LA CROSSE BOILING WATER REACTOR

LICENSE TERMINATION PLAN

CHAPTER 6

COMPLIANCE WITH THE RADIOLOGICAL CRITERIA FOR LICENSE TERMINATION

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LIST OF ACRONYMS AND ABBREVIATIONS

AF	Area Factor
ALARA	As Low As Reasonable Achievable
AMCG	Average Member of the Critical Group
AMSL	Above Mean Sea Level
ANL	Argonne National Laboratory
BFM	Basement Fill Model
BFM $Insitu_{gw}$	BFM Insitu Groundwater
BFM $Insitu_{ds}$	BFM Insitu Drilling Spoils
bgs	Below Ground Surface
DCGL	Derived Concentration Guideline Level
DF	Dose Factor
DPC	Dairyland Power Cooperative
FRS	Final Radiation Survey
G-3	Genoa-3
GW	Groundwater
HSA	Historical Site Assessment
HTD	Hard-to-Detect
ISFSI	Independent Spent Fuel Storage Installation
LACBWR	La Crosse Boiling Water Reactor
LSE	LACBWR Site Enclosure
LTP	License Termination Plan
MARSAME	Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	Minimum Detectable Activity
MDC	Minimal Detectable Concentration
NRC	Nuclear Regulatory Commission
PRCC	Partial Rank Correlation Coefficient
RESRAD	RESidual RADioactive materials
ROC	Radionuclides of Concern
TEDE	Total Effective Dose Equivalent
USACE	U.S. Army Corps of Engineers
WGTV	Waste Gas Tank Vault
WTB	Waste Treatment Building

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6. Compliance with the Radiological Criteria for License Termination

6.1. Site Release Criteria

The site release criteria for the La Crosse Boiling Water Reactor (LACBWR) are the radiological criteria for unrestricted release specified in Title 10, Section 20.1402, of the *Code of Federal Regulations* (10 CFR 20.1402):

- Dose Criterion: The residual radioactivity that is distinguishable from background radiation results in a Total Effective Dose Equivalent (TEDE) to an average member of the critical group that does not exceed 25 mrem/yr, including that from groundwater sources of drinking water; and
- As Low As Reasonably Achievable (ALARA) Criterion: The residual radioactivity has been reduced to levels that are ALARA.

Chapter 4 describes the methods and results for demonstrating compliance with the ALARA Criterion. This Chapter describes the methods for demonstrating compliance with the Dose Criterion.

6.2. General Site Description

This section provides a general description of the geology and hydrogeology at the LACBWR site. Land and groundwater use in the vicinity of site are also described. A detailed site description of site geology and hydrogeology is provided in Haley & Aldrich, Inc., *Hydrogeological Investigation Report, La Crosse Boiling Water Reactor, Dairyland Power Cooperative, Genoa Wisconsin* (1).

The LACBWR facility is located 17 miles south of the City of La Crosse and a mile south of the Village of Genoa (population about 800) (see Figure 6-1). The nearest community (three miles to the northwest) is Reno, Minnesota, an unincorporated hamlet of about 300 people located on the west shore of the Mississippi River. The nearest community in Iowa is New Albin (pop. 522), five miles southwest of the plant. Victory, Wisconsin, five miles south of the plant on the east shore, is an unincorporated hamlet of about 80 people. The LACBWR licensed site area is shown in Figure 6-2, with a more detailed view of the facilities inside the LACBWR Site Enclosure (LSE) fence shown in Figure 6-3.

6.2.1. Site Geology

LACBWR is located on the east bank of the Mississippi River in the Wisconsin Driftless section of the Central Lowland Physiographic Province. The local geology of the site is generally described as approximately 15 feet of hydraulic fill overlying 100 to 130 feet of glacial outwash and fluvial deposits. These unconsolidated deposits are underlain by flat lying sandstone and shales of the Dreshbach Group and by dense Precambrian crystalline rocks encountered at approximately 650 feet below the ground surface (bgs).

The primary soil types encountered at the site are:

- 0 to 20 feet bgs. Hydraulic Fill – Fill sands are encountered from approximately 0 to 20 feet bgs and described as light brown to brown, fine to medium sands with occasional fine gravel,
- 20 to 30 feet bgs. Brown to grey, fine to medium fine sands underlie the fill, with an average thickness of 7 to 28 feet,
- 30 to 100 feet bgs. Brown, fine to medium sands that also have zones of coarse sand and fine gravel below the finer sands,
- 100 to 115 feet bgs. Brown fine to medium sand and fine to medium gravels,
- 115 to 135 feet bgs. Brown fine to medium sand with trace silt, occasional zones of gravel.

6.2.2. Site Hydrogeology

Regionally, groundwater flows from the bluff towards the Mississippi River. Closer to the river, it is likely that the groundwater flow direction turns "downstream" as groundwater discharges to the surface water. Groundwater elevation data from eight onsite wells agrees with regional groundwater flow and also shows seasonal variation on upward and downward gradients that are influenced by the river stage.

6.2.3. Area Land Use

The LACBWR facility is located in the far western portion of Vernon County on the east bank of the Mississippi River. Although the site area is 163.5 acres, it is relatively isolated as it is bounded by the Mississippi River to the west, a rail line to the east, U.S. Army Corps of Engineers (USACE) property to the north, and a wildlife and fish refuge to the south.

The 163.5 acre site is comprised of the following:

- the 1.5 acre LACBWR facility,
- the Genoa-3 (G-3) coal-fired, 379 MWe electric power station that was completed in 1969 and is owned and operated by Dairyland Power Cooperative (DPC). The G-3 station is located to the south, adjacent to LACBWR,
- an area south of G-3 where the LACBWR Independent Spent Fuel Storage Installation (ISFSI) is located,
- an approximately 36 acre area surrounding the ISFSI containing the closed coal ash landfill from past operations,
- the land north of the LACBWR plant was the site of the former Genoa-1 (G-1) coal (and later oil) fueled power plant (removed in 1989) which now includes the site switchyard and barge washing area (an approximately 900 m^2 coal ash landfill is also present),
- a parcel of land to the east of Highway 35, across from LACBWR.

The area of the Mississippi River adjacent to the site is used for recreational purposes (boating and fresh water fishing) and commercial barge and ship traffic (e.g. barges of coal are delivered to the G-3 station located south of the LACBWR plant). There is a public boat landing on the site, located approximately 4,000 feet south of the plant. There is a portion (Pool 9) of the Upper Mississippi River National Wildlife & Fish Refuge just south of the site which has limited access for hunting, fishing and recreational activities. Further south are public land areas and the Genoa National Fish Hatchery.

Lock and Dam No. 8, located on the Mississippi River at mile 679.2, is approximately 0.6 miles north of the site. The dam is a 110 feet wide, 600 feet long lock and dam structure owned and operated by the USACE. This facility also allows public access to an observation platform, open from dawn to dusk during the months of April through November. The State of Wisconsin maintains a highway wayside off State Highway 35 approximately ½ mile north of the LACBWR site, across from Lock and Dam No. 8.

The closest town is Genoa, located approximately 1 mile to the northeast of the site. There are no residences within 2,000 feet of any LACBWR structure.

6.2.4. Area Groundwater Use

There are two water supply wells on the site (Deep Well 3 and Deep Well 4) that were installed in 1963 to 129 feet and 116 feet bgs, respectively. Both wells are located upgradient from the LSE and are still in use as potable water for LACBWR. Separate groundwater wells supply water to the G-3 plant. Regionally, there are five domestic wells south of the LACBWR site and east of Highway 35.

6.3. Basements, Structures and Piping to Remain after License Termination (End State)

The configuration of the remaining backfilled basements, buried piping, open land areas and buildings at the time of license termination is designated as the "End State."

All but two LACBWR buildings will be demolished to at least three feet below grade which corresponds to an elevation of 636 foot Average Mean Sea Level (AMSL). The two buildings that will remain intact are the LACBWR Administration Building and LACBWR Crib House. The below ground portions of the buildings to be demolished and backfilled are listed in Table 6-1 and shown in Figures 6-4 and 6-5. Figure 6-6 provides a cross-section of the Reactor Building basement below 636 foot elevation which is the only basement with a portion below the average water table elevation. Note that there are also three very small sumps with floors that extend to one foot below the average water table elevation.

As seen in Figure 6-2, there are numerous buildings associated with the G-3 coal plant that are outside of the LSE but within the LACBWR licensed boundary. However, these buildings and adjacent open land areas were not used to support LACBWR operations. The majority of open land areas and buildings outside of the LSE fence are designated as non-impacted. See LTP Chapters 2 and 5 for additional discussion and justification of the non-impacted classification of areas outside of the LSE.

The structures to be backfilled will be comprised of concrete only and include full and partial basements, isolated sumps and remaining portions of foundations. All systems and components will be removed. The backfilled structures are generally referred to as either basements or structures in this LTP Chapter. For the Reactor Building, only the concrete exterior to the steel liner will remain; all interior concrete and the steel liner will be removed. All remaining

Table 6-1 Basements and Below Ground Structures 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 Treatment Building	Concrete	101.90	630
Waste Gas Tank Vault	Concrete	460.04	621
Remaining Structures			
• Piping and Ventilation Tunnels	Concrete	177.07	629
• Reactor/Generator Plant	Concrete	359.59	629
• Chimney Slab	Concrete	117.86	635
• Turbine Sump	Concrete	5.64	618
• Turbine Pit	Concrete	7.09	618

concrete will be decontaminated as necessary to meet the 10 CFR 20.1402 unrestricted use criteria.

For the purpose of dose assessment, the basements other than the Reactor Building, Waste Treatment Building (WTB), and Waste Gas Tank Vault (WGTV) are grouped into one category designated as the "Remaining Structures". This creates four separate areas to consider in dose assessment and Final Radiation Survey (FRS) design; Reactor Building, WTB, WGTV and Remaining Structures. There are several reasons for this organization. The Reactor Building has a unique configuration, including a portion below the average water table elevation and a very low potential for containing significant residual radioactivity after all interior concrete and the steel liner is removed. This leads to unique dose assessment assumptions and FRS classification. In addition, the FRS design can effectively accommodate a survey unit consisting of only the Reactor Building. The WTB has the highest contamination potential of all End State structures and needs to be addressed separately to ensure that the source term in the WTB is not inappropriately averaged with the other structures. The small size of the WTB structure to remain is not particularly conducive to an efficient FRS design and implementation but due to the relatively higher contamination potential this loss of efficiency is considered justified. The WGTV was evaluated separately because the floor is at a lower elevation than the WTB and the Remaining Structures, which requires different modeling parameters.

As seen in Table 6-1, the Remaining Structures consist of a group of structures that all have relatively low contamination potential. Two of the structures, the Turbine Sump and Turbine Pit, are very small in size. Treating each of the basements in the "Remaining Structure" category separately does not provide a meaningful distinction in dose modeling due to their generally similar elevations and contamination potential. Treating the Remaining Structures separately would result in unnecessary complexity in FRS design, implementation and documentation. See LTP Chapter 5 for discussion of the FRS process.

The End State will also include a limited number of buried pipes, with the majority not associated with contaminated operational systems. The exception is the remaining portion of the Circulating Water Discharge pipe which was used as for liquid effluent discharge as well as circulating water discharge. For the purpose of this License Termination Plan (LTP), buried piping is defined as that contained in soil. Typical commercial power plants also contain piping that penetrates walls and is embedded in concrete. The design of the LACBWR plant includes a tunnel to contain all systems piping that ran between buildings which eliminated the need for penetrations. There is no embedded piping present. The buried piping to remain in the LACBWR End State is listed in Table 6-2.

Table 6-2 Buried Piping to remain in LACBWR End State

Description of Piping	Quantity
Administration Building Sanitary System including drain piping, leach field laterals, and tanks	104' of 4"Sched. 40 PVC 57' of 2" PVC 2500 gal septic tank 750 gal dosing tank 94 gal distribution tank 708' perforated 4" PVC 144' 4" PVC
High Pressure Service Water from LACBWR Crib House to G-3	50' of 6" 222' of 8"
Well water piping for Well #3	511' of 3" 95' of 2"
Storm Water Piping	938' of 48" concrete pipe 3 steel grates at grade 100' of 10" PVC
Remaining portion of Circulating Water Discharge Pipe	525' of 60" steel pipe

The potential for significant surface or subsurface soil contamination at LACBWR is low based on the findings of the EnergySolutions Technical Support Document (TSD) RS-TD-313196-003, *La Crosse Boiling Water Reactor Historical Site Assessment* (HSA) (2) and the results of extensive characterization performed in 2014 (see LTP Chapter 2). There are indications of subsurface soil contamination under the Turbine Building based on positive groundwater monitoring results down gradient of suspected broken drain lines. However, geoprobe samples collected under the Turbine Building in the vicinity of the suspect drain lines did not identify plant-derived radionuclides above background. Full characterization of the subsurface soil will be performed after the Turbine Building foundation is removed and the underlying soil is exposed.

Low concentrations of groundwater contamination have been identified adjacent to the suspected broken floor drains under the Turbine Building. Groundwater sampling in 1983 from a well located down gradient of the Turbine Building identified contamination at relatively low concentrations. In late 2012, five additional monitoring well pairs were installed to support site characterization and license termination. Results indicated lower groundwater contamination levels than found in 1983, predominantly H-3. See LTP Chapter 2, section 2.3.7 for a summary of groundwater sampling results.

6.4. Future Land Use Scenario and Average Member of the Critical Group

The "Reasonably Foreseeable Scenario", is defined in NUREG-1757, Volume 2, Revision 1 *Consolidated Decommissioning Guidance - Characterization, Survey, and Determination of Radiological Criteria* (NUREG-1757), (3), Table 5.1 as a land use scenario that is likely within the next 100 years. The Reasonably Foreseeable Scenario for LACBWR is industrial use.

DPC first acquired land at the site in 1941to build its first coal-fired generation station, G-1. In 1949 an additional 18.6 acres were acquired for G-1 coal ash disposal. An additional 80.8 acres were acquired in 1962. Finally, an additional 26.8 acres was filled by dredging in 1962-63. The total area owned or controlled by DPC was then, and continues to be, 163.5 acres.

The G-1 plant began operation in 1941 and was decommissioned and dismantled in 1989. LACBWR construction began in 1963, was completed in1967, and was permanently shut down in 1987. DPC's third plant onsite, G-3, began commercial operation in 1969 and continues operation as a major generation resource to the DPC system. The G-3 plant has been updated to meet current environmental standards and is currently performing a major turbine overhaul. The projected remaining operation life of G-3 is projected to be 20-25 years.

Residential use of the site over the next 100 years appears unlikely. The site is relatively isolated as it is bounded by the Mississippi River to the west, a rail line to the east, USACE property to the north, and a wildlife and fish refuge to the south. There are several small communities nearby that would be more suitable to additional residential development than the DPC site. In addition, the presence of over 36 acres of closed coal ash landfills further supports the assumption of no foreseeable future residential development. Based on surrounding land use, the conversion of the property to recreational use at some point in the distant future is more likely than residential use.

In summary, the DPC site has been in continuous industrial use for 74 years and DPC has no plans to change the land use in the future. The site contains a transmission station and valuable infrastructure to support the sites future use for power supply after G-3 is decommissioned in 20-25 years. Adjacent land, and a part of the DPC site is currently used for recreational purposes. Finally, there are large tracts of land nearby that would be preferable, and more cost-effective to develop for residential use within at least the next 100 year time period than the conversion of the DPC site from industrial use. Residential land use is therefore categorized as "less likely but plausible" in accordance with NUREG-1757, Table 5.1 definitions. Based on the above discussion of future land use, the Average Member of the Critical Group (AMCG) for the LACBWR dose assessment is the Industrial Worker.

6.5. Dose Model Overview

Dose modeling is performed to demonstrate that residual radioactivity remaining at the time of license termination will not result in a dose to the AMCG (industrial worker) exceeding the 25 mrem/yr criterion. This section provides a general overview of the LACBWR site conceptual model and computational methods for dose assessment.

There are four potential sources of residual radioactivity in the End State that were categorized as follows for the purpose of dose modeling; backfilled basements, soil, buried piping, and groundwater. The intact LACBWR Administration Building will also remain intact but has a very low potential of containing significant levels of residual radioactivity, if any. The vast majority of residual radioactivity to remain at the time of license termination will be in the concrete of backfilled basements. There is no indication that significant soil contamination is currently present at the LACBWR site or will be present in the End State. With the exception of the remaining portion of the Circulating Water Discharge Pipe, the limited buried piping that will remain was not associated with contaminated systems and is expected to contain minimal, if any, contamination. The potential for significant groundwater contamination is also very low but groundwater exposure factors were calculated. The dose from each of the four sources will be summed as applicable to demonstrate compliance with the 25 mrem/yr dose criterion.

An overview of the dose assessment methods for the four sources is provided below. Detailed descriptions and results are provided in sections 6.7 to 6.17.

6.5.1. Backfilled Basements

The dose model for backfilled basements to remain below 636 foot elevation (see Table 6-1) is designated as the Basement Fill Model (BFM). The BFM calculates the dose to the AMCG from residual radioactivity remaining in the basements.

The basement End State will be comprised of backfilled concrete structures that are physically altered to a condition that would not realistically allow the remaining structures to be occupied. The BFM conceptual model includes two source term geometries; 1) the Insitu geometry where the concrete remains in the "as-left" configuration at the time of license termination and 2) the Excavation geometry where some or all of the concrete is excavated and brought to the surface.

The results of the BFM dose assessments are expressed as Dose Factors (DF) in units of mrem/yr per mCi total activity for each of the three basements and the Remaining Structures group. It cannot be ruled out that a portion of the backfilled structures could be excavated and a portion remain in the ground. Therefore, the final dose for demonstrating compliance will conservatively include the sum of the BFM Insitu and BFM Excavation dose.

6.5.1.1. BFM Insitu Scenario

The BFM Insitu geometry includes two exposure scenarios; 1) exposure to well water containing residual radioactivity as a result of leaching from the backfilled concrete surfaces into the fill material and 2) exposure to drilling spoils that are brought to the surface during the assumed installation of an onsite water supply well. The well water scenario is designated as BFM Insitu Groundwater (BFM $Insitu_{gw}$). The drilling spoils scenario is designated as BFM Insitu Drilling Spoils (BFM $Insitu_{ds}$).

The conceptual model for the BFM $Insitu_{gw}$ scenario assumes that the residual radioactivity in floors and walls is released to adjacent fill through leaching into water that comes into contact with the concrete surfaces after backfill. The scenario assumes that 100% of the residual radioactivity is released instantly into the fill which is then treated as contaminated soil. The release occurs immediately after license termination taking no credit for radioactive decay. A water supply well is assumed to be installed adjacent to the down gradient edge of the building and flow to the well is conservatively modeled assuming that structures are not present. Because a clean cover of at least 3 feet is present over potentially contaminated surfaces the dose from direct exposure and soil ingestion/inhalation is negligible or zero. The BFM $Insitu_{gw}$ exposure pathway to the industrial worker AMCG is drinking water from the onsite well.

The BFM $Insitu_{ds}$ scenario assumes that the drilling spoils from the installation of the onsite well are brought to the surface. The well installation is assumed to occur immediately after license termination, before any leaching from concrete occurs and taking no credit for radioactive decay. The residual radioactivity in the floor concrete that is contacted by the borehole during installation is assumed to be inadvertently mixed with the fill material above the floor surface, brought to the ground surface, and spread over a 15 cm thick layer. The BFM $Insitu_{ds}$ exposure pathways are the same as those that apply to contaminated surface soil.

The BFM $Insitu_{gw}$ dose assessment is implemented using the RESidual RADioactive materials (RESRAD) v7.0 model. The BFM $Insitu_{ds}$ dose assessment is implemented using Excel spreadsheet calculations coupled with RESRAD modeling. The results of the BFM Insitu dose assessments are expressed as DFs in units of mrem/yr per mCi total activity inventory in each basement (and the Remaining Structures) (see Table 6-1). The inventory of residual radioactivity at the time of license termination, as determined by the FRS, will be multiplied by the BFM DFs for each Radionuclide of Concern (ROC), and summed as necessary, to demonstrate compliance with the 25 mrem/yr dose criterion.

6.5.1.2. <u>BFM Excavation Scenario</u>

The BFM Excavation scenario assumes that some or all of the backfilled structure concrete is excavated and spread on the ground surface at some time after license termination. For conservatism, the excavation is assumed to occur immediately after license termination taking no credit for radioactive decay. The residual radioactivity remaining in the backfilled basements is assumed to inadvertently mix with the mass of structural concrete removed during excavation which is consistent with the guidance in NUREG-1757, Appendix J, for addressing subsurface contamination. The calculation is performed using Excel spreadsheet and results in BFM Excavation DFs that are expressed in the same units as the DFs for the BFM Insitu scenario, i.e., mrem/yr per total mCi. The fundamental driver of the BFM Excavation DF calculation is that the average concentration in the excavated concrete is limited such that the surface soils DCGLs are not exceeded.

BFM Excavation DFs were calculated separately for the Reactor Building, WTB, WGTV, and "Remaining Structures" consistent with the BFM Insitu DF calculations.

6.5.2. Soil

Derived Concentration Guideline Levels (DCGLs), in units of pCi/g, were developed for residual radioactivity in surface soils that correspond to the 25 mrem/yr dose criterion. RESRAD was used to perform the calculation.

For conservatism, and to optimize remediation efficiency, surface soil is defined as that contained in a 1 m depth from the surface. A standard surface soil contamination thickness of 15 cm would result in lower dose (i.e., higher DCGL). However, in the unlikely event that soil contamination is identified at LACBWR with a thickness greater than 15 cm additional dose modeling may be required if the conceptual model assumed a 15 cm contamination thickness. Using a 1 m thickness reduces the potential for delays or unnecessary remediation if contamination with a thickness somewhat greater than 15 cm is encountered. There is low potential for subsurface contamination to remain in the End State with a geometry comprised of a clean soil layer over a contaminated soil layer at depth.

In the unlikely event that geometries are encountered during continuing characterization or during FSS that are not bounded by the assumed 1 m soil contamination thickness, the discovered geometries will be addressed by additional modeling. The U.S. Nuclear Regulatory Commission (NRC) will be notified if additional modeling is required.

Standard methods for RESRAD parameter selection and uncertainty analysis are used consistent with guidance in NUREG-1757. The AMCG for soil is the Industrial Worker.

6.5.3. Buried Piping

With the exception of the portion of the Circulating Water Discharge Pipe, none of the buried piping to remain at LACBWR was associated with contaminated systems and therefore contamination potential is minimal (see Table 6-2). A buried piping dose assessment was conducted to develop DCGLs for pipe.

The conceptual model for the buried piping dose assessment is similar to the BFM and includes two scenarios: Insitu and Excavation. In the Insitu scenario the residual radioactivity on the internal surfaces of the pipe is assumed to instantaneously release and mix with a thin 2.54 cm layer of soil in an area equal to the internal surface area of the pipe. For the Excavation scenario, the soil mixing layer is 15 cm due to the extensive ground surface disturbance associated with the pipe excavation. The Insitu scenario 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 assumes that the pipe is excavated followed by instant release of all radioactivity into a 15 cm layer of soil on the ground surface with no cover. The Industrial Worker is exposed to the Insitu and Excavated soil via the same pathways applicable to the BFM and soil dose assessment scenarios. RESRAD modeling is used in conjunction with Excel spreadsheet to calculate DCGLs in units of dpm/100 cm^2.

6.5.4. Existing Groundwater

Groundwater monitoring has been and will continue to be conducted until sometime before license termination. The final monitoring date will depend on the evaluation of sampling results. Low levels of H-3 and Sr-90 have been identified in samples collected since 2012 after five new well pairs were installed at the site. Groundwater exposure factors in units of mrem/yr per pCi/L groundwater concentration are provided to perform dose assessment for existing groundwater contamination present at license termination, if any.

6.5.5. Remaining Above Ground Buildings

The LACBWR Administrative Building, LACBWR Crib House and Turbine Building Switchyard Fire Service Water System will remain intact. The buildings are not expected to contain residual radioactivity. They will be free released in accordance with the guidance in NUREG-1575, Supplement 1, *Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual* (MARSAME) (4) .

6.5.6. Dose Summation for Compliance

The various source terms and conceptual models discussed above are not necessarily mutually exclusive. For example, although a low probability, a given basement could be subject to the BFM Insitu drilling spoils scenario and subsequently excavated. Another example could be that the activity released to groundwater in the BFM $Insitu_{gw}$ scenario for one basement combines with the groundwater activity released from another basement that is down gradient before encountering the well. Therefore, the BFM $Insitu_{gw}$ dose will be summed across all basements. The dose from soil, buried piping, and groundwater could also be viewed as occurring simultaneously with the BFM dose scenarios. Therefore, the final site-wide dose assessment to demonstrate compliance with the 25 mrem/yr dose criterion will include the summation of the following using the mean values from FRS:

- maximum BFM $Insitu_{ds}$ dose,
- maximum BFM Excavation dose,
- sum of the BFM $Insitu_{gw}$ dose from all basements combined,
- maximum soil dose,
- maximum buried piping dose,
- maximum existing groundwater dose.

6.5.7. Alternate Scenarios

As discussed in section 6.4, the industrial use scenario was selected as a "reasonably foreseeable" scenario based on past and projected use of the LACBWR site. Two alternate land use scenarios were considered including recreational use, and residential use with a water supply well and onsite garden.

A qualitative evaluation of a recreational land use scenario concluded that the dose would be lower than that calculated for the industrial use scenario because occupancy time would be less than that assigned to an industrial worker. In addition, if a water supply well were installed in the recreational land use scenario the recreational user's intake rate from the well would be less than assumed for the industrial worker.

The resident gardener land use was considered to be a "less likely but plausible" land use scenario as defined in NUREG-1757, Table 5-1. RESRAD was used, in conjunction with Excel spreadsheet, to calculate the dose from the Resident Gardener alternate scenario. 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. The alternate scenario is addressed in section 6.15.

6.6. <u>Mixture Fractions for Initial Suite Radionuclides</u>

A comprehensive "initial suite' of 21 radionuclides were identified that could potentially be present at the LACBWR site. As discussed below, the initial suite includes many radionuclides that have not been positively identified in LACBWR 10 CFR Part 61 analysis or during characterization but could theoretically be present, albeit at very low mixture fractions, relative the primary radionuclide which is Cs-137.

The initial suite mixture fractions were used in the RESRAD uncertainty analyses for Soil DCGL and BFM DF dose assessments. The initial suite mixture fractions were used in conjunction with the soil DCGLs and BFM DFs to identify the insignificant dose contributors and final list of ROC that will be considered during the FRS and final dose summation for compliance as described in section 6.5.6.

6.6.1. Potential Radionuclides of Concern and Initial Suite

Energy*Solutions* TSD RS-TD-313196-001, *Radionuclides of Concern During LACBWR Decommissioning* (5) established an initial suite of potential ROC. Two industry guidance documents were reviewed including NUREG/CR-3474, *Long-Lived Activation Products in Reactor Materials,* (6), and NUREG/CR-4289, *Residual Radionuclide Concentration Within and Around Commercial Nuclear Power Plants; Origin, Distribution, Inventory, and Decommissioning Assessment* (7). The review also included an evaluation of a LACBWR spent fuel inventory assessment conducted in 1988 that was decay corrected to January 2015. Several 10 CFR Part 61 waste stream analyses were also reviewed.

The list of activation product radionuclides for consideration in the initial suite was developed after eliminating noble gases, radionuclides with half-lives less than two years, and radionuclides with theoretical neutron activation products with abundances less than 0.01 percent relative to Co-60 and Ni-63 (the prominent activation products identified in LACBWR 10 CFR Part 61 samples). The review of Reference 6, which includes both activation and fission products, coupled with review of the LACBWR fuel inventory and 10 CFR Part 61 analyses resulted in several additional radionuclides being included in the list of those that could be potentially present during the decommissioning of LACBWR.

Finally, the results of concrete core samples collected from the WTB, Reactor Building and Piping and Ventilation Tunnels were reviewed. No radionuclides were positively identified that were not already accounted for by the assessments described above.

The resulting list of potentially present radionuclides is called the "Initial Suite" and is provided in Table 6-3. The process for determining the mixture fractions is described below.

6.6.2. Mixture Fractions for Initial Suite Radionuclides

As described in Reference 5, the mixture fractions for the Initial Suite radionuclides were developed from concrete core data collected during characterization from the Reactor Building, WTB, and Piping/Ventilation Tunnels. The vast majority of the activity was located in the first 1.27 cm slices from the cores which were therefore used to determine the radionuclide mixture fractions. The use of cores with higher concentrations was required to ensure that the mixture fractions assigned to low abundance radionuclides were not overly influenced by the reported Minimum Detectable Concentration (MDC) values which were in many cases the only concentration data available. The mixture fractions assigned to the Initial Suite radionuclides are provided in Table 6-3.

Table 6-3 Initial Suite of Potential Radionuclides and Mixture Fractions

Nuclide	Mixture Fractions
H-3	0.00071
C-14	0.00065
Fe-55	0.00294
Ni-59	0.01038
Co-60	0.01221
Ni-63	0.08048
Sr-90	0.00907
Nb-94	0.00008
Tc-99	0.00015
Cs-137	0.87736
Eu-152	0.00093
Eu-154	0.00080
Eu-155	0.00045
Pu-238	0.00014
Pu-239/240	0.00013
Pu-241	0.00306
Am-241	0.00037
Am-243	0.00004
Cm-243/244	0.00005
Total	1.00

The mixture was based on a compilation of 12 cores from all buildings to determine one mixture fraction for all buildings. The application of the combined data to determine the mixture was justified in Reference 5 by a review of Cs-137/Sr-90 ratios which were relatively consistent across cores from the different areas. The potential effect of uncertainty in the mixture fractions on the final compliance dose calculations is minimized by the fact that the vast majority of the mixture is comprised of Cs-137 which is a beta-gamma emitter. There is no dose impact from uncertainty in the mixture fractions for Cs-137, or any other beta-gamma emitting radionuclides, because the FRS for structures and soil will be performed using gamma spectroscopy. Compliance with the 25 mrem/yr dose criterion will be demonstrated using actual measured concentrations for gamma-beta emitters. Note that the dose contribution from beta-gamma emitters that were designated as insignificant contributors is already accounted for in the insignificant contributor dose calculation and the corresponding adjustments to the BFM DFs, soil DCGLs and Buried Pipe DCGLs. The additional dose from any beta-gamma radionuclide that is positively identified during FRS will be directly calculated and included in the compliance demonstration.

The primary source of potential dose impact from mixture uncertainty is limited to the Hard-to-Detect (HTD) mixture fractions because there will be no analysis of HTD radionuclides during FRS. However, the method used to calculate the insignificant contributor dose percentage is conservative and provides sufficient margin to account for uncertainty in the HTD mixture fraction. See section 6.13 for the assessment of insignificant contributor dose percentage.

There were only a few positive soil sample results identified during characterization, predominantly Cs-137, and the concentrations were insufficient to provide a meaningful evaluation of the relative mixture fractions for the HTD radionuclides which were all reported as less than the MDC. When the Cs-137 concentrations are low the relative mixture fractions of the HTD radionuclides that are not positively identified are artificially increased due to using the MDC value which could be orders of magnitude higher than the actual concentrations present. Therefore, the radionuclide mixture fractions determined from the concrete cores were applied to soil and used to determine the soil ROC. However, as described in section 6.13 the insignificant contributor dose percentage assigned to soil is demonstrated to be conservative and to provide sufficient margin to account for mixture uncertainty.

6.7. <u>Soil Dose Assessment and DCGL</u>

Site-specific DCGLs were developed for residual radioactivity in surface soil that represent the 10 CFR 20.1402 dose criterion of 25 mrem/yr. A DCGL was calculated for each initial suite radionuclide in order to provide an input to the determination of insignificant contributors dose percentage and the final list of ROC.

The surface soil conceptual model assumes that the soil contamination is contained in a uniformly contaminated 1 m layer of soil from the ground surface downward. There are no expectations that at the time of license termination residual radioactivity will remain with a geometry consisting of a clean surface layer of soil over a contaminated subsurface soil layer with concentrations exceeding the surface soil DCGL.

6.7.1. Soil Source Term

There is limited potential for significant surface or subsurface soil contamination at LACBWR based on the results of soil characterization performed in 2014. There are indications of subsurface soil contamination under the Turbine Building based on positive groundwater monitoring results down gradient of suspected broken drain lines. However, geoprobe samples collected under the Turbine Building in the vicinity of the suspect drain lines did not identify plant-derived radionuclides above background. Subsurface soil will be evaluated during continuing characterization after the Turbine Building foundation is removed and the underlying soil exposed.

Soil characterization results are provided in LTP Chapter 2 and summarized here. A total of 22 biased surface soil samples and 79 subsurface soil samples (at varying depths to six meters) were collected inside the LSE fence. Thirteen of the surface soil sample analyses results indicated Cs-137 above the MDC with a maximum of 1.07 pCi/g. Two of the surface soil sample results indicated Co-60 above the MDC with a maximum of 0.287 pCi/g. Fifteen of the subsurface soil samples indicated Cs-137 above MDC with a maximum of 0.161 pCi/g with no subsurface Co-60 results greater than MDC. The Cs-137 results are all in the range of natural background.

6.7.2. Soil Exposure Pathways and Critical Group

The AMCG at the LACBWR site is the Industrial Worker. The following exposure pathways apply:

- Direct exposure to external radiation
- Inhalation of airborne radioactivity
- Ingestion of soil
- Ingestion of water from onsite well

The agricultural and gardening pathways are not applicable to industrial land use. The meat, milk, grain and vegetable ingestion pathways are therefore not included.

6.8. <u>Soil DCGL Computation Model – RESRAD v7.0</u>

The RESRAD model was used to calculate DCGLs for surface soil. The RESRAD output reports for the modeling discussed below are provided electronically in conjunction with Energy*Solutions* TSD RS-TD-313196-004, *LACBWR Soil DCGL and Concrete BFM Dose Factors* (8).

6.8.1. Parameter Selection Process

RESRAD parameters are classified as behavioral, metabolic or physical. Some parameters may belong to more than one category. Physical parameters are determined by the geometry and location of the source term and the geological characteristics of the site (i.e., source-specific and site-specific) including the geohydrologic, geochemical, and meteorologic characteristics. The characteristics of atmospheric and biospheric transport up to, but not including, uptake by, or exposure to, the dose receptor are also considered physical input parameters.

Behavioral parameters define the receptor's behavior considering the conceptual model selected for the site. For the same group of receptors, a parameter value could change if the scenario changed (e.g., parameters for industrial use could be different from residential use). For LACBWR, the behavioral parameters are based on an industrial use scenario and are the same for both the BFM and soil dose assessments.

Metabolic parameters define certain physiological characteristics of the potential receptor. One set of metabolic parameters applies to both the BFM and soil dose assessments.

Physical, behavioral and metabolic parameters are treated as deterministic parameters in the final dose modeling to calculate soil DCGLs (and BFM DFs). The deterministic module of the code uses single values for input parameters and generates a single value for dose. The parameter selection process is described below.

Argonne National Laboratory (ANL) ranked physical parameters by priority as 1, 2, or 3. Priority 1 parameters have the highest potential impact on dose and Priority 3 the least. This ranking is documented in Attachment B to the ANL report, NUREG/CR-6697, *Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes*, (NUREG/CR-6697) (9).

Priority 3 physical parameters were assigned either a site-specific value or the median values from the parameter distributions defined in NUREG/CR-6697. Priority 1 and 2 parameters were either assigned site-specific deterministic values, evaluated by uncertainty analysis using the parameter distributions defined in NUREG/CR-6697, or evaluated by uncertainty analysis using site-specific parameter distributions. The Partial Rank Correlation Coefficient (PRCC) values from the RESRAD uncertainty analysis were used to evaluate the relative sensitivity of the Priority 1 and 2 parameters. A PRCC value less than -0.25 was considered sensitive and negatively correlated to dose. The 25th percentile of the parameter distribution was assigned to negatively correlated parameters. A PRCC value greater than +0.25 was considered sensitive and positively correlated to dose. The 75th percentile of the parameter distribution was assigned to positively correlated parameters. Priority 1 and 2 parameters with a PRCC absolute value less than 0.25 were assigned the median value of the parameter distribution.

Consistent with the guidance in NUREG-1757, section I.6.4.2, metabolic and behavioral parameters were assigned the mean values from NUREG/CR-5512 Vol. 3, *Residual Radioactive Contamination From Decommissioning Parameter Analysis* (NUREG/CR-5512) (10) Table 6.87.

Figure 6-7 provides a flow chart of the parameter selection process. The set of selected deterministic parameters and parameter distributions is used in a RESRAD Uncertainty Analysis to determine the final deterministic parameter set used to calculate soil DCGLs.

6.8.2. RESRAD Parameter Selection for Uncertainty Analysis

The uncertainty analysis included all of the initial suite radionuclides from Table 6-3 that had rounded mixture fractions of 0.1% or greater. The concentrations assigned to the selected radionuclides, and entered into RESRAD for the uncertainty analysis, were values equal to their respective mixture factions. This approach is consistent with the guidance in NUREG-1757, Section I.7.5 and ensures that the sensitivities of the significant radionuclides are fully accounted for. The threshold of 0.1% for including radionuclides was primarily applied to facilitate a practical implementation of the RESRAD uncertainty analysis module but is also fully consistent with the objective of identifying sensitive parameters for significant radionuclides. The rationale for selection of deterministic parameters through the uncertainty analysis is discussed below.

Attachment 6-1 provides a table with the deterministic values and parameter distributions used for the uncertainty analysis. The references or justifications for the parameter selections are listed in Attachment 6-1. The basis for the behavioral and metabolic parameters (NUREG/CR-5512) and the generic parameter distributions (NUREG/CR-6697) are straightforward and consistent with the process flow chart in Figure 6-7. The basis for the site-specific parameters and parameter distributions are discussed in more detail below.

The contaminated area was assumed to be the full 7500 m^2 area inside the LSE fence. The site-specific soil type is sand. The depth of soil contamination was conservatively assumed to be 1 m to ensure efficient remediation (if necessary) and FRS if contamination is found at depths greater than the typical default value of 0.15 m. The following site-specific deterministic parameters from Reference 1 were applied:

- 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 (CRA) Report, *Evaluation of Hydrological Parameters in Support of Dose Modeling for the Zion Restoration Project* (11).

The Inhalation Rate parameter for the industrial worker AMCG was derived from NUREG/CR-5512, Table 5.1.1 which provides an annual inhalation rate of 8400/y for a residential user. This equates to 23 m^3/d. The inhalation rate the industrial worker was then calculated as follows: Inhalation Rate (m^3/yr) = 23 m^3/d ÷ 24h/d * 2000 h/y = 1917 m^3/yr.

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 and Outdoor Time Fractions 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 year, this equates to 2190 hours per year. The majority of industrial work is expected to be indoors. Consistent with Table 2-3 of the ANL report *User's Manual for RESRAD Version 6* (12) , 75% of work time is assumed to be indoors and 25% outdoors. The corresponding RESRAD Indoor Fraction parameter = (2190*.75)/(24*365) = .1875. The Outdoor Time Fraction is then calculated as (2190*.25)/(24*365) = 0.0625.

Site-specific parameter distributions were developed for the Well Pump Intake Depth and Well Pumping Rate Parameters. There are two existing onsite industrial water supply wells supporting LACBWR. The well depths are 116 feet and 129 feet below the ground surface (bgs) (1). The 129 foot depth is 109 feet (33.1 m) below the average water table elevation which is 20 feet bgs. The 33.1 m depth is assumed to be maximum well depth. The minimum well depth is assumed to be represented by a nominal 20 foot screen depth (6.08 m) starting at the average water table elevation. The mode of the recommended triangular distribution is assumed to be mid-point between 6.08 m and 33.1 m which is 19.6 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 industry. To ensure that well pumping rate is included 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 the minimum industrial well pumping rate assuming four workers. A nominal maximum rate is assumed based on supply to 20 workers which equates to1643.5 m^3/yr. These minimum and maximum values are not intended to predict actual water use at an unknown 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.

The remaining parameters in Attachment 6-1 not discussed above were selected in accordance with the process flow chart in Figure 6-7.

6.8.3. Soil DCGL Uncertainty Analysis Results

The full RESRAD Uncertainty Report for Soil DCGL parameters is provided electronically with Reference 8. The uncertainty analysis results are provided in Tables 6-4 to 6-6.

The uncertainty analysis results for the Kd parameters indicated that only three Kd parameters were sensitive which are listed, along with the selected deterministic parameters, in Table 6-4. The sensitive parameter for Cs-137 was assigned the 75^{th} percentile value from the sand Kd distributions in Sheppard and Thibault, *Default Soil/Solid /Liquid Partition Coefficients, K_ds, for Four Major Soil Types: A Compendium*, (13) which are listed in Reference 8. Europium was not provided in Reference 13 and was therefore assigned the 75^{th} percentile value from the default NUREG/CR-6697 distribution. All non-sensitive Kd parameters were assigned the mean deterministic values for sand from Reference 13 as listed in NUREG-6697, Table 3.9-2 (see Table 6-5). The uncertainty analysis results and the selected deterministic values for all other parameters evaluated are listed in Table 6-6.

Table 6-4 Deterministic Values selected for Sensitive Kd parameters used in to calculate Soil DCGLs

Radionuclide	Kd in Contaminated Zone		Kd in Unsaturated Zone		Kd in Saturated Zone	
Cs-137	75th	1460	NS	NS	NS	NS
Eu-152	NS[1]	NS	75th	7302	NS	NS
Eu-154	75th	7302	NS	NS	NS	NS

Note 1: NS indicates non-sensitive parameter

Table 6-5 Deterministic parameter values selected for non-sensitive Kd parameters for soil DCGL calculation

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

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

Table 6-6 Soil DCGL Uncertainty Result and Deterministic Values selected for Non-Nuclide Specific Parameter Distributions

Parameter	Uncertainty Result	Selected Deterministic Value
Contaminated zone erosion rate	median	0.0015
Contaminated zone b parameter	median	0.97
Evapotranspiration coefficient	median	0.62
Wind Speed[1]	median	6.8
Runoff coefficient	75th	0.45
Saturated zone b parameter	median	0.97
Well pump intake depth	median	19.6
b Parameter of Unsaturated zone	median	0.97
Mass loading for inhalation	median	2.35E-05
Indoor dust filtration factor	median	0.55
External gamma shielding factor	75th	0.4
Well Pumping Rate	median	986.1
Depth of Soil Mixing Layer	25th	0.15

6.9. Soil Deterministic Analysis and Soil DCGLs

The soil DCGLs were calculated using the parameter set provided in Attachment 6-1 with the parameter distributions replaced by the deterministic values listed in Tables 6-4, 6-5 and 6-6. The Contaminated Zone Field Capacity was also changed from 0.2 to 0.066 to be consistent with the unsaturated and saturated zone. The full RESRAD Summary Report for Soil DCGLs is provided electronically with Reference 8. The Soil DCGLs for the Initial Suite are listed in Table 6-7.

6.10. **Basement Fill Conceptual Model**

The BFM is used to calculate dose to the industrial worker AMCG from residual radioactivity in the backfilled basements to remain after license termination. A general description of the BFM conceptual model was provided in section 6.5.1. This section describes the conceptual model in more detail including assumed physical configuration, geohydrology, source-term and exposure pathways. The computational model is described in sections 6.11 and 6.12.

The BFM conceptual model assumes that all structures are removed to a depth of three feet bgs (639 foot), i.e., to an elevation of 636 foot, and then backfilled. The average water table depth is 20 feet bgs at 619 foot elevation (1) which defines the beginning of the saturated zone. The site groundwater is in direct communication with the Mississippi river resulting in river driven seasonal groundwater fluctuation. Based on direct observation of water ingress into the Piping and Ventilation Tunnels, the seasonal fluctuation can result in water rising up to 10 feet above the average water table level, i.e., to the 629 foot elevation. An onsite water supply well is assumed to be installed in the saturated zone below the 619 foot average water table elevation. The seasonal water fluctuations result in flushing of water into and out of the unsaturated zone above 619 foot and contacting backfilled structure surfaces. Note that the Reactor Building is somewhat of an exception in that a portion of building is below 619 foot and is assumed to be in in the saturated zone (see Figure 6-6).

Table 6-7 LACBWR Soil DCGLs for Initial Suite Radionuclides

Radionuclide	Soil DCGL (pCi/g)
H-3	5.352E+06
C-14	6.768E+06
Fe-55	1.019E+07
Ni-59	2.599E+07
Co-60	1.281E+01
Ni-63	9.495E+06
Sr-90	6.577E+03
Nb-94	2.018E+01
Tc-99	2.008E+03
Cs-137	5.811E+01
Eu-152	2.844E+01
Eu-154	2.635E+01
Eu-155	1.122E+03
Pu-238	1.693E+03
Pu-239	1.523E+03
Pu-240	1.525E+03
Pu-241	3.691E+04
Am-241	1.105E+03
Am-243	1.872E+02
Cm-243	2.892E+02
Cm-244	2.720E+03

The BFM includes two scenarios; Insitu 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 assumed to be brought to the surface during the installation of the onsite well. The BFM Excavation scenario assumes large scale industrial excavation of some or all of the backfilled concrete and spreading the concrete over a 1 m layer on the ground surface.

6.10.1. Source Term

The source term for the BFM is the total inventory of residual radioactivity remaining in Basement End State at the time of license termination. LTP Chapter 2 provides the characterization data for the basements that will remain. The dimensions and surface areas are provided in Reference 8. The expected source term configurations and activity levels projected to remain in each basement are summarized below.

6.10.1.1. Reactor Building

The Reactor Building is a right circular cylinder with a hemispherical dome and semi-ellipsoidal bottom. It has an overall internal height of 144 feet and an inside diameter of 60 feet, and it extends 26 feet 6 inches below grade level. The steel shell thickness is 1.16 inch, except for the upper hemispherical dome, which is 0.60 inch thick. The lowest floor elevation is at 612 foot elevation.

The total wall/floor surface area in the portion of the building to be backfilled, i.e., below 636 foot elevation, is 512 m^2. The surface area below the 619 foot average water table elevation is 363 m^2. Remediation plans call for all below grade concrete interior to the steel liner to be removed exposing the steel liner. Subsequent to interior concrete removal, the remaining portion of the steel liner will be removed. The remaining structural concrete outside the liner and below the 636 foot elevation will remain. The remaining concrete "bowl" sits on an external support structure comprised of a concrete pile cap and piles. The pile cap and piles were isolated from reactor operations by the interior concrete, the steel liner and the exterior concrete bowl. There is no evidence of contamination leakage beyond the steel liner or the concrete bowl exterior to the liner. Therefore the pile cap and piles are considered to be non-impacted areas.

Six 1.27 cm thick core slices were collected from the surface downward and shipped to an offsite laboratory for analysis. The cores were collected from biased locations as indicated by elevated survey measurements and represent the areas expected to contain the highest levels of contamination. As shown in Table 6-3, Cs-137 is the predominate radionuclide at 88% of the radionuclide mixture. The Cs-137 results from the six cores ranged from 66 pCi/g to 7,500 pCi/g with an average of 1,903 pCi/g.

There is no indication that contamination is present in the concrete to remain after the steel liner is removed therefore no cores were collected from the concrete outside the steel liner. In addition, general cleanup of loose contamination on the steel liner (concrete dust) after demolition and removal of the internal concrete is expected for operational radiation protection purposes before the steel liner is removed. This reduces the already low potential for transfer of activity in contaminated dust from the steel liner to the underlying concrete during removal of the liner. Therefore, minimal source term is expected in the Reactor Building End State.

6.10.1.2. Waste Treatment Building

The WTB contained facilities and equipment for decontamination and the collection, processing, storage, and disposal of low level solid radioactive waste. The size of the WTB floor to remain below 636 foot elevation is small at 36.9 m^2 with a total wall and floor surface area of 102 m^2. The WTB basement floor is at elevation 630 feet. A small sump is present with a floor elevation of 626 feet.

Concrete cores were collected at biased locations as indicated by elevated survey measurements. The Cs-137 concentrations in the first core slices (0 - 1.27 cm) of the three cores analyzed by the offsite laboratory ranged from 1240 pCi/g to 25,400 pCi/g with an average of 12,003 pCi/g. The Cs-137 concentrations in the two core slices from 1.27cm - 2.54 cm were much lower with values that were approximately 1% of those found in the 0 - 1.27 cm slices. The majority of the source term is expected to be on the floor as opposed to walls.

Decontamination will be required to meet the unrestricted use criteria. The initial decontamination threshold is the open air demolition criteria of 2 mR/hr per Energy*Solutions* Technical Support Document RS-TD-313196-005, *La Crosse Open Air Demolition Limits* (14). This equates to approximately 10,000 pCi/g Cs-137 assuming that contamination is present in a 1.27 cm thick uniform layer. Although the biased characterization samples likely identified the approximate maximum concentrations, the full areal extent and concentrations of contamination remaining after remediation to the open air demolition criteria will not be known until remediation is completed.

6.10.1.3. Waste Gas Tank Vault

The WGTV is a 29 foot by 31 foot underground concrete structure with 14 feet high walls and 2 feet thick floors, walls, and ceiling located 3 feet bgs just outside of the WTB. The gas decay system routed main condenser gases through various components for drying, filtering, recombining, monitoring and holdup for decay in the WGTV. The vault floor is at 621 foot elevation. A small sump is present that extends to 618 foot elevation.

Concrete cores were not collected from the WGTV due to access restrictions and low expectation of significant contamination. However, 10 CFR Part 61 samples collected from liquid in the WGTV and WTB sumps can be used to provide a very rough estimate of potential contamination levels in the WGTV. The most recent samples from the sumps indicate Cs-137 concentrations of 0.547 µCi/L and 0.0215 µCi/L for the WTB and WGTV, respectively. By simple ratio of the concentrations in the sump liquid, the contamination levels in the WGTV could be in the range of 4% of the contamination levels in the WTB. Additional surveys and/or core samples will be collected from the WGTV as a part of continuing characterization after all tanks and equipment is removed to provide a better estimate of contamination levels to support remediation planning and FRS classification.

6.10.1.4. Remaining Structures

The Remaining Structures category includes the Piping and Ventilation Tunnel, Reactor Plant/Generator Plant area, a one foot thick remnant of the four foot thick Chimney foundation slab, a small sump in the Turbine Building and a small pit in the Turbine Building.

Three concrete core samples were collected from the Piping and Ventilation Tunnel. The Cs-137 concentrations in the three cores ranged from 10 pCi/g to 20 pCi/g with an average of 15 pCi/g. The activity was identified in the core slice from 0-1.27 cm. Minimal activity near or below the MDC was found in the slice from 1.27-2.54 cm.

Cores were not collected in the Reactor Plant/Ventilation Plant area or the Turbine Building sump and pit due to the low expectation of significant contamination being present and their very small areas. Additional concrete cores and/or dose rate surveys will be performed during continuing characterization in these areas to support FRS classification and planning.

The remnant of the Chimney foundation slab has a very low potential of being contaminated because it is the lowest one foot portion of a solid four foot slab. The top surface of the existing four foot thick foundation slab is expected to contain minimal contamination levels and the potential for contamination to migrate three feet into the solid concrete slab is very low.

6.10.2. BFM Exposure Pathways

The BFM includes two exposure scenarios, Insitu and Excavation. As discussed in section 6.4 the "reasonably foreseeable" future land use at the LACBWR site is industrial and the AMCG is therefore the industrial worker.

The following exposure pathways are applicable to the BFM scenarios:

- Direct exposure to external radiation in "as left" End State geometry (negligible),
- Inhalation of airborne radioactivity in "as left" End State geometry (negligible),
- Ingestion of concrete or fill material in "as left" End State geometry (negligible),
- Ingestion of water from onsite well,
- Direct exposure, inhalation dose and ingestion dose from contaminated drilling spoils brought to the surface during installation of the onsite well into the fill material, and
- Direct exposure, inhalation dose and ingestion dose from concrete that is brought to the surface by excavation.

The agricultural and gardening pathways are not applicable to industrial land use. The meat, milk, grain and vegetable ingestion pathways are therefore not included.

6.11. <u>BFM Insitu Scenario</u>

6.11.1. BFM Insitu Groundwater Scenario

The BFM Insitu groundwater (BFM $Insitu_{gw}$) conceptual model is based on a conservative screening approach. One hundred percent of the inventory in the backfilled basement concrete is assumed to release and instantly mix with the fill material. RESRAD is then used to perform the dose modeling assuming that the source term is in the fill and that the structures provide no resistance to water flow, i.e., are not present.

The fill volume into which the released activity mixes is proportional to the distance that the activity moves from the concrete surface into the fill. A portion of the Reactor Basement is below the average water table elevation of 619 foot. Mixing is assumed to occur over the entire fill volume in the Reactor Basement below 619 foot because the fill is assumed to be in contact with water continuously for the full year. With the exception of three small sumps with floor elevations at 618 foot, the remaining End State basement floors are above 619 foot elevation. The surface areas below 619 foot in the three sumps are insignificant (less than 1% of the total backfilled basement surface area) and are included with the basements above 619 foot for the purpose of fill mixing assumptions.

The mixing distance into the fill after leaching from floor and wall surfaces above 619 foot is more uncertain than leaching into the Reactor Building fill volume below 619 foot. Above 619 foot, contact with water is the result of periodic flushing from seasonal water level rise, or rainwater infiltration, as opposed to continual contact with water in the saturated zone. To address this uncertainty in a manner consistent with the screening approach used to develop the BFM conceptual model, a simple sensitivity analysis was conducted to determine the dependence of dose on the mixing distance. The mixing volume sensitivity calculation is provided in Reference 8.

The fill mixing distances evaluated ranged from 2.54 cm to full mixing throughout the entire fill volume. For the Reactor Building above 619 foot an assumption of full mixing resulted in the highest dose. For the remaining basements the nominal minimum mixing depth of 2.54 cm resulted in the highest dose. The Reactor Building above 619 foot differed from the other basements because the source term is entirely on the walls of a right circular cylinder which caused the RESRAD Length Parallel to Flow parameter to be correlated to the mixing distance from the walls. This reduced the modeled well water concentrations.

Based on the results of the sensitivity analysis, full mixing with the fill was assumed for the Reactor Building, above and below 619 foot, and a 2.54 cm mixing distance into the fill was assumed for all other basements/structures.

The RESRAD non-dispersion groundwater model is used in the BFM $Insitu_{gw}$ assessment. An important parameter is the vertical flow rate of water through the unsaturated zone which is typically determined by the infiltration rate as defined by the precipitation, evapotranspiration and runoff coefficient parameters. A different approach to defining the vertical flow rate was required for LACBWR due to the site groundwater being hydraulically connected to the Mississippi River and the resulting seasonal water level fluctuation into and out of the unsaturated zone.

The vertical water flow rate is conservatively modeled in RESRAD by assuming that the annual rate is defined by the distance that water recedes from the seasonal high elevation of 629 foot to the 619 foot average water table elevation (10 ft or 3.05 m). This seasonal 3.05 m water elevation change is used to conservatively bound the net flow of water to the saturated zone in RESRAD by forcing the infiltration rate to be 3.05 m/y. See Equation 1 and corresponding discussion below for a description of the method used to assign a 3.05 m/yr infiltration rate in RESRAD.

The use of 3.05 m/yr is conservative because the seasonal water level fluctuation includes periods of increase and decrease, as well as a horizontal component, that are not accounted for. Full resolution of the actual water flow pattern during the seasonal fluctuations into the unsaturated zone would require detailed groundwater transport and dispersion modeling which is not justified given the bounding/screening approach used to develop the BFM conceptual model.

As listed in Table 6-1, there are portions of eight structures that will be backfilled and remain at license termination. Due to differences in configuration and contamination potential, the BFM was run separately for the Reactor Building, WTB, WGTV, and the “Remaining Structures” group.

6.11.1.1. BFM $Insitu_{gw}$ Computation Model

RESRAD was used to develop Dose to Source Ratios (DSRs), with units of mrem/yr per pCi/g, for each radionuclide in the initial suite. The DSRs were used in conjunction with calculated fill concentrations to determine BFM $Insitu_{gw}$ DFs. The fill concentrations were calculated assuming that a unit source term of 1 pCi total inventory was present in the basement concrete at the time of license termination which was instantly released and mixed with a volume of fill that is dependent on the mixing distance as discussed above. The fill concentration then has units that can be described as pCi/g in fill per total pCi in concrete. BFM $Insitu_{gw}$ DFs, in units of mrem/yr per mCi total activity in concrete, were then calculated by converting pCi to mCi and multiplying the DSR by the pCi/g per mCi value. Excel spreadsheet calculations were used to calculate the BFM $Insitu_{gw}$ DFs as detailed in Reference 8.

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

An uncertainty analysis was performed to select deterministic RESRAD parameters for the calculation of DSRs for the BFM $Insitu_{gw}$ model. 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 6-7).

The parameter set developed to perform the soil DCGL uncertainty analysis is applicable to the BFM $Insitu_{gw}$ analysis with changes to account for the geometries of the backfilled 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 Fraction of Contaminated Zone below the Water Table.

The uncertainty analysis was performed for five structure configurations; Reactor Building above 619 foot elevation, Reactor Building below 619 foot elevation, WTB, WTGV, and Remaining Structures resulting in five separate uncertainty analyses. The parameters used for the five BFM $Insitu_{gw}$ uncertainty analyses are listed in Attachment 6-2. The parameters listed as "Variable" in Attachment 6-2 were assigned the values shown in Table 6-8 for the respective structures.

The selection of the Precipitation, Evapotranspiration Rate, and Runoff Coefficient parameters in the BFM $Insitu_{gw}$ RESRAD model requires additional explanation. As discussed above, the BFM $Insitu_{gw}$ conceptual model assumes that the onsite groundwater is in communication with the Mississippi river and fluctuates seasonally into the unsaturated zone. River stage measurements indicate fluctuations that are up to five feet higher than the average site water table elevation of 619 foot. However, the river stage does not precisely represent site water table levels. For example, it is known that water level seasonally rises to an elevation sufficiently high for water to be observed in the Piping and Ventilation Tunnels with a floor at 629 foot elevation which is 10 feet (3.05 m) above the average water table elevation.

The seasonal water table rise must be accounted for in the conceptual model for the BFM $Insitu_{gw}$ dose assessment but does not precisely fit the RESRAD groundwater modeling approach. The seasonal water rise was addressed by assuming that the boundary of the saturated and unsaturated zone is the average water table elevation of 619 foot. The seasonal 3.05 m water rise above the 619 foot results in water periodically entering backfilled structures that are in the unsaturated zone.

Table 6-8 Deterministic Geometry RESRAD Parameters used in the Uncertainty Analysis for the five BFM Insitu$_{gw}$ Configurations

Parameter	Rx Building Above 619'	Rx Building Below 619'	WTB	WGTV	Remaining Structures
Cover Depth (m)	0.91	6.10	2.72	5.46	2.4
Area of Contaminated Zone (m^2)	262.68	182.41	101.90	460.04	667.26
Thickness of Contaminated zone (m)	5.18	0.75	0.0254	0.0254	0.0254
Length Parallel to Aquifer Flow (m)	18.29	15.24	6.10	9.75	38.10
Unsaturated Zone Thickness (m)	1E-10	0	3.35	0.61	3.67
Fraction of contaminated zone below the water table	0	1	0	0	0

The effect of the 3.05 m seasonal flushing height is accounted for in the BFM Insitu$_{gw}$ scenario by conservatively assuming that the distance that the water recedes after the seasonal (3.05 m) rise represents a constant infiltration rate of 3.05 m/yr. This is conservative relative to the actual precipitation driven infiltration rate at the LACBWR site which is 0.25 m/yr (as calculated from precipitation, evapotranspiration and runoff coefficient in the Soil DCGL parameter set). Maximizing the infiltration rate maximizes the well water concentrations for all significant radionuclides when the non-dispersion groundwater model is selected in RESRAD.

To force RESRAD to use a 3.05 m/yr infiltration rate, the precipitation parameter is used to represent the infiltration rate directly by assigning 3.05 m/yr to the precipitation parameter and setting the Evapotranspiration Rate and Runoff Coefficient parameters to zero. From Equation 6-1 in Reference 12, it is seen that this will result in an infiltration rate equal to the precipitation parameter.

Equation 6-1

$$I = (1 - E) * (1 - R) * P$$

Where:

I = Infiltration Rate (m/yr)
E = Evapotranspiration Coefficient (dimensionless)
R = Runoff Coefficient (dimensionless)
P = Precipitation Rate (m/yr)

The distribution evaluated in the sensitivity analysis was a uniform distribution with a minimum value of 0.25 m/yr (the actual precipitation driven infiltration rate at the site) and a maximum value of 3.05 m/yr selected to represent the seasonal water table fluctuation.

Consistent with NUREG-1757 guidance, the uncertainty analysis was performed assuming that the initial suite radionuclides are present at their mixture fractions as listed in Table 6-3. Only the radionuclides that were greater than 0.1% of the mixture were included in the uncertainty analysis. This limitation was necessary to result in practical RESRAD run times. However, including all radionuclides with greater than 0.1% of the mixture fraction provides confidence that all sensitive parameters will be identified.

The RESRAD Uncertainty Reports are provided electronically with Reference 8. Tables 6-9 to 6-14 provide summaries of the uncertainty analysis results with the selected deterministic parameters. Table 6-9 provides the results for the non-radionuclide specific parameters. Tables 6-10 to 6-14 provide the radionuclide specific Kd results for each of the basements evaluated.

The parameter distributions for the site-specific soil type of sand from Reference 14 were used to generate the median, 25th and 75th percentile deterministic values. Note that Reference 14 does not contain values for Europium; the 25th percentile from the NUREG-6697 Kd parameter distribution was used.

The majority of the uncertainty analysis results that were sensitive indicated a negative correlation between Kd and dose (i.e., 30 of the 34 sensitive parameters were negatively correlated). The parameters with positive correlations were only slightly above the 0.25 threshold and each occurred in only one of the three uncertainty runs. The predominance of negative correlation with Kd was expected since the primary dose pathway in the BFM Insitu$_{gw}$ scenario is through the ingestion of well water and lower Kd values result in a greater percentage of radioactivity in the water phase at equilibrium. Therefore, the deterministic Kd values selected for the non-sensitive radionuclides that were included in the uncertainty analysis were also conservatively assigned the 25th percentile values from Reference 14. The 75th percentiles were assigned as indicated by the PRCC results in order to follow the parameter selection process in Figure 6-7 but this will have a very minor, if any, effect on dose since the parameters were shown to be only slightly sensitive.

The Kd values selected for the very low abundance (<0.1%) initial suite radionuclides that were not included in the uncertainty analysis were also assigned the 25th percentile values for sand listed in Reference 14. Using the 25th percentiles for all initial suite radionuclides is conservative and provides consistency in determining the insignificant dose contributors and the dose fraction attributable to the removed radionuclides.

6.11.1.3. BFM Insitu$_{gw}$ RESRAD Deterministic Analysis and DSR Results

As discussed above, the BFM Insitu$_{gw}$ RESRAD dose assessments were performed separately for the Reactor Building (above and below 619' elevation), WTB, WGTV and Remaining Structures. The parameters provided in Attachment 6-2 were applied to all five analyses with the deterministic values in Tables 6-8 replacing the "variable" parameters and the values in Tables 6-9 to 6-14 replacing the parameter distributions. The Contaminated Zone Field Capacity was also changed from 0.2 to 0.066 to be consistent with the unsaturated and saturated zone.

The RESRAD Uncertainty Reports are provided electronically with Reference 8. The resulting DSRs are provided in Table 6-15.

6.11.1.4. BFM Insitu$_{gw}$ Dose Factors

The BFM Insitu$_{gw}$ DFs were calculated by Excel spreadsheet in Reference 8. The resulting BFM Insitu$_{gw}$ DFs are listed in Table 6-16. Note that the DFs for the Reactor Building Above 619 foot and Below 619 foot were summed in Reference 8 to determine the Reactor Building DFs in Table6-16.

Table 6-9 Results of RESRAD Uncertainty Analysis for BFM Insitugw and Selected Deterministic Parameters

Parameter	Reactor Building Above 619		Reactor Building Below 619		WTB		WGTV		Remaining Structures	
	Percentile	Value	Percentile	Value	Percentile	Value	Percentile	Value	Percentile	Value
Cover Erosion Rate	75th	0.0029	75th	0.0029	75th	0.0029	median	0.0015	75th	0.0029
Contaminated zone erosion rate	median	0.0015	75th	0.0029	median	0.0015	median	0.0015	median	0.0015
Contaminated zone b parameter	median	0.97	median	0.97	median	0.97	median	0.97	median	0.97
Wind Speed (Note 3)	25th	3.3	median	6.8	75th	10.2	median	6.8	75th	10.2
Precipitation	Note 4	3.05	Note 4	3.05	Note 1	3.05	Note 1	3.05	Note 1	3.05
Saturated zone b parameter	median	0.97	median	0.97	median	0.97	25th	0.84	median	0.97
Well pump intake depth	Note 2	6.08	Note 2	6.08	Note 2	6.08	Note 2	6.08	Note 2	6.08
Well Pumping Rate	median	986.1	median	986.1	median	986.1	median	986.1	75th	1311.2
Unsaturated zone b parameter	median	0.97	median	0.97	median	0.97	median	0.97	median	0.97
Mass loading for inhalation	median	2.35E-5	median	2.35E-5	median	2.35E-5	median	2.35E-5	median	2.35E-5
Indoor dust filtration factor	median	0.55	25th	0.35	median	0.55	median	0.55	median	0.55
External gamma shielding factor	median	0.27	median	0.27	median	0.27	median	0.27	median	0.27
Depth of Soil Mixing Layer	median	0.23	median	0.23	median	0.23	median	0.23	median	0.23

Note 1: Positive correlation with dose. Maximum site-specific value based on seasonal water rise value (3.05 m) used for conservatism and linkage to conceptual model.
Note 2: Negative correlation with dose. Minimum site-specific value used for conservatism
Note 3: Site-specific wind speed data used (US Army Corps of Engineers, Mississippi River Lock and Damn 4, Alma WI, Web address http://www.mvp-wc.usace.army.mil/projects/Lock4.shtml)
Note 4: The precipitation parameter was not sensitive for the Reactor Building Above and Below 619 foot. The 3.05 m/yr rate was applied for consistency with the other basements.

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Table 6-10 BFM Insitu$_{gw}$ Rx Building above 619: Uncertainty Analysis Results for Distribution Coefficients (Kd)

Radionuclide	Kd in Contaminated Zone		Kd in Unsaturated Zone		Kd in Saturated Zone	
H-3	25th	0.05	NS	0.05	NS	0.05
C-14	NS	1.8	25th	1.8	NS	1.8
Fe-55	NS	38	NS	38	NS	38
Ni-59	NS	147	NS	147	NS	147
Co-60	NS	9	NS	9	NS	9
Ni-63	NS	147	NS	147	NS	147
Sr-90	25th	5	NS	5	25th	5
Cs-137	25th	50	NS	50	25th	50
Eu-152	NS	95	NS	95	NS	95
Eu-154	75th	7302	NS	95	NS	95
Pu-241	NS	173	NS	173	NS	173

Table 6-11 BFM Insitu$_{gw}$ Rx Building below 619 Uncertainty Analysis Results for Distribution Coefficients (Kd)

Radionuclide	Kd in Contaminated Zone		Kd in Unsaturated Zone		Kd in Saturated Zone	
H-3	NS	0.05	NA	NA	NS	0.05
C-14	NS	1.8	NA	NA	NS	1.8
Fe-55	NS	38	NA	NA	NS	38
Ni-59	NS	147	NA	NA	NS	147
Co-60	NS	9	NA	NA	NS	9
Ni-63	NS	147	NA	NA	NS	147
Sr-90	25th	5	NA	NA	25th	5
Cs-137	25th	50	NA	NA	25th	50
Eu-152	NS	95	NA	NA	NS	95
Eu-154	NS	95	NA	NA	NS	95
Pu-241	NS	173	NA	NA	NS	173

Table 6-12 BFM Insitu$_{gw}$ WTB Uncertainty Analysis Results for Distribution Coefficients (Kd)

Radionuclide	Kd in Contaminated Zone		Kd in Unsaturated Zone		Kd in Saturated Zone	
H-3	NS	0.05	NS	0.05	NS	0.05
C-14	NS	1.8	NS	1.8	NS	1.8
Fe-55	NS	38	NS	38	NS	38
Ni-59	NS	147	NS	147	25th	147
Co-60	NS	9	NS	9	NS	9
Ni-63	NS	147	NS	147	NS	147
Sr-90	25th	5	25th	5	25th	5
Cs-137	NS	50	25th	50	25th	50
Eu-152	NS	95	NS	95	NS	95
Eu-154	NS	95	NS	95	NS	95
Pu-241	NS	173	NS	173	NS	173

Table 6-13 BFM Insitu$_{gw}$ WGTV Uncertainty Analysis Results for Distribution Coefficients (Kd)

Radionuclide	Kd in Contaminated Zone		Kd in Unsaturated Zone		Kd in Saturated Zone	
H-3	NS	0.05	75th	0.09	NS	0.05
C-14	NS	1.8	NS	1.8	NS	1.8
Fe-55	NS	38	75th	1279	NS	38
Ni-59	NS	147	75th	1110	NS	147
Co-60	NS	9	NS	9	25th	9
Ni-63	25th	147	NS	147	75th	1110
Sr-90	25th	5	25th	5	25th	5
Cs-137	NS	50	25th	50	25th	50
Eu-152	NS	95	NS	95	NS	95
Eu-154	25th	95	NS	95	NS	95
Pu-241	NS	173	NS	173	NS	173

Table 6-14 BFM Insitu$_{gw}$ Remaining Structures Uncertainty Analysis Results for Distribution Coefficients (Kd)

Radionuclide	Kd in Contaminated Zone		Kd in Unsaturated Zone		Kd in Saturated Zone	
H-3	NS	0.05	NS	0.05	NS	0.05
C-14	NS	1.8	NS	1.8	NS	1.8
Fe-55	NS	38	75th , 25th (Note 1)	38	NS	38
Ni-59	NS	147	NS	147	NS	147
Co-60	NS	9	NS	9	25th	9
Ni-63	NS	147	NS	147	NS	147
Sr-90	NS	5	25th	5	25th	5
Cs-137	NS	50	25th	50	25th	50
Eu-152	NS	95	NS	95	NS	95
Eu-154	NS	95	NS	95	NS	95
Pu-241	NS	173	NS	173	25th	173

Note 1: Inconsistent uncertainty results with PRCC values only slightly above 0.25 criteria. 25th percentile value was used.

Table 6-15 BFM Insitu$_{gw}$ DSRs for Reactor Building, WTB, WGTV, and Remaining Structures

Radionuclide	Rx Building Above 619' (mrem/yr per pCi/g)	Rx Building Below 619' (mrem/yr per pCi/g)	WTB Excavation Dose Factor (mrem/yr per pCi/g)	WGTV Excavation Dose Factor (mrem/yr per pCi/g)	Remaining Structure Excavation Dose Factor (mrem/yr per pCi/g)
H-3	3.51E-03	7.13E-04	7.16E-06	1.23E-05	4.62E-05
C-14	1.94E-02	2.26E-02	1.99E-04	2.93E-04	1.26E-03
Fe-55	6.14E-05	5.65E-04	7.61E-13	0.00E+00	1.53E-13
Ni-59	2.65E-05	5.75E-05	2.11E-06	2.15E-06	2.18E-06
Co-60	4.15E-02	1.10E-01	2.95E-04	2.41E-03	4.05E-04
Ni-63	6.01E-05	1.58E-04	9.26E-07	5.26E-07	7.82E-07
Sr-90	5.26E-01	1.13E+00	1.30E-02	2.20E-02	3.47E-02
Nb-94	8.77E-02	6.42E-03	2.32E-04	2.40E-04	2.43E-04
Tc-99	8.22E-02	1.64E-02	1.10E-04	2.49E-04	7.82E-04
Cs-137	1.48E-02	3.97E-02	1.84E-04	9.58E-04	1.53E-04
Eu-152	5.12E-04	2.67E-03	1.61E-08	1.68E-05	7.17E-09
Eu-154	7.30E-06	3.88E-03	1.62E-10	9.19E-06	4.50E-11
Eu-155	4.35E-05	6.03E-04	4.51E-16	1.72E-07	4.49E-17
Pu-238	2.65E-01	7.42E-01	2.33E-03	1.64E-02	1.85E-03
Pu-239	3.79E-01	8.24E-01	3.00E-02	3.08E-02	3.09E-02
Pu-240	3.78E-01	8.24E-01	2.93E-02	3.06E-02	3.00E-02
Pu-241	6.33E-03	1.59E-02	1.32E-04	3.58E-04	2.02E-04
Am-241	1.86E-01	4.46E-01	6.34E-03	1.35E-02	5.83E-03
Am-243	2.22E-01	4.44E-01	1.55E-02	1.64E-02	1.57E-02
Cm-243	5.35E-03	1.14E-01	9.04E-06	1.37E-05	7.79E-05
Cm-244	3.02E-03	9.08E-02	2.91E-05	4.36E-05	3.13E-05

Table 6-16 BFM Insitu$_{gw}$ Dose Factors

Radionuclide	Rx Building BFM Insitu$_{gw}$ DF (mrem/yr per mCi)	WTB BFM Insitu$_{gw}$ DF Dose Factor (mrem/yr per mCi)	WGTV BFM Insitu$_{gw}$ DF (mrem/yr per mCi)	Remaining Structures BFM Insitu$_{gw}$ DF (mrem/yr per mCi)
H-3	4.44E-03	1.57E-03	6.00E-04	1.55E-03
C-14	1.02E-01	4.36E-02	1.43E-02	4.21E-02
Fe-55	2.37E-03	1.67E-10	0.00E+00	5.12E-12
Ni-59	2.50E-04	4.63E-04	1.04E-04	7.29E-05
Co-60	4.74E-01	6.48E-02	1.17E-01	1.36E-02
Ni-63	6.80E-04	2.03E-04	2.56E-05	2.62E-05
Sr-90	4.91E+00	2.85E+00	1.07E+00	1.16E+00
Nb-94	6.36E-02	5.10E-02	1.17E-02	8.14E-03
Tc-99	1.03E-01	2.42E-02	1.21E-02	2.62E-02
Cs-137	1.71E-01	4.05E-02	4.66E-02	5.14E-03
Eu-152	1.13E-02	3.54E-06	8.18E-04	2.40E-07
Eu-154	1.61E-02	3.55E-08	4.47E-04	1.51E-09
Eu-155	2.52E-03	9.91E-14	8.37E-06	1.51E-15
Pu-238	3.20E+00	5.10E-01	7.97E-01	6.21E-02
Pu-239	3.59E+00	6.59E+00	1.50E+00	1.04E+00
Pu-240	3.58E+00	6.44E+00	1.49E+00	1.00E+00
Pu-241	6.88E-02	2.90E-02	1.74E-02	6.78E-03
Am-241	1.93E+00	1.39E+00	6.57E-01	1.95E-01
Am-243	1.94E+00	3.40E+00	7.98E-01	5.27E-01
Cm-243	4.74E-01	1.98E-03	6.67E-04	2.61E-03
Cm-244	3.79E-01	6.40E-03	2.12E-03	1.05E-03

6.11.2. BFM Insitu Drilling Spoils Scenario and DF Calculation

The BFM Insitu Drilling Spoils (BFM $Insitu_{ds}$) scenario addresses one of the BFM exposure pathways listed in section 1. The dose from residual radioactivity in the concrete is assumed to be brought to the 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 $Insitu_{ds}$ DFs are calculated with units of mrem/yr per total mCi.

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 in order to minimize the mixing volume for all basements. 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 by RESRAD using the surface soil DCGLs and AFs. The AFs were calculated using the deterministic parameters applied for soil DCGLs and the spoils spread area which was determined to be 0.457 m^2. The RESRAD Summary Reports are provided electronically with Reference 8.

The AFs and BFM $Insitu_{ds}$ DFs were calculated by Excel spreadsheet in Reference 8 using RESRAD results. The BFM $Insitu_{ds}$ DFs are listed in Table 6-17.

6.12. <u>BFM Excavation Scenario</u>

The BFM Excavation scenario assumes that some or all of the backfilled structures are excavated and the concrete spread on the surface immediately after license termination taking no credit for decay. The calculation of allowable total mCi is driven by the baseline limitation in the conceptual model that the average radionuclide concentrations in the concrete after inadvertent mixing during excavation will not exceed the surface soil DCGLs. The assessment provides BFM Excavation DFs in units of mrem/yr per total mCi.

Due to differences in configuration and contamination potential, the BFM Excavation DFs were calculated separately for the Reactor Building, WTB, WGTV, and Remaining Structures in the same manner as was done for the BFM Insitu assessments.

The BFM Excavation DFs are calculated by Excel spreadsheet in Reference 8. The results are listed in Table 6-18.

Table 6-17 BFM Insitu Drilling Spoils Dose Factors

Radionuclide	BFM Insitu$_{ds}$ Reactor Building (mrem/yr per mCi)	BFM Insitu$_{ds}$ WTB (mrem/yr per mCi)	BFM Insitu$_{ds}$ WGTV (mrem/yr per mCi)	BFM Insitu$_{ds}$ Remaining Structures (mrem/yr per mCi)
H-3	7.15E-09	7.03E-08	3.64E-08	8.02E-09
C-14	1.26E-08	1.24E-07	6.42E-08	1.41E-08
Fe-55	2.43E-09	2.39E-08	1.24E-08	2.73E-09
Ni-59	1.38E-09	1.36E-08	7.01E-09	1.55E-09
Co-60	1.16E-01	1.14E+00	5.91E-01	1.30E-01
Ni-63	3.50E-09	3.45E-08	1.78E-08	3.93E-09
Sr-90	2.05E-04	2.02E-03	1.04E-03	2.30E-04
Nb-94	7.94E-02	7.81E-01	4.04E-01	8.91E-02
Tc-99	3.10E-07	3.05E-06	1.58E-06	3.48E-07
Cs-137	2.83E-02	2.78E-01	1.44E-01	3.17E-02
Eu-152	5.46E-02	5.38E-01	2.78E-01	6.13E-02
Eu-154	5.81E-02	5.72E-01	2.96E-01	6.52E-02
Eu-155	2.01E-03	1.97E-02	1.02E-02	2.25E-03
Pu-238	1.08E-04	1.06E-03	5.47E-04	1.21E-04
Pu-239	1.19E-04	1.17E-03	6.04E-04	1.33E-04
Pu-240	1.18E-04	1.16E-03	6.00E-04	1.32E-04
Pu-241	1.65E-05	1.62E-04	8.39E-05	1.85E-05
Am-241	6.94E-04	6.83E-03	3.53E-03	7.79E-04
Am-243	9.57E-03	9.41E-02	4.87E-02	1.07E-02
Cm-243	5.88E-03	5.78E-02	2.99E-02	6.60E-03
Cm-244	6.77E-05	6.66E-04	3.44E-04	7.60E-05

Table 6-18 BFM Excavation Dose Factors

Radionuclide	Rx Building Excavation Dose Factor (mrem/yr per mCi)	WTB Excavation Dose Factor (mrem/yr per mCi)	WGTV Excavation Dose Factor (mrem/yr per mCi)	Remaining Structure Excavation Dose Factor (mrem/yr per mCi)
H-3	3.69E-06	4.88E-05	1.63E-05	8.18E-06
C-14	2.92E-06	3.86E-05	1.29E-05	6.47E-06
Fe-55	1.94E-06	2.56E-05	8.56E-06	4.30E-06
Ni-59	7.60E-07	1.01E-05	3.36E-06	1.69E-06
Co-60	1.54E+00	2.04E+01	6.81E+00	3.42E+00
Ni-63	2.08E-06	2.75E-05	9.19E-06	4.61E-06
Sr-90	3.00E-03	3.97E-02	1.33E-02	6.66E-03
Nb-94	9.79E-01	1.29E+01	4.32E+00	2.17E+00
Tc-99	9.84E-03	1.30E-01	4.35E-02	2.18E-02
Cs-137	3.40E-01	4.50E+00	1.50E+00	7.54E-01
Eu-152	6.94E-01	9.19E+00	3.07E+00	1.54E+00
Eu-154	7.50E-01	9.92E+00	3.31E+00	1.66E+00
Eu-155	1.76E-02	2.33E-01	7.78E-02	3.90E-02
Pu-238	1.17E-02	1.54E-01	5.15E-02	2.59E-02
Pu-239	1.30E-02	1.72E-01	5.73E-02	2.88E-02
Pu-240	1.30E-02	1.71E-01	5.72E-02	2.87E-02
Pu-241	5.35E-04	7.08E-03	2.36E-03	1.19E-03
Am-241	1.79E-02	2.36E-01	7.90E-02	3.96E-02
Am-243	1.06E-01	1.40E+00	4.66E-01	2.34E-01
Cm-243	6.83E-02	9.03E-01	3.02E-01	1.51E-01
Cm-244	7.26E-03	9.61E-02	3.21E-02	1.61E-02

6.13. Insignificant Dose Contributors and Radionuclides of Concern

NUREG-1757, section 3.3 states that radionuclides contributing no greater than 10% of the dose criterion (i.e., 2.5 mrem/yr) are considered to be "insignificant contributors". The 10% criterion applies to the sum of the dose contributions from the aggregate of radionuclides considered insignificant. This section provides the assessment of dose contributions from the initial suite and identifies the radionuclides that can be designated as insignificant dose contributors.

The radionuclides remaining after the removal of insignificant contributors were designated as the ROC. The ROC list is determined for concrete using the BFM DFs and for soil using the soil DCGLs. The dose from the removed insignificant contributors was accounted for by adjusting the soil DCGLs and BFM DFs for the ROC. The insignificant contributors will be excluded from further detailed evaluations during FRS and demonstration of compliance with the 25 mrem/yr dose criteria.

Note that Sr-90 was included in the ROC list for soil although the dose contribution was very low. Assuming the radionuclide mixture in Table 6-3, the Sr-90 dose fraction was 0.009% of the 25 mrem/yr criterion. When the actual soil characterization data for the initial suite radionuclides was used to calculate dose percentages, the Sr-90 dose was determined to be 2.06E-02 mrem/yr or 0.053% percent of the 25 mrem/yr criterion. Sr-90 was included as a soil ROC for the qualitative reason that it was positively identified in some concrete samples not because it represented a significant dose fraction.

6.13.1. Radionuclides of Concern and Adjusted Soil DCGLs and BFM DFs

The soil DCGLs and BFM DFs were used in Reference 5 to calculate the relative dose contributions from the initial suite radionuclides, identify the insignificant contributors, select the final ROCs and adjust the ROCs for the dose percentage attributable to the removed insignificant contributor radionuclides.

The dose percentages for the initial suite radionuclides were calculated for soil and for each of the three BFM scenarios; BFM $Insitu_{gw}$, BFM $Insitu_{ds}$, and BFM Excavation. The final list of insignificant contributors removed was the same for soil and the BFM scenarios but the dose percentages attributable to the insignificant contributors were different for each. Attachment 6-3 contains a copies of Tables 20 and 22 from Reference 5 which provide the dose percentages for the initial suite and the dose percentages attributable to the aggregate of the insignificant contributors that were removed. Two methods were used for the calculation and the results of both are provided in Attachment 6-3. The first method applied the radionuclide mixture fractions in Table 6-3 and the second applied the actual concentrations of characterization results.

The Table 6-3 mixture was based on concrete cores but was also applied to soil. Results of surface and subsurface soil characterization in the impacted area surrounding LACBWR indicate that there is minimal residual radioactivity in soil. Based on the characterization survey results to date, LACBWR does not anticipate the presence of significant soil contamination in any remaining subsurface soil that has not yet been characterized. Due to the very low concentrations of radionuclides identified in LACBWR soil, the direct determination of radionuclide mixture fractions for initial suite radionuclides in soil is not technically feasible due to the MDC biasing issues discussed above. Based on a generalized assumption that the contaminated water that caused concrete contamination would be similar to the source of soil contamination, the ROC and radionuclide mixture derived for the concrete was considered to be reasonably representative of soils for FRS planning and implementation.

From Attachment 6-3, it is seen that for all soil and concrete scenarios, Cs-137, Co-60 and Sr-90 contribute greater than 97.28% of the total dose. Therefore, the final ROCs for LACBWR soil and basement concrete are Cs-137, Co-60 and Sr-90. The remaining radionuclides are designated as insignificant contributors and are eliminated from further detailed evaluation.

The data from high activity cores that were used to calculate the radionuclide mixture in Table 6-3 is the most representative data available. The most accurate radionuclide mixture fractions are calculated when the HTD radionuclides are positively detected. If the HTD radionuclides are not positively detected, then the mixture percentages assigned to the HTD radionuclides are based on the MDC values which is conservative. However, the accuracy of the mixture fractions assigned to HTD radionuclides using MDC values will decrease as the total sample activity, predominately Cs-137, decreases.

The potential effect of mixture variability on dose is conservatively accounted for by applying the most limiting insignificant contributor dose percentage from all of the scenarios evaluated to the adjustment of soil DCGLs and BFM Dose Factors (i.e. 2.179% as seen in Attachment 6-3). The dose percentage ranged from 0.403% to 2.179%.

The 2.179% value represents the hypothetical dose contribution of the insignificant radionuclides (0.68 mrem/yr) at the dose limit of 25 mrem/yr, assuming that the mixture fractions of the insignificant contributors remain constant as activity increases. However, it is unlikely that the HTD radionuclide concentrations will increase linearly with dose up to 25 mrem/yr. Based on a review of the characterization data over a range of total activity in the samples, it is clear that the concentrations of insignificant contributor radionuclides are below MDC over a wide range of total sample activity up to and exceeding a total activity representing 25 mrem/yr. For example, the maximum 2.179% value was calculated for the WTB Groundwater scenario. When the actual mean activity of the selected core samples is used the dose calculated for the WTB Groundwater scenario is 0.787 mrem/yr with a corresponding dose percentage attributed to the insignificant contributors of only 0.086% (0.021 mrem/yr) (see Attachment 6-3). The realistic expectation is that the insignificant radionuclides would remain at their MDC values as concentrations approach values corresponding to 25 mrem/yr and that the insignificant contributor dose fraction would actually be closer to 0.086% than the 2.179% value calculated using the mixture in Table 6-3.

As another example, the concrete core samples taken during characterization that represent the worst case dose consequences are from the WTB basement. The average total activity for the core samples taken in the WTB is 1.2E+04 pCi/g. Assuming that the average activity is homogeneously distributed over the entire surface of the WTB basement (101.9 m^2) to a depth of ½ inch, the worst case dose consequence was 155 mrem/yr for the WTB Excavation scenario. (see Attachment 6-3). This result obviously indicates that remediation is necessary but the point is that even in this worst case scenario, the dose based on actual core concentrations from the WTB results in an insignificant contributor dose percentage of 1.587% which is below the worst case value of 2.179%.

As a conservative measure, the most limiting insignificant dose contributor percentage of 2.179% (calculated for the Groundwater scenario for the WTB) was used to adjust the soil DCGLs and BFM Dose Factors to account for the insignificant contributor dose (Reference 5). See Tables 6-19 to 6-23 for the adjusted soil DCGLs and BFM Dose Factors. A separate analysis of insignificant contributor dose percent was performed for Buried Pipe. See section 6-18.

Table 6-19 Soil DCGLs for ROC Adjusted for Insignificant Contributor Dose Fraction

ROC	Adjusted Soil DCGLs (pCi/g)
Co-60	1.25E+01
Sr-90	6.40E+03
Cs-137	5.65E+01

Table 6-20 Reactor Building BFM DFs for ROC Adjusted for Insignificant Contributor Dose Fraction

ROC	Reactor Building Adjusted BFM DFs (mrem/yr per mCi)		
	Insitu GW	Insitu Drilling Spoils	Excavation
Co-60	4.87E-01	1.19E-01	1.58E+00
Sr-90	5.05E+00	2.11E-04	3.08E-03
Cs-137	1.76E-01	2.91E-02	3.50E-01

Table 6-21 WTB BFM DFs for ROC Adjusted for Insignificant Contributor Dose Fraction

ROC	WTB Adjusted BFM DFs (mrem/yr per mCi)		
	Insitu GW	Insitu Drilling Spoils	Excavation
Co-60	6.66E-02	1.17E+00	2.10E+01
Sr-90	2.93E+00	2.08E-03	4.08E-02
Cs-137	4.16E-02	2.86E-01	4.63E+00

Table 6-22 WGTV BFM DFs for ROC Adjusted for Insignificant Contributor Dose Fraction

ROC	WGTV Adjusted BFM DFs (mrem/yr per mCi)		
	Insitu GW	Insitu Drilling Spoils	Excavation
Co-60	1.20E-01	6.08E-01	7.00E+00
Sr-90	1.10E+00	1.07E-03	1.37E-02
Cs-137	4.79E-02	1.48E-01	1.54E+00

Table 6-23 Remaining Structures BFM DFs for ROC Adjusted for Insignificant Contributor Dose Fraction

ROC	Remaining Structures Adjusted BFM DFs (mrem/yr per mCi)		
	Insitu GW	Insitu Drilling Spoils	Excavation
Co-60	1.40E-02	1.34E-01	3.52E+00
Sr-90	1.19E+00	2.36E-04	6.85E-03
Cs-137	5.28E-03	3.26E-02	7.75E-01

The mixture fraction for the ROC and the mixture fraction for the aggregate of insignificant contributors is listed in Table 6-24. Note that the majority of the 0.1013 mixture fraction for the insignificant contributors is attributable to Ni-63 (with a fraction of 0.08) which has a very low dose impact and was therefore included in the group of insignificant contributors.

Table 6-24 ROC and Insignificant Radionuclide Mixture Fractions

ROC	Mixture Fractions
Co-60	0.0122
Sr-90	0.0091
Cs-137	0.8774
Insignificant Contributors	0.1013
Total	1.00

6.14. Concentrations in Excavated Fill Material

A check calculation was performed in Reference 8 to determine the maximum hypothetical concentrations of ROC in fill material after excavation. The calculation assumed that 100% of the residual radioactivity in the concrete was instantly released to the fill and uniformly mixed in the fill during basement concrete excavation. Therefore, the source term would be in the fill and not in the concrete. The calculation was based on BFM DFs that were the summation of BFM $Insitu_{gw}$ + BFM $Insitu_{ds}$ + BFM Excavation. The summation DF will be applied during FRS for compliance (see LTP Chapter 5). For all ROC and all basements, the hypothetical maximum fill concentrations were less than the surface soil DCGLs.

6.15. Alternate Land Use Scenario Dose

As discussed in section 6.4, 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, these less likely but plausible scenarios were not analyzed for compliance, but were used to risk-inform the decision of Industrial Use as the "reasonably foreseeable" land use. 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 scenario (with onsite well for drinking water and irrigation) was performed. The Resident Gardener pathways included direct dose, inhalation, soil ingestion and fruit and vegetables from an onsite garden. It was considered highly unlikely that livestock would be raised on the site so the meat and milk pathways were inactive. The alternate scenario dose assessment was performed for backfilled concrete and soil source terms. The dose assessments included the ROC at their respective mixture fractions as listed in Table 6-24.

The Resident Gardener soil dose was calculated with the RESRAD deterministic parameters used for the Industrial Use soil dose assessment with the parameter changes listed below. The contaminated zone thickness was changed to more closely represent actual site conditions as opposed to the 1 m depth assumed in the screening approach used in the Industrial scenario. The root depth parameter was added since the plant pathway is active in the Resident Gardener scenario. The remaining parameter changes are metabolic and behavioral (from NUREG/CR-5512). The parameters changes are:

- Contaminated Zone Thickness - 0.15m,
- Inhalation Rate - 8400 m^3/yr,
- Fraction of Time Spent Indoors - 0.649,
- Fraction of Time Spent Outdoors - 0.124,
- Fruit, Vegetable and Grain Consumption - 112 kg/yr,
- Leafy Vegetable Consumption - 21.4,
- Drinking Water Intake - 478 L/yr,
- Depth of Roots - 1.22 m.

The assessment of the soil dose from the Resident Gardener alternate scenario was performed in two ways. First, the maximum soil concentrations identified during characterization were used to provide the most accurate estimate of dose from soil in the Resident Gardener scenario. Second, the alternate scenario dose was calculated assuming the ROC concentrations were theoretically equal to the maximum allowable soil concentrations in the Industrial Scenario (i.e., concentrations that result in 25 mrem/yr). The doses were calculated assuming that a resident 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 (see section 6.4). The dose calculations are documented in Reference 8.

The soil dose from the Resident Gardener alternate scenario using the maximum concentrations identified during characterization as the source term was 0.66 mrem/yr. When the source term was the hypothetical maximum soil concentrations that could remain given the Industrial Scenario DCGLs, the dose was 31.4 mrem/yr. A dose assessment was also performed using the hypothetical maximum radionuclide concentrations in fill material. The fill is assumed to be excavated and spread on the ground surface during the excavation of structure concrete (see section 6.14). The resulting dose from the Resident Gardener was 26.9 mrem/yr.

The dose from backfilled concrete was also calculated for the Resident Gardener Alternate Scenario assuming the BFM Insitu geometry described in section 6.11.1. The RESRAD deterministic parameters used for the BFM Insitu_{gw} dose assessment were modified as listed above to represent the Resident Gardener scenario. The WTB was used for the assessment since it is projected to contain the majority of residual radioactivity at license termination.

The resulting Resident Gardener dose from backfilled concrete in the insitu geometry (i.e., the as-left condition at the time of license termination) was 0.94 mrem/yr. Note that the Resident Gardener dose from the BFM Insitu scenario is low because the BFM DFs applied for compliance during FRS will be the summation of the BFM Insitu_{gw} + BFM Insitu_{ds} + BFM Excavation (see LTP Chapter 5) which is dominated by the Excavation Scenario. This results in low dose from the BFM Insitu scenario. For example, the dose from the BFM Insitu geometry for the WTB in the Industrial Use scenario, assuming no decay, is 1.77 mrem/yr. For comparison, when the 30 year decay period is included the dose is 0.84 mrem/yr.

The final consideration is the dose from the Resident Gardener alternative scenario given the BFM Excavation Scenario. Because the BFM Excavation conceptual model is based on the limitation that the excavated concrete would not exceed the surface soil DCGLs, the maximum alternate scenario dose from excavated concrete would be essentially the same as calculated for soil. However, the dose from concrete would be less since plants cannot be grown in concrete.

In conclusion, the dose from the Recreational Use and Resident Gardener alternate scenarios is not significant and therefore greater assurance that these scenarios will not occur is unnecessary.

6.16. BFM Elevated Area Considerations

The BFM is a mixing model that uses the total inventory as the source term and is independent of the concentration and distribution of the residual radioactivity. The standard approach for calculating Area Factors (AFs) in conjunction with concentration-based DCGLs to determine the acceptability of elevated areas of activity does not apply.

Although AFs are not applicable to the BFM, the maximum concentrations that could remain in the Basements are limited by the implementation of the open air demolition limits described in Reference 14. The Basements will be remediated to the open air demolition limits prior to demolition of structures above 636 foot elevation. The open air demolition limits are:

- Less than 2 mR/hr beta-gamma total surface contamination on contact with structural concrete.
- Less than 1,000 dpm/100cm^2 beta-gamma loose surface contamination.

These limits define the acceptable operational levels of fixed (as measured by contact exposure rate) and removable contamination that can remain prior to open air demolition. The limits ensure that the dose to the public from airborne contamination generated during demolition is acceptable. The open air demolition limits are operational levels and are not a part of the compliance calculations for 10 CFR 20.1402.

To comply with the open air demolition limits, radiological surveys will be performed prior to demolition. These surveys will use conventional gamma instruments in typical scanning and measurement modes. Scanning coverage for pre-remediation surveys on structures prior to open air demolition could include up to 100% of the accessible surface area depending on the contamination potential. The pre-remediation surveys performed to prepare building surfaces for open air demolition will provide confidence that contamination above the limits will be identified and remediated.

The dose from a hypothetical maximum concentration that could remain after remediation to the open air demolition limits was evaluated using the drilling spoils scenario. The purpose of the assessment was to further "risk-inform" the acceptability of a worst-case condition in the context of potential dose. The Worst-Case Drilling Spoils assessment is considered a "less likely but plausible" scenario (as defined in NUREG-1757, Table 5.1). Consistent with NUREG 1757, Table 5.1, the scenario is not analyzed for compliance with the 10 CFR 20.1402 dose criterion, but is used to help "risk inform" and justify the decision that the hypothetical maximum concentration that could remain in elevated areas after remediation to the 2 mR/hr demolition limit are acceptable, assuming all activity is accounted for and included in the final compliance demonstration using the BFM DFs.

The Worst-Case Drilling Spoils scenario assumes that the water supply well is drilled directly into a spot of residual radioactivity in basement floor concrete that contains the highest hypothetical Cs-137 concentration. The drilling I assumed to occur immediately after license termination taking no credit for decay. The entire inventory within the drill diameter is assumed to be excavated and brought to the surface while mixing with overburden fill and soil. This is very unlikely for two reasons. First, the scenario assumes that a water supply well is installed immediately after license termination. Second, the probability of an assumed eight inch borehole hitting an area containing the maximum hypothetical contamination level during drilling is low.

From Reference 8, assuming an arbitrary circular area with a 36 inch diameter and uniform contamination through the first half inch of concrete, the Cs-137 concentration that would result in 2 mR/hr at contact is approximately 10,000 pCi/g Cs-137. The levels of loose contamination have essentially no effect on the dose rate because the activity associated with a very thin layer of loose "dust" is trivial. For example, a loose contamination level of 10,000 dpm/100 cm^2 corresponds to approximately 45 pCi/cm^2 compared to 29,000 pCi/cm^2 total inventory in a 1 cm^2 area containing uniform radioactivity through a half inch layer at a concentration of 10,000 pCi/g.

Also from Reference 8, the Cs-137 concentration that would result in 25 mrem/yr in the Drilling Spoils scenario, assuming one-half inch contamination depth, was approximately 80,000 pCi/g Cs-137. Therefore, the dose from this "less likely but plausible" scenario would be approximately 10,000/80,000*25 = 3.1 mrem/yr and is not significant. Further reduction of the hypothetical maximum area of residual radioactivity, beyond that required for remediation to meet the 2 mR/hr open air demolition limit, is not justified on a risk-informed basis. Demonstrating compliance with the dose criterion using the total inventory and BFM DFs is sufficient to account for the activity, and assess the dose, in the areas with the hypothetical maximum concentrations.

6.17. Soil Area Factors

The RESRAD modeling for soil assumes that the entire area within the LSE, 7500 m^2, is contaminated. Isolated areas of contamination that are smaller than 7500 m^2 will have a lower dose for a given concentration. The ratio of the dose from the full source term area to the dose from a smaller area is defined as the Area Factor (AF).

Reference 8 calculates AFs for each ROC 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. The need to apply AFs to contaminated areas greater than 100 m^2 is unlikely. The AFs were calculated by dividing the pCi/g per 25 mrem/yr value from RESRAD for each smaller area by the soil DCGLs in Table 6-7.

The full RESRAD Summary Reports are provided electronically with Reference 8. The resulting AFs are provided in Table 6-25.

Table 6-25 Surface Soil Area Factors

Radionuclide	Area Factors				
	$1m^2$	$2m^2$	$5m^2$	$10m^2$	$100m^2$
Cs-137	9.44	5.56	3.07	2.04	1.19
Co-60	9.11	5.42	3.01	2.00	1.18
Sr-90	11.22	6.66	3.69	2.45	1.41

6.18. 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. The calculations are performed by RESRAD and Excel spreadsheet as detailed in Reference 8.

6.18.1. Source Term and Radionuclide Mixture

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. See Table 6-2 for list of buried pipe to remain. 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 and will continue operation after license termination. No DCGLs or FSS is required for non-impacted areas.

DCGLs for buried pipe were calculated for the initial suite radionuclides. To date, no characterization has been performed in buried piping due to the very low contamination potential. The radionuclide mixture is assumed to be the same as listed in Table 6-3. As discussed in LTP Chapter 5, if continuing characterization is performed for buried pipe and the results indicate that the buried piping dose could exceed 50% of the 25 mrem/yr dose criterion, then samples will be analyzed for HTD radionuclides and additional assessments performed.

6.18.2. Exposure Scenario and Critical Group

Consistent with the guidance in NUREG-1757, Appendix J regarding assessment of buried material, two exposure scenarios were considered; 1) inadvertent intrusion which results in the buried pipe being excavated and spread across the surface (Excavation scenario), and 2) dose from buried pipe remaining 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 buried pipe excavation conceptual model is more conservative than the NUREG-1757, Appendix J conceptual model in that no mixing is assumed to occur with the soil in the 1 m cover or the interspersing clean soil between pipes during excavation.

The conceptual models for the buried pipe Insitu and Excavation scenarios are similar to those developed for the BFM. In the Insitu scenario the residual radioactivity on the internal surfaces of the pipe is assumed to instantaneously release and mix with a thin 2.54 cm layer of soil in an area equal to the internal surface area of the pipe. The Insitu scenario model assumes that the released radioactivity as 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 assumption of a thin soil mixing layer for buried material was shown to be conservative on the sensitivity analysis for the BFM (see section 6.11.1). The Excavation scenario model assumes that the released radioactivity is mixed with a 15 cm layer of soil on the ground surface after excavation. A 15 cm mixing layer is assumed due to the extensive ground surface disturbance caused by the large scale excavation required to remove pipe. The Industrial Worker is exposed to the Insitu and Excavated soil via the same pathways applicable to the BFM and soil models.

6.18.3. Buried Piping Dose Assessment

RESRAD modeling was 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 Pipe only. The separation of the Circulating Water pipe was necessary because the geometry was significantly different from the other pipe and the pipes are located in distinctly different parts 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 input parameters applied to the BFM Insitu Groundwater scenario with adjustments to the source term geometry (see Table 6-26). The depth of the buried piping varies but is in all cases greater than one meter below the ground surface in order to be below the freeze zone. The elevation of the thin layer (2.54 cm) source term was nominally assumed to be the same as the deepest basement floor, i.e.., the WGTV at 621 foot elevation. Using a lower elevation maximizes the insitu dose, which is driven by the groundwater pathway, by minimizing the distance to the water table. The assumed 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 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 pipe (630 foot). The contaminated area was set equal to the internal surface area of the pipe. See Table 6-26 for the source term parameters. 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 used to calculate surface soil DCGLs with source term adjustments as listed in Table 6-26.

6.18.4. Buried Pipe DCGLs Initial Suite

The RESRAD Summary Report file names for the RESRAD Buried Piping runs are listed in Reference 8. The full RESRAD Summary Reports are stored electronically. The detailed inputs

Table 6-26 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)	5.465	0	2.74	0
Area of Contaminated Zone (m^2)	1349.71	1349.71	766.14	766.14
Thickness of Contaminated zone (m)	0.0254	0.15	0.0254	0.15
Length Parallel to Aquifer Flow (m)	41.45	41.45	160.02	160.02
Unsaturated Zone Thickness (m)	0.61	6.0706	3.33	6.0706

to the DCGL calculation, including RESRAD source term parameter calculations, a list of the resulting RESRAD DSRs generated by modeling and all unit conversions are provided in an Excel spreadsheet as described in Reference 8. The buried pipe DCGLs for the initial suite are provided in Table 6-27.

6.18.5. Buried Pipe Radionuclides of Concern and Adjusted DCGLs

The Buried Pipe DCGLs in Table 6-27 were used in Reference 5 to calculate the relative dose contributions from the initial suite radionuclides, identify the insignificant contributors, select the final ROCs and adjust the ROCs for the dose fraction attributable to the removed insignificant contributors. The dose percentages for the initial suite were calculated using the mixture fractions from Table 6-3.

The dose percentages for the initial suite radionuclides were calculated for each of the buried pipe scenarios; Insitu and Excavation. The final list of insignificant contributors was the same for all buried pipe scenarios and the same as identified for soil and basements. The ROCs are Co-60, Sr-90 and Cs-137.

The dose percentages for the insignificant contributors were different for each of the four buried pipe DCGL categories. Therefore, adjustments to the Buried Pipe DCGLs to account for the insignificant radionuclide fractions were calculated separately for each of the four. Attachment 6-3 contains a copy of Table 24 from Reference 5 which provides the dose percentages for the initial suite and the dose percentages attributable to the aggregate of the insignificant contributors that were removed.

Table 6-27 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	4.69E+08	4.65E+09	1.56E+08	6.23E+09
C-14	1.82E+07	2.43E+10	1.53E+07	2.45E+10
Fe-55	0.00E+00	5.95E+10	0.00E+00	7.77E+10
Ni-59	1.12E+10	1.52E+11	0.00E+00	1.98E+11
Co-60	9.12E+06	8.43E+04	4.92E+07	8.58E+04
Ni-63	4.67E+10	5.55E+10	1.98E+11	7.24E+10
Sr-90	5.84E+05	3.99E+07	6.94E+05	4.23E+07
Nb-94	1.01E+08	1.27E+05	1.01E+08	1.29E+05
Tc-99	2.33E+07	8.79E+07	7.26E+06	1.19E+08
Cs-137	2.57E+07	3.60E+05	1.31E+08	3.66E+05
Eu-152	1.46E+09	1.82E+05	1.45E+12	1.86E+05
Eu-154	2.68E+09	1.70E+05	1.40E+14	1.73E+05
Eu-155	1.43E+11	6.62E+06	4.72E+19	6.71E+06
Pu-238	1.50E+06	9.90E+06	1.04E+07	1.29E+07
Pu-239	7.85E+05	8.91E+06	7.88E+05	1.16E+07
Pu-240	7.93E+05	8.92E+06	8.11E+05	1.16E+07
Pu-241	5.14E+07	3.04E+08	1.11E+08	3.68E+08
Am-241	1.82E+06	6.52E+06	3.84E+06	7.93E+06
Am-243	1.49E+06	1.11E+06	1.52E+06	1.16E+06
Cm-243	7.57E+08	1.71E+06	6.63E+08	1.79E+06
Cm-244	3.03E+08	1.59E+07	3.01E+08	2.07E+06

The dose fraction of the aggregate of the insignificant contributors ranges from 0.413% to 1.961%. Table 6-28 provides the final Buried Pipe DCGLs for the ROC adjusted for the removed insignificant dose percentage.

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, i.e., the insitu and excavation scenarios may occur in parallel. The summed Buried Pipe DCGLs are provided in Table 6-29.

Table 6-28 Buried Pipe DCGLs for ROCs Adjusted for Insignificant Radionuclide Fractions

Radionuclide	Buried Pipe Group Insitu (dpm/100 cm²)	Buried Pipe Group Excavation (dpm/100 cm²)	Circulating Water Discharge Pipe Insitu (dpm/100 cm²)	Circulating Water Discharge Pipe Excavation (dpm/100 cm²)
Co-60	9.01E+06	8.39E+04	4.82E+07	8.55E+04
Sr-90	5.77E+05	3.98E+07	6.80E+05	4.22E+07
Cs-137	2.54E+07	3.59E+05	1.28E+08	3.65E+05

Table 6-29 Summed Buried Pipe DCGLs for ROCs adjusted for Insignificant Radionuclide Fractions

Radionuclide	Buried Pipe Group (dpm/100 cm²)	Circulating Water Discharge Pipe (dpm/100 cm²)
Co-60	8.31E+04	8.53E+04
Sr-90	5.69E+05	6.70E+05
Cs-137	3.54E+05	3.64E+05

6.19. <u>Existing Groundwater Dose</u>

There is low potential for significant groundwater contamination to be present although low concentrations have been identified in groundwater adjacent to suspected broken floor drains under the Turbine Building. Sampling in 1983 from a well located down gradient of the Turbine Building indicated positive groundwater contamination at relatively low concentrations.

In late 2012, five additional monitoring well pairs were installed to support site characterization and license termination. Results indicated lower groundwater contamination levels than found in 1983, predominantly H-3. See LTP Chapter 2 for a summary of characterization and HSA results. Groundwater Exposure Factors were calculated to determine the dose from existing groundwater contamination that may be present at the time of license termination.

Groundwater Exposure Factors for existing GW contamination were calculated for the three ROCs identified in Table 6-24 plus H-3. Because the industrial scenario does not include irrigation the only exposure pathway from groundwater is potable water from an onsite well. The

GW Exposure Factors were therefore calculated in Reference 8 directly using the Federal Guidance Report 11 Ingestion Dose Conversion Factors and the assumed industrial worker AMCG drinking water intake rate of 327 L/yr. See Table 6-30.

Table 6-30 Groundwater Exposure Factors

Radionuclide	Groundwater Exposure Factors (mrem/yr per pCi/L)
Co-60	8.80E-03
Cs-137	1.64E-02
Sr-90	4.64E-02
H-3	2.09E-05

6.20. Demonstrating Compliance with Dose Criterion

As discussed in section 6.5.5, the final demonstration of compliance with the dose criterion will be made through the summation of dose from exposure scenarios that are not mutually exclusive and could potentially occur in parallel.

After compliance is demonstrated independently through the FRS of each structure, open land area and buried piping, the mean concentrations or inventory values from the FRS will be used to calculate dose and summed as shown in Equation 6-2.

Equation 6-2

$$\textbf{Compliance Dose} = \textbf{Max BFM Insitu}(\textbf{ds}) + \textbf{Max BFM Excavation} + \textbf{Summation BFM Insitu}(\textbf{gw}) \textbf{ and Buried Pipe Insitu} + \textbf{Max Open Land} + \textbf{Max Buried Pipe Excavation} + \textbf{Max Existing Groundwater}$$

where:

Compliance Dose	= Dose to Industrial Worker AMCG (mrem/yr)
Max BFM Insitu (ds)	= maximum BFM $Insitu_{ds}$ dose from basements (mrem/yr)
Max BFM Excavation	= maximum BFM Excavation dose from basements (mrem/yr)
Summation BFM Insitu (gw) and Buried Pipe Insitu	= summation of BFM $Insitu_{gw}$ dose from all basements (mrem/yr) and Buried Pipe Insitu dose (mrem/yr) from all pipe
Max Open Land	= maximum dose from open land survey units (mrem/yr)
Max Buried Piping Excavation	= maximum dose from buried piping Excavation (mrem/yr)
Max Existing Groundwater	= maximum dose from existing groundwater

The dose for basements is calculated directly from mean STS results. The dose for open land and buried piping is calculated by dividing the mean FSS concentrations by the DCGLs and multiplying the ratio by 25 mrem/yr. Note that the BFM $Insitu_{gw}$ dose from the basement assigned the Maximum BFM Excavation dose in Equation 6-2 will not be included in the "BFM $Insitu_{gw}$ Summation" term in Equation 6-2. The two scenarios are mutually exclusive; the contamination can either be retained in the concrete and excavated or released to the fill and contribute to dose from well water, not both. The Buried Pipe Insitu dose is included in groundwater summation because it is based only on the groundwater pathway.

6.21. **References**

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10. Sandia National Laboratory, NUREG/CR-5512, Volume 3, Residual Radioactive Contamination From Decommissioning Parameter Analysis – October 1999.
11. 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.
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13. 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.
14. EnergySolutions Technical Support Document RS-TD-313196-005, La Crosse Open Air Demolition Limits.

Figure 6-1 Site Regional Location

Figure 6-2 Site Overview

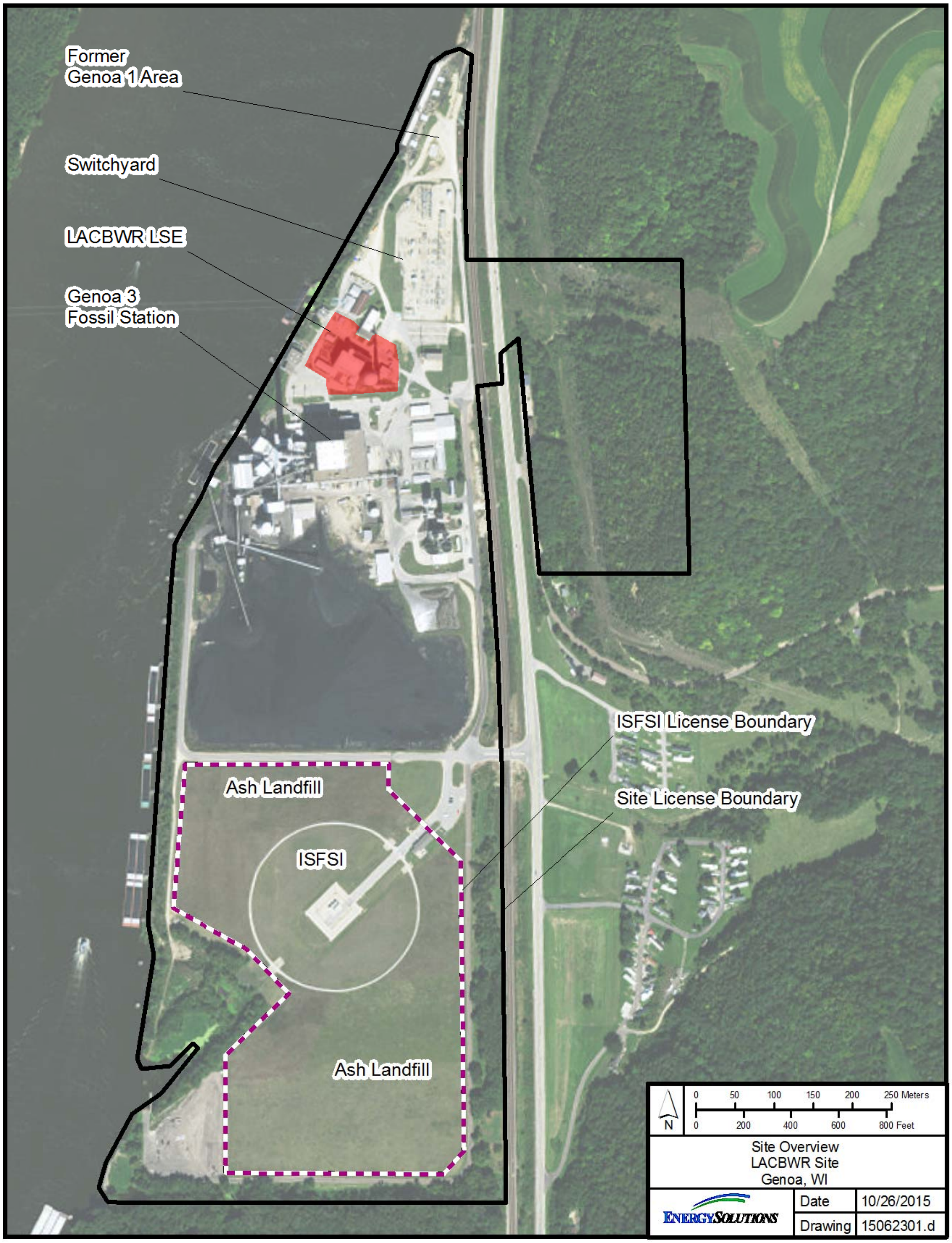


Figure 6-3 LACBWR Buildings

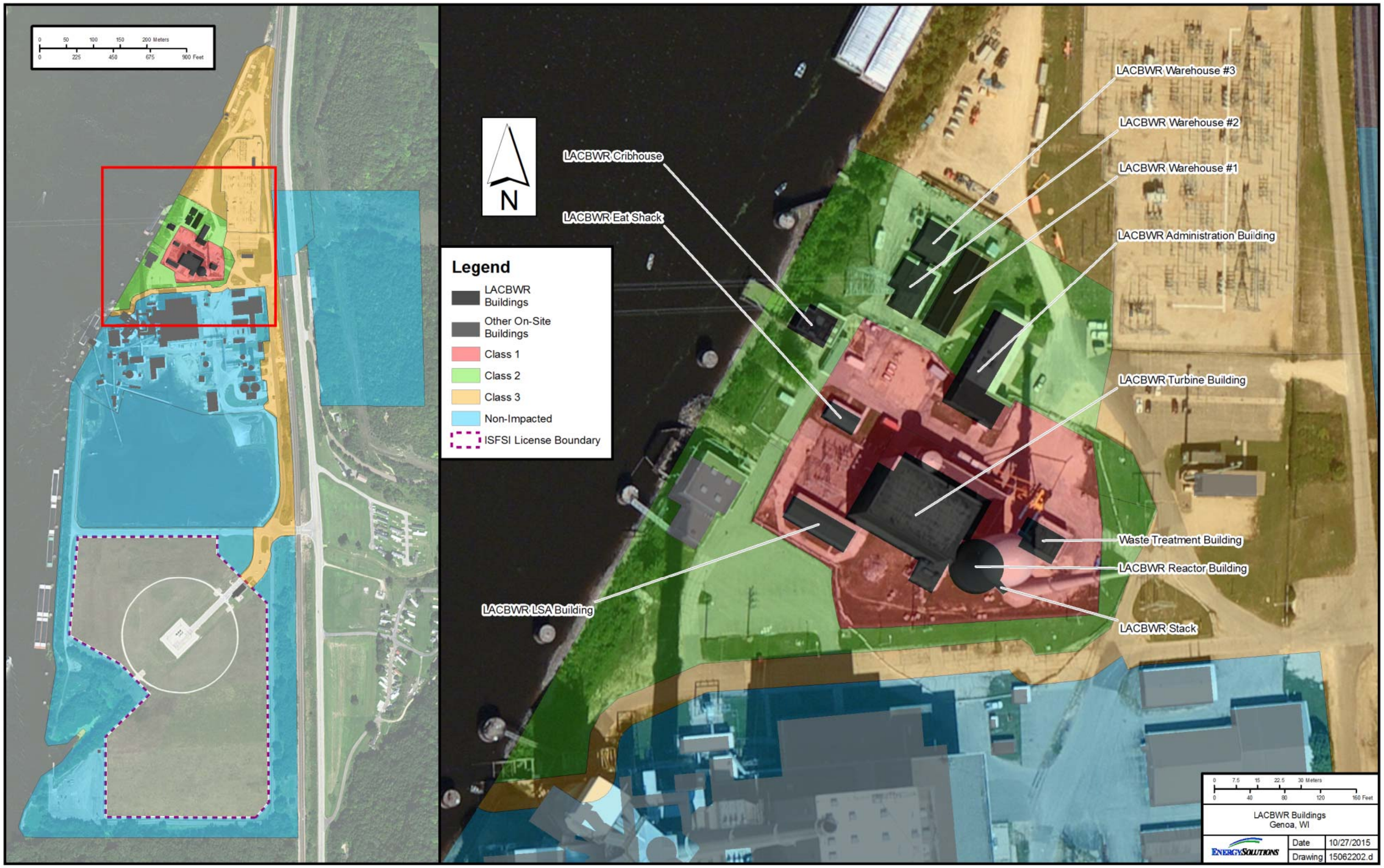


Figure 6-4 LACBWR End State

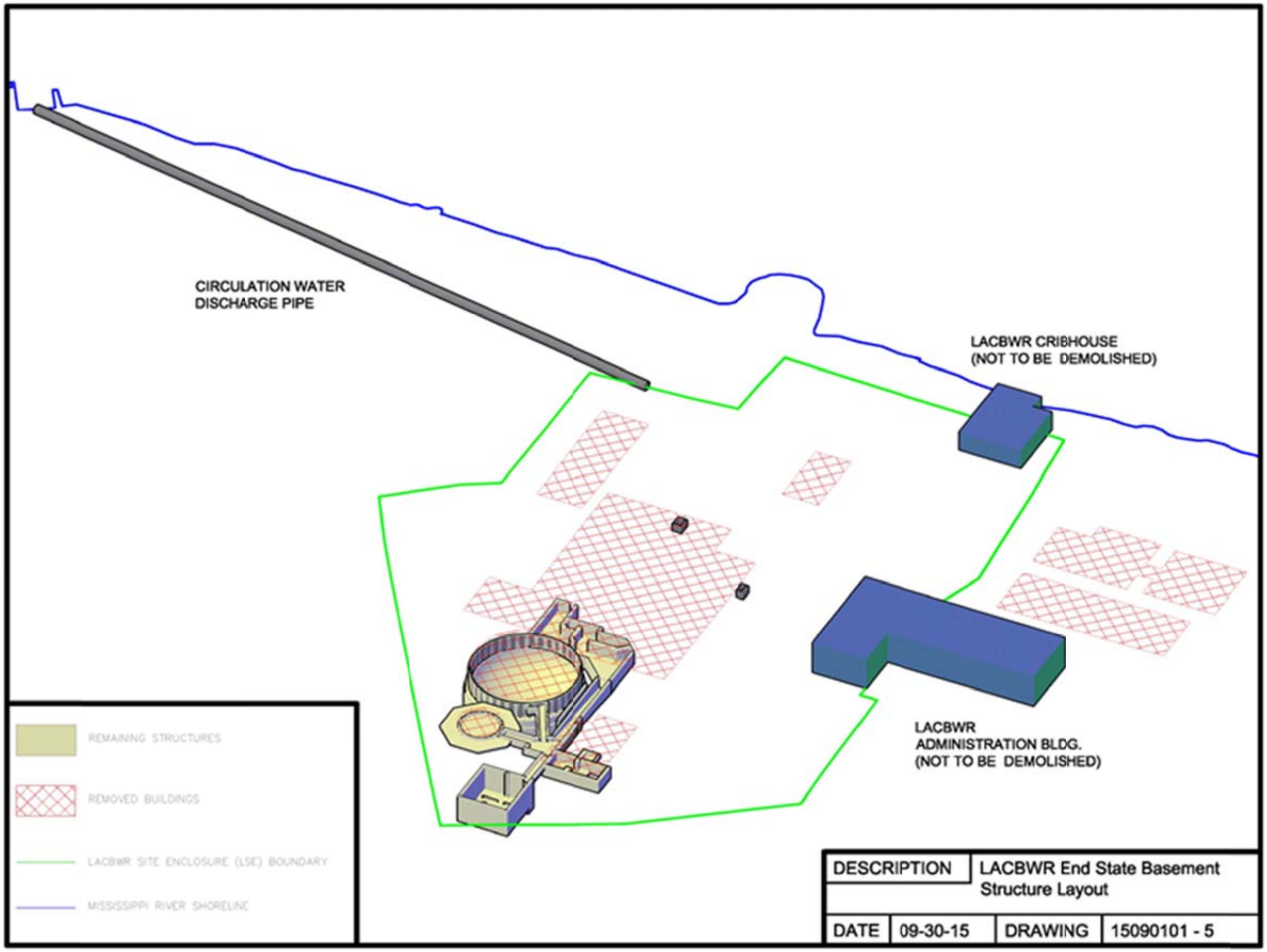


Figure 6-5 LACBWR End State - Backfilled Structures

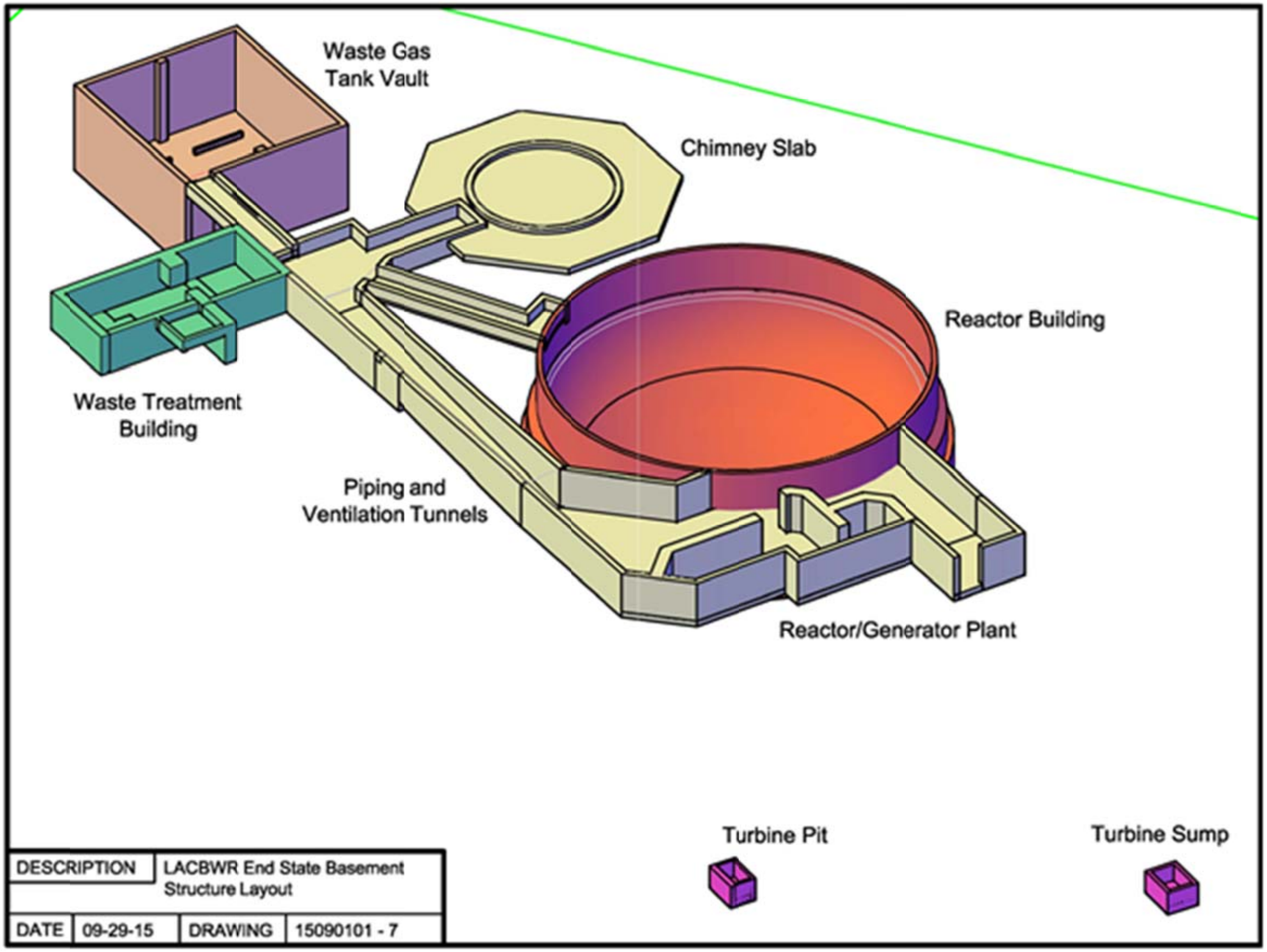


Figure 6-6 LACBWR End State – Backfilled Reactor Building Basement Elevation View

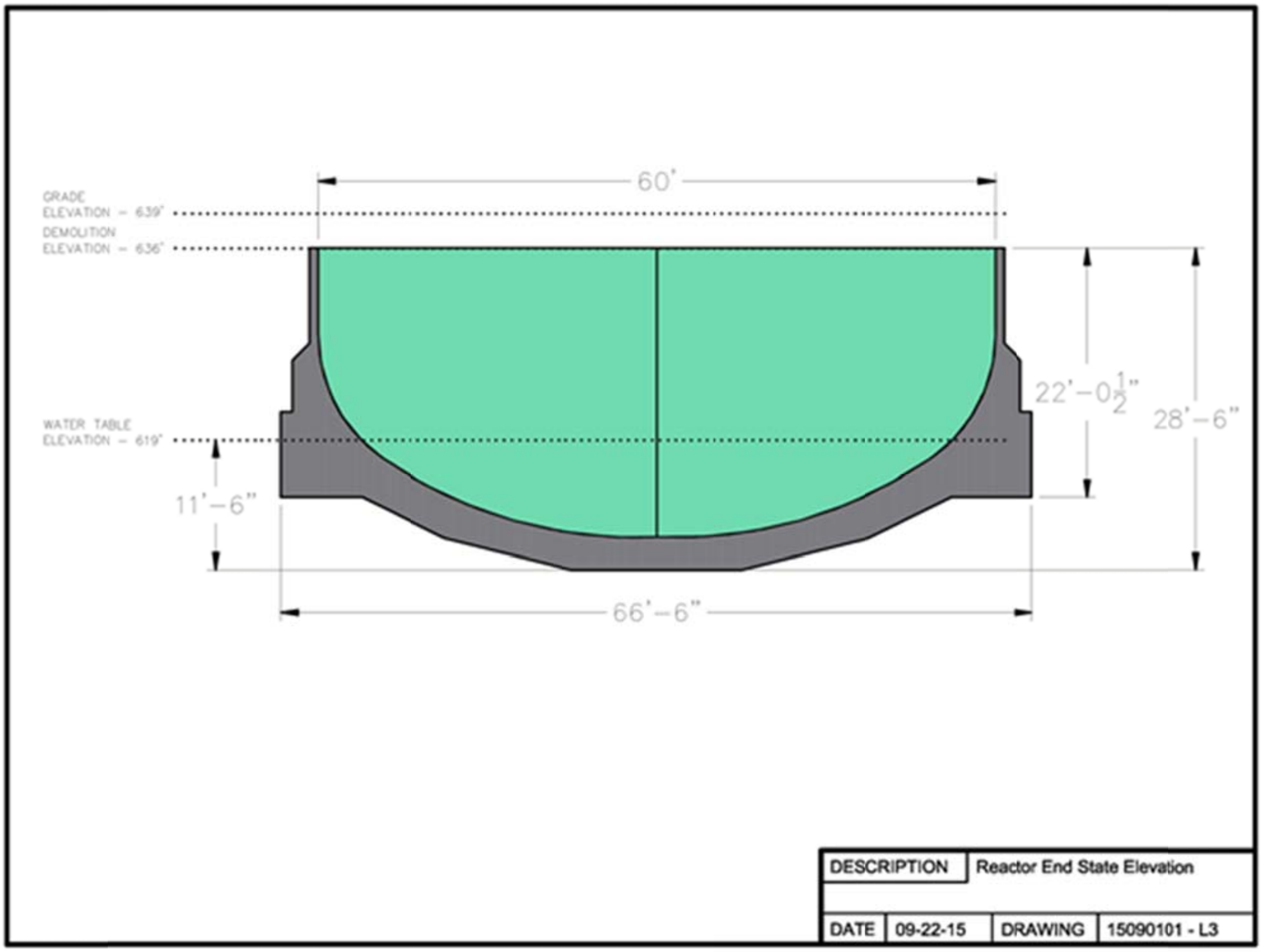
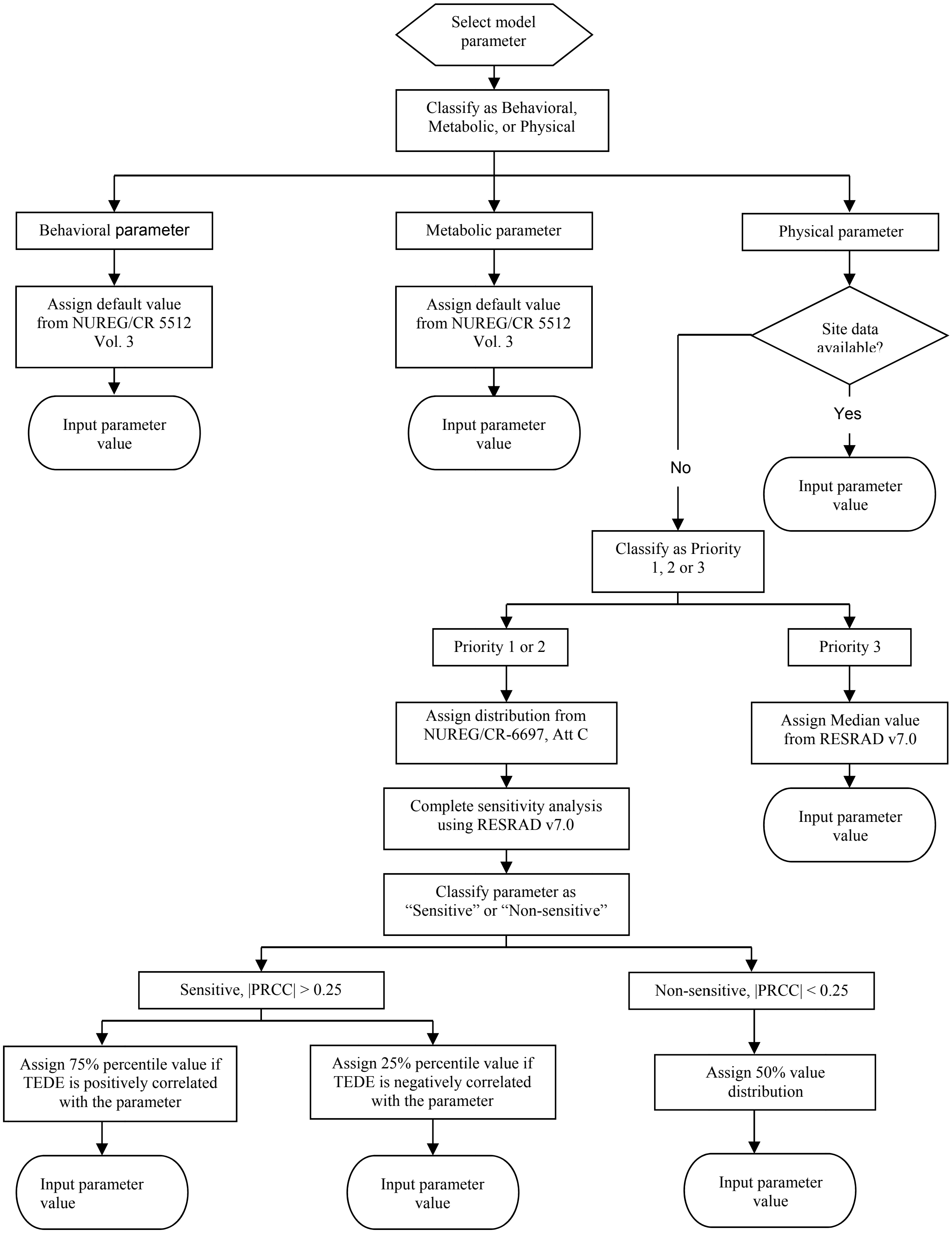


Figure 6-7 RESRAD Parameter Selection Flow Chart



ATTACHMENT 6-1

RESRAD Input Parameters for LACBWR Soil DCGL Uncertainty Analysis

SOIL DCGL: RESRAD PARAMETERS FOR 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 N	R NR		NR	
Initial principal radionuclide (pCi/g) P		2 D		1	Unit Value	NR N	R 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 3.2	2 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 N	A NA		NA NA	
Am-243	P	1	S	Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA N	A NA		NA NA	
C-14	P	1 S		Lognormal-N	NUREG/CR-6697 Att. C	2.4 3.2	2 NA		NA 11	
Cm-243	P	1 S		Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA N	A NA		NA NA	
Cm-244	P	1 S		Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA N	A NA		NA NA	
Co-60	P	1 S		Lognormal-N	NUREG/CR-6697 Att. C	5.46 2.5	3 NA		NA 235	
Cs-137	P	1 S		Lognormal-N	NUREG/CR-6697 Att. C	6.1 2.3	3 NA		NA 446	
Eu-152	P	1 S		Lognormal-N	NUREG/CR-6697 Att. C	6.72 3.2	2 NA		NA 825	
Eu-154	P	1 S		Lognormal-N	NUREG/CR-6697 Att. C	6.72 3.2	2 NA		NA 825	
Eu-155	P	1 S		Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA N	A NA		NA NA	
Fe-155	P	1 S		Lognormal-N	NUREG/CR-6697 Att. C	5.34 2.6	7 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 3.2	2 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 N	A 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 N	A NA		NA NA	
Ni-59	P	1 S		Lognormal-N	NUREG/CR-6697 Att. C	6.05 1.4	6 NA		NA 424	
Ni-63	P	1 S		Lognormal-N	NUREG/CR-6697 Att. C	6.05 1.4	6 NA		NA 424	

SOIL DCGL: RESRAD PARAMETERS FOR 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 N	A 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 N	A NA		NA NA	
Pb-210 (daughter for Pu-238)	P	1 D		Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA N	A NA		NA NA	
Po-210 (daughter Pu-238)	P	1 D		Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA N	A NA		NA NA	
Pu-238	P	1 S		Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA N	A NA		NA NA	
Pu-239 (also daughter for Cm-243)	P	1 S		Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA N	A NA		NA NA	
Pu-240 (also daughter for Cm-244)	P	1 S		Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA N	A NA		NA NA	
Pu-241	P	1 S		Lognormal-N	NUREG/CR-6697 Att. C	6.86 1.8	9 NA		NA 953	
Ra-226 (daughter Pu-238)	P	1 D		Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA N	A 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 N	A 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 3.2	2 NA		NA 825	
Sr-90	P	1 S		Lognormal-N	NUREG/CR-6697 Att. C	3.45 2.1	2 NA		NA 32	
Tc-99	P	1 S		Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA N	A 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 N	A 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 3.6	2 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 N	A 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 N	A 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 3.1	3 NA		NA 126	

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SOIL DCGL: RESRAD PARAMETERS FOR 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 (daughter Pu-238)	P	1 D		Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA N	A NA		NA NA	
U-235 (daughter Cm-243 and Pu-239)	P	1 D		Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA N	A 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 N	A NA		NA NA	
Initial concentration of radionuclides present in groundwater (pCi/l)	P	3 D		0	No existing groundwater contamination	NR N	R NR		NR	
Calculation Times										
Time since placement of material (y)	P	3 D		0	Start of dose calculation immediately after license termination	NR N	R NR		NR	
Time for calculations (y)	P	3 D		0, 1, 3, 10, 30, 100, 300, 1000	RESRAD Default	NR N	R NR		NR	
Contaminated Zone										
Area of contaminated zone (m^2) P		2 D		7500	Size of LACBWR “Licensed Site Exclusion” (LSE) area	NR N	R NR		NR	
Thickness of contaminated zone (m)	P	2 D		1	Surface Soil contamination thickness not expected to exceed 1 m.	NR N	R NR		NR	
Length parallel to aquifer flow (m) P		2 D		98	Diameter of 7500 m2 contaminated zone	NR N	R NR		NR	
Does the initial contamination penetrate the water table?	NA	NA NA		No	Contaminated zone at surface	NA N	A NA		NA	
Contaminated fraction below water table	P	3 D		0	Contaminated zone at surface	NR N	R NR		NR	
Cover and Contaminated Zone Hydrological Data										
Cover depth (m)	P	2 D		0	No cover	NR N	R NR		NR	
Density of cover material	P	2 D		NA	No cover	NR N	R NR		NR	
Cover erosion rate	P,B	2 D		NA	No cover	NR N	R NR		NR	
Density of contaminated zone (g/cm^3)	P	1 D		1.76 Site	specific[e]	NR N	R 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 0.00	07 0.005		0.2 0.0015	
Contaminated zone total porosity P		2 D		0.31 Site	specific[e]	NR N	R NR		NR	

SOIL DCGL: RESRAD PARAMETERS FOR 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 field capacity P		3 D		0.2	RESRAD default. No distribution or median value provided in NURE/CR-6697 Att. C	NR N	R NR		NR	
Contaminated zone hydraulic conductivity (m/y)	P	2 D		34822	Site specific[e] 313 feet/day = 34822 m/y	NR N	R 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 0.21	6 N	A	NA 0.97	
Humidity in air (g/m^3)	P	3 D		7.2	Median NUREG/CR-6697 Att. C	1.98 0.33	4 0.001		0.999 7.2	
Evapotranspiration coefficient	P	2 S		Uniform	NUREG/CR-6697 Att. C Figure 4.3-1	0.5 0.7	5 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 0.24	19 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 N	R NR		NR	
Irrigation (m/y)	B	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Irrigation mode	B	3 D		NA	Industrial Scenario	NR N	R 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 R	ESRAD Default	NR N	R NR		NR	
Accuracy for water/soil computations	-	3 D		1.00E-03 R	ESRAD Default	NR N	R NR		NR	
Saturated Zone Hydrological Data										
Density of saturated zone (g/cm^3) P		2 D		1.76	Site-specific[e]	NR N	R NR		NR	
Saturated zone total porosity	P	1 D		0.31	Site-specific[e]	NR N	R NR		NR	
Saturated zone effective porosity P		1 D		0.28	Site-specific[e]	NR N	R NR		NR	
Saturated zone field capacity	P	3 D		0.066	Calculated values for sand soil type[f]	NR N	R NR		NR	
Saturated zone hydraulic conductivity (m/y)	P	1 D		34822	Site-specific value[e] 313 feet/day = 34822 m/y	NR N	R NR		NR	
Saturated zone hydraulic gradient P		2 D		0.0045	Site-specific[e]	NR N	R NR		NR	

SOIL DCGL: RESRAD PARAMETERS FOR 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 b parameter	P	2 S		Lognormal-N	Site specific soil type sand NUREG/CR-6697 Att. C Table 3.5-1	-.0253 0.21	6 N	A	NA	0.97
Water table drop rate (m/y)	P	3 D		0	Assumed zero due to hydraulic connectivity with Mississippi river.	NR N	R 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 33.1 m below the water table). 33.1 m assumed to be maximum well depth. Minimum well depth assumed to be represented by a nominal 20' screen depth (6.08 m) starting at the water table. Mode is assumed to be mid-point between 6.08 m and 33.1 m which is 19.6 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.	6.08 19	6 33.1		NR 19.6	
Model: Nondispersion (ND) or Mass-Balance (MB)	P	3 D		ND	Applicable to flowing groundwater	NR N	R NR		NR	

SOIL DCGL: RESRAD PARAMETERS FOR 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 N	R NR		NR	
Unsat. zone thickness (m)	P	1 D		5.1 m Site	Specific[e]	NR N	R NR		NR	
Unsat. zone soil density (g/cm^3) P		2 D		1.76	Site-specific[e]	NR N	R NR		NR	
Unsat. zone total porosity	P	2 D		0.31 Site-sp	ecific[e]	NR N	R NR		NR	
Unsat. zone effective porosity	P	2 D		0.28 Site-sp	ecific[e]	NR N	R NR		NR	
Unsat. zone field capacity	P	3 D		0.066 Calcul	ated values for sand soil type[f]	NR N	R NR		NR	
Unsat. zone hydraulic conductivity (m/y)	P	2 D		34822	Site-specific[e]	NR N	R 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 0.21	6 N	A	NA 0.97	
Occupancy										

SOIL DCGL: RESRAD PARAMETERS FOR 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		1917	NUREG/CR-5512, Vol. 3 Table 5.1.1 mean value is 8400/y which equates to 23 m^3/d Industrial Scenario m^3/yr =23 m^3/d ÷ 24h/d * 2000 h/y)	NR N	R NR		NR	
Mass loading for inhalation (g/m^3) P,B		2 S		Continuous Linear NURE	G/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 N	R NR		NR	
Indoor dust filtration factor	P,B	2 S		Uniform	NUREG/CR-6697, Att. C Figure 7.1-1	0.15 0.9	5 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 0.5	9 0.044		1 0.2725	
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 N	R NR		NR	

SOIL DCGL: RESRAD PARAMETERS FOR 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 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 N	R NR		NR	
Shape factor flag, external gamma P		3 D		Circular	Circular contaminated zone assumed for modeling purposes	NR N	R NR		NR	
Ingestion, Dietary										
Fruits, non-leafy vegetables, grain consumption (kg/y)	M,B	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Leafy vegetable consumption (kg/y) M,B		3 D		NA	Industrial Scenario	NR N	R NR		NR	
Milk consumption (L/y)	M,B	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Meat and poultry consumption (kg/y)	M,B	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Fish consumption (kg/y)	M,B	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Other seafood consumption (kg/y)	M,B	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Soil ingestion rate (g/y)	M,B	2 D		18.3	NUREG/CR-5512, Vol. 3 Table 6.87	NR N	R 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 N	R NR		NR	

SOIL DCGL: RESRAD PARAMETERS FOR 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 drinking water	B,P	3 D		1	All water assumed contaminated	NR N	R 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 N	R NR		NR	
Contamination fraction of irrigation water	B,P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Contamination fraction of aquatic food	B,P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Contamination fraction of plant food	B,P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Contamination fraction of meat B,P		3 D		NA	Industrial Scenario	NR N	R NR		NR	
Contamination fraction of milk	B,P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Ingestion, Non-Dietary										
Livestock fodder intake for meat (kg/day)	M	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Livestock fodder intake for milk (kg/day)	M	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Livestock water intake for meat (L/day)	M	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Livestock water intake for milk (L/day)	M	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Livestock soil intake (kg/day)	M	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Mass loading for foliar deposition (g/m^3)	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Depth of soil mixing layer (m)	P	2 S		Triangular	NUREG/CR-6697, Att. C Figure 3.12-1	0 0.1	5 0.6		NR 0.15	
Depth of roots (m)	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Drinking water fraction from ground water	B,P	3 D		1	Industrial Scenario	NR N	R NR		NR	
Household water fraction from ground water (if used)	B,P	3		1	Industrial Scenario	NR N	R NR		NR	
Livestock water fraction from ground water	B,P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Irrigation fraction from ground water B,P		3 D		NA	Industrial Scenario	NR N	R NR		NR	
Wet weight crop yield for Non-Leafy (kg/m^2)	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	

SOIL DCGL: RESRAD PARAMETERS FOR 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 D		NA	Industrial Scenario	NR N	R NR		NR	
Wet weight crop yield for Fodder (kg/m^2)	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Growing Season for Non-Leafy (y)	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Growing Season for Leafy (y) P		3 D		NA	Industrial Scenario	NR N	R NR		NR	
Growing Season for Fodder (y) P		3 D		NA	Industrial Scenario	NR N	R NR		NR	
Translocation Factor for Non-Leafy P		3 D		NA	Industrial Scenario	NR N	R NR		NR	
Translocation Factor for Leafy P		3 D		NA	Industrial Scenario	NR N	R NR		NR	
Translocation Factor for Fodder P		3 D		NA	Industrial Scenario	NR N	R NR		NR	
Weathering Removal Constant for Vegetation (1/y)	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Wet Foliar Interception Fraction for Non-Leafy	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Wet Foliar Interception Fraction for Leafy	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Wet Foliar Interception Fraction for Fodder	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Dry Foliar Interception Fraction for Non-Leafy	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Dry Foliar Interception Fraction for Leafy	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Dry Foliar Interception Fraction for Fodder	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Storage times of contaminated foodstuffs (days):										
Fruits, non-leafy vegetables, and grain	B	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Leafy vegetables	B	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Milk	B	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Meat and poultry	B	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Fish	B	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Crustacea and mollusks	B	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Well water	B	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Surface water	B	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Livestock fodder	B	3 D		NA	Industrial Scenario	NR N	R NR		NR	

LACROSSE SOLUTIONS

SOIL DCGL: RESRAD PARAMETERS FOR UNCERTAINTY ANALYSIS										
Parameter (unit)	**Type[a]**	**Priority[b]**	**Treatment[c]**	**Value/Distribution**	**Basis**	**Distribution's Statistical Parameters[d]**				
						1	**2**	**3**	**4**	**Mean/ Median**
Special Radionuclides (C-14)										
C-12 concentration in water (g/cm^3) P		3 D		NA	Industrial Scenario	NR N	R NR		NR	
C-12 concentration in contaminated soil (g/g)	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Fraction of vegetation carbon from soil	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Fraction of vegetation carbon from air	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
C-14 evasion layer thickness in soil (m)	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
C-14 evasion flux rate from soil (1/sec)	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
C-12 evasion flux rate from soil (1/sec)	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Fraction of grain in beef cattle feed B		3 D		NA	Industrial Scenario	NR N	R NR		NR	
Fraction of grain in milk cow feed B		3 D		NA	Industrial Scenario	NR N	R NR		NR	
Dose Conversion Factors (Inhalation mrem/pCi)										
Ac-227	M	3 D		6.70E+00 FGR	11	NR N	R NR		NR	
Am-241	M	3 D		4.44E-01 FGR	11	NR N	R NR		NR	
Am-243	M	3 D		4.40E-01 FGR	11	NR N	R NR		NR	
C-14	M	3 D		2.09E-06 FGR	11	NR N	R NR		NR	
Cm-243	M	3 D		3.07E-01 FGR	11	NR N	R NR		NR	
Cm-244	M	3 D		2.48E-01 FGR	11	NR N	R NR		NR	
Cm-245	M	3 D		4.55E-01 FGR	11	NR N	R NR		NR	
Cm-246	M	3 D		4.51E-01 FGR	11	NR N	R NR		NR	
Co-60	M	3 D		2.19E-04 FGR	11	NR N	R NR		NR	
Cs-134	M	3 D		4.62E-05 FGR	11	NR N	R NR		NR	
Cs-137	M	3	D	3.19E-05	FGR11	NR N	R NR		NR	
Eu-152	M	3 D		2.21E-04 FGR	11	NR N	R NR		NR	
Eu-154	M	3 D		2.86E-04 FGR	11	NR N	R NR		NR	
Gd-152	M	3 D		2.43E-01 FGR	11	NR N	R NR		NR	
H-3	M	3 D		6.40E-08 FGR	11	NR N	R NR		NR	

SOIL DCGL: RESRAD PARAMETERS FOR 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	M	3 D		1.74E-04 FGR	11	NR N	R NR		NR	
Nb-94	M	3 D		4.14E-04 FGR	11	NR N	R NR		NR	
Nd-144[e]	M	3 D		7.04E-02 ICRP6	0	NR N	R NR		NR	
Ni-59	M	3 D		2.70E-06 FGR	11	NR N	R NR		NR	
Ni-63	M	3 D		6.29E-06 FGR	11	NR N	R NR		NR	
Np-237	M	3 D		5.40E-01 FGR	11	NR N	R NR		NR	
Pa-231	M	3 D		1.28E+00 FGR	11	NR N	R NR		NR	
Pb-210	M	3 D		1.36E-02 FGR	11	NR N	R NR		NR	
Po-210	M	3 D		9.40E-03 FGR	11	NR N	R NR		NR	
Pu-238	M	3 D		3.92E-01 FGR	11	NR N	R NR		NR	
Pu-239	M	3 D		4.29E-01 FGR	11	NR N	R NR		NR	
Pu-240	M	3 D		4.29E-01 FGR	11	NR N	R NR		NR	
Pu-241	M	3 D		8.25E-03 FGR	11	NR N	R NR		NR	
Pu-242	M	3 D		4.11E-01 FGR	11	NR N	R NR		NR	
Ra-226	M	3 D		8.58E-03 FGR	11	NR N	R NR		NR	
Ra-228	M	3 D		4.77E-03 FGR	11	NR N	R NR		NR	
Sm-148[e]	M	3 D		7.34E-02 ICRP6	0	NR N	R NR		NR	
Sr-90	M	3 D		1.30E-03 FGR	11	NR N	R NR		NR	
Tc-99	M	3 D		8.32E-06 FGR	11	NR N	R NR		NR	
Th-228	M	3 D		3.42E-01 FGR	11	NR N	R NR		NR	
Th-229	M	3 D		2.15E+00 FGR	11	NR N	R NR		NR	
Th-230	M	3 D		3.26E-01 FGR	11	NR N	R NR		NR	
Th232	M	3 D		1.64e+00 FGR	11	NR N	R NR		NR	
U-233	M	3 D		1.35E-01 FGR	11	NR N	R NR		NR	
U-234	M	3 D		1.32E-01 FGR	11	NR N	R NR		NR	
U-235	M	3 D		1.23E-01 FGR	11	NR N	R NR		NR	
U-236	M	3 D		1.25E-01 FGR	11	NR N	R NR		NR	
U-238	M	3 D		1.18E-01 FGR	11	NR N	R NR		NR	
Dose Conversion Factors (Ingestion mrem/pCi)										
Ac-227	M	3 D		1.41E-02 FGR	11	NR N	R NR		NR	

SOIL DCGL: RESRAD PARAMETERS FOR 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	M	3 D		3.64E-03 FGR	11	NR N	R NR		NR	
Am-243	M	3 D		3.62E-03 FGR	11	NR N	R NR		NR	
C-14	M	3 D		2.09E-06 FGR	11	NR N	R NR		NR	
Cm-243	M	3 D		2.51E-03 FGR	11	NR N	R NR		NR	
Cm-244	M	3 D		2.02E-03 FGR	11	NR N	R NR		NR	
Cm-245	M	3 D		3.74E-03 FGR	11	NR N	R NR		NR	
Cm-246	M	3 D		3.70E-03 FGR	11	NR N	R NR		NR	
Co-60	M	3 D		2.69E-05 FGR	11	NR N	R NR		NR	
Cs-134	M	3 D		7.33E-05 FGR	11	NR N	R NR		NR	
Cs-137	M	3 D		5.00E-05 FGR	11	NR N	R NR		NR	
Eu-152	M	3 D		6.48E-06 FGR	11	NR N	R NR		NR	
Eu-154	M	3 D		9.55E-06 FGR	11	NR N	R NR		NR	
Gd-152	M	3 D		1.61E-04 FGR	11	NR N	R NR		NR	
H-3	M	3 D		6.40E-08 FGR	11	NR N	R NR		NR	
I-129	M	3 D		2.76E-04 FGR	11	NR N	R NR		NR	
Nb-94	M	3 D		7.14E-06 FGR	11	NR N	R NR		NR	
Nd-144[e]	M	3 D		1.51E-04 ICRP6	0	NR N	R NR		NR	
Ni-59	M	3 D		2.10E-07 FGR	11	NR N	R NR		NR	
Ni-63	M	3 D		5.77E-07 FGR	11	NR N	R NR		NR	
Np-237	M	3 D		4.44E-03 FGR	11	NR N	R NR		NR	
Pa-231	M	3 D		1.06E-02 FGR	11	NR N	R NR		NR	
Pb-210	M	3 D		5.37E-03 FGR	11	NR N	R NR		NR	
Po-210	M	3 D		1.90E-03 FGR	11	NR N	R NR		NR	
Pu-238	M	3 D		3.20E-03 FGR	11	NR N	R NR		NR	
Pu-239	M	3 D		3.54E-03 FGR	11	NR N	R NR		NR	
Pu-240	M	3 D		3.54E-03 FGR	11	NR N	R NR		NR	
Pu-241	M	3 D		6.84E-05 FGR	11	NR N	R NR		NR	
Pu-242	M	3 D		3.36E-03 FGR	11	NR N	R NR		NR	
Ra-226	M	3 D		1.32E-03 FGR	11	NR N	R NR		NR	
Ra-228	M	3 D		1.44E-03 FGR	11	NR N	R NR		NR	

SOIL DCGL: RESRAD PARAMETERS FOR UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Sm-148[e]	M	3 D		1.58E-04 ICRP6	0	NR N	R NR		NR	
Sr-90	M	3 D		1.42E-04 FGR	11	NR N	R NR		NR	
Tc-99	M	3 D		1.46E-06 FGR	11	NR N	R NR		NR	
Th-228	M	3 D		3.96E-04 FGR	11	NR N	R NR		NR	
Th-229	M	3 D		3.53E-03 FGR	11	NR N	R NR		NR	
Th-230	M	3 D		5.48E-04 FGR	11	NR N	R NR		NR	
Th-232	M	3 D		2.73E-03 FGR	11	NR N	R NR		NR	
U-233	M	3 D		2.89E-04 FGR	11	NR N	R NR		NR	
U-234	M	3 D		2.83E-04 FGR	11	NR N	R NR		NR	
U-235	M	3 D		2.66E-04 FGR	11	NR N	R NR		NR	
U-236	M	3 D		2.69E-04 FGR	11	NR N	R NR		NR	
U-238	M	3 D		2.55E-04 FGR	11	NR N	R NR		NR	
Plant Transfer Factors (pCi/g plant)/(pCi/g soil)										
Ac-227	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Am-241	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Am-243	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
C-14	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Cm-243	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Cm-244	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Co-60	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Cs-134	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Cs-137	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Eu-152	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Eu-154	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Fe-55	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Gd-152	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
H-3	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Nb-94	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Nd-144	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Ni-59	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	

SOIL DCGL: RESRAD PARAMETERS FOR UNCERTAINTY ANALYSIS										
Parameter (unit)	**Type[a]**	**Priority[b]**	**Treatment[c]**	**Value/Distribution**	**Basis**	**Distribution's Statistical Parameters[d]**				
						1	**2**	**3**	**4**	**Mean/ Median**
Ni-63	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Np-237	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Pa-231	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Pb-210	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Pm-147	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Po-210	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-238	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-239	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-240	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-241	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Ra-226	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Ra-228	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Sb-125	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Sm-148	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Sr-90	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Tc-99	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-228	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-229	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-230	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-232	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
U-233	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
U-234	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
U-235	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
U-236	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Meat Transfer Factors (pCi/kg)/(pCi/d)										
Ac-227	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Ag-108m	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Am-241	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Am-243	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
C-14	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	

SOIL DCGL: RESRAD PARAMETERS FOR 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-243	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Cm-244	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Co-60	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Cs-134	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Cs-137	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Eu-152	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Eu-154	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Fe-55	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Gd-152	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
H-3	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Nb-94	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Nd-144	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Ni-59	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Ni-63	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Np-237	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Pa-231	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Pb-210	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Po-210	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-238	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-239	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-240	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-241	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Ra-226	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Ra-228	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Sb-125	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Sm-148	P	1 D		NA	Industrial Scenario	NR N	R NR		NR	
Sr-90	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Tc-99	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-228	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-229	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	

SOIL DCGL: RESRAD PARAMETERS FOR 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	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-232	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
U-233	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
U-234	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
U-235	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
U-236	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Milk Transfer Factors (pCi/L)/(pCi/d)										
Ac-227	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Am-241	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Am-243	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
C-14	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Cm-243	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Cm-244	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Co-60	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Cs-134	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Cs-137	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Eu-152	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Eu-154	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Fe-55	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Gd-152	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
H-3	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Nb-94	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Nd-144	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Ni-59	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Ni-63	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Np-237	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Pa-231	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Pb-210	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Po-210	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-238	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	

SOIL DCGL: RESRAD PARAMETERS FOR 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 N	R NR		NR	
Pu-240	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-241	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Ra-226	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Ra-228	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Sm-148	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Sr-90	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Tc-99	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-228	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-229	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-230	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-232	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
U-233	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
U-234	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
U-235	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
U-236	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Bioaccumulation Factors for Fish ((pCi/kg)/(pCi/L))										
Ac-227	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Am-241	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Am-243	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
C-14	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Cm-243	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Cm-244	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Cm-245	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Cm-246	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Co-60	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Cs-137	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Eu-152	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Eu-154	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Gd-152	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	

SOIL DCGL: RESRAD PARAMETERS FOR 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	2 D		NA	Industrial Scenario	NR N	R NR		NR	
I-129	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Nb-94	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Ni-59	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Ni-63	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Np-237	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Pa-231	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Po-210	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Pb-210	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-238	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-239	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-240	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-241	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-242	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Ra-226	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Ra-228	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Sr-90	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-228	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-229	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-230	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-232	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
U-233	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
U-234	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
U-235	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
U-236	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
U-238	P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Bioaccumulation Factors for Crustacea/ Mollusks ((pCi/kg)/(pCi/L))										
Ac-227	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Am-241	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	

SOIL DCGL: RESRAD PARAMETERS FOR 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	3 D		NA	Industrial Scenario	NR N	R NR		NR	
C-14	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Cm-243	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Cm-244	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Cm-245	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Cm-246	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Co-60	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Cs-137	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Eu-152	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Eu-154	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Gd-152	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
H-3	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
I-129	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Nb-94	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Ni-59	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Ni-63	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Np-237	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Pa-231	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Pb-210	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Po-210	P	S D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-238	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-239	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-240	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-241	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-242	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Ra-226	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Ra-228	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Sr-90	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-228	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	

SOIL DCGL: RESRAD PARAMETERS FOR 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	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-230	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-232	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
U-233	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
U-234	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
U-235	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
U-236	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
U-238	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Graphics Parameters										
Number of points				32	RESRAD Default	NR N	R NR		NR	
Spacing				log	RESRAD Default	NR N	R NR		NR	
Time integration parameters										
Maximum number of points for dose				17	RESRAD Default	NR N	R 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 6-2

RESRAD Input Parameters for LACBWR BFM Uncertainty Analysis

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR 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 N	R NR		NR	
Initial principal radionuclide (pCi/g) P		2 D		1	Unit Value	NR N	R 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 3.2	2 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 N	A NA		NA NA	
Am-243	P	1 S		Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA N	A NA		NA NA	
C-14	P	1 S		Lognormal-N	NUREG/CR-6697 Att. C	2.4 3.2	2 NA		NA 11	
Cm-243	P	1 S		Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA N	A NA		NA NA	
Cm-244	P	1 S		Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA N	A 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 2.3	3 NA		NA 446	
Eu-152	P	1 S		Lognormal-N	NUREG/CR-6697 Att. C	6.72 3.2	2 NA		NA 825	
Eu-154	P	1 S		Lognormal-N	NUREG/CR-6697 Att. C	6.72 3.2	2 NA		NA 825	
Eu-155	P	1 S		Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA N	A NA		NA NA	
Fe-55	P	1 S		Lognormal-N	NUREG/CR-6697 Att. C	5.34 2.6	7 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 3.2	2 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 N	A 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 N	A NA		NA NA	
Ni-59	P	1 S		Lognormal-N	NUREG/CR-6697 Att. C	6.05 1.4	6 NA		NA 424	
Ni-63	P	1 S		Lognormal-N	NUREG/CR-6697 Att. C	6.05 1.4	6 NA		NA 424	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR 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 N	A 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 N	A NA		NA NA	
Pb-210 (daughter for Pu-238) P		1 D		Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA N	A NA		NA NA	
Po-210 (daughter Pu-238)	P	1 D		Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA N	A NA		NA NA	
Pu-238	P	1 S		Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA N	A NA		NA NA	
Pu-239 (also daughter for Cm-243)	P	1 S		Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA N	A NA		NA NA	
Pu-240 (also daughter for Cm-244)	P	1 S		Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA N	A 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 N	A 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 N	A 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 3.2	2 NA		NA 825	
Sr-90	P	1 S		Lognormal-N	NUREG/CR-6697 Att. C	3.45 2.1	2 NA		NA 32	
Tc-99	P	1 S		Not Included in Uncertainty Analysis	< 0.1% of radionuclide mixture	NA N	A 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 N	A 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 3.6	2 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 N	A 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 N	A 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 3.1	3 NA		NA 126	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR 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 (daughter Pu-238)	P	1 D		Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA N	A NA		NA NA	
U-235 (daughter Cm-243 and Pu-239)	P	1 D		Not Included in Uncertainty Analysis	parent < 0.1% of radionuclide mixture	NA N	A 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 N	A NA		NA NA	
Initial concentration of radionuclides present in groundwater (pCi/l)	P	3 D		0	No existing groundwater contamination	NR N	R NR		NR	
Calculation Times										
Time since placement of material (y)	P	3 D		0	Start of dose calculation immediately after license termination	NR N	R NR		NR	
Time for calculations (y)	P	3 D		0, 1, 3, 10, 30, 100, 300, 1000	RESRAD Default	NR N	R NR		NR	
Contaminated Zone										
Area of contaminated zone (m^2) P		2 D		Variable	Source term and physical geometries vary for the five structures evaluated for BFM Insitu$_{gw}$ Uncertainty Analyses (see Table 6-8 in text)	NR N	R NR		NR	
Thickness of contaminated zone (m)	P	2 D		Variable	Source term and physical geometries vary for the five structures evaluated for BFM Insitu$_{gw}$ Uncertainty Analyses (see Table 6-8 in text)	NR N	R NR		NR	
Length parallel to aquifer flow (m)	P	2 D		Variable	Source term and physical geometries vary for the five structures evaluated for BFM Insitu$_{gw}$ Uncertainty Analyses (see Table 6-8 in text)	NR N	R NR		NR	
Contaminated fraction below water table	P	3 D		Variable	Source term and physical geometries vary for the five structures evaluated for BFM Insitu$_{gw}$ Uncertainty Analyses (see Table 6-8 in text)	NR N	R NR		NR	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Cover and Contaminated Zone Hydrological Data										
Cover depth (m)	P	2 D		Variable	Source term and physical geometries vary for the five structures evaluated for BFM Insitu$_{gw}$ Uncertainty Analyses (see Table 6-8 in text)	NR N	R NR		NR	
Density of cover material	P	2 D		1.76 Site-s	pecific[e]	NR N	R NR		NR	
Cover erosion rate	P,B	2 S		Continuous Logarithmic	NUREG/CR-6697 Att. C Table 3.8-1	5E-08 0.00	07 0.005		0.2 0.0015	
Density of contaminated zone (g/cm^3)	P	1 D		1.76 Site-s	pecific[e]	NR N	R 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 0.00	07 0.005		0.2 0.0015	
Contaminated zone total porosity P		2 D		0.31 Site-s	pecific[e]	NR N	R 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 N	R NR		NR	
Contaminated zone hydraulic conductivity (m/y)	P	2 D		34822	Site-specific[e] 313 feet/day = 34822 m/y	NR N	R 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 0.2	16 N	A	NA	0.97
Humidity in air (g/m^3)	P	3 D		7.2	Median NUREG/CR-6697 Att. C	1.98 0.3	34 0.001		0.999 7.2	
Evapotranspiration coefficient P		2 S		0	Site-specific value to force the Precipitation parameter to equal to the infiltration rate (see text section 6.11.1.2)	NR N	R NR		NR NR	
Average annual wind speed (m/s)	P	2 S		Bounded Lognormal - N	NUREG/CR-6697 Att. C Figure 4.5-1	1.445 0.24	19 1.4		13 4.2	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Precipitation (m/y)	P	2 S		Uniform	For the BFM analysis the Evapotranspiration coefficient and Runoff coefficient were set to zero to force the Precipitation parameter to equal the infiltration rate. This was necessary to incorporate the effect of seasonal ground water elevation rise associated with the Mississippi river stage. Minimum value of 0.25 is traditional infiltration rate based on Evapotranspiration coefficient, Runoff coefficient and site precipitation rate parameters listed in the parameter set for Soil DCGL. The maximum value of 3.05 is the seasonal high groundwater elevation at the site as driven by river stage.	0.25 3.0	5 NR		NR	
Irrigation (m/y)	B	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Irrigation mode	B	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Runoff coefficient	P	2 D		0	Site-specific value to force the Precipitation parameter to equal to the infiltration rate. See section 6.11.1.2.	NR N	R NR		NR NR	
Watershed area for nearby stream or pond (m^2)	P	3 D		1.00E+06 RESR	AD Default	NR N	R NR		NR	
Accuracy for water/soil computations	-	3 D		1.00E-03 RESR	AD Default	NR N	R NR		NR	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR 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 Hydrological Data										
Density of saturated zone (g/cm^3) P		2 D		1.76 Site-s	pecific[e]	NR N	R NR		NR	
Saturated zone total porosity	P	1 D		0.31 Site-s	pecific[e]	NR N	R NR		NR	
Saturated zone effective porosity P		1 D		0.28 Site-s	pecific[e]	NR N	R NR		NR	
Saturated zone field capacity	P	3 D		0.066	Calculated values for sand soil type[f]	NR N	R NR		NR	
Saturated zone hydraulic conductivity (m/y)	P	1 D		34822	Site-specific[e] 313 feet/day = 34822 m/y	NR N	R NR		NR	
Saturated zone hydraulic gradient P		2 D		0.0045 S	ite-specific value[e]	NR N	R 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 0.2	16 N	A	NA 0.97	
Water table drop rate (m/y)	P	3 D		0	Assumed zero due to hydraulic connectivity with Mississippi river.	NR N	R NR		NR	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR 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 33.1 m below the water table). 33.1 m assumed to be maximum well depth. Minimum well depth assumed to be represented by nominal 20' screen depth (6.08 m) from top of water table. Mode is mid-point between 6.08m and 33.1 m which is 19.6 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.	6.08	19.6 33.1		NR 10	
Model: Nondispersion (ND) or Mass-Balance (MB)	P	3 D		ND Applic	able to moving groundwater	NR N	R NR		NR	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR 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.	328.7 164	3.5 NR		NR 986.1	
Unsaturated Zone Hydrological Data										
Number of unsaturated zone strata P		3 D		1	Site-specific	NR N	R NR		NR	
Unsat. zone thickness (m)	P	1 D		Variable Struct	ure specific	NR N	R NR		NR	
Unsat. zone soil density (g/cm^3) P		2 D		1.76 Site	specific [e]	NR N	R NR		NR	
Unsat. zone total porosity	P	2 D		0.31 Site	specific [e]	NR N	R NR		NR	
Unsat. zone effective porosity P		2 D		0.28 Site	specific [e]	NR N	R NR		NR	
Unsat. zone field capacity	P	3 D		0.066	Calculated values for sand soil type[f]	NR N	R NR		NR	
Unsat. zone hydraulic conductivity (m/y)	P	2 D		34822 S	ite-specific value[e]	NR N	R 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 0.2	16 N	A	NA	0.97
Occupancy										
Inhalation rate (m^3/y)	M,B	3 D		1917	NUREG/CR-5512, Vol. 3 Table 5.1.1 mean value is 8400/y which equates to 23 m^3/d Industrial Scenario m^3/yr =23 m^3/d ÷ 24h/d * 2000 h/y)	NR N	R NR		NR	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR 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 NURE	G/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 NR dose calculation		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		0.1875	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"[9] 75% of work time is indoors and 25% outdoors. The corresponding RESRAD indoor Fraction parameter = (2190*.75)/(24*365) = .1875	NR N	R 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 N	R NR		NR	
Shape factor flag, external gamma P		3 D		Circular	Circular contaminated zone assumed for modeling purposes	NR N	R NR		NR	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Ingestion, Dietary										
Fruits, non-leafy vegetables, grain consumption (kg/y)	M,B	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Leafy vegetable consumption (kg/y)	M,B	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Milk consumption (L/y)	M,B	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Meat and poultry consumption (kg/y)	M,B	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Fish consumption (kg/y)	M,B	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Other seafood consumption (kg/y)	M,B	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Soil ingestion rate (g/y)	M,B	2 D		18.3	NUREG/CR-5512, Vol. 3 Table 6.87	NR N	R 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 N	R NR		NR	
Contamination fraction of drinking water	B,P	3 D		1	All water assumed contaminated	NR N	R 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 N	R NR		NR	
Contamination fraction of irrigation water	B,P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Contamination fraction of aquatic food	B,P	2 D		NA	Industrial Scenario	NR N	R NR		NR	
Contamination fraction of plant food	B,P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Contamination fraction of meat B,P		3 D		NA	Industrial Scenario	NR N	R NR		NR	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR 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 milk B,P		3 D		NA	Industrial Scenario	NR N	R NR		NR	
Ingestion, Non-Dietary										
Livestock fodder intake for meat (kg/day)	M	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Livestock fodder intake for milk (kg/day)	M	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Livestock water intake for meat (L/day)	M	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Livestock water intake for milk (L/day)	M	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Livestock soil intake (kg/day)	M	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Mass loading for foliar deposition (g/m^3)	P	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Depth of soil mixing layer (m) P		2 D		Triangular	NUREG/CR-6697, Att. C Figure 3.12-1	0 0.1	5 0.6		NR 0.15	
Depth of roots (m)	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Drinking water fraction from ground water	B,P	3 D		1	Industrial Scenario	NR N	R NR		NR	
Household water fraction from ground water (if used)	B,P	3		1	Industrial Scenario	NR N	R NR		NR	
Livestock water fraction from ground water	B,P	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Irrigation fraction from ground water B,P		3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Wet weight crop yield for Non-Leafy (kg/m^2)	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Wet weight crop yield for Leafy (kg/m^2)	P	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Wet weight crop yield for Fodder (kg/m^2)	P	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Growing Season for Non-Leafy (y)	P	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Growing Season for Leafy (y) P		3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Growing Season for Fodder (y)	P	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Translocation Factor for Non-Leafy P		3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Translocation Factor for Leafy P		3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Translocation Factor for Fodder P		3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Weathering Removal Constant for Vegetation (1/y)	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR 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 Foliar Interception Fraction for Non-Leafy	P	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Wet Foliar Interception Fraction for Leafy	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Wet Foliar Interception Fraction for Fodder	P	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Dry Foliar Interception Fraction for Non-Leafy	P	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Dry Foliar Interception Fraction for Leafy	P	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Dry Foliar Interception Fraction for Fodder	P	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Storage times of contaminated foodstuffs (days):										
Fruits, non-leafy vegetables, and grain	B	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Leafy vegetables	B	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Milk	B	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Meat and poultry	B	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Fish	B	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Crustacea and mollusks	B	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Well water	B	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Surface water	B	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Livestock fodder	B	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Special Radionuclides (C-14)										
C-12 concentration in water (g/cm^3) P		3 D		NA Indust	rial Scenario	NR N	R NR		NR	
C-12 concentration in contaminated soil (g/g)	P	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Fraction of vegetation carbon from soil	P	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Fraction of vegetation carbon from air	P	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
C-14 evasion layer thickness in soil (m)	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
C-14 evasion flux rate from soil (1/sec)	P	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
C-12 evasion flux rate from soil (1/sec)	P	3 D		NA Indust	rial Scenario	NR N	R NR		NR	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR 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 grain in beef cattle feed	B	3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Fraction of grain in milk cow feed B		3 D		NA Indust	rial Scenario	NR N	R NR		NR	
Dose Conversion Factors **(Inhalation mrem/pCi)**										
Ac-227	M	3 D		6.70E+00 FGR	11	NR N	R NR		NR	
Am-241	M	3 D		4.44E-01 FGR	11	NR N	R NR		NR	
Am-243	M	3 D		4.40E-01 FGR	11	NR N	R NR		NR	
C-14	M	3 D		2.09E-06 FGR	11	NR N	R NR		NR	
Cm-243	M	3 D		3.07E-01 FGR	11	NR N	R NR		NR	
Cm-244	M	3 D		2.48E-01 FGR	11	NR N	R NR		NR	
Cm-245	M	3 D		4.55E-01 FGR	11	NR N	R NR		NR	
Cm-246	M	3 D		4.51E-01 FGR	11	NR N	R NR		NR	
Co-60	M	3 D		2.19E-04 FGR	11	NR N	R NR		NR	
Cs-134	M	3 D		4.62E-05 FGR	11	NR N	R NR		NR	
Cs-137	M	3	D	3.19E-05	FGR11	NR N	R NR		NR	
Eu-152	M	3 D		2.21E-04 FGR	11	NR N	R NR		NR	
Eu-154	M	3 D		2.86E-04 FGR	11	NR N	R NR		NR	
Eu-155	M	3 D		4.14E-05 FGR	11	NR N	R NR		NR	
Gd-152	M	3 D		2.43E-01 FGR	11	NR N	R NR		NR	
H-3	M	3 D		6.40E-08 FGR	11	NR N	R NR		NR	
I-129	M	3 D		1.74E-04 FGR	11	NR N	R NR		NR	
Nb-94	M	3 D		4.14E-04 FGR	11	NR N	R NR		NR	
Nd-144[e]	M	3 D		7.04E-02 ICRP6	0	NR N	R NR		NR	
Ni-59	M	3 D		2.70E-06 FGR	11	NR N	R NR		NR	
Ni-63	M	3 D		6.29E-06 FGR	11	NR N	R NR		NR	
Np-237	M	3 D		5.40E-01 FGR	11	NR N	R NR		NR	
Pa-231	M	3 D		1.28E+00 FGR	11	NR N	R NR		NR	
Pb-210	M	3 D		1.36E-02 FGR	11	NR N	R NR		NR	
Po-210	M	3 D		9.40E-03 FGR	11	NR N	R NR		NR	
Pu-238	M	3 D		3.92E-01 FGR	11	NR N	R NR		NR	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR 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	M	3 D		4.29E-01 FGR	11	NR N	R NR		NR	
Pu-240	M	3 D		4.29E-01 FGR	11	NR N	R NR		NR	
Pu-241	M	3 D		8.25E-03 FGR	11	NR N	R NR		NR	
Pu-242	M	3 D		4.11E-01 FGR	11	NR N	R NR		NR	
Ra-226	M	3 D		8.58E-03 FGR	11	NR N	R NR		NR	
Ra-228	M	3 D		4.77E-03 FGR	11	NR N	R NR		NR	
Sm-148[e]	M	3 D		7.34E-02 ICRP6	0	NR N	R NR		NR	
Sr-90	M	3 D		1.30E-03 FGR	11	NR N	R NR		NR	
Tc-99	M	3 D		8.32E-06 FGR	11	NR N	R NR		NR	
Th-228	M	3 D		3.42E-01 FGR	11	NR N	R NR		NR	
Th-229	M	3 D		2.15E+00 FGR	11	NR N	R NR		NR	
Th-230	M	3 D		3.26E-01 FGR	11	NR N	R NR		NR	
Th232	M	3 D		1.64e+00 FGR	11	NR N	R NR		NR	
U-233	M	3 D		1.35E-01 FGR	11	NR N	R NR		NR	
U-234	M	3 D		1.32E-01 FGR	11	NR N	R NR		NR	
U-235	M	3 D		1.23E-01 FGR	11	NR N	R NR		NR	
U-236	M	3 D		1.25E-01 FGR	11	NR N	R NR		NR	
U-238	M	3 D		1.18E-01 FGR	11	NR N	R NR		NR	
Dose Conversion Factors (Ingestion mrem/pCi)										
Ac-227	M	3 D		1.41E-02 FGR	11	NR N	R NR		NR	
Am-241	M	3 D		3.64E-03 FGR	11	NR N	R NR		NR	
Am-243	M	3 D		3.62E-03 FGR	11	NR N	R NR		NR	
C-14	M	3 D		2.09E-06 FGR	11	NR N	R NR		NR	
Cm-243	M	3 D		2.51E-03 FGR	11	NR N	R NR		NR	
Cm-244	M	3 D		2.02E-03 FGR	11	NR N	R NR		NR	
Cm-245	M	3 D		3.74E-03 FGR	11	NR N	R NR		NR	
Cm-246	M	3 D		3.70E-03 FGR	11	NR N	R NR		NR	
Co-60	M	3 D		2.69E-05 FGR	11	NR N	R NR		NR	
Cs-134	M	3 D		7.33E-05 FGR	11	NR N	R NR		NR	
Cs-137	M	3 D		5.00E-05 FGR	11	NR N	R NR		NR	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Eu-152	M	3 D		6.48E-06 FGR	11	NR N	R NR		NR	
Eu-154	M	3 D		9.55E-06 FGR	11	NR N	R NR		NR	
Eu-155	M	3 D		1.53E-06 FGR	11	NR N	R NR		NR	
Gd-152	M	3 D		1.61E-04 FGR	11	NR N	R NR		NR	
H-3	M	3 D		6.40E-08 FGR	11	NR N	R NR		NR	
I-129	M	3 D		2.76E-04 FGR	11	NR N	R NR		NR	
Nb-94	M	3 D		7.14E-06 FGR	11	NR N	R NR		NR	
Nd-144[e]	M	3 D		1.51E-04 ICRP6	0	NR N	R NR		NR	
Ni-59	M	3 D		2.10E-07 FGR	11	NR N	R NR		NR	
Ni-63	M	3 D		5.77E-07 FGR	11	NR N	R NR		NR	
Np-237	M	3 D		4.44E-03 FGR	11	NR N	R NR		NR	
Pa-231	M	3 D		1.06E-02 FGR	11	NR N	R NR		NR	
Pb-210	M	3 D		5.37E-03 FGR	11	NR N	R NR		NR	
Po-210	M	3 D		1.90E-03 FGR	11	NR N	R NR		NR	
Pu-238	M	3 D		3.20E-03 FGR	11	NR N	R NR		NR	
Pu-239	M	3 D		3.54E-03 FGR	11	NR N	R NR		NR	
Pu-240	M	3 D		3.54E-03 FGR	11	NR N	R NR		NR	
Pu-241	M	3 D		6.84E-05 FGR	11	NR N	R NR		NR	
Pu-242	M	3 D		3.36E-03 FGR	11	NR N	R NR		NR	
Ra-226	M	3 D		1.32E-03 FGR	11	NR N	R NR		NR	
Ra-228	M	3 D		1.44E-03 FGR	11	NR N	R NR		NR	
Sm-148[e]	M	3 D		1.58E-04 ICRP6	0	NR N	R NR		NR	
Sr-90	M	3 D		1.42E-04 FGR	11	NR N	R NR		NR	
Tc-99	M	3 D		1.46E-06 FGR	11	NR N	R NR		NR	
Th-228	M	3 D		3.96E-04 FGR	11	NR N	R NR		NR	
Th-229	M	3 D		3.53E-03 FGR	11	NR N	R NR		NR	
Th-230	M	3 D		5.48E-04 FGR	11	NR N	R NR		NR	
Th-232	M	3 D		2.73E-03 FGR	11	NR N	R NR		NR	
U-233	M	3 D		2.89E-04 FGR	11	NR N	R NR		NR	
U-234	M	3 D		2.83E-04 FGR	11	NR N	R NR		NR	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR 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		2.66E-04 FGR	11	NR N	R NR		NR	
U-236	M	3 D		2.69E-04 FGR	11	NR N	R NR		NR	
U-238	M	3 D		2.55E-04 FGR	11	NR N	R NR		NR	
Plant Transfer Factors (pCi/g plant)/(pCi/g soil)										
Ac-227	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Am-241	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Am-243	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
C-14	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Cm-243	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Cm-244	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Co-60	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Cs-134	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Cs-137	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Eu-152	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Eu-154	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Fe-55	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Gd-152	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
H-3	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Nb-94	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Nd-144	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Ni-59	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Ni-63	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Np-237	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pa-231	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pb-210	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pm-147	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Po-210	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pu-238	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pu-239	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pu-240	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR 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	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Ra-226	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Ra-228	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Sb-125	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Sm-148	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Sr-90	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Tc-99	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Th-228	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Th-229	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Th-230	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Th-232	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
U-233	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
U-234	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
U-235	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
U-236	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Meat Transfer Factors (pCi/kg)/(pCi/d)										
Ac-227	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Ag-108m	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Am-241	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Am-243	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
C-14	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Cm-243	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Cm-244	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Co-60	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Cs-134	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Cs-137	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Eu-152	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Eu-154	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Fe-55	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Gd-152	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR 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	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Nb-94	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Nd-144	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Ni-59	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Ni-63	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Np-237	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pa-231	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pb-210	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Po-210	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pu-238	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pu-239	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pu-240	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pu-241	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Ra-226	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Ra-228	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Sb-125	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Sm-148	P	1 D		NA Indust	rial Scenario	NR N	R NR		NR	
Sr-90	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Tc-99	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Th-228	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Th-229	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Th-230	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Th-232	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
U-233	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
U-234	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
U-235	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
U-236	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Milk Transfer Factors (pCi/L)/(pCi/d)										
Ac-227	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Am-241	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Am-243	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR 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	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Cm-243	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Cm-244	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Co-60	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Cs-134	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Cs-137	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Eu-152	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Eu-154	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Fe-55	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Gd-152	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
H-3	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Nb-94	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Nd-144	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Ni-59	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Ni-63	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Np-237	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pa-231	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pb-210	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Po-210	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pu-238	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pu-239	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pu-240	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pu-241	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Ra-226	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Ra-228	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Sm-148	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Sr-90	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Tc-99	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Th-228	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Th-229	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR 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	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Th-232	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
U-233	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
U-234	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
U-235	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
U-236	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Bioaccumulation Factors for Fish **((pCi/kg)/(pCi/L))**										
Ac-227	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Am-241	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Am-243	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
C-14	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Cm-243	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Cm-244	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Cm-245	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Cm-246	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Co-60	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Cs-137	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Eu-152	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Eu-154	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Gd-152	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
H-3	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
I-129	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Nb-94	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Ni-59	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Ni-63	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Np-237	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pa-231	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Po-210	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pb-210	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pu-238	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR 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 Indust	rial Scenario	NR N	R NR		NR	
Pu-240	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pu-241	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Pu-242	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Ra-226	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Ra-228	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Sr-90	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Th-228	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Th-229	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Th-230	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Th-232	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
U-233	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
U-234	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
U-235	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
U-236	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
U-238	P	2 D		NA Indust	rial Scenario	NR N	R NR		NR	
Bioaccumulation Factors for Crustacea/ Mollusks ((pCi/kg)/(pCi/L))										
Ac-227	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Am-241	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Am-243	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
C-14	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Cm-243	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Cm-244	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Cm-245	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Cm-246	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Co-60	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Cs-137	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Eu-152	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Eu-154	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Gd-152	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR 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	3 D		NA	Industrial Scenario	NR N	R NR		NR	
I-129	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Nb-94	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Ni-59	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Ni-63	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Np-237	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Pa-231	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Pb-210	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Po-210	P	S D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-238	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-239	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-240	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-241	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Pu-242	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Ra-226	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Ra-228	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Sr-90	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-228	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-229	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-230	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Th-232	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
U-233	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
U-234	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
U-235	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
U-236	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
U-238	P	3 D		NA	Industrial Scenario	NR N	R NR		NR	
Graphics Parameters										
Number of points				32 RESR	AD Default	NR N	R NR		NR	
Spacing				log RESR	AD Default	NR N	R NR		NR	
Time integration parameters										

BFM INSITU$_{gw}$: RESRAD PARAMETERS FOR UNCERTAINTY ANALYSIS										
Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Mean/ Median
Maximum number of points for dose				17 RESR	AD Default	NR N	R 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 6-3
Dose Contribution Percentage for Initial Suite Radionuclides and Determination of Aggregate Dose Percentage from Insignificant Dose Contributors

Table 20 from Reference 5 (TSD RS-TD-313196-001) - Dose Contribution per ROC per Scenario

	Soil DCGLs		Rx Bldg Groundwater		Rx Bldg Drilling Spoils		Rx Bldg Excavation		WTB Groundwater		WTB Drilling Spoils		WTB Excavation	
	mrem/yr	Dose Fraction	mrem/yr	Dose Fraction	mrem/yr	Dose Fraction	mrem/yr	Dose Fraction	mrem/yr	Dose Fraction	mrem/yr	Dose Fraction	mrem/yr	Dose Fraction
H-3	3.30E-09	0.000%	3.14E-06	0.002%	5.05E-12	0.000%	2.61E-09	0.000%	1.11E-06	0.002%	4.96E-11	0.000%	3.45E-08	0.000%
C-14	2.41E-09	0.000%	6.66E-05	0.033%	8.23E-12	0.000%	1.91E-09	0.000%	2.85E-05	0.045%	8.10E-11	0.000%	2.52E-08	0.000%
Fe-55	7.21E-09	0.000%	6.96E-06	0.003%	7.14E-12	0.000%	5.70E-09	0.000%	4.91E-13	0.000%	7.02E-11	0.000%	7.52E-08	0.000%
Ni-59	9.98E-09	0.000%	2.59E-06	0.001%	1.43E-11	0.000%	7.89E-09	0.000%	4.80E-06	0.008%	1.41E-10	0.000%	1.05E-07	0.000%
Co-60	**2.38E-02**	**5.911%**	**5.79E-03**	**2.858%**	**1.42E-03**	**5.374%**	**1.88E-02**	**5.903%**	**7.91E-04**	**1.238%**	**1.39E-02**	**5.376%**	**2.49E-01**	**5.908%**
Ni-63	2.12E-07	0.000%	5.47E-05	0.027%	2.82E-10	0.000%	1.67E-07	0.000%	1.63E-05	0.026%	2.78E-09	0.000%	2.21E-06	0.000%
Sr-90	**3.45E-05**	**0.009%**	**4.45E-02**	**21.993%**	**1.86E-06**	**0.007%**	**2.72E-05**	**0.009%**	**2.58E-02**	**40.445%**	**1.83E-05**	**0.007%**	**3.60E-04**	**0.009%**
Nb-94	1.02E-04	0.025%	5.26E-06	0.003%	6.57E-06	0.025%	8.10E-05	0.025%	4.22E-06	0.007%	6.46E-05	0.025%	1.07E-03	0.025%
Tc-99	1.86E-06	0.000%	1.54E-05	0.008%	4.64E-11	0.000%	1.47E-06	0.000%	3.62E-06	0.006%	4.57E-10	0.000%	1.95E-05	0.000%
Cs-137	**3.77E-01**	**93.653%**	**1.50E-01**	**74.095%**	**2.48E-02**	**94.217%**	**2.98E-01**	**93.661%**	**3.55E-02**	**55.598%**	**2.44E-01**	**94.213%**	**3.95E+00**	**93.657%**
Eu-152	8.21E-04	0.204%	1.06E-05	0.005%	5.10E-05	0.194%	6.48E-04	0.204%	3.31E-09	0.000%	5.03E-04	0.194%	8.59E-03	0.204%
Eu-154	7.61E-04	0.189%	1.29E-05	0.006%	4.66E-05	0.177%	6.02E-04	0.189%	2.85E-11	0.000%	4.59E-04	0.177%	7.96E-03	0.189%
Eu-155	1.01E-05	0.003%	1.14E-06	0.001%	9.11E-07	0.003%	7.97E-06	0.003%	4.49E-17	0.000%	8.92E-06	0.003%	1.06E-04	0.003%
Pu-238	2.14E-06	0.001%	4.63E-04	0.229%	1.56E-08	0.000%	1.69E-06	0.001%	7.38E-05	0.115%	1.53E-07	0.000%	2.23E-05	0.001%
Pu-239/240*	2.18E-06	0.001%	4.77E-04	0.235%	1.58E-08	0.000%	1.73E-06	0.001%	8.75E-04	1.369%	1.55E-07	0.000%	2.28E-05	0.001%
Pu-241	2.07E-06	0.001%	2.10E-04	0.104%	5.05E-08	0.000%	1.64E-06	0.001%	8.87E-05	0.139%	4.95E-07	0.000%	2.17E-05	0.001%
Am-241	8.29E-06	0.002%	7.07E-04	0.349%	2.54E-07	0.001%	6.56E-06	0.002%	5.09E-04	0.797%	2.50E-06	0.001%	8.65E-05	0.002%
Am-243	5.21E-06	0.001%	7.58E-05	0.037%	3.74E-07	0.001%	4.14E-06	0.001%	1.33E-04	0.208%	3.67E-06	0.001%	5.47E-05	0.001%
Cm-243/244*	4.11E-06	0.001%	2.26E-05	0.011%	2.80E-07	0.001%	3.25E-06	0.001%	9.42E-08	0.000%	2.75E-06	0.001%	4.30E-05	0.001%
Insignificant contributor dose percentage based on mixture		0.427%		1.054%		0.403%		0.427%		**2.179%**		0.404%		0.427%
Insignificant contributor dose percentage based on actual data	2.60E-02		1.25E+01		1.63E+00		1.97E+01		7.87E-01		3.19E+00		5.19E+01	
Insignificant contributor dose based on actual data (mrem/yr)		0.0004%		0.528%		0.026%		0.336%		0.086%		0.051%		0.886%

Table 20 from Reference 5 (TSD RS-TD-313196-001) (cont.) - Dose Contribution per ROC per Scenario

	WGTV Groundwater		WGTV Drilling Spoils		WGTV Excavation		Remaining Basements Groundwater		Remaining Basements Drilling Spoils		Remaining Basements Excavation	
	mrem/yr	Dose Fraction	mrem/yr	Dose Fraction	mrem/yr	Dose Fraction	mrem/yr	Dose Fraction	mrem/yr	Dose Fraction	mrem/yr	Dose Fraction
H-3	4.24E-07	0.001%	2.57E-11	0.000%	1.15E-08	0.000%	1.09E-06	0.007%	5.66E-12	0.000%	5.78E-09	0.000%
C-14	9.34E-06	0.018%	4.19E-11	0.000%	8.42E-09	0.000%	2.75E-05	0.177%	9.21E-12	0.000%	4.23E-09	0.000%
Fe-55	0.00E+00	0.000%	3.64E-11	0.000%	2.51E-08	0.000%	1.50E-14	0.000%	8.02E-12	0.000%	1.26E-08	0.000%
Ni-59	1.08E-06	0.002%	7.27E-11	0.000%	3.49E-08	0.000%	7.57E-07	0.005%	1.61E-11	0.000%	1.75E-08	0.000%
Co-60	**1.43E-03**	**2.712%**	**7.21E-03**	**5.380%**	**8.31E-02**	**5.916%**	**1.66E-04**	**1.072%**	**1.59E-03**	**5.376%**	**4.18E-02**	**5.911%**
Ni-63	2.06E-06	0.004%	1.43E-09	0.000%	7.40E-07	0.000%	2.11E-06	0.014%	3.16E-10	0.000%	3.71E-07	0.000%
Sr-90	**9.70E-03**	**18.424%**	**9.43E-06**	**0.007%**	**1.21E-04**	**0.009%**	**1.05E-02**	**67.909%**	**2.09E-06**	**0.007%**	**6.04E-05**	**0.009%**
Nb-94	9.68E-07	0.002%	3.34E-05	0.025%	3.57E-04	0.025%	6.73E-07	0.004%	7.37E-06	0.025%	1.79E-04	0.025%
Tc-99	1.81E-06	0.003%	2.36E-10	0.000%	6.51E-06	0.000%	3.92E-06	0.025%	5.21E-11	0.000%	3.26E-06	0.000%
Cs-137	**4.09E-02**	**77.619%**	**1.26E-01**	**94.210%**	**1.32E+00**	**93.648%**	**4.51E-03**	**29.109%**	**2.78E-02**	**94.213%**	**6.62E-01**	**93.654%**
Eu-152	7.64E-07	0.001%	2.60E-04	0.194%	2.87E-03	0.204%	2.24E-10	0.000%	5.73E-05	0.194%	1.44E-03	0.204%
Eu-154	3.59E-07	0.001%	2.38E-04	0.177%	2.66E-03	0.189%	1.21E-12	0.000%	5.23E-05	0.177%	1.33E-03	0.189%
Eu-155	3.79E-09	0.000%	4.62E-06	0.003%	3.52E-05	0.003%	6.84E-19	0.000%	1.02E-06	0.003%	1.77E-05	0.003%
Pu-238	1.15E-04	0.219%	7.92E-08	0.000%	7.45E-06	0.001%	8.99E-06	0.058%	1.75E-08	0.000%	3.75E-06	0.001%
Pu-239/240*	1.99E-04	0.378%	8.02E-08	0.000%	7.61E-06	0.001%	1.38E-04	0.891%	1.77E-08	0.000%	3.82E-06	0.001%
Pu-241	5.32E-05	0.101%	2.57E-07	0.000%	7.22E-06	0.001%	2.07E-05	0.134%	5.66E-08	0.000%	3.64E-06	0.001%
Am-241	2.41E-04	0.457%	1.29E-06	0.001%	2.89E-05	0.002%	7.14E-05	0.461%	2.85E-07	0.001%	1.45E-05	0.002%
Am-243	3.12E-05	0.059%	1.90E-06	0.001%	1.82E-05	0.001%	2.06E-05	0.133%	4.18E-07	0.001%	9.14E-06	0.001%
Cm-243/244*	3.17E-08	0.000%	1.42E-06	0.001%	1.44E-05	0.001%	1.24E-07	0.001%	3.14E-07	0.001%	7.19E-06	0.001%
Insignificant contributor dose percentage based on mixture		1.246%		0.403%		0.428%		1.910%		0.403%		0.427%
Insignificant contributor dose based on actual data (mrem/yr)	2.93E+00		7.45E+00		7.81E+01		1.25E+00		2.38E+00		5.69E+01	
Insignificant contributor dose percentage based on actual data		0.146%		0.120%		1.336%		0.095%		0.038%		0.972%

Table 22 from Reference 5 (TSD RS-TD-313196-001) - Insignificant Contributor Dose Percent Using the Highest Activity Cores

	WTB Groundwater		WTB Drilling Spoils		WTB Excavation	
	mrem/yr	Dose Fraction	mrem/yr	Dose Fraction	mrem/yr	Dose Fraction
H-3	1.59E-07	0.000%	7.14E-12	0.000%	4.95E-09	0.000%
C-14	2.21E-05	0.035%	6.28E-11	0.000%	1.96E-08	0.000%
Fe-55	1.92E-13	0.000%	2.74E-11	0.000%	2.94E-08	0.000%
Ni-59	6.28E-06	0.010%	1.85E-10	0.000%	1.37E-07	0.000%
Co-60	**7.26E-04**	**1.147%**	**1.28E-02**	**5.002%**	**2.29E-01**	**5.499%**
Ni-63	1.83E-05	0.029%	3.11E-09	0.000%	2.48E-06	0.000%
Sr-90	**2.59E-02**	**40.855%**	**1.83E-05**	**0.007%**	**3.60E-04**	**0.009%**
Nb-94	2.30E-06	0.004%	3.51E-05	0.014%	5.81E-04	0.014%
Tc-99	1.28E-06	0.002%	1.61E-10	0.000%	6.85E-06	0.000%
Cs-137	**3.52E-02**	**55.694%**	**2.42E-01**	**94.749%**	**3.92E+00**	**94.236%**
Eu-152	2.19E-09	0.000%	3.32E-04	0.130%	5.67E-03	0.137%
Eu-154	1.47E-11	0.000%	2.37E-04	0.093%	4.12E-03	0.099%
Eu-155	2.93E-17	0.000%	5.83E-06	0.002%	6.90E-05	0.002%
Pu-238	5.98E-05	0.095%	1.24E-07	0.000%	1.81E-05	0.000%
Pu-239/240	7.29E-04	1.152%	1.29E-07	0.000%	1.90E-05	0.000%
Pu-241	5.33E-05	0.084%	2.98E-07	0.000%	1.30E-05	0.000%
Am-241	4.87E-04	0.769%	2.39E-06	0.001%	8.27E-05	0.002%
Am-243	7.84E-05	0.124%	2.17E-06	0.001%	3.23E-05	0.001%
Cm-243/244	5.40E-08	0.000%	1.58E-06	0.001%	2.46E-05	0.001%
		2.304%		0.242%		0.256%

Dose Based on Concentrations (mrem/yr)	Insignificant Contributor % Based on Dose	Dose Based on Concentrations (mrem/yr)	Insignificant Contributor % Based on Dose	Dose Based on Concentrations (mrem/yr)	Insignificant Contributor % Based on Dose
2.36E+00	0.218%	9.52E+00	0.092%	1.55E+02	1.587%

Table 24 from Reference 5 (TSD RS-TD-313196-001) Buried Piping Dose Contribution per ROC per Scenario

	Buried Pipe Group Excavation		Buried Pipe Group InSitu		Circ Water Pipe Excavation		Circ Water Pipe InSitu	
	mrem/yr	Dose Fraction	mrem/yr	Dose Fraction	mrem/yr	Dose Fraction	mrem/yr	Dose Fraction
H-3	1.52E-13	0.000006%	1.51E-12	0.002918%	1.13E-13	0.000004%	4.53E-12	0.022182%
C-14	2.68E-14	0.000001%	3.59E-11	0.069510%	2.67E-14	0.000001%	4.28E-11	0.209552%
Fe-55	4.93E-14	0.000002%	0.00E+00	0.000000%	3.78E-14	0.000001%	0.00E+00	0.000000%
Ni-59	6.83E-14	0.000003%	9.23E-13	0.001788%	5.24E-14	0.000002%	0.00E+00	0.000000%
Co-60	1.45E-07	5.588696%	1.34E-09	2.592108%	1.42E-07	5.580068%	2.48E-10	1.215574%
Ni-63	1.45E-12	0.000056%	1.72E-12	0.003333%	1.11E-12	0.000044%	4.07E-13	0.001991%
Sr-90	2.27E-10	0.008762%	1.55E-08	30.046145%	2.14E-10	0.008401%	1.31E-08	64.004473%
Nb-94	6.52E-10	0.025163%	8.23E-13	0.001593%	6.41E-10	0.025160%	8.18E-13	0.004008%
Tc-99	1.70E-12	0.000066%	6.43E-12	0.012456%	1.26E-12	0.000049%	2.06E-11	0.101008%
Cs-137	2.44E-06	93.988458%	3.42E-08	66.198432%	2.40E-06	93.998448%	6.70E-09	32.818795%
Eu-152	5.12E-09	0.197504%	6.39E-13	0.001238%	5.03E-09	0.197405%	6.45E-16	0.000003%
Eu-154	4.73E-09	0.182523%	3.00E-13	0.000581%	4.65E-09	0.182371%	5.72E-18	0.000000%
Eu-155	6.84E-11	0.002638%	3.17E-15	0.000006%	6.75E-11	0.002648%	9.61E-24	0.000000%
Pu-238	1.46E-11	0.000564%	9.65E-11	0.186737%	1.12E-11	0.000440%	1.39E-11	0.067971%
Pu-239/240	1.49E-11	0.000575%	1.69E-10	0.327211%	1.14E-11	0.000449%	1.69E-10	0.825476%
Pu-241	1.01E-11	0.000388%	5.95E-11	0.115147%	8.31E-12	0.000326%	2.77E-11	0.135521%
Am-241	5.62E-11	0.002168%	2.01E-10	0.389710%	4.62E-11	0.001813%	9.53E-11	0.466862%
Am-243	3.52E-11	0.001357%	2.62E-11	0.050785%	3.38E-11	0.001324%	2.57E-11	0.125811%
Cm-243/244	2.78E-11	0.001071%	1.57E-13	0.000304%	2.66E-11	0.001043%	1.58E-13	0.000774%
Insignificant Radionuclide Dose Percent		0.414%		1.163%		0.413%		1.961%