

Parameters for the Model of the Waste Control Specialists Site, Andrews County, Texas WCS Site Model v0.205

19 November 2013



Prepared by
NEPTUNE AND COMPANY, INC.
1505 15th St, Suite B, Los Alamos, NM 87544

CONTENTS

1.0	Introduction.....	1
2.0	Distribution Specification.....	1
3.0	GoldSim Simulation Settings and Model Options.....	1
3.1	Simulation Settings • Time.....	2
3.2	Simulation Settings • Monte Carlo.....	2
3.2.1	Probabilistic Simulation.....	2
3.2.2	Deterministic Simulation.....	2
3.3	Simulation Settings • Globals.....	3
3.4	Simulation Settings • Information.....	3
3.5	Model Options.....	3
3.6	Model Options • Contaminant Transport.....	3
4.0	\Miscellaneous.....	3
4.1	\Miscellaneous\MCC_Calculations.....	4
4.1.1	\Miscellaneous\MCC_Calculations\CementitiousMaterialsCalcs.....	4
4.1.2	\Miscellaneous\MCC_Calculations\RebarCalcs.....	4
4.1.3	\Miscellaneous\MCC_Calculations\MCC_Cylinder.....	4
4.1.4	\Miscellaneous\MCC_Calculations\MCC_Box.....	5
4.1.5	\Miscellaneous\MCC_Calculations\MCC_PackingEfficiency.....	5
5.0	\SimulationControl.....	6
5.1	\SimulationControl\Switches.....	6
6.0	\Chronology.....	6
6.1	\Chronology\CementTitrationTime.....	6
7.0	\Materials.....	7
7.1	\Materials\DecayChains.....	7
7.2	\Materials\Water_Properties.....	12
7.3	\Materials\Solubilities.....	13
7.3.1	\Materials\Solubilities\Solubilities_FreshWater.....	13
7.3.2	\Materials\Solubilities\Solubilities_CementWater.....	13
7.4	\Materials\Air_Properties.....	14
7.5	\Materials\Kd_Values.....	15
7.5.1	\Materials\Kd_Values\Clay_Kds.....	15
7.5.2	\Materials\Kd_Values\Sand_Kds.....	17
7.5.3	\Materials\Kd_Values\Cement_Kds.....	19
7.6	\Materials\ETCover_Properties.....	21
7.7	\Materials\BioBarrierGravel_Properties.....	21
7.8	\Materials\Redbed_Clay_Properties.....	22

7.9	\Materials\Sand_Properties.....	22
7.10	\Materials\PerformanceClay_Properties.....	22
7.11	\Materials\LLW_Properties	23
7.12	\Materials\Waste_Properties_RCRA.....	23
7.13	\Materials\ClayAbove125_Properties	23
7.14	\Materials\Sandstone125_Properties	24
7.15	\Materials\ClayAbove180_Properties	24
7.16	\Materials\Sandstone180_Properties	24
7.17	\Materials\ClayAbove225_Properties	25
7.18	\Materials\Sandstone225_Properties	25
8.0	\Processes.....	25
8.1	\Processes\AirTransport	26
8.2	\Processes\WaterTransport	26
8.2.1	\Processes\WaterTransport\HYDRUS_Modeling.....	27
8.2.2	\Processes\WaterTransport\GroundwaterHydraulics_UZ.....	27
8.2.3	\Processes\WaterTransport\GroundwaterHydraulics_SZ	27
8.3	\Processes\PlantTransport.....	27
8.3.1	\Processes\PlantTransport\PlantParameters	27
8.3.1.1	\Processes\PlantTransport\PlantParameters\PlantCR	28
8.3.1.2	\Processes\PlantTransport\PlantParameters\BiomassCalcs	28
8.3.1.3	\Processes\PlantTransport\PlantParameters\MesquiteData	28
8.3.1.4	\Processes\PlantTransport\PlantParameters\GrassData	28
8.3.1.5	\Processes\PlantTransport\PlantParameters\ForbData.....	29
8.3.1.6	\Processes\PlantTransport\PlantParameters\ShrubData.....	29
8.4	\Processes\AnimalTransport.....	29
8.4.1	\Processes\AnimalTransport\AnimalParameters	29
8.4.1.1	\Processes\AnimalTransport\AnimalParameters\AntData.....	30
8.4.1.2	\Processes\AnimalTransport\AnimalParameters MammalData	30
9.0	\Inventory.....	30
9.1	\Inventory\Inventory_CWF	31
9.2	\Inventory\Inventory_FWF.....	31
9.3	\Inventory\WCL_Inventory_RCRA	31
10.0	\Transport.....	32
10.1	\Transport\CWF.....	32
10.1.1	\Transport\CWF\Waste_System.....	32
10.1.1.1	\Transport\CWF\Waste_System\CementVolumeCalcs	32
10.1.2	\Transport\CWF\CellDimensions_UZ	32
10.1.3	\Transport\CWF\CellDimensions_SZ	34
10.2	\Transport\FWF	34
10.2.1	\Transport\FWF\Waste_System	34

10.2.1.1	\Transport\FWF\Waste_System\CementVolumeCalcs	35
10.2.2	\Transport\FWF\CellDimensions_UZ.....	35
10.2.3	\Transport\FWF\CellDimensions_SZ	36
10.3	\Transport\RCRA	37
10.3.1	\Transport\RCRA\RCRA_Layout	37
10.3.2	\Transport\RCRA\RCRA_Dimensions	38
10.3.2.1	\Transport\RCRA\RCRA_Dimensions \RCRA_Dimensions_West	38
10.3.2.2	\Transport\RCRA\RCRA_Dimensions \RCRA_Dimensions_East.....	38
10.3.3	\Transport\RCRA\Cell_Dimensions_UZ	39
10.3.4	\Transport\RCRA\CellDimensions_SZ.....	40
10.3.5	\Transport\RCRA\RCRA_Erosion.....	40
10.3.5.1	\Transport\RCRA\RCRA_Erosion\GullyVolumeCalcs	41
10.3.5.1.1	\Transport\RCRA\RCRA_Erosion \GullyVolumeCalcs\Dimensions	41
10.3.5.1.2	\Transport\RCRA\RCRA_Erosion \GullyVolumeCalcs\IterativeSolution_h.....	41
11.0	\DoseAssessment	41
11.1	\DoseAssessment\BoreholeCuttings_Calcs.....	42
11.1.1	\DoseAssessment\BoreholeCuttings_Calcs\OilWellLocation	42
11.1.2	\DoseAssessment\SoilConc_Calcs\OilWorkerSoilConc_Calcs.....	42
11.1.3	\DoseAssessment\SoilConc_Calcs\GardenSoilConc_Calcs	42
11.1.4	\DoseAssessment\SoilConc_Calcs\RanchHuntFarmSoilConc_Calcs	43
11.2	\DoseAssessment\AirConc_Calcs	43
11.3	\DoseAssessment\ProduceConc_Calcs	43
11.4	\DoseAssessment\MeatConc_Calcs	43
11.5	\DoseAssessment\GrainConc_Calcs	44
11.6	\DoseAssessment\ReceptorActivity	44
11.7	\DoseAssessment\H3_C14_biota_models.....	45
11.8	\DoseAssessment\ResidenceGardenLocations.....	46
11.9	\DoseAssessment\DCFs	46
11.9.1	\DoseAssessment\DCFs\DCF_Ext_modifiers.....	47
11.10	\DoseAssessment\DoseCalculations.....	47
11.10.1	\DoseAssessment\DoseCalculations\ResidenceGardenLocations	47
12.0	\LegacyScenarios	47
12.1	\LegacyScenarios\WaterConcs.....	48
12.2	\LegacyScenarios\LegacyResident_SoilConcs	48
12.3	\LegacyScenarios\LegacyResident_FoodConcs.....	48
12.4	\LegacyScenarios\LegacyResident_H3_C14	48
12.5	\LegacyScenarios\LegacyResidentDose.....	49

12.6	\LegacyScenarios\WellYieldCalcs_225	49
12.7	\LegacyScenarios\MudPit_Microshield	49
12.8	\LegacyScenarios\MudPitDose_2011	49

FIGURES

Figure 1.	Decay chains diagram, part 1 (non-actinoid radionuclides part 1).	8
Figure 2.	Decay chains diagram, part 2 (non-actinoid radionuclides part 2).	9
Figure 3.	Decay chains diagram, part 3 (neptunium and uranium series).	10
Figure 4.	Decay chains diagram, part 4 (actinium and thorium series).	11
Figure 5.	Decay chains diagram, part 5 (actinoid details).	12

TABLES

Table 1.	Distributional forms and their arguments	1
Table 2.	Settings for Simulation Settings • Time.....	2
Table 3.	Miscellaneous element definitions.....	3
Table 4.	Parameters defined in \Miscellaneous\MCC_Calculations\CementitiousMaterialsCalcs	4
Table 5.	Parameters defined in \Miscellaneous\MCC_Calculations\RebarCalcs	4
Table 6.	Parameters defined in \Miscellaneous\MCC_Calculations\MCC_Cylinder	4
Table 7.	Parameters defined in \Miscellaneous\MCC_Calculations\MCC_Box.....	5
Table 8.	Parameters defined in \Miscellaneous\MCC_Calculations\MCC_PackingEfficiency	5
Table 9.	Parameters defined in \Chronology	6
Table 10.	Parameters defined in \Chronology\CementTitrationTime	7
Table 11.	Parameters defined in \Materials\Water_Properties	12
Table 12.	Parameters defined in \Materials\Solubilities\Solubilities_FreshWater	13
Table 13.	Parameters defined in \Materials\Solubilities\Solubilities_CementWater.....	13
Table 14.	Parameters defined in \Materials\Air_Properties.....	14
Table 15.	Parameters defined in \Materials\Kd_Values\Clay_Kds	15
Table 16.	Parameters defined in \Materials\Kd_Values\Sand_Kds.....	17
Table 17.	Parameters defined in \Materials\Kd_Values\Cement_Kds	19
Table 18.	Parameters defined in \Materials\ETCover_Properties	21
Table 19.	Parameters defined in \Materials\BioBarrierGravel_Properties	21
Table 20.	Parameters defined in \Materials\Redbed_Clay_Properties	22
Table 21.	Parameters defined in \Materials\Sand_Properties	22
Table 22.	Parameters defined in \Materials\PerformanceClay_Properties	22
Table 23.	Parameters defined in \Materials\LLW_Properties	23
Table 24.	Parameters defined in \Materials\Waste_Properties_RCRA	23
Table 25.	Parameters defined in \Materials\Clay_Above_125_Properties.....	23
Table 26.	Parameters defined in \Materials\Sandstone125_Properties.....	24
Table 27.	Parameters defined in \Materials\ClayAbove180_Properties	24
Table 28.	Parameters defined in \Materials\Clay_Above_180_Properties	24
Table 29.	Parameters defined in \Materials\ClayAbove225_Properties	25
Table 30.	Parameters defined in \Materials\Sandstone225_Properties.....	25
Table 31.	Parameters defined in \Processes\AirTransport	26
Table 32.	Parameters defined in \Processes\WaterTransport.....	26
Table 33.	Parameters defined in \Processes\WaterTransport\GroundwaterHydraulics_SZ	27
Table 34.	Parameters defined in \Processes\PlantTransport\PlantParameters	27
Table 35.	Parameters defined in \Processes\PlantTransport\PlantParameters\PlantCR	28
Table 36.	Parameters defined in \Processes\PlantTransport\PlantParameters \MesquiteData	28
Table 37.	Parameters defined in \Processes\PlantTransport\PlantParameters\GrassData	28

Table 38.	Parameters defined in \Processes\PlantTransport\PlantParameters\ForbData.....	29
Table 39.	Parameters defined in \Processes\PlantTransport\PlantParameters\ShrubData.....	29
Table 40.	Parameters defined in \Processes\AnimalTransport\AnimalParameters\AntData.....	30
Table 41.	Parameters defined in \Processes\AnimalTransport\AnimalParameters \MammalData	30
Table 42.	Parameters defined in \Inventory	30
Table 43.	Parameters defined in \Inventory\Inventory_CWF.....	31
Table 44.	Parameters defined in \Inventory\Inventory_FWF	31
Table 45.	Parameters defined in \Transport\CWF\Waste_System\CementVolumeCalcs	32
Table 46.	Parameters defined in \Transport\CWF\CellDimensions_UZ	33
Table 47.	Parameters defined in \Transport\CWF\CellDimensions_SZ.....	34
Table 48.	Parameters defined in \Transport\FWF\Waste_System\CementVolumeCalcs	35
Table 49.	Parameters defined in \Transport\FWF\CellDimensions_UZ	35
Table 50.	Parameters defined in \Transport\FWF\CellDimensions_SZ	37
Table 51.	Parameters defined in \Transport\RCRA\RCRA_Layout.....	37
Table 52.	Parameters defined in \Transport\RCRA\RCRA_Dimensions\RCRA_Dimensions_West	38
Table 53.	Parameters defined in \Transport\RCRA\RCRA_Dimensions\RCRA_Dimensions_East.....	38
Table 54.	Parameters defined in \Transport\RCRA\CellDimensions_UZ.....	39
Table 55.	Parameters defined in \Transport\RCRA\CellDimensions_SZ	40
Table 56.	Parameters defined in \Transport\RCRA\RCRA_Erosion.....	40
Table 57.	Parameters defined in \ Transport\RCRA\RCRA_Erosion\GullyVolumeCalcs\Dimensions	41
Table 58.	Parameters defined in \ Transport\RCRA\RCRA_Erosion\GullyVolumeCalcs\IterativeSolution_h.....	41
Table 59.	Parameters defined in \DoseAssessment\BoreholeCuttings_Calcs	42
Table 60.	Parameters defined in \DoseAssessment\BoreholeCuttings_Calcs \OilWellLocation	42
Table 61.	Parameters defined in \DoseAssessment\SoilConc_Calcs \OilWorkerSoilConc_Calcs	42
Table 62.	Parameters defined in \DoseAssessment\SoilConc_Calcs\GardenConc_Calcs	42
Table 63.	Parameters defined in \DoseAssessment\SoilConc_Calcs \RanchHuntFarmConc_Calcs	43
Table 64.	Parameters defined in \DoseAssessment\AirConc_Calcs.....	43
Table 65.	Parameters defined in \DoseAssessment\ProduceConc_Calcs	43
Table 66.	Parameters defined in \DoseAssessment\MeatConc_Calcs.....	43
Table 67.	Parameters defined in \DoseAssessment\GrainConc_Calcs.....	44
Table 68.	Parameters defined in \DoseAssessment\ReceptorActivity.....	44
Table 69.	Parameters defined in \DoseAssessment\H3_C14_biota_models	45
Table 70.	Parameters defined in \DoseAssessment\DCFf.....	46
Table 71.	Parameters defined in \DoseAssessment\DCFf.....	46

Table 72. Parameters defined in \DoseAssessment\ DoseCalculations\ResidenceAndMudPitLocations	47
Table 73. Parameters defined in \LegacyScenarios\WaterConcs	48
Table 74. Parameters defined in \LegacyScenarios\LegacyResident_SoilConcs	48
Table 75. Parameters defined in \LegacyScenarios\LegacyResident_H3_C14.....	48
Table 76. Parameters defined in \LegacyScenarios\LegacyResidentDose	49
Table 77. Parameters defined in \LegacyScenarios\WellYieldCalcs_225.....	49
Table 78. Parameters defined in \LegacyScenarios\MudPitDose_2011	49

1.0 Introduction

This document, along with the complementary Excel spreadsheet workbooks *WCS Site Model Parameters v0.205.xlsx* (which in turn references *NUREGCR-5512 Tables.xlsx*) and *WCS Master Species List.xlsx*, is a collection of all the input parameters used in the WCS Site Model, developed using the GoldSim modeling platform. The workbooks contain those parameters which are most conveniently stored in arrays (such as collections of values by contaminant Species), and this document contains individual parameter values and distributions, organized by Containers in the model.

2.0 Distribution Specification

Distributions in this document are specified according to the following notation. Small is a very small value defined as an element in the GoldSim model, and Large is a similarly-defined very large number. Table 1 contains a list of distributional forms used in the model.

Table 1. Distributional forms and their arguments

distribution type	value or distribution
discrete	value
uniform	U(minimum, maximum)
triangular	Tri(minimum, expected, maximum)
normal	N(mean μ , standard deviation σ)
truncated normal	N(μ , σ , minimum, maximum)
log-normal	LN(geometric mean GM, geometric standard deviation GSD)
truncated log-normal	LN(GM, GSD, minimum, maximum)
log-uniform	LU(minimum, maximum)
beta	beta(v, w, a, b)
truncated gamma	gamma(μ , σ , minimum, maximum)

The following sections itemize, in detail, the parameters and distributions used in the *WCS Site Model v0.205*. The first section is devoted to global settings set in the GoldSim platform. The following sections are organized according to the GoldSim container hierarchy in the model.

3.0 GoldSim Simulation Settings and Model Options

These settings are specified in

- the Simulation Settings dialog box, accessed in the GoldSim interface by choosing Run | Simulation Settings (or pressing the F2 button), and

- the Options dialog box, accessed in the GoldSim interface by choosing Model | Options.

Settings on each tab are recorded below.

3.1 Simulation Settings • Time

Error! Reference source not found. shows the setting on the Time tab of the Simulation Settings dialog. Note that these settings are not particularly critical, and may be changed to suit various purposes.

Table 2. Settings for Simulation Settings • Time

Basic Time Settings				
Time Display Units	yr			
Duration	100000 yr			
Time Phase Settings				
Time Range	#Steps	Length [yr]	Plot Every	FV
0 – 10	10	1	1	
10 – 110	20	5	1	
110 – 500	39	10	1	
500 – 1000	50			
1000 – 10000	180	50	10	×
10000 – 100000	900	100	10	×

3.2 Simulation Settings • Monte Carlo

The settings on the Monte Carlo tab depend on the user's choice between a deterministic or probabilistic simulation.

3.2.1 Probabilistic Simulation

The number of realizations and random seed will vary. Use Latin Hypercube Sampling should be checked, with the drop-down menu option typically set to Use random points in strata. Repeat Sampling Sequences should also be checked to ensure reproducibility.

3.2.2 Deterministic Simulation

Typically, the user should select the radio button indicating the use of Element Deterministic Values. The deterministic values for each element listed in this document is set to the median value unless otherwise noted.

3.3 Simulation Settings • Globals

No global values are identified in this model.

3.4 Simulation Settings • Information

Author and Analysis Description are set to reflect who wrote the model and what it is about. There are no settings in the Information text box.

3.5 Model Options

The settings in the General, Graphic, and Results tabs may be adjusted according to the preferences of the user or model programmer. The Modules tab will require that the Radionuclide Transport Module be enabled. If your copy of GoldSim does not include this module, run the model using the GoldSim Player, or contact GoldSim Technology Group to obtain a license for the RT Module.

3.6 Model Options • Contaminant Transport

Model programmers have several options to choose from on this tab. The General Options settings used in this analysis are as follows: Solution precision is set to Medium, Warning messages are not logged, the decay of Species is not disabled, and cell-network details are not logged.

For the Source Term, Barriers are set to use a random failure time, and the computed number of waste package failures is rounded, rather than truncated.

The selection of units should be left to show Mass in pathways in g, Mass fluxes in g/yr, Fluid concentrations in kg/m³, and Solid concentrations in g/kg.

4.0 Miscellaneous

The Miscellaneous container holds various useful elements with global scope, listed in Table 3.

Table 3. Miscellaneous element definitions

GoldSim element	value or distribution	units	reference / comment
Small	1×10^{-30}	—	a very small value
Large	1×10^{30}	—	a very large value
Random_0_1_negDeterm	U(0, 1), with a deterministic value of -1	—	a standard distribution

4.1 \Miscellaneous\MCC_Calculations

Also considered among the miscellaneous calculations are those that determine the fate and timing of cementitious materials in the modular cement containers, MCCs. These are defined in this container and its subcontainers. Most of these input parameters are for engineered materials, with little uncertainty in their dimensions, so they are defined as Data elements.

4.1.1 \Miscellaneous\MCC_Calculations\CementitiousMaterialsCalcs

The Miscellaneous container holds various useful elements with global scope, listed in Table 4.

Table 4. Parameters defined in \Miscellaneous\MCC_Calculations\CementitiousMaterialsCalcs

GoldSim element	value	units	reference / comment
CementMass _Concrete_MCC	750	lbm/yd ³	Values from "WCS mix design development 0.30 6% V1.2.pdf"
CementMass _Grout_MCC	400	lbm/yd ³	"Exhibit D - Grout Mix Design.pdf"

4.1.2 \Miscellaneous\MCC_Calculations\RebarCalcs

The Miscellaneous container holds various useful elements with global scope, listed in Table 5.

Table 5. Parameters defined in \Miscellaneous\MCC_Calculations\RebarCalcs

GoldSim element	value	units	reference / comment
Diameter_rebarNo4	0.5	in	Values from http://www.unitedstatesconcrete.com/rebar_chart.html
Diameter_rebarNo5	0.625	in	<i>ibid.</i>

4.1.3 \Miscellaneous\MCC_Calculations\MCC_Cylinder

The Miscellaneous container holds various useful elements with global scope, listed in Table 6.

Table 6. Parameters defined in \Miscellaneous\MCC_Calculations\MCC_Cylinder

GoldSim element	distribution or value	units	reference / comment
ThicknessLid_Cyl	16	in	Values from drawing numbers WCS-LLRW-13-11-292-004 sheet S2.3 WCS-LLRW-13-11-006 sheet S2.5
OutsideRadius_Cyl	3' 10"	ft, in	<i>ibid.</i>
InsideRadius_Cyl	3' 4"	ft, in	<i>ibid.</i>

OutsideHeight_Cyl	10' 4"	ft, in	<i>ibid.</i>
FloorHeight_Cyl	1' 2"	ft, in	<i>ibid.</i>
ThicknessPad_Cyl	12"	in	<i>ibid.</i>
Volume_DrumInMCC	N(55 gal, 0.001 m ³ , Small m ³ , Large m ³)	vol.	nominal variation in volume of a 55 gallon drum
NumberDrumsInMCC_Cyl	14	—	source needed

4.1.4 \Miscellaneous\MCC_Calculations\MCC_Box

The Miscellaneous container holds various useful elements with global scope, listed in Table 7.

Table 7. Parameters defined in \Miscellaneous\MCC_Calculations\MCC_Box

GoldSim element	distribution or value	units	reference / comment
ThicknessLid_Box	18	in	Values from drawing numbers WCS-LLRW-13-11-005 sheet S2.4 WCS-LLRW-13-11-006 sheet S2.5
OutsideLength_Box	10' 10"	ft, in	<i>ibid.</i>
InsideLength_Box	9' 6"	ft, in	<i>ibid.</i>
OutsideWidth_Box	9'	ft, in	<i>ibid.</i>
InsideWidth_Box	7' 8"	ft, in	<i>ibid.</i>
OutsideHeight_Box	10' 4"	ft, in	<i>ibid.</i>
FloorHeight_Box	1' 2"	ft, in	<i>ibid.</i>
ThicknessPad_Box	12"	in	<i>ibid.</i>
Volume_WasteInMCC_Box	N(10, 1, Small, InsideVolume_Box)	m ³	source needed

4.1.5 \Miscellaneous\MCC_Calculations\MCC_PackingEfficiency

The Miscellaneous container holds various useful elements with global scope, listed in Table 8.

**Table 8. Parameters defined in
\Miscellaneous\MCC_Calculations\MCC_PackingEfficiency**

GoldSim element	distribution or value	units	reference / comment
-----------------	-----------------------	-------	---------------------

AvgHorizSpacingMCC_Cyl	N(1, 0.01, Small, Large)	ft	See Engineering white paper Mean value is from “Canister Configurations.docx”; distribution is a placeholder
AvgHorizSpacingMCC_Box	N(1, 0.01, Small, Large)	ft	<i>ibid.</i>

5.0 \SimulationControl

The SimulationControl container has several subcontainers related to settings and control for the simulation.

5.1 \SimulationControl\Switches

Although switches are implemented as GoldSim Data elements, they do not have set values, but rather are set via the Control Panel or some other dashboard or model condition.

6.0 \Chronology

Model events are collected into the Chronology container, and are documented in Table 9.

Table 9. Parameters defined in \Chronology

GoldSim element	value or distribution	units	reference / comment
IC_Period	N(100, 10, Small, Large)	yr	regulatory definition
ConcreteStc_Failure_Time	500	yr	modeling assumption
WasteDecompositionTime	N(1000, 100, Small, Large)	yr	mean from WCS (2007) ; distribution is a placeholder
CoverNaturalizationTime	N(500, 100, Small, Large)	yr	mean from WCS (2007) ; distribution is a placeholder
ClimateTransitionTime	N(25000, 1000, Small, Large)	yr	distribution is a placeholder
RCRA_TOC	1000 (user-defined)	yr	regulatory definition

6.1 \Chronology\CementTitrationTime

Calculations specific to the timing if the titration of cement are collected into the CementTitrationTime container, as documented in Table 10.

Table 10. Parameters defined in \Chronology\CementTitrationTime

GoldSim element	value or distribution	units	reference / comment
WaterMassForTransition_1st	N(0.35 kg / 1000 cm ³ , 0.05 kg / 1000 cm ³ , Small, Large)	kg/m ³	see Geochemistry white paper Source: NIROND TR-2008-23E, pp. 13, 14
WaterMassForTransition_2nd	N(70 kg / 1000 cm ³ , 5 kg / 1000 cm ³ , Small, Large)	kg/m ³	<i>ibid.</i>
WaterContent_Concrete	N(0.3, 0.05, Small, Large)	—	<i>ibid.</i>

7.0 \Materials

The Materials container defines all materials used in the model, including Species, the fluids Water and Air, and a number of Solid materials. Because they are tabular in nature, the definitions of the Species Element and the HalfLife Data vector are to be found in the associated *WCS Site Model Parameters v0.205.xlsx* spreadsheet workbook.

7.1 \Materials\DecayChains

The DecayChains container does not have Data or Stochastic input elements, but does contain values, in the diagrams, that are used to construct the Species list. These diagrams are provided here in Figures 1 through 5.

Decay chains implemented in contaminant transport and dose calculations

Note that the radionuclides and stable nuclides in black are maintained in the Species list. Any modification to the decay chain diagram needs to have an associated modification to the Species list, and vice versa.

The radionuclides noted in green italic are considered in the dose assessment only, through the "roll-up" of dose conversion factors. Environmental transport of these progeny is assumed to follow their respective parents, with which they are in secular equilibrium. Radionuclides in green italic need to have any reported inventory converted to the next long-lived progeny.

Radionuclides in olive are extremely long-lived, and do not have significant contributions to dose. These are not modeled.

Radionuclides in orange are short-lived, and if reported in inventory are to be converted to the next long-lived progeny on an activity basis (e.g. Bq for Bq).

Radionuclides, stable nuclides, and decay arrows in gray are not represented in the model, but are shown here for completeness. Details in the Actinoid_detail Container are also not modeled.

Each decay mode is shown in blue (alpha, beta, beta positron, isomeric transition, and electron capture), with modeled alpha decay arrows shown in red.

Branching fractions are shown in purple, and are assumed to be 1 unless a value is shown. Branching fractions less than 0.001 are identified as "~0" and are not modeled. Branching fractions are used in the dose roll up calculations (external to the model) and in the Stoichiometry definitions in the Species element specification. These come from Tuli's Nuclear Wallet Cards (2005).

In a few cases, complex decay paths have been simplified, and are shown in the detail Container. These cases are invariably inconsequential, as the branching fractions in question are extremely small.

Revised 5 June 2012 - JT

Non-actinoid decay chains:

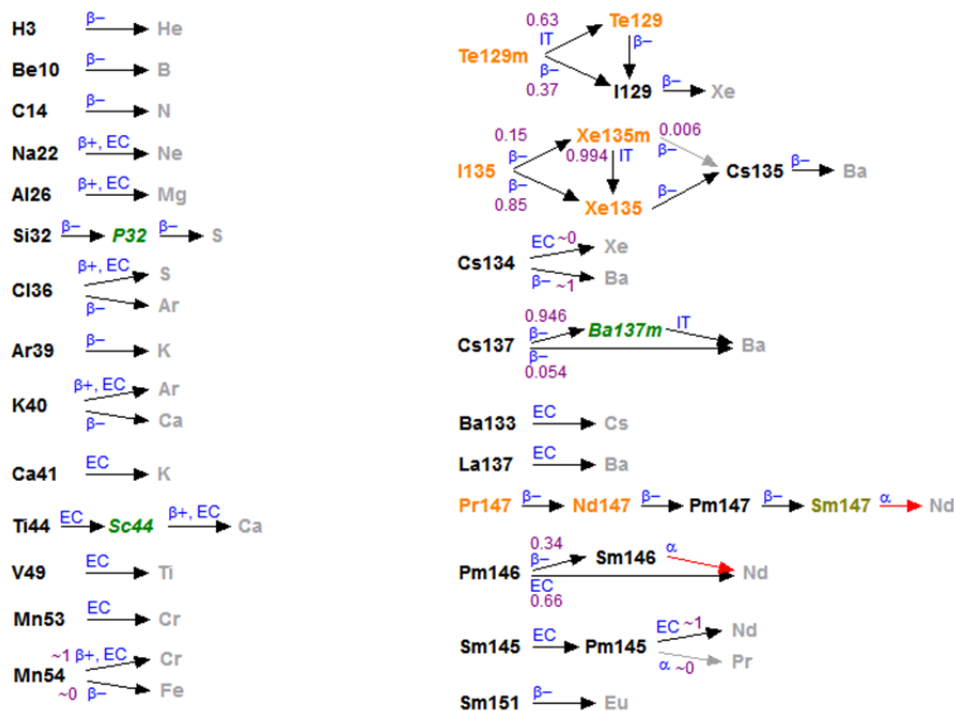


Figure 1. Decay chains diagram, part 1 (non-actinoid radionuclides part 1).

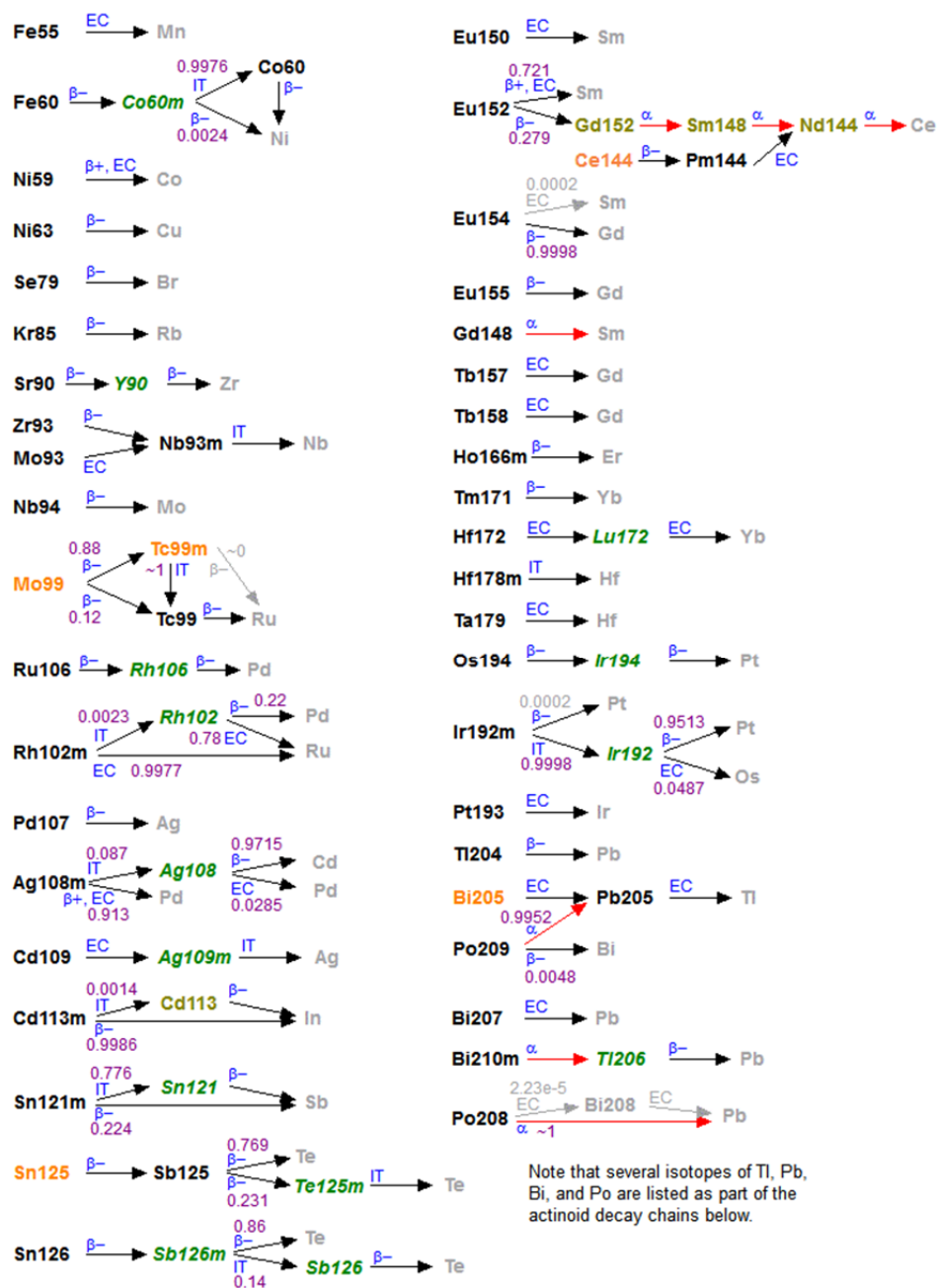
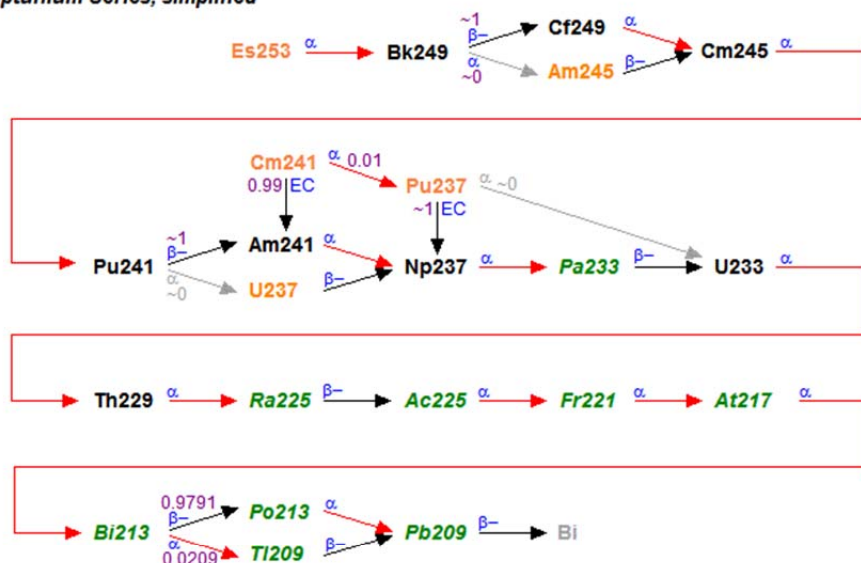


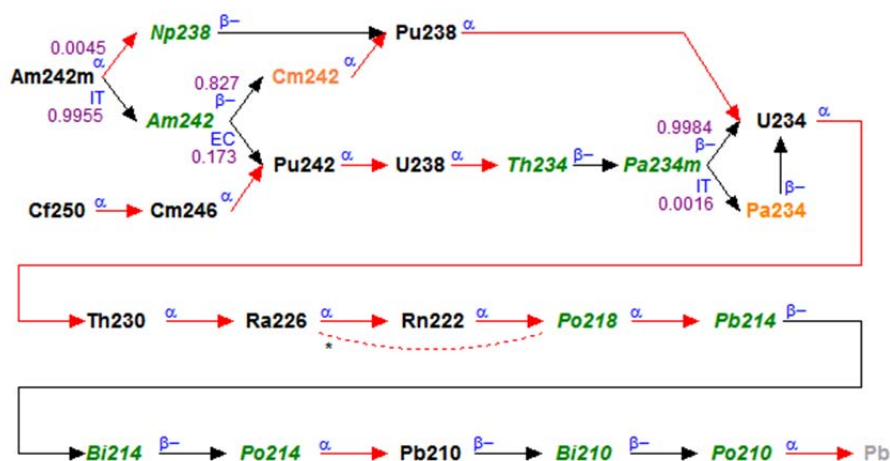
Figure 2. Decay chains diagram, part 2 (non-actinoid radionuclides part 2).

Actinoid decay chains:

Neptunium Series, simplified



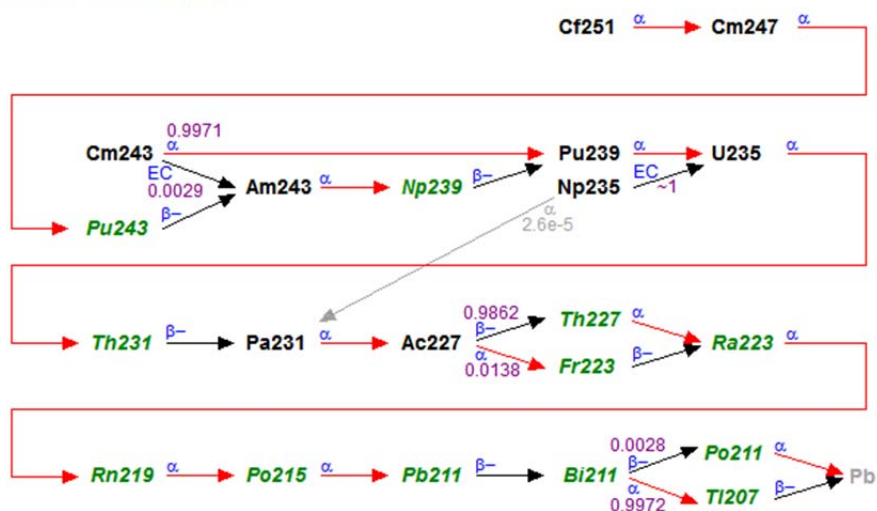
Uranium Series, simplified



* $\text{Rn}222$ is partially bypassed in proportion to account for partial emanation.

Figure 3. Decay chains diagram, part 3 (neptunium and uranium series).

Actinium Series, simplified



Thorium Series, simplified

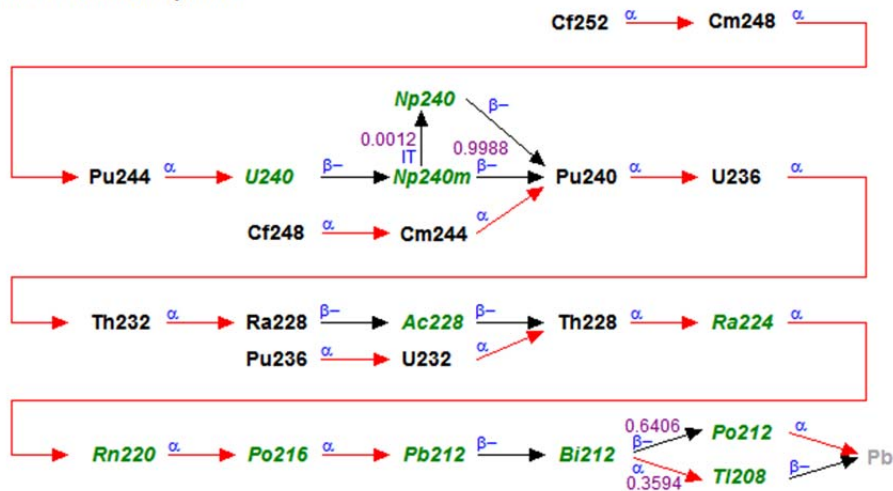


Figure 4. Decay chains diagram, part 4 (actinium and thorium series).

Decay chain detail for the actinoids

Note that the radionuclides and stable nuclides in black are maintained in the Species list. Any modification to the decay chain diagram needs to have an associated modification to the Species list, and vice versa.

The radionuclides noted in green italic are considered in the dose assessment only. Environmental transport of these progeny is assumed to follow their respective parents, with which they are in secular equilibrium.

Radionuclides, stable nuclides, and decay arrows in gray are not represented in the model, but are shown here for completeness. Details in the detail Containers are also not modeled.

Neptunium Series

The detail of the Neptunium Series decay chain starts at Fr221, from Th229 > Ra225 > Ac225 > Fr221.



Uranium Series

The detail of the Uranium Series decay chain starts at Po218, from Ra226 > Rn222 > Po218.



Actinium Series

The detail of the Actinium Series decay chain starts at Ac227.



Figure 5. Decay chains diagram, part 5 (actinoid details).

7.2 \Materials\Water_Properties

The properties of water are defined in this container. This is limited to diffusion parameters. The density of water is a GoldSim constant called WatDens.

Table 11. Parameters defined in \Materials\Water_Properties

GoldSim element	value or distribution	units	reference / comment
RefDiffusivity_Water	1	m ² /s	This is a GoldSim modeling construct.
DiffusionCoeff_Water_Default	N(1×10 ⁻⁹ , 1×10 ⁻¹² , Small, Large)	m ² /s	see Geochemical Modeling white paper; distribution is a placeholder

7.3 \Materials\Solubilities

Definitions are provided for aqueous solubility in fresh water and in water equilibrated with cementitious materials for each chemical element.

7.3.1 \Materials\Solubilities\Solubilities_FreshWater

The solubilities for each chemical element in fresh water (local naturally-occurring groundwater) are defined in this container. For now, many values are defined as “-1 mol/L”, a special designation that signals GoldSim to allow for unlimited solubility. The development of stochastic solubility values for these is pending.

Table 12. Parameters defined in \Materials\Solubilities\Solubilities_FreshWater

GoldSim element	value or distribution	units	reference / comment
C	LU(1e-7, 1e-4)	mol/L	see Geochemical Modeling white paper
Cl	LU(1e-5, 1)	mol/L	<i>ibid.</i>
I	-1	mol/L	<i>ibid.</i>
Ra	LTri(1e-9, 1e-7, 1e-5)	mol/L	<i>ibid.</i>
Tc	-1	mol/L	<i>ibid.</i>
U	LU(1e-6, 1e-3)	mol/L	<i>ibid.</i>
others, Ac, ..., Zr	-1	mol/L	<i>ibid.</i> default value

7.3.2 \Materials\Solubilities\Solubilities_CementWater

The solubilities for each chemical element in fresh water (local naturally-occurring groundwater) are defined in this container. For now, many values are defined as “-1” (with any consistent units), a special designation that signals GoldSim to allow for unlimited solubility. The development of stochastic solubility values for these is pending. For those values that are defined by simply pointing to their fresh water components, the significance of pointing with an expression, rather than defining a separate (though identical) distribution is that the distributions are not sampled independently, so that the solubilities are always the same within a given realization.

Table 13. Parameters defined in \Materials\Solubilities\Solubilities_CementWater

GoldSim element	value or distribution	units	reference / comment
C	= Solubility_FreshWater[C]	mol/L	see Geochemical Modeling white paper
Cl	= Solubility_FreshWater[Cl]	mol/L	<i>ibid.</i>
I	= Solubility_FreshWater[I]	mol/L	<i>ibid.</i>
Ra	= Solubility_FreshWater[Ra]	mol/L	<i>ibid.</i>

Tc	LN(1.0263e-7, 3.7518)	mol/L	<i>ibid.</i>
U	= Solubility_FreshWater[U]	mol/L	<i>ibid.</i>
others, Ac, ..., Zr	-1	mol/L	<i>ibid.</i> default value

7.4 \Materials\Air_Properties

Properties of the material Air pertain to diffusion coefficients, Henry's Law partition coefficients, and the escape/production ratio for radon gas.

Table 14. Parameters defined in \Materials\Air_Properties

GoldSim element	value or distribution	units	reference / comment
RefDiffusivity_Air	1	cm ² /s	see Geochemical Modeling white paper
AirDiffusionCoeff_H	0.25	cm ² /s	<i>ibid.</i>
AirDiffusionCoeff_C	0.16	cm ² /s	<i>ibid.</i>
AirDiffusionCoeff_Ar	0.148	cm ² /s	<i>ibid.</i>
AirDiffusionCoeff_Kr	0.14	cm ² /s	<i>ibid.</i>
AirDiffusionCoeff_I	0.09	cm ² /s	<i>ibid.</i>
AirDiffusionCoeff_Rn	0.11	cm ² /s	<i>ibid.</i>
Kh_H	N(1.7×10^{-5} , 1×10^{-9} , Small, Large) determ value: 1.7×10^{-5}	—	<i>ibid.</i> ; deterministic value provided since the median may not be exactly the expected value in this truncated distribution
Kh_C	N(1.2, 0.001, Small, Large) determ value: 1.2	—	<i>ibid.</i> ; see above re deterministic value
Kh_Ar	N(29.5, 0.001, Small, Large) determ value: 29.5	—	<i>ibid.</i> ; see above re deterministic value
Kh_Kr	N(16.1, 0.001, Small, Large) determ value: 16.1	—	<i>ibid.</i> ; see above re deterministic value
Kh_I	N(0.013, 0.00001, Small, Large) determ value: 0.013	—	<i>ibid.</i> ; see above re deterministic value
Kh_Rn	N(4.6, 0.001, Small, Large) determ value: 4.6	—	<i>ibid.</i> ; see above re deterministic value

Radon_EP_Ratio*	1	—	<i>ibid.</i> ; see above re deterministic value
-----------------	---	---	---

* Note that there is a separate radon E/P ratio defined for each waste type. See §9.0, Table 42.

7.5 \Materials\Kd_Values

Previously used constant values for solid/water partition coefficients (K_d s) in sand, clay, and cementitious materials are most appropriately stored as vectors, so these values are documented in the associated *WCS Site Model Parameters v0.205.xlsx* spreadsheet workbook.

Stochastic definitions for these parameters are defined in the following tables.

7.5.1 \Materials\Kd_Values\Clay_Kds

The stochastic distributions for the revised K_d s for the redbed claystone are given in the following Table.

Table 15. Parameters defined in \Materials\Kd_Values\Clay_Kds

GoldSim element	value or distribution	units	reference / comment
Ac	discrete(2400)	mL/g	See Geochemical Modeling white paper. Values are from WCS (2007).
Ag	discrete(180)	mL/g	<i>ibid.</i>
Al	discrete(353)	mL/g	<i>ibid.</i>
Am	discrete(8400)	mL/g	<i>ibid.</i>
Ar	0	mL/g	<i>ibid.</i>
Ba	discrete(52)	mL/g	<i>ibid.</i>
Be	discrete(1300)	mL/g	<i>ibid.</i>
Bi	discrete(600)	mL/g	<i>ibid.</i>
Bk	discrete(70)	mL/g	<i>ibid.</i>
C	discrete(0)	mL/g	<i>ibid.</i>
Ca	discrete(50)	mL/g	<i>ibid.</i>
Cd	discrete(560)	mL/g	<i>ibid.</i>
Cf	discrete(510)	mL/g	<i>ibid.</i>
Cl	0	mL/g	<i>ibid.</i>
Cm	discrete(6000)	mL/g	<i>ibid.</i>
Co	discrete(550)	mL/g	<i>ibid.</i>
Cs	discrete(1900)	mL/g	<i>ibid.</i>

Eu	discrete(240)	mL/g	<i>ibid.</i>
Fe	discrete(165)	mL/g	<i>ibid.</i>
Gd	discrete(240)	mL/g	<i>ibid.</i>
H	0	mL/g	<i>ibid.</i>
Hf	discrete(2400)	mL/g	<i>ibid.</i>
Ho	discrete(1300)	mL/g	<i>ibid.</i>
I	discrete(0)	mL/g	<i>ibid.</i>
Ir	discrete(91)	mL/g	<i>ibid.</i>
K	discrete(75)	mL/g	<i>ibid.</i>
Kr	0	mL/g	<i>ibid.</i>
La	discrete(52)	mL/g	<i>ibid.</i>
Mn	discrete(180)	mL/g	<i>ibid.</i>
Mo	discrete(90)	mL/g	<i>ibid.</i>
Na	discrete(10)	mL/g	<i>ibid.</i>
Nb	discrete(900)	mL/g	<i>ibid.</i>
Ni	discrete(650)	mL/g	<i>ibid.</i>
Np	discrete(55)	mL/g	<i>ibid.</i>
Os	discrete(157)	mL/g	<i>ibid.</i>
Pa	discrete(2700)	mL/g	<i>ibid.</i>
Pb	discrete(550)	mL/g	<i>ibid.</i>
Pd	discrete(250)	mL/g	<i>ibid.</i>
Pm	discrete(240)	mL/g	<i>ibid.</i>
Po	= Pb	mL/g	<i>ibid.</i>
Pt	= Pd	mL/g	<i>ibid.</i>
Pu	discrete(5100)	mL/g	<i>ibid.</i>
Ra	discrete(9100)	mL/g	<i>ibid.</i>
Rh	discrete(4)	mL/g	<i>ibid.</i>
Rn	0	mL/g	<i>ibid.</i>
Ru	discrete(800)	mL/g	<i>ibid.</i>
Sb	discrete(250)	mL/g	<i>ibid.</i>
Se	discrete(740)	mL/g	<i>ibid.</i>
Si	discrete(180)	mL/g	<i>ibid.</i>
Sm	discrete(1300)	mL/g	<i>ibid.</i>
Sn	discrete(670)	mL/g	<i>ibid.</i>
Sr	discrete(110)	mL/g	<i>ibid.</i>

Ta	discrete(1200)	mL/g	<i>ibid.</i>
Tb	discrete(157)	mL/g	<i>ibid.</i>
Tc	discrete(0)	mL/g	<i>ibid.</i>
Th	discrete(5800)	mL/g	<i>ibid.</i>
Ti	discrete(310)	mL/g	<i>ibid.</i>
Tl	= Pb	mL/g	<i>ibid.</i>
Tm	0	mL/g	<i>ibid.</i>
U	discrete(1600)	mL/g	<i>ibid.</i>
V	discrete(310)	mL/g	<i>ibid.</i>
Zr	discrete(3300)	mL/g	<i>ibid.</i>

7.5.2 \Materials\Kd_Values\Sand_Kds

Table 16. Parameters defined in \Materials\Kd_Values\Sand_Kds

GoldSim element	value or distribution	units	reference / comment
Ac	discrete(450)	mL/g	See Geochemical Modeling white paper. Values are from WCS (2007).
Ag	discrete(90)	mL/g	<i>ibid.</i>
Al	discrete(353)	mL/g	<i>ibid.</i>
Am	discrete(1900)	mL/g	<i>ibid.</i>
Ar	0	mL/g	<i>ibid.</i>
Ba	discrete(52)	mL/g	<i>ibid.</i>
Be	discrete(250)	mL/g	<i>ibid.</i>
Bi	discrete(100)	mL/g	<i>ibid.</i>
Bk	discrete(70)	mL/g	<i>ibid.</i>
C	discrete(0)	mL/g	<i>ibid.</i>
Ca	discrete(5)	mL/g	<i>ibid.</i>
Cd	discrete(80)	mL/g	<i>ibid.</i>
Cf	discrete(510)	mL/g	<i>ibid.</i>
Cl	0	mL/g	<i>ibid.</i>
Cm	discrete(4000)	mL/g	<i>ibid.</i>
Co	discrete(60)	mL/g	<i>ibid.</i>
Cs	discrete(280)	mL/g	<i>ibid.</i>
Eu	discrete(240)	mL/g	<i>ibid.</i>

Fe	discrete(220)	mL/g	<i>ibid.</i>
Gd	discrete(240)	mL/g	<i>ibid.</i>
H	0	mL/g	<i>ibid.</i>
Hf	discrete(450)	mL/g	<i>ibid.</i>
Ho	discrete(250)	mL/g	<i>ibid.</i>
I	discrete(0)	mL/g	<i>ibid.</i>
Ir	discrete(91)	mL/g	<i>ibid.</i>
K	discrete(15)	mL/g	<i>ibid.</i>
Kr	0	mL/g	<i>ibid.</i>
La	discrete(52)	mL/g	<i>ibid.</i>
Mn	discrete(50)	mL/g	<i>ibid.</i>
Mo	discrete(10)	mL/g	<i>ibid.</i>
Na	discrete(10)	mL/g	<i>ibid.</i>
Nb	discrete(160)	mL/g	<i>ibid.</i>
Ni	discrete(400)	mL/g	<i>ibid.</i>
Np	discrete(5)	mL/g	<i>ibid.</i>
Os	discrete(157)	mL/g	<i>ibid.</i>
Pa	discrete(550)	mL/g	<i>ibid.</i>
Pb	discrete(270)	mL/g	<i>ibid.</i>
Pd	discrete(55)	mL/g	<i>ibid.</i>
Pm	discrete(240)	mL/g	<i>ibid.</i>
Po	= Pb	mL/g	<i>ibid.</i>
Pt	= Pd	mL/g	<i>ibid.</i>
Pu	discrete(550)	mL/g	<i>ibid.</i>
Ra	discrete(500)	mL/g	<i>ibid.</i>
Rh	discrete(4)	mL/g	<i>ibid.</i>
Rn	0	mL/g	<i>ibid.</i>
Ru	discrete(55)	mL/g	<i>ibid.</i>
Sb	discrete(45)	mL/g	<i>ibid.</i>
Se	discrete(150)	mL/g	<i>ibid.</i>
Si	discrete(35)	mL/g	<i>ibid.</i>
Sm	discrete(245)	mL/g	<i>ibid.</i>
Sn	discrete(130)	mL/g	<i>ibid.</i>
Sr	discrete(15)	mL/g	<i>ibid.</i>
Ta	discrete(220)	mL/g	<i>ibid.</i>

Tb	discrete(157)	mL/g	<i>ibid.</i>
Tc	discrete(0)	mL/g	<i>ibid.</i>
Th	discrete(3200)	mL/g	<i>ibid.</i>
Ti	discrete(310)	mL/g	<i>ibid.</i>
Tl	= Pb	mL/g	<i>ibid.</i>
Tm	0	mL/g	<i>ibid.</i>
U	discrete(35)	mL/g	<i>ibid.</i>
V	discrete(310)	mL/g	<i>ibid.</i>
Zr	discrete(0)	mL/g	<i>ibid.</i>

7.5.3 \Materials\Kd_Values\Cement_Kds

Table 17. Parameters defined in \Materials\Kd_Values\Cement_Kds

GoldSim element	value or distribution	units	reference / comment
Ac	discrete(20)	mL/g	See Geochemical Modeling white paper. Values are from WCS (2007) except for C, Cl, and I.
Ag	discrete(110)	mL/g	<i>ibid.</i>
Al	discrete(353)	mL/g	<i>ibid.</i>
Am	discrete(20)	mL/g	<i>ibid.</i>
Ar	0	mL/g	<i>ibid.</i>
Ba	discrete(52)	mL/g	<i>ibid.</i>
Be	discrete(23)	mL/g	<i>ibid.</i>
Bi	discrete(100)	mL/g	<i>ibid.</i>
Bk	discrete(70)	mL/g	<i>ibid.</i>
C	LN(500, 6.18)	mL/g	<i>ibid.</i>
Ca	discrete(5)	mL/g	<i>ibid.</i>
Cd	discrete(4300)	mL/g	<i>ibid.</i>
Cf	discrete(510)	mL/g	<i>ibid.</i>
Cl	LN(10, 4.06)	mL/g	<i>ibid.</i>
Cm	discrete(4000)	mL/g	<i>ibid.</i>
Co	discrete(45)	mL/g	<i>ibid.</i>
Cs	discrete(270)	mL/g	<i>ibid.</i>
Eu	discrete(240)	mL/g	<i>ibid.</i>
Fe	discrete(165)	mL/g	<i>ibid.</i>

Gd	discrete(240)	mL/g	<i>ibid.</i>
H	0	mL/g	<i>ibid.</i>
Hf	discrete(450)	mL/g	<i>ibid.</i>
Ho	discrete(250)	mL/g	<i>ibid.</i>
I	LN(14.1, 7.48)	mL/g	<i>ibid.</i>
Ir	discrete(91)	mL/g	<i>ibid.</i>
K	discrete(5.5)	mL/g	<i>ibid.</i>
Kr	0	mL/g	<i>ibid.</i>
La	discrete(52)	mL/g	<i>ibid.</i>
Mn	discrete(50)	mL/g	<i>ibid.</i>
Mo	discrete(20)	mL/g	<i>ibid.</i>
Na	discrete(10)	mL/g	<i>ibid.</i>
Nb	discrete(160)	mL/g	<i>ibid.</i>
Ni	discrete(1900)	mL/g	<i>ibid.</i>
Np	discrete(5)	mL/g	<i>ibid.</i>
Os	discrete(157)	mL/g	<i>ibid.</i>
Pa	discrete(50)	mL/g	<i>ibid.</i>
Pb	discrete(597)	mL/g	<i>ibid.</i>
Pd	discrete(55)	mL/g	<i>ibid.</i>
Pm	discrete(240)	mL/g	<i>ibid.</i>
Po	= Pb	mL/g	<i>ibid.</i>
Pt	= Pd	mL/g	<i>ibid.</i>
Pu	discrete(550)	mL/g	<i>ibid.</i>
Ra	discrete(70)	mL/g	<i>ibid.</i>
Rh	discrete(4)	mL/g	<i>ibid.</i>
Rn	0	mL/g	<i>ibid.</i>
Ru	discrete(55)	mL/g	<i>ibid.</i>
Sb	discrete(45)	mL/g	<i>ibid.</i>
Se	discrete(2.2)	mL/g	<i>ibid.</i>
Si	discrete(35)	mL/g	<i>ibid.</i>
Sm	discrete(245)	mL/g	<i>ibid.</i>
Sn	discrete(130)	mL/g	<i>ibid.</i>
Sr	discrete(15)	mL/g	<i>ibid.</i>
Ta	discrete(220)	mL/g	<i>ibid.</i>
Tb	discrete(157)	mL/g	<i>ibid.</i>

Tc	discrete(0)	mL/g	<i>ibid.</i>
Th	discrete(3200)	mL/g	<i>ibid.</i>
Ti	discrete(310)	mL/g	<i>ibid.</i>
Tl	= Pb	mL/g	<i>ibid.</i>
Tm	0	mL/g	<i>ibid.</i>
U	discrete(3000)	mL/g	<i>ibid.</i>
V	discrete(1000)	mL/g	<i>ibid.</i>
Zr	discrete (600)	mL/g	<i>ibid.</i>

The material properties for the layers above and including the Waste layer are defined using the input parameters provided by the HYDRUS modeling in the container \Processes \WaterTransport\HYDRUS_Modeling.

7.6 \Materials\ETCover_Properties

Properties are defined for Solid material ET_Cover_Material, a porous medium, in the following table. This material is a composite of all materials in the upper layers of the cover.

Table 18. Parameters defined in \Materials\ETCover_Properties

GoldSim element	value or distribution	units	reference / comment
ET_Cover_Porosity	= ET_Cover_Properties_HYDRUS .Porosity_ET_Cover	—	WCS (2007)
ET_Cover_Particle_Density	= ET_Cover_Properties_HYDRUS .ParticleDensity_ET_Cover	kg/m ³	<i>ibid.</i>

7.7 \Materials\BioBarrierGravel_Properties

Properties are defined for Solid material BioBarrierGravel, a porous medium, in the following table.

Table 19. Parameters defined in \Materials\BioBarrierGravel_Properties

GoldSim element	value or distribution	units	reference / comment
BioBarrier_Porosity	= BioBarrier_Properties_HYDRUS .Porosity_BioBarrier	—	WCS (2007)
BioBarrier_Particle Density	= BioBarrier_Properties_HYDRUS .ParticleDensity_BioBarrier	kg/m ³	<i>ibid.</i>

7.8 \Materials\Redbed_Clay_Properties

Properties are defined for Solid material Redbed_Clay, a porous medium, in the following table.

Table 20. Parameters defined in \Materials\Redbed_Clay_Properties

GoldSim element	value or distribution	units	reference / comment
RedbedClay_Porosity	= RedBedClay_Properties_HYDRUS .Porosity_RedBedClay	—	WCS (2007)
RedbedClay_ParticleDensity	= RedBedClay_Properties_HYDRUS .ParticleDensity_RedBedClay	kg/m ³	<i>ibid.</i>

7.9 \Materials\Sand_Properties

Properties are defined for Solid material Sand, a porous medium, in the following table.

Table 21. Parameters defined in \Materials\Sand_Properties

GoldSim element	value or distribution	units	reference / comment
Sand_Porosity	= Sand_Properties_HYDRUS .Porosity_Sand	—	WCS (2007)
Sand_ParticleDensity	= Sand_Properties_HYDRUS .ParticleDensity_Sand	kg/m ³	<i>ibid.</i>

7.10 \Materials\PerformanceClay_Properties

Properties are defined for Solid material PerformanceClay, a porous medium, in the following table.

Table 22. Parameters defined in \Materials\PerformanceClay_Properties

GoldSim element	value or distribution	units	reference / comment
PerformanceClay_Porosity	= PerfClay_Properties_HYDRUS .Porosity_PerformanceClay	—	WCS (2007)
PerformanceClay_ParticleDens	= PerfClay_Properties_HYDRUS .ParticleDensity_PerformanceClay	kg/m ³	<i>ibid.</i>

7.11 \Materials\LLW_Properties

Properties are defined for Solid porous media materials Transport\CWF\Waste and Transport\FWF\Waste, in the following table. These are provided by the HYDRUS modeling inputs.

Table 23. Parameters defined in \Materials\LLW_Properties

GoldSim element	value or distribution	units	reference / comment
Waste_Porosity	= Waste_Properties_HYDRUS .Porosity_Waste	—	WCS (2007)
Waste_Density	= Waste_Properties_HYDRUS .ParticleDensity_Waste	kg/m ³	<i>ibid.</i>

7.12 \Materials\Waste_Properties_RCRA

Properties for materials specific to the RCRA Landfill will be fully developed in the upcoming *WCS Site Model v0.3*.

Table 24. Parameters defined in \Materials\Waste_Properties_RCRA

GoldSim element	value or distribution	units	reference / comment
RCRA_Waste_Porosity	= Sand_Porosity	—	awaits v0.3
RCRA_Waste_ParticleDensity	= Sand_BulkDensity	kg/m ³	awaits v0.3

7.13 \Materials\ClayAbove125_Properties

Properties are defined for Solid material Clay_Above_125, a porous medium, in the following table.

Table 25. Parameters defined in \Materials\Clay_Above_125_Properties

GoldSim element	value or distribution	units	reference / comment
ClayAbove125_Porosity	N(0.2395, 0.0627, Small, 1-Small)	—	WCS (2007)

ClayAbove125 _ParticleDensity	2.65	g/cm ³	<i>ibid.</i>
----------------------------------	------	-------------------	--------------

7.14 \Materials\Sandstone125_Properties

Properties are defined for Solid material Sandstone_125, a porous medium, in the following table.

Table 26. Parameters defined in \Materials\Sandstone125_Properties

GoldSim element	value or distribution	units	reference / comment
Sandstone125 _Porosity	N(0.1827, 0.0640, Small, 1-Small)	—	WCS (2007)
Sandstone125 _ParticleDensity	2.65	g/cm ³	<i>ibid.</i>

7.15 \Materials\ClayAbove180_Properties

Properties are defined for Solid material ClayAbove180, a porous medium, in the following table.

Table 27. Parameters defined in \Materials\ClayAbove180_Properties

GoldSim element	value or distribution	units	reference / comment
ClayAbove180 _Porosity	N(0.2385, 0.0725, Small, 1-Small)	—	WCS (2007)
ClayAbove180 _Porosity	2.65	g/cm ³	<i>ibid.</i>

7.16 \Materials\Sandstone180_Properties

Properties are defined for Solid material Sandstone180, a porous medium, in the following table.

Table 28. Parameters defined in \Materials\Clay_Above_180_Properties

GoldSim element	value or distribution	units	reference / comment
-----------------	-----------------------	-------	---------------------

Sandstone180_Porosity	N(0.2241, 0.0802, Small, 1-Small)	—	WCS (2007)
Sandstone180_ParticleDensity	2.65	g/cm ³	<i>ibid.</i>

7.17 \Materials\ClayAbove225_Properties

Properties are defined for Solid material ClayAbove225, a porous medium, in the following table.

Table 29. Parameters defined in \Materials\ClayAbove225_Properties

GoldSim element	value or distribution	units	reference / comment
ClayAbove225_Porosity	N(0.2857, 0.0681, Small, 1-Small)	—	WCS (2007)
ClayAbove225_ParticleDensity	2.65	g/cm ³	<i>ibid.</i>

7.18 \Materials\Sandstone225_Properties

Properties are defined for Solid material Sandstone225, a porous medium, in the following table.

Table 30. Parameters defined in \Materials\Sandstone225_Properties

GoldSim element	value or distribution	units	reference / comment
Sandstone225_Porosity	N(0.2031, 0.0451, Small, 1-Small)	—	WCS (2007)
Sandstone225_ParticleDensity	2.65	g/cm ³	<i>ibid.</i>

8.0 \Processes

Physical contaminant transport processes share some parameters throughout the model, and so are defined at this high level.

8.1 \Processes\AirTransport

Parameters for general contaminant transport in Air are defined in the following table. The Data elements in this container, dimensioned by UZ_Units and named UZ_vGn, UZ_vGalpha, UZ_WCres, and UZ_WCsat, feed into the Moldrup estimate of air phase tortuosity. These are Data elements only in that this is the only way the data can be gathered into a vector. There are no direct input values as Data.

Table 31. Parameters defined in \Processes\AirTransport

GoldSim element	value or distribution	units	reference / comment
AtmMixingHeight	N(2.0, 0.1, Small, Large)	m	Value is placeholder pending revised atmospheric modeling
WindSpeed	N(3.1, 0.1, Small, Large)	m/s	<i>ibid.</i>
AtmosphereDiffusion Length	N(0.15, 0.02, Small, Large)	m	<i>ibid.</i>
Tritium_mask	vector by Species: 1 for H3; 0 for all others	—	self-explanatory modeling construct
GasPhase_mask	vector by Species: 1 for C14, Cl36, Ar39, Kr85, I129, Rn222; 0 for all others	—	self-explanatory modeling construct
ResuspensionFlux	U(2.5×10^{-7} , 0.3)	kg/m ² ·yr	Value is placeholder pending revised atmospheric modeling
Chi_Q_Boundary	N(6.08×10^{-5} , 1×10^{-6} , Small, Large)	s/m ³	<i>ibid.</i>
Chi_Q_Offsite	N(2.3×10^{-8} , 1×10^{-9} , Small, Large)	s/m ³	<i>ibid.</i>

8.2 \Processes\WaterTransport

Parameters for general contaminant transport in Water are defined in the following table. The only parameters at this level define the exponential coefficients for the tortuosity equations for Air and Water.

Table 32. Parameters defined in \Processes\WaterTransport

GoldSim element	value or distribution	units	reference / comment
-----------------	-----------------------	-------	---------------------

WaterContent_Exp_Twater	N(7/3, 0.01)	—	see Groundwater Modeling white paper
Porosity_Exp_Twater	N(2, 0.01)	—	<i>ibid.</i>

8.2.1 \Processes\WaterTransport\HYDRUS_Modeling

Parameters for contaminant transport in Water in unsaturated porous media are imported from the Excel workbook *Stochastic Infiltration Modeling for WCS PA.xlsx*. Since this part of the model is under development, those parameters are not repeated here.

8.2.2 \Processes\WaterTransport\GroundwaterHydraulics_UZ

Parameters defining unsaturated zone groundwater hydraulics are connected to input parameters imported from the HYDRUS modeling (see previous section).

8.2.3 \Processes\WaterTransport\GroundwaterHydraulics_SZ

Parameters for contaminant transport in Water in saturated porous media are defined in the following table.

Table 33. Parameters defined in \Processes\WaterTransport\GroundwaterHydraulics_SZ

GoldSim element	value or distribution	units	reference / comment
Sandstone_225 _Saturation	1	—	full saturation is 1 by definition

8.3 \Processes\PlantTransport

This container contains parameters and calculations for plant-induced contaminant transport in the model. There are no model inputs defined at this level.

8.3.1 \Processes\PlantTransport\PlantParameters

This container contains parameters for plant-induced contaminant transport in the model.

Table 34. Parameters defined in \Processes\PlantTransport\PlantParameters

GoldSim element	value or distribution	units	reference / comment
BiomassProductionRate	N(305, 27.67, Small, Large)	g/m ² ·yr	see Biological Modeling white paper

8.3.1.1 \Processes\PlantTransport\PlantParameters\PlantCR

The values for the geometric mean of these lognormal distributions are documented in the *WCS Site Model Parameters v0.205.xlsx* workbook. These are currently under revision.

Table 35. Parameters defined in \Processes\PlantTransport\PlantParameters\PlantCR

GoldSim element	value or distribution	units	reference / comment
PlantCR_GSD_default	1 (this implies no variation in the PlantCRs)	—	see Biological Modeling white paper
CR_GM_radon	= Small	—	essentially no CR for Rn
CR_GSD_radon	1	—	essentially no CR for Rn

8.3.1.2 \Processes\PlantTransport\PlantParameters\BiomassCalcs

These values in the percent cover tables are documented in the *WCS Site Model Parameters v0.205.xlsx* workbook. The stochastic PctCoverRandomSelector is merely a discrete distribution returning a number between 1 and 1000, inclusive, with equal weighting. This is GoldSim's version of a 1000-sided die.

8.3.1.3 \Processes\PlantTransport\PlantParameters\MesquiteData**Table 36. Parameters defined in \Processes\PlantTransport\PlantParameters\MesquiteData**

GoldSim element	value or distribution	units	reference / comment
RootShoot_Ratio	N(0.6731, 0.05, Small, Large)	—	see Biological Modeling white paper
MaxDepth	1000	cm	<i>ibid.</i>
b	N(25, 0.5, 1, Large)	—	<i>ibid.</i>

8.3.1.4 \Processes\PlantTransport\PlantParameters\GrassData**Table 37. Parameters defined in \Processes\PlantTransport\PlantParameters\GrassData**

GoldSim element	value or distribution	units	reference / comment
RootShoot_Ratio	N(1.11, 0.175, Small, Large)	—	see Biological Modeling white paper

MaxDepth	60	cm	<i>ibid.</i>
b	N(6, 0.12, 1, Large)	—	<i>ibid.</i>

8.3.1.5 \Processes\PlantTransport\PlantParameters\ForbData

Table 38. Parameters defined in \Processes\PlantTransport\PlantParameters\ForbData

GoldSim element	value or distribution	units	reference / comment
RootShoot_Ratio	N(0.59, 0.192, Small, Large)	—	see Biological Modeling white paper
MaxDepth	55	cm	<i>ibid.</i>
b	N(23.9, 0.466, 1, Large)	—	<i>ibid.</i>

8.3.1.6 \Processes\PlantTransport\PlantParameters\ShrubData

Table 39. Parameters defined in \Processes\PlantTransport\PlantParameters\ShrubData

GoldSim element	value or distribution	units	reference / comment
RootShoot_Ratio	N(0.6731, 0.25, Small, Large)	—	see Biological Modeling white paper
MaxDepth	60	cm	<i>ibid.</i>
b	N(2, 0.04, 1, Large)	—	<i>ibid.</i>

8.4 \Processes\AnimalTransport

This container contains parameters and calculations for animal-induced contaminant transport in the model. There are no model inputs defined at this level.

8.4.1 \Processes\AnimalTransport\AnimalParameters

This container contains parameters for plant-induced contaminant transport in the model. There are no model inputs defined at this level.

8.4.1.1 \Processes\AnimalTransport\AnimalParameters\AntData**Table 40. Parameters defined in \Processes\AnimalTransport\AnimalParameters\AntData**

GoldSim element	value or distribution	units	reference / comment
ColonyDensity	gamma(14.36, 1.094, 0, Large)	1/ha	see Biological Modeling white paper
NestVolume	N(0.64, 0.091, 0, Large)	m ³	<i>ibid.</i>
ColonyLifespan	N(20.2, 3.6, Small, Large)	yr	<i>ibid.</i>
b	N(10, 0.71, 1, Large)	—	<i>ibid.</i>
MaxDepth	400	cm	<i>ibid.</i>

8.4.1.2 \Processes\AnimalTransport\AnimalParameters \MammalData**Table 41. Parameters defined in \Processes\AnimalTransport\AnimalParameters \MammalData**

GoldSim element	value or distribution	units	reference / comment
MoundDensity	gamma(77.5, 5.08, 0, Large)	1/ha	see Biological Modeling white paper
BurrowVolume	N(0.1185, 0.025, Small, Large)	m ³	<i>ibid.</i>
AnnualTurnover	N(0.20, 0.05, 0, 1)	1/yr	<i>ibid.</i>
b	N(4.5, 0.84, 1, Large)	—	<i>ibid.</i>
MaxDepth	427	cm	<i>ibid.</i>

9.0 \Inventory

A few parameters, as defined in Table 42, apply to all inventories. The user-defined inventories defined in this container are not derived input parameters. They are, as the name implies, user-defined, and can be changed at the user's whim. Therefore, they are not defined here.

Table 42. Parameters defined in \Inventory

GoldSim element	value or distribution	units	reference / comment
WasteDecompositionTime	see \Chronology	yr	see \Chronology

ActivatedMetalCorrosionRate	N(1×10^{-5} , 1×10^{-6} , Small, Large)	1/yr	<i>ibid.</i>
Radon_EP_Ratio_Waste	N(0.2, 0.01, 0, 1)	—	<i>ibid.</i>

9.1 \Inventory\Inventory_CWF

The GoldSim Data Elements WasteStreamActivityConc_CWF and ActivityInventory_CWF contain a matrix and vector, respectively, of inventory information. Other input parameters are documented in the following table.

Table 43. Parameters defined in \Inventory\Inventory_CWF

GoldSim element	value or distribution	units	reference / comment
NumberPackages_CWF	1	—	modeling assumption
InventoryCapacityFactor_CWF	1	—	modeling assumption
MassInv_ActivatedMetal_CWF	46.8159 for C14, 0 for others	Ci	major amendment assumption

9.2 \Inventory\Inventory_FWF

The GoldSim Data Elements WasteStreamActivityConc_FWF and ActivityInventory_FWF contain a matrix and vector, respectively, of inventory information. Other input parameters are documented in the following table.

Table 44. Parameters defined in \Inventory\Inventory_FWF

GoldSim element	value or distribution	units	reference / comment
NumberPackages_FWF	1	—	modeling assumption
InventoryCapacityFactor_FWF	1	—	modeling assumption
MassInv_ActivatedMetal_FWF	25.9 for C14, 0 for others	Ci	major amendment assumption

9.3 \Inventory\WCL_Inventory_RCRA

The determination of waste concentration limits (WCLs) for the RCRA Landfill is done through an iterative calculation. No input parameters are derived, many being simple initial values and

the like which do not influence the final result. Many Data elements in this container and its subcontainers are also used only to collect outputs into vectors, and do not contain data input values. Several Data elements are controlled by the user through dashboards, so these also are not input parameters appropriate to list in this document. Ultimately, there are no true input parameters defined in this container.

10.0 \Transport

The Transport container has all the contaminant transport calculations from the disposal units up to the atmosphere and down to the saturated zone. There are no parameters defined at the \Transport level.

10.1 \Transport\CWF

The CWF container has all the contaminant transport calculations for the CWF disposal unit and its contributions to the atmosphere and saturated zone. There are no parameters defined at the \Transport\CWF level.

10.1.1 \Transport\CWF\Waste_System

No input parameters are defined at this level.

10.1.1.1 \Transport\CWF\Waste_System\CementVolumeCalcs

This container has calculations of the volume of cement in the CWF, and is closely associated with the container \Miscellaneous\MCC_Calculations. The input parameters defined at this level are provided in Table 45.

Table 45. Parameters defined in \Transport\CWF\Waste_System\CementVolumeCalcs

GoldSim element	value or distribution	units	reference / comment
NumberMCCinStack_CWF	4	—	WCS (2007)
AreaFractionMCC_Cyl_CWF	N(0.5, 0.1, Small, 1 - Small)	—	modeling assumption

10.1.2 \Transport\CWF\CellDimensions_UZ

This container defines the physical dimensions of the CWF disposal unit and overlying and underlying layers in the 1-dimensional column. Most of these parameters are part of the designed and constructed system, and have sufficiently low uncertainty that they are defined with single values.

Table 46. Parameters defined in \Transport\CWF\CellDimensions_UZ

GoldSim element	value or distribution		units	reference / comment
WasteArea_Top_Actual	33,150		m ²	Oct 2011 model
WasteArea_Bottom_Actual	16,070		m ²	
Waste_Thickness	13		m	
Facility_Volume	2.31×10 ⁶ ft ³ × 4		m ³	
Upper_Fill_Thickness	6.91		m	WCS (2007)
Redbed_Fill_Thickness_Total	6.91 m + 3.56 m		m	<i>ibid.</i>
TopSoil_Thickness	1		cm	modeling assumption
LayerThickness_UZ	array item	value	ft	These are constructed to most closely match the strata documented in WCS (2007) while maintaining a constant cell thickness throughout.
	TopSoil	TopSoil_Thickness		
	ET_Cover	4 ft – TopSoil_Thickness		
	BioBarrier	3		
	Upper_Fill	$f(x)$		
	Drainage	2		
	Clay_Cover	3		
	Concrete_Cover	1		
	Lower_Fill	$f(x)$		
	Waste	$f(x)$		
	Upper_Liner	1		
	Lower_Liner	3		
	Clay_Above_125	$f(x)$		
	Sandstone_125	$f(x)$		
	Clay_Above_180	$f(x)$		
	Sandstone_180	$f(x)$		
	Clay_Above_225	$f(x)$		
	array item	value	—	<i>ibid.</i>
	TopSoil	1		
	ET_Cover	8		
	BioBarrier	6		
	Upper_Fill	45		

Drainage	4
Clay_Cover	6
Concrete_Cover	2
Lower_Fill	23
Waste	13
Upper_Liner	2
Lower_Liner	6
Clay_Above_125	1
Sandstone_125	1
Clay_Above_180	4
Sandstone_180	2
Clay_Above_225	4

Thickness_Dockum_UZ	N(42.6, 1, Small, Large)	m	WCS (2007)
---------------------	----------------------------	---	------------

* $f(x)$ means that this element item is a function of other values, and is not a parameter unto itself.

10.1.3 \Transport\CWF\CellDimensions_SZ

These parameters define the dimensions of the Cells in the saturated zone water transport calculations for the CWF.

Table 47. Parameters defined in \Transport\CWF\CellDimensions_SZ

GoldSim element	value or distribution	units	reference / comment
Thickness_SZ	N(20, 1, Small, Large)	ft	see Groundwater Modeling white paper
NumberCells_BelowWaste	8	—	<i>ibid.</i>
Num_Cells_BeyondWaste	2	—	<i>ibid.</i>

10.2 \Transport\FWF

The FWF container has all the contaminant transport calculations for the FWF disposal unit and its contributions to the atmosphere and saturated zone. There are no parameters defined at the \Transport\FWF level.

10.2.1 \Transport\FWF\Waste_System

No input parameters are defined at this level.

10.2.1.1 \Transport\FWF\Waste_System\CementVolumeCalcs

This container has calculations of the volume of cement in the FWF, and is closely associated with the container \Miscellaneous\MCC_Calculations. The input parameters defined at this level are provided in Table 48.

Table 48. Parameters defined in \Transport\FWF\Waste_System\CementVolumeCalcs

GoldSim element	value or distribution	units	reference / comment
NumberMCCinStack_FWF	7	—	WCS (2007)
AreaFractionMCC_Cyl_FWF	N(0.25, 0.1, Small, 1 - Small)	—	modeling assumption

10.2.2 \Transport\FWF\CellDimensions_UZ

This container defines the physical dimensions of the CWF disposal unit and overlying and underlying layers in the 1-dimensional column. Most of these parameters are part of the designed and constructed system, and have sufficiently low uncertainty that they are defined with single values. Note that the FWF column as modeled does not include a “Clay_Above_125” layer.

Table 49. Parameters defined in \Transport\FWF\CellDimensions_UZ

GoldSim element	value or distribution		units	reference / comment
Waste_Volume_Actual	26,000,000 ft ³ × 4		m ³	Oct 2011 model
Waste_Side_Slope	1/2		—	
Waste_Thickness	19		m	
Upper_Fill_Thickness	6.91		m	WCS (2007)
Redbed_Fill_Thickness_Total	6.91 m + 3.56 m		m	<i>ibid.</i>
TopSoil_Thickness	1		cm	modeling assumption
LayerThickness_UZ	array item	value	ft	These are constructed to most closely match the strata documented in WCS (2007) while maintaining a constant cell thickness throughout.
	TopSoil	TopSoil_Thickness		
	ET_Cover	4 ft – TopSoil_Thickness		
	BioBarrier	3		
	Upper_Fill	$f(x)$		
	Drainage	2		
	Clay_Cover	3		

Concrete_Cover	1		
Lower_Fill	$f(x)$		
Waste	$f(x)$		
Upper_Liner	1		
Lower_Liner	3		
Clay_Above_125	0		
Sandstone_125	$f(x)$		
Clay_Above_180	$f(x)$		
Sandstone_180	$f(x)$		
Clay_Above_225	$f(x)$		
array item	value	—	<i>ibid.</i>
TopSoil	1		
ET_Cover	8		
BioBarrier	6		
Upper_Fill	45		
Drainage	4		
Clay_Cover	6		
Concrete_Cover	2		
Lower_Fill	23		
Waste	19		
Upper_Liner	2		
Lower_Liner	6		
Clay_Above_125	0		
Sandstone_125	2		
Clay_Above_180	4		
Sandstone_180	1		
Clay_Above_225	5		
Thickness_Dockum_UZ	N(40.5, 1, Small, Large)	m	<i>ibid.</i>

* $f(x)$ means that this element item is a function of other values, and is not a parameter unto itself.

10.2.3 \Transport\FWF\CellDimensions_SZ

These parameters define the dimensions of the Cells in the saturated zone water transport calculations for the FWF.

Table 50. Parameters defined in \Transport\FWF\CellDimensions_SZ

GoldSim element	value or distribution	units	reference / comment
Thickness_SZ	N(20, 1, Small, Large)	ft	see Groundwater Modeling white paper
NumberCells_BelowWaste	8	—	<i>ibid.</i>
Num_Cells_BeyondWaste	2	—	<i>ibid.</i>

10.3 \Transport\RCRA

The RCRA container has all the contaminant transport calculations for the RCRA Landfill and its contributions to the atmosphere and saturated zone. There are no input parameters defined at the \Transport\RCRA level.

10.3.1 \Transport\RCRA\RCRA_Layout

Properties for materials specific to the RCRA Landfill will be fully developed in the upcoming *WCS Site Model v0.3*.

Table 51. Parameters defined in \Transport\RCRA\RCRA_Layout

GoldSim element	value	units	reference / comment
Width_RCRA_OldSection	600	ft	awaits v0.3
Length_RCRA_OldSection	300	ft	awaits v0.3
Area_TransitionTriangle	$332^2 / 2$	ft ²	awaits v0.3
Width_RCRA_NewSection	932	ft	awaits v0.3
Length_RCRA_NewSection	2550	ft	awaits v0.3
Dike Slope	4	—	awaits v0.3
Elev_CoverEdge	3472	ft	awaits v0.3
AltGrade_Switch	T/F	—	awaits v0.3
Elev_AltGrade	3460	ft	awaits v0.3
Elev_LowestGrade	3440	ft	awaits v0.3
Width_Dike	150	ft	awaits v0.3
DikeToRidge	487.5	ft	awaits v0.3

Elev_RidgeTop	3486.82	ft	awaits v0.3
Elev_WasteTop	3470	ft	awaits v0.3

10.3.2 \Transport\RCRA\RCRA_Dimensions

Data elements in this container are collections of expressions, and involve no input parameters.

10.3.2.1 \Transport\RCRA\RCRA_Dimensions\RCRA_Dimensions_West

Many of the values entered into Data elements in this container are read directly from the design drawings. These are for the western RCRA Cells.

Table 52. Parameters defined in
\Transport\RCRA\RCRA_Dimensions\RCRA_Dimensions_West

GoldSim element	value	units	reference / comment
TopWasteElev_All	3469.9	ft	awaits v0.3
ExcBottomElev_All	3405	ft	awaits v0.3
CellWidth_BtoG	100	ft	awaits v0.3
CellEdgeSlope_All	2	ft	awaits v0.3
UpperLinerThickness	5	ft	awaits v0.3
LowerLinerThickness	3	—	awaits v0.3
ExcLengthBottom_AtoG	351.8	ft	awaits v0.3
CellTopWidth_A	150	ft	awaits v0.3

10.3.2.2 \Transport\RCRA\RCRA_Dimensions\RCRA_Dimensions_East

Many of the values entered into Data elements in this container are read directly from the design drawings. These are for the eastern RCRA Cells.

Table 53. Parameters defined in
\Transport\RCRA\RCRA_Dimensions\RCRA_Dimensions_East

GoldSim element	value	units	reference / comment
CellWidth_HtoS	200	ft	awaits v0.3
Control_P10_Northing	6873810.2404	ft	awaits v0.3

Control_P10_Easting	562426.5121	ft	awaits v0.3
Control_P11_Northing	6873206.6054	ft	awaits v0.3
Control_P11_Easting	562141.0532	ft	awaits v0.3

10.3.3 \Transport\RCRA\Cell_Dimensions_UZ

Table 54. Parameters defined in \Transport\RCRA\CellDimensions_UZ

GoldSim element	value or distribution		units	reference / comment
TopSoil_Thickness	1		cm	awaits v0.3
LayerThickness_UZ	array item	value	ft	awaits v0.3
	TopSoil	TopSoil_Thickness		
	ET_Cover	2 ft – TopSoil_Thickness		
	BioBarrier	0		
	Upper_Fill	0		
	Drainage	0		
	Clay_Cover	3		
	Concrete_Cover	0		
	Lower_Fill	$f(x)$		
	Waste	$f(x)$		
	Upper_Liner	4		
	Lower_Liner	4		
	Clay_Above_125	$f(x)$		
	Sandstone_125	$f(x)$		
	Clay_Above_180	$f(x)$		
	Sandstone_180	$f(x)$		
	Clay_Above_225	$f(x)$		
	array item	value	—	awaits v0.3
	TopSoil	1		
	ET_Cover	4		
	BioBarrier	0		
	Upper_Fill	0		

Drainage	0		
Clay_Cover	6		
Concrete_Cover	0		
Lower_Fill	12		
Waste	19		
Upper_Liner	8		
Lower_Liner	8		
Clay_Above_125	2		
Sandstone_125	2		
Clay_Above_180	4		
Sandstone_180	1		
Clay_Above_225	5		
Thickness_Dockum_UZ	N(45.5, 1, Small, Large)	m	awaits v0.3

* $f(x)$ means that this element item is a function of other values, and is not a parameter unto itself.

10.3.4 \Transport\RCRA\CellDimensions_SZ

These parameters define the dimensions of the Cells in the saturated zone water transport calculations for the RCRA Landfill.

Table 55. Parameters defined in \Transport\RCRA\CellDimensions_SZ

GoldSim element	value or distribution	units	reference / comment
Thickness_SZ	Thickness_SZ in CWF	ft	awaits v0.3
NumberCells_BelowWaste	8	—	awaits v0.3
Num_Cells_BeyondWaste	2	—	awaits v0.3

10.3.5 \Transport\RCRA\RCRA_Erosion

These parameters inform RCRA Landfill erosion calculations.

Table 56. Parameters defined in \Transport\RCRA\RCRA_Erosion

GoldSim element	value or distribution	units	reference / comment
AngleOfRepose_Fan	U(3, 10)	degrees	awaits v0.3

AngleOfRepose_Gully	N(45, 15, Small, 90-Small)	degrees	awaits v0.3
Gully_b_parameter	N(-0.4, 0.15, -0.75, -0.05)	—	awaits v0.3
NumberOfGullies	discrete sampling between 10 and 200, in increments of 10	—	awaits v0.3

10.3.5.1 \Transport\RCRA\RCRA_Erosion\GullyVolumeCalcs

There are no input parameters at this level.

10.3.5.1.1 \Transport\RCRA\RCRA_Erosion\GullyVolumeCalcs\Dimensions

These parameters inform RCRA Landfill erosion calculations specific to gully volumes.

Table 57. Parameters defined in \Transport\RCRA\RCRA_Erosion\GullyVolumeCalcs\Dimensions

GoldSim element	value or distribution	units	reference / comment
L_init	U(Small, 5)	m	awaits v0.3
L	100	m	awaits v0.3

10.3.5.1.2 \Transport\RCRA\RCRA_Erosion\GullyVolumeCalcs\IterativeSolution_h

These parameters inform RCRA Landfill erosion calculations specific to gully volumes and determination of the gully mouth height by iterative solution.

Table 58. Parameters defined in \Transport\RCRA\RCRA_Erosion\GullyVolumeCalcs\IterativeSolution_h

GoldSim element	value or distribution	units	reference / comment
ConvergenceCriterion	0.1	m ³	awaits v0.3

11.0 \DoseAssessment

The parameters for the dose assessment calculations are spread through a number of subcontainers.

11.1 \DoseAssessment\BoreholeCuttings_Calcs

Table 59. Parameters defined in \DoseAssessment\BoreholeCuttings_Calcs

GoldSim element	value or distribution	units	reference / comment
BoreholeDiameter_Oil	discrete: 1/9: 17.5 8/9: 12.25	in	see Dose Assessment white paper

11.1.1 \DoseAssessment\BoreholeCuttings_Calcs\OilWellLocation

Note that the Stochastics AnnualWellProb_CWF and _FWF defined in this container are not input parameters, since they are built on other Expressions in the model.

Table 60. Parameters defined in \DoseAssessment\BoreholeCuttings_Calcs\OilWellLocation

GoldSim element	value or distribution	units	reference / comment
WellDevelopmentPeriod	U(25, 100)	yr	see Dose Assessment white paper
WellsSited	5	—	<i>ibid.</i>
WellSitingArea	19.6	ac	<i>ibid.</i>

11.1.2 \DoseAssessment\SoilConc_Calcs\OilWorkerSoilConc_Calcs

Table 61. Parameters defined in \DoseAssessment\SoilConc_Calcs\OilWorkerSoilConc_Calcs

GoldSim element	value or distribution	units	reference / comment
OilWellExposureArea	150	m ²	see Dose Assessment white paper

11.1.3 \DoseAssessment\SoilConc_Calcs\GardenSoilConc_Calcs

Table 62. Parameters defined in \DoseAssessment\SoilConc_Calcs\GardenConc_Calcs

GoldSim element	value or distribution	units	reference / comment
GardenArea	150	m ²	see Dose Assessment white paper

11.1.4 \DoseAssessment\SoilConc_Calcs\RanchHuntFarmSoilConc_Calcs

**Table 63. Parameters defined in \DoseAssessment\SoilConc_Calcs
\RanchHuntFarmConc_Calcs**

GoldSim element	value or distribution	units	reference / comment
RanchArea	Tri(15, 150, 300)	mi ²	see Dose Assessment white paper
FarmArea	U(200, 5500)	ac	ibid.

11.2 \DoseAssessment\AirConc_Calcs

Table 64. Parameters defined in \DoseAssessment\AirConc_Calcs

GoldSim element	value or distribution	units	reference / comment
Alpha_Residence	LN(0.0092, 0.05, 2.5e-5, 0.94)	—	see Dose Assessment white paper

11.3 \DoseAssessment\ProduceConc_Calcs

Table 65. Parameters defined in \DoseAssessment\ProduceConc_Calcs

GoldSim element	value or distribution	units	reference / comment
DryWetConversion_ NonLeafyVegs	N(0.25, 0.025, Small, 1-Small)	—	see Dose Assessment white paper

11.4 \DoseAssessment\MeatConc_Calcs

Plant/soil concentration ratios in ForageSoilConcRatio_byElement and the transfer factors in RanchedBeef_TF_Elements and MuleDeer_TF_Elements are documented in the *WCS Site Model Parameters v0.205.xlsx* workbook.

Table 66. Parameters defined in \DoseAssessment\MeatConc_Calcs

GoldSim element	value or distribution	units	reference / comment
-----------------	-----------------------	-------	---------------------

DryWetConversion_Forage	N(0.22, 0.022, Small, 1-Small)	—	see Dose Assessment white paper
ForageIngestionRate_Cattle	N(27, 2, Small, Large)	kg/day	<i>ibid.</i>
SoilIngestionFraction_Cattle	N(0.05, 0.005, Small, 1-Small)	—	<i>ibid.</i>
BodyMass_MuleDeer	N(59.2, 2.3, Small, Large)	kg	<i>ibid.</i>
HomeRange_MuleDeer	N(1375, 200, Small, Large)	ha	<i>ibid.</i>

11.5 \DoseAssessment\GrainConc_Calcs

Table 67. Parameters defined in \DoseAssessment\GrainConc_Calcs

GoldSim element	value or distribution	units	reference / comment
DryWetConversion_Grain	N(0.91, 0.02, Small, 1-Small)	—	see Dose Assessment white paper

11.6 \DoseAssessment\ReceptorActivity

Table 68. Parameters defined in \DoseAssessment\ReceptorActivity

GoldSim element	value or distribution	units	reference / comment
IngestionRate_Soil	N(50, 1, Small, Large)	mg/day	see Dose Assessment white paper
IngestionRate_Milk	N(100, 10, Small, Large)	L/yr	<i>ibid.</i>
IngestionRate_Meat	N(59, 10, Small, Large)	kg/yr	<i>ibid.</i>
IngestionRate_Vegs	N(62, 10, Small, Large)	kg/yr	<i>ibid.</i>
IngestionRate_Fruits	N(46, 10, Small, Large)	kg/yr	<i>ibid.</i>
IngestionRate_Grains	N(69, 7, Small, Large)	kg/yr	<i>ibid.</i>
IngestionRate_Beef	N(59, 10, Small, Large)	kg/yr	<i>ibid.</i>
IngestionRate_Game	N(59, 10, Small, Large)	kg/yr	<i>ibid.</i>

InhalationRate_General	N(1.2, 0.001, Small, Large)	m ³ /hr	<i>ibid.</i>
InhalationRate_Moderate	N(1.2, 0.001, Small, Large)	m ³ /hr	<i>ibid.</i>
TimeFraction_Boundary	N(730, 1, Small, 1-Small)	hr/yr	<i>ibid.</i>
TimeFraction_Resident	N(8400, 100, 8000, 8766)	hr/yr	<i>ibid.</i>
TimeFraction_Res_Outdoor	N(300, 30, 190, 410)	hr/yr	<i>ibid.</i>
OutdoorFrac_Res_Garden	Tri(0.25, 0.5, 0.75)	—	<i>ibid.</i>
TimeFraction_MaintWorker	N(96, 1, Small, 1-Small)	hr/yr	<i>ibid.</i>
TimeFraction_Rancher	N(8 hr/day × 130 day/yr, 80 hr/yr, Small, 1-Small)	hr/yr	<i>ibid.</i>
TimeFraction_Hunter	N(8 hr/day × 5 day/yr, 8 hr/yr, Small, 1-Small)	hr/yr	<i>ibid.</i>
TimeFraction_Farmer	N(8 hr/day × 30 day/yr, 20 hr/yr, Small, 1-Small)	hr/yr	<i>ibid.</i>
YardArea_Resident	N(0.25 ac, 0.025 ac, 400 m ² , 1600 m ²)	m ²	<i>ibid.</i>
IndoorGammaFactor	N(0.4, 0.04, Small, 1)	—	<i>ibid.</i>

11.7 \DoseAssessment\H3_C14_biota_models

Table 69. Parameters defined in \DoseAssessment\H3_C14_biota_models

GoldSim element	value or distribution	units	reference / comment
SA_wvH	1	—	see Dose Assessment white paper
water_to_H	N(9, 0.01, Small, Large)	—	<i>ibid.</i>
f_Hv	N(0.1, 0.01, Small, 1-Small)	—	<i>ibid.</i>
CF_plant_carbon	N(0.7, 0.01, Small, Large)	—	<i>ibid.</i>
IR_forage_milk	N(36, 1, Small, Large)	kg/day	<i>ibid.</i>
IR_stored_hay_beef	N(14, 1, Small, Large)	kg/day	<i>ibid.</i>

IR_stored_hay_milk	N(29, 1, Small, Large)	kg/day	<i>ibid.</i>
IR_stored_grain_beef	N(3, 0.1, Small, Large)	kg/day	<i>ibid.</i>
IR_stored_grain_milk	N(2, 0.1, Small, Large)	kg/day	<i>ibid.</i>
f_H_forage	N(0.1, 0.01, Small, 1-Small)	—	<i>ibid.</i>
f_H_hay	N(0.1, 0.01, Small, 1-Small)	—	<i>ibid.</i>
f_H_grain	N(0.068, 0.01, Small, 1-Small)	—	<i>ibid.</i>
MilkDens	N(1030, 10, WatDens, Large)	g/L	<i>ibid.</i>
f_C_forage	N(0.09, 0.01, Small, 1-Small)	—	<i>ibid.</i>
f_C_hay	N(0.09, 0.01, Small, 1-Small)	—	<i>ibid.</i>
f_C_grain	N(0.4, 0.01, Small, 1-Small)	—	<i>ibid.</i>

11.8 \DoseAssessment\ResidenceGardenLocations

Table 70. Parameters defined in \DoseAssessment\DCFs

GoldSim element	value or distribution	units	reference / comment
HomeSitingRate	N(0.02, 0.001, 0, Large)	1/yr	see Dose Assessment white paper
HomeSitingArea	U(9, 23)	mi ²	<i>ibid.</i>

11.9 \DoseAssessment\DCFs

Dose conversion factors (DCFs) for the inhalation, ingestion, and external exposure pathways are tabulated for each radionuclide in the associated spreadsheet workbook *WCS Site Model Parameters v0.205.xlsx*. For ingestion and inhalation DCFs, entries exist for values from both FGR 11 and ICRP 72, with a switch for the user to select which reference to use.

Table 71. Parameters defined in \DoseAssessment\DCFs

GoldSim element	value or distribution	units	reference / comment
DCF_Radon	46	mrem-L/yr-pCi or mrem/yr per pCi/L	see Dose Assessment white paper

DCF_Ar39	1.1E-11	Sv/Bq-d-m ⁻³ or Sv/d per Bq/m ³	<i>ibid.</i>
DCF_Kr85	2.2E-11	Sv/Bq-d-m ⁻³ or Sv/d per Bq/m ³	<i>ibid.</i>
InhRate_Rn	discrete(8400)	m ³ /yr	<i>ibid.</i>
ProgenyEqmFactor _Rn222_Indoor	discrete(0.4)	—	<i>ibid.</i>
AirExchangeRate_Building	discrete(27)	min	<i>ibid.</i>

11.9.1 \DoseAssessment\DCF\DCF_Ext_modifiers

The parameters defined in \DoseAssessment\DCF\DCF_Ext_Modifiers are all defined in the Excel workbook *WCS Site Model Parameters v0.205.xlsx*.

11.10 \DoseAssessment\DoseCalculations

11.10.1 \DoseAssessment\DoseCalculations\ResidenceGardenLocations

**Table 72. Parameters defined in \DoseAssessment\
DoseCalculations\ResidenceAndMudPitLocations**

GoldSim element	value or distribution	units	reference / comment
HomeSitingRate	N(0.02, 0.001, 0, Large)	yr ⁻¹	see Dose Assessment white paper
HomeSitingArea	U(9, 23)	mi ²	<i>ibid.</i>

Other Stochastic elements defined in this container are not input parameters, since their inputs are outputs from other elements.

12.0 \LegacyScenarios

The elements and calculations defined in this container are a legacy of the Oct 2011 License Application model. These do not benefit from the same level of QA rigor as the rest of the model.

12.1 \LegacyScenarios\WaterConcs

Table 73. Parameters defined in \LegacyScenarios\WaterConcs

GoldSim element	value	units	reference / comment
WaterDemand	250	m ³ /yr	see October 2011 revision to the LA PA

12.2 \LegacyScenarios\LegacyResident_SoilConcs

Table 74. Parameters defined in \LegacyScenarios\LegacyResident_SoilConcs

GoldSim element	value	units	reference / comment
GravWaterContent_Garden	0.1	—	NUREG/CR-5512 vol. 1, Table D.1

12.3 \LegacyScenarios\LegacyResident_FoodConcs

The Arrays defined in this container are recorded in the *WCS Site Model Parameters v0.205.xlsx* workbook.

12.4 \LegacyScenarios\LegacyResident_H3_C14

Table 75. Parameters defined in \LegacyScenarios\LegacyResident_H3_C14

GoldSim element	value	units	reference / comment
IR_forage_milk	36	kg/day	NUREG/CR-5512 vol. 1, Table 6.8
IR_stored_hay_milk	29	kg/day	<i>ibid.</i>
IR_stored_hay_beef	14	kg/day	<i>ibid.</i>
IR_stored_grain_beef	3	kg/day	<i>ibid.</i>
IR_stored_grain_milk	2	kg/day	<i>ibid.</i>
MilkDens	1030	g/L	http://www.nal.usda.gov/fnic/foodcomp/search/
f_H_hay	0.1	—	NUREG/CR-5512 vol. 1, Table D.1
f_H_grain	0.068	—	<i>ibid.</i>
f_C_hay	0.09	—	NUREG/CR-5512 vol. 1, Table C.1

f_C_grain	0.4	—	ibid.
-----------	-----	---	-------

12.5 \LegacyScenarios\LegacyResidentDose

Table 76. Parameters defined in \LegacyScenarios\LegacyResidentDose

GoldSim element	value	units	reference / comment
IngestionRate_Water	2	L/d	see October 2011 revision to the LA PA
IngestionRate_Milk	100	L/yr	ibid.
Diet_LocalFraction	0.25	—	ibid.

12.6 \LegacyScenarios\WellYieldCalcs_225

Table 77. Parameters defined in \LegacyScenarios\WellYieldCalcs_225

GoldSim element	value	units	reference / comment
HydraulicConductivity_225	$\text{LN}(8.87 \times 10^{-9}, 1.33)$	cm/s	see Groundwater Modeling white paper
Radius_of_Influence	$\text{U}(\text{BoreholeDiameter_WaterWell} + 0.1 \text{ m}, 1000)$	m	ibid.
WellCasingDiameterDist_Water	$\text{beta}(7.0, 2.1, 1.5, 12.5)$ determ: 6	in	ibid.

12.7 \LegacyScenarios\MudPit_Microshield

The array Data elements in this container for pathway dose conversion factors (PDCFs) for the mud pit external doses are recorded in the *WCS Site Model Parameters v0.205.xlsx* workbook.

12.8 \LegacyScenarios\MudPitDose_2011

Table 78. Parameters defined in \LegacyScenarios\MudPitDose_2011

GoldSim element	value	units	reference / comment
-----------------	-------	-------	---------------------

Backfill_Factor	4.0	—	see October 2011 revision to the LA PA
Well_Depth	225	ft	<i>ibid.</i>
Facility_Lifetime	35	yr	<i>ibid.</i>
Resident_MudPitExposure _Time	48	hr/yr	WCS, 2007 (Table 8.0-6.13-1)
Driller_MudPitExposure _Time	8	hr/yr	WCS, 2007 (Table 8.0-6.13-1)
