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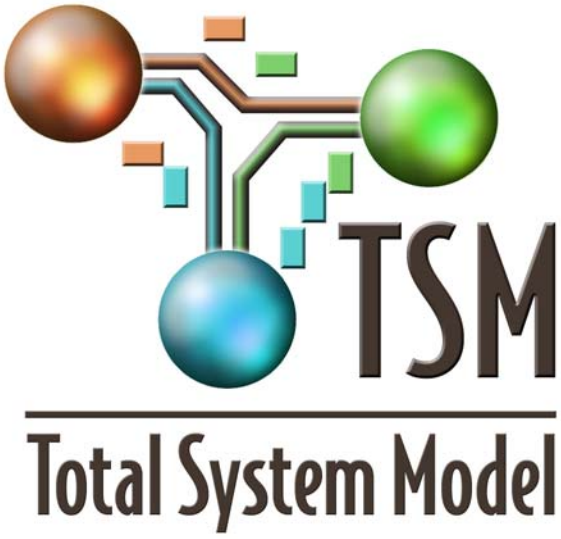
Total System Model Version 6.0 Dose Estimating Routines Design and Bases



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TOTAL SYSTEM MODEL VERSION 6.0 DOSE ESTIMATING ROUTINES DESIGN AND BASES

50040-DD-04-6.0-00

October 2007

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CHANGE HISTORY

Revision No.	Date	Description
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CONTENTS

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FIGURES

Page

TABLES

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ACRONYMS AND ABBREVIATIONS

BSC	Bechtel SAIC Company, LLC
CaS	Create-a-Soft
CSNF	Commercial Spent Nuclear Fuel
CHF	Canister Handling Facility
CRCF	Canister Receipt and Closure Facility
CRWMS	Civilian Radioactive Waste Management System
CRWMS M&O	Civilian Radioactive Waste Management System Management and Operating Contractor
DPC	Dual-Purpose Canister
DOE	U.S. Department of Energy
DOE SNF	DOE Spent Nuclear Fuel
DRG	Dose Report Generator
DTF	Dry Transfer Facility
FEIS	Final Environmental Impact Statement
GROA	Geologic Repository Operations Area
GUI	Graphical User Interface
HLW	High-Level Radioactive Waste
IHF	Initial Handling Facility
IS	Initial State
MSC	Monitored Geologic Repository Site-Specific Storage Cask
MGR	Monitored Geologic Repository
MTHM	Metric Tons of Heavy Metal
RF	Receipt Facility
SNF	Spent Nuclear Fuel
SRTC	Site Rail Transfer Cart

ACRONYMS AND ABBREVIATIONS (CONTINUED)

TAD	Transportation, Aging, and Disposal
TCRRF	Transportation Cask Receipt and Return Facility
TSC	Transportable Storage Cask
TSM	Total System Model
WHF	Wet Handling Facility
WP	Waste Package

1. INTRODUCTION

1.1. PURPOSE

This manual discusses the routines to estimate radiological doses from normal operations used in Version 6.0 of the Total System Model (TSM) as described in the TSM User Manual prepared for the U.S. Department of Energy (DOE) by Bechtel SAIC Company (BSC) (BSC 2007a). The TSM estimates doses during the simulation of the Civilian Radioactive Waste Management System (CRWMS) mission. The TSM is not intended to provide a robust dose evaluation tool and should only be used for relative comparisons of scenarios to general understand if doses are increased or decreased as options are modeled. **The TSM dose estimates should not be used as a substitute for more robust analyses to support regulatory compliance although the results may show similar trends.**

This report also covers how the simulation results are evaluated and prepared or displayed in studies or reports using the Dose Report Generator (DRG).

Some of the content such as the bases for the unit doses of this report is repeated from the dose calculation and check for the so-called "Phase 1 TAD Study" (BSC 2005a) that evaluated the impact of Transportation, Aging, and Disposal (TAD) canisters on the CRWMS. The dose calculation and check (BSC 2005b) was used for TSM V4.0 but applies to TSM V6.0 because the unit doses and the general methods for dose estimates have not been revised.

This manual assumes the reader has a basic knowledge of the TSM functionality and conventions in the *User Manual for the Total System Model Version 6.0* (BSC 2007a) and this manual must be read in conjunction with the User Manual.

TSM uses the SimCAD™ process simulation software developed by Create-a-Soft™, Inc. (CaS). More information on SimCAD™ conventions is in Reference CaS 2006.

This document was prepared in accordance with AP-ENG-006, *Total System Model (TSM) – Changes to Configuration Items and Base Case.*

1.2. CHANGES FOR VERSION 6.0

Changes in TSM V6.0 that impact dose results primarily arise from modifications to the Geologic Repository Operation Area (GROA) process lines and activities. As discussed in Section 1.5 of the *User Manual for the Total System Model Version 6.0* (BSC 2007a) the main changes are updating the process line configuration to the so called "CD-1 design" that replaces dry processing lines to transfer individual assemblies to a TAD canister with a Wet Handling Facility (WHF) and three flexible processing Canister Receipt and Closure Facilities (CRCF) to handle canistered wastes. In addition, an Initial Handling Facility (IHF) is added to process Naval SNF. Other changes are:

- The dose for TAD canister unloading that was not covered in the previous versions of TSM is counted in the TSM Version 6.0 simulation (the TAD canister unloading doses were added in post processing in previous analyses)
- Site Specific Canisters and Monitored Geologic Repository (MGR) Specific Canisters (MSC) are no longer used because all loadings are into TAD canisters to avoid double handling.
- Transportable Storage Casks (TSC) are now processed as bare casks and cannot be diverted to aging (there are few TSCs).
- Canister Handling Facility (CHF), Dry Transfer Facilities (DTF), Fuel Handling Facility, and TAD process lines have been removed. The TSC process line is retained for future use but is inactive in Version 6.0.
- The Transportation Cask Receipt and Return Facility (TCRRF) and the associated Site Rail Transportation Carts (SRTC) were removed from the design and the facility and associated doses have been removed from the simulation. This is important because the actions to remove the transportation shielding and personnel protective barriers and then replace them for movement on the SRTC were a key dose contributor. The doses for the casks receipt actions in the TCRRF are now in the process facilities or associated connections and in a total variable for GROA receipt. Doses for receipt of Navy cask loads are captured in the IHF, doses for TAD canister receipts are captured in the connectors downstream of the TAD buffers (being careful to account for TAD canisters returning from aging that do not incur a receipt dose), doses for bare cask loads are captured in the WHF, and doses for DOE wastes other than Navy are captured in the CRCF unload processes.
- The unit dose for "Load TSC in pool and prep for transport" (variable "radSiteTSCLoad") was corrected from 0.29 to 0.33. This will result in a difference of a few person-rem total for typical runs. Site doses for a typical case are 5,000 person-rem or greater.
- The unit dose for loading a Naval SNF waste package (WP) was assigned the same value as loading a TAD WP.

2. DOSE ESTIMATE METHODS AND PARAMETERS

2.1. GENERAL APPROACH

The TSM tracks doses at processes as the simulation progresses using variables discussed in Section 2.2, the general methods described in Sections 2.3-2.5, and the process extensions (script programming in the simulation processes) described in Section 2.6. The process extensions increment cumulative values by a unit dose value for each specific action for each object that is processed.

Post run, the cumulative variable values related to dose in the TSM output are analyzed using the DRG as described in Section 2.7. The doses reported include those for the primary CRWMS activities: GROA operations, Waste Site operations, and Transportation. Examples of doses vs. time and doses for the CRWMS elements using the DRG are presented in Appendix A of this report.

2.2. INPUT DATA AND BASES

Table 1 lists the dose variables used to calculate radiation exposure within a TSM run: The unit values used for the variables in Table 1 are listed in Appendix B and supported by Appendix C. Doses are analyzed for each individual GROA facility.

2.3. WASTE SITE DOSE

The waste site dose is calculated by the TSM at the generic cask join processes used for multiple waste sites where a cask load is joined with its transportation cask before the joined object proceeds to the waste site process. Notice this means that the doses are not available for each waste site or by utility. The variables radSiteDPCLoad, radSiteRailLoad, radSiteTruckLoad, radSiteTADLoad, and radSiteTSCLoad are used for the dose in person-rem per cask values. RadSiteCum is used to hold the cumulative dose for all waste site activities. RadSiteCum is incremented in the connector before each cask joining process using the event handler “Object Processing Completed”.

2.4. TRANSPORTATION DOSE

The variable radTransCum is used to hold the cumulative transportation dose. This variable is also updated when the cask load is joined with its transportation cask as this is the last time that the TSM can distinguish the waste object type for the load that is being shipped (after joining the waste type object the data is within the joined cask on rail object and cannot be assessed). Notice that the dose for each shipment depends on the waste object type. The variables radSiteRailShip, radSiteTADShip, radSiteTSCShip, and radSiteTruckShip are used for the person-rem per cask values.

Table 1. TSM Dose Variables

Variable	Purpose
radGROA_CRCF1	Doses from CRCF1 operations used to analyze facility doses
radGROA_CRCF2	Doses from CRCF2 operations used to analyze facility doses
radGROA_CRCF3	Doses from CRCF3 operations used to analyze facility doses
radGROA_IHF	Doses from IHF operations used to analyze facility doses
radGROA_RF	Doses from the Receipt Facility (RF) operations used to analyze facility doses
radGROA_TSC	TSC cumulative facility dose
radGROA_WHF	Doses from WHF operations used to analyze facility doses
radGROAcum	GROA total dose
radGROADPCDisp	Dose associated with the disposal of a Dual-Purpose Canister (DPC) carcass
radGROADPCDispCum	DPC disposal total dose
radGROAfromAge	Aging Return quarterly facility dose
radGROAfromAgeCum	Aging Return total dose
radGROAReceipt	Removal of impact barriers quarterly dose in facilities
radGROAReceiptCum	Removal of impact barriers cumulative
radGROAtoAge	Aging preparation and transport quarterly facility dose
radGROAtoAgeCum	Aging preparation and transport total dose
radGROAWP	Quarterly dose for filling WP
radGROAWPCum	Total dose for filling WP
radGROAWPEmplace	Total dose for WP Emplacement
radSiteCum	Total dose at all waste sites
radSiteDPCLoad	Dose associated with loading a DPC at waste sites (constant)
radSiteRailCum	Total dose for loading rail casks at waste sites
radSiteRailLoad	Dose associated with loading a rail cask at waste sites (constant)
radSiteRailShip	Dose associated with shipping a rail cask from waste sites (constant)
radSiteTADLoad	Dose associated with loading a TAD canister at waste sites (constant)
radSiteTADLoadCum	Total dose for loading TAD canisters at waste sites
radSiteTADShip	Dose associated with shipping a TAD canister from waste sites (constant)
radSiteTADShipCum	Total dose for shipping TAD canisters from waste sites
radSiteTruckCum	Total dose for shipping truck casks from all waste sites-Not implemented in V6.0
radSiteTruckLoad	Dose associated with loading a truck cask at waste sites (constant)

Table 1. TSM Dose Variables (continued)

Variable	Purpose
radSiteTruckship	Dose associated with shipping a truck cask from waste sites (constant)
radSiteTSCLoad	Dose associated with loading a TSC at waste sites (constant)
radSiteTSCLoadCum	Total dose for loading TSCs at waste sites
radSiteTSCShip	Dose associated with shipping a TSC from waste sites (constant)
radSiteTSCShipCum	Total dose for shipping TSCs from waste sites
radTransCum	Total dose for all transportation actions (includes dose at time of shipment departure from sites: loading at sites is in radSitecum).

2.5. GROA DOSE

The variable radGROACum is used to hold the cumulative dose for all operations at the GROA. Each of the facilities has its dose calculated separately to allow trending by facility. The variables with the 'Cum' suffix are used to hold the total dose for the facility while the "quarterly" variables are reset to zero after the data is written for the quarter just completed. Table 2 provides a listing of the facilities and where the facility dose is incremented.

2.6. TSM DOSE CALCULATION EXTENSIONS

The calculations for the various cumulative doses described in Sections 2.3-2.5 are implemented using TSM extensions at various processes and connections as shown in Appendix D.

2.7. OUTPUT DATA ANALYSIS

Results from the TSM runs are prepared by data analysis of the TSM .simdata access output file that is dynamically updated during a TSM simulation run. The TSM .simdata file includes data on the actions and status of all objects, process, variables, and resources recorded every 270 time steps (90 days) of the simulation.

The DRG is an EXCEL workbook with macro code that automatically reads data from the .simdata file and provides tabular and graphical results for the site doses, transportation doses and GROA doses. An example of the DRG outputs is in Appendix A. Details on the operation and results of the DRG are in the TSM User Manual (BSC 2007a).

Table 2. GROA Process Where Cumulative Doses Are Incremented

Facility/Line	Cumulative Variables	TSM Process
RF, CRCF1, WHF, IHF	radGROAReceipt	See below. Receipt doses captured in facilities in V6.0.
Aging	radGROAtoAge radGROAtoAgeCum	TADAgePrep; DPCAgePrep, TSCtoStaging (TSC not active in V6.0)). To Age also included in RF values.
Aging (Note 1)	radGROAfromAge	TSCReturnBuffer (Not active n V6.0)
CRCF Unload lines	radGROA_CRCF1 radGROA_CRCF3	CRCF1Unload, CRCF3 Unload (CRCF2 does not have unload for DOE)
CRCFs WP fill lines	radGROA_CRCF1 radGROA CRCF2 radGROA CRCF3 radGROA WP radGROAreceipt	CRCF1WPFill, CRCF2WPFill, CRCF3WPFill Connector after TAD buffer (cTADCRCF1, not applied for returns from aging)
CRCFs WP transfer lines	radGROA_CRCF1 radGROA CRCF2 radGROA CRCF3 radGROATAD	TADxfertoWP1, TADxfertoWP2, TADxfertoWP3
WHF	radGROA_WHF radGROADPCDisp radGROAreceipt	WHFDPCopen, WHFTADFill, WHFUnload
IHF	radGROA_IHF radGROAreceipt	IHFReceipt
RF	radGROA_RF radGROAtoAge radGROAReceipt	DPCagePrep, TADAgePrep, Connector after TAD buffer (cTADRF, not applied for returns from aging)
TSC	radGROA_TSC radGROAtoage	TSCtoStaging (Not active in Version 6.0)

Note 1: “From aging” variables are included but are not added to the GROA total or overall total because the values are already included in the WP loading operations when the item is returned from aging

2.8. KEY ASSUMPTIONS

The unit dose estimates, which are derived from previous studies, are presented in Appendix B. The assumptions and bases for the unit doses are discussed in the references in Appendix C. As discussed in Appendix B, unit doses for the Phase 1 TAD Study are typically taken as 50% of the previous study references because the previous studies concluded that the doses are conservative by a factor of two.

One assumption in the overall TSM method is that the unit doses for operations are assumed to be the same at all waste sites. Sites will have varying doses since the shielding configurations in the pool areas and the types of cask used vary.

Another key assumption is that the transportation doses from the site to the GROA are the same for all the waste sites. Doses will vary depending on the distance from the sites to the GROA but this is not factored into the estimate. As discussed in Appendix C, the values used are system averages and should provide a mid-range value for the transportation doses.

Because system averages are used for the site and transportation unit doses use of the TSM dose results must be limited to relative doses for comparison of various scenarios.

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3. DOSE ESTIMATE CHECKS

During system studies and TSM development, the TSM dose calculations have been checked by manual functional checks during development, manual and automated checks of system analysis results. Dose calculations were also checked as part of the validation of the DRG.

3.1. MANUAL CHECKS

As TSM was constructed, short test runs were done by the developers to check the validity of the results. These are usually undocumented short tests, typical for standard practice in code development. As development progresses, more processes and systems are added and undocumented checks are made for individual changes and overall system effects.

Other integrated manual checks using EXCEL spreadsheets were performed and these are documented in the backup calculation for the Phase 1 TAD Study (BSC 2005b), the DRG validation (BSC 2007c), and the overall TSM V6.0 validation (BSC 2007b). For example, the TSM can be run for a full case and the Initial State (IS) file for this case can be analyzed to count the items completed by processes and these can be combined with the proper unit doses to check that the total dose agrees with the result of the TSM.

3.2. SYSTEM ANALYSIS CHECKS

Detailed, integrated systems studies such as the Phase 1 TAD Study (BSC 2005a) provided an opportunity to check the dose calculations at the detailed functional level and also at a general systems level for TSM V4.0. The dose estimate results and checks are discussed in the backup dose calculation to support the Phase 1 TAD Study (BSC 2005b). The Phase 1 TAD canister analysis was documented with considerable rigor and the logistics results and dose results were carefully analyzed for consistency and to identify and correct any errors or problems in the TSM dose estimating routines. Doses were not revalidated for TSM V5.0. The TSM V6.0 uses many of the same dose algorithms that were used for TSM V4.0 for the Phase 1 TAD Study, but requires checks of the revisions needed for the GROA modifications that are shown in Appendix D.

As discussed in the backup dose calculation to support the Phase 1 TAD Study (BSC 2005b) the dose analyses and checks included both manual checks and a separate EXCEL workbook that evolved into the DRG. These methods for estimating doses and checking them provide additional assurance that the logistics that provide the counts of objects used as the basis for dose estimating routines in the TSM are adequate.

The Phase 1 TAD Study also provided the opportunity to check dose impacts on a system level. For example, if the number of TAD canisters increased from one case to another, the analyst can predict the associated dose increase by hand and compare it to the TSM result. In these situations the TSM dose results become another way to judge if the system analysis “makes sense” and that the impacts from changes are predictable.

The Phase 1 TAD Study is also a good example of how doses are used in the system assessment. Relative dose results were used to understand dose impacts of various scenarios. In these cases, the absolute values of the doses and the underlying unit dose values are not particularly relevant. As mentioned, the TSM is not a robust dose estimating tool but is suitable for relative dose comparisons. The Phase 1 TAD Study demonstrates that the TSM meets its intended function to show system impacts as key parameters are changed.

3.3. DRG VALIDATION

The DRG validation in Reference BSC 2007c is an additional check since it requires that the values from the .simdata file be manually extracted and compared to the DRG results. While both methods use the same data source and ergo the same algorithm, the validation provides an additional opportunity for experienced developer and analyst to review the results in detail and question the validity and sensibility of the results. There are also opportunities to confirm dose buildups using the objects completed in a process with the associated unit doses.

4. REFERENCES

4.1. DOCUMENTS CITED

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4.2. CODES, STANDARDS, REGULATIONS, AND PROCEDURES

AP-ENG-006 REV 1 ICN 0. *Total System Model (TSM) – Changes to Configuration Items and Base Case*. Washington, DC: BSC. ACC: Submit to RPC.

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APPENDIX A

EXAMPLE DOSE RESULTS

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APPENDIX A
EXAMPLE DOSE RESULTS

This appendix provides example results for two typical TAD canister cases provided in the Phase 1 TAD Study (BSC 2005a). These results were generated by the TSM Dose Report Generator (DRG) discussed in Section 2.7 of this report. The "Total Dose" value shown on each result page is cut and pasted from the DRG.

This example is for Scenario 25 that assumes rail sites with 75 ton or lower capacity will load small TAD canisters (12/24). All other rail sites will load medium TAD canisters (21/44). Truck sites will continue to ship bare Commercial Spent Nuclear Fuel (CSNF). A TAD canister/WP heat limit of 11.8 Kilowatts is assumed. The Scenario 25A uses the "full inventory" (142,000 Metric Tons Heavy Metal [MTHM]; 129,000 MTHM CSNF) waste stream, and Scenario 25B uses the 70,000 MTHM (63,000 MTHM CSNF) waste stream. See the Phase 1 TAD Study for more information on the details of these scenarios.

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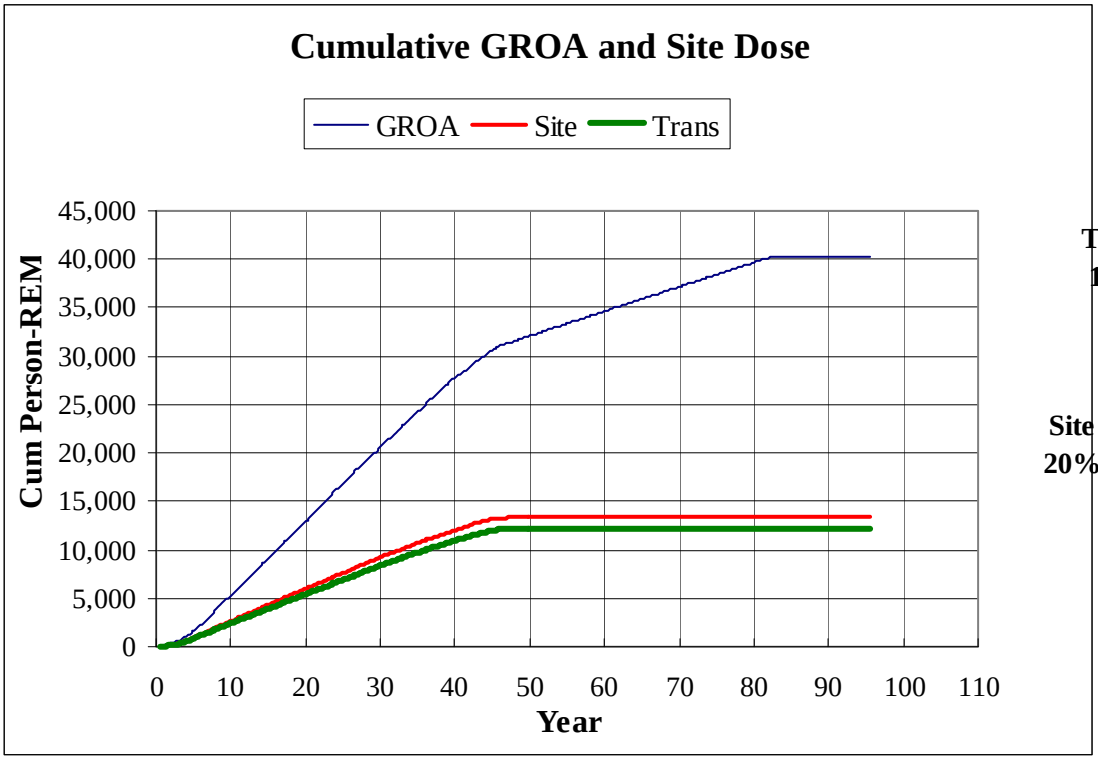
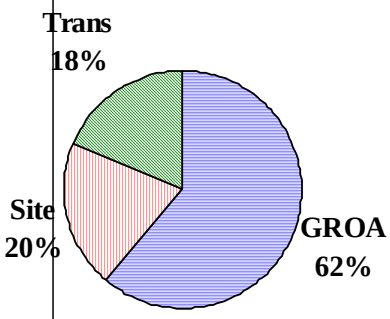
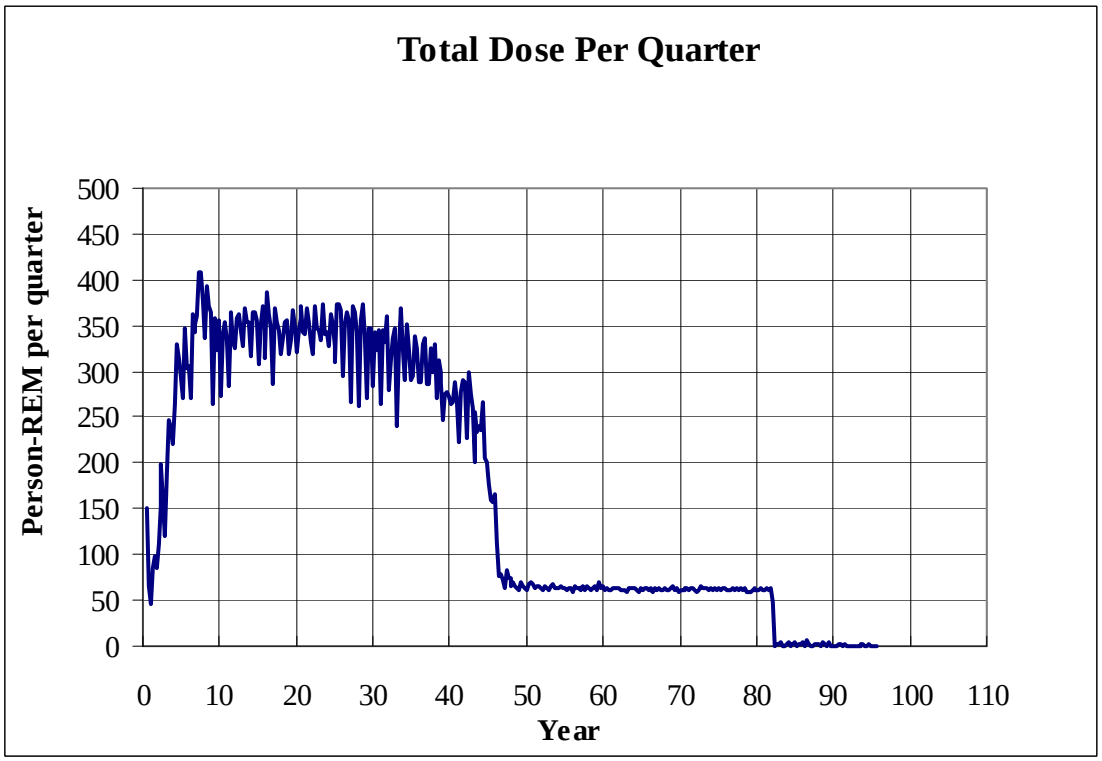
Total 65,788.77

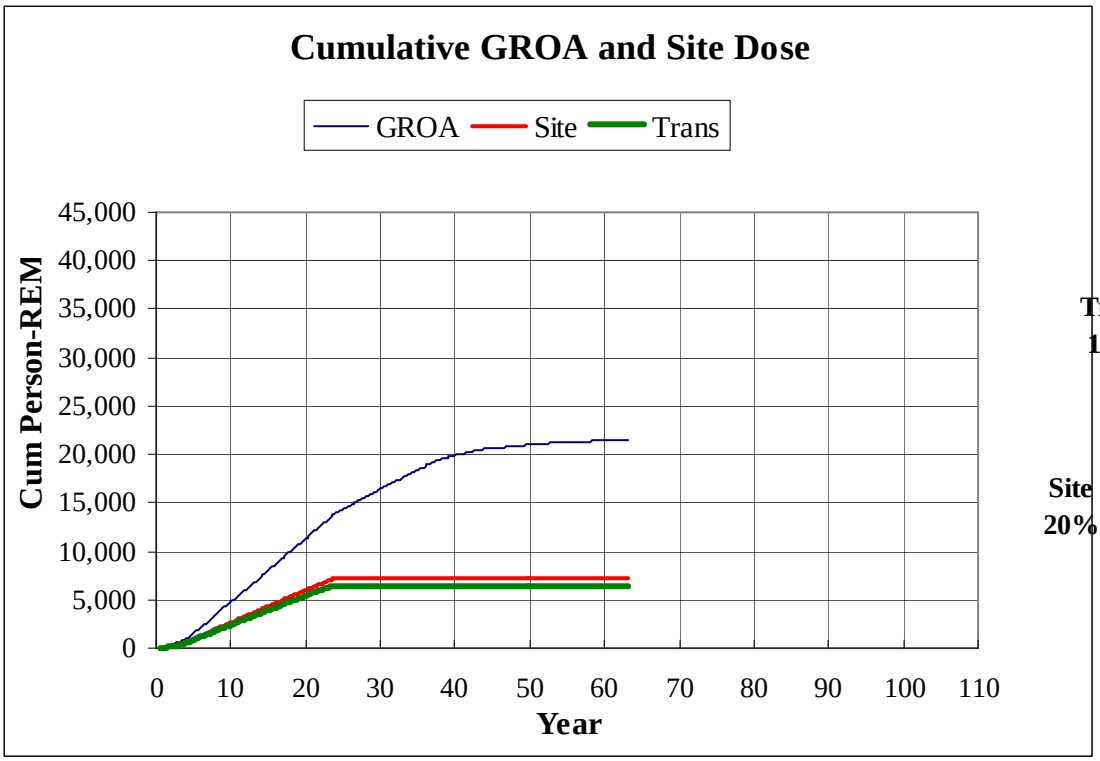


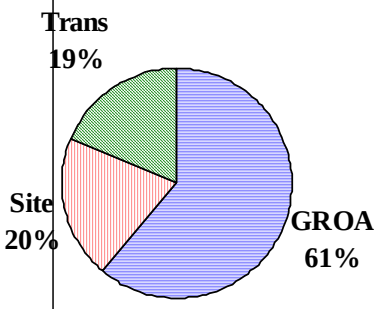


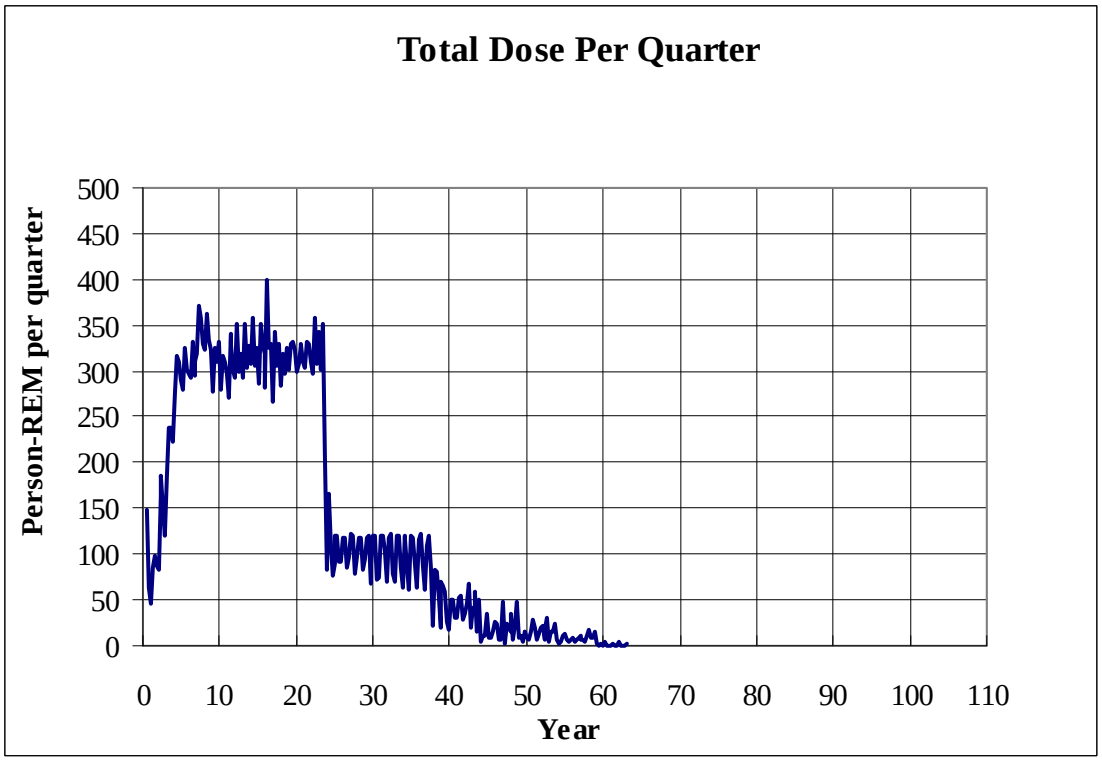


Scenario 25B

Total 35,062.89







APPENDIX B

TSM UNIT RADIATION DOSES FOR SNF PROCESSES

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APPENDIX B
TSM UNIT RADIATION DOSES FOR SNF PROCESSES

This appendix shows the values used for the unit doses assigned to the unit dose variables in TSM from Table 1 of the main text. The rationale for the estimating approach, and the principal source of the unit dose estimates are in Appendix C.

Table B-1. Unit Radiation Doses

Activity – TSM Simulation Action	Unit Doses per Operation (person-rem)	TSM Unit Dose Variable Assigned [1]	Cumulative or Quarterly Dose Variable Where Used
Operations at Waste Sites			
Load truck transport cask in pool and prepare for transport	0.22	radSiteTruckLoad	radSiteCum
Load rail transport cask in pool and prepare for transport	0.33	radSiteRailLoad	radSiteCum
Load welded TAD canister in pool using transportation overpack and prepare for transport	0.87	radSiteTADLoad radSiteDPCLoad	radSiteCum radSiteTADLoadCum
Load welded TAD canister in pool using transfer cask and prepare for transport	1.17	radSiteTADLoad	radSiteCum radSiteTADLoadCum
Load welded TAD canister in pool and place in storage	1.00	Not Used	
Load bolted TAD canister in pool using transportation overpack and prepare for transport	0.47	radSiteTADLoad	radSiteCum radSiteTADLoadCum
Load bolted TAD canister in pool using transfer cask and prepare for transport	0.77	radSiteTADLoad	radSiteCum radSiteTADLoadCum
Load bolted TAD canister in pool and place in storage	0.60	Not Used	
Remove welded Single Purpose (SP) canister from storage and unload into pool	0.89	Direct input	radGROAfromage
Load SP storage cask in pool and place in storage	0.33	Not Used	
Remove SP storage cask from storage and unload in pool	0.33	Not Used	
Load TSC in pool and place in storage	0.37	Not Used	
Load TSC in pool and prepare for transport	0.33	radSiteTSCLoad	radSiteCum radSiteTSCLoadCum
Remove TSC from storage and prepare for transport	0.27	Not Used	
Remove TAD canister from storage, transfer to transportation overpack	0.33	Not Used	

Activity – TSM Simulation Action	Unit Doses per Operation (person-rem)	TSM Unit Dose Variable Assigned [1]	Cumulative or Quarterly Dose Variable Where Used
Transportation Operations			
Truck transport to GROA - average worker dose per cask	0.45	radSiteTruckShip	radTransCum
Rail transport to GROA - average worker dose per cask	0.70	radSiteRailShip	radTransCum
Repository Operations [2]			
Receive truck cask and remove shielding and personnel barriers	0.14	Direct Input	radGROAReceipt
Receive rail cask and remove shielding and personnel barriers	0.23	Direct Input	radGROAReceipt
Receive truck cask in WHF and unload SNF assemblies, also use for DOE unload	0.26	Direct Input	radGROA_CRCF1, 2, 3 radGROA_WHF
Receive rail cask in WHF and unload SNF assemblies	0.33	Direct Input	radGROA_WHF
Receive and unload bolted canister/overpack	0.58	Not Used	
Receive and Unload TSC or bolted TAD canister	0.35	Direct Input	radGROA_WHF
Receive and Transfer TSC to aging pad	0.22	Direct Input	radGROA_TSC radGROAtoAge Not active in V6.0
Remove TSC from aging pad and unload	0.32	Direct Input	radGROAfromAge Not active in V6.0
Load TAD canister and move to aging pad	0.43	Direct Input	radGROA_CRCF1, 2, 3 radGROAtoAge
Remove TAD canister or DPC from aging pad and unload	0.55	Not used	
RF transfer TAD canister or DPC into aging overpack and move to aging pad	0.73	Direct Input	radGROAtoAge
Load bare CSNF or co-disposal waste package-also use for DOE WP load	0.52	Direct input	radGROA_CRCF1, 2, 3 radGROA_WHF radGROAWP
Transfer TAD canister from transport overpack to waste package	0.75	Direct input	radGROA_CRCF1, 2, 3 radGROAWP
Remove TAD canister from aging, load waste package	0.43	Direct Input	radCRCF1,2,3 radGROAWP
Move waste package underground and emplace in drift	0.5	Direct input	radGROAWPEmplace
Other Operations			
Dispose of empty canisters: preparation, transport, disposal	0.15	radGROADPCDisp	radGROADPCDispCum

Activity – TSM Simulation Action	Unit Doses per Operation (person-rem)	TSM Unit Dose Variable Assigned [1]	Cumulative or Quarterly Dose Variable Where Used
Dispose of unusable MSCs: preparation, transport, disposal	0.15	Not Used	

Note 1: "Direct Input" means the value is directly used in the TSM process extension.
Note 2: Assumes values for Naval SNF casks/canisters are the same as those for TAD cask/canisters; values for DOE Spent Nuclear Fuel (DOE SNF) and High Level radioactive Waste (HLW) transportation casks are the same as those for CSNF truck casks.

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APPENDIX C

BASIS FOR UNIT RADIATION DOSES FOR SNF PROCESSES

APPENDIX C
BASIS FOR UNIT RADIATION DOSES FOR SNF PROCESSES

PURPOSE

This appendix summarizes the basis for estimating the system-average occupational radiation doses per cask and per waste package for most alternative technologies for the storage, transport and disposal of SNF. The purpose and intended application is to provide a consistent set of unit process dose data for use in the Total System Model (TSM). The rationale for the estimating approach, the principal source of the estimates, and the suggested unit dose results are briefly described.

RATIONALE FOR THE ESTIMATING APPROACH

There are large differences between utility sites in the average doses for performing a specific function, such as storage cask loading. The sources of these differences include:

- The crane weight limits which determine the amount of shielding in transfer casks. Sites with 100-ton cranes have less shielding and thus higher doses than sites with 125 ton cranes.
- The ability to use portable temporary shielding which depends upon the availability of space around pools and cask handling areas. Sites with compact layouts cannot use as much temporary shielding to reduce doses.

It is therefore important to have data from various utility sites for calibrating the dose estimates but data is limited. It is equally important to have an internally consistent method for estimating system-average doses for the various different processes across the system. The original 1994 multi-purpose canister (MPC) study (CRWMS M&O 1994) used such a consistent and documented method and considered the staffing and staff time for each step in a process, the proximity to the cask, plus the general radiation background in the area. It was selected as the basis for the TSM because it appears to be the most complete and relevant of such evaluations. However, the documentation clearly states:

- "The level of conservatism is potentially more than two times."
- The calculations are based on nominal exposure values and times, and do not assume the use of ALARA techniques. A specific illustration of the substantial dose reductions available via ALARA practices is found in Chapter 9 of the Centralized Interim Storage Facility Safety Analysis Report, Pages 451-500 (CRWMS M&O 1998). These ALARA considerations were not used in the TSM dose estimates. The TSM unit values were based on the values in Appendix A of CRWMS M&O 1994.
- The handling times used are for the first casks and canisters in the program, and do not reflect the significant learning-curve reductions that can be realized from the many repetitive operations that are anticipated.

Because of the above, and also because the limited available utility data indicates that the MPC Study results are about a factor of two above actual experience, the estimates for unit doses for the TSM use 50% of the MPC estimates. The 1994 MPC study did not include dose estimates for actual shipping, nor for moving waste packages from the surface and emplacement in the

drifts. Data provided in the Yucca Mountain Final Environmental Impact Statement (FEIS) (DOE 2002) were used for these estimated doses.

RESULTS

The results of the above estimates of process unit doses are intended to be treated as system averages, with the expectation that actual doses will be both higher and lower than the estimates. This is particularly true of the unit doses for transport, which do not reflect the substantial differences in shipping distances, nor the impacts of any intermodal transfers that will be encountered in practice. Table C-1 provides a summary of the results of using the foregoing approach to estimate the potential unit doses of the more important of the many potential processes in the storage, transport and disposal of civilian SNF. The Reference numbers in Table C-1 refer to the "Ref" numbers in the first column of Table C-2, which identifies the specific sources and location of the relevant dose data in the detailed Appendix A of the 1994 MPC study. An associated EXCEL spreadsheet, SystemProcessUnitDosesR3.xls (see Table 8 of BSC 2005b), provides some additional details in the development of the estimates, and is the source of the tables in this appendix.

Table C-1. Unit Doses for SNF Processes (person-rem)

Process Or Operation	TSM basis [2]	Table C-2 Basis
OPERATIONS AT UTILITY SITES		
Load truck transport cask in pool and prepare for transport	0.22	0.432, Ref 1
Load *1-lid rail transport cask in pool and prepare for transport	0.33	0.656, Ref 2
Load Welded TAD canister in pool and prepare for offsite transport	0.87, 1.17	MPC=1.73 in transport overpack, 2.33 via transfer cask, Ref 10,11
Same, but placed in storage	1.00	Canister=1.943, MPC=1.992. Ref 3, 8
Load bolted TAD canister in pool and prepare for offsite transport	0.47, 0.77	As for welded above less 50% of 0.80, Ref 27
Same, but placed in storage	0.60	As for welded above less 50% of 0.80 Ref 27
Remove welded SP canister from storage and unload into pool.	0.89	1.785, Ref 4
Load 1-lid storage-only cask in pool and place in storage	0.37	0.934, Ref 6 less 0.203, Ref 26
Remove 1-lid storage-only cask from storage, unload in pool.	0.37	Reverse of above
Load 1-lid TSC in pool and place in storage	0.37	0.934, Ref 6 less 0.203, Ref 26
Load *1-lid TSC in pool and prepare for transport	0.33	0.859, Ref 5 less 0.203, Ref 26
Remove TSC from storage and prepare for transport	0.27	0.530, Ref 7
Remove TAD canister from storage, transfer to transportation overpack	0.33	0.663, Ref 9
TRANSPORTATION OPERATIONS		
Truck transport to MGR - average dose per cask	0.45	Uses FEIS, Tables 6-11 and J-1
Rail transport to MGR - average dose per cask	0.70	Uses FEIS, Tables 6-11 and J-1
GROA OPERATIONS [3]		
Receive truck cask at Security/TCRRF	0.14	0.271, Ref 30
Receive rail cask at Security/TCRRF	0.23	0.459, Ref 31
Receive truck cask and unload SNF	0.26	0.518, Ref 12
Receive *1-lid rail cask and unload SNF	0.33	0.654, Ref 13
Unload welded canister/overpack. Canister/overpack in interim storage	0.98	1.966, Ref 15
Receive and Unload *1-lid TSC	0.35	0.899, Ref 14 less 0.203, Ref 26
Transfer TSC into storage	0.22	0.431, Ref 18
Remove, unload *1-lid TSC from storage. Empty TSC in interim storage	0.32	0.835, Ref 19 less 0.203, Ref 26
Load and store bolted storage cask	0.43	0.867, Ref 16
Remove and unload bolted storage cask	0.55	1.094, Ref 17

Transfer TAD canister into overpack/storage	0.73	1.457, Ref 21
Load bare fuel waste package	0.52	1.036, Ref 25
Transfer TAD canister from transport overpack to waste package	0.75	1.501, Ref 24
Remove TAD canister/overpack from storage, load waste package.	0.43	0.855, Ref 23
Move waste package underground and emplace in drift. Collective repository worker dose, 7,800-12,000 p-rem (EIS, Table F-23) for Proposed Action (7,471 CSNF WPs)	0.5	Estimated using total MGR for trucks, 1.28, with storage, 2.16. Total MGR for TADS, 1.25, with storage, 1.75. Compare to FEIS total MGR range, 1.04 to 1.61
OTHER OPERATIONS		
Dispose of empty canisters: Preparation, transport, and disposition.	0.15	Estimate. Most is background at point of origin.
Dispose of unusable storage casks: Prep, transport, and disposition.	0.15	Estimate. Most is background at point of origin.

Note 1. 1-lid vs. 2-lid difference is +0.10 person-rem for 2-lid casks: 0.203, Ref 26
Note 2. TSM usually uses 50% of the Table C-2 dose except as noted. Dose is in person-rem.
Note 3. Staging operations in 1994 MPC study (Table C-2) were for the Monitored Retrievable Storage facility

Table C-2. Unit Doses for Cask/Canister/WP Operations

From CRWMS M&O 1994, Appendix A

Ref		At Utility	p-mrem Direct	p-mrem BackGrd	p-mrem Total
Load Truck Cask for Shipping					
	1	Receive empty truck cask	0	2.4	2.4
	2	Prepare cask for loading in pool	0	34	34
	3a	Load SNF into Cask	2.2	13	15.2
	4a	Remove and seal cask	178.4	33	211.4
	5a	Prepare cask for shipment	168.7	0	168.7
1		Total	349.3	82.4	431.7
Load 1-lid Rail Cask for Shipping					
	1	Receive empty rail cask	0	2.4	2.4
	2	Prepare cask for loading in pool	0	34	34
	3b	Load SNF into Cask	5.6	33	38.6
	4b	Remove and seal cask	292.3	49.3	341.6
	5b	Prepare cask for shipment	235.6	3.4	239
2		Total	533.5	122.1	655.6
Load Canister and transfer into Overpack/Storage					
	6	Receive empty canister	0	1.3	1.3
	7	Prepare transfer cask	0	12.5	12.5
	8	Load canister into transfer cask	0	1.7	1.7
	9	Prepare and transfer to pool	0	5.8	5.8
	10	Load SNF into canister/cask	5.6	33	38.6
	11	Remove from pool, weld canister, bolt lid	1357	25.9	1383
	12	Prepare and move to Interim Spent Fuel Storage Facility	157.8	1.4	159.2
	13	Transfer canister into storage overpack	299.2	41.7	340.9
3		Total	1820	123.3	1943
Remove canister from storage and unload into pool					
	14	Transfer canister into transfer cask	408.4	51.8	460.2
	15	Move canister to pool, open, flood canister	1123	68.5	1192
	16	Unload SNF into pool	5.5	0	5.5
	17	Remove empty canister/cask from pool	49.2	14.6	63.8
	18	Move empty canister/cask to storage	63.4	0	63.4
4		Total	1650	134.9	1785
Other					
5		Load 2-lid TSC for rail shipment	717	142	859

Ref		At Utility	p-mrem Direct	p-mrem BackGrd	p-mrem Total
6		Load 2-lid TSC and place in storage	782	152	934
7		Remove TSC from storage, prep for rail shipment	493	37	530
8		Load MPC and transfer into Overpack/Storage	1878	114	1992
9		Move MPC from storage, transfer into transport	592	71	663
10		Load MPC for shipping, direct in transport overpack	1657	74	1731
11		Load MPC for immediate shipping, via transfer cask	2235	97	2332
12		Receive and unload truck cask	507	11	518
13		Receive and unload rail cask	652	12	654
14		Receive and unload 2-lid TSC	894	5	899
15		Receive & unload welded canister. Canister in interim storage	1877	89	1966
16		Load bolted storage cask and store	854	13	867
17		Unload bolted storage cask	1083	11	1094
18		Transfer rail TSC into storage	421	10	431
19		Remove TSC from storage & unload. Cask to internal storage	803	32	835
20		Remove Canister/Overpack from storage and unload	1083	11	1094
21		Transfer MPC into storage	1438	19	1457
22		Remove MPC/Overpack from storage	709	26	735
23		Load MPC from storage into Waste Package	851	4	855
24		Load MPC from transport into Waste Package	1487	14	1501
25		Load waste package	1030	6	1036
26		Bolted containers, 2-lid vs 1-lid	183	20	203
27		Welded vs 1-lid Bolted TAD Canister Weld MPC Bolt Single Lid	 925.2 117.1	 11.6 15.7 Diff	 936.8 132.8 804
28		Welded vs 2-lid Bolted TAD Canister			601
29		Transfer Waste Package Underground and Emplace			NA
30		Receive truck cask at Security/TCRRF	260	11	271
31		Receive rail cask at Security/TCRRF	447	12	459

APPENDIX D

PROCESS EXTENSIONS FOR DOSE

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APPENDIX D PROCESS EXTENSIONS FOR DOSE

As discussed in Sections 2.3-2.6 TSM extensions are used to calculate the doses. The tables show the TSM process and connector extensions related to doses. The list is limited to processes that are actively used in the TSM Version 6.0.. For example, extensions for truck waste sites that are not actively used are not included. If the extension is on a connection, the second column indicates the process that the connection is "from" and the third column indicates the process the connection is "to." The numbers in the first column are provided for reference in this report.

As discussed in Section 1, the major changes in the dose algorithms are associated with the changes to the GROA. Therefore, there is a table (D-1) for just the GROA extensions followed by a table (D-2) of other extensions. The image of the GROA graphical user interface (GUI) is included for reference to help follow the extensions for the GROA. Refer to the GROA description for more details (BSC 2007d). For the other extensions, this table is unchanged from previous versions of TSM.

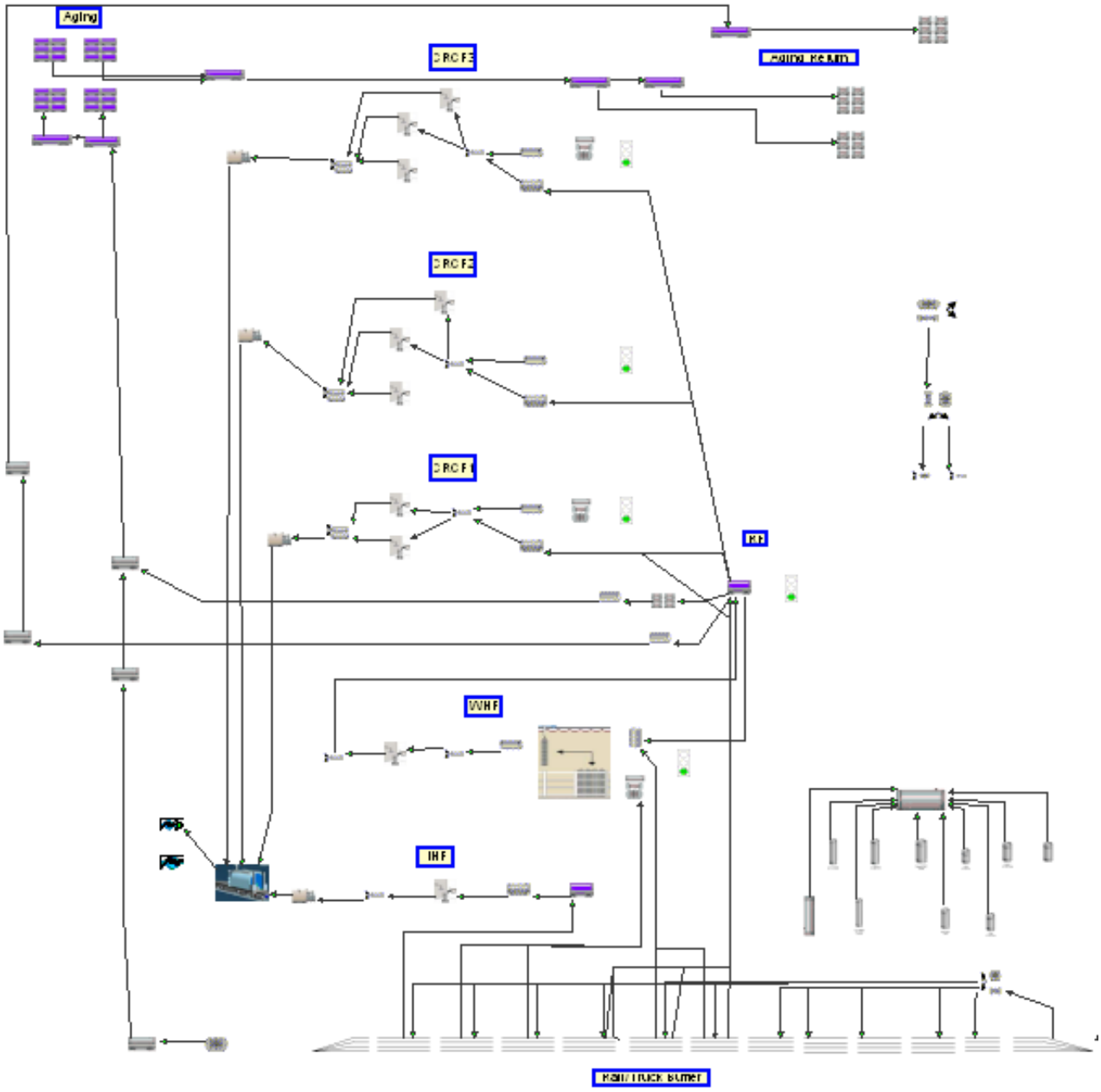

Figure D-1. GROA Layout

Note: Open TSM and view the GROA GUI for details.

Table D-1. TSM GROA Process Extensions for Dose Calculations

	Process or Connector	Event Handler and Con. From	Extension Action and Connection to	GROA Line Formula
1	Model Extensions			
2			Comment	RAD: Update accumulators
3			Expression	radGROAtoAgeCum = radGROAtoAgeCum + radGROAtoAge
4			Expression	radGROAWPCum = radGROAWPCum + radGROAWP
5			Expression	radGROAfromAgeCum = radGROAfromAgeCum + radGROAfromAge
6			Expression	radGROAReceiptCum = radGROAReceiptCum + radGROAReceipt
7			Expression	radGROAcum = radGROA_CRCF1 + radGROA_CRCF2 + radGROA_CRCF3 + radGROA_WHF + radGROA_RF + radGROA_IHF + radGROAWPEmplace
8			Expression	radGROAtoAge = 0
9			Expression	radGROAWP = 0
10			Expression	radGROAfromAge = 0
11			Expression	radGROAReceipt = 0
12	CRCF1Unload			
13		ObjectActivated		
14			Comment	RAD: Unload DOE SNF = .26 (Gillespie 4/29/05)
15			Expression	radGROA_CRCF1 = radGROA_CRCF1 + .26
15a			Comment	RAD: Load DOE WP = .52 (Gillespie 4/29/05)
15b			Expression	radGROAWP = radGROAWP+.52
15c			Expression	radGROAReceipt = radGROAReceipt + .26
16	CRCF1WPfill			
17		Object:NextProcessDefined		

	Process or Connector	Event Handler and Con. From	Extension Action and Connection to	GROA Line Formula
18			Comment	RAD: Load DOE WP = .52 (Gillespie 4/29/05)
19			Expression	radGROA_CRCF1 = radGROA_CRCF1+.52
19a	CRCF2Unload			
20a			Comment	RAD: Unload DOE SNF = .26 (Gillespie 4/29/05)
21a			Expression	radGROA_CRCF3 = radGROA_CRCF3 + .26
22a			Expression	radGROAReceipt = radGROAReceipt + .26
20	CRCF2WPfill			
21		Object:NextProcessDefined		
22			VB Call	= CallVB CHF_WP_Finished( ) As Double
23			Comment	RAD: Load DOE WP = .52 (Gillespie 4/29/05)
24			Expression	radGROAWP = radGROAWP + .52
25	CRCF3Unload			
26			Comment	RAD: Unload DOE SNF = .26 (Gillespie 4/29/05)
27			Expression	radGROA_CRCF3 = radGROA_CRCF3 + .26
27a			Expression	radGROAReceipt = radGROAReceipt + .26
28	CRCF3WPfill			
29		Object:NextProcessDefined		
30			Comment	RAD: Load DOE WP = .52 (Gillespie 4/29/05)
31			Expression	radGROAWP = radGROAWP+.52
31a			Comment	RAD: Unload DOE SNF = .26 (Gillespie 4/29/05)
31b			Expression	radGROA_CRCF1 = radGROA_CRCF1 + .26
32	DPCAgePrep			
33		ObjectActivated		
34			Comment	RAD: Transfer DPC to Aging = .73
35			Expression	radGROAtoAge = radGROAtoAge + .73

	Process or Connector	Event Handler and Con. From	Extension Action and Connection to	GROA Line Formula
36			Expression	radGROA_RF = radGROA_RF + .73
36a	IHFReceipt			
36b		ObjectActivated		
36c			Comment	RAD: Receive rail = .23; Use TAD values for WP creation (Gillespie 8/7/07)
36d			Expression	radGROA_IHF = radGROA_IHF + .23 + .75
36e			Expression	radGROAReceipt = radGROAReceipt + .23
37	TADAgePrep			
38			Comment	RAD: Transfer TAD to Aging = .73
39			Expression	radGROAtoAge = radGROAtoAge + .73
40			Expression	radGROA_RF = radGROA_RF + .73
41	cTADRF	TADBuffer	RF_Router	
42		ObjectActivated		
43			Comment	RAD: receive TAD = .23
44			Condition	IF (CompareStr(ObjectType, 'TADreturn') <> 1) is TRUE
45			Expression	radGROAReceipt = radGROAReceipt + .23
46			Expression	radGROA_RF = radGROA_RF + .23
47			Condition	END IF
48	cTADCRCF1	TADBuffer	TADxfertoWP1	
49		ObjectActivated		
50			Comment	RAD: receive TAD = .23
51			Condition	IF (CompareStr(ObjectType, 'TADreturn') <> 1) is TRUE
52			Expression	radGROAReceipt = radGROAReceipt + .23
53			Expression	radGROA_CRCF1 = radGROA_CRCF1 + .23
54			Condition	END IF
55	TADxfertoWP1			

	Process or Connector		Event Handler and Con. From	Extension Action and Connection to	GROA Line Formula
56			ObjectActivated		
57				Condition	IF (CompareStr('TADreturn', ObjectType) = 1) is TRUE
58				Comment	RAD: Return TAD from Aging and place in WP = .43
59				Expression	radGROAWP = radGROAWP + .43
60				Expression	radGROA_CRCF1 = radGROA_CRCF1 + .43
61				Condition	ELSE
62				Comment	RAD: Transfer TAD to WP = .75
63				Expression	radGROAWP = radGROAWP + .75
64				Expression	radGROA_CRCF1 = radGROA_CRCF1 + .75
65				Condition	END IF
66		TADxfertoWP2			
67			ObjectActivated		
68				Condition	IF (CompareStr('TADreturn', ObjectType) = 1) is TRUE
69				Comment	RAD: Return TAD from Aging and place in WP = .43
70				Expression	radGROAWP = radGROAWP + .43
71				Expression	radGROA_CRCF2 = radGROA_CRCF2 + .43
72				Condition	ELSE
73				Comment	RAD: Transfer TAD to WP = .75
74				Expression	radGROAWP = radGROAWP + .75
75				Expression	radGROA_CRCF2 = radGROA_CRCF2 + .75
76				Condition	END IF
77		TADxfertoWP3			
78			ObjectActivated		
79				Comment	RAD: Transfer TAD to WP = .75
80				Condition	IF (CompareStr('TADreturn', ObjectType) = 1) is TRUE

	Process or Connector	Event Handler and Con. From	Extension Action and Connection to	GROA Line Formula
81			Comment	RAD: Return TAD from Aging and place in WP = .43
82			Expression	radGROAWP = radGROAWP + .43
83			Expression	radGROA_CRCF3 = radGROA_CRCF3 + .43
84			Condition	ELSE
85			Expression	radGROAWP = radGROAWP + .75
86			Expression	radGROA_CRCF3 = radGROA_CRCF3 + .75
87			Condition	END IF
88	TSCReturnBuffer			Process not active in V6.0
89		Object:NextProcessDefined		
90			Expression	radGROAfromAge = radGROAfromAge + .32
91	TSCtoStaging			Process not active in V6.0
92		ObjectActivated		
93			Comment	RAD: Transfer TSC to Aging = .22
94			Expression	radGROAtoAge = radGROAtoAge + .22
95			Expression	radGROA_TSC = radGROA_TSC + .22
96	WHFDPCOpen			
97		ObjectActivated		
98			Comment	RAD: Unload welded canister = .98
99			Expression	radGROA_WHF = radGROA_WHF + .98
100			Comment	RAD: Receive rail cask = .23
101			Expression	radGROAReceipt = radGROAReceipt + .23
102			Expression	radGROA_WHF = radGROA_WHF + .23
103		Object:NextProcessDefined		
104			Comment	RAD: Dispose of empty DPC = .15
105			Expression	radGROADPCDispCum = radGROADPCDispCum + radGROADPCDisp

	Process or Connector	Event Handler and Con. From	Extension Action and Connection to	GROA Line Formula
106			Expression	radGROA_WHF = radGROA_WHF + radGROADPCDisp
107	WHFTADfill			
108		ObjectActivated		
109			Comment	RAD: Load TAD = .87
110			Expression	radGROA_WHF = radGROA_WHF + .87
111	WHFUnload			
112		ObjectActivated		
113			Comment	RAD: Unload Truck = .26; Rail = .33; TSC = .35
114			Comment	RAD: Receive truck = .14; receive rail = .23
115			Condition	IF (CompareStr('T-', Left(ObjectType,2))=1) is TRUE
116			Expression	radGROA_WHF = radGROA_WHF + .26 + .14
117			Expression	radGROAReceipt = radGROAReceipt + .14
118			Condition	END IF
119			Condition	IF (CompareStr('R-', Left(ObjectType,2))=1) is TRUE
120			Expression	radGROA_WHF = radGROA_WHF + .33 + .23
121			Expression	radGROAReceipt = radGROAReceipt + .23
122			Condition	END IF
123			Condition	IF (CompareStr('TSC', Left(ObjectType,3))=1) is TRUE
124			Expression	radGROA_WHF = radGROA_WHF + .35 + .23
125			Expression	radGROAReceipt = radGROAReceipt + .23

Table D-2. TSM Non-GROA Process Extensions for Dose Calculations

	Process or Connector	Event Handler and Con. From	Extension Action and Connection to	Non-GROA Line Formulas
1	Model Extensions			
2		SimulationStepStarted		
3			Condition	IF (GetSystemTime(ModelID) MOD 270=0) is TRUE
4			Comment	RAD: Update accumulators
14			Expression	= PublishDB(ModelID , '')
15			Expression	mvHHmin = 500
16			Expression	mvBargemin = 500
17			Expression	mvRailmin = 500
18			Expression	mvTruckmin = 500
19			Expression	mvAgingMax = 0
28			Condition	END IF
173	c26	HS-100B	26load	
174		ObjectProcessingCompleted		
175			Comment	Increment rad for this cask shipment
176			Expression	radSiteCum = radSiteCum+ radSiteRailLoad
177			Expression	radTransCum = radTransCum + radSiteRailShip
178	c200	HS-100Bcan	200load	
179		ObjectProcessingCompleted		
180			Comment	Increment rad for this cask shipment
181			Expression	radSiteCum = radSiteCum+ radSiteDPCLoad
182			Expression	radTransCum = radTransCum + radSiteRailShip

	Process or Connector	Event Handler and Con. From	Extension Action and Connection to	Non-GROA Line Formulas
183	c27	HS-100P	27load	
184		ObjectProcessingCompleted		
185			Comment	Increment rad for this cask shipment
186			Expression	radSiteCum = radSiteCum+ radSiteRailLoad
187			Expression	radTransCum = radTransCum + radSiteRailShip
188	c203	HS-100Pcan	203load	
189		ObjectProcessingCompleted		
190			Comment	Increment rad for this cask shipment
191			Expression	radSiteCum = radSiteCum+ radSiteDPCLoad
192			Expression	radTransCum = radTransCum + radSiteRailShip
193	c242	HS-HBcan	242load	
194		ObjectProcessingCompleted		
195			Comment	Increment rad for this cask shipment
196			Expression	radSiteCum = radSiteCum+ radSiteDPCLoad
197			Expression	radTransCum = radTransCum + radSiteRailShip
198	c218	HS-TROcan	218load	
199		ObjectProcessingCompleted		
200			Comment	Increment rad for this cask shipment
201			Expression	radSiteCum = radSiteCum+ radSiteDPCLoad
202			Expression	radTransCum = radTransCum + radSiteRailShip
203	MGRemplace			
204		ObjectActivated		
205			Expression	radGROAWPEmplace = radGROAWPEmplace + .5
206	c64	NAC-STC	64load	

	Process or Connector	Event Handler and Con. From	Extension Action and Connection to	Non-GROA Line Formulas
207		ObjectProcessingCompleted		
208			Comment	Increment rad for this cask shipment
209			Expression	radSiteCum = radSiteCum+ radSiteRailLoad
210			Expression	radTransCum = radTransCum + radSiteRailShip
211	c221	NAC-STCcan	221load	
212		ObjectProcessingCompleted		
213			Comment	Increment rad for this cask shipment
214			Expression	radSiteCum = radSiteCum+ radSiteDPCLoad
215			Expression	radTransCum = radTransCum + radSiteRailShip
216	c77	NAC-UMSB	77load	
217		ObjectProcessingCompleted		
218			Comment	Increment rad for this cask shipment
219			Expression	radSiteCum = radSiteCum+ radSiteRailLoad
220			Expression	radTransCum = radTransCum + radSiteRailShip
221	c236	NAC-UMSBcan	236load	
222		ObjectProcessingCompleted		
223			Comment	Increment rad for this cask shipment
224			Expression	radSiteCum = radSiteCum+ radSiteDPCLoad
225			Expression	radTransCum = radTransCum + radSiteRailShip
226	c65	NAC-UMSP	65load	
227		ObjectProcessingCompleted		
228			Comment	Increment rad for this cask shipment
229			Expression	radSiteCum = radSiteCum+ radSiteRailLoad
230			Expression	radTransCum = radTransCum + radSiteRailShip

	Process or Connector	Event Handler and Con. From	Extension Action and Connection to	Non-GROA Line Formulas
231	c239	NAC-UMSPcan	239load	
232		ObjectProcessingCompleted		
233			Comment	Increment rad for this cask shipment
234			Expression	radSiteCum = radSiteCum+ radSiteDPCLoad
235			Expression	radTransCum = radTransCum + radSiteRailShip
236	c212	NAC-YRcan	212load	
237		ObjectProcessingCompleted		
238			Comment	Increment rad for this cask shipment
239			Expression	radSiteCum = radSiteCum+ radSiteDPCLoad
240			Expression	radTransCum = radTransCum + radSiteRailShip
241	c68	MP-187-24	68load	
242		ObjectProcessingCompleted		
243			Comment	Increment rad for this cask shipment
244			Expression	radSiteCum = radSiteCum+ radSiteRailLoad
245			Expression	radTransCum = radTransCum + radSiteRailShip
246	c224	MP-187-24can	224load	
247		ObjectProcessingCompleted		
248			Comment	Increment rad for this cask shipment
249			Expression	radSiteCum = radSiteCum + radSiteDPCLoad
250			Expression	radTransCum = radTransCum + radSiteRailShip
251	c69	MP-187-32	69load	
252		ObjectProcessingCompleted		
253			Comment	Increment rad for this cask shipment
254			Expression	radSiteCum = radSiteCum+ radSiteRailLoad

	Process or Connector	Event Handler and Con. From	Extension Action and Connection to	Non-GROA Line Formulas
255			Expression	radTransCum = radTransCum + radSiteRailShip
256	c248	MP-187-32can	248load	
257		ObjectProcessingCompleted		
258			Comment	Increment rad for this cask shipment
259			Expression	radSiteCum = radSiteCum+ radSiteDPCLoad
260			Expression	radTransCum = radTransCum + radSiteRailShip
261	c70	MP-197	70load	
262		ObjectProcessingCompleted		
263			Comment	Increment rad for this cask shipment
264			Expression	radSiteCum = radSiteCum+ radSiteRailLoad
265			Expression	radTransCum = radTransCum + radSiteRailShip
266	c245	MP-197can	245load	
267		ObjectProcessingCompleted		
268			Comment	Increment rad for this cask shipment
269			Expression	radSiteCum = radSiteCum+ radSiteDPCLoad
270			Expression	radTransCum = radTransCum + radSiteRailShip
271	c291	NUHOM52Bcan	291load	
272		ObjectProcessingCompleted		
273			Comment	Increment rad for this cask shipment
274			Expression	radSiteCum = radSiteCum+ radSiteDPCLoad
275			Expression	radTransCum = radTransCum + radSiteRailShip
276	c58	TMIcanonce	58load	
277		ObjectProcessingCompleted		
278			Comment	Increment rad for this cask shipment

	Process or Connector	Event Handler and Con. From	Extension Action and Connection to	Non-GROA Line Formulas
279			Expression	radSiteCum = radSiteCum+ radSiteDPCLoad
280			Expression	radTransCum = radTransCum + radSiteRailShip
281	c60	STPBare	60load	
282		ObjectProcessingCompleted		
283			Comment	Increment rad for this cask shipment
284			Expression	radSiteCum = radSiteCum+ radSiteRailLoad
285			Expression	radTransCum = radTransCum + radSiteRailShip
286	c227	STPcan	227load	
287		ObjectProcessingCompleted		
288			Comment	Increment rad for this cask shipment
289			Expression	radSiteCum = radSiteCum+ radSiteDPCLoad
290			Expression	radTransCum = radTransCum + radSiteRailShip
291	c28	MedRailB	28load	
292		ObjectProcessingCompleted		
293			Comment	Increment rad for this cask shipment
294			Expression	radSiteCum = radSiteCum+ radSiteRailLoad
295			Expression	radTransCum = radTransCum + radSiteRailShip
296	c29	MedRailP	29load	
297		ObjectProcessingCompleted		
298			Comment	Increment rad for this cask shipment
299			Expression	radSiteCum = radSiteCum+ radSiteRailLoad
300			Expression	radTransCum = radTransCum + radSiteRailShip
301	c30	SmallRailB	30load	
302		ObjectProcessingCompleted		

	Process or Connector	Event Handler and Con. From	Extension Action and Connection to	Non-GROA Line Formulas
303			Comment	Increment rad for this cask shipment
304			Expression	radSiteCum = radSiteCum+ radSiteRailLoad
305			Expression	radTransCum = radTransCum + radSiteRailShip
306	c31	SmallRailP	31load	
307		ObjectProcessingCompleted		
308			Comment	Increment rad for this cask shipment
309			Expression	radSiteCum = radSiteCum+ radSiteRailLoad
310			Expression	radTransCum = radTransCum + radSiteRailShip
311	cTADLB	TADLargeB	253load1	
312		ObjectProcessingCompleted		
313			Condition	IF (CompareStr(Cask_Source, 'POOL')) is TRUE
314			Comment	Increment rad for this cask shipment
315			Expression	radSiteCum = radSiteCum+ radSiteTADLoad
316			Expression	radSiteTADLoadCum = radSiteTADLoadCum + radSiteTADLoad
317			Condition	END IF
318			Expression	radTransCum = radTransCum + radSiteRailShip
319	c251	TADLargeBBare	251load	
320		ObjectProcessingCompleted		
321			Condition	IF (CompareStr(Cask_Source, 'POOL')) is TRUE
322			Comment	Increment rad for this cask shipment
323			Expression	radSiteCum = radSiteCum+ radSiteTADLoad
324			Expression	radSiteTADLoadCum = radSiteTADLoadCum + radSiteTADLoad
325			Expression	costcumcaskTAD = costcumcaskTAD+ costTADLMB
326			Expression	costutilloadcum = costutilloadcum+ costutilloadLMTAD

	Process or Connector	Event Handler and Con. From	Extension Action and Connection to	Non-GROA Line Formulas
327			Condition	END IF
328			Expression	radTransCum = radTransCum + radSiteRailShip
329	cTADLP	TADLargeP	253load2	
330		ObjectProcessingCompleted		
331			Condition	IF (CompareStr(Cask_Source, 'POOL')) is TRUE
332			Comment	Increment rad for this cask shipment
333			Expression	radSiteCum = radSiteCum+ radSiteTADLoad
334			Expression	radSiteTADLoadCum = radSiteTADLoadCum + radSiteTADLoad
335			Condition	END IF
336			Expression	radSiteCum = radSiteCum + radSiteRailShip
337	c254	TADLargePBare	254load	
338		ObjectProcessingCompleted		
339			Condition	IF (CompareStr(Cask_Source, 'POOL')) is TRUE
340			Comment	Increment rad for this cask shipment
341			Expression	radSiteCum = radSiteCum+ radSiteTADLoad
342			Expression	radSiteTADLoadCum = radSiteTADLoadCum + radSiteTADLoad
343			Expression	costcumcaskTAD = costcumcaskTAD+ costTADLMP
344			Expression	costutilloadcum = costutilloadcum+ costutilloadLMTAD
345			Condition	END IF
346			Expression	radTransCum = radTransCum + radSiteRailShip
347	cTADSB	TADSmallB	208load1	
348		ObjectProcessingCompleted		
349			Comment	Increment rad for this cask shipment
350			Condition	IF (CompareStr(Cask_Source, 'POOL')) is TRUE

	Process or Connector	Event Handler and Con. From	Extension Action and Connection to	Non-GROA Line Formulas
351			Expression	radSiteCum = radSiteCum+ radSiteTADLoad
352			Expression	radSiteTADLoadCum = radSiteTADLoadCum + radSiteTADLoad
353			Condition	END IF
354			Expression	radTransCum = radTransCum + radSiteRailShip
355	c206	TADSmallBBare	206load	
356		ObjectProcessingCompleted		
357			Condition	IF (CompareStr(Cask_Source, 'POOL')) is TRUE
358			Comment	Increment rad for this cask shipment
359			Expression	radSiteCum = radSiteCum+ radSiteTADLoad
360			Expression	radSiteTADLoadCum = radSiteTADLoadCum + radSiteTADLoad
361			Expression	costcumcaskTAD = costcumcaskTAD+ costTADSB
362			Expression	costutilloadcum = costutilloadcum+ costutilloadSTAD
363			Condition	END IF
364			Expression	radTransCum = radTransCum + radSiteRailShip
365	cTADSP	TADSmallP	208load2	
366		ObjectProcessingCompleted		
367			Condition	IF (CompareStr(Cask_Source, 'POOL')) is TRUE
368			Comment	Increment rad for this cask shipment
369			Expression	radSiteCum = radSiteCum+ radSiteTADLoad
370			Expression	radSiteTADLoadCum = radSiteTADLoadCum + radSiteTADLoad
371			Condition	END IF
372			Expression	radTransCum = radTransCum + radSiteRailShip
373	c209	TADSmallPBare	209load	
374		ObjectProcessingCompleted		

	Process or Connector	Event Handler and Con. From	Extension Action and Connection to	Non-GROA Line Formulas
375			Condition	IF (CompareStr(Cask_Source, 'POOL')) is TRUE
376			Comment	Increment rad for this cask shipment
377			Expression	radSiteCum = radSiteCum+ radSiteTADLoad
378			Expression	radSiteTADLoadCum = radSiteTADLoadCum + radSiteTADLoad
379			Expression	costcumcaskTAD = costcumcaskTAD+ costTADSP
380			Expression	costutilloadcum = costutilloadcum+ costutilloadSTAD
381			Condition	END IF
382			Expression	radTransCum = radTransCum + radSiteRailShip
383	c215	BRPcan	215load	
384		ObjectProcessingCompleted		
385			Comment	Increment rad for this cask shipment
386			Expression	radSiteCum = radSiteCum+ radSiteDPCLoad
387			Expression	radTransCum = radTransCum + radSiteRailShip
388	c102	VSC-24can	102load	
389		ObjectProcessingCompleted		
390			Comment	Increment rad for this cask shipment
391			Expression	radSiteCum = radSiteCum+ radSiteDPCLoad
392			Expression	radTransCum = radTransCum + radSiteRailShip
393	c106	CastorV21once	106load	
394		ObjectProcessingCompleted		
395			Comment	Increment rad for this cask shipment
396			Expression	radSiteCum = radSiteCum+ radSiteTSCLoad
397			Expression	radSiteTSCLoadCum = radSiteTSCLoadCum + radSiteTSCLoad
398			Expression	radTransCum = radTransCum + radSiteRailShip

	Process or Connector	Event Handler and Con. From	Extension Action and Connection to	Non-GROA Line Formulas
399	c109	CastorV33once	109load	
400		ObjectProcessingCompleted		
401			Comment	Increment rad for this cask shipment
402			Expression	radSiteCum = radSiteCum+ radSiteTSCLoad
403			Expression	radSiteTSCLoadCum = radSiteTSCLoadCum + radSiteTSCLoad
404			Expression	radTransCum = radTransCum + radSiteRailShip
405	c295	MC-10once	295load	
406		ObjectProcessingCompleted		
407			Comment	Increment rad for this cask shipment
408			Expression	radSiteCum = radSiteCum + radSiteTSCLoad
409			Expression	radSiteTSCLoadCum = radSiteTSCLoadCum + radSiteTSCLoad
410			Expression	radTransCum = radTransCum + radSiteRailShip
411	c298	NAC-128once	298load	
412		ObjectProcessingCompleted		
413			Comment	Increment rad for this cask shipment
414			Expression	radSiteCum = radSiteCum + radSiteTSCLoad
415			Expression	radSiteTSCLoadCum = radSiteTSCLoadCum + radSiteTSCLoad
416			Expression	radTransCum = radTransCum + radSiteRailShip
417	c76	TN-32TSC	76load	
418		ObjectProcessingCompleted		
419			Comment	Increment rad for this cask shipment
420			Expression	radSiteCum = radSiteCum+ radSiteTSCLoad
421			Expression	radSiteTSCLoadCum = radSiteTSCLoadCum + radSiteTSCLoad
422			Expression	radTransCum = radTransCum + radSiteRailShip

	Process or Connector	Event Handler and Con. From	Extension Action and Connection to	Non-GROA Line Formulas
423	c235	TN-32once	235load	
424		ObjectProcessingCompleted		
425			Comment	Increment rad for this cask shipment
426			Expression	radSiteCum = radSiteCum+ radSiteTSCLoad
427			Expression	radSiteTSCLoadCum = radSiteTSCLoadCum + radSiteTSCLoad
428			Expression	radTransCum = radTransCum + radSiteRailShip
429	c290	TN-40once	290load	
430		ObjectProcessingCompleted		
431			Comment	Increment rad for this cask shipment
432			Expression	radSiteCum = radSiteCum + radSiteTSCLoad
433			Expression	radSiteTSCLoadCum = radSiteTSCLoadCum + radSiteTSCLoad
434			Expression	radTransCum = radTransCum + radSiteRailShip
435	c66	TN-68TSC	66load	
436		ObjectProcessingCompleted		
437			Comment	Increment rad for this cask shipment
438			Expression	radSiteCum = radSiteCum+ radSiteTSCLoad
439			Expression	radSiteTSCLoadCum = radSiteTSCLoadCum + radSiteTSCLoad
440			Expression	radTransCum = radTransCum + radSiteRailShip
441	c232	TN-68once	232load	
442		ObjectProcessingCompleted		
443			Comment	Increment rad for this cask shipment
444			Expression	radSiteCum = radSiteCum+ radSiteTSCLoad
445			Expression	radSiteTSCLoadCum = radSiteTSCLoadCum + radSiteTSCLoad
446			Expression	radTransCum = radTransCum + radSiteRailShip

	Process or Connector	Event Handler and Con. From	Extension Action and Connection to	Non-GROA Line Formulas
447	c18	FSVrain	18load	
448		ObjectProcessingCompleted		
449			Expression	radSiteCum = radSiteCum + radSiteTruckLoad
450			Expression	radTransCum = radTransCum + radSiteTruckShip
451	c6	GA-4	6Tload	
452		ObjectProcessingCompleted		
453			Expression	radSiteCum = radSiteCum + radSiteTruckLoad
454			Expression	radTransCum = radTransCum + radSiteTruckShip
455	c1	GA-9	1Tload	
456		ObjectProcessingCompleted		
457			Expression	radSiteCum = radSiteCum + radSiteTruckLoad
458			Expression	radTransCum = radTransCum + radSiteTruckShip
459	c11	NAC-LWTB	11Tload	
460		ObjectProcessingCompleted		
461			Expression	radSiteCum = radSiteCum + radSiteTruckLoad
462			Expression	radTransCum = radTransCum + radSiteTruckShip
463	c12	NAC-LWTP	12Tload	
464		ObjectProcessingCompleted		
465			Expression	radSiteCum = radSiteCum + radSiteTruckLoad
466			Expression	radTransCum = radTransCum + radSiteTruckShip