Energy*Solutions*
Technical Support Document

RS-TD-313196-004

LACBWR Soil DCGL, Basement Concrete DCGL, and Buried Pipe DCGL

Revision 4

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<u>Summary of Changes in this Revision</u>:

- Revision 0 – Initial Issuance.
- Revision 1 – Changed Title, added basement concrete DCGL and Area Factor for WTB BFM Groundwater Scenario, revised insignificant contributor dose percentage to 5% in calculation of adjusted DCGLs for basements, soil, and buried pipe
- Revision 2 – Various revisions in response to NRC request for additional information
- Revision 3 – Revised Buried Group DCGLs due to addition of Low Pressure Service Water Pipe to group.
- Revision 4
  – Three corrections as a result of two transcription errors from soil uncertainty analysis reports in Table 3.
    - Revised “Depth of Soil Mixing Layer” from 0.34 to 0.23. Changed has no effect on soil DCGL but new RESRAD report generated for administrative purposes to ensure parameters match Table 3.
    - Deleted Fe-55 as sensitive to Wind Speed and entered as sensitive to Runoff coefficient. No change in soil RESRAD parameters required.
    - Revised “Depth of Soil Mixing Layer” from 0.34 in Buried Pipe RESRAD analyses to 0.15 and reran RESRAD reports. Minor changes to DCGLs for certain radionuclides in Tables 26, 27, and 28 (Excavation Scenario only)
  - Corrected transcription error in Table 29: replace soil DCGLs with correct values from Table 5. No change to conclusions.

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LIST OF ACRONYMS AND ABBREVIATIONS

AF	Area Factor
ALARA	As Low As (is) Reasonable Achievable
AMCG	Average Member of the Critical Group
ANL	Argonne National Laboratory
BFM	Basement Fill Model
BFM $Insitu_{gw}$	BFM *in-situ* Groundwater Scenario
BFM $Insitu_{ds}$	BFM *in-situ* Drilling Spoils Scenario
bgs	Below Ground Surface
DCGL	Derived Concentration Guideline Level
$DCGL_B$	Derived Concentration Guideline Level Basement Concrete
$DCGL_{BS}$	Derived Concentration Guideline Level Basement Concrete Scenario
DF	Dose Factor
DSR	Dose to Source Ratios
FSS	Final Status Survey
IC	Insignificant Contributor
Insitu	*in situ*
LACBWR	La Crosse Boiling Water Reactor
LSE	LACBWR Site Enclosure
LTP	License Termination Plan
PDF	Probability Density Function
PRCC	Partial Rank Correlation Coefficient
RESRAD	RESidual RADioactive materials
ROC	Radionuclides of Concern
SA	Surface Area
SOF	Sum of Fractions
SRRC	Standardized Rank Regression Coefficient
TSD	Technical Support Document
V	Volume
WGTV	Waste Gas Tank Vault

1. Purpose

This Technical Support Document (TSD) provides the dose assessment calculations required for the La Crosse Boiling Water Reactor (LACBWR) License Termination Plan (LTP) including RESRAD input parameters, modeling results and spreadsheet calculations.

The scenarios, RESRAD parameters, RESRAD results and spreadsheet calculations used to produce Derived Concentration Guideline Levels (DCGL) for Soil, Backfilled Basements, and Buried Pipe are provided. The dose assessment of backfilled basements includes the groundwater and drilling spoils scenarios under the assumption of an *in situ* basement geometry, i.e., the as left configuration at the time of license termination. The dose from the excavation of backfilled concrete is also included in the basement dose assessment. The Basement Fill Model (BFM) is the terminology used in this TSD to describe the dose assessment of all three basement dose scenarios, i.e., *in situ* groundwater, *in situ* drilling spoils and excavation. Note that the term "Insitu" is used in this TSD to represent "*in situ*" to simplify descriptions and presentation. DCGLs for existing groundwater are also calculated as a contingency in the event that groundwater contamination is identified during continuing characterization (see LACBWR LTP Chapter 5 for discussion of continuing characterization). RESRAD was not required to calculate existing groundwater DCGLs.

The justification for selection of the Industrial Land Use scenario and the Industrial Worker as the Average Member of the Critical Group (AMCG) is provided in LACBWR LTP Chapter 6. The dose from alternate land use scenarios are also evaluated in this TSD and documented in LACBWR LTP Chapter 6. All parameters and derivations necessary to allow independent review of the dose calculations and DCGL calculations are provided in this TSD. In some cases, additional details regarding parameter derivation and/or justification are provided in LACBWR LTP Chapter 6 to support stakeholder review.

The Industrial Use Scenario includes the following exposure pathways:

- Direct exposure to external radiation,
- Inhalation dose from airborne radioactivity,
- Soil ingestion,
- Direct exposure, inhalation dose and ingestion dose from drilling spoils that are brought to the surface during installation of the onsite water supply well into the fill and concrete of backfilled structures, and
- Direct exposure, inhalation dose and ingestion dose from concrete that is brought to the surface by excavation after license termination.

RESRAD Version 7.0 was used for the assessment. RESRAD Version 7.2 was used for the uncertainty analysis of some actinides to decrease run time. The file names of the RESRAD output reports are listed for reference in this TSD. The full reports are provided electronically. Separate documentation of the RESRAD output reports in this TSD facilitates independent review and verification of the RESRAD input parameters and results. Providing the RESRAD reports in this TSD, as opposed to in Chapter 6 of the LTP, also allows revision of the RESRAD parameters and reports, if necessary, without full revision, replacement and resubmittal of a large number of LTP attachments. Only the summary tables in the LTP would be revised as necessary. The following RESRAD modeling was required to support the dose assessment:

- Uncertainty Analysis for Soil DCGL
- Uncertainty Analysis for Dose to Source Ratios (DSR) required to calculate BFM Insitu Groundwater DCGLs

- Deterministic Calculation of Soil DCGLs
- Deterministic Calculation of BFM Insitu Groundwater DSRs
- Deterministic Calculation of Soil Area Factors (AF)
- Deterministic Calculation of BFM Insitu Drilling Spoils AF
- Uncertainty Analyses and Deterministic Calculations for Alternates Scenarios

The following Excel spreadsheet calculations were performed to support the dose assessment:

- BFM Excavation Scenario DCGLs
- BFM Insitu Groundwater (BFM $Insitu_{gw}$) Scenario DCGLs
- BFM Insitu Drilling Spoils (BFM $Insitu_{ds}$) Scenario DCGLs
- Buried Piping DCGLs
- Existing Groundwater Exposure Factors
- Alternate Scenario Dose

A soil DCGL and BFM DCGL (including the dose from the Insitu Groundwater, Insitu Drilling Spoils and Excavation scenarios) was calculated for each radionuclide in the initial suite of radionuclides. The process for selecting the initial suite radionuclides is described in Energy*Solutions* TSD RS-TD-313196-001, "Radionuclides of Concern During LACBWR Decommissioning." [1]. Reference [1] also calculates the radionuclide mixture fractions for the initial suite which are listed in Table 1.

Table 1 - LACBWR Initial Suite of Radionuclides and Mixture Fractions

Radionuclide	Half Life (Years)	75th Percentile Mixture		
		Rx Building	WGTV	Soil
H-3	1.24E+01	2.36E-02	2.52E-01	1.51E-01
C-14	5.73E+03	1.27E-03	9.37E-03	1.72E-03
Fe-55	2.70E+00	1.40E-02	-8.13E-03	2.36E-02
Ni-59	7.50E+04	2.48E-04	4.74E-02	7.40E-04
Co-60	5.27E+00	4.58E-02	4.76E-03	3.43E-02
Ni-63	9.60E+01	2.77E-01	1.89E-01	2.64E-01
Sr-90	2.91E+01	7.59E-02	9.12E-03	5.22E-02
Nb-94	2.03E+04	1.07E-04	1.01E-03	1.68E-04
Tc-99	2.13E+05	2.16E-03	6.91E-03	2.06E-03
Cs-137	3.00E+01	4.92E-01	4.49E-01	4.41E-01
Eu-152	1.33E+01	1.84E-03	4.49E-03	2.93E-03
Eu-154	8.80E+00	2.49E-03	1.60E-03	1.50E-03
Eu-155	4.76E+00	6.61E-04	4.56E-03	2.08E-03
Np-237	2.14E+06	2.17E-06	0.00E+00	2.15E-06
Pu-238	8.78E+01	2.27E-03	7.95E-04	1.16E-03
Pu-239/240	2.41E+04	3.17E-03	1.90E-04	7.80E-04
Pu-241	6.60E+03	4.58E-02	2.35E-02	1.56E-02
Am-241	1.44E+01	1.03E-02	3.25E-03	3.56E-03
Am-243	4.32E+02	6.18E-04	4.55E-04	5.85E-04
Cm-243/244	7.37E+03	1.58E-04	1.78E-04	1.65E-04

The Soil DCGLs and BFM DCGLs calculated in this TSD for the initial suite radionuclides were used in conjunction with the radionuclide mixture fractions to eliminate the radionuclides that have insignificant dose contributions as defined in NUREG-1757, Volume 2, Revision 1, "Consolidated Decommissioning Guidance: Characterization, Survey and Determination of Radiological Criteria" (NUREG-1757) [2]. The radionuclides remaining after the insignificant contributors have been eliminated are designated as the Radionuclides of Concern (ROC). In accordance with NUREG-1757

guidance, the dose contribution attributed to the eliminated insignificant radionuclides is accounted for by adjusting the Soil DCGLs and BFM DCGLs for each ROC. The assessment of insignificant contributor (IC) dose and selection of ROCs is provided in Reference [1]. The resulting IC dose and ROC selection, and adjustment of DCGLs for Soil ROC and BFM ROC, are described in sections 2.3 and 4.1, respectively.

2. RESRAD Modeling for Soil DCGL Determination

Site-specific DCGLs, in units of pCi/g, were developed for residual radioactivity in surface soil. The DCGLs are the concentrations in soil that correspond to the 10 CFR 20.1402 dose criterion of 25 mrem/yr and are used to demonstrate compliance during the Final Status Survey (FSS). The industrial scenario exposure pathways listed in Section 1 are evaluated. The surface soil conceptual model assumes a one meter depth of contamination is present from the surface downward.

2.1. Soil Uncertainty Analysis

Uncertainty analysis was performed to ensure that conservative values are selected for parameters that have a relatively high correlation to dose. Attachment 1 provides the input parameter set used to perform the uncertainty analysis for soil DCGL parameters. The parameter selection process is discussed below.

NUREG/CR-6697 "Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes" (NUREG/CR-6697) [3], Appendix B, evaluates the relative sensitivity of the approximately 200 parameters in the RESRAD model. The results of the evaluation are provided in NUREG/CR-6697, Appendix B, Table 4.2 which categorizes parameters as Priority 1, 2 or 3 with 1 being most sensitive and 3 being least sensitive. Consistent with NUREG-1757 guidance, deterministic parameters were selected for behavioral, metabolic and Priority 3 physical parameters in accordance with the process flow chart provided in Figure 1. The Priority 1 and 2 physical parameters were evaluated through uncertainty analysis to determine their sensitivity. A number of the Priority 1 and 2 physical parameters were assigned the Parameter Distribution Functions (PDF) from NUREG/CR-6697 in accordance with the flow chart in Figure 1. Several Priority 1 and 2 parameters were assigned site-specific deterministic values. A few parameters were assigned site-specific PDFs.

The Partial Rank Correlation Coefficient (PRCC) value reported in the RESRAD Uncertainty Report is used to evaluate parameter sensitivity. The number of sample runs ranged from 300 to 500 to manage run time. Soil parameters with PRCC values greater than the absolute value of 0.25 are considered sensitive with respect to dose. This PRCC threshold is consistent with the methods used for parameter sensitivity analysis in NUREG/CR-6676, “Probabilistic Dose Analysis Using Parameter Distributions Developed for RESRAD and RESRAD-BUILD Codes” (NUREG/CR-6676) [4].

The RESRAD Uncertainty Report provides PRCC calculations for each parameter evaluated. The uncertainty analysis was performed for each radionuclide individually. This conservatively disregards the reduced influence of low abundance radionuclides on the total dose and eliminates the potential impact of uncertainty in mixture fractions.

Attachment 1 lists the deterministic values and Probability Density Functions (PDFs) selected for the uncertainty analysis and the reference or justification for the selections. The reference for the behavioral and metabolic parameters is NUREG/CR-5512, Volume 3, “Residual Radioactive Contamination from Decommissioning Parameter Analysis” (NUREG/CR-5512) [5]. The median values from the NUREG/CR-6697 parameter distributions were assigned as deterministic values for the Priority 3 physical parameters. The PDFs from NUREG/CR-6697 were selected for the Priority 1 and 2 physical parameters that were not site-specific. The Kd PDFs for the contaminated zone,

unsaturated zone and saturated zone were correlated in the uncertainty analysis with Rank Correlation Coefficients of 0.99. The bases for the Priority 1 and 2 physical parameters that were assigned site-specific deterministic values or PDFs are discussed below.

The contaminated area was assumed to be the full 7500 m^2 area inside the LACBWR Site Enclosure (LSE) fence. The site-specific soil type was determined to be sand in the Haley & Aldrich Inc. report, "Hydrogeological Investigation Report, La Crosse Boiling Water Reactor, Dairyland Power Cooperative, Genoa Wisconsin" [6]. The depth of soil contamination was conservatively assumed to be 1 m. This allows for a more efficient remediation (if necessary) and FSS process because a single DCGL applies to the soil depths from 0 to 1 m as opposed to requiring separate DCGLs for 0.0 to 0.15 m and 0.15 m to 1.0 m. Site-specific deterministic values from Reference 6 were applied to the following hydrogeological parameters:

- Contaminated Zone Hydraulic Conductivity,
- Soil Density,
- Soil Porosity,
- Soil Effective Porosity,
- Saturated Zone Hydraulic Gradient.

A site-specific deterministic value was also selected for the "Saturated Zone Field Capacity" parameter based on a calculation performed for a sand soil type in Zion*Solutions* Technical Support Document 14-006 Conestoga Rovers & Associates Report, "Evaluation of Hydrological Parameters in Support of Dose Modeling for the Zion Restoration Project" [7].

A similar process was followed to determine the Drinking Water Intake Rate parameter for the industrial worker. NUREG/CR-5512, Table 6.87, provides a water intake rate of 478 L/yr for a residential user which corresponds to 1.31 L/d. This rate was conservatively applied as the intake rate for a worker as follows: 1.31 L/d * 250 work days/yr = 327 L/yr.

The RESRAD parameters "Indoor Time Fraction" and "Outdoor Time Fraction" were derived from NUREG/CR-6697 Att. C, Table 7.6-1 which recommends a median indoor work day of 8.76 hours/day. Assuming 5 days a week and 50 weeks per years, this equates to 2190 hours per year. The majority of industrial work is expected to be indoors. Consistent with Table 2-3 of the Argonne National Laboratory (ANL) report "User's Manual for RESRAD Version 6" [8], 75% of work time is assumed to be indoors and 25% outdoors. The corresponding RESRAD Indoor Fraction parameter = (2190*0.75)/(24*365)= 0.1875. The Outdoor Time Fraction is then calculated as (2190*0.25)/(24*365) = 0.0625.

The Inhalation Rate parameter for the industrial worker AMCG was derived from NUREG/CR-5512, Section 5.3.4 which recommends an inhalation rate for workers in light industry of 1.4 m^3/hr. . The annual inhalation rate was then calculated as follows: Annual Inhalation Rate (m^3/yr) = 1.4 m^3/hr*2190 hr/yr = 3066 m^3/yr.

Site-specific PDFs were developed for the Well Pump Intake Depth and Well Pumping Rate Parameters. There are two existing onsite industrial water supply wells supporting LACBWR with depths of 116 feet and 129 feet below the ground surface (bgs) [6]. The 129 foot depth equals 36.3 m below the maximum water table elevation of 629 feet [6]. The 36.3 m depth is assumed to be the maximum well depth. The minimum well depth is represented by a nominal 20 foot screen depth (6.1 m) starting at the maximum water table elevation. NUREG/CR-6697 recommends a triangular distribution for the Well Pump Intake Depth parameter. The mode of the triangular distribution was assumed to be mid-point between 6.1 m and 36.3 m which is 21.2 m. Note that the site-specific

distribution is reasonably similar to the NUREG/CR-6697 distribution values of 6, 10, and 30 for the triangular distribution.

NUREG/CR-6697 does not provide a recommended value for well pumping rate due to high variability. For an industrial use scenario, the pump rate depends on the industry. To ensure that well pumping rate is evaluated in the uncertainty analysis a nominal uniform distribution was developed. NUREG-6697, Table 3.10-1 applies a sanitary and potable water usage rate for four persons of 328.7 m^3/yr. This value is assumed to be a nominal minimum industrial well pumping rate assuming four workers. A maximum rate is assumed based on supply to 20 workers which equates to 1643.5 m^3/yr. These minimum and maximum values are not intended to predict actual water use at an assumed future industrial facility on the site after license termination but to provide a range that can be used to determine if the dose is sensitive to well pumping rate.

Attachment 2 provides the file names of the RESRAD Uncertainty Analysis Reports for Soil. The Uncertainty Reports are provided electronically.

The site-specific soil type is sand. The Kds assigned to radionuclides that are sensitive to Kd are the 75th or 25th percentile values for the sand distributions from Sheppard and Thibault, "Default Soil/Solid /Liquid Partition Coefficients, Kds, for Four Major Soil Types: A Compendium" [9], as listed in Attachment 3. The Kds assigned to radionuclides that are not sensitive to Kd are the mean deterministic values for sand from Reference 9 as listed in NUREG/CR-6697, Table 3.9-2.

The uncertainty analysis results and the selected deterministic values for Kds are provided in Table 2. The results for non-nuclide specific parameters are provided in Table 3. If a non-nuclide-specific parameter is sensitive for any radionuclide the corresponding deterministic value (75th or 25th percentile depending on the correlation) is assigned to all radionuclides

Table 2 - Deterministic Kd Values Selected for Soil DCGL Calculation.

Radionuclide	Correlation to Dose	Basis of Deterministic Parameter Selection[1]	Selected Deterministic Value(cm^3/g)
H-3	NS[2]	mean	0.06
C-14	NS	mean	5
Fe-55	NS	mean	220
Ni-59	Positive	75th	1110
Co-60	NS	mean	60
Ni-63	Positive	75th	1110
Sr-90	NS	mean	15
Nb-94	NS	mean	160
Tc-99	Negative	25th	0.04
Cs-137	NS	mean	280
Eu-152[3]	NS	mean	825
Eu-154[3]	NS	mean	825
Eu-155[3]	NS	mean	825
Np-237	Negative	25th	1
Pu-238	NS	mean	550
Pu-239	NS	mean	550
Pu-240	NS	mean	550
Pu-241	NS	mean	550
Am-241	NS	mean	1900
Am-243	NS	mean	1900
Cm-243	NS	mean	4000
Cm-244	NS	mean	4000

Note 1: Mean values for sand from NUREG/CR-6697 Table 3.9.2. The 75th and 25th values for sand from Reference 9 (see Attachment 3) Note 2: NS indicates non-sensitive parameter. Note 3: Sand Kds not listed in NUREG-6697 Table 3.9-2 for this radionuclide. The mean value from NUREG-6697.

Table 3 - Soil Uncertainty Results and Deterministic Values Selected for Non-Nuclide Specific Parameter Distributions

Parameter	Correlation to Dose	Radionuclide	Basis of Deterministic Parameter Selection	Selected Deterministic Value
Contaminated zone erosion rate	Positive	Nb-94	75th	0.0029
Contaminated zone b parameter	NS	NA	median	0.97
Evapotranspiration coefficient	Negative	H-3, Tc-99	25th	0.56
Wind Speed	Negative	Am-241, C-14, Cm-243, Cm-244, Ni-59, Ni-63, Pu-238, Pu-239, Pu-240, Pu-241, Fe-55	Minimum Site-Specific Monthly Average[1]	3.7
Runoff coefficient	Negative	H-3, Np-237, Tc-99	25th	0.27
Saturated zone b parameter	NS	NA	median	0.97
Well pump intake depth	Negative	H-3, Np-237, Tc-99	minimum site-specific value	6.1
b Parameter of Unsaturated zone	NS	NA	median	0.97
Mass loading for inhalation	Positive	Cm-243, Cm-244, Fe-55, Ni-59, Ni-63, Pu-238, Pu-239, Pu-240, Pu-241,	75th	2.87E-05
Indoor dust filtration factor	Positive	Cm-243, Cm-244, Fe-55, Ni-59, Ni-63, Pu-238, Pu-239, Pu-240, Pu-241	75th	0.75
External gamma shielding factor	Positive	Am-241, Am-243, Cm-243, Co-60, Cs-137, Eu-152, Eu-154, Eu-155, Nb-94, Np-237, Pu-241, Sr-90	75th	0.40
Well Pumping Rate	NS	NA	median	986.1
Depth of Soil Mixing Layer	NS	NA	median	0.23

(1) Site-specific average wind speed data from Wisconsin State Climatology Office converted to m/s (Web Address: http://www.aos.wisc.edu/~sco/clim-history/7cities/la_crosse.html)

2.2. Soil Deterministic Analysis and Soil DCGLs

The soil DCGLs were calculated using the parameter set provided in Attachment 1 with the listed PDFs replaced by the deterministic values in Table 2 and Table 3.

The file name for the Soil DCGL RESRAD Summary Report is listed in Attachment 2. The RESRAD Summary report is provided electronically.

The Soil DCGLs for the initial suite are provided in Table 4.

Table 4 - LACBWR Soil DCGLs Initial Suite of Radionuclides

Radionuclide	Soil DCGL (pCi/g)
H-3	1.746E+04
C-14	2.448E+05
Fe-55	1.018E+07
Ni-59	2.594E+07
Co-60	1.281E+01
Ni-63	9.478E+06
Sr-90	6.586E+03
Nb-94	2.018E+01
Tc-99	3.563E+02
Cs-137	5.812E+01
Eu-152	2.844E+01
Eu-154	2.636E+01
Eu-155	1.122E+03
Np-237	7.991E-01
Pu-238	1.660E+03
Pu-239	1.494E+03
Pu-240	1.496E+03
Pu-241	3.637E+04
Am-241	1.089E+03
Am-243	1.868E+02
Cm-243	2.884E+02
Cm-244	2.668E+03

2.3. Soil Insignificant Contributor Dose and ROC

Reference [1] calculates the relative dose from the radionuclides in the initial suite using the LACBWR radionuclide mixture and the DCGLs in Table 4. The radionuclides that in total represent less than 10% of the dose criterion are eliminated for detailed consideration during implementation of FSS. The radionuclides remaining are the Radionuclides of Concern (ROC). The soil DCGLs for the ROC are adjusted by the total dose attributed to the insignificant radionuclides that were removed to account for the dose from the insignificant radionuclides. Reference [1] determined that the ROC for LACBWR are Co-60, Sr-90, Cs-137, Eu-152 and Eu-154. Using the conservative 75th percentile mixture in Table 1, the insignificant contributor (IC) dose for soil is 0.34% of the 25 mrem/yr dose criteria. To account for variability in radionuclide mixture data used to calculate the IC dose, the 0.34% value is increased to 10%. The 10% value is used to calculate the adjustment factor which is 1-0.10 or 0.90. The ROC soil DCGLs are multiplied by 0.90 to calculate the adjusted ROC DCGLs and are provided in Table 5. The ROC DCGLs in Table 5 were also adjusted to account for the maximum Resident Gardener Alternate Scenario soil dose of 27.07 mrem/yr (see section 9.1) by multiplying the DCGLs by an additional factor of 0.92 (25/27.07).

Table 5 – Soil DCGLs for ROC Adjusted for IC Dose and Alternate Scenario Dose

ROC	Adjusted DCGL (pCi/g)
Co-60	1.06E+01
Sr-90	5.47E+03
Cs-137	4.83E+01
Eu-152	2.36E+01
Eu-154	2.19E+01

3. Basement Fill Model

The BFM conceptual model assumes that all structures are removed to a depth of three feet below grade surface (bgs), which is at the 639′ elevation, and backfilled. There are parts of two structures that are three feet or greater bgs and will remain after LACBWR license termination as listed in Table 6.

Table 6 - Basements to Remain in LACBWR End State. Ground Surface Elevation is 639 Feet AMSL.

Basement/Structure	Material remaining	Floor and Wall Surface Area (m^2)	Floor Elevation (feet AMSL)
Reactor Building	Concrete	511.54	612
Waste Gas Tank Vault	Concrete	310.56	621

The site groundwater is in direct communication with the Mississippi river and fluctuates with river stage. The maximum groundwater elevation is 10 feet bgs at 629′ [6]. Although seasonal, the water table is assumed to be at 629′ elevation. An onsite water supply well is assumed to be installed below the 629'maximum water table elevation.

The BFM includes two scenarios; *in-situ* (designated as "Insitu" in this TSD) and Excavation. The BFM Insitu scenario includes two exposure pathways; ingestion of drinking water from an onsite well and direct exposure to drilling spoils that are brought to the surface during the installation of the onsite well. The BFM Excavation scenario assumes large scale industrial excavation of all or a portion of the backfilled concrete and spreading the concrete over a 1 m layer on the ground surface. The dose from the Insitu and Excavation scenarios are summed in the DCGL calculation.

3.1. BFM Insitu Scenario

3.1.1. BFM Insitu Groundwater Scenario Conceptual Model

The BFM Insitu Groundwater (BFM $Insitu_{gw}$) scenario assumes that residual radioactivity in the backfilled structure concrete is instantly released to adjacent fill upon contact with rainwater or groundwater. The released activity mixes with the fill. The fill mixing volume is proportional to the distance that the activity moves from the concrete surface into the fill. The concrete structures are assumed to provide no resistance to groundwater flow.

The two remaining basements (Reactor Building and WGTV) have different geometries and contamination potential and are therefore modeled as separate contaminated zones with portions above and below the water table after backfill. This configuration is addressed in the RESRAD model using

the "contaminated fraction below the water table" parameter. The conceptual model assumes full mixing over the fill volume. For the portions of the Reactor Building and WGTV that are below the maximum water table elevation of 629′, full mixing over the entire fill volume below 629′ is a reasonable assumption given that the fill is saturated and the conceptual model assumes unrestricted groundwater flow. Mixing within the fill that is above the 629′ water table elevation is more uncertain because the source of the water is vertical rainwater infiltration as opposed to horizontal flowing groundwater. To evaluate the effect of mixing volume, a sensitivity analysis was conducted to determine the dependence of dose on the mixing distance into the fill (see section 3.1.5).

The BFM conceptual model applies a conservative screening approach. One hundred percent of the inventory in the backfilled basement concrete is assumed to instantly release and mix with the fill material. RESRAD is used to perform the dose modeling for the BFM $Insitu_{gw}$ scenario assuming that the source term is in the fill and that the structures provide no resistance to groundwater flow, i.e., are not present. RESRAD produces a DSR (in units of mrem/yr per pCi/g) for each radionuclide. The DSRs are used in conjunction with unitized fill material concentrations (i.e., the pCi/g concentration in fill resulting from the release of 1 pCi/m^2 from the structure concrete) to calculate DCGLs for the BFM $Insitu_{gw}$ scenario in units of pCi/m^2 (see section 3.1.4).

3.1.2. **BFM $Insitu_{gw}$ RESRAD Uncertainty Analysis for Initial Suite**

The process for determining the input parameters for the BFM $Insitu_{gw}$ RESRAD uncertainty analysis was the same as that used for the soil DCGL uncertainty analysis (see process flowchart in Figure 1). The parameter set applied to soil DCGL uncertainty analysis is also applicable to the BFM $Insitu_{gw}$ assessment with changes to account for the geometries of the structures. The affected RESRAD geometry parameters are cover depth, area of contaminated zone, thickness of contaminated zone, length parallel to aquifer flow, unsaturated zone thickness, and contaminated fraction below the water table.

The uncertainty analysis was performed for the two structures to remain at license termination; Reactor Building and WGTV. The parameters used for the two BFM $Insitu_{gw}$ uncertainty analyses are listed in Attachment 5. The parameters listed as "Variable" in Attachment 5 were assigned the values shown in Table 7.

Table 7 - Deterministic Geometry RESRAD Parameters Used in the Uncertainty Analysis for the Two BFM $Insitu_{gw}$ Configurations

Parameter	Rx Building Above 619'	WGTV
Cover Depth (m)	0.91	0.91
Area of Contaminated Zone (m^2)	262.68	86.33
Thickness of Contaminated zone (m)	7.32	4.57
Length Parallel to Aquifer Flow (m)	18.29	9.6
Unsaturated Zone Thickness (m)	0	0
Contaminated Fraction Below the Water Table	0.71	0.53

The uncertainty analysis was performed for each radionuclide individually. This conservatively disregards the reduced influence of low abundance radionuclides on the total dose and eliminates the potential impact of uncertainty in mixture fractions. The RESRAD Uncertainty Report file names for

the Rx Building and the WGTV BFM Insitu$_{gw}$ analyses are listed in Attachment 2. The Uncertainty Reports are provided electronically.

The Kd values are radionuclide-specific. The uncertainty analyses for all radionuclides, except Nb-94 which had a positive PRCC value near zero, showed a negative correlation between dose and Kd. With a few exceptions, the negative correlation exceeded the PRCC |0.25| threshold. The predominance of negative correlation with Kd was expected because the majority of the contamination is below the water table and the primary dose pathway in the BFM Insitu$_{gw}$ scenario is through the ingestion of well water. To ensure conservatism, the deterministic Kd values selected for all negatively correlated radionuclides, in both the Rx Building and WGTV, were the 25th percentile values from Reference 9. The positive correlation to the Nb-94 Kd was investigated further primarily because a cross-check of the Standardized Rank Regression Coefficient (SRRC) indicated more significant positive correlation than the PRCC. The cause of the positive correlation was found to be direct dose from the water independent pathway after long term cover erosion. The maximum Nb-94 dose occurs when the 75th percentile Kd is applied, as opposed to the 25th percentile, for both the Rx and WGTV. The time of maximum dose is year 312. This result is due to the unique decay characteristics of Nb-94 which include gamma emission with a very long half-life. Although the maximum dose from Nb-94 occurs at year 312, the 75th percentile Kd was applied to ensure conservatism.

The assigned Kd values for all radionuclides are listed in Table 8. The parameter distributions for the site-specific soil type of sand [9] were used to generate the median, 25th and 75th percentile deterministic values (see Attachment 3). Note that Reference [9] does not contain values for Europium; the 25th percentile from the NUREG-6697 Kd parameter distribution was used.

Table 8 - BFM Insitu$_{gw}$ Rx Building and WGTV Deterministic Values Selected for Distribution Coefficients (Kd)

Radionuclide	Kd in Contaminated Zone and Saturated Zone (No Unsaturated Zone Present)	
H-3	Negative	0.05
C-14	Negative	1.8
Fe-55	Negative	38
Ni-59	Negative	147
Co-60	Negative	9
Ni-63	Negative	147
Sr-90	Negative	5
Nb-94	Positive	611
Tc-99	Negative	0.04
Cs-137	Negative	50
Eu-152[1]	Negative	95
Eu-154[1]	Negative	95
Eu-155[1]	Negative	95
Np-237	Negative	1
Pu-238	Negative	173
Pu-239/240	Negative	173
Pu-241	Negative	173
Am-241	Negative	329

Radionuclide	Kd in Contaminated Zone and Saturated Zone (No Unsaturated Zone Present)	
Am-243	Negative	329
Cm-243/244	Negative	881

Table 9 and Table 10 provide the uncertainty analysis results for the parameters that are not radionuclide-specific and the selected deterministic parameters. If a parameter is sensitive for any radionuclide the corresponding deterministic value (75th or 25th percentile depending on the correlation) is assigned to all radionuclides.

Table 9 – Rx Building: BFM Insitu$_{gw}$ Uncertainty Analysis Results and Deterministic Values Selected for Non-Nuclide Specific Parameter Distributions

Parameter	Correlation to Dose[1]	Radionuclide	Basis of Deterministic Parameter Selection	Selected Deterministic Value
Contaminated zone erosion rate	NS	NA	median	0.0015
Contaminated zone b parameter	NS	NA	median	0.97
Evapotranspiration coefficient	NS	NA	median	0.62
Wind Speed[2]	NS	NA	median	4.5
Runoff coefficient	NS	NA	median	0.45
Saturated zone b parameter	NS	NA	inactive	NA
Well pump intake depth	Negative	H-3, C-14, Fe-55, Ni-59, Co-60, Ni-63, Sr-90, Tc-99, Cs-137, Eu-152, Eu-154, Eu-155, Np-237, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Am-243, Pu-241, Cm-243, Cm-244	25th Percentile	6.1
Mass loading for inhalation	NS	NA	median	2.35E-05
Indoor dust filtration factor	NS	NA	median	0.55
External gamma shielding factor	NS	NA	median	0.27
Well Pumping Rate	NS	NA	median	986.1
Depth of Soil Mixing Layer	NS	NA	median	0.15
Cover Erosion Rate	Positive	Nb-94, Cs-137, Eu-152, Eu-154, Am-243	75th Percentile	0.0029

(1) NS = Not Sensitive
(2) Site-specific annual average wind speed from Wisconsin State Climatology Office converted to m/s (Web Address http://www.aos.wisc.edu/~sco/clim-history/7cities/la_crosse.html)

Table 10 – WGTV: BFM Insitu$_{gw}$ Uncertainty Analysis Results and Deterministic Values Selected for Non-Nuclide Specific Parameter Distributions

Parameter	Correlation to Dose[1]	Radionuclide	Basis of Deterministic Parameter Selection	Selected Deterministic Value
Contaminated zone erosion rate	NS		Median	0.0015
Contaminated zone b parameter	NS		Median	0.97
Evapotranspiration coefficient	NS		Median	0.62
Wind Speed[2]	NS		Median	4.5
Runoff coefficient	NS		Median	0.45
Saturated zone b parameter	NS		Inactive	NA
Well pump intake depth	Negative	H-3, C-14, Fe-55, Ni-59, Co-60, Ni-63, Sr-90, Tc-99, Cs-137, Eu-152, Eu-154, Eu-155, Np-237, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Am-243, Cm-243, Cm-244	Minimum Depth	6.1
Mass loading for inhalation	NS		Median	2.35E-05
Indoor dust filtration factor	NS		Median	0.55
External gamma shielding factor	NS		Median	0.27
Well Pumping Rate	NS		Median	986.1
Depth of Soil Mixing Layer	NS		Median	0.15
Cover Erosion Rate	Positive	Nb-94, Cs-137, Eu-152, Eu-154, Am-241, Am-243	75th Percentile	0.0029

(1) NS = Not Sensitive
(2) Site-specific annual average wind speed data from Wisconsin State Climatology Office converted to m/s (Web Address: http://www.aos.wisc.edu/~sco/clim-history/7cities/la_crosse.html)

3.1.3. BFM Insitu$_{gw}$ RESRAD Deterministic Analysis

As discussed above, the BFM Insitu$_{gw}$ RESRAD dose assessments were performed separately for the Reactor Building and WGTV. The deterministic parameters provided in Attachment 5 were applied to both analyses. The parameters identified as "Variable" in Attachment 5 were replaced by the values in Table 7 for each basement. The PDFs listed in Attachment 5 were replaced with the deterministic values in Table 8 through Table 10.

The file names for the BFM Insitu$_{gw}$ deterministic RESRAD Summary Reports are listed in Attachment 2. The Summary Reports are provided electronically. The resulting DSRs are provided in Table 11.

Table 11 - BFM Insitu$_{gw}$ DSRs

Radionuclide	Rx Building (mrem/yr per pCi/g)	WGTV (mrem/yr per pCi/g)
H-3	5.916E-03	2.703E-03
C-14	1.581E-01	8.069E-02
Fe-55	3.787E-03	1.852E-03
Ni-59	3.940E-04	2.032E-04
Co-60	6.691E-01	3.759E-01
Ni-63	1.079E-03	5.003E-04
Sr-90	6.440E+00	3.661E+00
Nb-94	1.546E-01	6.640E-02
Tc-99	1.355E-01	6.195E-02
Cs-137	2.674E-01	1.295E-01
Eu-152	1.824E-02	8.675E-03
Eu-154	2.649E-02	1.260E-02
Eu-155	4.112E-03	1.955E-03
Np-237	3.887E+02	1.854E+02
Pu-238	5.089E+00	2.398E+00
Pu-239	5.652E+00	2.911E+00
Pu-240	5.651E+00	2.907E+00
Pu-241	1.090E-01	5.311E-02
Am-241	3.066E+00	1.499E+00
Am-243	3.054E+00	1.567E+00
Cm-243	7.831E-01	3.658E-01
Cm-244	6.260E-01	2.924E-01

3.1.4. BFM Insitu$_{gw}$ Scenario DCGLs

The BFM Insitu$_{gw}$ DCGLs were calculated using Equation 1 where the inputs and calculation results are provided in Attachments 7 and 8. The BFM Insitu$_{gw}$ DCGLs are listed in Table 13.

Equation 1

$$BFM\ Insitu_{gw}\ DCGL(i) = \frac{25}{DSR(i) * FC_{unit}}$$

Where:

BFM $Insitu_{gw}$ DCGL(i)	= DCGL for radionuclide (i) (pCi/m^2)
DSR (i)	= RESRAD Dose to Source Ratio for radionuclide i (mrem/yr per pCi/g)
FC_{unit}	= Basement-specific unit fill concentration (pCi/g) assuming release of unit inventory of 1 pCi/m^2 from concrete (pCi/g per pCi/m^2).

Table 12 - BFM Insitu$_{gw}$ DCGLs

Radionuclide	Rx Building BFM Insitu$_{gw}$ DCGL (pCi/m^2)	WGTV BFM Insitu$_{gw}$ DCGL (pCi/m^2)
H-3	2.16E+10	1.60E+10
C-14	8.08E+08	5.35E+08
Fe-55	3.37E+10	2.33E+10
Ni-59	3.24E+11	2.13E+11
Co-60	1.91E+08	1.15E+08
Ni-63	1.18E+11	8.63E+10
Sr-90	1.98E+07	1.18E+07
Nb-94	8.26E+08	6.50E+08
Tc-99	9.43E+08	6.97E+08
Cs-137	4.78E+08	3.34E+08
Eu-152	7.00E+09	4.98E+09
Eu-154	4.82E+09	3.43E+09
Eu-155	3.11E+10	2.21E+10
Np-237	3.29E+05	2.33E+05
Pu-238	2.51E+07	1.80E+07
Pu-239	2.26E+07	1.48E+07
Pu-240	2.26E+07	1.49E+07
Pu-241	1.17E+09	8.13E+08
Am-241	4.17E+07	2.88E+07
Am-243	4.18E+07	2.76E+07
Cm-243	1.63E+08	1.18E+08
Cm-244	2.04E+08	1.48E+08

3.1.5. BFM Insitu Drilling Spoils Scenario DCGLs

The residual radioactivity in the concrete is assumed to be brought to the ground surface during the installation of a well that randomly hits backfilled structural concrete. The driller is assumed to be unaware that the backfilled structure is present. The residual radioactivity in the concrete surfaces is brought to the surface with the drilling spoils which includes the fill material above the structure floor. The source term for the BFM Insitu$_{ds}$ scenario is the residual radioactivity remaining in concrete at the time of license termination assuming no decay or release to the fill. The BFM Insitu$_{ds}$ DCGLs are calculated with units of pCi/m^2.

There are a number of ways that installers handle and dispose of drilling spoils, including the use of slurry pits, tanks, and dumping the drilling spoils on the existing surface soils. The use of pits would likely involve additional dilution by refilling the pit with the material excavated during its construction. As a conservative assumption, no dilution of the spoil material is assumed after being brought to the surface.

The well is assumed to be drilled into the basement fill down to the concrete floor where refusal is met and drilling stopped. The extent of drilling into concrete is assumed to be sufficient to capture 100 percent of the remaining residual radioactivity in the concrete surface within the borehole area. The volume of spoil material brought to the surface is calculated based on the borehole diameter and depth of drilling which is conservatively assumed to be the minimum fill depth of 3 feet for all basements in order to minimize the mixing volume. The concrete and fill are uniformly mixed and spread over a circular area on the ground surface to a depth of 0.15 m.

The dose from the circular area at the surface was calculated using the surface soil DCGLs and AFs for an area of 0.457 m^2. The AFs were calculated using the deterministic parameters applied for soil DCGLs. The file name for the RESRAD Summary Report for the AF calculation is listed in Attachment 2. The RESRAD Summary report is provided electronically. The AFs and BFM calculation inputs and results are provided in Attachment 8. The BFM $Insitu_{ds}$ DCGLs are listed in Table 13.

Table 13 - BFM $Insitu_{ds}$ DCGLs (same values for both basements)

Radionuclide	Reactor Building BFM $Insitu_{ds}$ DCGL (pCi/m^2)	WGTV BFM $Insitu_{ds}$ DCGL (pCi/m^2)
H-3	5.09E+13	5.09E+13
C-14	4.40E+15	4.40E+15
Fe-55	4.53E+16	4.53E+16
Ni-59	6.15E+16	6.15E+16
Co-60	6.00E+08	6.00E+08
Ni-63	2.52E+16	2.52E+16
Sr-90	3.41E+11	3.41E+11
Nb-94	8.72E+08	8.72E+08
Tc-99	1.37E+12	1.37E+12
Cs-137	2.45E+09	2.45E+09
Eu-152	1.27E+09	1.27E+09
Eu-154	1.19E+09	1.19E+09
Eu-155	3.44E+10	3.44E+10
Np-237	9.83E+09	9.83E+09
Pu-238	5.59E+11	5.59E+11
Pu-239	5.07E+11	5.07E+11
Pu-240	5.11E+11	5.11E+11
Pu-241	4.95E+12	4.95E+12
Am-241	9.68E+10	9.68E+10
Am-243	7.21E+09	7.21E+09
Cm-243	1.17E+10	1.17E+10
Cm-244	8.90E+11	8.90E+11

3.2. BFM Excavation Scenario DCGLs

The BFM Excavation scenario assumes that some or all of the backfilled structure concrete is excavated and spread on the surface at some time after license termination. A typical excavation

process for a backfilled structure would entail using a medium sized excavator with a 1.0 to 1.5 cubic yard bucket to excavate and stockpile fill. After removing the fill to the planned excavation depth, a hoe-ram would be used to pound out the concrete walls and floor (if the excavation reaches the floor). The concrete would be segregated, the rebar removed, and remaining concrete size reduced. The excavation scenario assumes that the size reduced concrete is used as onsite fill. Large-scale industrial excavation of the entire basement may require different methods but the result would be the same, i.e., a volume of sized concrete to be used as onsite fill.

The excavation scenario takes no credit for decay. The assessment provides BFM Excavation DCGLs in units of pCi/m^2. The DCGLs are calculated to ensure that the average radionuclide concentrations in the excavated, mixed, and sized concrete do not exceed the soil DCGLs which is a conservative approach given that the surface area of excavated concrete, assuming 1 m spread depth, would be less than the 7500 m^2 area assumed in the calculation of the soil DCGL (see section 2.1). Due to differences in geometry and contamination potential, the BFM Excavation DCGLs are calculated separately for the Reactor Building and WGTV.

The radionuclide concentrations (pCi/g) in the inadvertently mixed, excavated concrete that is assumed to be spread on the site surface is a linear function of the ratio of concrete surface area (SA) to concrete volume (V). The SA/V ratio was calculated in two ways; 1) assuming full excavation of the entire basement, and 2) assuming partial excavation that includes only the walls with the minimum thickness (0.75 feet for both the Reactor Building and WGTV). The walls with minimum thickness will have the maximum SA/V ratio and will result in the maximum concentration in the excavated concrete.

The SA/V ratios and BFM Excavation DCGLs are provided in Attachment 9. As seen in Table 14, the SA/V ratios for the partial excavation of the minimum thickness wall is greater than the SA/V ratio assuming full excavation. To ensure conservatism, the maximum SA/V ratio was used in the DCGL calculation which results in the maximum radionuclide concentrations in the excavated concrete.

Table 14 - BFM Concrete Excavation SA/V Ratios for Full and Partial Excavation

Structure	Full Excavation SA/V (m^2/m^3)	Partial Excavation SA/V (Minimum Wall Thickness) (m^2/m^3)	Partial SA/V ÷ Full SA/V
Waste Gas Tank Vault	2.55	4.37	1.72
Reactor Building	0.95	4.37	4.61

The BFM Excavation DCGLs are listed in Table 15 and are the same for the Reactor Building and WGTV because the concentrations in the excavated concrete are both based on the same partial (i.e., maximum) SA/V ratio of 4.37 (see Table 14).

Table 15 - BFM Excavation DCGLs (same values for both basements)

Radionuclide	Rx Building Excavation DCGL (pCi/m^2)	WGTV Excavation DCGL (pCi/m^2)
H-3	9.38E+09	9.38E+09
C-14	1.32E+11	1.32E+11
Fe-55	5.47E+12	5.47E+12
Ni-59	1.39E+13	1.39E+13
Co-60	6.88E+06	6.88E+06
Ni-63	5.09E+12	5.09E+12
Sr-90	3.54E+09	3.54E+09
Nb-94	1.08E+07	1.08E+07
Tc-99	1.91E+08	1.91E+08
Cs-137	3.12E+07	3.12E+07
Eu-152	1.53E+07	1.53E+07
Eu-154	1.42E+07	1.42E+07
Eu-155	6.03E+08	6.03E+08
Np-237	4.29E+05	4.29E+05
Pu-238	8.92E+08	8.92E+08
Pu-239	8.03E+08	8.03E+08
Pu-240	8.04E+08	8.04E+08
Pu-241	1.95E+10	1.95E+10
Am-241	5.85E+08	5.85E+08
Am-243	1.00E+08	1.00E+08
Cm-243	1.55E+08	1.55E+08
Cm-244	1.43E+09	1.43E+09

4. Reactor Building and WGTV DCGLs for Radionuclides of Concern

4.1. Radionuclides of Concern and Insignificant Contributor Dose Adjustment

Reference [1] calculates the dose for the radionuclides in the initial suite using the LACBWR radionuclide mixture and the DCGLs in Table 12, Table 13, and Table 15. The radionuclides that in total represent less than 10% of the dose criterion are eliminated for detailed consideration during implementation of FSS. The radionuclides remaining are the Radionuclides of Concern (ROC). The DCGLs for the ROC are adjusted by the total dose attributed to the insignificant radionuclides that were removed to account for the dose from the insignificant radionuclides. Reference [1] determined that the ROC for LACBWR are Co-60, Sr-90, Cs-137, Eu-152 and Eu-154. Using the conservative 75th percentile mixture in Table 1, the IC dose is 2.13% and 7.14% of the 25 mrem/yr dose criteria for the Reactor Building and WGTV, respectively. To provide additional margin, the IC dose assigned to both basements was increased to 10%. The 10% value is used to calculate the adjustment factor which is 1-0.10 or 0.90. The DCGLs are multiplied by 0.90 to calculate the adjusted DCGLs for ROC.

4.2. BFM Groundwater Scenario Mixing Volume Sensitivity Analysis for ROC

The BFM $DCGL_{gw}$ are based on a conceptual model that assumes instant release of all activity and uniform mixing throughout the entire fill volume. The concentration in fill is a function of the mixing volume which is proportional to the distance away from the wall that the released activity is assumed to mix. The fill concentration increases with decreasing mix distance but the source term geometries, and dose per pCi/g in fill, also change with mixing distance. A sensitivity analysis was performed for the ROC to evaluate the impact of mixing distance on the dose from the BFM Groundwater scenario. Mixing distance does not impact the dose from the BFM Drilling Spoils scenario which assumes all activity remains in the concrete.

The mixing distance sensitivity analyses for the BFM Groundwater scenario were performed assuming that released activity mixes over distances of 1 m, 2 m, and 3 m from the floor and wall surfaces, as opposed to full mixing. A mixing distance of 1 m was assumed to conservatively represent a minimum width from which a well drawdown zone would not include dilution with adjacent, uncontaminated, groundwater.

Separate analyses were performed for the Reactor Building and the WGTV. For the WGTV, three fill mixing geometries were evaluated including; 1) mixing in fill adjacent to the two walls perpendicular to groundwater flow, 2) mixing in fill adjacent to a wall parallel to groundwater flow, and 3) mixing in fill adjacent to the floor. RESRAD modeling was performed with the deterministic parameters used to calculate the BFM $Insitu_{gw}$ DCGLs (see section 3.1.4) but changing the source term parameters to represent the three mixing geometries, for 1, 2, and 3 m distances, as shown in Table 16.

Table 16 provides the geometric input values and Attachment 4 provides the additional inputs and results of this calculation.

Table 16 – WGTV Mixing Sensitivity RESRAD Source Term Geometries

Parameter	Mixing Distance	Perpendicular Walls	Parallel Wall	Floor
Area of Contaminated Zone (m^2)	1	18	9.6	86.4
	2	36	19.2	86.4
	3	54	28.8	86.4
Thickness of Contaminated zone (m)	1	4.57	4.57	1
	2	4.57	4.57	2
	3	4.57	4.57	3
Length Parallel to Aquifer Flow (m)	1	2	9.6	9.6
	2	4	9.6	9.6
	3	6	9.6	9.6

The values in Table 16 are directly related to the WGTV structure geometry with the exception of the values listed for the perpendicular walls. There are two walls perpendicular to groundwater flow and the activity in each wall is assumed to mix in the layer of fill immediately adjacent to the wall. The fill layers from each of the two perpendicular walls are assumed to be contiguous resulting in a length parallel to flow of 2 times the mixing distance.

The Reactor Building is circular as opposed to rectangular. Therefore, there is no geometry equivalent to the Parallel Wall geometry in the WGTV. The Perpendicular Walls and Floor geometries were evaluated. The Reactor Building mix sensitivity source term geometries for 1, 2, and 3 m distances are provided in Table 17.

Table 17 – Reactor Building Mixing Sensitivity RESRAD Source Term Geometries

Parameter	Mixing Distance	Perpendicular Walls	Floor
Area of Contaminated Zone (m^2)	1	102.34	262.68
	2	179.55	262.68
	3	231.62	262.68
Thickness of Contaminated zone (m)	1	7.32	1
	2	7.32	2
	3	7.32	3
Length Parallel to Aquifer Flow (m)	1	2	18.29
	2	4	18.29
	3	6	18.29

The RESRAD file names for the analyses of the 15 mixing sensitivity geometries in Table 16 and Table 17 are listed in Attachment 2. The RESRAD Summary Reports are provided electronically.

The impact of mixing distance on dose was evaluated by calculating the ratio of the dose factor (mrem/year per pCi/m^2) for each partial mixing distance (1, 2, and 3 m) to the dose factor under the full mixing assumption. The maximum values of the ratios of Partial/Full mixing dose, for all ROC, and all 15 geometries listed in Tables 16 and 17 are provided in Table 18. The dose from the perpendicular wall and floor geometries were summed, for each partial mixing distance, to determine the maximum ratio because both the floor and perpendicular wall fill source terms can contribute to a well simultaneously under partial mixing. The parallel wall source term (WGTV only) includes the fill from the top of the wall down to the floor. The residual radioactivity in the floor is therefore included in the calculation of fill concentration. The well is assumed to be placed at the downstream edge of the parallel wall source term.

Table 18 – Mixing Sensitivity Analysis Results Summary. Maximum Ratio of Dose Factor Partial Mix/Full Mix

ROC	Rx Building Wall + Floor	WGTV Wall + Floor
Co-60	1.25	1.19
Cs-137	1.91	1.42
Sr-90	1.08	1.18
Eu-152	2.03	1.41
Eu-154	2.03	1.40

To ensure a conservative and bounding $DCGL_{gw}$ for ROCs in backfilled basement surfaces, The $DCGL_{gw}$ values calculated for each ROC under the full mixing assumption (Table 12) were reduced by the ratios in Table 18.

4.3. Reactor Building and WGTV DCGL

The DCGLs for each ROC, each basement, and each dose scenario (Groundwater, Drilling Spoils, Excavation), after adjusting for the IC dose fraction (and the mixing volume sensitivity for the groundwater scenario), are provided in Table 19. These values are designated as the DCGL Basement Scenario ($DCGL_{BS}$). The $DCGL_{BS}$ for the ROC, including the IC dose adjustment, and mixing sensitivity adjustment for the groundwater scenario, are calculated using Equation 2.

Equation 2

$$DCGL_{BS,i}\ GW = \frac{BFM\ Insitu_{gw,i}\ DCGL * IC\ Dose\ Adjust}{MS\ Ratio_i}$$

$$DCGL_{BS,i}\ DS = BFM\ Insitu_{ds,i}\ DCGL * IC\ Dose\ Adjust$$

$$DCGL_{BS,i}\ Excavation = BFM\ Excavation\ DCGL_i * IC\ Dose\ Adjust$$

Where:

$DCGL_{BS,i}$ GW	= BFM Insitu Groundwater, for ROC (i), adjusted for IC dose and mixing sensitivity
BFM $Insitu_{gw,i}$ DCGL	= BFM $Insitu_{gw}$ DCGL, for ROC (i), from Table 12
IC Dose Adjust	= Insignificant contributor adjustment factor of 0.9 (see section 4.1)
MS $Ratio_i$	= Maximum Mixing Sensitivity ratio, for ROC (i), from Table 18.
$DCGL_{BS,i}$ DS	= $DCGL_{BS}$, for ROC (i), adjusted for IC dose.
BFM $Insitu_{ds,i}$ DCGL	= BFM $Insitu_{ds}$ DCGL, for ROC (i), from Table 13
$DCGL_{BS,i}$ Excavation	= BFM Excavation DCGL, for ROC (i), adjusted for IC dose
BFM Excavation $DCGL_i$	= BFM Excavation DCGL, for ROC (i), from Table 15.

The final correction to the ROC DCGLs is to account for the maximum alternate scenario dose for each basement which is 28.4 mrem/yr and 34.9 mrem/yr for the Rx Building and WGTV, respectively (see section 9.2). The values generated by Equation 2 were multiplied by a factor = 25/28.4 and 25/34.9 for the Rx Building and WGTV, respectively. The adjusted $DCGL_{BS}$ are provided in Table 19.

The three adjusted $DCGL_{BS}$ for each basement are summed using Equation 3 to calculate the Basement DCGL ($DCGL_B$) for the ROCs as listed in Table 20.

Table 19 – ROC DCGLs for Each Basement and Individual BFM Scenarios ($DCGL_{BS}$). Adjusted for IC Dose, Mixing Sensitivity and Alternate Scenario Dose

ROC	Reactor Building $DCGL_{BS}$			Waste Gas Tank Vault $DCGL_{BS}$		
	Groundwater Scenario	Drilling Spoils Scenario	Excavation Scenario	Groundwater Scenario	Drilling Spoils Scenario	Excavation Scenario
	(pCi/m^2)			(pCi/m^2)		
Co-60	1.21E+08	4.75E+08	5.45E+06	6.23E+07	3.86E+08	4.43E+06
Sr-90	1.46E+07	2.70E+11	2.80E+09	6.42E+06	2.20E+11	2.28E+09
Cs-137	1.98E+08	1.94E+09	2.47E+07	1.52E+08	1.58E+09	2.01E+07
Eu-152	2.73E+09	1.00E+09	1.21E+07	2.28E+09	8.16E+08	9.84E+06
Eu-154	1.88E+09	9.43E+08	1.12E+07	1.57E+09	7.67E+08	9.12E+06

Table 20 – ROC DCGL Summation Values for each Basements ($DCGL_B$). Adjusted for IC Dose, Mixing Sensitivity and Alternate Scenario Dose.

ROC	Rx Bldg $DCGL_B$ (pCi/m^2)	WGTV $DCGL_B$ (pCi/m^2)
Co-60	5.16E+06	4.10E+06
Sr-90	1.45E+07	6.40E+06
Cs-137	2.17E+07	1.76E+07
Eu-152	1.19E+07	9.69E+06
Eu-154	1.10E+07	8.97E+06

Note that the $DCGL_{BS}$ values in Table 19 are all larger than the $DCGL_B$ values for the same basement in

Table 20. This is because the values in Table 19 are the $DCGL_{BS}$ values that lead to a dose of 25 mrem/yr for each scenario individually. For conservatism, the $DCGL_B$ is the value that leads to a dose of 25 mrem/yr under the assumption that all three exposure scenarios occur simultaneously, which is not physically possible. The $DCGL_{B,i,j}$ for basement j and nuclide i as shown in **Error! Reference source not found.** is determined from each of the $DCGL_{BS,i,\,j}$ values from Table 19 using Equation 3 as follows.

Equation 3

$$\boldsymbol{DCGL_{B,i,j}} = \frac{\mathbf{1}}{\Sigma_1^3\left[\mathbf{1}/\boldsymbol{DCGL_{BS,i,j}}\right]}$$

Where:

$DCGL_{B,i,j}$ = $DCGL_B$ for radionuclide (i) and basement (j)
$DCGL_{BS}$ = DCGL Basement Scenario for (i) and basement (j)

5. Soil Area Factors

The RESRAD modeling for soil assumes a large source term area of 7500 m^2. Isolated areas of contamination that are smaller than 7500 m^2 will have a lower dose for a given concentration. To address small, isolated elevated areas of soil contamination AFs were developed. An Area Factor is defined as the ratio of the dose from the full source term area to the dose from a smaller area.

Area Factors were calculated for each ROC [1] using RESRAD with the deterministic parameter set used to calculate soil DCGLs. The "Area of Contaminated Zone" parameter was varied from 1.0 m^2 to 100 m^2 as shown in Table 21. The need to apply AFs to contaminated areas greater than 100 m^2 is unlikely. The AFs are calculated by dividing the concentrations corresponding to 25 mrem/yr for each of the areas evaluated by the soil DCGLs in Table 4.

The RESRAD Summary Report file names for the RESRAD AF runs are listed in Attachment 2. The full RESRAD Summary Reports are provided electronically. The results are summarized in Table 21 and the corresponding area factors are provided in Table 22

Table 21 - RESRAD Results for Area Dependent pCi/g value corresponding to 25 mrem/yr

ROC	Concentration Corresponding to 25 mrem/yr (pCi/g)				
	1 m^2	2 m^2	5 m^2	10 m^2	100 m^2
Co-60	1.209E+02	7.128E+01	3.929E+01	2.609E+01	1.520E+01
Cs-137	5.294E+02	3.152E+02	1.749E+02	1.164E+02	6.873E+01
Sr-90	7.384E+04	4.387E+04	2.428E+04	1.615E+04	9.284E+03
Eu-152	2.646E+02	1.565E+02	8.642E+01	5.744E+01	3.358E+01
Eu-154	2.473E+02	1.460E+02	8.055E+01	5.351E+01	3.122E+01

Table 22 - Soil Area Factors

ROC	Area Factor (Unitless)				
	1 m^2	2 m^2	5 m^2	10 m^2	100 m^2
Co-60	9.44	5.56	3.07	2.04	1.19
Cs-137	9.11	5.42	3.01	2.00	1.18
Sr-90	11.21	6.66	3.69	2.45	1.41
Eu-152	9.30	5.50	3.04	2.02	1.18
Eu-154	9.38	5.54	3.06	2.03	1.18

6. Groundwater Exposure Factors

Groundwater Exposure Factors were calculated to address the possibility of low concentrations of groundwater contamination to present at the time of license termination. Groundwater Exposure Factors were calculated for the five ROCs identified in Reference [1]. H-3 was also included because H-3 has been identified in past groundwater samples. Because the industrial scenario does not include irrigation, the only exposure pathway from groundwater is drinking water from onsite well. The GW Exposure factors were therefore calculated directly using Ingestion Dose Conversion Factors from [10] and the assumed drinking water intake rate of 327 L/yr (see Attachment 1). The GW Exposure factors are provided in Table 23.

Table 23 - Groundwater Exposure Factors for a Water Concentration of 1 pCi/L

ROC	FGR 11 Dose Conversion Factor (mrem/pCi)	Water Intake Rate (L/yr)	GW Exposure Factor (mrem/yr per pCi/L)
Co-60	2.690E-05	327	8.80E-03
Cs-137	5.000E-05	327	1.64E-02
Sr-90	1.420E-04	327	4.64E-02
H-3	6.400E-08	327	2.09E-05
Eu-152	6.480E-06	327	2.12E-03
Eu-154	9.550E-06	327	3.12E-03

7. Buried Piping Dose Assessment and DCGL

Buried piping is defined as below ground pipe located outside of structures and basements. This section describes the buried pipe dose assessment methods and provides the resulting DCGLs for the initial suite radionuclides.

With the exception of a portion of the Circulating Water System Pipe, none of the buried piping to remain at LACBWR was associated with contaminated systems and therefore contamination potential is minimal. Table 24 provides the list of buried pipe planned to remain following license termination. The High Pressure Service Water from LACBWR Crib House to G-3 and Well water piping for Well #3 are considered non-impacted because they only contacted clean river water or groundwater with no potential for contamination.

7.1. Exposure Scenario and Critical Group

The dose assessment approach was generally consistent with the guidance for buried material in NUREG-1757, Appendix J in that two exposure scenarios were considered; 1) inadvertent intrusion due to construction of a structure with a basement which results in the buried pipe being excavated and spread across the surface (Excavation scenario), and 2) assuming buried pipe remains *in situ* (Insitu scenario).

NUREG-1757, Appendix J states that it should be appropriate to use the arithmetic average of the radionuclide concentration in the analysis, including any interspersing clean soil. The buried piping at LACBWR is a minimum of 1 m below grade. The LACBWR excavation scenario is more conservative than recommended in NUREG-1757 in that no mixing is assumed to occur between the residual radioactivity in the buried pipe and interspersing clean soil during excavation.

Table 24 - Buried Pipe to Remain in LACBWR End State

Description of Piping	Quantity	Pipe Elevation (Bottom)
Remaining portion of Circulating Water Discharge Pipe[1]	525’ of 60” steel pipe	630.5′
Deicing Line	105' of 18"	630.5′
South Storm Drain	630' of 48" 100' of 10"	625.0′ 635.0′
North Storm Drain	435' of 24' 250' of 32"	632 .0′ 626.0′
Remaining Portion of High Pressure Service Water Supply to LACBWR Fire Suppression System	863' of 6"	632.75
Remaining Portion of Low Pressure Service Water Pipe	44' of 16"	632.0
Remaining portion of Circulating Water Intake Pipe	40' of 60"	630.5′
High Pressure Service Water from LACBWR Crib House to G-3[2]	40′ of 6", 222′ of 8"	627′
Well Water piping for Well #3[2]	438′ of 3", 115′ of 2", 285′ of 1.5"	well water #3 pipe installed vertically to depth of 129′

Note 1: CW Discharge drops 10’ to 620.5’ at the outfall.
Note 2: G-3 service water supply pipe and well water supply pipe considered non-impacted. No FSS will be performed.

The conceptual models for the buried pipe Insitu and Excavation scenarios are similar to those developed for the BFM. In both the Insitu and Excavation scenarios the residual radioactivity on the internal surfaces of the pipe is assumed to instantaneously release and mix with a layer of soil in an area equal to the internal surface area of the pipe. The Insitu scenario model assumes that the released radioactivity is a below ground 2.54 cm layer of soil with no credit taken for the presence of the pipe to reduce environmental transport and migration. This is a conservative assumption, particularly for the Circulating Water Discharge Pipe which will be filled with a flowable fill material.

The Excavation scenario model assumes that the released radioactivity is mixed in a 15 cm layer of soil on the ground surface after excavation with no cover. Assuming a 15 cm layer is considered the minimum plausible mixing depth given the large scale industrial process required to excavate the pipe. The Industrial Worker is exposed to the Insitu and Excavated soil via the same pathways applicable to the BFM and soil DCGL models.

7.2. Buried Piping Dose Assessment

Dose assessments were performed to calculate DSRs which are the basis for determining DCGLs for the internal surfaces of the pipes after converting units to dpm/100 cm^2.

The buried piping was separated into two categories. The first category included the summation and grouping of all impacted buried pipe other than the Circulating Water Discharge piping and is designated as the "Group". The second category consisted of the Circulating Water Discharge piping only. The separation of the Circulating water piping was necessary because the geometry was significantly different from the other piping and the pipes are in distinctly different areas of the site.

The Insitu dose calculation for the buried piping "Group" (which as stated above does not include the Circulating Water Discharge pipe) was performed by RESRAD modeling using the RESRAD parameters applied to the BFM Insitu Groundwater scenario with adjustments to the source term geometry. The lowest elevation at the bottom of the Group piping is 625′ (excluding water well #3 piping which is considered non-impacted). Using the lowest elevation maximizes the Insitu dose, which is driven by the groundwater pathway, by minimizing the distance to the water table. The RESRAD parameters "Area of Contaminated Zone" and "Length Parallel to Flow" were calculated assuming that the all of the pipe in the Group was located in one circular area equal in size to the summed internal surface area of all Group pipes. The RESRAD parameters applied were the same as listed for the BFM Groundwater Insitu model with the exception of the source term parameters listed in

Table 25. The internal surface area of the High Pressure Service Water from LACBWR Crib House to G-3 Well and water piping for Well #3 are conservatively included in the calculation of total area for the Group piping notwithstanding their classification as non-impacted (i.e., no FSS to be performed).

The Insitu dose for the Circulating Water Discharge pipe was also calculated using the BFM Insitu Groundwater parameters with the elevation of the thin contaminated layer being set at the elevation of the bottom of the piping (630.5 foot). The Circulating Water Discharge pipe drops 10′ to 620.5′ elevation at the outfall but this 10-foot length is trivial compared to the total 525′ length at 630.5′ elevation. In addition, it is not plausible to locate a well between the location where the pipe drops and the outfall. The contaminated area was set equal to the internal surface area of the pipe.

The dose from the Excavation scenarios (and corresponding DCGLs) for both the Buried Pipe Group and the Circulating Water Discharge pipe were calculated using the RESRAD parameters applied to calculate surface soil DCGLs with source term adjustments as listed in

Table 25.

Table 25 - RESRAD Source Term Parameters for Buried Piping DCGL Calculations

Parameter	Buried Pipe Group Insitu	Buried Pipe Group Excavation	Circulating Water Discharge Pipe Insitu	Circulating Water Discharge Pipe Excavation
Cover Depth (m)	3.02	0	2.59	0
Area of Contaminated Zone (m^2)	1552.70	1552.70	766.14	766.14
Thickness of Contaminated zone (m)	0.0254	0.15	0.0254	0.15
Length Parallel to Aquifer Flow (m)	44.46	44.46	160.02	160.02
Unsaturated Zone Thickness (m)	0	2.90	0.43	2.90
Depth of Soil Mixing Layer (m)	0.15	0.15	0.15	0.15

7.3. RESRAD Results and Buried Piping DCGLs for Initial Suite

The RESRAD Summary Report file names for the RESRAD Buried Piping runs are listed in Attachment 2. The full RESRAD Summary Reports are provided electronically. The buried pipe DCGLs are provided in Table 26.

The calculation of the buried pipe DCGLs, including RESRAD source term parameter calculations, the DSRs generated by the RESRAD model, insignificant contributor dose adjustment, and all unit conversions are provided in Attachment 10.

Table 26 - Buried Piping DCGLs

Radionuclide	Buried Pipe Group Insitu (dpm/100 cm^2)	Buried Pipe Group Excavation (dpm/100 cm^2)	Circulating Water Discharge Pipe Insitu (dpm/100 cm^2)	Circulating Water Discharge Pipe Excavation (dpm/100 cm^2)
H-3	4.59E+08	9.65E+08	1.61E+08	1.34E+09
C-14	4.65E+07	4.81E+09	2.60E+07	4.81E+09
Fe-55	1.27E+09	5.98E+10	2.03E+26	7.81E+10
Ni-59	1.15E+10	1.52E+11	2.03E+26	1.99E+11
Co-60	6.37E+06	8.44E+04	2.51E+08	8.62E+04
Ni-63	4.61E+09	5.56E+10	1.11E+11	7.26E+10
Sr-90	5.81E+05	4.03E+07	8.55E+05	4.29E+07
Nb-94	1.02E+08	1.27E+05	1.02E+08	1.29E+05
Tc-99	2.00E+07	2.41E+07	6.50E+06	3.43E+07
Cs-137	1.82E+07	3.60E+05	6.53E+08	3.67E+05
Eu-152	2.71E+08	1.82E+05	5.08E+14	1.86E+05
Eu-154	1.87E+08	1.70E+05	9.89E+17	1.73E+05
Eu-155	1.20E+09	6.62E+06	2.03E+26	6.71E+06
Np-237	6.52E+03	1.52E+04	4.34E+03	2.09E+04
Pu-238	9.79E+05	9.79E+06	6.82E+07	1.27E+07
Pu-239	8.06E+05	8.81E+06	8.15E+05	1.14E+07
Pu-240	8.10E+05	8.82E+06	8.57E+05	1.14E+07
Pu-241	4.56E+07	3.58E+08	2.45E+08	4.37E+08
Am-241	1.62E+06	6.46E+06	8.88E+06	7.84E+06
Am-243	1.51E+06	1.11E+06	1.90E+06	1.16E+06
Cm-243	6.41E+06	1.71E+06	6.78E+08	1.79E+06
Cm-244	8.02E+06	1.57E+07	3.11E+08	2.04E+07

7.4. Buried Pipe Radionuclides of Concern and Adjusted DCGLs

The Buried Pipe DCGLs in Table 26 were used in Reference [1] to: calculate the relative dose contributions from the initial suite radionuclides, identify the insignificant dose contributors, select the final ROCs, and adjust the ROCs for the dose fraction attributable to the removed insignificant contributors. To date, no characterization has been performed in buried piping due to the very low contamination potential and lack of access. The dose percentages for the initial suite radionuclides were calculated using the summed DCGLs, which include the Insitu and Excavation scenarios, using the 75th percentile mixture for “Soil” from Table 1.

The IC dose percentage was 0.5% of the 25 mrem/yr dose limit for both the Group and Circulating Water Discharge Pipe. However, consistent with the approach used for concrete and soil, the IC dose adjustment was made using a value of 10% to provide additional margin. Table 27 provides the Buried Pipe DCGLs for the ROC adjusted for IC dose.

Table 27 - Buried Pipe DCGLs for ROCs Adjusted for IC Dose

Radionuclide	Buried Pipe Group Insitu (dpm/100 cm^2)	Buried Pipe Group Excavation (dpm/100 cm^2)	Circulating Water Discharge Pipe Insitu (dpm/100 cm^2)	Circulating Water Discharge Pipe Excavation (dpm/100 cm^2)
Co-60	5.73E+06	7.60E+04	2.26E+08	7.76E+04
Sr-90	5.23E+05	3.63E+07	7.70E+05	3.86E+07
Cs-137	1.64E+07	3.24E+05	5.88E+08	3.30E+05
Eu-152	2.44E+08	1.64E+05	4.57E+14	1.67E+05
Eu-154	1.68E+08	1.53E+05	8.90E+17	1.56E+05

The final DCGLs to be used during FSS account for the fact that the dose from the Insitu and Excavation scenarios must be summed in the conceptual model for buried pipe dose assessment since the Insitu and Excavation scenarios may occur concurrently to some extent. The summed Buried Pipe DCGLs are provided in Table 28.

Table 28 - Summed Buried Pipe DCGLs for ROC Adjusted for IC Dose

Radionuclide	Buried Pipe Group (dpm/100 cm^2)	Circulating Water Discharge Pipe (dpm/100 cm^2)
Co-60	7.50E+04	7.75E+04
Sr-90	5.16E+05	7.55E+05
Cs-137	3.18E+05	3.30E+05
Eu-152	1.64E+05	1.67E+05
Eu-154	1.52E+05	1.56E+05

8. Concentrations in Excavated Fill Material

A final check calculation was performed to determine the maximum hypothetical concentrations of each ROC in fill material after excavation. The calculation was performed for each ROC separately. Each ROC was assumed to be present in basement concrete at their respective $DCGL_B$ values. 100% of the residual radioactivity in the concrete was assumed to instantly release and uniformly mix with fill.

Consistent with the discussion in section 3.2 regarding the excavation of concrete, the concentrations in the fill are calculated for two excavation and mixing scenarios; 1) full excavation of fill and mixing of all activity in concrete (100% release) with all of the fill in the basement, and 2) partial excavation of fill and mixing of the activity in concrete (100% release) with the fill adjacent to the concrete that is excavated. The concentration in fill subject to partial excavation is calculated assuming that the minimum mixing volume is 1 m^3 based on a typical fill excavation process which entails using a 1.0 to 1.5 cubic yard bucket (see discussion in section 3.2). The partial excavation fill concentration is calculated assuming that all of the activity in a 1 m^2 concrete surface area is captured and mixed in a single 1 m^3 bucket load (1 m distance from a 1 m^2 surface). To ensure conservatism, several worst-case bucket loads are assumed to be stockpiled together such that area over which the excavated fill is spread results in a soil AF of 1. A single bucket load would have an AF >1.

The fill concentrations from the two excavation scenarios are compared to the soil DCGLs. All maximum fill concentrations were less than their respective soil DCGLs. Therefore, if all activity in basement surfaces is instantly released, mixed with the fill, and excavated, the dose will be less than the dose assigned to the basement concrete.

The calculation inputs and results are provided in Attachment 11. The fill concentrations for the Full and Partial excavation assumptions are provided in Table 29. The partial mix fill concentration for the WGTV are slightly less than the full mix concentrations. This is due to the relatively small size of the WGTV and the presence of a center wall and concrete tank support structures which result in a slightly greater ratio of surface area to fill volume for full mix as compared to the 1/1 ratio assumed for partial mix.

Table 29 – Maximum Fill Concentration for Full and Partial Mix

Radionuclide	Soil DCGL (pCi/g)	Reactor Building		WGTV	
		Full Mix (pCi/g)	Partial Mix (pCi/g)	Full Mix (pCi/g)	Partial Mix (pCi/g)
Co-60	10.6	1.15E+00	3.33E+00	3.31E+00	3.25E+00
Sr-90	54.73	3.23E+00	9.37E+00	5.18E+00	5.08E+00
Cs-137	48.3	4.83E+00	1.40E+01	1.42E+01	1.39E+01
Eu-152	23.6	2.65E+00	7.69E+00	7.83E+00	7.69E+00
Eu-154	21.9	2.45E+00	7.11E+00	7.25E+00	7.12E+00

9. Alternate Land Use Scenario Dose

Two alternate "less likely but plausible" land use scenarios were considered, Resident Gardener with onsite well and Recreational Use with onsite well. In accordance with NUREG-1757, the less likely but plausible scenarios were not analyzed for compliance, but were used to risk-inform the decision. NUREG-1757 states that if the peak dose from a less likely put plausible scenario is "significant" then greater assurance that the scenario is unlikely would be necessary.

A quantitative evaluation of the dose from the Recreational Use scenario was not required. A simple qualitative evaluation concluded that the dose than the Recreational Use scenario will be less than the dose from the Industrial Use scenario because the occupancy time and well water intake rate would be less.

A dose assessment of the Resident Gardener (with onsite well) scenario was performed. The assessment was performed for soil, for the *in situ* geometry of two backfilled basements to remain (Reactor Building and WGTV), and for the excavation concrete (and fill) from the basements. The doses were calculated assuming that a resident gardener could not plausibly occupy the LACBWR site until after the G-3 plant ceased operation and was decommissioned which was conservatively assumed to be 30 years after license termination.

The full initial suite of radionuclides was evaluated to determine the dose from insignificant contributor (IC) radionuclides specifically for the Resident Gardener scenarios. The Resident Gardener dose was calculated using the ROC (which are the same as selected for the Industrial Use scenario), after adjusting the ROC for the Resident Gardener – specific IC dose. The dose was calculated using worst-case ROC source terms as described in sections 9.1 through 9.3.

9.1. Resident Gardener Dose: Soil

The RESRAD assessment of Resident Gardener dose from soil applied the Industrial Use deterministic parameters with nine parameter changes or additions as listed in Table 30. The contaminated zone thickness was changed to 0.15 m to more closely represent actual site conditions as opposed to the 1 m depth assumed in the screening approach used in the Industrial Use scenario. The remaining parameter changes in Table 30 are metabolic and behavioral. The reference or basis for the selected parameters are also listed in Table 30.

Table 30 –Additions/Revisions to Industrial Use Parameters Required for Resident Gardener Scenario

Parameter	Value	Basis
Contaminated Zone Thickness	0.15 m	Standard surface soil contamination depth assumption and consistent with expected site conditions
Inhalation Rate	8400 m^3/yr	NUREG/CR-5512, Vol. 3 Table 6.29 (23 m^3/d x 365 d)
Fraction of Time Spent Indoors	0.649	NUREG/CR-5512, Vol. 3 Table 6.87
Fraction of Time Spent Outdoors	0.124	NUREG/CR-5512, Vol. 3 Table 6.87 (outdoors + gardening)
Fruit, Vegetable and Grain Consumption	112 kg/yr	NUREG/CR-5512, Vol. 3 Table 6.87 (other vegetables + fruits + grain)
Leafy vegetable Consumption	21.4 Kg/yr	NUREG/CR-5512, Vol. 3 Table 6.87
Drinking Water Intake	478 L/yr	NUREG/CR-5512, Vol. 3 Table 6.87
Well Pumping Rate	530 m^3/yr	NUREG/CR-6697, Att. C Section 3.10 method assuming 7500 m^2 land area and Wisconsin irrigation rate.
Plant Food Contaminated Fraction	1	All plant food assumed to be grown onsite

An uncertainty analysis was performed specifically for the soil Resident Gardener Scenario including all radionuclides in the initial suite. The process outlined in Figure 1 was used to perform the uncertainty analysis and to select deterministic parameters for each radionuclide in the initial suite. Attachment 12 lists the deterministic parameters and parameter distribution functions (PDF) used for the uncertainty analysis.

A separate uncertainty analysis was performed for each radionuclide, ignoring the effect of radionuclide mixture fractions. This conservatively ensures that all sensitive parameters are identified for low abundance radionuclides regardless of actual impact on total dose given the mixture. The results of the uncertainty analyses are provided in Table 31 and Table 32.

The RESRAD Uncertainty Report file names for the soil Resident Gardener scenario are listed in Attachment 2. The RESRAD Uncertainty Reports are provided electronically.

Table 31 – Soil Alternate Scenario Resident Gardener Uncertainty Analysis Results and Deterministic Values Selected for Non-Nuclide Specific Parameter Distributions

Parameter	Correlation to Dose[1]	Radionuclide	Basis of Deterministic Parameter Selection	Selected Deterministic Value
Contaminated zone erosion rate	Negative	Ni-59, Ni-63, Pu-241	25th	7.6E-04
Contaminated zone b parameter	NS	NA	median	0.97
Evapotranspiration coefficient	Positive	Tc-99	75th	0.69
Wind Speed	Negative	C-14	25th	3.6
Runoff coefficient	Positive	H-3, Tc-99	75th	0.62
Well pump intake depth	NS	NA	mode	21.2
b Parameter of Unsaturated zone	NS	NA	median	0.97
Mass loading for inhalation	NS	NA	median	2.35E-05
Indoor dust filtration factor	NS	NA	median	0.55
External gamma shielding factor	Positive	Co-60, Nb-94, Cs-137, Eu-152, Eu-154, Eu-155, Am-243, Cm-243	75th	0.4
Depth of Soil Mixing Layer	Negative	Fe-55, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Cm-243, Cm-244	25th	0.15
Depth of roots	Negative	H-3, Fe-55, Ni-59, Ni-63, Sr-90, Tc-99, Cs-137, Np-237, Pu-238, Pu-239.Pu-240, Pu-241, Am-241, Am-243, Cm-243, Cm-244	25th	1.22
Wet weight crop yield of fruit, grain, and non-leafy vegetables	NS	NA	median	1.75
Weathering removal constant for all vegetation	NS	NA	median	33
Wet foliar interceptions fraction of leafy vegetables	NS	NA	median	0.58

(3) NS = Not Sensitive

Table 32 – Soil Alternate Scenario Resident Gardener Uncertainty Analysis Results for Distribution Coefficients (K_d) andDeterministic Values Selected

Radionuclide	Kd in Contaminated Zone, Unsaturated Zone and Saturated Zone (cm^3/mg)	
H-3	NS	0.06
C-14	NS	5
Fe-55	NS	220
Ni-59	NS	400
Co-60	NS	60
Ni-63	NS	400
Sr-90	NS	15
Nb-94	NS	160
Tc-99	NS	0.1
Cs-137	NS	280
Eu-152[1]	NS	825
Eu-154[1]	NS	825
Eu-155[1]	NS	825
Np-237	NS	5
Pu-238	NS	550
Pu-239/240	NS	550
Pu-241	NS	550
Am-241	NS	1900
Am-243	NS	1900
Cm-243/244	NS	4000

Note 1: Sand Kds not listed in NUREG-6607 Table 3.9-2 for Europium.
The mean value from NUREG-6697, Table 3.9-1 was used.

Resident Gardener "Alternate Scenario DCGLs" for soil (pCi/g per 25 mrem/yr) were calculated for each initial suite radionuclide using the deterministic parameters in Attachment 13, with the PDFs replaced by the deterministic values from Table 31 and Table 32. RESRAD default deterministic Plant Transfer Factors were used for the uncertainty analysis. However, the Plant Transfer Factors are expected to be positively correlated for most, if not all radionuclides. The Plant Transfer Factors for all initial suite radionuclides were therefore conservatively assigned the 75th percentile of the NUREG-6697 distribution.

The IC dose was determined specifically for the soil Resident Gardener scenario. The 75th percentile probabilistic radionuclide mixture in Table 1 was used in the analysis. The calculation inputs and calculation results are provided in Attachment 12. The ROC were adjusted to account for the Resident Gardener-specific soil IC dose which was 0.31% of the 25 mrem/yr limit.

Two soil source terms were used to calculate the dose from the Resident Gardener scenario. The first source term is comprised of the maximum ROC soil concentrations identified during characterization. The second source term is comprised of the ROC soil concentrations corresponding to 25 mrem/yr in the Industrial Use Scenario based on the IC adjusted Industrial Use soil DCGLs (Table 5), the 75th percentile radionuclide mixture (Table 1), and the unity rule.

The RESRAD Summary Report file names for the Resident Gardener soil dose calculations for each of the two source terms are listed in Attachment 2. The full reports are provided electronically. The calculation inputs and results are provided in Attachment 13.

The dose from the Resident Gardener alternate scenario, after 30-year decay, using the maximum soil concentrations identified during characterization is 1.13 mrem/yr.

The dose from the Resident Gardener alternate scenario, after 30-year decay, using the hypothetical maximum soil concentrations that could remain under the Industrial Use Scenario is 27.07 mrem/yr. The Soil DCGLs reported in Table 5 (section 2.3) were adjusted to ensure that the Alternate Scenario soil dose does not exceed 25 mrem/yr.

9.2. Resident Gardener Dose: Reactor Building and WGTV

The Resident Gardener dose was also calculated using the backfilled Reactor Building and WGTV basement concrete as the source terms. As for soil, the Resident Gardener scenario is assumed to occur after 30 years. The dose assessment includes the three BFM dose scenarios, Insitu Groundwater, Insitu Drilling Spoils, and Excavation.

9.2.1. Resident Gardener Dose: Basement Insitu Groundwater

This section provides the Resident Gardener dose from the basement Insitu Groundwater scenario and maximum hypothetical radionuclide concentrations.

An uncertainty analysis was performed specifically for the Reactor Building and WGTV as source terms using the Resident Gardener Scenario parameter set. All radionuclides in the initial suite were included. The uncertainty analysis process outlined in Figure 1 was followed.

Attachment 12 provides the deterministic parameters and PDFs used for the uncertainty analysis. Certain parameters, as listed below, relate to the geometry of each basement. These were changed to the deterministic values listed in Table 7. The affected RESRAD geometry parameters are:

- cover depth,
- area of contaminated zone,
- thickness of contaminated zone,
- length parallel to aquifer flow, unsaturated zone thickness, and
- contaminated fraction below the water table.

A separate uncertainty analysis was performed for each initial suite radionuclide, ignoring the effect of radionuclide mixture fractions. This conservatively ensures that all sensitive parameters are identified for low abundance radionuclides regardless of actual impact on total dose given the mixture.

The RESRAD Uncertainty Report file names for the Reactor Building and WGTV Resident Gardener scenario are listed in Attachment 2. The RESRAD Uncertainty Reports are provided electronically. The results of the uncertainty analyses are provided in Table 33 and Table 34.

The Kds were negatively correlated for all but two radionuclides, Tc-99 and Nb-94. The absolute values of the PRCC were less than the 0.25 threshold for a number of radionuclides. However, A cross-check with the SRRC in the uncertainty analysis report indicates that the correlation may be more significant than indicated by the PRCC. A sensitivity analysis was performed using the 25th percentile Kds and the median Kds for the radionuclides with PRCC < |0.25|. The 25th percentile Kds resulted in higher dose for the negatively correlated radionuclides and were therefore assigned to all

negatively correlated radionuclides. The cause of the positive correlation to the Tc-99 Kd was the effect on the plant dose, primarily the water independent pathway. The 75^{th} percentile Kd resulted in the highest dose and was assigned to Tc-99. The cause of the positive correlation to the Nb-94 Kd was found to be direct dose from the water independent pathway after long term cover erosion. The maximum Nb-94 dose occurs when the 75^{th} percentile Kd is applied but the time of maximum dose is year 312. This result is due to the unique decay characteristics of Nb-94 which include gamma emission with a very long half-life. Although the maximum dose from Nb-94 occurs at year 312, the 75^{th} percentile Kd was applied.

Resident Gardener "Alternate Scenario Basement Groundwater DCGLs" (pCi/g per 25 mrem/yr) were calculated for each initial suite radionuclide using the deterministic parameters in Attachment 12, with the PDFs replaced by the deterministic values from Tables 33 and 34 and the basement geometry parameters replaced with the values in Table 7. The RESRAD default deterministic Plant Transfer Factors were used for the uncertainty analysis. However, the Plant Transfer Factors are expected to be positively correlated for most, if not all radionuclides. The Plant Transfer Factors for all initial suite radionuclides were therefore conservatively assigned the 75^{th} percentile of the NUREG-6697 PDF.

The RESRAD Summary report file names for the calculation of the Reactor Building and WGTV DCGLs and DSRs for the alternate scenario are listed in Attachment 2. The full reports are provided electronically.

Table 33 – BFM Insitu$_{gw}$ Alternate Scenario Resident Gardener Uncertainty Analysis Results and Deterministic Values Selected for Non-Nuclide Specific Parameter Distributions

Parameter	Correlation to Dose[1]	Radionuclide		Basis of Deterministic Parameter Selection	Selected Deterministic Value
		Rx Building	WGTV		
Cover erosion rate	Positive	Ni-59, Nb-94, Pu-241, Pu-239, Am-241	Ni-59, Ni-63, Nb-94. Pu-239, Pu-241, Am-241	75th	2.9E-03
Contaminated zone b parameter	NS			median	0.97
Contaminated Zone Erosion Rate	NS			median	0.00015
Evapotranspiration coefficient	Positive (Rx Building) NS (WGTV)	H-3		75th (Rx Building) Median (WGTV)	0.69 (Rx Building) 0.62 (WGTV)
Wind Speed	NS			median	3.6
Runoff coefficient	Positive (Rx Building) NS (WGTV)	H-3		75th (Rx Building) Median (WGTV)	0.62 (Rx Building) 0.45 (WGTV)
Well pump intake depth	Negative	H-3, C-14, Fe-55, Sr-90, Np-237, Pu-241, Pu-239,	H-3, C-14, Fe-55, Sr-90, Np-237, Pu-239,	Minimum Depth	6.1
b Parameter of Unsaturated zone	NS			median	0.97
Mass loading for inhalation	NS			median	2.35E-05
Indoor dust filtration factor	NS			median	0.55
External gamma shielding factor	NS			median	0.4
Depth of Soil Mixing Layer	NS			median	0.15
Depth of roots	Positive	C-14, Fe-55, Co-60, Ni-59, Ni-63, Sr-90, Tc-99, Cs-137, Eu-152, Eu-154, Eu-155, Np-237, Pu-241, Pu-239, Am-241	H-3, C-14, Fe-55, Ni-59, Co-60, Ni-63, Sr-90, Tc-99, Cs-137, Eu-152, Eu-154, Eu-155, Np-237, Pu-239, Pu-241, Am-241	75th	3.07
Wet weight crop yield of fruit, grain, and non-leafy vegetables	NS			median	1.75
Weathering removal constant for all vegetation	NS			median	33
Wet foliar interceptions fraction of leafy vegetables	NS			median	0.58

(1) NS = Not Sensitive

Table 34 – BFM Insitu$_{gw}$ Alternate Scenario Resident Gardener Uncertainty Analysis Results for Distribution Coefficients (K_d) and Deterministic Values Selected

Radionuclide	Rx Building Kd in Contaminated Zone and Saturated Zone (cm^3/mg)		WGTV Kd in Contaminated Zone and Saturated Zone (cm^3/mg)	
H-3	Negative[1]	0.05	Negative[1]	0.05
C-14	Negative	1.8	Negative	1.8
Fe-55	Negative	38	Negative	38
Ni-59	Negative	147	Negative	147
Co-60	Negative	9	Negative	9
Ni-63	Negative	147	Negative	147
Sr-90	Negative	5	Negative	5
Nb-94	Positive[1]	611	Negative	611
Tc-99	Positive	0.46	Positive[1]	0.46
Cs-137	Negative	50	Negative	50
Eu-152[2]	Negative	95	Negative	95
Eu-154[2]	Negative	95	Negative	95
Eu-155	Negative	95	Negative	95
Np-237	Negative	1	Negative	1
Pu-238	Negative	173	Negative	173
Pu-239/240	Negative	173	Negative	173
Pu-241	Negative	173	Negative	173
Am-241	Negative	329	Negative	329
Am-243	Negative	329	Negative	329
Cm-243/244	Negative	881	Negative	881

Note 1: 25th and 75th percentile values for sand from Reference 9 (see Attachment 3)
Note 2: Sand Kds not listed in NUREG-6697 Table 3.9-2 for Europium. The mean value from NUREG-6697, Table 3.9-1 was used.

The IC dose is calculated specifically for the Insitu Groundwater Reactor Building and WGTV using the "Alternate Scenario Groundwater DCGLs". The Resident Gardener scenario-specific IC dose calculations and inputs are provided in Attachment 13. The Resident Gardener-specific IC doses for the Reactor Building and WGTV are 7.0% and 14.1%, respectively, and the "Alternate Scenario Groundwater DCGLs" were adjusted using these values.

The Resident Gardener dose is calculated separately for the Reactor Building and WGTV using the "Alternate Scenario Groundwater DCGLs" for ROC (adjusted for the Resident Gardener-specific IC dose). The radionuclide concentrations used for the calculation were the maximum values in concrete that would be allowed to remain in each basement under the BFM Industrial Use scenario. The maximum concentrations are those corresponding to 25 mrem/yr using the BFM $DCGL_B$ values in

Table 20, the 75th percentile mixture in Table 1, and all ROC contributions using the unity rule. The inputs and calculation results of the maximum ROC concentrations used for the source term and the corresponding Resident Gardener dose are provided in Attachment 13.

The Resident Gardener Insitu Groundwater doses, after 30-year decay, for the Reactor Building and WGTV are 7.51 mrem/yr and 8.72 mrem/yr, respectively.

9.2.2. Resident Gardener Dose: Basement Drilling Spoils

This section provides the Resident Gardener dose from the Reactor Building and WGTV basements Insitu Drilling Spoils scenario.

The Resident Gardener dose from the drilling spoils scenario is calculated using the methods described in section 3.1.5 but replacing the Industrial Use soil DCGLs, and the 0.457 m^2 soil area factors, with corresponding Resident Gardener "Alternate Scenario Soil DCGLs" and area factors. The "Alternate Scenario Basement Drilling Spoils DCGLs" for the ROC were adjusted for IC dose using a conservative assumption that the IC dose percentage was 10% as was used for the BFM Drilling spoils adjustment. The actual IC dose is expected to be the same as that calculated for the Resident Gardener soil scenario (i.e., 0.35%). The radionuclide concentrations applied in the Insitu Drilling Spoils Resident Gardener dose assessment were the same maximum allowable ROC concentrations that were calculated in section 9.2.1.

The alternate scenario drilling spoils dose inputs and calculation results are provided in Attachment 13. The name of the RESRAD Summary report that provides the Resident Gardener soil areas factors for the 0.457 m^2 drilling spoils area is listed in Attachment 2. The Summary Report is provided electronically.

The Resident Gardener Insitu Drilling Spoils doses (after 30-year decay) for the Reactor Building and WGTV are 0.25 mrem/yr and 0.35 mrem/yr, respectively.

9.2.3. Resident Gardener Dose: Basement Concrete Excavation Scenario

This section provides the Resident Gardener dose from the Reactor Building and WGTV basement Excavation scenarios.

The BFM Industrial Use Excavation DCGLs are derived by limiting the concentrations in the excavated concrete to the concentrations of the Industrial Use soil DCGLs (see section 3.2). To calculate the Resident Gardener dose from excavated concrete, the BFM Excavation DCGLs are multiplied by the ratio of the Industrial Use Soil DSR to the Resident Gardener "Alternate Scenario Soil DSR". Note that the "Alternate Scenario Soil DSR" are adjusted for Resident Gardener – specific IC dose as discussed in section 9.1. The "Alternate Scenario Excavation DCGLs" are used to calculate the Resident Gardener dose from excavated basement concrete using the maximum concrete ROC concentrations calculated in section 9.2.1.

The alternate scenario concrete excavation dose calculations and the corresponding inputs are provided in Attachment 13.

The Resident Gardener Concrete Excavation dose (after 30-year decay) for the Reactor Building and WGTV are 20.7 mrem/yr and 25.9 mrem/yr, respectively.

9.2.4. Total Resident Gardener Alternate Scenario Dose: Reactor Building and WGTV

The total Resident Gardener doses from the Reactor Building and WGTV are calculated by summing the dose from the Insitu Groundwater, Insitu Drilling Spoils and Excavation scenarios. The Total

Resident Gardener doses from the Reactor Building and WGTV, assuming maximum allowable concentrations in the basement concrete (see section 9.1), are 28.4 mrem/yr and 34.9 mrem/yr, respectively. To ensure conservatism, the BFM $DCGL_{BS}$ and $DCGL_B$ values reported in Table 19 and

Table 20 (section 4.3) were adjusted to ensure that the Alternate Scenario dose does not exceed 25 mrem/yr.

The Total Resident Gardener alternate scenario dose calculations and inputs are provided in Attachment 13.

9.3. Resident Gardener Dose from Excavated Basement Fill

The Resident Gardener dose was also calculated using the maximum hypothetical fill concentrations in the Reactor Building and WGTV from Table 29. The doses from excavated fill (after 30-year decay) were 6.3 mrem/yr and 8.0 mrem/yr for the Reactor Building and WGTV, respectively.

The Resident Gardener Excavated Fill dose calculations and inputs are provided in Attachment 13.

9.4. Conclusion: Resident Gardener Alternate Scenario Dose

The Resident Gardener dose, after 30 years decay, was evaluated for soil and basements. The maximum soil dose is 27.07 mrem/yr. The maximum basement doses are 28.4 mrem/y r and 34.9 mrem/yr, for the Reactor Building and WGTV, respectively. These doses are not considered significant and therefore greater assurance that these scenarios will not occur is not necessary. However, adjustments were made to the soil and basement DCGLs to ensure that no Alternate Scenario dose exceeds 25 mrem/yr.

10. Summation DCGLs ($DCGL_B$) For Initial Suite Radionuclides for Insignificant Contributor Dose Evaluation

One of the evaluations in Reference [1] determines the insignificant contributor radionuclide dose for the BFM. To support this evaluation, the $DCGL_{BS}$ values in Table 12, Table 13, and Table 15 are summed to calculate a "$DCGL_B$" for the initial suite of radionuclides in each of two basements. The $DCGL_B$ values are provided in

Table 35.

Table 35 - Summed Basement DCGL ($DCGL_B$) for Initial Suite Radionuclides

Radionuclide	Rx Building $DCGL_B$ (pCi/m^2)	WGTV $DCGL_B$ (pCi/m^2)
H-3	6.54E+09	5.91E+09
C-14	8.03E+08	5.33E+08
Fe-55	3.35E+10	2.32E+10
Ni-59	3.17E+11	2.09E+11
Co-60	6.57E+06	6.42E+06
Ni-63	1.16E+11	8.49E+10
Sr-90	1.97E+07	1.18E+07
Nb-94	1.06E+07	1.05E+07
Tc-99	1.59E+08	1.50E+08
Cs-137	2.90E+07	2.82E+07
Eu-152	1.51E+07	1.51E+07
Eu-154	1.40E+07	1.39E+07
Eu-155	5.81E+08	5.77E+08
Np-237	1.86E+05	1.51E+05
Pu-238	2.44E+07	1.77E+07
Pu-239	2.20E+07	1.46E+07
Pu-240	2.20E+07	1.46E+07
Pu-241	1.11E+09	7.81E+08
Am-241	3.89E+07	2.75E+07
Am-243	2.94E+07	2.16E+07
Cm-243	7.89E+07	6.66E+07
Cm-244	1.79E+08	1.34E+08

11. **Conclusion**

This TSD documents the RESRAD modeling and calculations required for the dose assessment to determine the BFM DCGLs for backfilled concrete, Soil and Buried Pipe required in LTP Chapter 6 to demonstrate compliance with the 25 mrem/yr dose criteria.

The following RESRAD modeling was required to support the dose assessment:

- Uncertainty Analysis for Soil DCGL
- Uncertainty Analysis for Dose to Source Ratios (DSR) required to calculate BFM Insitu DFs
- Deterministic Calculation of Soil DCGLs
- Deterministic Calculation of BFM Insitu DSRs
- Deterministic Calculation of Soil AFs
- Deterministic Calculation of Groundwater Exposure Factors
- Uncertainty Analysis and Deterministic Calculations for Alternates Scenarios

The following calculations were performed to support the dose assessment:

- BFM Excavation DCGLs
- BFM $Insitu_{ds}$ DCGLs
- BFM $Insitu_{gw}$ DCGLs
- Buried Piping DCGLs
- Groundwater Exposure Factors
- Alternate Scenario Dose

12. References

[1] "EnergySolutions Technical Support Document (TSD) RS-TD-313196-001, "Radionuclides of Concern During LACBWR Decommissioning"".

[2] "U.S. Nuclear Regulatory Commission, NUREG-1757, Volume 2, Revision 1, "Consolidated Decommissioning Guidance - Characterization, Survey, and Determination of Radiological Criteria, Final Report" - September 2006".

[3] "Argonne National Laboratories, NUREG/CR-6697 "Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes" - December 2000".

[4] "Argonne National Laboratories, NUREG/CR-6676, "Probabilistic Dose Analysis Using Parameter Distributions Developed for RESRAD and RESRAD-BUILD Codes," July 2000".

[5] "Sandia National Laboratory, NUREG/CR-5512, Volume 3, "Residual Radioactive Contamination From Decommissioning Parameter Analysis" – October 1999".

[6] "Haley & Aldrich Inc., "Hydrogeological Investigation Report, La Crosse Boiling Water Reactor, Dairyland Power Cooperative, Genoa Wisconsin," File No. 38705-008, January 2015".

[7] "ZionSolutions Technical Support Document 14-006, Conestoga Rovers & Associates (CRA) Report, "Evaluation of Hydrological Parameters in Support of Dose Modeling for the Zion Restoration Project"".

[8] "Argonne National Laboratory, User's Manual for RESRAD Version 6", ANL/EAD-4, July 2001".

[9] "Sheppard and Thibault, Default Soil/Solid /Liquid Partition Coefficients, Kds, for Four Major Soil Types: A Compendium, Health Physics, Vol. 59 No 4, October 1990".

[10] K. F. Eckerman, A. B. Wolbarst and A. C. Richardson, "Federal Guidance Report No. 11; Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," Oak Ridge National Laboratory and Office of Radiation Programs, US EPA, Oak Ridge TN, and Washington DC, 1988.

13. **Attachments**

13.1. Attachment 1: RESRAD Input Parameters for Soil DCGL Uncertainty Analysis

13.2. Attachment 2: RESRAD Output Report File Names

13.3. Attachment 3: Sand Kd Distributions, 25th Percentile and 75th Percentile

13.4. Attachment 4: Fill Material Mixing Volume Sensitivity Analysis

13.5. Attachment 5: BFM $Insitu_{gw}$ RESRAD Uncertainty Analysis Input Parameters

13.6. Attachment 6: Calculation of BFM Insitu Groundwater DCGL Reactor Building

13.7. Attachment 7: Calculation of BFM Insitu Groundwater DCGL Waste Gas Tank Vault

13.8. Attachment 8: BFM Drilling Spoils DCGL Calculation

13.9. Attachment 9: BFM Excavation DF Calculation

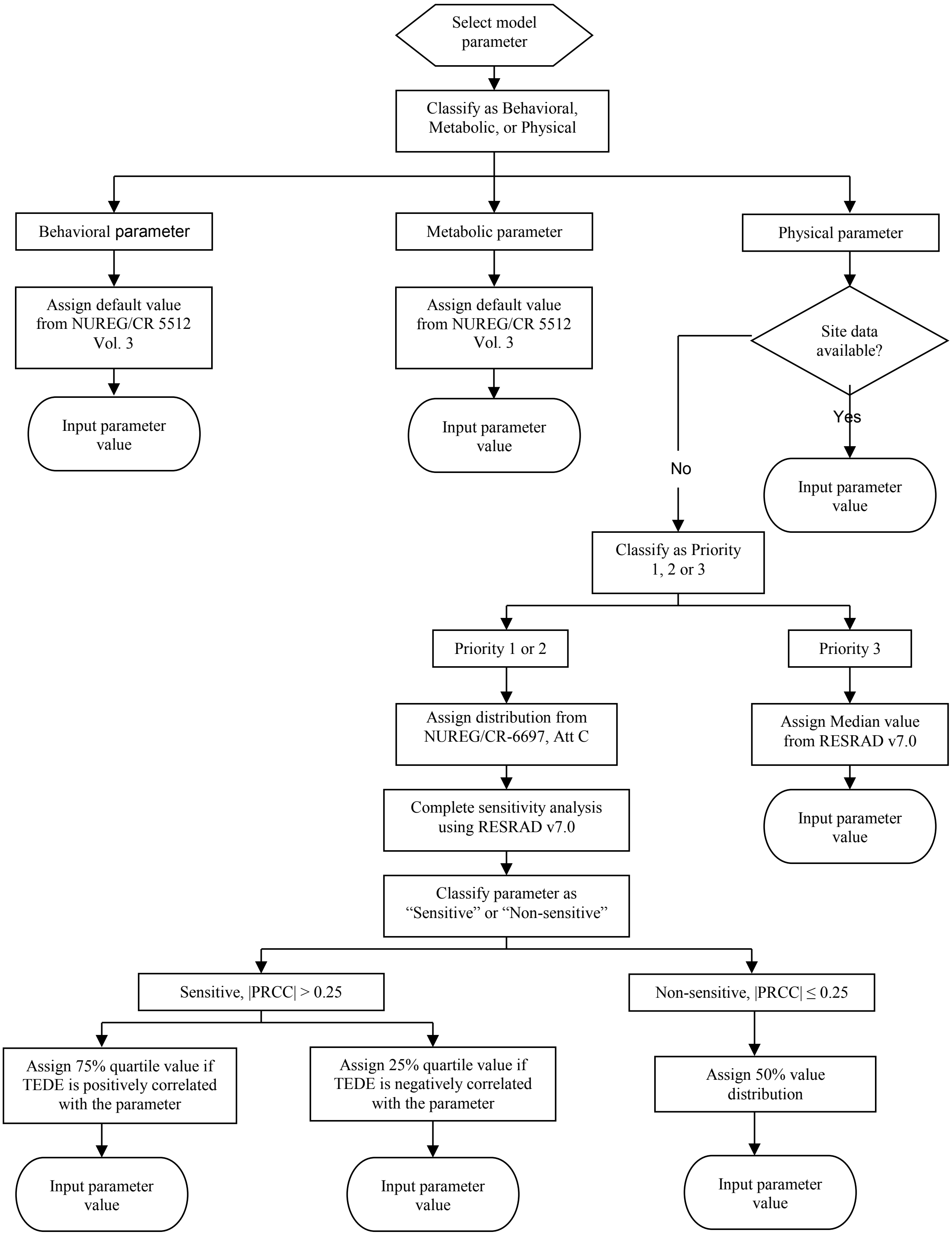
13.10. Attachment 10: Buried Pipe DCGL Calculation

13.11. Attachment 11: Check Calculation for Maximum Concentration in Fill Material

13.12. Attachment 12: Alternate Scenario Uncertainty Analysis Input Parameters

13.13. Attachment 13: Alternate Scenario Dose Calculation

Figure 1 – RESRAD Parameter Selection Process



Attachment 1
RESRAD Input Parameters for Soil DCGL Uncertainty Analysis

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Soil Concentrations										
Basic radiation dose limit (mrem/y)		3	D	25	10 CFR 20.1402	NR	NR	NR	NR	
Initial principal radionuclide (pCi/g)	P	2	D	1	Unit Value	NR	NR	NR	NR	
Distribution coefficients (contaminated, unsaturated, and saturated zones) (cm^3/g)										
Ac-227 (daughter of Cm-243 and Pu-239)	P	1	D	450	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	NA	NA	NA	NA	825
Am-241 (also daughter of Cm-245 and Pu-241)	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	7.28	3.15	NA	NA	1445
Am-243	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	7.28	3.15	NA	NA	1445
C-14	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	2.4	3.22	NA	NA	11
Cm-243	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	8.82	1.82	NA	NA	6761
Cm-244	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	8.82	1.82	NA	NA	6761
Co-60	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	5.46	2.53	NA	NA	235
Cs-137	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.1	2.33	NA	NA	446
Eu-152	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.72	3.22	NA	NA	825
Eu-154	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.72	3.22	NA	NA	825
Eu-155	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.72	3.22	NA	NA	825
Fe-155	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	5.34	2.67	NA	NA	209
Gd-152 (daughter for Eu-152)	P	1	D	825	Mean Value NUREG/CR-6697, Att. C (No sand value listed in Table 3.9-2)	NA	NA	NA	NA	825
H-3	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	-2.81	0.5	NA	NA	0.06
Nb-94	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	5.94	3.22	NA	NA	380
Nd-144 (daughter for Eu-152)	P	1	D	158	RESRADv.7.0 Default Nd not listed in NUREG/CR-6697	NA	NA	NA	NA	NA
Ni-59	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.05	1.46	NA	NA	424
Ni-63	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.05	1.46	NA	NA	424
Np-237 (also daughter for Am-241, Cm-245, and Pu-241)	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	NA	NA	NA	NA	NA

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Pa-231 (daughter for Cm-243 and Pu-239)	P	1	D	550	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	NA	NA	NA	NA	NA
Pb-210 (daughter for Pu-238)	P	1	D	270	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	NA	NA	NA	NA	NA
Po-210 (daughter Pu-238)	P	1	D	150	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	NA	NA	NA	NA	NA
Pu-238	P	1	S	Lognormal-N	< 0.1% of radionuclide mixture	6.86	1.89	NA	NA	953
Pu-239 (also daughter for Cm-243)	P	1	S	Lognormal-N	< 0.1% of radionuclide mixture	6.86	1.89	NA	NA	953
Pu-240 (also daughter for Cm-244)	P	1	S	Lognormal-N	< 0.1% of radionuclide mixture	6.86	1.89	NA	NA	953
Pu-241	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.86	1.89	NA	NA	953
Ra-226 (daughter Pu-238)	P	1	D	500	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	NA	NA	NA	NA	NA
Ra-228 (daughter Cm-244 and Pu-240)	P	1	D	500	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	NA	NA	NA	NA	NA
Sm-148 (daughter Eu-152)	P	1	D	245	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	NA	NA	NA	NA	825
Sr-90	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	3.45	2.12	NA	NA	32
Tc-99	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	-0.67	3.16	NA	NA	0.51
Th-228 (daughter Cm-244 and Pu-240)	P	1	D	3200	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	NA	NA	NA	NA	NA
Th-229 (daughter Am-241, Cm-245, Np-237, and Pu-241)	P	1	D	3200	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	NA	NA	NA	NA	5884

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	**Type[a]**	**Priority[b]**	**Treatment[c]**	**Value/Distribution**	**Basis**	**Distribution's Statistical Parameters[d]**				
						1	**2**	**3**	**4**	**Mean/ Median**
Th-230 (daughter Cm-246 and Pu-238)	P	1	D	3200	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	NA	NA	NA	NA	NA
Th-232 (daughter Cm-244 and Pu-240)	P	1	D	3200	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	NA	NA	NA	NA	NA
U-233 (daughter Am-241, Cm-245, Np-237, and Pu-241)	P	1	D	35	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault C	NA	NA	NA	NA	126
U-234 (daughter Pu-238)	P	1	D	35	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault C	NA	NA	NA	NA	NA
U-235 (daughter Cm-243 and Pu-239)	P	1	D	35	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault C	NA	NA	NA	NA	NA
U-236 (daughter Cm-244 and Pu-240)	P	1	D	35	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault C	NA	NA	NA	NA	NA
Initial concentration of radionuclides present in groundwater (pCi/l)	P	3	D	0	No existing groundwater contamination	NR	NR	NR	NR	
Calculation Times										
Time since placement of material (y)	P	3	D	0	Start of dose calculation immediately after license termination	NR	NR	NR	NR	
Time for calculations (y)	P	3	D	0, 1, 3, 10, 30, 100, 300, 1000	RESRAD Default	NR	NR	NR	NR	
Contaminated Zone										
Area of contaminated zone (m^2)	P	2	D	7500	Size of LACBWR "Licensed Site Exclusion" (LSE) area	NR	NR	NR	NR	
Thickness of contaminated zone (m)	P	2	D	1	Surface Soil contamination thickness not expected to exceed 1 m.	NR	NR	NR	NR	
Length parallel to aquifer flow (m)	P	2	D	98	Diameter of 7500 m2 contaminated zone	NR	NR	NR	NR	
Does the initial contamination penetrate the water table?	NA	NA	NA	No	Contaminated zone at surface	NA	NA	NA	NA	

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Contaminated fraction below water table	P	3	D	0	Contaminated zone at surface	NR	NR	NR	NR	
Cover and Contaminated Zone Hydrological Data										
Cover depth (m)	P	2	D	0	No cover	NR	NR	NR	NR	
Density of cover material	P	2	D	NA	No cover	NR	NR	NR	NR	
Cover erosion rate	P,B	2	D	NA	No cover	NR	NR	NR	NR	
Density of contaminated zone (g/cm^3)	P	1	D	1.76	Site-specific[e]	NR	NR	NR	NR	
Contaminated zone erosion rate m/y)	P,B	2	S	Continuous Logarithmic	NUREG/CR-6697 Att. C Table 3.8-1	5E-08	0.0007	0.005	0.2	0.0015
Contaminated zone total porosity	P	2	D	0.31	Site-specific[e]	NR	NR	NR	NR	
Contaminated zone field capacity	P	3	D	0.066	Calculated values for sand soil type[f]	NR	NR	NR	NR	
Contaminated zone hydraulic conductivity (m/y)	P	2	D	34822	Site specific[e] 313 feet/day = 34822 m/y	NR	NR	NR	NR	
Contaminated zone b parameter	P	2	S	Lognormal-N	Site specific soil type sand NUREG/CR-6697 Att. C Table 3.5-1	-.0253	0.216	NA	NA	0.97
Humidity in air (g/m^3)	P	3	D	7.2	Median NUREG/CR-6697 Att. C	1.98	0.334	0.001	0.999	7.2
Evapotranspiration coefficient	P	2	S	Uniform	NUREG/CR-6697 Att. C Figure 4.3-1	0.5	0.75	NR	NR	0.625
Average annual wind speed (m/s)	P	2	S	Bounded Lognormal - N	NUREG/CR-6697 Att. C Figure 4.5-1	1.445	0.2419	1.4	13	4.2
Precipitation (m/y)	P	2	D	0.78	NUREG/CR-6697 Att. C La Crosse, WI Table 4.1-2	NR	NR	NR	NR	
Irrigation (m/y)	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Irrigation mode	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Runoff coefficient	P	2	S	Uniform	NUREG/CR-6697 Att. C Figure 4.2-1	0.1	0.8	NR	NR	0.45
Watershed area for nearby stream or pond (m^2)	P	3	D	1.00E+06	RESRAD Default	NR	NR	NR	NR	
Accuracy for water/soil computations	-	3	D	1.00E-03	RESRAD Default	NR	NR	NR	NR	
Saturated Zone Hydrological Data										
Density of saturated zone (g/cm^3)	P	2	D	1.76	Site-specific[e]	NR	NR	NR	NR	

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	**Type[a]**	**Priority[b]**	**Treatment[c]**	**Value/Distribution**	**Basis**	**Distribution's Statistical Parameters[d]**				
						1	**2**	**3**	**4**	**Mean/ Median**
Saturated zone total porosity	P	1	D	0.31	Site-specific[e]	NR	NR	NR	NR	
Saturated zone effective porosity	P	1	D	0.28	Site-specific[e]	NR	NR	NR	NR	
Saturated zone field capacity	P	3	D	0.066	Calculated values for sand soil type[f]	NR	NR	NR	NR	
Saturated zone hydraulic conductivity (m/y)	P	1	D	34822	Site-specific value[e] 313 feet/day = 34822 m/y	NR	NR	NR	NR	
Saturated zone hydraulic gradient	P	2	D	0.0045	Site-specific[e]	NR	NR	NR	NR	
Saturated zone b parameter	P	2	S	Lognormal-N	Site specific soil type sand NUREG/CR-6697 Att. C Table 3.5-1	-.0253	0.216	NA	NA	0.97
Water table drop rate (m/y)	P	3	D	0	Assumed zero due to hydraulic connectivity with Mississippi river.	NR	NR	NR	NR	

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	**Type[a]**	**Priority[b]**	**Treatment[c]**	**Value/Distribution**	**Basis**	**Distribution's Statistical Parameters[d]**				
						1	**2**	**3**	**4**	**Mean/ Median**
Well pump intake depth (m below water table)	P	2	S	Triangular	Site-specific distribution Existing industrial water supply wells onsite at depth of 116' and 129' below ground surface (the 129' depth equals 36.3 m below the water table). 36.3 m assumed to be maximum well depth. Minimum well depth assumed to be represented by a nominal 20' screen depth (6.1 m) starting at the maximum "seasonal" water table elevation of 629' and extending to 10' below 619' elevation where water table continuously present. Mode is assumed to be mid-point between 6.1 m and 36.3 m which is 21.2 m. Note that the site-specific distribution is reasonably similar to the NUREG-6697 distribution values of 6, 10, and 30 for the triangular distribution.	6.1	21.2	36.3	NR	19.6
Model: Nondispersion (ND) or Mass-Balance (MB)	P	3	D	ND	Applicable to flowing groundwater	NR	NR	NR	NR	

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Well pumping rate (m^3/y)	P	2	S	Uniform	NUREG/CR-6697, Att. C provides no recommended value due to high variability. Industrial Scenario pump rate depends on industry. NUREG-6697, Table 3.10-1 applies a sanitary and potable water usage rate for four persons of 328.7 m^3/yr. This value is assumed to be the minimum industrial rate. Maximum industrial rate assumed to supply 20 workers which equates to1643.5 m^3/yr.	328.7	1643.5	NR	NR	986.1
Unsaturated Zone Hydrological Data										
Number of unsaturated zone strata	P	3	D	1	Site-specific[e]	NR	NR	NR	NR	
Unsat. zone thickness (m)	P	1	D	2.05 m	Site Specific[e] Calculated assuming ground surface 639' elevation, Contaminated Zone Thickness 1 m, and maximum water table elevation of 629'.	NR	NR	NR	NR	
Unsat. zone soil density (g/cm^3)	P	2	D	1.76	Site-specific[e]	NR	NR	NR	NR	
Unsat. zone total porosity	P	2	D	0.31	Site-specific[e]	NR	NR	NR	NR	
Unsat. zone effective porosity	P	2	D	0.28	Site-specific[e]	NR	NR	NR	NR	
Unsat. zone field capacity	P	3	D	0.066	Calculated values for sand soil type[f]	NR	NR	NR	NR	
Unsat. zone hydraulic conductivity (m/y)	P	2	D	34822	Site-specific[e]	NR	NR	NR	NR	
Unsat. zone soil-specific b parameter	P	2	S	Lognormal-N	Site specific soil type sand NUREG/CR-6697 Att. C Table 3.5-1	-.0253	0.216	NA	NA	0.97

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Occupancy										
Inhalation rate (m^3/y)	M,B	3	D	3066	NUREG-6697 Att. C, Table 7.6-1 recommends a median indoor work day as 8.76 hours/day. Assuming 5 days a week and 50 weeks per years this equates to 2190 hours per year. NUREG/CR-5512, Vol. 3, Section 5.3.4 recommends an inhalation rate for workers in light industry of 1.4 m^3/hr. Industrial Scenario m^3/yr = 1.4 m^3/hr * 2190 hr/yr = 3066 m^3/yr.	NR	NR	NR	NR	
Mass loading for inhalation (g/m^3)	P,B	2	S	Continuous Linear	NUREG/CR-6697, Att. C	See NUREG-6697 Table 4.6-1	See NUREG-6697 Table 4.6-1	See NUREG-6697 Table 4.6-1	See NUREG-6697 Table 4.6-1	2.35E-05
Exposure duration	B	3	D	30	RESRAD User's Manual parameter value not used in dose calculation	NR	NR	NR	NR	
Indoor dust filtration factor	P,B	2	S	Uniform	NUREG/CR-6697, Att. C Figure 7.1-1	0.15	0.95	NR	NR	0.55
Shielding factor, external gamma	P	2	S	Bounded Lognormal-N	NUREG/CR-6697, Att. C Table 7.10-1	-1.3	0.59	0.044	1	0.2725

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Fraction of time spent indoors	B	3	D	0.1875	NUREG-6697 Att. C, Table 7.6-1 recommends a median indoor work day as 8.76 hours/day. Assuming 5 days a week and 50 weeks per years this equates to 2190 hours per year. Majority of industrial work is expected to be indoors. Consistent with Table 2-3 of the “User’s Manual for RESRAD Version 6”[g] 75% of work time is indoors and 25% outdoors. The corresponding RESRAD indoor Fraction parameter = (2190*0.75)/(24*365) = 0.1875	NR	NR	NR	NR	
Fraction of time spent outdoors (on site)	B	3	D	0.0625	As explained in the basis for the Indoor Fraction parameter, the indoor time fraction was set at 75% and outdoor time fraction at 25%. (2190*0.25)/(24*365) = 0.0625	NR	NR	NR	NR	
Shape factor flag, external gamma	P	3	D	Circular	Circular contaminated zone assumed for modeling purposes	NR	NR	NR	NR	
Ingestion, Dietary										
Fruits, non-leafy vegetables, grain consumption (kg/y)	M,B	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Leafy vegetable consumption (kg/y)	M,B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Milk consumption (L/y)	M,B	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Meat and poultry consumption (kg/y)	M,B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Fish consumption (kg/y)	M,B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Other seafood consumption (kg/y)	M,B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Soil ingestion rate (g/y)	M,B	2	D	18.3	NUREG/CR-5512, Vol. 3 Table 6.87	NR	NR	NR	NR	
Drinking water intake (L/y)	M,B	2	D	327	NUREG/CR-5512, Vol. 3 Table 6.87 Industrial Scenario water supply assumed to be from an onsite well. 478 L/y from NUREG/CR-5512 corresponds to 1.31 L/d which is considered a conservative value for 8 hour work day. 1.31 L/d * 250 work days = 327 L/y	NR	NR	NR	NR	
Contamination fraction of drinking water	B,P	3	D	1	All water assumed contaminated	NR	NR	NR	NR	
Contamination fraction of household water (if used)	B,P	3		1	All water from well					
Contamination fraction of livestock water	B,P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Contamination fraction of irrigation water	B,P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Contamination fraction of aquatic food	B,P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Contamination fraction of plant food	B,P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Contamination fraction of meat	B,P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Contamination fraction of milk	B,P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ingestion, Non-Dietary										
Livestock fodder intake for meat (kg/day)	M	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Livestock fodder intake for milk (kg/day)	M	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Livestock water intake for meat (L/day)	M	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Livestock water intake for milk (L/day)	M	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Livestock soil intake (kg/day)	M	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Mass loading for foliar deposition (g/m^3)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Depth of soil mixing layer (m)	P	2	S	Triangular	NUREG/CR-6697, Att. C Figure 3.12-1	0	0.15	0.6	NR	0.15
Depth of roots (m)	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Drinking water fraction from ground water	B,P	3	D	1	Industrial Scenario	NR	NR	NR	NR	
Household water fraction from ground water (if used)	B,P	3		1	Industrial Scenario	NR	NR	NR	NR	
Livestock water fraction from ground water	B,P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Irrigation fraction from ground water	B,P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Wet weight crop yield for Non-Leafy (kg/m^2)	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Wet weight crop yield for Leafy (kg/m^2)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Wet weight crop yield for Fodder (kg/m^2)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Growing Season for Non-Leafy (y)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Growing Season for Leafy (y)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Growing Season for Fodder (y)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Translocation Factor for Non-Leafy	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Translocation Factor for Leafy	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Translocation Factor for Fodder	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Weathering Removal Constant for Vegetation (1/y)	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Wet Foliar Interception Fraction for Non-Leafy	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Wet Foliar Interception Fraction for Leafy	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Wet Foliar Interception Fraction for Fodder	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Dry Foliar Interception Fraction for Non-Leafy	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Dry Foliar Interception Fraction for Leafy	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Dry Foliar Interception Fraction for Fodder	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Storage times of contaminated foodstuffs (days):										
Fruits, non-leafy vegetables, and grain	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Leafy vegetables	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Milk	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Meat and poultry	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Fish	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Crustacea and mollusks	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Well water	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Surface water	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Livestock fodder	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Special Radionuclides (C-14)										
C-12 concentration in water (g/cm^3)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
C-12 concentration in contaminated soil (g/g)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Fraction of vegetation carbon from soil	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Fraction of vegetation carbon from air	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
C-14 evasion layer thickness in soil (m)	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
C-14 evasion flux rate from soil (1/sec)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
C-12 evasion flux rate from soil (1/sec)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Fraction of grain in beef cattle feed	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Fraction of grain in milk cow feed	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Dose Conversion Factors (Inhalation mrem/pCi)										
Ac-227	M	3	D	6.70E+00	FGR11	NR	NR	NR	NR	
Am-241	M	3	D	4.44E-01	FGR11	NR	NR	NR	NR	
Am-243	M	3	D	4.40E-01	FGR11	NR	NR	NR	NR	
C-14	M	3	D	2.09E-06	FGR11	NR	NR	NR	NR	
Cm-243	M	3	D	3.07E-01	FGR11	NR	NR	NR	NR	
Cm-244	M	3	D	2.48E-01	FGR11	NR	NR	NR	NR	
Cm-245	M	3	D	4.55E-01	FGR11	NR	NR	NR	NR	
Cm-246	M	3	D	4.51E-01	FGR11	NR	NR	NR	NR	
Co-60	M	3	D	2.19E-04	FGR11	NR	NR	NR	NR	

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Cs-134	M	3	D	4.62E-05	FGR11	NR	NR	NR	NR	
Cs-137	M	3	D	3.19E-05	FGR11	NR	NR	NR	NR	
Eu-152	M	3	D	2.21E-04	FGR11	NR	NR	NR	NR	
Eu-154	M	3	D	2.86E-04	FGR11	NR	NR	NR	NR	
Gd-152	M	3	D	2.43E-01	FGR11	NR	NR	NR	NR	
H-3	M	3	D	6.40E-08	FGR11	NR	NR	NR	NR	
I-129	M	3	D	1.74E-04	FGR11	NR	NR	NR	NR	
Nb-94	M	3	D	4.14E-04	FGR11	NR	NR	NR	NR	
Nd-144[e]	M	3	D	7.04E-02	ICRP60	NR	NR	NR	NR	
Ni-59	M	3	D	2.70E-06	FGR11	NR	NR	NR	NR	
Ni-63	M	3	D	6.29E-06	FGR11	NR	NR	NR	NR	
Np-237	M	3	D	5.40E-01	FGR11	NR	NR	NR	NR	
Pa-231	M	3	D	1.28E+00	FGR11	NR	NR	NR	NR	
Pb-210	M	3	D	1.36E-02	FGR11	NR	NR	NR	NR	
Po-210	M	3	D	9.40E-03	FGR11	NR	NR	NR	NR	
Pu-238	M	3	D	3.92E-01	FGR11	NR	NR	NR	NR	
Pu-239	M	3	D	4.29E-01	FGR11	NR	NR	NR	NR	
Pu-240	M	3	D	4.29E-01	FGR11	NR	NR	NR	NR	
Pu-241	M	3	D	8.25E-03	FGR11	NR	NR	NR	NR	
Pu-242	M	3	D	4.11E-01	FGR11	NR	NR	NR	NR	
Ra-226	M	3	D	8.58E-03	FGR11	NR	NR	NR	NR	
Ra-228	M	3	D	4.77E-03	FGR11	NR	NR	NR	NR	
Sm-148[e]	M	3	D	7.34E-02	ICRP60	NR	NR	NR	NR	
Sr-90	M	3	D	1.30E-03	FGR11	NR	NR	NR	NR	
Tc-99	M	3	D	8.32E-06	FGR11	NR	NR	NR	NR	
Th-228	M	3	D	3.42E-01	FGR11	NR	NR	NR	NR	
Th-229	M	3	D	2.15E+00	FGR11	NR	NR	NR	NR	
Th-230	M	3	D	3.26E-01	FGR11	NR	NR	NR	NR	
Th232	M	3	D	1.64e+00	FGR11	NR	NR	NR	NR	
U-233	M	3	D	1.35E-01	FGR11	NR	NR	NR	NR	
U-234	M	3	D	1.32E-01	FGR11	NR	NR	NR	NR	

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
U-235	M	3	D	1.23E-01	FGR11	NR	NR	NR	NR	
U-236	M	3	D	1.25E-01	FGR11	NR	NR	NR	NR	
U-238	M	3	D	1.18E-01	FGR11	NR	NR	NR	NR	
Dose Conversion Factors (Ingestion mrem/pCi)										
Ac-227	M	3	D	1.41E-02	FGR11	NR	NR	NR	NR	
Am-241	M	3	D	3.64E-03	FGR11	NR	NR	NR	NR	
Am-243	M	3	D	3.62E-03	FGR11	NR	NR	NR	NR	
C-14	M	3	D	2.09E-06	FGR11	NR	NR	NR	NR	
Cm-243	M	3	D	2.51E-03	FGR11	NR	NR	NR	NR	
Cm-244	M	3	D	2.02E-03	FGR11	NR	NR	NR	NR	
Cm-245	M	3	D	3.74E-03	FGR11	NR	NR	NR	NR	
Cm-246	M	3	D	3.70E-03	FGR11	NR	NR	NR	NR	
Co-60	M	3	D	2.69E-05	FGR11	NR	NR	NR	NR	
Cs-134	M	3	D	7.33E-05	FGR11	NR	NR	NR	NR	
Cs-137	M	3	D	5.00E-05	FGR11	NR	NR	NR	NR	
Eu-152	M	3	D	6.48E-06	FGR11	NR	NR	NR	NR	
Eu-154	M	3	D	9.55E-06	FGR11	NR	NR	NR	NR	
Gd-152	M	3	D	1.61E-04	FGR11	NR	NR	NR	NR	
H-3	M	3	D	6.40E-08	FGR11	NR	NR	NR	NR	
I-129	M	3	D	2.76E-04	FGR11	NR	NR	NR	NR	
Nb-94	M	3	D	7.14E-06	FGR11	NR	NR	NR	NR	
Nd-144[e]	M	3	D	1.51E-04	ICRP60	NR	NR	NR	NR	
Ni-59	M	3	D	2.10E-07	FGR11	NR	NR	NR	NR	
Ni-63	M	3	D	5.77E-07	FGR11	NR	NR	NR	NR	
Np-237	M	3	D	4.44E-03	FGR11	NR	NR	NR	NR	
Pa-231	M	3	D	1.06E-02	FGR11	NR	NR	NR	NR	
Pb-210	M	3	D	5.37E-03	FGR11	NR	NR	NR	NR	
Po-210	M	3	D	1.90E-03	FGR11	NR	NR	NR	NR	
Pu-238	M	3	D	3.20E-03	FGR11	NR	NR	NR	NR	
Pu-239	M	3	D	3.54E-03	FGR11	NR	NR	NR	NR	
Pu-240	M	3	D	3.54E-03	FGR11	NR	NR	NR	NR	

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Pu-241	M	3	D	6.84E-05	FGR11	NR	NR	NR	NR	
Pu-242	M	3	D	3.36E-03	FGR11	NR	NR	NR	NR	
Ra-226	M	3	D	1.32E-03	FGR11	NR	NR	NR	NR	
Ra-228	M	3	D	1.44E-03	FGR11	NR	NR	NR	NR	
Sm-148[e]	M	3	D	1.58E-04	ICRP60	NR	NR	NR	NR	
Sr-90	M	3	D	1.42E-04	FGR11	NR	NR	NR	NR	
Tc-99	M	3	D	1.46E-06	FGR11	NR	NR	NR	NR	
Th-228	M	3	D	3.96E-04	FGR11	NR	NR	NR	NR	
Th-229	M	3	D	3.53E-03	FGR11	NR	NR	NR	NR	
Th-230	M	3	D	5.48E-04	FGR11	NR	NR	NR	NR	
Th-232	M	3	D	2.73E-03	FGR11	NR	NR	NR	NR	
U-233	M	3	D	2.89E-04	FGR11	NR	NR	NR	NR	
U-234	M	3	D	2.83E-04	FGR11	NR	NR	NR	NR	
U-235	M	3	D	2.66E-04	FGR11	NR	NR	NR	NR	
U-236	M	3	D	2.69E-04	FGR11	NR	NR	NR	NR	
U-238	M	3	D	2.55E-04	FGR11	NR	NR	NR	NR	
Plant Transfer Factors (pCi/g plant)/(pCi/g soil)										
Ac-227	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Am-241	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Am-243	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
C-14	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-243	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-244	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Co-60	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cs-134	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cs-137	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-152	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-154	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Fe-55	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Gd-152	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
H-3	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Nb-94	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Nd-144	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-59	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-63	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Np-237	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pa-231	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pb-210	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pm-147	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Po-210	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-238	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-239	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-240	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-241	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-226	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-228	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sb-125	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sm-148	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sr-90	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Tc-99	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-228	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-229	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-230	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-232	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-233	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-234	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-235	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-236	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Meat Transfer Factors (pCi/kg)/(pCi/d)										
Ac-227	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ag-108m	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Am-241	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Am-243	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
C-14	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-243	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-244	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Co-60	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cs-134	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cs-137	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-152	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-154	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Fe-55	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Gd-152	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
H-3	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Nb-94	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Nd-144	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-59	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-63	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Np-237	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pa-231	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pb-210	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Po-210	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-238	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-239	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-240	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-241	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-226	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-228	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sb-125	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sm-148	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sr-90	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Tc-99	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-228	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Th-229	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-230	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-232	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-233	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-234	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-235	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-236	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Milk Transfer Factors (pCi/L)/(pCi/d)										
Ac-227	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Am-241	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Am-243	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
C-14	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-243	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-244	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Co-60	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cs-134	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cs-137	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-152	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-154	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Fe-55	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Gd-152	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
H-3	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Nb-94	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Nd-144	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-59	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-63	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Np-237	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pa-231	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pb-210	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Po-210	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-238	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Pu-239	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-240	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-241	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-226	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-228	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sm-148	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sr-90	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Tc-99	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-228	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-229	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-230	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-232	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-233	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-234	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-235	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-236	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Bioaccumulation Factors for Fish ((pCi/kg)/(pCi/L))										
Ac-227	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Am-241	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Am-243	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
C-14	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-243	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-244	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-245	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-246	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Co-60	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cs-137	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-152	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-154	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Gd-152	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
H-3	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
I-129	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Nb-94	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-59	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-63	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Np-237	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pa-231	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Po-210	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pb-210	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-238	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-239	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-240	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-241	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-242	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-226	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-228	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sr-90	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-228	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-229	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-230	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-232	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-233	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-234	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-235	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-236	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-238	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Bioaccumulation Factors for Crustacea/ Mollusks ((pCi/kg)/(pCi/L))										
Ac-227	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Am-241	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Am-243	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
C-14	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-243	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Cm-244	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-245	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-246	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Co-60	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cs-137	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-152	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-154	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Gd-152	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
H-3	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
I-129	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Nb-94	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-59	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-63	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Np-237	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pa-231	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pb-210	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Po-210	P	S	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-238	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-239	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-240	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-241	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-242	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-226	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-228	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sr-90	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-228	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-229	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-230	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-232	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-233	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-234	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	

RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
U-235	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-236	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-238	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Graphics Parameters										
Number of points				32	RESRAD Default	NR	NR	NR	NR	
Spacing				log	RESRAD Default	NR	NR	NR	NR	
Time integration parameters										
Maximum number of points for dose				17	RESRAD Default	NR	NR	NR	NR	

Notes:
a P = physical, B = behavioral, M = metabolic; (see NUREG/CR-6697, Attachment B, Table 4.)
b 1 = high-priority parameter, 2 = medium-priority parameter, 3 = low-priority parameter (see NUREG/CR-6697, Attachment B, Table 4.1)
c D = deterministic, S = stochastic
d Distributions Statistical Parameters:
Lognormal-n: 1= mean, 2 = standard deviation
Bounded lognormal-n: 1= mean, 2 = standard deviation, 3 = minimum, 4 = maximum
Truncated lognormal-n: 1= mean, 2 = standard deviation, 3 = lower quantile, 4 = upper quantile
Bounded normal: 1 = mean, 2 = standard deviation, 3 = minimum, 4 = maximum
Beta: 1 = minimum, 2 = maximum, 3 = P-value, 4 = Q-value
Triangular: 1 = minimum, 2 = mode, 3 = maximum
Uniform: 1 = minimum, 2 = maximum e Sm-148 an ND-144 not listed in RESRAD FGR 11 DCF file
e Reference: Haley and Aldrich, Inc., "Hydrogeological Investigation Report La Crosse Boiling Water Reactor, Dairyland Power Cooperative, Genoa, WI" January 2015
f Zion*Solutions* Technical Support Document 14-003, Conestoga Rovers & Associates (CRA) Report, "Zion Hydrogeologic Investigation Report"
g Argonne National Laboratory, "User's Manual for RESRAD Version 6", ANL/EAD 4, July 2001

Attachment 2
RESRAD Output Report File Names

RESRAD Output Report File Names

Soil DCGL Uncertainty Analysis

- LACBWR Soil UA Am-241 092117
- LACBWR Soil UA Am-243 092117
- LACBWR Soil UA C-14 092117
- LACBWR Soil UA Co-60 092117
- LACBWR Soil UA Cs-137 092117
- LACBWR Soil UA Eu-152 092117
- LACBWR Soil UA Eu-154 092117
- LACBWR Soil UA Eu-155 092117
- LACBWR Soil UA Fe-55 092117
- LACBWR Soil UA H-3 092117
- LACBWR Soil UA Nb-94 092117
- LACBWR Soil UA Ni-59 092117
- LACBWR Soil UA Ni-63 092117
- LACBWR Soil UA Np-237 092117
- LACBWR Soil UA Pu-238 092117
- LACBWR Soil UA Pu-239 092117
- LACBWR Soil UA Pu-240 090217
- LACBWR Soil UA Pu-241 092117
- LACBWR Soil UA Sr-90 092117
- LACBWR Soil UA Tc-99 092117
- LACBWR Soil UA Cm-243 043018
- LACBWR Soil UA Cm-244 043018

Soil DCGL

- LACBWR Soil DCGL Initial Suite RESRAD Summary Report 052618

BFM Insitu$_{gw}$ Reactor Building Uncertainty Analysis Reports

- BFM Rx Rev 1 UA Am-241 092117
- BFM Rx Rev 1 UA Am-243 092117
- BFM Rx Rev 1 UA C0-60 092117
- BFM Rx Rev 1 UA C-14 092117
- BFM Rx Rev 1 UA Cm-243 092117
- BFM Rx Rev 1 UA Cm-244 092117
- BFM Rx Rev 1 UA Cs-137 092117
- BFM Rx Rev 1 UA Eu-152 092117
- BFM Rx Rev 1 UA Eu-154 092117
- BFM Rx Rev 1 UA Eu-155 092117
- BFM Rx Rev 1 UA Fe-55 092117
- BFM Rx Rev 1 UA H-3 092117
- BFM Rx Rev 1 UA Nb-94 092117
- BFM Rx Rev 1 UA Ni-59 092117
- BFM Rx Rev 1 UA Ni-63 092117
- BFM Rx Rev 1 UA Np-237 092117
- BFM Rx Rev 1 UA Pu-238 092117
- BFM Rx Rev 1 UA Pu-239 092117
- BFM Rx Rev 1 UA Pu-240 092117
- BFM Rx Rev 1 UA Pu-241 092117
- BFM Rx Rev 1 UA Sr-90 092117
- BFM Rx Rev 1 UA Tc-99 092117

BFM Insitu$_{gw}$ Reactor Building RESRAD Summary Report

- LACBWR BFM Rx DSR 121117

BFM Insitu$_{gw}$ WGTV Uncertainty Analysis Reports

- BFM WGTV Rev 1 UA Am-241 092117
- BFM WGTV Rev 1 UA Am-243 092117
- BFM WGTV Rev 1 UA C-14 092117
- BFM WGTV Rev 1 UA Cm-243 092117
- BFM WGTV Rev 1 UA Cm-244 092117
- BFM WGTV Rev 1 UA Co-60 092117
- BFM WGTV Rev 1 UA Cs-137 092117
- BFM WGTV Rev 1 UA Eu-152 092117
- BFM WGTV Rev 1 UA Eu-154 092117
- BFM WGTV Rev 1 UA Eu-155 092117
- BFM WGTV Rev 1 UA Fe-55 092117
- BFM WGTV Rev 1 UA H-3 092117
- BFM WGTV Rev 1 UA Nb-94 092117
- BFM WGTV Rev 1 UA Ni-59 092117
- BFM WGTV Rev 1 UA Ni-63 092117
- BFM WGTV Rev 1 UA Np-237 092117
- BFM WGTV Rev 1 UA Pu-238 092117
- BFM WGTV Rev 1 UA Pu-239 092117
- BFM WGTV Rev 1 UA Pu-240 092117
- BFM WGTV Rev 1 UA Pu-241 092117
- BFM WGTV Rev 1 UA Sr-90 092117
- BFM WGTV Rev 1 UA Tc-99 092117

BFM Insitu$_{gw}$ WGTV RESRAD Summary Report

- LACBWR BFM WGTV DSR 121117

Drilling Spoils Area Factor Calculation

- LACBWR Drilling Spoils AF 092317

Soil Area Factors

- LACBWR Rev 1 Soil AF 1m 092317
- LACBWR Rev 1 Soil AF 2m 092317
- LACBWR Rev 1 Soil AF 5m 092317
- LACBWR Rev 1 Soil AF 10m 092317
- LACBWR Rev 1 Soil AF 100m 092317

Buried Pipe DCGLs

- LACBWR Buried Pipe Circ Excavation DSR 052618
- LACBWR Buried Pipe Circ Insitu DSR 052618
- LACBWR Buried Pipe Group Excavation DSR 052618
- LACBWR Buried Pipe Group Insitu DSR 052618

Alternate Scenario Dose Assessment

AS Soil

- AS Soil UA Am-241 082417
- AS Soil UA Am-243 082417
- AS Soil UA C-14 082817
- AS Soil UA Cm-243 082417
- AS Soil UA Cm-244 082417
- AS Soil UA Co-60 082817
- AS Soil UA Cs-137 082417
- AS Soil UA EU-152 082417
- AS Soil UA EU-154 082417
- AS Soil UA Eu-155 082417
- AS Soil UA Fe-55 082817
- AS Soil UA H-3 082817
- AS Soil UA Nb-94 082417
- AS Soil UA Ni-59 082817
- AS Soil UA Ni-63 082817
- AS Soil UA Np-237 082417
- AS Soil UA Pu-238 082417
- AS Soil UA Pu-239 082417
- AS Soil UA Pu-240 082417
- AS Soil UA Pu-241 082417
- AS Soil UA Sr-90 082417
- AS Soil UA Tc-99 082417

- AS Soil DSR Initial Suite 083017

AS BFM Rx

- AS BFM Rx UA Am-241 090517
- AS BFM Rx UA Am-243 090517
- AS BFM Rx UA C0-60 090517
- AS BFM Rx UA C-14 090517
- AS BFM Rx UA Cm-243 090517
- AS BFM Rx UA Cm-244 090517
- AS BFM Rx UA Cs-137 090517
- AS BFM Rx UA Eu-152 090517
- AS BFM Rx UA Eu-154 090517
- AS BFM Rx UA Eu-155 090517
- AS BFM Rx UA Fe-55 090517
- AS BFM Rx UA H-3 090517
- AS BFM Rx UA Nb-94 090517
- AS BFM Rx UA Ni-59 090517
- AS BFM Rx UA Ni-63 090517
- AS BFM Rx UA Np-237 090517
- AS BFM Rx UA Pu-238 090517
- AS BFM Rx UA Pu-239 090517
- AS BFM Rx UA Pu-240 090517
- AS BFM Rx UA Pu-241 090517
- AS BFM Rx UA Sr-90 090517
- AS BFM Rx UA Tc-99 090517

- AS BFM Rx DSR 121117

AS BFM WGTV

- AS BFM WGTV UA Am-241 090517
- AS BFM WGTV UA Am-243 090517
- AS BFM WGTV UA C-14 090517
- AS BFM WGTV UA Cm-243 090517
- AS BFM WGTV UA Cm-244 090517
- AS BFM WGTV UA Co-60 090517
- AS BFM WGTV UA Cs-137 090517
- AS BFM WGTV UA Eu-152 090517
- AS BFM WGTV UA Eu-154 090517
- AS BFM WGTV UA Eu-155 090517
- AS BFM WGTV UA Fe-55 090517
- AS BFM WGTV UA H-3 090517
- AS BFM WGTV UA Nb-94 090517
- AS BFM WGTV UA Ni-59 090517
- AS BFM WGTV UA Ni-63 090517
- AS BFM WGTV UA Np-237 090517
- AS BFM WGTV UA Pu-238 090517
- AS BFM WGTV UA Pu-239 090517
- AS BFM WGTV UA Pu-240 090517
- AS BFM WGTV UA Pu-241 090517
- AS BFM WGTV UA Sr-90 090517
- AS BFM WGTV UA Tc-99 090517

- AS BFM WGTV DSR 121117

AS Drilling Spoils Area Factor

- Alternate Scenario Drilling Spoils Area Factor 083017

Fill Mixing Sensitivity Analysis

- LACBWR Rx Mix Sensitivity Floor 1 m 100817
- LACBWR Rx Mix Sensitivity Floor 2m 100817
- LACBWR Rx Mix Sensitivity Floor 3m 100817
- LACBWR Rx Mix Sensitivity Wall 1 m 100817
- LACBWR Rx Mix Sensitivity Wall 2m 100817
- LACBWR Rx Mix Sensitivity Wall 3 m 100817

- LACBWR WGTV Mix Floor 1m 092517
- LACBWR WGTV Mix Floor 2m 092517
- LACBWR WGTV Mix Floor 3m 092517
- LACBWR WGTV Mix Par Wall 1m 092517
- LACBWR WGTV Mix Par Wall 2m 092517
- LACBWR WGTV Mix Par Wall 3m 092517
- LACBWR WGTV Mix Perp Wall 1m 092517
- LACBWR WGTV Mix Perp Wall 2m 092517
- LACBWR WGTV Mix Perp Wall 3m 092517

Attachment 3
Sand Kd Distributions, 25th Percentile and 75th Percentile

Sand soil K_d values (Sheppard and Thibault, Table A-1, 1990).

Element	Number of Samples	ln (mean)	Standard Deviation	25% value, K_d (cm^3/g)	Mean, K_d (cm^3/g)	75% Value, K_d (cm^3/g)
Am	29	7.55	2.6	329	1900	10978
C	3	1.1	0.8	1.8	5	5.2
Cm	2	8.4	2.4	881	4000	22444
Co	33	4.1	2.8	9	60	399
Cs	81	5.6	2.5	50	280	1460
Eu	*	6.72	3.22	95	832	7302
Fe	16	5.4	2.6	38	220	1279
H	3	-2.7	0.4	0.05	0.06	0.09
I	22	0.04	2.2	0.24	1.04	4.59
Nb	*	5.1	1.95	44	160	611
Ni	11	6	1.5	147	403	1110
Np	16	1.4	1.7	1	4	13
Pu	39	6.3	1.7	173	550	1714
Sr	81	2.6	1.6	5	15	40
Tc	19	-2	1.8	0.04	0.10	0.46
Th	10	8	2.1	723	3200	12289
U	24	3.5	3.2	3.8	35	287

* Eu, Nb K_ds not provided in Sheppard and Thibault, 1990; values from NUREG CR-6697.

Attachment 4
Fill Material Mixing Volume Sensitivity Analysis

REACTOR BUILDING

Sensitivity Analysis of Mixing Distance from Reactor Building Surfaces

Mixing Sensitivity Rx Building - Walls Only

Inputs to Calculation[1]

Diameter	60	ft
Diameter	18.29	m
Radius	9.14	m
Demolition elevation	636	ft
Maximum Water Table elevation	629	ft
Unit Conversion Factor	0.0929	m^2 per ft^2
Unit Conversion Factor	0.0283	m^3 per ft^3
Unit Conversion Factor	0.3048	m per ft
Fill Density	1.76	g/cm^3
Unit Conversion Factor	1.00E+06	cm^3 per m^3
Unit Conversion Factor	1.00E+09	pCi/mCi
Reactor Building Fill Volume below 636	1485.16	m^3
Reactor Building Fill Volume Below 629	136.67	m^3
Reactor Building Fill Volume between 636-619	1348.49	m^3
Backfilled Structure fill Depth	7.32	m
cover depth	0.91	m
Unit concentration	1	pCi/m^2

Note 1: Reference TSD RS-TD-313196-002 La Crosse End State Basement Concrete Surface Areas, Volumes, and Void Spaces for structure dimensions and volumes

Sensitivity Analysis of Mixing Distance from Reactor Building Surfaces

Mixing Sensitivity Rx Building - Floor Only

Inputs to Calculation[1]

Diameter	60	ft
Diameter	18.29	m
Radius	9.14	m
Demolition elevation	636	ft
Maximum Water Table elevation	629	ft
Unit Conversion Factor	0.0929	m2 per ft2
Unit Conversion Factor	0.0283	m3 per ft3
Unit Conversion Factor	0.3048	m per ft
Fill Density	1.76	g/cm3
Unit Conversion Factor	1.00E+06	cm3 per m3
Unit Conversion Factor	1.00E+09	pCi/mCi
Reactor Building Fill Volume below 636	1485.16	m3
Reactor Building Fill Volume Below 629	136.67	m3
Reactor Building Fill Volume between 636-619	1348.49	m3
Backfilled Structure fill Depth	7.32	m
cover depth	0.91	m
Unit concentration	1	pCi/m2

Note 1: Reference TSD RS-TD-313196-002 La Crosse End State Basement Concrete Surface Areas, Volumes, and Void Spaces for structure dimensions and volumes

Calculation: Mixing Sensitivity Rx Building Walls Only

Fill Mix distance from Wall (m)	Contam Fill Volume (m3)	contam fill mass (g)	pCi/g in fill per pCi in concrete	RESRAD Contam area (m^2)	Length parallel to flow (m)	Contaminated Zone Thickness (m)	pCi/g per pCi/m^2
1	749.13	1.32E+09	7.58E-10	102.34	2.0	7.32	3.19E-07
2	1314.29	2.31E+09	4.32E-10	179.55	4.0	7.32	1.82E-07
3	1695.48	2.98E+09	3.35E-10	231.62	6.0	7.32	1.41E-07
		DSR 1[1] mrem/yr per pci/g	DSR 2[2] mrem/yr per pci/g	DSR 3[3] mrem/yr per pci/g			
Co-60		2.558E-01	4.220E-01	5.158E-01			
Cs-137		2.204E-01	2.447E-01	2.539E-01			
Sr-90		1.546E+00	2.931E+00	3.980E+00			
Eu-152		1.640E-02	1.739E-02	1.774E-02			
Eu-154		2.383E-02	2.526E-02	2.577E-02			
		BFM DF 1.0 mrem/yr per pCi/m^2	BFM DF 2.0 mrem/yr per pCi/m^2	BFM DF 3.0 mrem/yr per pCi/m^2			
Co-60		8.16E-08	7.67E-08	7.27E-08			
Cs-137		7.03E-08	4.45E-08	3.58E-08			
Sr-90		4.93E-07	5.33E-07	5.61E-07			
Eu-152		5.23E-09	3.16E-09	2.50E-09			
Eu-154		7.60E-09	4.59E-09	3.63E-09			

Note 1: RESRAD Summary Report "LACBWR Rx Mix Sensitivity Wall 1 m 100817"

Note 1: RESRAD Summary Report "LACBWR Rx Mix Sensitivity Wall 2 m 100817"

Note 1: RESRAD Summary Report "LACBWR Rx Mix Sensitivity Wall 3 m 100817"

Calculation: Mixing Sensitivity Rx Building Floor Only

Fill Mix distance from Floor (m)	**Contam Fill Volume (m3)**	**contam fill mass (g)**	**pCi/g in fill per pCi in concrete**	**RESRAD Contam area (m2)**	**Length parallel to flow (m)**	**Contaminated Zone Thickness (m)**	**pCi/g per pCi/m2**
1	262.68	4.62E+08	2.16E-09	262.68	18.29	1	5.68E-07
2	525.35	9.25E+08	1.08E-09	262.68	18.29	2	2.84E-07
3	788.03	1.39E+09	7.21E-10	262.68	18.29	3	1.89E-07
		DSR 1[1] mrem/yr per pci/g	DSR 2[2] mrem/yr per pci/g	DSR 3[3] mrem/yr per pci/g			
Co-60		1.448E-01	2.779E-01	3.992E-01			
Cs-137		5.262E-02	1.043E-01	1.552E-01			
Sr-90		1.520E+00	2.842E+00	3.996E+00			
Eu-152		3.552E-03	7.071E-03	1.056E-02			
Eu-154		5.159E-03	1.027E-02	1.534E-02			
		BFM DF 1.0 mrem/yr per pCi/m2	BFM DF 3.0 mrem/yr per pCi/m2	BFM DF 6.0 mrem/yr per pCi/m2			
Co-60		8.23E-08	7.89E-08	7.56E-08			
Cs-137		2.99E-08	2.96E-08	2.94E-08			
Sr-90		8.64E-07	8.07E-07	7.57E-07			
Eu-152		2.02E-09	2.01E-09	2.00E-09			
Eu-154		2.93E-09	2.92E-09	2.91E-09			

Note 1: RESRAD Summary Report "LACBWR Rx Mix Sensitivity Floor 1 m 100817"
Note 1: RESRAD Summary Report "LACBWR Rx Mix Sensitivity Floor 2 m 100817"
Note 1: RESRAD Summary Report "LACBWR Rx Mix Sensitivity Floor 3 m 100817"

Rx Bldg Mixing Distance Sensitivity Analysis Results -Wall Only

	Ratio 1m DF/BFM DF	Ratio 2m DF/BFM DF	Ratio 3m DF/BFM DF
Co-60	0.62	0.59	0.56
Cs-137	1.34	0.85	0.68
Sr-90	0.39	0.42	0.45
Eu-152	1.47	0.89	0.70
Eu-154	1.47	0.89	0.70

Rx Bldg Mixing Distance Sensitivity Analysis Results - Floor Only

	Ratio 1m DF/BFM DF	Ratio 2m DF/BFM DF	Ratio 3m DF/BFM DF
Co-60	0.63	0.60	0.58
Cs-137	0.57	0.57	0.56
Sr-90	0.69	0.64	0.60
Eu-152	0.57	0.56	0.56
Eu-154	0.57	0.56	0.56

WGTV

Sensitivity Analysis of Mixing Distance from WGTV Surfaces

Input to Calculation

WGTV length[1]	31.51	ft
WGTV length	9.60	m
WGTV width[1]	29.51	ft
WGTV width	8.99	m
Floor Elevation1	621.00	feet
Demolition elevation	636.00	feet
Backfilled Structure fill Depth	4.57	m
Unit concentration	1	pCi/m2

Note 1: Reference TSD RS-TD-313196-002 La Crosse End State Basement Concrete Surface Areas, Volumes, and Void Spaces for structure dimensions and volumes

Mixing Sensitivity Check WGTV 1.0 m mix Distance

Wall or Floor	Fill Mix Distance (m)	Volume[4] (m^3)	mass (g)	pCi/g per pCi	RESRAD Contam area (m^2)	Length parallel to flow	Contaminated Zone Thickness (m)	pCi/g per pCi/m2
Perpendicular Wall	1.00	8.22E+01	1.45E+08	6.91E-09	18.0	2.00	4.57	5.68E-07
Parralel Wall	1.00	4.39E+01	7.73E+07	1.29E-08	9.6	9.60	4.57	6.92E-07
Floor	1.00	8.64E+01	1.52E+08	6.58E-09	86.4	9.60	1.00	5.68E-07

	DSR 1.0 m[1] Perpendicular Wall mrem/yr per pCi/g	DSR 1.0 m[2] Parallel Wall mrem/yr per pCi/g	DSR 1.0 m[3] Floor mrem/yr per pCi/g
Co-60	2.094E-01	3.732E-01	1.425E-01
Cs-137	1.346E-01	1.292E-01	5.247E-02
Sr-90	1.330E+00	3.623E+00	1.261E+00
Eu-152	8.871E-03	8.667E-03	3.546E-03
Eu-154	1.288E-02	1.259E-02	5.151E-03

	BFM DF 1.0 m Perpendicular Wall mrem/yr per pCi/m^2	BFM DF 1.0 m Parallel Wall mrem/yr per pCi/m^2	BFM DF 1.0 m Floor mrem/yr per pCi/m^2	BFM DF 1.0 m Sum Floor and Perpendicular Wall
Co-60	1.19E-07	2.58E-07	8.10E-08	2.00E-07
Cs-137	7.65E-08	8.95E-08	2.98E-08	1.06E-07
Sr-90	7.56E-07	2.51E-06	7.16E-07	1.47E-06
Eu-152	5.04E-09	6.00E-09	2.01E-09	7.06E-09
Eu-154	7.32E-09	8.72E-09	2.93E-09	1.02E-08

Note 1: LACBWR WGTV Mix Perp Wall 1m 092517
Note 2: LACBWR WGTV Mix Par Wall 1m 092517
Note 3: LACBWR WGTV Mix Floor 1m 092517
Note 4: Assumed flow through the two walls that are perpendicular to flow because each wall is a separate source and the two walls are therefore combined — 2 perpendicular walls

WGTV Mixing Depth Sensitivity Analysis Results

	Ratio 1.0 m Mix Depth Perpendicular Wall/BFM	Ratio 1.0 m Mix Depth Parallel Wall/BFM	Ratio 1.0 Mix Depth Floor /BFM	Ratio Sum Floor and Perpendicular Wall
Co-60	0.55	1.19	0.37	0.92
Cs-137	1.02	1.19	0.40	1.42
Sr-90	0.36	1.18	0.34	0.69
Eu-152	1.00	1.20	0.40	1.41
Eu-154	1.00	1.20	0.40	1.40

Mixing Sensitivity Check Waste Gas Tank Vault (All Basement: Saturated and Unsaturated Zones)

Input to Calculation

WGTV length1	31.51	ft
WGTV length	9.60	m
WGTV width1	29.51	ft
WGTV width	8.99	m
Floor Elevation1	621.00	feet
Demolition elevation	636.00	feet
Backfilled Structure fill Depth	4.57	m
Unit concentration	1.00	pCi/m2

Note 1: Reference TSD RS-TD-313196-002 La Crosse End State Basement Concrete Surface Areas, Volumes, and Void Spaces for structure dimensions and volumes

Mixing Sensitivity Check WGTV 2.0 m mix Distance

Wall or Floor	Fill Mix Distance (m)	Volume[4] (m^3)	mass (g)	pCi/g per pCi	RESRAD Contam area (m^2)	Length parallel to flow	Contaminated Zone Thickness (m)	pCi/g per pCi/m2
Perpendicular Wall	2	1.64E+02	2.90E+08	3.45E-09	36.0	4.00	4.57	2.84E-07
Parralel Wall	2	8.78E+01	1.55E+08	6.47E-09	19.2	9.60	4.57	4.08E-07
Floor	2	1.73E+02	3.04E+08	3.29E-09	86.4	9.60	2.00	2.84E-07
		DSR 2.0 m[1] Perpendicular Wall mrem/yr per pCi/g	DSR 2.0 m[2] Parallel Wall mrem/yr per pCi/g	DSR 2.0 m[3] Floor mrem/yr per pCi/g				
	Co-60	3.116E-01	3.762E-01	2.662E-01				
	Cs-137	1.347E-01	1.295E-01	1.033E-01				
	Sr-90	2.377E+00	3.661E+00	2.314E+00				
	Eu-152	8.750E-03	8.675E-03	7.031E-03				
	Eu-154	1.271E-02	1.260E-02	1.021E-02				
		BFM DF 2.0 m Perpendicular Wall mrem/yr per pCi/m2	BFM DF 2.0 m Parallel Wall mrem/yr per pCi/m2	BFM DF 2.0 m Floor mrem/yr per pCi/m2			BFM DF 2.0 m Sum Floor and Perpendicular Wall	
	Co-60	8.85E-08	1.54E-07	7.56E-08			1.64E-07	
	Cs-137	3.83E-08	5.29E-08	2.93E-08			6.76E-08	
	Sr-90	6.75E-07	1.50E-06	6.57E-07			1.33E-06	
	Eu-152	2.49E-09	3.54E-09	2.00E-09			4.48E-09	
	Eu-154	3.61E-09	5.15E-09	2.90E-09			6.51E-09	

Note 1: LACBWR WGTV Mix Perp Wall 2m 092517
Note 2: LACBWR WGTV Mix Par Wall 2m 092517
Note 3: LACBWR WGTV Mix Floor 2m 092517
Note 1: Assumed flow through the two walls that are perpendicular to flow — 2 perpendicular walls
because each wall is a separate source and the two walls are thefore combined

WGTV Mixing Depth Sensitivity Analysis Results

	Ratio 2.0 m Mix Depth Perpendicular Wall/BFM	Ratio 2.0 m Mix Depth Parallel Wall/BFM	Ratio 2.0 Mix Depth Floor /BFM
Co-60	0.41	0.71	0.35
Cs-137	0.51	0.71	0.39
Sr-90	0.32	0.71	0.31
Eu-152	0.50	0.71	0.40
Eu-154	0.50	0.71	0.40

	Ratio 2.0 m Mix Sum Floor and Perpendicular Wall
Co-60	0.75
Cs-137	0.90
Sr-90	0.63
Eu-152	0.89
Eu-154	0.89

Mixing Sensitivity Check Waste Gas Tank Vault (All Basement: Saturated and Unsaturated Zones)

Input to Calculation

WGTV length1	31.51	ft
WGTV length	9.60	m
WGTV width1	29.51	ft
WGTV width	8.99	m
Floor Elevation1	621.00	feet
Demolition elevation	636.00	feet
Backfilled Structure fill Depth	4.57	m
Unit concentration	1	pCi/m2

Note 1: Reference TSD RS-TD-313196-002 La Crosse End State Basement Concrete Surface Areas, Volumes, and Void Spaces for structure dimensions and volumes

Mixing Sensitivity Check WGTV 3.0 m mix Distance

Wall or Floor	Fill Mix Distance (m)	Volume[4] (m3)	mass (g)	pCi/g per pCi	RESRAD Contam area (m2)	Length parallel to flow	Contaminated Zone Thickness (m)	pCi/g per pCi/m2
Perpendicular Wall	3	2.47E+02	4.34E+08	2.30E-09	54.0	6.00	4.57	1.89E-07
Parralel Wall	3	1.32E+02	2.32E+08	4.31E-09	28.8	9.60	4.57	3.14E-07
Floor	3	2.59E+02	4.56E+08	2.19E-09	86.4	9.60	3.00	1.89E-07

	DSR 3.0 m[1] Perpendicular Wall mrem/yr per pCi/g	DSR 3.0 m[2] Parallel Wall mrem/yr per pCi/g	DSR 3.0[3] Floor mrem/yr per pCi/g
Co-60	3.548E-01	3.762E-01	3.705E-01
Cs-137	1.325E-01	1.295E-01	1.524E-01
Sr-90	3.036E+00	3.661E+00	3.160E+00
Eu-152	8.708E-03	8.675E-03	1.046E-02
Eu-154	1.265E-02	1.260E-02	1.519E-02

	BFM DF 3.0 m Perpendicular Wall mrem/yr per pCi/m2	BFM DF 3.0 m Parallel Wall mrem/yr per pCi/m2	BFM DF 3.0 m Floor mrem/yr per pCi/m2	BFM DF 3.0 m Sum Floor and Perpendicular Wall
Co-60	6.72E-08	1.18E-07	7.02E-08	1.37E-07
Cs-137	2.51E-08	4.06E-08	2.89E-08	5.40E-08
Sr-90	5.75E-07	1.15E-06	5.98E-07	1.17E-06
Eu-152	1.65E-09	2.72E-09	1.98E-09	3.63E-09
Eu-154	2.40E-09	3.95E-09	2.88E-09	5.27E-09

Note 1: LACBWR WGTV Mix Perp Wall 3m 092517

Note 2: LACBWR WGTV Mix Par Wall 3m 092517

Note 3: LACBWR WGTV Mix Floor 3m 092517

Note 4: Assumed flow through the two walls that are perpendicular to flow   2 perpendicular walls

WGTV Mixing Depth Sensitivity Analysis Results

	Ratio 3.0 m Mix Depth Perpendicular Wall/BFM	Ratio 3.0 m Mix Depth Parallel Wall/BFM	Ratio 3.0 Mix Depth Floor /BFM	Ratio 3.0 m Mix Sum Floor and Perpendicular Wall
Co-60	0.31	0.54	0.32	0.63
Cs-137	0.33	0.54	0.39	0.72
Sr-90	0.27	0.54	0.28	0.55
Eu-152	0.33	0.54	0.39	0.72
Eu-154	0.33	0.54	0.39	0.72

REACTOR BUIDING AND WGTV RESULTS SUMMARY

Mixing Sensitivity Analysis Results Summary
Maximum Ratio of Dose Factor Partial Mix/Full Mix

	Rx Building Wall + Floor	WGTV Wall + Floor
Co-60	1.25	1.19
Cs-137	1.91	1.42
Sr-90	1.08	1.18
Eu-152	2.03	1.41
Eu-154	2.03	1.40

Attachment 5
BFM Insitu$_{gw}$ RESRAD Uncertainty Analysis Input Parameters

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Soil Concentrations										
Basic radiation dose limit (mrem/y)		3	D	25	10 CFR 20.1402	NR	NR	NR	NR	
Initial principal radionuclide (pCi/g)	P	2	D	1	Unit Value	NR	NR	NR	NR	
Distribution coefficients (contaminated, unsaturated, and saturated zones) (cm^3/g)										
Ac-227 (daughter of Cm-243 and Pu-239)	P	1	D	450	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	6.72	3.22	NA	NA	825
Am-241 (also daughter of Cm-245 and Pu-241)	P	1	S	Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
Am-243	P	1	S	Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
C-14	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	2.4	3.22	NA	NA	11
Cm-243	P	1	S	Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
Cm-244	P	1	S	Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
Co-60	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	5.46	2.53	NA	NA	235
Cs-137	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.1	2.33	NA	NA	446
Eu-152	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.72	3.22	NA	NA	825
Eu-154	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.72	3.22	NA	NA	825
Eu-155	P	1	S	Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
Fe-55	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	5.34	2.67	NA	NA	209
Gd-152 (daughter for Eu-152)	P	1	D	825	Median Value NUREG/CR-6697, Att. C (No sand value listed in Table 3.9-2)	6.72	3.22	NA	NA	825
H-3	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	-2.81	0.5	NA	NA	0.06
Nb-94	P	1	S	Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
Nd-144 (daughter for Eu-152)	P	1	D	158	RESRADv.7.0 Default Nd not listed in NUREG/CR-6697	NA	NA	NA	NA	NA
Ni-59	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.05	1.46	NA	NA	424
Ni-63	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.05	1.46	NA	NA	424

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Np-237 (also daughter for Am-241, Cm-245, and Pu-241)	P	1	S	Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
Pa-231 (daughter for Cm-243 and Pu-239)	P	1	D	Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
Pb-210 (daughter for Pu-238)	P	1	D	Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
Po-210 (daughter Pu-238)	P	1	D	Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
Pu-238	P	1	S	Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
Pu-239 (also daughter for Cm-243)	P	1	S	Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
Pu-240 (also daughter for Cm-244)	P	1	S	Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
Pu-241	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.86	1.89	NA	NA	953
Ra-226 (daughter Pu-238)	P	1	D	Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
Ra-228 (daughter Cm-244 and Pu-240)	P	1	D	Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
Sm-148 (daughter Eu-152)	P	1	D	245	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	6.72	3.22	NA	NA	825
Sr-90	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	3.45	2.12	NA	NA	32
Tc-99	P	1	S	Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
Th-228 (daughter Cm-244 and Pu-240)	P	1	D	Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
Th-229 (daughter Am-241, Cm-245, Np-237, and Pu-241)	P	1	D	3200	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	8.68	3.62	NA	NA	5884
Th-230 (daughter Cm-246 and Pu-238)	P	1	D	Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
Th-232 (daughter Cm-244 and Pu-240)	P	1	D	Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
U-233 (daughter Am-241, Cm-245, Np-237, and Pu-241)	P	1	D	35	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault C	4.84	3.13	NA	NA	126
U-234 (daughter Pu-238)	P	1	D	Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA	NA	NA	NA	NA

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
U-235 (daughter Cm-243 and Pu-239)	P	1	D	Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
U-236 (daughter Cm-244 and Pu-240)	P	1	D	Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA	NA	NA	NA	NA
Initial concentration of radionuclides present in groundwater (pCi/l)	P	3	D	0	No existing groundwater contamination	NR	NR	NR	NR	
Calculation Times										
Time since placement of material (y)	P	3	D	0	Start of dose calculation immediately after license termination	NR	NR	NR	NR	
Time for calculations (y)	P	3	D	0, 1, 3, 10, 30, 100, 300, 1000	RESRAD Default	NR	NR	NR	NR	
Contaminated Zone										
Area of contaminated zone (m^2)	P	2	D	Variable	Structure Dependent	NR	NR	NR	NR	
Thickness of contaminated zone (m)	P	2	D	Variable	Structure Dependent	NR	NR	NR	NR	
Length parallel to aquifer flow (m)	P	2	D	Variable	Structure Dependent	NR	NR	NR	NR	
Does the initial contamination penetrate the water table?	NA	NA	NA	Variable	Structure Dependent	NA	NA	NA	NA	
Contaminated fraction below water table	P	3	D	Variable	Structure Dependent	NR	NR	NR	NR	
Cover and Contaminated Zone Hydrological Data										
Cover depth (m)	P	2	D	0.91	Structure removed to 3 feet below grade.	NR	NR	NR	NR	
Density of cover material	P	2	D	1.76	Site-specific[e]	NR	NR	NR	NR	
Cover erosion rate	P,B	2	S	Continuous Logarithmic	NUREG/CR-6697 Att. C Table 3.8-1	5E-08	0.0007	0.005	0.2	0.0015
Density of contaminated zone (g/cm^3)	P	1	D	1.76	Site-specific[e]	NR	NR	NR	NR	
Contaminated zone erosion rate m/y)	P,B	2	S	Continuous Logarithmic	NUREG/CR-6697 Att. C Table 3.8-1	5E-08	0.0007	0.005	0.2	0.0015
Contaminated zone total porosity	P	2	D	0.31	Site-specific[e]	NR	NR	NR	NR	0.43
Contaminated zone field capacity	P	3	D	0.2	RESRAD default. No distribution or median value provided in NURE/CR-6697 Att. C	NR	NR	NR	NR	

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Contaminated zone hydraulic conductivity (m/y)	P	2	D	34822	Site-specific[e] 313 feet/day = 34822 m/y	NR	NR	NR	NR	
Contaminated zone b parameter	P	2	S	Lognormal-N	Site specific soil type sand NUREG/CR-6697 Att. C Table 3.5-1	-.0253	0.216	NA	NA	0.97
Humidity in air (g/m^3)	P	3	D	7.2	Median NUREG/CR-6697 Att. C	1.98	0.334	0.001	0.999	7.2
Evapotranspiration coefficient	P	2	S	Uniform	NUREG/CR-6697 Att. C Figure 4.3-1	0.5	0.75	NR	NR	0.625
Average annual wind speed (m/s)	P	2	S	Bounded Lognormal - N	NUREG/CR-6697 Att. C Figure 4.5-1	1.445	0.2419	1.4	13	4.2
Precipitation (m/y)	P	2	S	0.78	NUREG/CR-6697 Att. C La Crosse, WI Table 4.1-2	NR	NR	NR	NR	
Irrigation (m/y)	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Irrigation mode	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Runoff coefficient	P	2	D	0	Site-specific value to force the Precipitation parameter to equal to the infiltration rate.	NR	NR	NR	NR	NR
Watershed area for nearby stream or pond (m^2)	P	3	D	1.00E+06	RESRAD Default	NR	NR	NR	NR	
Accuracy for water/soil computations	-	3	D	1.00E-03	RESRAD Default	NR	NR	NR	NR	
Saturated Zone Hydrological Data										
Density of saturated zone (g/cm^3)	P	2	D	1.76	Site-specific[e]	NR	NR	NR	NR	
Saturated zone total porosity	P	1	D	0.31	Site-specific[e]	NR	NR	NR	NR	
Saturated zone effective porosity	P	1	D	0.28	Site-specific[e]	NR	NR	NR	NR	
Saturated zone field capacity	P	3	D	0.066	Calculated values for sand soil type[f]	NR	NR	NR	NR	
Saturated zone hydraulic conductivity (m/y)	P	1	D	34822	Site-specific[e] 313 feet/day = 34822 m/y	NR	NR	NR	NR	
Saturated zone hydraulic gradient	P	2	D	0.0045	Site-specific value[e]	NR	NR	NR	NR	
Saturated zone b parameter	P	2	S	Lognormal-N	Site specific soil type sand NUREG/CR-6697 Att. C Table 3.5-1	-.0253	0.216	NA	NA	0.97

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	**Type[a]**	**Priority[b]**	**Treatment[c]**	**Value/Distribution**	**Basis**	**Distribution's Statistical Parameters[d]**				
						1	**2**	**3**	**4**	**Mean/ Median**
Water table drop rate (m/y)	P	3	D	0	Assumed zero due to hydraulic connectivity with Mississippi river.	NR	NR	NR	NR	
Well pump intake depth (m below water table)	P	2	S	Triangular	Site-specific distribution Existing industrial water supply wells onsite at depth of 116' and 129' below ground surface (the 129' depth equals 36.3 m below the 129' bgs water table). 36.3 m assumed to be maximum well depth. Minimum well depth assumed to be represented by nominal 20' screen depth (6.1 m) starting at maximum water table elevation of 629' and extending to 10' below 619' elevation where groundwater continuously present. Mode is mid-point between 6.1 m and 36.3 m which is 21.2 m. Note that the site-specific distribution is reasonably similar to the NUREG-6697 distribution values of 6, 10, and 30 for the triangular distribution.	6.1	21.2	36.3	NR	21.2
Model: Nondispersion (ND) or Mass-Balance (MB)	P	3	D	ND	Applicable to moving groundwater	NR	NR	NR	NR	

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Well pumping rate (m^3/y)	P	2	S	Uniform	NUREG/CR-6697, Att. C provides no recommended value due to high variability. Industrial Scenario pump rate depends on industry. General water usage rate for four persons is 328.7 m^3/yr (NUREG-6697, Table 3.10-1) which is assumed to be minimum industrial rate. Maximum industrial rate assumed to supply 20 workers which equals 1643.5 m^3/yr.	328.7	1643.5	NR	NR	986.1
Unsaturated Zone Hydrological Data										
Number of unsaturated zone strata	P	3	D	0	Site-specific	NR	NR	NR	NR	
Unsat. zone thickness (m)	P	1	D	NA	No unsaturated zone	NR	NR	NR	NR	
Unsat. zone soil density (g/cm^3)	P	2	D	NA	No unsaturated zone	NR	NR	NR	NR	
Unsat. zone total porosity	P	2	D	NA	No unsaturated zone	NR	NR	NR	NR	
Unsat. zone effective porosity	P	2	D	NA	No unsaturated zone	NR	NR	NR	NR	
Unsat. zone field capacity	P	3	D	NA	No unsaturated zone	NR	NR	NR	NR	
Unsat. zone hydraulic conductivity (m/y)	P	2	D	NA	No unsaturated zone	NR	NR	NR	NR	
Unsat. zone soil-specific b parameter	P	2	S	NA	No unsaturated zone	NR	NR	NR	NR	
Occupancy										

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Inhalation rate (m^3/y)	M,B	3	D	3066	NUREG-6697 Att. C, Table 7.6-1 recommends a median indoor work day as 8.76 hours/day. Assuming 5 days a week and 50 weeks per years this equates to 2190 hours per year. NUREG/CR-5512, Vol. 3, Section 5.3.4 recommends an inhalation rate for workers in light industry of 1.4 m^3/hr. Industrial Scenario inhalation rate (m^3/yr) = 1.4 m^3/hr * 2190 hr/yr = 3066 m^3/yr	NR	NR	NR	NR	
Mass loading for inhalation (g/m^3)	P,B	2	S	Continuous Linear	NUREG/CR-6697, Att. C	See NUREG-6697 Table 4.6-1	See NUREG-6697 Table 4.6-1	See NUREG-6697 Table 4.6-1	See NUREG-6697 Table 4.6-1	2.35E-05
Exposure duration	B	3	D	30	RESRAD User's Manual parameter value not used in dose calculation	NR	NR	NR	NR	
Indoor dust filtration factor	P,B	2	S	Uniform	NUREG/CR-6697, Att. C Figure 7.1-1	0.15	0.95	NR	NR	0.55
Shielding factor, external gamma	P	2	S	Bounded Lognormal-N	NUREG/CR-6697, Att. C Table 7.10-1	-1.3	0.59	0.044	1	0.2725

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Fraction of time spent indoors	B	3	D	0.1875	NUREG-6697 Att. C, Table 7.6-1 recommends a median indoor work day as 8.76 hours/day. Assuming 5 days a week and 50 weeks per years this equates to 2190 hours per year. Majority of industrial work is expected to be indoors. Consistent with Table 2-3 of the "User's Manual for RESRAD Version 6"[g] 75% of work time is indoors and 25% outdoors. The corresponding RESRAD indoor Fraction parameter = (2190*.75)/(24*365) = .1875	NR	NR	NR	NR	
Fraction of time spent outdoors (on site)	B	3	D	0.0625	As explained in the basis for the Indoor Fraction parameter, the indoor time fraction was set at 75% and outdoor time fraction at 25%. (2190*.25)/(24*365) = 0.0625	NR	NR	NR	NR	
Shape factor flag, external gamma	P	3	D	Circular	Circular contaminated zone assumed for modeling purposes	NR	NR	NR	NR	
Ingestion, Dietary										
Fruits, non-leafy vegetables, grain consumption (kg/y)	M,B	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Leafy vegetable consumption (kg/y)	M,B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Milk consumption (L/y)	M,B	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Meat and poultry consumption (kg/y)	M,B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Fish consumption (kg/y)	M,B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Other seafood consumption (kg/y)	M,B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Soil ingestion rate (g/y)	M,B	2	D	18.3	NUREG/CR-5512, Vol. 3 Table 6.87	NR	NR	NR	NR	
Drinking water intake (L/y)	M,B	2	D	327	NUREG/CR-5512, Vol. 3 Table 6.87 Industrial Scenario water supply assumed to be from an onsite well. 478 L/y from NUREG/CR-5512 corresponds to 1.31 L/d which is considered a conservative value for 8 hour work day. 1.31 L/d * 250 work days = 327 L/y	NR	NR	NR	NR	
Contamination fraction of drinking water	B,P	3	D	1	All water assumed contaminated	NR	NR	NR	NR	
Contamination fraction of household water (if used)	B,P	3		1	All water from well					
Contamination fraction of livestock water	B,P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Contamination fraction of irrigation water	B,P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Contamination fraction of aquatic food	B,P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Contamination fraction of plant food	B,P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Contamination fraction of meat	B,P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Contamination fraction of milk	B,P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ingestion, Non-Dietary										
Livestock fodder intake for meat (kg/day)	M	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Livestock fodder intake for milk (kg/day)	M	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Livestock water intake for meat (L/day)	M	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Livestock water intake for milk (L/day)	M	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Livestock soil intake (kg/day)	M	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Mass loading for foliar deposition (g/m^3)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Depth of soil mixing layer (m)	P	2	D	Triangular	NUREG/CR-6697, Att. C Figure 3.12-1	0	0.15	0.6	NR	0.23
Depth of roots (m)	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Drinking water fraction from ground water	B,P	3	D	1	Industrial Scenario	NR	NR	NR	NR	
Household water fraction from ground water (if used)	B,P	3		1	Industrial Scenario	NR	NR	NR	NR	
Livestock water fraction from ground water	B,P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Irrigation fraction from ground water	B,P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Wet weight crop yield for Non-Leafy (kg/m^2)	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Wet weight crop yield for Leafy (kg/m^2)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Wet weight crop yield for Fodder (kg/m^2)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Growing Season for Non-Leafy (y)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Growing Season for Leafy (y)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Growing Season for Fodder (y)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Translocation Factor for Non-Leafy	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Translocation Factor for Leafy	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Translocation Factor for Fodder	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Weathering Removal Constant for Vegetation (1/y)	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Wet Foliar Interception Fraction for Non-Leafy	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Wet Foliar Interception Fraction for Leafy	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Wet Foliar Interception Fraction for Fodder	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Dry Foliar Interception Fraction for Non-Leafy	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Dry Foliar Interception Fraction for Leafy	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Dry Foliar Interception Fraction for Fodder	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Storage times of contaminated foodstuffs (days):										
Fruits, non-leafy vegetables, and grain	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Leafy vegetables	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Milk	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Meat and poultry	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Fish	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Crustacea and mollusks	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Well water	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Surface water	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Livestock fodder	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Special Radionuclides (C-14)										
C-12 concentration in water (g/cm^3)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
C-12 concentration in contaminated soil (g/g)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Fraction of vegetation carbon from soil	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Fraction of vegetation carbon from air	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
C-14 evasion layer thickness in soil (m)	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
C-14 evasion flux rate from soil (1/sec)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
C-12 evasion flux rate from soil (1/sec)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Fraction of grain in beef cattle feed	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Fraction of grain in milk cow feed	B	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Dose Conversion Factors (Inhalation mrem/pCi)										
Ac-227	M	3	D	6.70E+00	FGR11	NR	NR	NR	NR	
Am-241	M	3	D	4.44E-01	FGR11	NR	NR	NR	NR	
Am-243	M	3	D	4.40E-01	FGR11	NR	NR	NR	NR	
C-14	M	3	D	2.09E-06	FGR11	NR	NR	NR	NR	
Cm-243	M	3	D	3.07E-01	FGR11	NR	NR	NR	NR	
Cm-244	M	3	D	2.48E-01	FGR11	NR	NR	NR	NR	
Cm-245	M	3	D	4.55E-01	FGR11	NR	NR	NR	NR	
Cm-246	M	3	D	4.51E-01	FGR11	NR	NR	NR	NR	
Co-60	M	3	D	2.19E-04	FGR11	NR	NR	NR	NR	
Cs-134	M	3	D	4.62E-05	FGR11	NR	NR	NR	NR	

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Cs-137	M	3	D	3.19E-05	FGR11	NR	NR	NR	NR	
Eu-152	M	3	D	2.21E-04	FGR11	NR	NR	NR	NR	
Eu-154	M	3	D	2.86E-04	FGR11	NR	NR	NR	NR	
Eu-155	M	3	D	4.14E-05	FGR11	NR	NR	NR	NR	
Gd-152	M	3	D	2.43E-01	FGR11	NR	NR	NR	NR	
H-3	M	3	D	6.40E-08	FGR11	NR	NR	NR	NR	
I-129	M	3	D	1.74E-04	FGR11	NR	NR	NR	NR	
Nb-94	M	3	D	4.14E-04	FGR11	NR	NR	NR	NR	
Nd-144[e]	M	3	D	7.04E-02	ICRP60	NR	NR	NR	NR	
Ni-59	M	3	D	2.70E-06	FGR11	NR	NR	NR	NR	
Ni-63	M	3	D	6.29E-06	FGR11	NR	NR	NR	NR	
Np-237	M	3	D	5.40E-01	FGR11	NR	NR	NR	NR	
Pa-231	M	3	D	1.28E+00	FGR11	NR	NR	NR	NR	
Pb-210	M	3	D	1.36E-02	FGR11	NR	NR	NR	NR	
Po-210	M	3	D	9.40E-03	FGR11	NR	NR	NR	NR	
Pu-238	M	3	D	3.92E-01	FGR11	NR	NR	NR	NR	
Pu-239	M	3	D	4.29E-01	FGR11	NR	NR	NR	NR	
Pu-240	M	3	D	4.29E-01	FGR11	NR	NR	NR	NR	
Pu-241	M	3	D	8.25E-03	FGR11	NR	NR	NR	NR	
Pu-242	M	3	D	4.11E-01	FGR11	NR	NR	NR	NR	
Ra-226	M	3	D	8.58E-03	FGR11	NR	NR	NR	NR	
Ra-228	M	3	D	4.77E-03	FGR11	NR	NR	NR	NR	
Sm-148[e]	M	3	D	7.34E-02	ICRP60	NR	NR	NR	NR	
Sr-90	M	3	D	1.30E-03	FGR11	NR	NR	NR	NR	
Tc-99	M	3	D	8.32E-06	FGR11	NR	NR	NR	NR	
Th-228	M	3	D	3.42E-01	FGR11	NR	NR	NR	NR	
Th-229	M	3	D	2.15E+00	FGR11	NR	NR	NR	NR	
Th-230	M	3	D	3.26E-01	FGR11	NR	NR	NR	NR	
Th232	M	3	D	1.64e+00	FGR11	NR	NR	NR	NR	
U-233	M	3	D	1.35E-01	FGR11	NR	NR	NR	NR	
U-234	M	3	D	1.32E-01	FGR11	NR	NR	NR	NR	

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
U-235	M	3	D	1.23E-01	FGR11	NR	NR	NR	NR	
U-236	M	3	D	1.25E-01	FGR11	NR	NR	NR	NR	
U-238	M	3	D	1.18E-01	FGR11	NR	NR	NR	NR	
Dose Conversion Factors (Ingestion mrem/pCi)										
Ac-227	M	3	D	1.41E-02	FGR11	NR	NR	NR	NR	
Am-241	M	3	D	3.64E-03	FGR11	NR	NR	NR	NR	
Am-243	M	3	D	3.62E-03	FGR11	NR	NR	NR	NR	
C-14	M	3	D	2.09E-06	FGR11	NR	NR	NR	NR	
Cm-243	M	3	D	2.51E-03	FGR11	NR	NR	NR	NR	
Cm-244	M	3	D	2.02E-03	FGR11	NR	NR	NR	NR	
Cm-245	M	3	D	3.74E-03	FGR11	NR	NR	NR	NR	
Cm-246	M	3	D	3.70E-03	FGR11	NR	NR	NR	NR	
Co-60	M	3	D	2.69E-05	FGR11	NR	NR	NR	NR	
Cs-134	M	3	D	7.33E-05	FGR11	NR	NR	NR	NR	
Cs-137	M	3	D	5.00E-05	FGR11	NR	NR	NR	NR	
Eu-152	M	3	D	6.48E-06	FGR11	NR	NR	NR	NR	
Eu-154	M	3	D	9.55E-06	FGR11	NR	NR	NR	NR	
Eu-155	M	3	D	1.53E-06	FGR11	NR	NR	NR	NR	
Gd-152	M	3	D	1.61E-04	FGR11	NR	NR	NR	NR	
H-3	M	3	D	6.40E-08	FGR11	NR	NR	NR	NR	
I-129	M	3	D	2.76E-04	FGR11	NR	NR	NR	NR	
Nb-94	M	3	D	7.14E-06	FGR11	NR	NR	NR	NR	
Nd-144[e]	M	3	D	1.51E-04	ICRP60	NR	NR	NR	NR	
Ni-59	M	3	D	2.10E-07	FGR11	NR	NR	NR	NR	
Ni-63	M	3	D	5.77E-07	FGR11	NR	NR	NR	NR	
Np-237	M	3	D	4.44E-03	FGR11	NR	NR	NR	NR	
Pa-231	M	3	D	1.06E-02	FGR11	NR	NR	NR	NR	
Pb-210	M	3	D	5.37E-03	FGR11	NR	NR	NR	NR	
Po-210	M	3	D	1.90E-03	FGR11	NR	NR	NR	NR	
Pu-238	M	3	D	3.20E-03	FGR11	NR	NR	NR	NR	
Pu-239	M	3	D	3.54E-03	FGR11	NR	NR	NR	NR	

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Pu-240	M	3	D	3.54E-03	FGR11	NR	NR	NR	NR	
Pu-241	M	3	D	6.84E-05	FGR11	NR	NR	NR	NR	
Pu-242	M	3	D	3.36E-03	FGR11	NR	NR	NR	NR	
Ra-226	M	3	D	1.32E-03	FGR11	NR	NR	NR	NR	
Ra-228	M	3	D	1.44E-03	FGR11	NR	NR	NR	NR	
Sm-148[e]	M	3	D	1.58E-04	ICRP60	NR	NR	NR	NR	
Sr-90	M	3	D	1.42E-04	FGR11	NR	NR	NR	NR	
Tc-99	M	3	D	1.46E-06	FGR11	NR	NR	NR	NR	
Th-228	M	3	D	3.96E-04	FGR11	NR	NR	NR	NR	
Th-229	M	3	D	3.53E-03	FGR11	NR	NR	NR	NR	
Th-230	M	3	D	5.48E-04	FGR11	NR	NR	NR	NR	
Th-232	M	3	D	2.73E-03	FGR11	NR	NR	NR	NR	
U-233	M	3	D	2.89E-04	FGR11	NR	NR	NR	NR	
U-234	M	3	D	2.83E-04	FGR11	NR	NR	NR	NR	
U-235	M	3	D	2.66E-04	FGR11	NR	NR	NR	NR	
U-236	M	3	D	2.69E-04	FGR11	NR	NR	NR	NR	
U-238	M	3	D	2.55E-04	FGR11	NR	NR	NR	NR	
Plant Transfer Factors (pCi/g plant)/(pCi/g soil)										
Ac-227	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Am-241	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Am-243	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
C-14	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-243	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-244	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Co-60	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cs-134	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cs-137	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-152	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-154	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Fe-55	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Gd-152	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
H-3	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Nb-94	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Nd-144	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-59	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-63	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Np-237	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pa-231	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pb-210	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pm-147	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Po-210	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-238	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-239	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-240	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-241	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-226	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-228	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sb-125	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sm-148	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sr-90	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Tc-99	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-228	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-229	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-230	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-232	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-233	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-234	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-235	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-236	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Meat Transfer Factors (pCi/kg)/(pCi/d)										
Ac-227	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ag-108m	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Am-241	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Am-243	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
C-14	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-243	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-244	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Co-60	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cs-134	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cs-137	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-152	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-154	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Fe-55	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Gd-152	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
H-3	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Nb-94	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Nd-144	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-59	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-63	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Np-237	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pa-231	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pb-210	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Po-210	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-238	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-239	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-240	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-241	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-226	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-228	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sb-125	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sm-148	P	1	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sr-90	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Tc-99	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Th-228	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-229	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-230	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-232	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-233	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-234	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-235	**P**	**2**	**D**	**NA**	**Industrial Scenario**	**NR**	**NR**	**NR**	**NR**	
U-236	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Milk Transfer Factors (pCi/L)/(pCi/d)										
Ac-227	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Am-241	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Am-243	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
C-14	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-243	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-244	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Co-60	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cs-134	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cs-137	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-152	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-154	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Fe-55	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Gd-152	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
H-3	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Nb-94	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Nd-144	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-59	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-63	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Np-237	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pa-231	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pb-210	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Po-210	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-238	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Pu-239	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-240	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-241	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-226	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-228	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sm-148	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sr-90	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Tc-99	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-228	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-229	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-230	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-232	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-233	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-234	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-235	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-236	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Bioaccumulation Factors for Fish ((pCi/kg)/(pCi/L))										
Ac-227	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Am-241	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Am-243	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
C-14	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-243	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-244	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-245	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-246	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Co-60	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cs-137	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-152	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-154	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Gd-152	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
H-3	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
I-129	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Nb-94	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-59	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-63	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Np-237	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pa-231	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Po-210	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pb-210	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-238	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-239	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-240	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-241	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-242	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-226	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-228	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sr-90	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-228	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-229	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-230	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-232	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-233	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-234	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-235	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-236	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-238	P	2	D	NA	Industrial Scenario	NR	NR	NR	NR	
Bioaccumulation Factors for Crustacea/ Mollusks ((pCi/kg)/(pCi/L))										
Ac-227	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Am-241	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Am-243	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
C-14	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-243	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-244	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Cm-245	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cm-246	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Co-60	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Cs-137	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-152	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Eu-154	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Gd-152	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
H-3	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
I-129	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Nb-94	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-59	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ni-63	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Np-237	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pa-231	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pb-210	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Po-210	P	S	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-238	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-239	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-240	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-241	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Pu-242	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-226	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Ra-228	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Sr-90	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-228	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-229	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-230	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Th-232	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-233	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-234	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-235	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
U-236	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	

BFM INSITU RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
U-238	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Graphics Parameters										
Number of points				32	RESRAD Default	NR	NR	NR	NR	
Spacing				log	RESRAD Default	NR	NR	NR	NR	
Time integration parameters										
Maximum number of points for dose				17	RESRAD Default	NR	NR	NR	NR	

Notes:
a P = physical, B = behavioral, M = metabolic; (see NUREG/CR-6697, Attachment B, Table 4.)
b 1 = high-priority parameter, 2 = medium-priority parameter, 3 = low-priority parameter (see NUREG/CR-6697, Attachment B, Table 4.1)
c D = deterministic, S = stochastic
d Distributions Statistical Parameters:
Lognormal-n: 1= mean, 2 = standard deviation
Bounded lognormal-n: 1= mean, 2 = standard deviation, 3 = minimum, 4 = maximum
Truncated lognormal-n: 1= mean, 2 = standard deviation, 3 = lower quantile, 4 = upper quantile
Bounded normal: 1 = mean, 2 = standard deviation, 3 = minimum, 4 = maximum
Beta: 1 = minimum, 2 = maximum, 3 = P-value, 4 = Q-value
Triangular: 1 = minimum, 2 = mode, 3 = maximum
Uniform: 1 = minimum, 2 = maximum e Sm-148 an ND-144 not listed in RESRAD FGR 11 DCF file
e Reference: Haley and Aldrich, Inc., "Hydrogeological Investigation Report La Crosse Boiling Water Reactor, Dairyland Power Cooperative, Genoa, WI, January 2015
f ZionSolutions Technical Support Document 14-003, Conestoga Rovers & Associates (CRA) Report, "Zion Hydrogeologic Investigation Report"
g Argonne National Laboratory, "User's Manual for RESRAD Version 6", ANL/EAD 4, July 2001

Attachment 6
Calculation of BFM Insitu Groundwater DCGL Reactor Building

Reactor Building: BFM Insitu Groundwater DCGLs

RESRAD Parameter Calculations

Inputs to RESRAD Parameter Calculation

ground surface	639.00	foot elevation
Maximum water table level	629	foot elevation
Cover Depth	3	ft
conversion factor	0.3048	m per ft
conversion factor	0.0283	m3 per ft3
Fill Density	1.76	g/cm^3
conversion factor	1.00E+06	cm^3 per m^3
conversion Factor	9.29E-02	m^2/ft^2
Bottom of Rx Building Liner[1]	612.00	foot elevation
Reactor Building Diameter above 619'[1]	60	ft
Reactor Building Diameter above 619'	18.288	m
Reactor Building Diameter below 619'[1]	50	ft
Reactor Building Diameter below 619'	15.24	m
Reactor Building Fill Volume below 636'[1]	52479.32	ft^3
Reactor Building Fill Volume Below 619[1]	4829.46	ft^3
Reactor Building Fill Volume above 636-619	47649.86	ft^3
Reactor Building Surface Area below 636[1]	5506.36	ft2
Reactor Building Surface Area Below 619[1]	2646.77	ft2
Reactor Building Surface Area above 636-619	2859.59	ft2

Note 1: Reference TSD RS-TD-313196-002 La Crosse End State Basement Concrete Surface Areas, Volumes, and Void Spaces

Reactor Building Fill Volume at Various Depths

	Fill Volume Below 636' (m3)	Fill Volume Below 619' (m3)	Fill Volume Between 636' and 619' (m3)
Reactor Building	1485.16	136.67	1348.49

Calculation - RESRAD Parameters Rx (629' WT)

cover depth	0.91	m
Area of Contaminated Zone	262.68	m2
Source Term Thickness	7.32	m
Unsaturated Zone Thickness	0	m
Length Parallel to flow	18.29	m
Source Term Above Water Table	2.13	m
Contaminated Fraction Below Wate	0.71	

Reactopr Building: Calculation of BFM Insitu$_{gw}$ DCGLs

Inputs to BFM Insitu$_{gw}$ DCGL Calculation

Unit inventory in concrete	1	pci/m^2
pCi/g fill per pCi/m^2 in concrete Below 619' Elevation	1.02E-06	pCi/g per pCi/m^2
pCi/g fill per pCi/m^2 in concrete Between 636' and 612' Elevation	1.96E-07	pCi/g per pCi/m2

BFM Insitu$_{gw}$ DCGLs for Reactor Building

Radionuclide	RESRAD DSR[1] (mrem/yr per pCi/g fill)	BFM Insitu$_{gw}$ (mrem/y per pCi/m^2)	Reactor Building BFM Insitu$_{gw}$ DCGL (pCi/m^2)
H-3	5.916E-03	1.16E-09	2.16E+10
C-14	1.581E-01	3.09E-08	8.08E+08
Fe-55	3.787E-03	7.41E-10	3.37E+10
Ni-59	3.940E-04	7.71E-11	3.24E+11
Co-60	6.691E-01	1.31E-07	1.91E+08
Ni-63	1.079E-03	2.11E-10	1.18E+11
Sr-90	6.440E+00	1.26E-06	1.98E+07
Nb-94	1.546E-01	3.03E-08	8.26E+08
Tc-99	1.355E-01	2.65E-08	9.43E+08
Cs-137	2.674E-01	5.23E-08	4.78E+08
Eu-152	1.824E-02	3.57E-09	7.00E+09
Eu-154	2.649E-02	5.18E-09	4.82E+09
Eu-155	4.112E-03	8.05E-10	3.11E+10
Np-237	3.887E+02	7.61E-05	3.29E+05
Pu-238	5.089E+00	9.96E-07	2.51E+07
Pu-239	5.652E+00	1.11E-06	2.26E+07
Pu-240	5.651E+00	1.11E-06	2.26E+07
Pu-241	1.090E-01	2.13E-08	1.17E+09
Am-241	3.066E+00	6.00E-07	4.17E+07
Am-243	3.054E+00	5.98E-07	4.18E+07
Cm-243	7.831E-01	1.53E-07	1.63E+08
Cm-244	6.260E-01	1.23E-07	2.04E+08

Note 1: Reference RESRAD Report "LACBWR BFM Rx DSR 12117.pdf"

Attachment 7
Calculation of BFM Insitu Groundwater DCGL Waste Gas Tank Vault

Waste Gas Tank Vault: Basement Fill Model Insitu Groundwater DCGLs

WGTV Specific RESRAD Parameters

Inputs to Calculation

WGTV Floor Elevation	621.00	ft
Maximum Water Table Elevation	629.00	ft
Ground Surface Elevation	639.00	ft
Cover depth	3.00	ft
WGTV Total Surface Area (floor, walls, ceiling)	3343.00	ft2
WGTV Width[1]	29.50	ft
WGTV Length[1]	31.50	ft
WGTV Fill Volume[1]	10772.60	ft3
Conversion Factor	0.3048	m per ft
Conversion Factor	0.0929	m2/ft2
Conversion Factor	0.0283	m3/ft3

Note 1: Reference TSD RS-TD-313196-002 La Crosse End State Basement Concrete Surface Areas, Volumes, and Void Spaces, Rev 0

WGTV RESRAD Parameters (629' GW Elevation)

Cover depth	0.91	m
Thickness of Contaminated Zone	4.57	m
Area of Contaminated Zone	86.33	m^2
Length Parallel to flow	9.60	m
Unsaturated Zone Thickness	0.00	m
Depth of contamination above water table	2.13	m
Depth of contamination below water table	2.44	m
fraction below water table	0.53	

WGTV: Calculation of BFM Insitu$_{gw}$ DCGL

Inputs to Calculation

Fill Density	1.76	g/cm^3
conversion factor	1.00E+04	cm^2 per m^2
conversion factor	1.00E+06	cm3 per m3
unit inventory in concrete	1	pCi/m^2
pCi/g fill per pCi/m^2 in concrete	5.79E-07	pCi/g per pCi/m^2

BFM Insitu$_{gw}$ DCGLs for WGTV

Radionuclide	**RESRAD DSR**[1] (mrem/yr per pCi/g)	**WGTV BFM Insitu$_{gw}$ DF** (mrem/yr per pCi/m^2)	**WGTV BFM Insitu$_{gw}$ DCGL** (pCi/m^2)
H-3	2.703E-03	1.56E-09	1.60E+10
C-14	8.069E-02	4.67E-08	5.35E+08
Fe-55	1.852E-03	1.07E-09	2.33E+10
Ni-59	2.032E-04	1.18E-10	2.13E+11
Co-60	3.759E-01	2.18E-07	1.15E+08
Ni-63	5.003E-04	2.90E-10	8.63E+10
Sr-90	3.661E+00	2.12E-06	1.18E+07
Nb-94	6.640E-02	3.84E-08	6.50E+08
Tc-99	6.195E-02	3.59E-08	6.97E+08
Cs-137	1.295E-01	7.50E-08	3.34E+08
Eu-152	8.675E-03	5.02E-09	4.98E+09
Eu-154	1.260E-02	7.29E-09	3.43E+09
Eu-155	1.955E-03	1.13E-09	2.21E+10
Np-237	1.854E+02	1.07E-04	2.33E+05
Pu-238	2.398E+00	1.39E-06	1.80E+07
Pu-239	2.911E+00	1.68E-06	1.48E+07
Pu-240	2.907E+00	1.68E-06	1.49E+07
Pu-241	5.311E-02	3.07E-08	8.13E+08
Am-241	1.499E+00	8.68E-07	2.88E+07
Am-243	1.567E+00	9.07E-07	2.76E+07
Cm-243	3.658E-01	2.12E-07	1.18E+08
Cm-244	2.924E-01	1.69E-07	1.48E+08

Note 1: Reference RESRAD Report "LACBWR BFM WGTV DSR 121117.pdf"

Attachment 8
BFM Drilling Spoils DCGL Calculation

Basement Fill Model (BFM) Insitu - Drilling Spoils Scenario

Assumptions and Unit Conversion Factors

Diameter Borehole[1]	12.00	inch
Minimum Depth to Backfilled	91.44	cm
Depth of contamination within	2.54	cm
unit conversion	1.00E+06	cm3/m3
Fill Density[2]	1.76	g/cm3
unit conversion	1.00E-09	mCi/pCi
Diameter Borehole	30.48	cm
Area Borehole	729.66	cm2
concrete	93.98	cm
Unit Concentration	1.00	pCi/g
Unit Area Factor	1.00	unitless
unit conversion	1.00E+04	cm2/m2
unit conversion	0.0929	m2 per ft2
unit conversion	2.54	cm per inch
unit conversion	30.48	cm per ft

Note 1: Based on Diameter of existing water wells at LACBWR site for industrial use

Note 2: Haley & Aldrich Inc., "Hydrogeological Investigation Report, La Crosse Boiling Water Reactor, Dairyland Power Cooperative, value Hydro Report Genoa Wisconsin", File No. 38705-008, January 2015.

Calculations

Total Spoils Volume	6.86E+04	cm3
Total Spoils Volume	6.86E-02	m3
Total Spread Area	4.57E-01	m2
Total Drilling Spoils Mass	1.21E+05	g
Total pCi in Spoils	1.21E+05	pCi (assuming Unit Concentration 1 pCi/g in spoils and AF=1)
pCi/cm2 borehole	1.65E+02	pCi/cm2 (assuming unit concentration 1 pCi/g in spoils and AF=1)
pCi/m2 borehole	1.65E+06	pCi/m2 (assuming unit concentration 1 pCi/g in spoils and AF=1)

Calculation of Area Factors and DCGLs (pCi/m ^{2}) for BFM Insitu Drilling Spoils Scenario (Insitu $_{ds}$)

Radionuclide	Soil DCGL (pCi/g per 25 mrem/yr)	Drilling Spoils 0.457 m^2 Spread Area Dose/Source Ratio (DSR)[1] (mrem/yr per pCi/g)	Area Factor	BFM Insitu $_{ds}$ DCGLs For All Basements (pCi/m ^{2})
H-3	1.746E+04	8.123E-07	1762.70	5.09E+13
C-14	2.448E+05	9.407E-09	10856.19	4.40E+15
Fe-55	1.018E+07	9.119E-10	2693.05	4.53E+16
Ni-59	2.594E+07	6.727E-10	1432.68	6.15E+16
Co-60	1.281E+01	6.896E-02	28.30	6.00E+08
Ni-63	9.478E+06	1.642E-09	1606.39	2.52E+16
Sr-90	6.586E+03	1.213E-04	31.29	3.41E+11
Nb-94	2.018E+01	4.742E-02	26.13	8.72E+08
Tc-99	3.563E+02	3.009E-05	2331.86	1.37E+12
Cs-137	5.812E+01	1.689E-02	25.47	2.45E+09
Eu-152	2.844E+01	3.265E-02	26.92	1.27E+09
Eu-154	2.636E+01	3.474E-02	27.30	1.19E+09
Eu-155	1.122E+03	1.201E-03	18.55	3.44E+10
Np-237	7.991E-01	4.206E-03	7438.23	9.83E+09
Pu-238	1.660E+03	7.392E-05	203.74	5.59E+11
Pu-239	1.494E+03	8.150E-05	205.32	5.07E+11
Pu-240	1.496E+03	8.097E-05	206.39	5.11E+11
Pu-241	3.637E+04	8.353E-06	82.29	4.95E+12
Am-241	1.089E+03	4.270E-04	53.76	9.68E+10
Am-243	1.868E+02	5.734E-03	23.34	7.21E+09
Cm-243	2.884E+02	3.521E-03	24.62	1.17E+10
Cm-244	2.668E+03	4.648E-05	201.60	8.90E+11

Note 1: Reference RESRAD Summary Report "LACBWR Drilling Spoils AF 092317.pdf"

Attachment 9
BFM Excavation DCGL Calculation

Basement Fill Model - Excavation Scenario

Inputs to Calculation

Unit Conversion Factor	0.0929	m2/ft2
Unit Conversion Factor	0.0283	m3/ft3
Unit Conversion Factor	0.3048	m/ft
Unit Concentration	1.00E+00	pCi/g
Concrete Density	2.35	g/cm^3
Unit Conversion Factor	1.00E+06	cm^3 per m^3
Unit Conversion Factor	1.00E-09	mCi/pCi
Unit Conversion Factor	1.00E+09	pCi/mCi

Surface Area, Mass and Void Space of Backfilled End State Structures (> 3' below grade)[1,2]

Structure	Floor Surface Area ft^2	Wall Surface Area ft^2	Ceiling Surface Area ft^2	Floor Concrete Volume ft^3	Wall Concrete Volume ft^3	Ceiling Concrete Volume ft^3	Void Space Vol ft^3
Waste Gas Tank Vault	767.00	2576.00	0.00	1027.25	2372.62	907.75	10772.60
Reactor Building	3904.15	1602.21	0.00	17816.02	1216.68	0.00	52479.32

Note 1: Reference TSD RS-TD-313196-002 "La Crosse End State Basement Concrete Surface Areas, Volumes, and Void Spaces" Rev 0

Note 2: TSD RS-TD-313196-002, Rev 0 assumed ceiling of WGTV would remain. A decision was made after issuance of TSD to remove ceiling

All Basement Concrete Excavated: Calculation of BFM Excavation Scenario total activity assuming unit concentration in concrete mass (1 pCi/g)[1]

Structure	Total Volume ft^3	Total Volume m^3	Total Surface Area ft^2	Total Surface Area m^2	Total Activity at Unit Concrete Concentration (pCi/m^2 per pCi/g)
Reactor Building	19032.70	538.63	5506.36	511.54	2.47E+06
Waste Gas Tank Vault	4307.62	121.91	3343.00	310.56	9.22E+05

Note 1: Reference TSD RS-TD-313196-002 "La Crosse End State Basement Concrete Surface Areas, Volumes, and Void Spaces" Rev 0

Total Basement Concrete Excavation: Calculation of BFM Excavation Scenario DCGLs for Reactor Building, Waste Treatment Building and Remaining Structures

Radionuclide	Soil DCGL (pCi/g per 25 mrem/yr)	Rx Building Total Excavation DCGL (pCi/m^2 per 25 mrem/yr)	WGTV Total Excavation DCGL (pCi/m2 per 25 mrem/yr)
H-3	1.746E+04	4.32E+10	1.61E+10
C-14	2.448E+05	6.06E+11	2.26E+11
Fe-55	1.018E+07	2.52E+13	9.39E+12
Ni-59	2.594E+07	6.42E+13	2.39E+13
Co-60	1.281E+01	3.17E+07	1.18E+07
Ni-63	9.478E+06	2.35E+13	8.74E+12
Sr-90	6.586E+03	1.63E+10	6.08E+09
Nb-94	2.018E+01	4.99E+07	1.86E+07
Tc-99	3.563E+02	8.82E+08	3.29E+08
Cs-137	5.812E+01	1.44E+08	5.36E+07
Eu-152	2.844E+01	7.04E+07	2.62E+07
Eu-154	2.636E+01	6.52E+07	2.43E+07
Eu-155	1.122E+03	2.78E+09	1.03E+09
Np-237	7.991E-01	1.98E+06	7.37E+05
Pu-238	1.660E+03	4.11E+09	1.53E+09
Pu-239	1.494E+03	3.70E+09	1.38E+09
Pu-240	1.496E+03	3.70E+09	1.38E+09
Pu-241	3.637E+04	9.00E+10	3.35E+10
Am-241	1.089E+03	2.69E+09	1.00E+09
Am-243	1.868E+02	4.62E+08	1.72E+08
Cm-243	2.884E+02	7.14E+08	2.66E+08
Cm-244	2.668E+03	6.60E+09	2.46E+09

Partial Basement Concrete Excavation (walls only any depth): Ratio of Partial Excavation SA/V to Total Excation SA/V (surface area to volume)

Structure	Total Surface Area m2	Total Concrete SA/V (m^2/m^3)	Minimum Concrete Wall Thickness (ft)[1]	SA/V of concrete wall[2] (m^2/m^3)	Worst-Case SA/V ratio (Partial Excavation/ Total Excavation)
Waste Gas Tank Vault	310.56	2.55	0.75	4.37	1.72
Reactor Building	511.54	0.95	0.75	4.37	4.61

Note 1: Reference TSD RS-TD-313196-002 "La Crosse End State Basement Concrete Surface Areas, Volumes, and Void Spaces"

WGTV minimum wall thickness equal to 1/2 of center dividing wall thickness of 1.5 ft	1.5	ft
Rx Building minimum wall thickness is 9 inches.	9.0	inches
Note 2: Calculation based on 1m^2 wall section	1.0	m^2

Partial Basement Concrete Excavation: Calculation of BFM Excavation Scenario DCGLs for Reactor Building and WGTV Assuming Worst Case (i.e., thinnest) Concrete Wall SA/V ratio

Radionuclide	Rx Building Excavation Partial Excavation DCGL (pCi/m^2 per 25 mrem/yr)	WGTV Excavation Partial Excavation DCGL (pCi/m2 per 25 mrem/yr)
H-3	9.38E+09	9.38E+09
C-14	1.32E+11	1.32E+11
Fe-55	5.47E+12	5.47E+12
Ni-59	1.39E+13	1.39E+13
Co-60	6.88E+06	6.88E+06
Ni-63	5.09E+12	5.09E+12
Sr-90	3.54E+09	3.54E+09
Nb-94	1.08E+07	1.08E+07
Tc-99	1.91E+08	1.91E+08
Cs-137	3.12E+07	3.12E+07
Eu-152	1.53E+07	1.53E+07
Eu-154	1.42E+07	1.42E+07
Eu-155	6.03E+08	6.03E+08
Np-237	4.29E+05	4.29E+05
Pu-238	8.92E+08	8.92E+08
Pu-239	8.03E+08	8.03E+08
Pu-240	8.04E+08	8.04E+08
Pu-241	1.95E+10	1.95E+10
Am-241	5.85E+08	5.85E+08
Am-243	1.00E+08	1.00E+08
Cm-243	1.55E+08	1.55E+08
Cm-244	1.43E+09	1.43E+09

Attachment 10
Buried Pipe DCGL Calculation

Calculation of Buried Piping DCGLs

Inputs to Calculation

conversion Factor	0.0254	m/inch
soil density	1.76	g/cm^3
conversion factor	1.00E+06	cm^3/m^3
conversion factor	1.00E+04	cm^2/m^2
conversion factor	2.2	dpm/pCi
conversion factor	0.3048	m/ft
conversion factor	0.0929	m^2/ft^2
conversion factor	7.5	gal/ft^3
pipe length	1	m

Pipe Area, Volume and Internal Soil Mass Calculations for 1 m Length

Pipe Diameter (inch)	Pipe Circumference (m)	Pipe Surface Area for 1 m length (m^2)	Pipe Volume for 1 m length (m^3)
1.5	0.12	0.12	1.14E-03
2	0.16	0.16	2.03E-03
3	0.24	0.24	4.56E-03
6	0.48	0.48	1.82E-02
8	0.64	0.64	3.24E-02
10	0.80	0.80	5.07E-02
18	1.44	1.44	1.64E-01
24	1.92	1.92	2.92E-01
32	2.55	2.55	5.19E-01
48	3.83	3.83	1.17E+00
60	4.79	4.79	1.82E+00

Internal Surface Area of Buried Pipe (Group)

Pipe Diameter (in)	Pipe Length (ft)	Pipe Length (m)	Total Pipe Surface Area (m^2)	Total Pipe Volume (m^3)	Pipe Description
1.5	285	86.87	10.40	0.10	Water Well #3
2	115	35.05	5.59	0.07	Water Well #3
3	438	133.50	31.96	0.61	Water Well #3
6	40	12.19	5.84	0.22	High Pressure Service Water from LACBWR Crib House to G-3
6	863	263.04	125.94	4.80	Remaining Portion of High Pressure Service Water Supply to LACBWR Fire Suppression System
8	222	67.67	43.20	2.19	High Pressure Service Water from LACBWR Crib House to G-3
10	100	30.48	24.32	1.54	South Storm Drain
16	44	13.41	17.12	1.74	Low Pressure Service Water
18	105	32.00	45.97	5.25	Deicing Line
24	435	132.59	253.92	38.70	North Storm Drain
32	250	76.20	194.58	39.54	North Storm Drain
48	630	192.02	735.50	224.18	South Storm Drain
60	40	12.19	58.37	22.24	Remaining Portion of Circulating Water Intake Pipe
	Total		1552.70	341.19	

RESRAD Parameters for Insitu Scenario for Buried Pipe DSR calculation (no Circulating Water Discharger Piping)

Effective Insitu Buried Piping "Area of Contaminated Zone" RESRAD Parameter	1552.70	m^2
Effective Insitu Buried Piping "Thickness of Contaminated Zone" RESRAD Parameter	0.0254	m
Effective "Length Parallel to Flow" RESRAD Parameter	44.46	m
Cover Depth	3.02	m
Assumed "Thickness of Unsaturated Zone"[1]	0.00	m

Note 1: Depth of all pipe conservatively assumed to be equal to depth of lowest pipe @ 625 foot AMSL which is below the assumed water table elevation of 629'. All activity asumed to be in saturated zone.

RESRAD Parameters for Excavation Scenario for Buried Pipe DSR calculation (no Circulating Water Discharge Piping)

Effective Insitu Buried Piping "Area of Contaminated Zone" RESRAD Parameter	1552.70	m2
Effective Insitu Buried Piping "Thickness of Contaminated Zone" RESRAD Parameter	0.15	m
Effective "Length Parallel to Flow" RESRAD Parameter	44.46	m
Cover Depth	0.00	m
Assumed "Thickness of Unsaturated Zone"	2.90	m

Soil Concentration after 100% release of unit concentration (1 dpm/100 cm^2) surface contamination layer from buried pipe

conversion factor	2.2	dpm/pCi
Soil Density	1.76	g/cm^3
Assumed Thickness of initu mixing with adjacent soil	2.54	cm
Assumed Thickness of initu mixing with adjacent soil	15	cm
pCi/g per 1 dpm/100 cm^2 Insitu (assuming 1.76 g/cm^3 density and 2.54 cm thickness)	1.02E-03	pCi/g per dpm/100 cm^2
pCi/g per 1 dpm/100 cm2 Excavation (assuming 1.76 g/cm3 density and 15 cm thickness)	1.72E-04	pCi/g per dpm/100 cm2

Group Excavation Geometry: Calculation of dpm/100 cm2 corresponding to 25 mrem per year for all buried pipe combined (except Circulating Water Discharge pipe)

Radionuclide	**RESRAD DSR**[1] (mrem/yr per pCi/g)	**pCi/g per 25 mrem/yr**	**dpm/100cm**[2] per 25 mrem/yr
H-3	1.504E-04	1.66E+05	9.65E+08
C-14	3.017E-05	8.29E+05	4.81E+09
Fe-55	2.428E-06	1.03E+07	5.98E+10
Ni-59	9.537E-07	2.62E+07	1.52E+11
Co-60	1.720E+00	1.45E+01	8.44E+04
Ni-63	2.610E-06	9.58E+06	5.56E+10
Sr-90	3.599E-03	6.95E+03	4.03E+07
Nb-94	1.145E+00	2.18E+01	1.27E+05
Tc-99	6.026E-03	4.15E+03	2.41E+07
Cs-137	4.031E-01	6.20E+01	3.60E+05
Eu-152	7.963E-01	3.14E+01	1.82E+05
Eu-154	8.565E-01	2.92E+01	1.70E+05
Eu-155	2.195E-02	1.14E+03	6.62E+06
Np-237	9.549E+00	2.62E+00	1.52E+04
Pu-238	1.483E-02	1.69E+03	9.79E+06
Pu-239	1.648E-02	1.52E+03	8.81E+06
Pu-240	1.646E-02	1.52E+03	8.82E+06
Pu-241	4.051E-04	6.17E+04	3.58E+08
Am-241	2.248E-02	1.11E+03	6.46E+06
Am-243	1.311E-01	1.91E+02	1.11E+06
Cm-243	8.491E-02	2.94E+02	1.71E+06
Cm-244	9.235E-03	2.71E+03	1.57E+07

Note 1: Reference RESRAD File "LACBWR Buried Pipe Group Excavation 052618"

Group Insitu Geometry: Calculation of dpm/100 cm2 corresponding to 25 mrem per year for all buried pipe combined (except Circulating Water Discharge pipe)

Radionuclide	**RESRAD DSR**[1] (mrem/yr per pCi/g)	**pCi/g per 25 mrem/yr**	**dpm/100cm^2** per 25 mrem/yr[2]
H-3	5.354E-05	4.67E+05	4.59E+08
C-14	5.285E-04	4.73E+04	4.65E+07
Fe-55	1.930E-05	1.30E+06	1.27E+09
Ni-59	2.134E-06	1.17E+07	1.15E+10
Co-60	3.860E-03	6.48E+03	6.37E+06
Ni-63	5.333E-06	4.69E+06	4.61E+09
Sr-90	4.230E-02	5.91E+02	5.81E+05
Nb-94	2.417E-04	1.03E+05	1.02E+08
Tc-99	1.228E-03	2.04E+04	2.00E+07
Cs-137	1.351E-03	1.85E+04	1.82E+07
Eu-152	9.073E-05	2.76E+05	2.71E+08
Eu-154	1.318E-04	1.90E+05	1.87E+08
Eu-155	2.045E-05	1.22E+06	1.20E+09
Np-237	3.769E+00	6.63E+00	6.52E+03
Pu-238	2.512E-02	9.95E+02	9.79E+05
Pu-239	3.052E-02	8.19E+02	8.06E+05
Pu-240	3.034E-02	8.24E+02	8.10E+05
Pu-241	5.395E-04	4.63E+04	4.56E+07
Am-241	1.514E-02	1.65E+03	1.62E+06
Am-243	1.631E-02	1.53E+03	1.51E+06
Cm-243	3.835E-03	6.52E+03	6.41E+06
Cm-244	3.065E-03	8.16E+03	8.02E+06

Note 1: Reference RESRAD File "LACBWR Buried Pipe Group Insitu 031018"

CALCULATION OF DCGL FOR CIRCULATING WATER DISCHARGE LINE

Area, Volume and Depth of End State Circulating Water Discharge Pipe

Diameter (inch)	Length (m)	Surface Area (m^2)	Internal Volume (m^3)	Depth @ Pipe Bottom[1,2] (ft AMSL)
60.00	160.02	766.14	291.90	630.5

Note 1: Reference Drawing "Allison-Chambers, Circulating Water Plans and Sections, LACBWR Generator Plant,
Note 2: Centerline of pipe at 633 feet AMSL, Pipe Diameter 5 feet, therefore, pipe bottom at 630.5 feet AMSL.

RESRAD Parameters Circulating Water Discharge Pipe
Inputs

LACBWR Ground Surface	639	ft AMSL
LACBWR Ground Water Level	629	ft AMSL
Depth to Ground Water	3.05	m
Depth to bottom of circ water pipe	2.59	m

RESRAD Parameters Insitu Circulating Water Discharge Pipe

Area of Contaminated Zone	766.14	m^2
Length Parallel to Flow	160.02	m
Thickness of Contaminated Zone	0.0254	m
Cover Depth	2.59	m
Unsaturated Zone Depth	0.43	m

RESRAD Parameters Excavation Circulating Water Discharge Pipe

Area of Contaminated Zone	766.14	m2
Length Parallel to Flow	31.23	m
Thickness of Contaminated Zone	0.15	m
Cover Depth	0	m
Unsaturated Zone Depth	2.90	m

Circ Insitu Geometry: Calculation of dpm/100 cm^2 corresponding to 25 mrem per year for Circulating Water Discharge Pipe Only

Radionuclide	**RESRAD DSR**[1] (mrem/yr per pCi/g)	**pCi/g per 25 mrem/yr**	**dpm/100cm^2** per 25 mrem/yr[2]
H-3	1.527E-04	1.64E+05	1.61E+08
C-14	9.461E-04	2.64E+04	2.60E+07
Fe-55	1.536E-17	1.63E+18	2.03E+26
Ni-59	2.141E-06	1.17E+07	2.03E+26
Co-60	9.800E-05	2.55E+05	2.51E+08
Ni-63	2.213E-07	1.13E+08	1.11E+11
Sr-90	2.875E-02	8.70E+02	8.55E+05
Nb-94	2.421E-04	1.03E+05	1.02E+08
Tc-99	3.785E-03	6.61E+03	6.50E+06
Cs-137	3.763E-05	6.64E+05	6.53E+08
Eu-152	4.837E-11	5.17E+11	5.08E+14
Eu-154	2.485E-14	1.01E+15	9.89E+17
Eu-155	1.214E-22	2.06E+23	2.03E+26
Np-237	5.668E+00	4.41E+00	4.34E+03
Pu-238	3.606E-04	6.93E+04	6.82E+07
Pu-239	3.018E-02	8.28E+02	8.15E+05
Pu-240	2.868E-02	8.72E+02	8.57E+05
Pu-241	1.002E-04	2.50E+05	2.45E+08
Am-241	2.769E-03	9.03E+03	8.88E+06
Am-243	1.292E-02	1.93E+03	1.90E+06
Cm-243	3.629E-05	6.89E+05	6.78E+08
Cm-244	7.901E-05	3.16E+05	3.11E+08

Note 1: RESRAD File: "LACBWR Buried Pipe Circ Insitu 101117"

Circ Excavation Geometry: Calculation of dpm/100 cm^2 corresponding to 25 mrem per year for Circulating Water Discharge Pipe Only

Radionuclide	RESRAD DSR[1] (mrem/yr per pCi/g)	pCi/g per 25 mrem/yr	dpm/100cm^2 per 25 mrem/yr
H-3	1.080E-04	2.31E+05	1.34E+09
C-14	3.020E-05	8.28E+05	4.81E+09
Fe-55	1.860E-06	1.34E+07	7.81E+10
Ni-59	7.311E-07	3.42E+07	1.99E+11
Co-60	1.685E+00	1.48E+01	8.62E+04
Ni-63	2.001E-06	1.25E+07	7.26E+10
Sr-90	3.388E-03	7.38E+03	4.29E+07
Nb-94	1.123E+00	2.23E+01	1.29E+05
Tc-99	4.233E-03	5.91E+03	3.43E+07
Cs-137	3.955E-01	6.32E+01	3.67E+05
Eu-152	7.810E-01	3.20E+01	1.86E+05
Eu-154	8.396E-01	2.98E+01	1.73E+05
Eu-155	2.163E-02	1.16E+03	6.71E+06
Np-237	6.937E+00	3.60E+00	2.09E+04
Pu-238	1.143E-02	2.19E+03	1.27E+07
Pu-239	1.270E-02	1.97E+03	1.14E+07
Pu-240	1.269E-02	1.97E+03	1.14E+07
Pu-241	3.321E-04	7.53E+04	4.37E+08
Am-241	1.852E-02	1.35E+03	7.84E+06
Am-243	1.256E-01	1.99E+02	1.16E+06
Cm-243	8.120E-02	3.08E+02	1.79E+06
Cm-244	7.118E-03	3.51E+03	2.04E+07

Note 1: RESRAD File: "LACBWR Buried Pipe Circ Excavation DSR 052618"

Buried Pipe DCGLs for Radionuclides of Concern Adjusted for Insignificant Contributor Dose

Insignificant Contributor Dose Percentage[1]

Buried Pipe Group Insitu	10.000%
Buried Pipe Group Excavation	10.000%
Buried Pipe Circ Insitu	10.000%
Buried Pipe Circ Excavation	10.000%

Note 1: Reference TSD RS-TD-313196-001 Revision 4

Adjusted Buried Pipe DCGLs for Radionuclides of Concern (dpm/100 cm^2)

Radionuclide	Group Insitu	Group Excavation	Circ Insitu	Circ Excavation
Co-60	5.73E+06	7.60E+04	2.26E+08	7.76E+04
Sr-90	5.23E+05	3.63E+07	7.70E+05	3.86E+07
Cs-137	1.64E+07	3.24E+05	5.88E+08	3.30E+05
Eu-152	2.44E+08	1.64E+05	4.57E+14	1.67E+05
Eu-154	1.68E+08	1.53E+05	8.90E+17	1.56E+05

Combined Buried Pipe DCGL (dpm/100 cm^2)

Radionuclide	Group DCGL	Circ DCGL
Co-60	7.50E+04	7.75E+04
Sr-90	5.16E+05	7.55E+05
Cs-137	3.18E+05	3.30E+05
Eu-152	1.64E+05	1.67E+05
Eu-154	1.52E+05	1.56E+05

Attachment 11
Check Calculation for Maximum Concentration in Fill Material

Excavated Fill Material Concentration After 100% Release of Maximum Allowable Activity from Concrete

Input to Calculation

Adjusted BFM Individual Scenario DCGLs for ROC ($DCGL_{BS}$)

	Rx Bldg GW	Rx Bldg Drilling Spoils	Rx Bldg Excavation	WGTV GW	WGTV Drilling Spoils	WGTV Excavation
		pCi/m^2			pCi/m^2	
Co-60	1.37E+08	5.40E+08	6.19E+06	8.71E+07	5.40E+08	6.19E+06
Sr-90	1.66E+07	3.07E+11	3.18E+09	8.97E+06	3.07E+11	3.18E+09
Cs-137	2.25E+08	2.20E+09	2.81E+07	2.12E+08	2.20E+09	2.81E+07
Eu-152	3.10E+09	1.14E+09	1.38E+07	3.19E+09	1.14E+09	1.38E+07
Eu-154	2.14E+09	1.07E+09	1.27E+07	2.20E+09	1.07E+09	1.27E+07

Adjusted Summation BFM DCGLs ($DCGL_B$)

	Summation Rx Bldg BFM $DCGL_B$ (pCi/m^2)	Summation WGTV BFM $DCGL_B$ (pCi/m^2)
Co-60	5.86E+06	5.72E+06
Sr-90	1.65E+07	8.94E+06
Cs-137	2.47E+07	2.45E+07
Eu-152	1.35E+07	1.35E+07
Eu-154	1.25E+07	1.25E+07

Adjusted Soil DCGLs

	(pCi/g)
Co-60	11.53
Sr-90	5927.40
Cs-137	52.31
Eu-152	25.596
Eu-154	23.724

Basement Total Surface Area

Structure	Total Surface Area m2
Waste Gas Tank	
Vault	310.56
Reactor Building	511.54

Note 1: Reference TSD RS-TD-313196-002 La Crosse End State Basement Concrete Surface Areas, Volumes, and Void Spaces, Rev 0

Basement Total Fill Mass

	Void Volume (ft^3)	Void Volume (m^3)	Fill Density (g/cm^3)	Fill Mass (g)
Rx Bldg	52479.32	1485.16	1.76	2.61E+09
WGTV	10772.60	304.865	1.76	5.4E+08

Inputs to Calculation	Conversion Factor	1.00E+06	cm^3/m^3
	Conversion Factor	0.0283	m^3 per ft^3
	Conversion Factor	0.0929	m^2 per ft^2

Fill Concentration: Full Excavation and Activity Mixing with all Fill

Concentration Levels for each Radionuclide (Assuming Each ROC at BFM $DCGL_B$ Concentration)

	Fill Concentration Rx Bldg (pCi/g)	Fill Concentration WGTV (pCi/g)
Co-60	1.15E+00	3.31E+00
Sr-90	3.23E+00	5.18E+00
Cs-137	4.83E+00	1.42E+01
Eu-152	2.65E+00	7.83E+00
Eu-154	2.45E+00	7.25E+00

Unit Area	1 m^2
1 m fill distance from wall	1 m

Fill Concentration: Partial Fill Excavation and Activity Mixing Limited to 1 m^3 of Fill Imediately Adjacent

Concentration Levels for each Radionuclide (Assuming Each ROC at BFM $DCGL_B$ Concentration)

	Fill Concentration Rx Bldg (pCi/g)	Fill Concentration WGTV (pCi/g)
Co-60	3.33E+00	3.25E+00
Sr-90	9.37E+00	5.08E+00
Cs-137	1.40E+01	1.39E+01
Eu-152	7.69E+00	7.69E+00
Eu-154	7.11E+00	7.12E+00

Attachment 12
Alternate Scenario Uncertainty Analysis Input Parameters

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters [d]				
						1	2	3	4	Mean/ Median
Soil Concentrations										
Basic radiation dose limit (mrem/y)		3	D	25	10 CFR 20.1402	NR	NR	NR	NR	
Initial principal radionuclide (pCi/g)	P	2	D	Varies based on Radionuclide Mixture	Unit Value	NR	NR	NR	NR	
Distribution coefficients (contaminated, unsaturated, and saturated zones) (cm^3/g)										
Ac-227 (daughter of Cm-243 and Pu-239)	P	1	D	450	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	6.72	3.22	NA	NA	825
Am-241 (also daughter of Cm-245 and Pu-241)	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	7.28	3.15	NA	NA	1445
Am-243	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	7.28	3.15	NA	NA	1445
C-14	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	2.4	3.22	NA	NA	11
Cm-243	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	8.82	1.82	NA	NA	6761
Cm-244	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	8.82	1.82	NA	NA	6761
Co-60	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	5.46	2.53	NA	NA	235
Cs-137	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.1	2.33	NA	NA	446
Eu-152	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.72	3.22	NA	NA	825
Eu-154	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.72	3.22	NA	NA	825
Eu-155	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.72	3.22	NA	NA	825
Fe-55	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	5.34	2.67	NA	NA	209
Gd-152 (daughter for Eu-152)	P	1	D	825	Median Value NUREG/CR-6697, Att. C (No sand value listed in Table 3.9-2)	6.72	3.22	NA	NA	825
H-3	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	-2.81	0.5	NA	NA	0.06
Nb-94	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	5.94	3.22	NA	NA	380
Nd-144 (daughter for Eu-152)	P	1	D	158	RESRADv.7.0 Default Nd not listed in NUREG/CR-6697	NA	NA	NA	NA	NA
Ni-59	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.05	1.46	NA	NA	424
Ni-63	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.05	1.46	NA	NA	424
Np-237 (also daughter for Am-241, Cm-245, and Pu-241)	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	2.84	2.25	NA	NA	17

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	**Type[a]**	**Priority[b]**	**Treatment[c]**	**Value/Distribution**	**Basis**	**Distribution's Statistical Parameters [d]**				
						1	**2**	**3**	**4**	**Mean/ Median**
Pa-231 (daughter for Cm-243 and Pu-239)	P	1	D	550	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	5.94	3.22	NA	NA	380
Pb-210 (daughter for Pu-238)	P	1	D	270	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	7.78	2.76	NA	NA	181
Po-210 (daughter Pu-238)	P	1	D	150	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	5.20	1.68	NA	NA	181
Pu-238	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.86	1.89	NA	NA	953
Pu-239 (also daughter for Cm-243)	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.86	1.89	NA	NA	953
Pu-240 (also daughter for Cm-244)	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.86	1.89	NA	NA	953
Pu-241	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	6.86	1.89	NA	NA	953
Ra-226 (daughter Pu-238)	P	1	D	500	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	8.17	1.70	NA	NA	3533
Ra-228 (daughter Cm-244 and Pu-240)	P	1	D	500	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	8.17	1.70	NA	NA	3533
Sm-148 (daughter Eu-152)	P	1	D	245	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	6.72	3.22	NA	NA	825
Sr-90	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	3.45	2.12	NA	NA	32
Tc-99	P	1	S	Lognormal-N	NUREG/CR-6697 Att. C	-0.67	3.16	NA	NA	0.51
Th-228 (daughter Cm-244 and Pu-240)	P	1	D	3200	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	8.68	3.62	NA	NA	5884
Th-229 (daughter Am-241, Cm-245, Np-237, and Pu-241)	P	1	D	3200	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	8.68	3.62	NA	NA	5884

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters [d]				
						1	2	3	4	Mean/ Median
Th-230 (daughter Cm-246 and Pu-238)	P	1	D	3200	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	8.68	3.62	NA	NA	5884
Th-232 (daughter Cm-244 and Pu-240)	P	1	D	3200	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault	8.68	3.62	NA	NA	5884
U-233 (daughter Am-241, Cm-245, Np-237, and Pu-241)	P	1	D	35	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault C	4.84	3.13	NA	NA	126
U-234 (daughter Pu-238)	P	1	D	35	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault C	4.84	3.13	NA	NA	126
U-235 (daughter Cm-243 and Pu-239)	P	1	D	35	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault C	4.84	3.13	NA	NA	126
U-236 (daughter Cm-244 and Pu-240)	P	1	D	35	Mean Kd Value for sand NUREG/CR-6697, Table 3.9-2, Sheppard and Thibault C	4.84	3.13	NA	NA	126
Initial concentration of radionuclides present in groundwater (pCi/l)	P	3	D	0	No existing groundwater contamination	NR	NR	NR	NR	
Calculation Times										
Time since placement of material (y)	P	3	D	0	Start of dose calculation immediately after license termination	NR	NR	NR	NR	
Time for calculations (y)	P	3	D	0, 1, 3, 10, 30, 100, 300, 1000	RESRAD Default	NR	NR	NR	NR	
Contaminated Zone										
Area of contaminated zone (m^2)	P	2	D	7500	Size of LACBWR "Licensed Site Exclusion" (LSE) area	NR	NR	NR	NR	
Thickness of contaminated zone (m)	P	2	D	0.15	Assumed depth of surface soil	NR	NR	NR	NR	
Length parallel to aquifer flow (m)	P	2	D	98	Diameter of 7500 m2 contaminated zone	NR	NR	NR	NR	
Does the initial contamination penetrate the water table?	NA	NA	NA	No	Contaminated zone at surface	NA	NA	NA	NA	

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters [d]				
						1	2	3	4	Mean/ Median
Contaminated fraction below water table	P	3	D	0	Contaminated zone at surface	NR	NR	NR	NR	
Cover and Contaminated Zone Hydrological Data										
Cover depth (m)	P	2	D	0	No cover	NR	NR	NR	NR	
Density of cover material	P	2	D	NA	No cover	NR	NR	NR	NR	
Cover erosion rate	P,B	2	S	Continuous Logarithmic	NUREG/CR-6697 Att. C Table 3.8-1	5E-08	0.0007	0.005	0.2	0.0015
Density of contaminated zone (g/cm^3)	P	1	D	1.76	Site specific[e]	NR	NR	NR	NR	
Contaminated zone erosion rate m/y)	P,B	2	S	Continuous Logarithmic	NUREG/CR-6697 Att. C Table 3.8-1	5E-08	0.0007	0.005	0.2	0.0015
Contaminated zone total porosity	P	2	D	0.31	Site specific[e]	NR	NR	NR	NR	
Contaminated zone field capacity	P	3	D	0.2	RESRAD default. No distribution or median value provided in NURE/CR-6697 Att. C	NR	NR	NR	NR	
Contaminated zone hydraulic conductivity (m/y)	P	2	D	34822	Site specific[e] 313 feet/day = 34822 m/y	NR	NR	NR	NR	
Contaminated zone b parameter	P	2	S	Lognormal-N	Site specific soil type sand NUREG/CR-6697 Att. C Table 3.5-1	-.0253	0.216	NA	NA	0.97
Humidity in air (g/m^3)	P	3	D	7.2	Median NUREG/CR-6697 Att. C	1.98	0.334	0.001	0.999	7.2
Evapotranspiration coefficient	P	2	S	Uniform	NUREG/CR-6697 Att. C Figure 4.3-1	0.5	0.75	NR	NR	0.625
Average annual wind speed (m/s)	P	2	S	Bounded Lognormal - N	NUREG/CR-6697 Att. C Figure 4.5-1	1.445	0.2419	1.4	13	4.2
Precipitation (m/y)	P	2	D	0.78	NUREG/CR-6697 Att. C La Crosse, WI Table 4.1-2	NR	NR	NR	NR	
Irrigation (m/y)	B	3	D	0.20	NUREG-5512, Vol. 3, Table 6-18 (Wisconsin Average) Converted 0.56 $L/m^2/d$ to m/y	NR	NR	NR	NR	

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters [d]				
						1	2	3	4	Mean/ Median
Irrigation mode	B	3	D	NA	Overhead irrigation is common practice in U. S.	NR	NR	NR	NR	
Runoff coefficient	P	2	S	Uniform	NUREG/CR-6697 Att. C Figure 4.2-1	0.1	0.8	NR	NR	0.45
Watershed area for nearby stream or pond (m^2)	P	3	D	1.00E+06	RESRAD Default	NR	NR	NR	NR	
Accuracy for water/soil computations	-	3	D	1.00E-03	RESRAD Default	NR	NR	NR	NR	
Saturated Zone Hydrological Data										
Density of saturated zone (g/cm^3)	P	2	D	1.76	Site-specific[e]	NR	NR	NR	NR	
Saturated zone total porosity	P	1	D	0.31	Site-specific[e]	NR	NR	NR	NR	
Saturated zone effective porosity	P	1	D	0.28	Site-specific[e]	NR	NR	NR	NR	
Saturated zone field capacity	P	3	D	0.066	Calculated values for sand soil type[f]	NR	NR	NR	NR	
Saturated zone hydraulic conductivity (m/y)	P	1	D	34822	Site-specific value[e] 313 feet/day = 34822 m/y	NR	NR	NR	NR	
Saturated zone hydraulic gradient	P	2	D	0.0045	Site-specific[e]	NR	NR	NR	NR	
Saturated zone b parameter	P	2	S	Lognormal-N	Site specific soil type sand NUREG/CR-6697 Att. C Table 3.5-1	-.0253	0.216	NA	NA	0.97
Water table drop rate (m/y)	P	3	D	0	Assumed zero due to hydraulic connectivity with Mississippi river.	NR	NR	NR	NR	

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters [d]				
						1	2	3	4	Mean/ Median
Well pump intake depth (m below water table)	P	2	S	Triangular	Site-specific distribution Existing industrial water supply wells onsite at depth of 116' and 129' below ground surface (the 129' depth equals 36.3 m below the water table). 36.3 m assumed to be maximum well depth. Minimum well depth assumed to be represented by a nominal 20' screen depth (6.1 m) starting at the maximum "seasonal" water table elevation of 629' and extending to 10' below 619' elevation where water table continuously present. Mode is assumed to be mid-point between 6.1 m and 36.3 m which is 21.2 m. Note that the site-specific distribution is reasonably similar to the NUREG-6697 distribution values of 6, 10, and 30 for the triangular distribution.	6.1	21.2	36.3	NR	
Model: Nondispersion (ND) or Mass-Balance (MB)	P	3	D	ND	Applicable to flowing groundwater	NR	NR	NR	NR	

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	**Type[a]**	**Priority[b]**	**Treatment[c]**	**Value/Distribution**	**Basis**	**Distribution's Statistical Parameters [d]**				
						1	**2**	**3**	**4**	**Mean/ Median**
Well pumping rate (m^3/y)	P	2	S	530	Calculated according to method described in NUREG/CR-6697, Att. C Section 3.10 assuming 7,500 m2 land area (LACBWR site area) and Wisconsin specific irrigation rate. Resident gardener with no livestock.	NR	NR	NR	NR	
Unsaturated Zone Hydrological Data										
Number of unsaturated zone strata	P	3	D	1	Site-specific[e]	NR	NR	NR	NR	
Unsat. zone thickness (m)	P	1	D	2.90 m	Site Specific Assumed ground surface 639’ elevation, contaminated Zone thickness 0.15 m, and maximum water table elevation of 629’.	NR	NR	NR	NR	
Unsat. zone soil density (g/cm^3)	P	2	D	1.76	Site-specific[e]	NR	NR	NR	NR	
Unsat. zone total porosity	P	2	D	0.31	Site-specific[e]	NR	NR	NR	NR	
Unsat. zone effective porosity	P	2	D	0.28	Site-specific[e]	NR	NR	NR	NR	
Unsat. zone field capacity	P	3	D	0.066	Calculated values for sand soil type[f]	NR	NR	NR	NR	
Unsat. zone hydraulic conductivity (m/y)	P	2	D	34822	Site-specific[e]	NR	NR	NR	NR	
Unsat. zone soil-specific b parameter	P	2	S	Lognormal-N	Site specific soil type sand NUREG/CR-6697 Att. C Table 3.5-1	-.0253	0.216	NA	NA	0.97
Occupancy										
Inhalation rate (m^3/y)	M,B	3	D	8400	NUREG/CR-5512, Vol. 3 Table 6.29 (23 m^3/d x 365 d)	NR	NR	NR	NR	

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters [d]				
						1	2	3	4	Mean/ Median
Mass loading for inhalation (g/m^3)	P,B	2	S	Continuous Linear	NUREG/CR-6697, Att. C	See NUREG-6697 Table 4.6-1	See NUREG-6697 Table 4.6-1	See NUREG-6697 Table 4.6-1	See NUREG-6697 Table 4.6-1	2.35E-05
Exposure duration	B	3	D	30	RESRAD User's Manual parameter value not used in dose calculation	NR	NR	NR	NR	
Indoor dust filtration factor	P,B	2	S	Uniform	NUREG/CR-6697, Att. C Figure 7.1-1	0.15	0.95	NR	NR	0.55
Shielding factor, external gamma	P	2	S	Bounded Lognormal-N	NUREG/CR-6697, Att. C Table 7.10-1	-1.3	0.59	0.044	1	0.2725
Fraction of time spent indoors	B	3	D	0.649	NUREG/CR-5512, Vol. 3 Table 6.87	NR	NR	NR	NR	
Fraction of time spent outdoors (on site)	B	3	D	0.124	NUREG/CR-5512, Vol. 3 Table 6.87 (outdoors + gardening)	NR	NR	NR	NR	
Shape factor flag, external gamma	P	3	D	Circular	Circular contaminated zone assumed for modeling purposes	NR	NR	NR	NR	
Ingestion, Dietary										
Fruits, non-leafy vegetables, grain consumption (kg/y)	M,B	2	D	112	NUREG/CR-5512, Vol. 3 (other vegetables + fruits + grain) Table 6.87	NR	NR	NR	NR	
Leafy vegetable consumption (kg/y)	M,B	3	D	21.4	NUREG/CR-5512, Vol. 3 Table 6.87	NR	NR	NR	NR	
Milk consumption (L/y)	M,B	2	D	NA	No Livestock	NR	NR	NR	NR	
Meat and poultry consumption (kg/y)	M,B	3	D	NA	No Livestock	NR	NR	NR	NR	
Fish consumption (kg/y)	M,B	3	D	NA	No Fish consumption	NR	NR	NR	NR	
Other seafood consumption (kg/y)	M,B	3	D	NA	No Seafood consumption	NR	NR	NR	NR	
Soil ingestion rate (g/y)	M,B	2	D	18.3	NUREG/CR-5512, Vol. 3 Table 6.87	NR	NR	NR	NR	
Drinking water intake (L/y)	M,B	2	D	478	NUREG/CR-5512, Vol. 3 Table 6.87	NR	NR	NR	NR	
Contamination fraction of drinking water	B,P	3	D	1	All water assumed contaminated	NR	NR	NR	NR	
Contamination fraction of household water (if used)	B,P	3		NA	Only applicable to radon pathway					

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters [d]				
						1	2	3	4	Mean/ Median
Contamination fraction of livestock water	B,P	3	D	NA	No Livestock	NR	NR	NR	NR	
Contamination fraction of irrigation water	B,P	3	D	1	All water assumed contaminated	NR	NR	NR	NR	
Contamination fraction of aquatic food	B,P	2	D	NA	No aquatic food ingestion	NR	NR	NR	NR	
Contamination fraction of plant food	B,P	3	D	1	NUREG/CR-5512, Table 6.87 ingestion rates assumes source is residential garden	NR	NR	NR	NR	
Contamination fraction of meat	B,P	3	D	NA	No Livestock	NR	NR	NR	NR	
Contamination fraction of milk	B,P	3	D	NA	No Livestock	NR	NR	NR	NR	
Ingestion, Non-Dietary										
Livestock fodder intake for meat (kg/day)	M	3	D	NA	No Livestock	NR	NR	NR	NR	
Livestock fodder intake for milk (kg/day)	M	3	D	NA	No Livestock	NR	NR	NR	NR	
Livestock water intake for meat (L/day)	M	3	D	NA	No Livestock	NR	NR	NR	NR	
Livestock water intake for milk (L/day)	M	3	D	NA	No Livestock	NR	NR	NR	NR	
Livestock soil intake (kg/day)	M	3	D	NA	No Livestock	NR	NR	NR	NR	
Mass loading for foliar deposition (g/m^3)	P	3	D	4.00E-04	NUREG/CR-5512, Vol. 3 Table 6.87, gardening	NR	NR	NR	NR	
Depth of soil mixing layer (m)	P	2	S	Triangular	NUREG/CR-6697, Att. C Figure 3.12-1	0	0.15	0.6	NR	0.15
Depth of roots (m)	P	1	S	Uniform	NUREG/CR-6697, Att. C	0.3	4.0			2.15
Drinking water fraction from ground water	B,P	3	D	1	All water assumed to be supplied from groundwater	NR	NR	NR	NR	
Household water fraction from ground water (if used)	B,P	3	D	NA	Only applicable to radon pathway	NR	NR	NR	NR	
Livestock water fraction from ground water	B,P	3	D	NA	No Livestock	NR	NR	NR	NR	
Irrigation fraction from ground water	B,P	3	D	1	All water assumed to be supplied from groundwater	NR	NR	NR	NR	
Wet weight crop yield for Non-Leafy (kg/m^2)	P	2	S	Truncated Lognormal - N	NUREG/CR-6697, Att. C	0.56	0.48	0.001	0.999	1.75

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	**Type[a]**	**Priority[b]**	**Treatment[c]**	**Value/Distribution**	**Basis**	**Distribution's Statistical Parameters [d]**				
						1	**2**	**3**	**4**	**Mean/ Median**
Wet weight crop yield for Leafy (kg/m^2)	P	3	S	2.89	NUREG/CR-5512, Vol. 3 Table 6.87	NR	NR	NR	NR	
Wet weight crop yield for Fodder (kg/m^2)	P	3	D	NA	Industrial Scenario	NR	NR	NR	NR	
Growing Season for Non-Leafy (y)	P	3	D	0.246	NUREG/CR-5512, Vol. 3 Table 6.87	NR	NR	NR	NR	
Growing Season for Leafy (y)	P	3	D	0.123	NUREG/CR-5512, Vol. 3 Table 6.87	NR	NR	NR	NR	
Growing Season for Fodder (y)	P	3	D	NA	No Livestock	NR	NR	NR	NR	
Translocation Factor for Non-Leafy	P	3	D	0.1	NUREG/CR-5512, Vol. 3 Table 6.87	NR	NR	NR	NR	
Translocation Factor for Leafy	P	3	D	1	NUREG/CR-5512, Vol. 3 Table 6.87	NR	NR	NR	NR	
Translocation Factor for Fodder	P	3	D	NA	No Livestock	NR	NR	NR	NR	
Weathering Removal Constant for Vegetation (1/y)	P	2	S	Triangular	NUREG/CR-6697, Att. C	5.1	18	84		33
Wet Foliar Interception Fraction for Non-Leafy	P	3	D	0.35	NUREG/CR-5512, Vol. 3 Table 6.87	NR	NR	NR	NR	
Wet Foliar Interception Fraction for Leafy Vegetables	P	2	S	Triangular	NUREG/CR-6697, Att. C	0.06	0.67	0.95		0.58
Wet Foliar Interception Fraction for Fodder	P	3	D	NA	No Livestock	NR	NR	NR	NR	
Dry Foliar Interception Fraction for Non-Leafy	P	3	D	0.35	NUREG/CR-5512, Vol. 3 Table 6.87	NR	NR	NR	NR	
Dry Foliar Interception Fraction for Leafy	P	3	D	0.35	NUREG/CR-5512, Vol. 3 Table 6.87	NR	NR	NR	NR	
Dry Foliar Interception Fraction for Fodder	P	3	D	NA	No Livestock	NR	NR	NR	NR	
Storage times of contaminated foodstuffs (days):										
Fruits, non-leafy vegetables, and grain	B	3	D	14	NUREG/CR-5512, Vol. 3 Table 6.87	NR	NR	NR	NR	
Leafy vegetables	B	3	D	1	NUREG/CR-5512, Vol. 3 Table 6.87	NR	NR	NR	NR	
Milk	B	3	D	NA	No Livestock	NR	NR	NR	NR	
Meat and poultry	B	3	D	NA	No Livestock	NR	NR	NR	NR	
Fish	B	3	D	NA	No Aquatic Food Consumption	NR	NR	NR	NR	
Crustacea and mollusks	B	3	D	NA	No Aquatic Food Consumption	NR	NR	NR	NR	

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters [d]				
						1	2	3	4	Mean/ Median
Well water	B	3	D	1	RESRAD User's Manual Table D.6	NR	NR	NR	NR	
Surface water	B	3	D	1	RESRAD User's Manual Table D.6	NR	NR	NR	NR	
Livestock fodder	B	3	D	NA	No Livestock	NR	NR	NR	NR	
Special Radionuclides (C-14)										
C-12 concentration in water (g/cm³)	P	3	D	NA	NA	NR	NR	NR	NR	
C-12 concentration in contaminated soil (g/g)	P	3	D	NA	NA	NR	NR	NR	NR	
Fraction of vegetation carbon from soil	P	3	D	NA	NA	NR	NR	NR	NR	
Fraction of vegetation carbon from air	P	3	D	NA	NA	NR	NR	NR	NR	
C-14 evasion layer thickness in soil (m)	P	2	D	NA	NA	NR	NR	NR	NR	
C-14 evasion flux rate from soil (1/sec)	P	3	D	NA	NA	NR	NR	NR	NR	
C-12 evasion flux rate from soil (1/sec)	P	3	D	NA	NA	NR	NR	NR	NR	
Fraction of grain in beef cattle feed	B	3	D	NA	NA	NR	NR	NR	NR	
Fraction of grain in milk cow feed	B	3	D	NA	NA	NR	NR	NR	NR	
Dose Conversion Factors (Inhalation mrem/pCi)										
All Nuclides (except two listed below)	M	3	D	Values in RESRAD "FGR 11" DCF File	FGR11	NR	NR	NR	NR	
Nd-144[e]	M	3	D	7.04E-02	ICRP 107	NR	NR	NR	NR	
Sm-148[e]	M	3	D	7.34E-02	ICRP 107	NR	NR	NR	NR	
Dose Conversion Factors (Ingestion mrem/pCi)										
All Nuclides (except two listed below)	M	3	D	Values in RESRAD "FGR 11" DCF File	FGR11	NR	NR	NR	NR	
Nd-144[e]	M	3	D	1.51E-04	ICRP107	NR	NR	NR	NR	
Sm-148[e]	M	3	D	1.58E-04	ICRP107	NR	NR	NR	NR	
Plant Transfer Factors (pCi/g plant)/(pCi/g soil)										
Ac-227	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.91	1.1	NR	NR	9.98E-04
Am-241	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.91	0.9	NR	NR	9.98E-04
Am-243	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.91	0.9	NR	NR	9.98E-04

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters [d]				
						1	2	3	4	Mean/ Median
C-14	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-0.36	0.9	NR	NR	6.98E-01
Cm-243	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.91	0.9	NR	NR	9.98E-04
Cm-244	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.91	0.9	NR	NR	9.98E-04
Co-60	P	1	S	Lognormal - N	NUREG/CR-6697, Att. C	-2.53	0.9	NR	NR	7.97E-02
Cs-134	P	1	S	Lognormal - N	NUREG/CR-6697, Att. C	-3.22	1.0	NR	NR	4.00E-02
Cs-137	P	1	S	Lognormal - N	NUREG/CR-6697, Att. C	-3.22	1.0	NR	NR	4.00E-02
Eu-152	P	1	S	Lognormal - N	NUREG/CR-6697, Att. C	-6.21	1.1	NR	NR	2.01E-03
Eu-154	P	1	S	Lognormal - N	NUREG/CR-6697, Att. C	-6.21	1.1	NR	NR	2.01E-03
Eu-155				Lognormal - N	NUREG/CR-6697, Att. C	-6.21	1.1	NR	NR	2.01E-03
Fe-55	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.91	0.9	NR	NR	9.98E-04
Gd-152	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.21	1.1	NR	NR	2.01E-03
H-3	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	1.57	1.1	NR	NR	4.81E+00
Nb-94	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-4.61	1.1	NR	NR	9.95E-03
Nd-144	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.21	1.0	NR	NR	2.01E-03
Ni-59	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-3.00	0.9	NR	NR	4.98E-02
Ni-63	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-3.00	0.9	NR	NR	4.98E-02
Np-237	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-3.91	0.9	NR	NR	2.00E-02
Pa-231	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-4.61	1.1	NR	NR	9.95E-03
Pb-210	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-5.52	0.9	NR	NR	4.01E-03
Pm-147	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.21	1.1	NR	NR	2.01E-03
Po-210	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.9	0.9	NR	NR	1.01E-03
Pu-238	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.91	0.9	NR	NR	9.98E-04
Pu-239	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.91	0.9	NR	NR	9.98E-04
Pu-240	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.91	0.9	NR	NR	9.98E-04
Pu-241	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.91	0.9	NR	NR	9.98E-04
Ra-226	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-3.22	0.9	NR	NR	4.00E-02
Ra-228	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-3.22	0.9	NR	NR	4.00E-02
Sb-125	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-4.61	1.0	NR	NR	9.95E-03
Sm-148	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.21	1.1	NR	NR	2.01E-03
Sr-90	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-1.20	1.0	NR	NR	3.01E-01
Tc-99	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	1.61	0.9	NR	NR	5.00E+00

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters [d]				
						1	2	3	4	Mean/ Median
Th-228	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.91	0.9	NR	NR	9.98E-04
Th-229	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.91	0.9	NR	NR	9.98E-04
Th-230	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.91	0.9	NR	NR	9.98E-04
Th-232	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.91	0.9	NR	NR	9.98E-04
U-233	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.21	0.9	NR	NR	2.01E-03
U-234	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.21	0.9	NR	NR	2.01E-03
U-235	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.21	0.9	NR	NR	2.01E-03
U-236	P	1	D	Lognormal - N	NUREG/CR-6697, Att. C	-6.21	0.9	NR	NR	2.01E-03
Meat Transfer Factors (pCi/kg)/(pCi/d)										
Ac-227	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Ag-108m	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Am-241	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Am-243	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
C-14	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Cm-243	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Cm-244	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Co-60	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Cs-134	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Cs-137	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Eu-152	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Eu-154	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Fe-55	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Gd-152	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
H-3	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	**Type[a]**	**Priority[b]**	**Treatment[c]**	**Value/Distribution**	**Basis**	**Distribution's Statistical Parameters [d]**				
						1	**2**	**3**	**4**	**Mean/ Median**
Nb-94	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Nd-144	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Ni-59	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Ni-63	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Np-237	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Pa-231	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Pb-210	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Po-210	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Pu-238	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Pu-239	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Pu-240	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Pu-241	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Ra-226	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Ra-228	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Sb-125	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Sm-148	P	1	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Sr-90	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Tc-99	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Th-228	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Th-229	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Th-230	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters [d]				
						1	2	3	4	Mean/ Median
Th-232	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
U-233	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
U-234	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
U-235	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
U-236	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Milk Transfer Factors (pCi/L)/(pCi/d)										
Ac-227	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Am-241	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Am-243	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
C-14	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Cm-243	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Cm-244	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Co-60	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Cs-134	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Cs-137	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Eu-152	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Eu-154	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Fe-55	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Gd-152	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
H-3	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Nb-94	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters [d]				
						1	2	3	4	Mean/ Median
Nd-144	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Ni-59	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Ni-63	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Np-237	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Pa-231	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Pb-210	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Po-210	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Pu-238	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Pu-239	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Pu-240	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Pu-241	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Ra-226	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Ra-228	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Sm-148	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Sr-90	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Tc-99	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Th-228	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Th-229	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Th-230	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Th-232	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
U-233	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters [d]				
						1	2	3	4	Mean/ Median
U-234	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
U-235	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
U-236	P	2	D	NA	Resident Gardener No Livestock	NR	NR	NR	NR	
Bioaccumulation Factors for Fish ((pCi/kg)/(pCi/L))										
Ac-227 (daughter of Cm-243 and Pu-239)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Am-241 (also daughter of Pu-241)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Am-243	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
C-14	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Cm-243	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Cm-244	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Co-60	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Cs-137	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Eu-152	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Eu-154	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Eu-155	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Fe-155	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Gd-152 (daughter of Eu-152)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
H-3	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Nb-94	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Nd-144 (daughter of Eu-152)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Ni-59	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Ni-63	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Np-237 (also daughter of Am-241, Cm-245, and Pu-241)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Pa-231 (daughter of Cm-243 and Pu-239)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Pb-210 (daughter of Pu-238)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Po-210 (daughter of Pu-238)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Pu-238	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Pu-239 (also daughter of Cm-243)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters [d]				
						1	2	3	4	Mean/ Median
Pu-240 (also daughter of Cm-244)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Pu-241	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Ra-226 (daughter of Pu-238)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Ra-228 (daughter of Cm-244 and Pu-240)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Sm-148 (daughter Eu-152)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Sr-90	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Tc-99	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Th-228 (daughter Cm-244 and Pu-240)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Th-229 (daughter Am-241, Cm-245, Np-237, and Pu-241)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Th-230 (daughter Cm-246 and Pu-238)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Th-232 (daughter Cm-244 and Pu-240)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
U-233 (daughter Am-241, Cm-245, Np-237, and Pu-241)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
U-234 (daughter Pu-238)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
U-235 (daughter Cm-243 and Pu-239)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
U-236 (daughter Cm-244 and Pu-240)	P	2	D	NA	No Fish Consumption	NR	NR	NR	NR	
Bioaccumulation Factors for Crustacea/ Mollusks ((pCi/kg)/(pCi/L))										
Ac-227	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Am-241	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Am-243	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
C-14	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Cm-243	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Cm-244	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Cm-245	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters [d]				
						1	2	3	4	Mean/ Median
Cm-246	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Co-60	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Cs-137	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Eu-152	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Eu-154	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Gd-152	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
H-3	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
I-129	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Nb-94	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Ni-59	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Ni-63	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Np-237	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Pa-231	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Pb-210	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Po-210	P	S	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Pu-238	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Pu-239	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Pu-240	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Pu-241	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Pu-242	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Ra-226	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	

ALTERNATE SCENARIO RESIDENT GARDENER RESRAD INPUT PARAMETERS INITIAL SUITE RADIONUCLIDES UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters [d]				
						1	2	3	4	Mean/ Median
Ra-228	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Sr-90	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Th-228	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Th-229	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Th-230	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Th-232	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
U-233	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
U-234	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
U-235	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
U-236	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
U-238	P	3	D	NA	No Crustacea/Mollusks Consumption	NR	NR	NR	NR	
Graphics Parameters										
Number of points				32	RESRAD Default	NR	NR	NR	NR	
Spacing				log	RESRAD Default	NR	NR	NR	NR	
Time integration parameters										
Maximum number of points for dose				17	RESRAD Default	NR	NR	NR	NR	

Notes:
a P = physical, B = behavioral, M = metabolic; (see NUREG/CR-6697, Attachment B, Table 4.1)
b 1 = high-priority parameter, 2 = medium-priority parameter, 3 = low-priority parameter (see NUREG/CR-6697, Attachment B, Table 4.1)
c D = deterministic, S = stochastic
d NUREG/CR-6697 Distributions Statistical Parameters:
Lognormal-n: 1= mean, 2 = standard deviation
Bounded lognormal-n: 1= mean, 2 = standard deviation, 3 = minimum, 4 = maximum
Truncated lognormal-n: 1= mean, 2 = standard deviation, 3 = lower quantile, 4 = upper quantile
Bounded normal: 1 = mean, 2 = standard deviation, 3 = minimum, 4 = maximum
Beta: 1 = minimum, 2 = maximum, 3 = P-value, 4 = Q-value
Triangular: 1 = minimum, 2 = mode, 3 = maximum
Uniform: 1 = minimum, 2 = maximum e Sm-148 an ND-144 not listed in RESRAD FGR 11 DCF file
e Haley and Aldrich, Inc., "Hydrogeological Investigation Report La Crosse Boiling Water Reactor, Dairyland Power Cooperative, Genoa, WI" January 2015
f ZionSolutions Technical Support Document 14-003, Conestoga Rovers & Associates (CRA) Report, "Zion Hydrogeologic Investigation Report"
g Argonne National Laboratory, "User's Manual for RESRAD Version 6", ANL/EAD 4, July 2001

Attachment 13
Alternate Scenario Dose Calculation

Alternate Scenario (Resident Gardener) Dose Basements and Soil

Inputs to Calculation

Conversion Factor	1.00E-09	mCi/pCi
Dose limit	25	mrem/yr

Summation BFM DCGL$_B$ (BFM Excavation + BFM Insitu$_{gw}$ + BFM Insitu$_{ds}$) Adjusted for IC Dose and Mixing Sensitivity

	Summation Rx Bldg BFM DCGLs (DCGL$_B$) (pCi/m^2)	Summation WGTV BFM DCGLs (DCGL$_B$) (pCi/m^2)
Co-60	5.86E+06	5.72E+06
Sr-90	1.65E+07	8.94E+06
Cs-137	2.47E+07	2.45E+07
Eu-152	1.35E+07	1.35E+07
Eu-154	1.25E+07	1.25E+07

Concentrations Corresponding to 25 mrem/yr in BFM Rx Bldg Based on DCGL$_B$

	Relative Dose Fraction	Normalized Dose Fraction	BFM DCGL$_B$ (pCi/m^2)	pCi/m^2 corresponding to 25 mrem/yr in BFM (Dose From All ROC Summed)	BFM Dose Check (mrem/yr)
Co-60	7.81E-09	2.39E-01	5.86E+06	1.401E+06	5.98
Sr-90	4.60E-09	1.41E-01	1.65E+07	2.322E+06	3.52
Cs-137	1.99E-08	6.10E-01	2.47E+07	1.506E+07	15.25
Eu-152	1.36E-10	4.16E-03	1.35E+07	5.626E+04	0.10
Eu-154	1.99E-10	6.10E-03	1.25E+07	7.635E+04	0.15
sum	3.27E-08	1.00			25.00

Concentrations Corresponding to 25 mrem/yr in BFM WGTV Based on DCGLB

	Relative Dose Fraction	Normalized Dose Fraction	BFM DCGL (pCi/m^2)	pCi/m^2 corresponding to 25 mrem/yr in BFM (all ROC summed)	BFM Dose Check (mrem/yr)
Co-60	8.32E-10	4.03E-02	5.721E+06	2.31E+05	1.01
Sr-90	1.02E-09	4.94E-02	8.943E+06	4.42E+05	1.23
Cs-137	1.83E-08	8.88E-01	2.453E+07	2.18E+07	22.20
Eu-152	3.32E-10	1.61E-02	1.353E+07	2.18E+05	0.40
Eu-154	1.28E-10	6.21E-03	1.252E+07	7.78E+04	0.16
sum	2.06E-08	1.00			25.00

Ratio of RESRAD Alternate Scenario Rx Bldg DSR to RESRAD Rx Bldg BFM Insitu$_{gw}$ Scenario DSR

	Rx Bldg Resident Gardener Alt Scenario DSR[1] (mrem/yr per pCi/g)	Insignificant Contributor Adjusted Rx Bldg Resident Gardener Alt Scenario DSR (mrem/yr per pCi/g)	Rx Bldg BFM Insitu$_{gw}$ DSR (mrem/yr per pCi/g)	Rx Bldg Ratio (Resident Gardener DSR)/ (BFM Insitu$_{gw}$ DSR)
Co-60	1.385E+00	1.49E+00	6.691E-01	2.22
Sr-90	1.698E+01	1.82E+01	6.440E+00	2.83
Cs-137	7.913E-01	8.50E-01	2.674E-01	3.18
Eu-152	3.245E-02	3.49E-02	1.824E-02	1.91
Eu-154	4.714E-02	5.07E-02	2.649E-02	1.91

Note 1: RESRAD Report "AS BFM Rx DSR 121117.pdf"

Ratio of RESRAD Alternate Scenario WGTV DSR to RESRAD WGTV BFM Insitu$_{gw}$ Scenario DSR

	WGTV Resident Gardener Alt Scenario DSR[1] (mrem/yr per pCi/g)	Insignificant Contributor Adjusted WGTV Resident Gardener Alt Scenario DSR (mrem/yr per pCi/g)	WGTV BFM Insitugw DSR (mrem/yr per pCi/g)	WGTV Ratio (Resident Gardener DSR/ BFM Insitugw DSR)
Co-60	8.819E-01	1.03E+00	3.759E-01	2.73
Sr-90	1.165E+01	1.36E+01	3.661E+00	3.71
Cs-137	5.592E-01	6.51E-01	1.295E-01	5.03
Eu-152	1.670E-02	1.95E-02	8.675E-03	2.24
Eu-154	2.426E-02	2.83E-02	1.260E-02	2.24

Note 1: RESRAD Report "AS BFM WGTV DSR 121117.pdf"

RESIDENT GARDENER ALTERNATE SCENARIO DOSE CALCULATIONS

Basement Resident Gardener Alternate Scenario Dose Insitu Groundwater Pathway (i.e., no excavaton).
Concentrations Applied Correspond to 25 mrem/yr (all ROC Summed) using BFM DCGL$_B$ and conservative site mixture

Radionuclide	Alternate Scenario Rx Bldg Insitu$_{gw}$ Dose (mrem/yr)	Alternate Scenario WGTV Insitu$_{gw}$ Dose (mrem/yr)
Co-60	5.68E-01	1.81E-01
Sr-90	9.92E+00	4.56E+00
Cs-137	5.33E+00	1.29E+01
Eu-152	8.66E-04	3.82E-03
Eu-154	1.71E-03	1.98E-03
sum	1.58E+01	1.77E+01
30 year decay	7.51E+00	8.72E+00

Basement Resident Gardener Alternate Scenario Dose Insitu Drilling Spoils pathway (i.e., no excavaton)

Concentrations Applied Correspond to 25 mrem/yr (all ROC Summed) using BFM $DCGL_B$ and conservative site mixture

Radionuclide	Alternate Scenario Rx Bldg Insitu$_{ds}$ Dose (mrem/yr)	Alternate Scenario WGTV Insitu$_{ds}$ Dose (mrem/yr)
Co-60	1.83E-01	3.01E-02
Sr-90	1.05E-03	2.01E-04
Cs-137	4.79E-01	6.93E-01
Eu-152	3.46E-03	1.34E-02
Eu-154	5.00E-03	5.09E-03
sum	6.63E-01	7.24E-01
30 year decay	2.46E-01	3.52E-01

Basement Resident Gardener Alternate Scenario Dose Concrete Exacavation Pathway

Concentrations Applied Correspond to 25 mrem/yr (all ROC Summed) using BFM $DCGL_B$ and conservative site mixture

Radionuclide	Ratio Industrial Use Soil DCGL/Resident Gardener Soil DCGL	Alternate Scenario Rx Bldg Concrete Excavatiuon Dose (mrem/yr)	Alternate Scenario WGTV Concrete Excavation Dose (mrem/yr)
Co-60	2.33E+00	1.319E+01	2.17E+00
Sr-90	3.43E+02	6.25E+00	1.19E+00
Cs-137	2.57E+00	3.44E+01	4.98E+01
Eu-152	2.36E+00	2.41E-01	9.33E-01
Eu-154	2.35E+00	3.53E-01	3.59E-01
sum		5.45E+01	5.45E+01
30 year decay		2.07E+01	2.59E+01

Basement Alternate Scenario Dose Summation Insitu and Excavation Scenarios

Concentrations Applied Correspond to 25 mrem/yr (all ROC Summed) using BFM DCGLB and conservative site mixture

Radionuclide	**Alternate Scenario Rx Bldg Summation[1] Dose (mrem/yr)**	**Alternate Scenario WGTV Summation[1] Dose (mrem/yr)**
Co-60	1.39E+01	2.38E+00
Sr-90	1.62E+01	5.75E+00
Cs-137	4.02E+01	6.34E+01
Eu-152	2.46E-01	9.50E-01
Eu-154	3.59E-01	3.66E-01
sum	7.04E+01	7.16E+01
30 year decay	2.84E+01	3.49E+01

Note 1: Summation of $Insitu_{gw}$ + $Insitu_{ds}$ + Excavation

Soil Alternate Scenario Dose Using Maximum Soil Concentrations Identified During Characterizati

Radionuclide	Resident Gardener (pCi/g per 25 mrem/yr)	Maximum Soil Concentration From Characterization[1] (pCi/g)	Resident Gardener Dose (mrem/yr)
Co-60	4.944E+00	0.52	2.63E+00
Sr-90	1.728E+01	0.44	6.37E-01
Cs-137	2.035E+01	1.07	1.31E+00
Eu-152	1.084E+01	0.10	2.31E-01
Eu-154	1.008E+01	0.25	6.20E-01
sum			4.58
30 year decay			1.13

Note 1: LTP Chapter 2 Tables 2-10 to 2-15

Soil Alternate Scenario Dose Using Soil Concentrations Corresponding to 25 mrem/yr for Industrial Scenario (summation oif dose from all ROC)

Radionuclide	Alternate Scenairo Resident Gardener Soil (pCi/g per 25 mrem/yr)	Alternate Scenario Resident Gardener Soil Dose (mrem/yr)
Co-60	4.945E+00	1.49E+01
Sr-90	1.729E+01	6.51E+00
Cs-137	2.036E+01	4.68E+01
Eu-152	1.085E+01	5.81E-01
Eu-154	1.008E+01	3.20E-01
sum		68.20
30 year decay		27.07

Calculation of Soil Concentrations Resulting in 25 mrem/yr in Industrial Scenario Using Conservative Radionuclide Mixture

	Industrial Use Adjusted Soil DCGLs (pCi/g)	Relative Dose Fraction	Normalized Dose Fraction	Radionuclide Concentrations resulting in 25 mrem/yr using Industrial use Soil DCGL	Industrial Use Soil Dose Check calculation
Co-60	11.53	2.97E-03	2.56E-01	2.95	6.41
Sr-90	5,927.40	8.81E-06	7.60E-04	4.50	1.90E-02
Cs-137	52.31	8.44E-03	7.28E-01	38.07	18.19
Eu-152	25.60	1.14E-04	9.85E-03	0.25	0.25
Eu-154	23.72	6.30E-05	5.43E-03	0.13	0.14
sum		1.16E-02	1.00E+00		25.00

Alternate Scenario Dose Assuming Excavation of Maximum Basement Fill Concentrations

Radionuclide	Alternate Scenairo Resident Gardener Soil (pCi/g per 25 mrem/yr)	Rx Bldg Fill Excavation Resident Gardener Dose (mrem/yr)	WGTV Fill Excavation Resident Gardener Dose (mrem/yr)
Co-60	4.945E+00	4.02	0.67
Sr-90	1.729E+01	1.91	0.37
Cs-137	2.036E+01	10.51	15.48
Eu-152	1.085E+01	0.07	0.29
Eu-154	1.008E+01	0.11	0.11
Sum		16.44	16.53
30 year decay		6.31	8.04

INPUT DATA AND CALCULATIONS FOR ALTERNATE SCENARIO DOSE ASSESSMENT

SOIL: Insignificant Contributor Adjustment Alternate Scenario

Radionuclide	Alternate Scenario Resident Gardener[1] Soil (pCi/g per 25 mrem/yr)	Soil 75th Percentile Radionculide Mixture	Relative Dose	Dose Fraction	ROC Adjusted for IC Dose Contribution (pCi/g per 25 mrem/yr)
H-3	3.312E+04	1.51E-01	1.142E-04	1.42E-04	
C-14	4.348E+02	1.72E-03	9.865E-05	1.23E-04	
Fe-55	1.030E+06	2.36E-02	5.734E-07	7.15E-07	
Ni-59	7.839E+04	7.40E-04	2.361E-07	2.95E-07	
Co-60	4.961E+00	3.43E-02	1.727E-01	2.15E-01	4.945E+00
Ni-63	2.863E+04	2.64E-01	2.306E-04	2.88E-04	
Sr-90	1.734E+01	5.22E-02	7.532E-02	9.40E-02	1.729E+01
Nb-94	7.561E+00	1.68E-04	5.565E-04	6.94E-04	
Tc-99	3.091E+02	2.06E-03	1.666E-04	2.08E-04	
Cs-137	2.042E+01	4.41E-01	5.405E-01	6.74E-01	2.036E+01
Eu-152	1.088E+01	2.93E-03	6.721E-03	8.39E-03	1.085E+01
Eu-154	1.011E+01	1.50E-03	3.697E-03	4.61E-03	1.008E+01
Eu-155	3.986E+02	2.08E-03	1.307E-04	1.63E-04	
Np-237	8.367E+00	2.15E-06	6.409E-06	8.00E-06	
Pu-238	1.747E+02	1.16E-03	1.655E-04	2.07E-04	
Pu-239/PU-240	1.573E+05	7.80E-04	1.239E-07	1.55E-07	
Pu-241	5.737E+03	1.56E-02	6.779E-05	8.46E-05	
Am-241	1.394E+02	3.56E-03	6.384E-04	7.97E-04	
Am-243	5.114E+01	5.85E-04	2.861E-04	3.57E-04	
Cm-243/Cm-244	7.799E+01	1.65E-04	5.303E-05	6.62E-05	
Sum Relative Dose			8.014E-01		
Dose Fraction Sum Check				1.00E+00	
IC Dose Percentage				0.314%	

Note 1: Reference RESRAD Summary Report "AS Soil DSR Initial Suite 083017"

75th Percentile Radionuclide Mixtures[1]

	Rx Bldg 75th Percentile Mixture	WGTV 75th Percentile Mixture[2]	Soil 75th Percentile Mixture
H-3	2.36E-02	2.52E-01	1.51E-01
C-14	1.27E-03	9.37E-03	1.72E-03
Fe-55	1.40E-02	-8.13E-03	2.36E-02
Ni-59	2.48E-04	4.74E-02	7.40E-04
Co-60	4.58E-02	4.76E-03	3.43E-02
Ni-63	2.77E-01	1.89E-01	2.64E-01
Sr-90	7.59E-02	9.12E-03	5.22E-02
Nb-94	1.07E-04	1.01E-03	1.68E-04
Tc-99	2.16E-03	6.91E-03	2.06E-03
Cs-137	4.92E-01	4.49E-01	4.41E-01
Eu-152	1.84E-03	4.49E-03	2.93E-03
Eu-154	2.49E-03	1.60E-03	1.50E-03
Eu-155	6.61E-04	4.56E-03	2.08E-03
Np-237	2.17E-06	0.00E+00	2.15E-06
Pu-238	2.27E-03	7.95E-04	1.16E-03
Pu-239/PU-240	3.17E-03	1.90E-04	7.80E-04
Pu-241	4.58E-02	2.35E-02	1.56E-02
Am-241	1.03E-02	3.25E-03	3.56E-03
Am-243	6.18E-04	4.55E-04	5.85E-04
Cm-243/Cm-244	1.58E-04	1.78E-04	1.65E-04

Note 1: Excel Spreadsheet "LACBWR TSD RS-TD-313196-001 Rev 3"

Decay Constants

	T 1/2 (years)[1]	Decay Const (λ) yrs^{-1}
H-3	1.23E+01	5.63E-02
C-14	5.70E+03	1.22E-04
Fe-55	2.74E+00	2.53E-01
Ni-59	1.01E+05	6.86E-06
Co-60	5.27E+00	1.31E-01
Ni-63	1.00E+02	6.92E-03
Sr-90	2.88E+01	2.41E-02
Nb-94	2.03E+04	3.41E-05
Tc-99	2.11E+05	3.28E-06
Cs-137	3.02E+01	2.30E-02
Eu-152	1.35E+01	5.12E-02
Eu-154	8.80E+00	7.88E-02
Eu-155	4.76E+00	1.46E-01
Np-237	2.14E+06	3.23E-07
Pu-238	8.77E+01	7.90E-03
Pu-239/240	2.41E+04	2.88E-05
Pu-241	1.44E+01	4.83E-02
Am-241	4.32E+02	1.60E-03
Am-243	7.37E+03	9.40E-05
Cm-243/244	2.85E+01	2.43E-02

(1) Reference NRC Radiological Toolbox

Alternate Scenario Drilling Spoils - pCi/m^2 per 25 mrem/yr (Adjusted for IC Dose)

	Alternate Scenario pCi/g per 25 mrem/yr (0.457 m^2 area)[1]	Alternate Scenario Area Factors (0.457 m^2 area)	Alt Scenario Drilling Spoils (pCi/m2 per 25 mrem/yr
H-3	3.420E+07	1.03E+03	5.09E+13
C-14	2.656E+07	6.11E+04	3.95E+13
Fe-55	1.569E+09	1.52E+03	2.34E+15
Ni-59	2.998E+08	3.82E+03	4.46E+14
Co-60	1.289E+02	2.60E+01	1.92E+08
Ni-63	1.115E+08	3.89E+03	1.66E+14
Sr-90	3.700E+04	2.13E+03	5.51E+10
Nb-94	1.878E+02	2.48E+01	2.80E+08
Tc-99	1.296E+06	4.19E+03	1.93E+12
Cs-137	5.276E+02	2.58E+01	7.85E+08
Eu-152	2.730E+02	2.51E+01	4.06E+08
Eu-154	2.566E+02	2.54E+01	3.82E+08
Eu-155	7.435E+03	1.87E+01	1.11E+10
Np-237	1.302E+03	1.56E+02	1.94E+09
Pu-238	1.698E+04	9.72E+01	2.53E+10
Pu-239	1.544E+04	9.82E-02	2.30E+10
Pu-240	1.546E+04	9.83E-02	2.30E+10
Pu-241	3.910E+05	6.82E+01	5.82E+11
Am-241	9.500E+03	6.81E+01	1.41E+10
Am-243	1.429E+03	2.79E+01	2.13E+09
Cm-243	2.304E+03	2.95E+01	3.43E+09
Cm-244	2.720E+04	3.49E+02	4.05E+10

Note 1: Reference RESRAD Summary Report "Alternate Scenario Driiling Spoils 083017"

RX BLDG: Insignificant Contributor Adjustment Alternate Scenario

Radionuclide	Alternate Scenario Resident Gardener[1] Rx Building (pCi/g per 25 mrem/yr)	Rx Building 75th Percentile Radionculide Mixture	Relative Dose	Dose Fraction	ROC Adjusted for IC Dose Contribution (pCi/g per 25 mrem/yr)
H-3	2.347E+03	2.36E-02	2.52E-04	1.35E-04	
C-14	9.252E+01	1.27E-03	3.43E-04	1.83E-04	
Fe-55	3.955E+03	1.40E-02	8.88E-05	4.75E-05	
Ni-59	1.023E+04	2.48E-04	6.07E-07	3.24E-07	
Co-60	1.805E+01	4.58E-02	6.34E-02	3.39E-02	16.80
Ni-63	3.736E+03	2.77E-01	1.86E-03	9.92E-04	
Sr-90	1.473E+00	7.59E-02	1.29E+00	6.88E-01	1.37
Nb-94	1.023E+04	1.07E-04	2.61E-07	1.39E-07	
Tc-99	4.844E+01	2.16E-03	1.11E-03	5.95E-04	
Cs-137	3.159E+01	4.92E-01	3.89E-01	2.08E-01	29.39
Eu-152	7.703E+02	1.84E-03	5.97E-05	3.19E-05	716.76
Eu-154	5.303E+02	2.49E-03	1.18E-04	6.29E-05	493.44
Eu-155	3.417E+03	6.61E-04	4.83E-06	2.58E-06	
Np-237	3.863E-02	2.17E-06	1.40E-03	7.51E-04	
Pu-238	2.808E+00	2.27E-03	2.02E-02	1.08E-02	
Pu-239/PU-240	2.528E+00	3.17E-03	3.13E-02	1.67E-02	
Pu-241	1.309E+02	4.58E-02	8.74E-03	4.67E-03	
Am-241	4.421E+00	1.03E-02	5.85E-02	3.13E-02	
Am-243	4.438E+00	6.18E-04	3.48E-03	1.86E-03	
Cm-243/Cm-244	1.465E+00	1.58E-04	2.70E-03	1.44E-03	
Sum Relative Dose			1.87		
Dose Fraction Sum Check				1	
IC Dose Percentage				6.95%	

Note 1: RESRAD Summary Report "AS BFM Rx DSR 121117.pdf"

WGTV: Insignificant Contributor Adjustment Alternate Scenario

Radionuclide	Alternate Scenario Resident Gardener[1] WGTV (pCi/g per 25 mrem/yr)	WGTV 75th Percentile Radionculide Mixture	Relative Dose	Dose Fraction	ROC Adjusted for IC Dose Contribution (pCi/g per 25 mrem/yr)
H-3	4.849E+03	2.52E-01	1.30E-03	3.37E-03	
C-14	1.775E+02	9.37E-03	1.32E-03	3.42E-03	
Fe-55	7.972E+03	-8.13E-03	-2.55E-05	-6.60E-05	
Ni-59	1.195E+04	4.74E-02	9.93E-05	2.57E-04	
Co-60	2.835E+01	4.76E-03	4.20E-03	1.09E-02	25.77
Ni-63	4.363E+03	1.89E-01	1.08E-03	2.81E-03	
Sr-90	2.146E+00	9.12E-03	1.06E-01	2.75E-01	1.95
Nb-94	1.104E+02	1.01E-03	2.28E-04	5.90E-04	
Tc-99	8.405E+01	6.91E-03	2.05E-03	5.32E-03	
Cs-137	4.470E+01	4.49E-01	2.51E-01	6.51E-01	40.63
Eu-152	1.497E+03	4.49E-03	7.50E-05	1.94E-04	1360.77
Eu-154	1.031E+03	1.60E-03	3.89E-05	1.01E-04	937.18
Eu-155	6.642E+03	4.56E-03	1.72E-05	4.44E-05	
Np-237[2]	8.069E-02	0.00E+00	0.00E+00	0.00E+00	
Pu-238	5.585E+00	7.95E-04	3.56E-03	9.22E-03	
Pu-239/PU-240	4.836E+00	1.90E-04	9.85E-04	2.55E-03	
Pu-241	2.533E+02	2.35E-02	2.32E-03	6.00E-03	
Am-241	8.404E+00	3.25E-03	9.66E-03	2.50E-02	
Am-243	8.408E+00	4.55E-04	1.35E-03	3.50E-03	
Cm-243/Cm-244	2.451E+01	1.78E-04	1.82E-04	4.71E-04	
Sum Relative Dose			0.39		
Dose Fraction Sum Check				1	
IC Dose Percentage				6.25%	

Note 1: RESRAD Report "AS WGTV BFM DSR 121117.pdf"
Note2: Np-237 not detected in any core from LACBWR - maximum MDC used to directly calculate maximum Np-237 IC dose (and Np-237 dose fraction) for WGTV.

Total WGTV IC Dose using maximum Np-237 Dose

Np-237 Max MDC WGTV Cores	0.239	pCi/g
BFM WGTV Np-237 Max Dose using Max MDC	1.181	mrem/yr
WGTV BFM DSR Np-237[1]	1.854E+02	mrem/yr per pCi/g
Alternate Scenario WGTV BFM Np-237 DSR[2]	3.098E+02	mrem/yr per pCi/g
Alternate Scenario BFM WGTV Max Dose using Max MDC	1.973E+00	
Alyernate Scenario WGTV Np-237 Max IC Dose Fraction using Max MDC	7.894E-02	
Total IC Dose Percentage WGTV	14.14%	

Note 1: Reference RESRAD Report "LACBWR BFM Rx DSR 12117.pdf"
Note 2: RESRAD Report "AS WGTV BFM DSR 121117.pdf"