer pools to minimize the spread of contamination throughout the assembly transfer area. The water from this operation will fall into the pools and be treated in the waste transfer pool water treatment system. [6]

- After SNF has been removed from the waste transfer pools, dried, and placed in the DC, a temporary lid is placed on the DC before it is passed into the weld station area. This temporary lid will be vacuumed off prior to the DC entering the welding area. Any loss contamination removed by this vacuuming will be collected on HEPA filters and processed as DAW.

- The DC, after welding and before being loaded onto the DC transporter, will be surveyed to ensure that no surface contamination exists. Because of the radiation fields associated with SNF/HLW in DCs, this operation will be remote in nature. If surface contamination is found, initial decontamination will be attempted using small spot decontamination techniques which will only generate DAW. If this decontamination step is unsuccessful, additional liquid washes will be employed using water (deionized/recycled) and/or citric acid. This liquid waste stream will be dispositioned accordingly. Actual decontamination techniques for DCs has not been analyzed. The use of bulk liquids may be prohibited due to the temperature of the DC. The numbers generated in this analysis are believed bounding and generated to ensure that waste volumes for DC decontamination are accounted for until additional analysis can be performed.

- Floor areas within the WHB radiological zones and within the WTB will be washed down for normal housekeeping purposes and for the removal of detected contamination. This water will be processed through the water recycle system. On certain occasions, detergent and/or other chemical agents may be required for these floor washdown operations. The liquid wastes from these operations will not be recycled, but instead will be dispositioned as a chemical waste.

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[6]This operation is mentioned for completeness of identification of decontamination processes. The washdown water which enters the pool is not itself a waste stream. The estimated quantity of this washdown water is included in this analysis.

- Minor amounts of DAW and liquid wastes will be generated during the course of decontamination activities associated with maintenance and equipment replacement actions. Liquid wastes will either be recycled or grouted directly depending upon their chemical constituents.

The liquid LLW treatment system, which will receive the liquid waste streams identified in this analysis, is based on a previous analysis, *Secondary Waste Treatment Analysis*, Reference 5.5. The system will consist of two primary processing systems: 1) the generated liquid waste streams which contain chemicals unsuitable for recycling which are grouted and disposed of as solid waste; and, 2) those liquid waste streams suitable for recycling which are treated in a series of processing steps including filtration, evaporation, and ion-exchange, and are recycled for further use. This recycling of wastewater represents a significant reduction in water demand by the repository facilities, as well as a major reduction in wastewater disposal requirements. (Assumption 4.3.3)

To prepare a LLW volume estimate, it is necessary to define, at least conceptually, the decontamination operations to be utilized, the frequency of these operations, and the volume of waste fluids generated at each step of each operation. For reasons previously stated, it is necessary to employ educated assumptions regarding the decontamination and washdown techniques employed and the secondary LLW generated. For aqueous decontamination of major equipment where ALARA considerations permit, i.e., excluding unsealed waste packages, and decontamination operations performed remotely, a two stage hands-on decontamination system is proposed consisting of increasingly severe measures. This stepwise approach is generally accepted as industry practice. The first step in this process is wiping or swiping of detected contamination areas on subject equipment. This wiping might include the use of spray bottles containing detergent or other chemical decontamination solutions on a small scale. The generation of significant liquid waste streams from this type of decontamination is not anticipated. Assuming that this procedure is ineffective in removing the contamination, the next approach consists of a more comprehensive washdown with an aqueous solution containing specialized chemicals or citric acid. This decontamination begins with water washing, followed by application of the chemical solution and completed by a water rinse. This technique would result in the generation of a chemical LLW stream presumed to be unsuitable for recycling. A modified version of this procedure would be employed in areas requiring remote operations.

Other types of decontamination procedures to be employed for specialized decontamination will include hands-on washdown of components exiting the fuel handling pools with demineralized water, remote spraying of components with recycle water or chemical solution, and vacuuming of potentially contaminated surfaces. Spray down with demineralized water would be performed above the waste transfer pools, with the wastewater stream entering the pool system. The pool water treatment system, in turn, processes this water stream. If during the course of this spray down over the pools, excess water is introduced into the pools, the excess water will be processed through the recycle water system for reuse in decontamination operations.

To establish the amount of secondary LLW generated by the various decontamination operations, the intuitive relationship of annual amount of LLW = (LLW generated/surface area) x (surface area) x (annual frequency of decon) is utilized.

The assumed quantities/surface area of secondary LLW generated as a result of application of each of these decontamination procedures are listed in Table 7.2-1. (Assumption 4.3.4)

Table 7.2-1 LLW Generation by Decontamination/Washdown Method

Decontamination Method	Type of LLW	DAW (Wiping) lbs/100 ft^2	Aqueous (Pool) gal/100 ft^2	Aqueous Recycle gal/100 ft^2	Chemical (Liquid) gal/100 ft^2
Small Scale Wipe Decon					
Rags	Solid	5.0	-	-	-
Swipes	Solid	5.0	-	-	-
Chemical/Detergent Decon					
Detergent/Chemical	Chemical	-	-	-	16.0
Water Rinse	Aqueous	-	-	24.0	-
Rags	Solid	1.0	-	-	-
Floor Washdown					
Detergent/Chemical	Chemical	-	-	-	16.0
Water Rinse	Aqueous	-	-	24.0	-
Rags	Solid	1.0	-	-	-
Above Pool Decon					
Demin. Water	Aqueous	-	20.0	-	-

The second step in establishing the annual rate of secondary LLW is to establish the surface areas of the various elements to be decontaminated. Table I-1, Attachment I presents the projected arrival of waste containers for processing at the MGR as identified in the CDA (Reference 5.6) (Assumption 4.3.5). Table I-1 also presents the sizes of the transportation casks (Assumption 4.3.6).

The first column of Table I-1 identifies the year in which the various transportation casks are anticipated. The second main column "TRUCK" refers to casks which will be trucked to the MGR. The subcolumns under this main column identify the various types of fuel to be trucked and the cask sizes associated with their transport. The size of the casks (length, diameter, and surface area) is identified beneath each type of fuel. The dimensions of the casks, i.e., the length and diameter, is taken from Reference 5.15 when identified in that reference. Additional cask dimensions are assumed, as necessary, to identify cask dimensions for all the various types of fuel shipments identified in the CDA (Assumption 4.3.6). The surface area of the cask is a calculated number generated in the following manner:

The transportation casks and DCs approximate right circular cylinders. From Reference 5.14, p. 2-6, the area of a circle is $\pi D^2 / 4$. The area of the lateral surface of a right circular cylinder, from Reference 5.14, p. 2-7, is 2π (radius)(altitude). Therefore, the total surface area of a right circular cylinder is:

$$A = 2(\pi D^2 / 4) + 2\pi (R)(h),$$

where:

A = area
R = radius
D = diameter ($D = 2 R$)
$\pi = 3.14$
h = height.

Using the GEN (Generic cask) 9 BWR fuel as an example:

the total surface area for the cask is approximately $\{[2 \times \pi \times (40.2\ \text{in}/12\ \text{in/ft})^2 / 4\ ] + [(2 \times \pi \times 40.2\ \text{in}/2)/12\ \text{in/ft}) \times 198.3\ \text{in}/12\ \text{in/ft}] = \}\ 191.4\ \text{ft}^2$.

For further explanation of Table I-1, the following discussion is provided. From Reference 5.6, there are 13 of these casks to be delivered by truck in the year 2010. Additionally, there will be 19 casks delivered containing GEN 4 (GA-4) PWR fuel. From Table I-1, the surface area for the GEN 4 PWR casks are 180.3 ft^2 each. The total surface area of casks to be trucked into the MGR in year 2010 would therefore be, approximately ($13 \times 191.4\ \text{ft}^2 + 19 \times 180.3\ \text{ft}^2 =$) 5913.9 ft^2, rounded to 5914 ft^2.

The total number of uncanistered fuel (UCF) casks arriving by rail is presented in the third main column "UCF." Using the year 2011 as example, the total surface area of casks containing uncanistered fuel to be received by rail is approximately 34,882 ft^2.

In a similar manner, the total surface area of canistered fuel (CF) is presented in the third main column of Table I-1 (second column of continuation page). This fuel will also be delivered by rail car. More importantly, this fuel will be contained in DPCs and will arrive with an outer-overpack shielded cask. The sizes and quantities of these outer casks is presented in the fourth main column. As an example, during the year 2010, there will be 25 of these shipments received with a total surface area of 12,957 ft^2.

The total surface area for decontamination associated with the processing of CF rail fuel is comprised of the surface area of the outer-overpack shielded cask plus the surface area of the DPC. For the purposes of this analysis, it is assumed that the surface area of a given DPC is the same as the surface area of the outer-overpack-shield-cask used for transport. (Assumption 4.3.7)

The last category of shipments is the DOE SNF/HLW shipments presented in the third column of the continuation of Table I-1, where for example, the total surface area of received casks in the year 2015 is 72,657 ft^2 for 137 casks.

The total surface area of emptied casks to be decontaminated would therefore be equal to the surface area of trucked casks + the surface area UCF rail casks + twice the surface area of CF rail casks (the DPC plus the overpack) + the surface area of HLW casks. For example, in the year 2018, the total surface area of arriving casks to be potentially decontaminated is approximately [21,097 ft^2 + 171,461 ft^2 + (2 x 20,200 ft^2) + 80,070 ft^2 =] 313,030 ft^2 (rounded). (Attachment I, page 3 of 4, next to last column of Table I-1)

In addition to decontamination activities associated with arriving SNF shipments, the potential exists for decontamination requirements on the DC prior to it being loaded onto the DC transporter. The surface area of these casks is presented in the fifth main column of the continuation of Table I-1, "Waste Packages". The quantity of DCs processed is taken from the CDA (Reference 5.6). The dimensions of the DCs are from Reference 5.25 (Assumption 4.3.8).

From Table I-1, the maximum surface area of transportation casks and DCs processed occurs in the year 2026, and is approximately 453,800 ft^2 for casks and DPCs, with the surface area for DCs being 185,312 ft^2 in year 2026. These areas form the basis for maximum LLW generation rates related to processing casks and DCs.

The second major component of decontamination is the washdown of WHB and WTB floor areas; this produces a significant amount of secondary LLW which will require treatment. It is assumed that the floor areas which will require decontamination are those floor areas within the WHB and the WTB which are within defined radiological areas (Assumption 4.3.9). The floor areas of the potentially contaminated spaces within the WHB and WTB are provided in Table 7.2-2.

These floor areas are taken from *Surface Nuclear Facilities Space Program Analysis,* DI:BCBD00000-01717-0200-00012, REV 01, Section 7.2 (Table 7.2-3) and 7.3 (page 94)

(Reference 5.16). The pool area to be washed down excludes the surface area of the three pools and the two Cross-Line Transfer Canals.

The floor areas from Reference 5.16 are the same as the present reference design, Viability Assessment (VA), and present projections on spent fuel delivery and processing. LLW generation rates, for both liquids and solids, are a direct function of square footages in radiological areas, and a direct function of spent fuel throughput. Future changes in the approved reference design or spent fuel throughput will directly impact the LLW generation rates defined in this analysis.

Table 7.2-2 WHB and WTB Floor Areas

FLOOR AREA	SQUARE FOOTAGE
WASTE HANDLING BUILDING	
PRIMARY AREAS	
Cask Prep	9,240
Pool Areas (Excluding Pool Water Surface Area)	8,658
Assembly Cell	8,910
DC Load and Decontamination Cell	4,450
Canister Transfer	11,500
DC Handling	61,100
WP Remediation	2,030
PRIMARY SUPPORT AREAS	24,500
POOL SUPPORT AREAS	8,020
WASTE TREATMENT BUILDING – Process Area	36,800
TOTAL WASHDOWN FLOOR AREA	175,208

Table 7.2-1 of Reference 5.16 provides the dimensions of the assembly transfer pools where:

	Length (ft)	Width (ft)
Cask Unloading Pool	30	15
Spent Fuel Storage Pool	24	21
Inter-Pool Transfer Canal	16	6
Cross-Line Transfer Canal	41	6.

The area of the Assembly Transfer Area is 12,300 ft^2 (Reference 5.16, Table 7.2-3)

Floor surface to be washed down is equal to

$$12{,}300 \text{ ft}^2 - 3 \times (30 \text{ ft} \times 15 \text{ ft} + 24 \text{ ft} \times 21 \text{ ft} + 16 \text{ ft} \times 6 \text{ ft}) - 2 \times (41 \text{ ft} \times 6 \text{ ft}) = 8{,}658 \text{ ft}^2$$

The final element necessary to determine LLW generation rates is the frequency at which the various decontamination activities are performed. Table I-2, Attachment I, presents the assumed frequencies for decontamination/floor washdown operations (Assumption 4.3.10). The LLW annual generation rates are then equal to: (decontamination application rate) x (surface area to be decontaminated) x (annual frequency of decontamination).

The following decontamination assumptions are utilized in the preparation of the estimate of waste generation quantities from decontamination/floor washdown used in Table I-2, Attachment I:

- It is assumed that year 2026, which has the highest total surface area of incoming casks represents a bounding case for design purposes of the generation of LLW.

- It is assumed that the solid LLW generation rate is 5 lb/100 ft^2 of surface area wiped during wipe decontamination. It is assumed that the solid LLW generation rate is 1 lb/100 ft^2 of surface area washed during wash decontamination.

- It is assumed that 5% of the SNF/HLW carriers will require decontamination, and that they have an average surface area of 400 ft^2. Of those carriers decontaminated, 80 percent will be decontaminated by wiping approximately 10 percent of the surface area, and 20 percent will be decontaminated by water washing 100 percent of the surface area.

- The following frequencies for floor washdown are assumed: Carrier Prep - 1/year; Assembly Transfer (Pool Areas - 1/month, Assembly Cell – 2/month, and DC Load/Decon – 2/year); Canister Transfer - 1/month; Disposal Container Handling - 2/year; Waste Package Remediation - 2/month; Primary Support Areas - 6/year; Pool

Support Area - 2/year; and, WTB Process Area - 1/year. When these areas are washed down, they will be 100 percent washed with 60 percent being water washed and 40 percent being chemical/detergent washed.

- It is assumed that the outer surfaces of incoming casks will be contamination free when they enter the WHB, and therefore, no additional decontamination will be required.

- It is assumed that all (100 percent) empty casks will require some form of decontamination.

  For casks used for uncanistered fuel, 100 percent will be washed down with demineralized water as they are removed from the waste transfer system pools. Five percent of these casks will require wipe decontamination over 5 percent of their surface area. Forty percent of these casks will require water wash over 100 percent of their surface area, and 20 percent will require chemical/detergent wash over 100 percent of their surface area.

  For empty casks which originally contained canistered SNF/HLW, and therefore were processed through the dry transfer lines, 5 percent will require wiping over 10 percent of their surface area. Ninety percent of these casks will require water washing over 100 percent of their surface area, and 10 percent will require chemical/detergent wash over 100 percent of their surface area.

- Pool tooling and miscellaneous items leaving the waste transfer system pools will receive 100 percent washdown with demineralized water as they leave the pool. The assumed quantity is 200, with an assumed surface area of 200 ft^2/unit.

- Pool yokes leaving the waste transfer system pools will receive 100 percent washdown with demineralized water as they leave the pools. The assumed quantity is 40, with an assumed surface area of 400 ft^2/unit.

- The DC top, after fuel loading, but prior to welding, will be decontaminated by vacuuming. The assumed surface area is 50 ft^2/top.

- One hundred percent of the DCs will be decontaminated before transfer to subsurface. Eighty percent will receive water wash over their entire exterior surface area. Twenty percent will receive chemical decontamination over their entire exterior surface area

- Fixtures and miscellaneous items, used in the canister transfer lines, will require decontamination every 6 months, on the average. The assumed surface area is 400 ft^2/unit. Twenty percent of the fixtures will be wiped over 10 percent of their surface area. Sixty percent of the fixtures will be water washed over 100 percent of their surface area, and 40 percent will be chemical/detergent washed over 100 percent of their surface area.

- Ten percent of the DC Handling Collars will require decontamination annually over their assumed surface area of 200 ft^2/unit. Ninety percent of these collars will be water washed over 100 percent of their surface area, and 10 percent will be chemical/detergent washed over 100 percent of their surface area.

Two examples are presented below which illustrate how the overall LLW generation rates are presented in Table I-2 of Attachment I.

EXAMPLE 1 - FLOOR WASHDOWN

For example, the floor in the Canister Transfer area will be washed down once per month. From Table I-2, this area has a surface area of 11,500 ft^2 (fifth column of Table I-2). This equates to an annual area of washdown of (12 x 11,500 ft^2 =) 138,000 ft^2/yr. The amount of this floor area which is washed down is 100 percent (8th column of Table I-2).

Three LLW streams will be generated from the washdown of the canister transfer area floor: solid LLW such as rags and paper towels used by personnel; recyclable liquid; and, chemical/detergent liquid.

Solid LLW

Using the assumed solid LLW generation rate of 1 lb/100 ft^2 of washed floor area (Assumption 4.3.10), the solid LLW generated by the washdown of the Canister Transfer area is approximately [(138,000 ft^2/yr/100 ft^2) x (1 lb solid/ 100 ft^2) =] 1,380 lb/yr solid LLW.

Recyclable Liquid Waste

The assumed type of decontamination agent is 60 percent water and 40 percent chemical/detergent (10th and 11th columns, respectively). (Assumption 4.3.10) Using the floor washdown aqueous recyclable rate (Table 7.2-1) of 24 gal/100 ft^2, the total annual volume of recycle water (15th column) is approximately (138,000 ft^2/yr x 0.60 x 24 gal/100 ft^2 =) 19,872 gal/yr.

Chemical/Detergent Liquid LLW

The assumed type of decontamination agent is 60 percent water and 40 percent chemical/detergent (10th and 11th columns, respectively). (Assumption 4.3.10) Using the floor washdown chemical liquid rate (Table 7.2-1) of 16 gal/100 ft^2, the total annual volume of recycle water (15th column) is approximately (138,000 ft^2/yr x 0.40 x 16 gal/100 ft^2 =) 8,832 gal/yr.

Example 2 - LLW Generated in Decontaminating Outgoing Casks in the Assembly Transfer Lines

The maximum quantity of outgoing casks is 429, in year 2026. This number is derived from Table I-1, and is the sum of UCF rail casks and CF rail casks received in the year 2026 (the emplacement year producing the largest cask surface area processed). It is assumed (Assumption 4.3.10) that 100 percent of the outgoing casks receive some form of decontamination (increasingly severe as required). All casks receive a washdown with demineralized water as they are withdrawn from the assembly transfer pools. The casks will then be allowed to dry and then surveyed prior to release. It is assumed (Assumption 4.3.10) that following the survey, additional decontamination will be required before these casks can be released.

Recyclable Liquid Waste

From Table I-2, 40 percent of the outgoing casks receive decontamination water which sprays 100 percent of the surface area of the casks to be decontaminated. This equates to approximately (192,243 ft^2/yr x 100% x 40% x 24 gal/100 ft^2 =) 18,455 gal/yr.

Chemical/Detergent Liquid LLW

From Table I-2, 20 percent of the outgoing casks receive additional water decontamination which sprays 100 percent of the surface area of the casks to be decontaminated. This equates to approximately (192,243 ft^2/yr x 100% x 20% x 16 gal/100 ft^2 =) 6,152 gal/yr.

Solid LLW

Solid LLW is generated during both recyclable water decontamination and chemical/detergent decontamination at a rate of 1 lb solid LLW/100 ft^2 decontaminated. Additionally, a small percentage (5 percent) of the casks will require spot decontamination before they are released. This spot decontamination is assumed to generate 5 lb of solid/100 ft^2 of surface area. It is also assumed that spot decontamination is only applied to 5 percent of the surface area of any given cask. The approximate amount of solid LLW generated during the decontamination of outgoing casks is therefore:

[(192,243 ft^2/yr x 100% x 40% x 1 lb/100 ft^2) + (192,243 ft^2/yr x 100% x 20% x 1 lb/100 ft^2) + (192,243 ft^2/yr x 5% x 5% x 5 lb/100 ft^2) =] 1,177.4 lb/yr, rounded to 1,177 lb/yr.

From Table I-2, the estimated rounded total quantities of solid LLW, recyclable liquid, and chemical/detergent LLW are 14,314 lbs/yr, 217,127 gal/yr, and 74,219 gal/yr, respectively, for the reference year 2026.

Overpacks, casks, DPCs, fuel assemblies, and handling equipment will be washed down with deionized and/or recycled water as these items are removed from the waste transfer pools. From Assumption 4.3.10, it is assumed that 100 percent of the casks are rinsed down with deionized water at a rate of 20 gal/100 ft^2 of surface area. From Table I-2, Attachment I, the following maximum annual surface area will be washed:

Outgoing Casks	192,243 ft^2
DPC Overpacks	182,547 ft^2
Pool Tooling & Misc.	40,000 ft^2
Pool Yokes	32,000 ft^2
total	446,790 ft^2

This results in approximately (446,790 ft^2 x 100% x 20 gal/100 ft^2 =) 89,358 gallons of water being introduced into the assembly transfer pools.

The *Site Gas/Liquid Systems Technical Report* (Reference 5.17) discussed the amount of estimated water loss from the waste transfer pools as a result of evaporation in Section 7.1.6.1 of that report at approximately 11 gal/hr. This represents an approximate annual evaporation loss of

(11 gal/hr x 24 hr/day x 365 day/yr =) 96,360 gal/yr. This volume is greater than the amount to be added by washdown. If washdown water volume increases beyond the evaporation rate for the pools, excess water can be processed as recyclable waste water for reuse.

7.2.2 Dry Active Waste

In addition to the solid LLW generated by decontamination and washdown operations, other solid LLWs are produced as a result of routine operations. These wastes are classified as DAW and include items such as paper, plastics, rags, rubber gloves, wood, HEPA filters, etc. This DAW can be further classified into two main categories: compactible waste and non-compactible waste. The volumes of these two classifications of waste are estimated in the following discussion.

<u>Compactible DAW</u>

DAW is generated for each cask handling operation. It is assumed that the average cloth (rags), plastic, and paper DAW generated through the processing of SNF/HLW through the MDGS system is 20 ft^3 of DAW/incoming cask (Assumption 4.3.11). The maximum number of casks to be received, from Table I-1, is 696 casks received in 2016. Therefore the amount of DAW to be dispositioned as a result of spent fuel processing operations is approximately (20 ft^3/ cask x 696 casks =) 13,920 ft^3. (See footnote 5)

DAW is generated by normal activities performed by operations and maintenance personnel through the process of changing into and out of anti-C protective clothing. This DAW is composed of surgical type rubber gloves, respirator paper filters, masking tape, etc. It is assumed that 100 ft^3/operating person/year is generated on an annual basis (Assumption 4.3.11).

From Table 7.2-3 (taken from data contained in Reference 5.19, Table 6-1), the 143 operating personnel are anticipated to generate DAW from wearing of anti-C clothing. The estimated annual compactible DAW from operational personnel is therefore (143 personnel x 100 ft^3 / operating person / year =) 14,300 ft^3/yr.

Compactible cloth, plastic, and paper DAW are generated during the course of decontamination and washdown activities. From Table I-2, the maximum rate, during year 2026, generated is 14,314 lb/yr. It is assumed that this DAW has a density of approximately 6 lb/ft^3 (Assumption 4.3.12). Therefore, the volume of this DAW is approximately (14,314 lb/yr / 6 lb/ft^3 =) 2385.7 ft^3/yr, rounded to 2390 ft^3/yr.

The total compactible cloth, plastic, and paper DAW is equal to the sum of these DAW generation sources, and is estimated at (13,920 ft^3/yr + 14,300 ft^3/yr + 2390 ft^3/yr =) 30,610 ft^3/yr.[7] From Assumption 4.3.11, based on Reference 5.20, the amount of cloth, plastic, and paper accounts for approximately 70% of the compactible DAW generated. Therefore, the total predicted annual compactible DAW is estimated at (30,610 ft^3/yr / 0.70 =) 43,728 ft^3/yr, rounded to 43,700 ft^3/yr.

Table 7.2-3 WHB and WTB Operator Headcount

WHB OPERATION	STAFF PERSONNEL	WTB OPERATION	STAFF PERSONNEL
Carrier Bay Operations	6	Process Operators	26
Assembly Transfer Oper.	54		

[7]It is recognized that the DAW rate from decontamination/floor washdown and other decontamination activities is taken from data for year 2026, while the DAW rate for cask handling operations is taken from year 2016. Since cask handling operations generates substantially more DAW than washdown, it is believed justifiable to use the maximum quantities (irregardless of year generated) for this summation. (Assumption 4.3.20)

WHB OPERATION	STAFF PERSONNEL	WTB OPERATION	STAFF PERSONNEL
Canister Transfer Oper.	9		
DC Handling Oper.	48		
WHB Total	117	WTB Total	26
TOTAL RADIATION WORKERS		143	

Non-Compactible DAW

Insufficient engineering detail exists on the WHB and WTB facilities and systems at this time to define the amount of non-compactible DAW (e.g., mechanical equipment being replaced, pipes, metal filter housing, etc.) to be generated from a reliability or maintenance basis. Historically, non-compactible DAW at power plants has accounted for anywhere from 19 percent to 57 percent of the total DAW, with PWRs averaging 52 percent and BWRs averaging 36 percent (Tables 2-6 and 2-7 of *Identification of Radwaste Sources and Reduction Techniques,* EPRI, Reference 5.21) . For the purpose of this analyses, it is assumed that non- compactible DAW represents 44 percent (the mid-point between BWRs and PWRs) of the total DAW (Assumption 4.3.13) . Non-compactible DAW would therefore be approximately equal to

[(compactible DAW)/(1 - 0.44)] x 0.44.

This calculates to approximately [0.44 x (43,700 ft^3/yr)/(0.56) =] 34,336 ft^3/yr, rounded to 34,300 ft^3/yr.

Total DAW

The total DAW is equal to the sum of compactible DAW and non-compactible DAW, which totals (43,700 ft^3/yr + 34,300 ft^3/yr =) 78,000 ft^3/yr.

7.2.3 Wet Solid LLW

Two forms of wet solid LLW which be generated as a result of processing SNF/HLW through the WHB. These two materials are the ion exchange resins (from the WHB's waste transfer pools' water treatment system and the WTB water recycle system), and the cartridge filters (from those same two systems).

Because there is no available data on what the pool water or recycle water solids and dissolved solids characteristics might be, it is assumed that the resin quantities generated will be equivalent to or less than that generated by the average PWR. From Reference 5.21, Table 3-2A, page 3-46, the average resin volume from a PWR is 1,295 ft^3/yr. It is assumed that the cartridge filter volume is equal to the resin volume. (Assumption 4.3.14)

The total wet solid LLW is therefore estimated at (2 x 1,295 ft^3/yr =) 2590 ft^3/yr, rounded to 2600 ft^3/yr.

7.2.4 Dual-purpose Canisters

Sealed DPCs containing SNF will be welded shut when they arrive at the MGR. These canisters will be placed into the waste transfer pool system within the WHB to be cut open to allow extraction of the fuel assemblies. After retrieval of the fuel from the DPC, there is no planned use for the spent canister, and it becomes solid radioactive LLW at that point in time.

Assuming that the fuel inside the DPC experienced no significant fuel cladding failures during loading, storage, or transit, the inside surface of the DPC will be contaminated with some amount of spalled or scraped off fuel crud (Assumption 4.3.15). This crud is scale that was deposited onto the fuel cladding surfaces during use inside a nuclear reactor. This crud has various composition, which is primarily a function of whether it is BWR or PWR fuel. In either case, the crud will contain activation products (e.g., ^{60}Co) and may contain soluble fission products (e.g., ^{137}Cs). Additional discussion on fuel crud is presented in Section 7.3.

Per the requirement invoked by Key Assumption 024, CDA, Reference 5. 6 and 49 CFR 173 *Shippers – General Requirements for Shipping and Packaging* (Section 4.4.1), used dual-purpose canisters (DPCs) will be prepared for off-site recycling. The waste generation rates estimated above in this section accounted for the external surface decontamination of the DPCs. However, the actual pathway for the disposal of the used DPCs has not been defined. Options being studied include:

Sealing the DPC for burial

Filling the DPC with LLW and then sealing it for burial

DPC size reduced and packaged for burial

Thorough decontamination onsite sufficient for the DPC to be recycled as non-radioactive scrap

Transfer of the DPC offsite for recycling (minimal onsite decontamination)

Because the ultimate disposition pathway for the DPC has not been precisely defined, the potential amount of LLW generated during DPC handling cannot be defined. From Table I-1, Appendix I, the total estimated number of DPCs to be disposed of is 3,493 (the number of canistered rail shipments which bounds the number of DPC shipments).

As discussed earlier in this subsection, it is anticipated that the DPCs will be contaminated with only small amounts of fuel crud containing activation and/or soluble fission products, which would result in the DPC being classified as LLW. There is a reasonable probability that a fuel assembly may have substantial cladding failure while within a DPC. If this occurs, the DPC may become sufficiently contaminated that it will have to be treated as TRU waste. Because there is insufficient performance data on how well large numbers of fuel assemblies will survive packaging in DPCs and transit to the MGR, there is no way of predicting the potential quantity of DPCs to be contaminated in this way. Provisions, both operational and equipment, should be allocated to the WHB to accommodate this potential occurrence.

7.2.5 Summary LLW Quantities

Table 7.2-4 presents a summary of the estimated maximum secondary LLW to be generated on an annual basis (reference year 2026) by the processing of SNF/HLW through the MGR.

The waste volumes associated with the 3,493 DPCs to be decontaminated and/or disposed of are not included in these waste volumes. The waste volumes identified are believed bounding for total operational liquid and solid wastes and should, therefore, include any anticipated quantities generated by DPC disposal.

Table 7.2-4 Secondary LLW Generation Rate Estimate (Summary)

LLW Stream:	Waste Rate
Recyclable Aqueous (gal/yr)	217,127
Chemical Aqueous (gal/yr)	74,219
Compactible DAW (ft^3/yr)	43,700
Non-Compactible DAW (ft^3/yr)	34,300

Spent Resin (ft^3/yr)	1,295
Cartridge Filters (ft^3/yr)	1,295

7.2.6 Other Radiological Waste Forms

The objective of this analysis is to quantify the quantities of LLW to be generated due to site operations at the MGR. Additional very low volumes of radiological waste forms will probably be generated on an irregular frequency. This section defines what is believed to be bounding annual projections of the quantities of these waste forms.

The production of mixed waste will be administratively controlled through the use of non-hazardous materials in MGR operations to prevent the inadvertent mixing of hazardous materials with radiological wastes. Even with these administrative controls, small amounts of mixed wastes may be generated; for example, the leakage of motor oil from a transport vehicle temporarily within the WHB. The assumed maximum quantities of mixed waste are 11 ft^3 of solid mixed waste and 32 gallons of liquid mixed waste (Assumption 4.3.21).

7.3 WASTE CHARACTERIZATION

This section addresses, in an overview manner, the radiological characteristics of the various LLW streams anticipated from the processing of SNF/HLW for disposal at the MGR.

It is anticipated that the secondary radioactive wastes generated during the course of repackaging SNF/HLW for disposal will be primarily contaminated with minor levels of activation products (e.g., ^{60}Co) and water soluble fission products (e.g., ^{137}Cs). The majority of this contamination will enter the system as crud, i.e., inorganic layers deposited on the fuel assembly surfaces as a result of their use within a power reactor. An additional small amount of contamination, e.g., ^{137}Cs, may result from the leaching of soluble fission products into the waste transfer pool from small fuel cladding failures.

Fuel cruds have varying compositions, thicknesses, adherence properties, and range of particle sizes after spallation. A number of partially successful correlations have been developed to predict fuel crud properties as a function of fuel type (BWR or PWR), fuel cladding material, reactor operating parameters, and water chemistry, etc. In addition, fuel crud adherence appears to change over time as the fuel is in wet storage, moved to dry storage or allowed to dry out, and/or subsequently handled (Page 15 of Reference 5.23, *Comments of Fuel Crud as a Safety and Operational Factor of Independent Spent Fuel Storage Installations (ISFSI)*. Since the fuel to be introduced into the waste transfer pool system for repackaging is a mixture of fuel types from various operating environments, with significant variations in post-reactor storage, any attempt to predict fuel crud performance inside the waste transfer storage pools or as fuel is being moved for placement into waste packages would have minimal success. It can be stated that some particulate material of varying composition will spall off the fuel assemblies during their movement and temporary storage within the waste transfer system pools. Fuel cruds typically contain the following constituents:

Al_2O_3	Fe_3O_4	$Co(OH)_2$	$Ni(OH)_2$
NiO	ZrO_2	$NiFe_2O_4$	MnO_2
CuO	Fe_2O_3	$Fe(OH)_2$	

These compounds are essentially insoluble in water, therefore if they spall off the fuel assembly surfaces, they will result in particulate materials being introduced into the pools. NUREG/CR-0163, Reference 5.23, Table A7, indicates that these particles typically run in the 1-5 micron range, with a small distribution of larger particles. These particles will be picked up in the cartridge filter system of waste transfer pools' treatment systems. The primary radioactive constituent of this particulate material will be ^{60}Co. (Reference 5.23)

Additional minor amounts of contamination enter the facility through contamination on the outer surfaces of casks. Even though casks will be surveyed and decontaminated as needed prior to shipment to the MGR, minor amounts of surface contamination may be encountered due to the phenomena of weeping of casks (Reference 5.24). Weeping is the result of radionuclides (primarily ^{60}Co) being sorbed below the surface and then migrating to the surface. Typically these small surface contaminations are smearable and easily removed with detergents and/or weak acids (citric acid is typically used because it exhibits chelating characteristics).

7.3.1 Radiological Characteristics of Dry Active Waste

DAW is a mixture of materials, with the compactible portion primarily being comprised of paper, plastic, and cloth. Although a repository like the MGR has never been operated, it is reasonable to assume that the DAW characteristics for the MGR will be similar to those for power reactors. (Assumption 4.3.16)

Reference 5.21 (Volume 2, page 4-15 for PWR and page 4-27 for BWR) identifies the characteristics for typical BWR and PWR DAW as identified in Table 7.3-1.

Table 7.3-1 Typical Reactor DAW

Reactor Type	DAW Type	Specific Activity (mCi/ft^3)	Isotopic Distribution (%)	Radiation Levels (As Shipped)
PWR	Compactible	0.7	^{60}Co – 41% ^{137}Cs – 16%	21 mR/hr
	Non-compactible	0.4	^{60}Co – 43% ^{137}Cs – 13%	17 mR/hr
BWR	Compactible	0.25	^{60}Co – 56% ^{137}Cs – 16%	17 mR/hr
	Non-compactible	0.20	^{60}Co – 55% ^{137}Cs - 17%	15 mR/hr

7.3.2 Liquid Low-Level Waste Radiological Characteristics

Although specific decontamination levels cannot be defined, and therefore liquid LLW radiological characteristics cannot be estimated, it is assumed that the average liquid LLW generated will have the following radiological characteristics:

Dose Rates - 5 mR/hr (contact)

Specific Activity - ^{60}Co - 1 x 10^{-3} micro Ci/ml
^{137}Cs -1.5 x 10^{-3} micro Ci/ml

(Assumption 4.3.17)

These levels are slightly higher than the average, but within the range typically experienced within fuel storage basins (Appendix B, Section 4.4.2.1)

7.3.3 Wet Solid Low-Level Waste

Wet solid LLW will be generated from filter cartridges and ion exchange resins used in pool water treatment and decontamination water recycle. It is envisioned that the bulk of this waste will be generated at the primary point of contamination, i.e., the waste transfer pools. As discussed above in this section, fuel cruds typically contain compounds essentially insoluble in water, therefore if they spall off the fuel assembly surfaces, they will result in particulate materials. These particles will be picked up in the cartridge filter system of the waste transfer pools' treatment systems. The primary radioactive constituent of this particulate material will be ^{60}Co (Reference 5.23). There is no way of predicting how much of this material may collect on a given filter cartridge before the filter would need to be changed out due to pressure drop across the cartridge. And more importantly, there is no way of predicting what the radioactive isotopic content of the cartridge would be. Appendix B of ANSI/ANS 57.7 (Section 4.4.2.1) recommends a design source term in the 1×10^4 mR/hr, 10 R/hr, range for shielding purposes for waste filter cartridges from water purification systems. For the purpose of establishing waste characterization properties, and waste handling requirements, it is assumed that filter cartridges will be administratively controlled below 10 R/hr. That is, if a filter cartridge does not load up with particulate material sufficient to require changeout due to pressure drop, the filter cartridge will be changed out as it approaches the 10 R/hr limit. (Assumption 4.3.18)

The other source of solid LLW from the waste transfer pools' treatment system will be ion exchange resin which is used to remove soluble constituents, both radioactive and non-radioactive from the pool water. As with the fuel crud, there is no way of predicting how much radioactive material (primarily Cs isotopes) will be placed into the pool systems from the fuel being processed at any given time. Appendix B of ANSI/ANS 57.7 (Section 4.4.2.1) recommends a design source term in the 1×10^4 mR/hr, 10 R/hr, range for shielding purposes for ion exchange resin units cartridges from water purification systems. For the purpose of establishing waste characterization properties and waste handling requirements, it is assumed that ion exchange resins will be administratively controlled below 10 R/hr. That is, if a ion exchange unit does not reach ionic breakthrough before 10 R/hr, the resin unit will be changed out as it approaches the 10 R/hr. (Assumption 4.3.19)

8. CONCLUSIONS

The results of this analysis are considered preliminary and will not be used directly for procurement, fabrication, or construction.

Certain of the references used in the preparation of this analysis were prepared for VA and contain preliminary data which is not tracked using the formal TBV/TBD process. However, potential alterations to these inputs will not impact the conclusions reached within this report.

This design analysis presents an update of the estimated secondary LLW generation rate for the processing of SNF/HLW through the MGR. It is anticipated that under normal operation, only LLW will be directly generated by the SNF/HLW repackaging and disposal operations. It is not anticipated that hazardous or mixed waste will be generated through routine operations surrounding SNF/HLW disposal. The possibility does exist for the reception of severely damaged fuel which may go undetected during the initial cask sampling. This could result in the generation of TRU waste. Provisions should be accommodated within the WHB for this off-normal occurrence.

LLW generation rate estimates are as follows:

Recyclable Liquid:	217,127 gal/yr
Chemical Aqueous:	74,219 gal/yr
Compactible DAW:	43,700 ft^3/yr
Non-Compactible DAW:	34,300 ft^3/yr
Spent Ion Exchange Resin:	1,295 ft^3/yr
Cartridge Filters:	1,295 ft^3/yr
DPCs:	3,493 (over 2010 - 2033 period)

For liquid waste streams, these rates are for the year 2026 in which it is anticipated that operations will generate the largest quantities of liquid LLW. The DAW waste stream rates are for year 2016 in which it is anticipated that operations will generate the largest volume of DAW. Per the guidance provided in CDA Key 001, Exceptions 1 , 2, and 3, design studies utilizing the developed LLW generation rates contained in this analysis should design sufficient spare capacity to accommodate higher peak rates. Using a 20 percent design factor, the design LLW rates are:

Recyclable Liquid:	260,600 gal/yr
Chemical Aqueous:	89,100 gal/yr
Compactible DAW:	52,400 ft^3/yr
Non-Compactible DAW:	41,200 ft^3/yr
Spent Ion Exchange Resin:	1,550 ft^3/yr
Cartridge Filters:	1,550 ft^3/yr
DPCs:	3,493 (over 2010 - 2033 period)

The primary radioactive constituents of the contamination in the LLW will be Cs and Co. Additional minor amounts of reactor activation products and fission products will be present in the contamination.

It is expected that the majority of the LLW will meet the criteria for Class A (NRC) designation. The ion exchange resins and cartridge filters are anticipated to be Class C or greater. Waste class is defined in 10 CFR 61 Section 61.55.

9. ATTACHMENTS

ATTACHMENT	DESCRIPTION
I	Table I-1 Annual Surface Area of Casks and Waste Packages Processed Table I-2 Secondary Waste Generation from Decontamination/Floor Washdown Operations

APPENDIX A

ACRONYMS AND ABBREVIATIONS

Al	aluminum
Am	americium
ANS	American Nuclear Society
ANSI	American National Standards Institute
Bk	Berkelium
BWR	boiling water reactor
CDA	Controlled Design Assumptions
Cf	californium
CF	canistered fuel
CFR	Code of Federal Regulations
Ci	curie
Cm	Curium
Co	cobalt
CPB	Carrier Preparation Building
CRWMS	Civilian Radioactive Waste Management System
Cs	cesium
Cu	copper
CWA	Clean Water Act
DAW	dry active waste
DC	disposal container
DCN	document change notice
DOE	U. S. Department of Energy
DPC	dual-purpose canister
EBDRD	Engineered Barrier Design Requirements Document
EPRI	Electric Power Research Institute
Fe	iron
ft	foot
FTE	full time equivalent
gal	gallon
GEN	Generic Cask
GROA	Geologic Repository Operations Area

H	hydrogen
HEPA	high-efficiency particulate air
HH	high heat
HLW	high-level waste
hr	hour
in	inch
LA	license application
lb	pound
LLW	low-level waste
M&O	management and operating
mCi	millicurie
MGDS	Mined Geological Disposal System
MGDS-RD	Mined Geological Disposal System Requirements Document
MGR	Monitored Geologic Repository
ml	milliliter
mm	millimeter
Mn	manganese
mR	millirad
MTU	metric ton uranium
Ni	nickel
NLP	Nevada Line Procedure
Np	neptunium
NRC	Nuclear Regulatory Commission
NTS	Nevada Test Site
NUREG	NRC Regulatory Guide
O	oxygen
OD	outer diameter
OL	outer length
PCB	polychlorinated biphenyl
Pu	plutonium
PWR	pressurized water reactor
QA	quality assurance
QAP	quality administrative procedure
QARD	Quality Assurance Requirements and Description Document
R	rad
RCRA	Resource Conservation and Recovery Act

RSC	Regional Service Contractor
SDD	system description document
SNF	spent nuclear fuel
SNL	Sandia National Laboratory
ST	South Texas
TBD	to be determined
TBV	to be verified
TRU	transuranic
UCF	uncanistered fuel
UTS	utility transfer system
VA	Viability Assessment
WAC	waste acceptance criteria
WHB	Waste Handling Building
WHF	Waste Handling Facility
WTB	Waste Treatment Building
yr	year
YMP	Yucca Mountain Project
Zr	zirconium

Table I-1 Annual Surface Area of Casks and Waste Packages Processed

YEAR/Cask Type	TRUCK								UCF RAIL								
Cask I.D.:	GEN	GEN	GEN	GEN	HH	HH		TOTAL TRUCK CASKS	LG GEN	LG GEN	SM GEN	SM GEN	HH	HH	LG ST		TOTAL UCF RAIL CASKS
Fuel Capacity:	9 BWR	7 BWR	4 PWR	3 PWR	7 BWR	3 PWR			61 BWR	26 PWR	24BWR	12 PWR	17 BWR	7 PWR	12 PWR		
Cask L (In):	198.3	198.3	187.8	187.8	198.3	187.8			210.0	193.0	201.5	203.8	203.8	203.8	233.2		
Cask Dia. (In):	40.2	40.2	39.8	39.8	40.2	39.8	Total		97.6	99.0	92.5	67.7	67.7	67.7	87.8	Total	
Area (ft^2):	191.4	191.4	180.3	180.3	191.4	180.3	Area (ft^2)		550.8	523.5	499.7	350.8	350.8	350.8	530.5	Area (ft^2)	
2010	13	0	19	0	0	0	5,914	32	0	0	0	0	0	0	0	0	0
2011	14	0	18	0	0	0	5,925	32	10	16	35	10	0	0	0	34,882	71
2012	34	0	15	0	0	0	9,213	49	15	36	53	51	0	0	7	75,198	162
2013	13	0	61	0	0	0	13,484	74	17	58	81	77	0	0	14	114,644	247
2014	12	0	67	14	0	2	17,258	95	38	85	137	140	0	35	0	195,283	435
2015	22	4	59	0	0	1	15,793	86	36	90	109	142	1	24	17	189,019	419
2016	16	0	53	0	0	48	21,269	117	42	77	123	133	4	26	7	185,806	412
2017	4	13	63	7	6	7	18,283	100	29	86	100	115	3	43	14	174,875	390
2018	13	35	31	11	1	23	21,097	114	36	86	96	123	6	20	12	171,461	379
2019	4	31	18	21	1	40	21,132	115	30	78	74	93	1	32	13	145,436	321
2020	25	0	31	36	3	14	19,961	109	30	77	50	66	5	32	7	121,667	267
2021	12	0	46	13	3	15	16,211	89	24	64	33	74	7	11	8	99,733	221
2022	25	0	44	36	2	3	20,130	110	29	67	22	51	9	20	11	95,943	209
2023	32	0	27	28	4	17	19,870	108	22	67	29	32	7	31	8	90,485	196
2024	27	0	28	15	2	21	17,088	93	24	54	23	41	6	7	10	77,231	165
2025	15	42	49	11	4	3	23,034	124	16	52	14	39	5	10	9	66,750	145
2026	0	0	0	0	0	0	0	0	10	8	0	0	0	0	0	9,696	18
2027	0	0	0	0	0	0	0	0	3	34	0	0	0	0	0	19,451	37
2028	0	0	0	0	0	0	0	0	5	24	0	0	0	0	0	15,318	29
2029	0	0	0	0	0	0	0	0	3	14	0	0	0	0	0	8,981	17
2030	0	0	0	0	0	0	0	0	7	26	0	0	0	0	0	17,466	33
2031	0	0	0	0	0	0	0	0	3	40	0	0	0	0	0	22,592	43
2032	0	0	0	0	0	0	0	0	82	182	0	0	0	0	14	147,868	278
2033	0	0	0	0	0	0	0	0	58	109	0	0	0	0	3	90,598	170
Total:	281	125	629	192	26	194	265,663	1,447	569	1,430	979	1,187	54	291	154	2,170,385	4,664

Cask Dimensions are from Reference 5.13

Table I-1(cont.) Annual Surface Area of Casks and Waste Packages Processed

YEAR/Cask Type	RAIL - CANISTERED									HLW & DSNF				TOTAL ALL CASKS
Cask I.D:	LG	LG	MED	MED	SM	SM	LG		TOTAL RAIL CASKS	HLW	DSNF	TOTAL		
Fuel Capacity:	61 BWR	24 PWR	44 BWR	21 PWR	24 BWR	12 PWR	22 BP							
Cask L (In):	210.0	210.0	205.2	205.2	203.8	203.8	233.2			233.2	225.0			
Cask Dia. (In):	97.6	97.6	87.8	87.8	67.7	67.7	87.8	Total		87.8	90.0		Total	
Area (ft^2):	550.8	550.8	476.9	476.9	350.8	350.8	530.5	Area (ft^2)		530.5	529.9		Area (ft^2)	
2010	5	9	4	7	0	0	0	12,957	25	0	1	1	530	58
2011	0	6	0	0	0	0	0	3,305	6	0	1	1	530	110
2012	0	2	0	0	0	0	0	1,102	2	0	3	3	1,590	216
2013	0	16	0	0	8	0	0	11,619	24	0	6	6	3,179	351
2014	0	5	0	0	4	0	1	4,688	10	0	8	8	4,239	548
2015	1	4	0	0	8	0	1	6,091	14	100	37	137	72,657	656
2016	0	7	0	0	10	4	1	9,298	22	100	45	145	76,896	696
2017	0	8	12	3	16	3	1	18,756	43	92	46	138	73,182	671
2018	2	5	3	4	24	4	6	20,200	48	92	59	151	80,070	692
2019	0	15	10	22	41	6	2	41,073	96	92	61	153	81,130	685
2020	6	22	23	26	38	8	0	54,929	123	92	62	154	81,660	653
2021	7	27	38	34	47	8	0	72,360	161	92	62	154	81,660	625
2022	2	25	23	47	68	12	0	76,321	177	92	48	140	74,241	636
2023	9	30	30	52	43	15	0	80,935	179	92	48	140	74,241	623
2024	9	39	43	56	40	12	0	91,895	199	92	53	145	76,891	602
2025	13	36	46	39	95	21	0	108,222	250	92	58	150	79,540	669
2026	33	81	52	70	143	31	1	182,547	411	92	57	149	79,010	578
2027	20	39	55	103	136	24	4	166,102	381	92	55	147	77,951	565
2028	26	54	59	100	88	19	1	157,960	347	92	55	147	77,951	523
2029	30	76	49	96	77	18	1	161,394	347	92	89	181	95,966	545
2030	51	76	21	94	64	11	2	152,167	319	92	95	187	99,146	539
2031	42	86	22	71	56	24	1	143,450	302	91	90	181	95,966	526
2032	0	3	0	0	0	0	3	3,244	6	42	101	143	75,799	427
2033	0	0	0	0	0	0	1	531	1	42	63	105	55,664	276
Total:	256	671	490	824	1,006	220	26	1,581,143	3,493	1,663	1,203	2,866	1,519,687	12,470

Table I-1(cont.) Annual Surface Area of Casks and Waste Packages Processed

YEAR/Cask Type	WASTE PACKAGES								TOTAL WP OUT	TOTAL CASK/DPC AREA (ft^2) (See Note *)	TOTAL WP AREA (ft^2)
Cask I.D:	LG WP	LG WP	SM WP	SM WP	ST-WP	HLW &	DSNF				
Fuel Capacity:	44 BWR	21 PWR	12 PWR	24 BWR	12 ST	DSNF					
Cask L (In):	210.0	210.0	210.0	210.0	231.1	211.3	242.7				
Cask Dia. (In):	63.1	65.5	52.0	52.7	53.1	78.6	77.1	Total			
Area (ft^2):	332.4	346.7	267.6	271.6	298.3	429.5	472.8	Area (ft^2)			
2010	14	21	2	0	0	0	1	12,942	38	32,357	12,942
2011	37	36	2	0	0	0	1	25,787	76	47,946	25,787
2012	58	75	9	0	7	0	3	51,195	152	88,204	51,195
2013	75	132	23	0	15	0	6	84,159	251	154,546	84,159
2014	133	202	30	0	0	0	8	126,050	373	226,156	126,050
2015	123	206	22	0	12	100	40	183,634	503	289,651	183,634
2016	137	191	32	0	8	100	56	192,134	524	302,566	192,134
2017	122	198	32	0	15	92	33	177,353	492	303,852	177,353
2018	135	189	31	0	12	92	65	192,521	524	313,029	192,521
2019	123	195	35	0	13	92	49	184,416	507	329,844	184,416
2020	130	194	36	0	8	92	50	185,645	510	333,145	185,645
2021	128	193	29	5	8	92	50	184,118	505	342,323	184,118
2022	117	195	38	15	11	92	31	178,191	499	342,956	178,191
2023	123	204	25	1	9	92	31	175,428	485	346,467	175,428
2024	127	196	26	8	10	92	36	178,815	495	354,999	178,815
2025	150	179	26	12	10	92	41	184,016	510	385,767	184,016
2026	188	191	0	2	0	92	35	185,312	508	453,800	185,312
2027	164	204	0	1	0	92	31	179,680	492	429,606	179,680
2028	152	203	0	1	0	92	31	175,345	479	409,189	175,345
2029	137	212	0	1	0	92	51	182,937	493	427,736	182,937
2030	139	222	0	2	0	92	58	190,650	513	420,946	190,650
2031	116	233	0	1	0	91	58	186,118	499	405,457	186,118
2032	116	230	0	0	14	42	71	174,084	473	230,155	174,084
2033	82	138	0	0	3	42	47	116,257	312	147,323	116,257
Total:	2,826	4,239	398	49	155	1,663	883	3,706,788	10,213		
										MAX 453,800	MAX 192,521

* Includes twice the area of DPCs, because casks containing DPCs are decontaminated as well as the DPC.

Table I-2 Secondary Waste Generation from Decontamanation/Floor Washdown Operations

Area/Item	Qty./ Year	Freq. (Mos.)	Percent Decon.	ft^2/ Unit	ft^2/ Year	Area Decon (%)		Decon (%) by Type				Solid LLW(lbs)	Liq.LLW (gals)	
						Wiped	Spray	Wipe	Water	Chem.	Vacuum		Rec. Liq	Chem. Liq
Pre WHB														
Carriers	578		5%	400	11,560	10%	100%	80%	20%			69	555	
WHB Washdown														
Cask Prep	na	12		9,240	9,240		100%		60%	40%		92	1,331	591
Assembly Transfer	na													
Pool Areas (excl. pools)	na	1		8,658	103,896		100%		60%	40%		1,039	14,961	6,649
Assy Cell (dry)	na	0.5		8,910	213,840		100%		60%	40%		2,138	30,793	13,686
DC Load/Decon	na	6		4,450	8,900		100%		60%	40%		89	1,282	570
Cannister Transfer	na	1		11,500	138,000		100%		60%	40%		1,380	19,872	8,832
DC Handling	na	6		61,100	122,200		100%		60%	40%		1,222	17,597	7,821
WP Remediation	na	0.5		2,030	48,720		100%		60%	40%		487	7,016	3,118
Primary Support Areas	na	2		24,500	147,000		100%		60%	40%		1,470	21,168	9,408
Pool Support Areas	na	6		8,020	16,040		100%		60%	40%		160	2,310	1,027
WTB Washdown														
Floor Areas	na	12		36,800	36,800		100%		60%	40%		368	5,299	2,355
WHB Items														
Assembly Xfer Lines														
Incoming Casks	429		0%		0	na	na	na	na	na				
Outgoing Casks	429		100%		192,243	5%	100%	5%	40%	20%		1,177	18,455	6,152
DPC Overpacks	411		100%		182,547	5%	100%	5%	40%	20%		1,118	17,525	5,842
Pool Tooling & Misc.	200		100%	200	40,000		100%							
Pool Yokes	40	6	100%	400	32,000		100%							
DC, Top Edge	508		100%	50	25,400		100%				100%	508		
DC, Full	508		100%		185,312		100%		80%	20%		1,853	35,580	5,930
Canister Xfer Lines														
Incoming Casks	149		0%		0	na	na	na	na	na				
Outgoing Casks	149		100%		79,010	10%	100%	5%	90%	10%		810	17,066	1,264
Fixtures & Misc.	10	6	100%	400	8,000	10%	100%	20%	60%	40%		88	1,152	512
DC Handling														
Collars	1146		10%	200	22,920		100%		90%	10%		229	4,951	367
Total:												14,299	216,911	74,123

na - not applicable