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EMDF Comment Resolution Matrix

Document Number: NA	**Document Title:** Briefings to LFRG on EMDF Performance Assessment and Composite Analysis		
Organization/Project: UCOR/EMDF	**Comment Due Date:**		

Reviewer	TDEC

Comment No.	Presentation Slide	Comment/Suggested Change/Rationale	Response
1		If possible during our scheduled discussion tomorrow morning (to discuss questions related to the 8/28 presentation to LFRG), I want to find out more about the numerical flow model being used in the PA/CA for the proposed EMDF, the model results thus far, and what adjustments to the model are planned. Specifically: What is the range of the bottom elevations for the dry cells at the EMDF footprint under the pre-construction condition (Figure D.9)?	Discussed Sept. 6, 2018 and October 15, 2019. The range of the bottom elevation of the dry cells at the Environmental Management Disposal Facility (EMDF) footprint under the pre-construction condition is from 910 to 935 ft in either model layer 1 (top layer) or model layer 2 (under the very top of the knob). See attached figures. The dry cells suggest that the future elevation the water table will be lower than the bottom elevation at the dry cell locations.
2		The contour labels on that figure are hard to read – what is the elevation of the closed contour shown in the upper right corner of the EMDF footprint and the contour interval?	Figures provided and discussed Sept. 6, 2018.
3		Why are there so many dry cells in the part of the model south of Bear Creek?	Discussed Sept. 6, 2018. Chestnut Ridge is a high ridge with a very steep northern slope. The water level is below the model layer (#1) since the model uses a relatively thin top model layer (20-40 ft).
4		What is the flux out of the drain cells representing NT-10 and NT-11 under the current conditions representation?	Discussed Sept. 6, 2018. Based on results from the base condition model that represents long-term annual average condition, the groundwater discharge to North Tributary (NT)-10 is 20.8 gpm and to NT-11 is 25.3 gpm. Note that these rates are groundwater contribution to the surface water flow only that should be compared to average annual surface water base flow condition.

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			Central Bear Creek Valley model values and corresponding field measurements for SW flows at six tributary locations are provided in Fig. D-11 of Appendix D of the PA.
5		What calibration criteria are defined for calibration to the site-specific water levels being measured now from the well pairs installed at the site 7C location?	Discussed September 6, 2018. The revision 1 Performance Assessment (PA) model was developed before the current site-specific data became available. The Federal Facilities Act regulatory agencies will have the opportunity to provide input on future model refinements to support remedial design. ~~Note that the Conceptual Design in the draft PA will be replaced with the Preliminary Design in the revised PA. The most recent site characterization information will also be incorporated into the groundwater model for this revision~~Calibration of the Central Bear Creek Valley groundwater flow model (pre-construction conditions model) is presented in detail in Sect. D.3.3 of Appendix D.
6	**Presentation 2a –** Slide 5	A number of events and processes impacting system performance for the related design features are listed. Relatively small changes in the performance of the lateral drainage layer (3x change in transmissivity) and clay layers (2x change in conductivity) in the cap over a time period of 800 yrs (model year 200 to 800) were assumed in the Base Case model. No further cover degradation was assumed after model year 1,000. Is there a basis for these assumptions, and an explanation for why this was considered protective in light of the applicable events and processes described in Figure C.18 and Table C.1? Is there a bounding case water balance evaluation that addresses a situation where the collective impact of these events and processes over time result in an effectively homogenized cover?	Discussed September 20, 2018. For the long-term period (>1000 years), it is assumed that the clay layer has degraded from its initial condition. These engineered layers, with the protection from the above layers in the cover system, will not likely degrade further. The predicted long-term infiltration rate through the cover (0.88 in./yr) using the Hydrologic Evaluation of Landfill Performance (HELP) model, is consistent with many other Department of Energy (DOE) sites in the eastern U.S. with a similar cover design [Portsmouth, Fernald, and Environmental Management Waste Management Facility (EMWMF)]. Infiltration rates considered in the performance modeling (including the sensitivity analyses) incorporate assumptions for the pessimistically-biased degradation of the cover over the period of compliance and the other time periods that require evaluation under the DOE Order through a variety of causes (see the discussion in the responses to related Comments #8, #58, #59, and #60). These assumptions are reasonably bounding for expected performance of the EMDF cover system. For these reasons, and to be consistent

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			with the cover design and the results of the HELP modeling, the long-term infiltration rate (post-1,000 years) ~~will be~~is 0.88 in./yr in the revised PA. The individual causes of degradation (such as erosion on the edges of the facility) are not addressed separately.
7	Slide 7	In relation to the meeting discussion of surface water management that was initiated by this slide, as well as slide 31 of the 2nd slide deck, it appears that the decision to exclude the potential impact of surface water flow from the surrounding environment is an important bounding assumption of the PA modeling. Degradation of berms, swales and drains could reasonably be expected to affect long-term system performance. Was this considered during project scoping and selection of modeling platforms?	Discussed September 20, 2018. These conditions were considered during site selection and cell design. This is the reason the proposed landfill is built on top of the knob and surrounded by drainage features (NT-10, NT-11, Bear Creek, and upgradient surface water saddle). Therefore, the surface water runoff is mostly radially away from the cover (waste) and berm which will have relatively small impact on the waste footprint itself. Selected modeling platform fit the site-specific conditions.

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8	Slide 13	How reliable is 1 in/year infiltration everywhere forever? The entire suite of models hinges on this value, and based on the provided explanation, there is not enough information to assess how accurate this is. At the very least, a more detailed sensitivity analysis with different infiltration rates should be provided. What would the model results look like if infiltration returned to background levels in the distant future?	Discussed September 20, 2018. See response above (slide 5, comment 6). The predicted long-term infiltration rate through the cover (0.88 in./yr) using the HELP model, is consistent with many other DOE sites in the eastern U.S. with a similar cover design (Portsmouth, Fernald, and EMWMF). In addition, recent reports from Craig Benson suggest that covers perform better and longer than assumed in the PA. A lower value is probably more reasonably expected. Some of the model uncertainties/sensitivities related to rate of infiltration through the cell were addressed in the system model (RESRAD-OFFSITE). For instance, during the uncertainty analysis the infiltration rate varied to approximately ~~7~~ 4 in./yr (which is higher than Dr. Benson's absolute worst case for a cover in a similar climate at the Savannah River Site). It is acknowledged that the covers are not the same, but Dr. Benson's analysis suggests that the engineered layers in a cover are likely to perform significantly better than assumed for the HELP modeling for EMDF. Also see the responses to Comments #6 and #58. Note that the Conceptual Design in the draft PA ~~will be~~has been replaced with the Preliminary Design in the revised PA. The performance modeling ~~will be~~was repeated with the changes included in the corrective actions to the Key and Secondary Issues identified by the Low-level Waste Disposal Facility Federal Review Group (LFRG). The HELP modeling has been completed. The infiltration rates in the revised PA ~~will be~~are 0 in./yr during the first 200 years after closure, ~~0.43 in./yr~~ linearly increasing from zero to 0.88 in./yr ~~from~~between 200~~-~~ and 1,000 years after closure, and 0.88 in./yr post-1,000 years ~~after closure.~~ A revised uncertainty/sensitivity analysis ~~will~~ evaluated the effects of varying infiltration rates.
9	Slide 14	This simple water balance indicates that after accounting for evapotranspiration, 94% of the remaining 23.4 inches of precipitation is lost to runoff. Since a zero erosion rate is assumed, the runoff presumably is occurring primarily from the drainage and rip-rap layers above the clay barrier. It would	Discussed September 20, 2018. The runoff refers to the application of the water ~~mass~~ balance in the RESRAD- OFFSITE application. The runoff includes all the water that is not infiltrated into the waste, which includes both true

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		seem essential to system integrity not only that these layers maintain high transmissivity, but that discharge of this water not result in surface erosion. This is another reason why it could be important to include surface water flow in the modeled environment.	surface runoff and subsurface drainage lateral flow in the cover. Detailed landfill hydrologic system performance is best evaluated in the HELP model. As shown in Slide #11, shallow subsurface lateral drainage in the cover carries a majority of the flow. The top surface of the cover system (see Slide # 10) is designed to minimize direct surface runoff and erosion. The cell is located above a topographic high such that most of the runoff travels radially away (diverges) from the waste, minimizing the possibility of erosion/degradation. Additionally, the liner and clay layer are expected to last a very long time, probably longer than assumed in the PA, and no significant lateral drainage is expected. Also note that infiltration rates considered in the performance modeling (including the sensitivity analyses) are believed to represent the pessimistically-biased degradation of the cover over the period of compliance and the other time periods that require evaluation under the DOE Order through a variety of causes. The individual causes of degradation (such as erosion on the edges of the facility) are not addressed separately.
10	Slide 22	What is the assumed form of tritium in the waste such that the Kd value for the tritiated solute is greater than the zero Kd for tritiated water?	Discussed September 20, 2018. The disposed waste will not be in a liquid form. Tritium is not a significant driver of dose due to the lined system, the low inventory, and the short half-life. However, the Kd for tritium ~~will be~~is assumed to be zero in the revised PA.
11	Slide 33	It's surprising that the infiltration rate for the berm/slope is identical to that of the engineered cover. Does the clay liner layer extend into the berm/slope for it to have such low infiltration?	Discussed September 20, 2018. The berm consists of engineered backfill with a rigid compaction requirement to ensure the long-term structural stability of the cells. The berms also have the greater thickness and sloped sides. Combining these factors, it is assumed that they have a long-term groundwater recharge rate (1 in./yr in the draft PA). Compared to native recharge rate (6-8 in./yr with thin soil cover over shallow weathered/fractured bedrock), the assumed rate for a multilayer sloped cover seems to be biased pessimistically high rather than low. Also, increasing the recharge rate for the berm, even though it

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			will increase the water level beneath slightly, will actually cause more groundwater mixing from the waste to the boundary due to additional uncontaminated water recharge along the flow path. Also see the note in the response to Comment #8 above. The clay liner layer will stop at edge of the cover system. The berm starts at the edge of the cover system in the model. In response to this comment, the infiltration rate for the berm was re-evaluated. Using an average K value for site-specific slug tests, and the K values and the recharge rates used in the shallow zone in the site-specific groundwater model, it was decided that the infiltration rate for the berm has ~~will~~ remained 1 in./yr in the revised PA.
12	Slide 42	Regarding a 0 my/year erosion rate of clean cover, Section 7.2.1 of the PA provides some explanation for why erosion modeling was not considered. Much of the explanation seems assumed; similar to other LFRG reviewer comments, a more detailed defense of this rational should be provided.	Discussed September 20, 2018. Cover surface erosion modeling was performed used RUSLE2 and presented in Appendix C (Sect. C.4).

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13	**Presentation 2b –**	Two related observations on modeling decisions that concern the practice of averaging are made. Averaging over space and time can be necessary and defensible, but the reasons should be explicit. The PA generally does not provide substantial explanations for averaging decisions. These decisions, in conjunction with the approach of evaluating only a few variables in the probabilistic uncertainty analysis, has resulted in a gross overestimation of the confidence in groundwater concentrations and dose over time as reflected in the uncertainty analysis.	Discussed September 20, 2018. It is noted that the comment suggested that the approach, while valid, may not be explained sufficiently in PA. Any specific concerns for averaging need to be provided for a more detailed response. There is no intent to imply a high level of confidence in the model's ability to predict exact groundwater concentrations and doses far in the future. However, there is an intent to provide reasonable expectation that doses and groundwater concentrations will be less than the applicable standards. The deliberate introduction of pessimism, for example, in the infiltration rate through the cover, is intended to build confidence. Additionally, a section ~~will be~~was added to the revised PA to document the major conservatisms in the assessment of the performance of the EMDF. These conservatisms ~~will~~ show that the use of average values in the assessment is overwhelmed by the numerous conservative assumptions and is done to avoid an overly conservative assessment. Section 3.3.5 of the revision 2 PA addresses the uncertainty in applying simplified (averaged) modeling approaches to radionuclide release for the dose analysis.
14	Slides 8-12	Assume cross-sections are representational since no geometry change is noted?	Discussed September 20, 2018. Yes, they are in the same scale.
15	Slide 18	Has the groundwater flow model been verified with the most recent site characterization data?	Discussed September 20, 2018. The revision 1 PA document was developed before any site-specific data were collected, therefore the modeling in the draft PA had not been verified with the most recent data. Calibration of the Central Bear Creek Valley groundwater flow model (pre-construction conditions model) is presented in detail in Sect. D.3.3 of Appendix D.~~Note that the Conceptual Design in the draft PA will be replaced with the Preliminary Design in the revised~~

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			~~PA. The most recent site characterization information will be incorporated into the groundwater model for this revision.~~
16	Slide 21	In the groundwater flow model, the karst Maynardville Limestone is represented as a traditional porous medium. Does the model account for transport to Bear Creek further downstream through karst pathways? Alternatively, is there any uncertainty accounted for in the hydraulic conductivity of the Maynardville, given that assumptions of porous media are generally insufficient for karst formations?	Discussed September 20, 2018. Earlier groundwater modeling included many sensitivity analyses on the potential impact from the karst/fracture Maynardville Limestone. With increased anisotropy and K values, the Maynardville may indeed have some further downstream impact on groundwater. However these flows will cause more mass spreading thus decreasing the risk at the point of assessment (POA) location. The PA is assessed along the plume longitudinal axis at the maximum plume location 100 meters from edge of the waste in the shale formation. Considering a hypothetical receptor located a~~long~~ the peak ~~flow path~~concentration is intended to bound any potential impacts that could occur down gradient if there were flow paths in the karst. Thus, it would have minimal impact on the PA result.
17	Slide 27	Are the represented flow vectors scaled?	Discussed September 20, 2018. Yes. Log scaled (length of the flow vector).
18	Slide 28	What is the nature of D-10W? Is it a spring or seep, which would make diversion difficult~~.~~. Even if it's primarily a surface feature, saprolite runs deep in this area, which would still be difficult to divert.	Discussed September 20, 2018. It is a drainage feature that varies greatly in flow rate from near dry in later summer to early fall to higher flow in spring storm event. It is not as well developed as NTs. The saprolite is typically well developed (thicker) in knob area than along the drainage ditches where erosion often causes the exposure of bedrock in the drainageways.
19	Slide 38	Similar question from previous week's presentation – was in-growth considered here? No mention of it in this slide.	Discussed September 20, 2018. No. The MT3D model did not consider in-growth. The model was not directly used for dose modeling. RESRAD-OFFSITE simulations included in-growth.
20	Slides 40 – 42	Differences among the various non-uniform release groundwater concentration curves are significant. These differences could be particularly important with respect to release rates and groundwater concentrations to the extent that	Discussed September 20, 2018. The MT3D model results reveals some differences in uniform and non-uniform source releases. However, the impact is variable

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		disposal of radiological inventory in practice not be homogenously distributed within the 5 waste cells. The EMDF modeling assumption of homogenous waste, and the decision to evaluate averaged (uniform) release rates across the entire EMDF footprint, should be re-evaluated. At a minimum, the conceptual basis for relying on comparisons of averages of uniform and non-uniform results should be explained. Modeling distinct cells or zones within the EMDF would provide more accurate estimates of groundwater concentrations over time, and provide a basis for a more realistic uncertainty analysis. It would also support a more defensible set of waste acceptance criteria that can differentiate among different disposal zones or layers within the landfill.	depending on the assessment locations relative to specific source release. For the given example, the 100-m well is located along the flow path (plume center) relative to source release therefore it has slightly higher concentrations. At the same time, for locations that are not directly along the plume center, the concentrations would be lower than the uniform release. Given the uncertainty on the waste placement in the cell in XY locations, decontamination and demolition times/locations, and vertical placement within the waste cell, uniform source release would provide the most generalized representation for source release. The preliminary design for leachate drainage results in a different impact of non-uniformity of release on the saturated zone concentrations at the POA. For the revision 2 PA that incorporates this design, the non-uniform release applied to the MT3D model results in attenuated peak saturated zone concentrations at the POA.
21	Slides 45 and 48	On slide 45, the depth of aquifer contributing to the well screen (29 m) and depth of aquifer contributing to the surface water body (30.48 m) are approximately the same. Attachment G.1 indicates the Base Case assumption of 29 m is related to the "total thickness of Layers 2 through 4." The importance of the assumption is shown in the relationship between the depth of aquifer contributing to the well screen and the peak Tc-99 well concentration, which is about 1:1 (slide 48). The assumed length of the well screen should be defended in relation to aquifer conductivity and well construction practices. If shorter well screens are feasible, then the practical consequence of assuming that water is drawn from the entire aquifer depth is to average exposure concentrations over many possible hypothetical wells and to eliminate uncertainty in the length and depth of the well screen as a factor in the model. Additionally, (Slides 47 and 48) and related to general comment above regarding averaging, MT3D Layer 2 Well shows Tc-99 concentrations of 1,000 pCi/L. Isn't it accepted practice to use worst case versus averaging?	Discussed September 20, 2018. As shown in the well concentration profiles based on 3-D MT3D model results, the well concentration would be varied from the highest (model layer 2) to the lowest (deeper model layer). Variation in well screen length and average method would produce any concentrations in between. Given the final dose of the analysis relative to final dose limit, varying these screen lengths and average method will not change the conclusion of the result. Well screen length was selected based on typical wells in the area and the MT3D results. Refer to the corrective action for LFRG PA Key Issue EMDF-K15-PA12-03 for information that ~~will be~~has been added to the revised PA to justify the well construction assumptions. Section 1.7.3 of the revision 2 PA addresses pessimistic assumptions made to manage uncertainties in exposure factors including well construction assumptions.

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22	**Presentation 3a** Slide 5	Discussion of potentially complete exposure pathways included inhalation in the shower. This pathway is not shown in slide 5. In principle, this could be a complete pathway for a soluble gas-phase radionuclide, such as radon. Was this pathway evaluated?	Discussed September 20, 2018. Inhalation in shower via vapors is included. It is not included for radon since radon is not included in the 25 mrem/yr criterion. From DOE Order 435.1, dose to representative members of the public shall not exceed 25 mrem (0.25 mSv) in a year total effective dose equivalent from all exposure pathways, excluding the dose from radon and its progeny in air.
23	Slide 6	Why was surface water selected as the basis for all food pathways? Radionuclide surface water concentrations are diluted relative to groundwater, and a home garden and small livestock (poultry) can be supported with well water. The resident (commercial) farmer is not the limiting exposure scenario for food pathways when the exposure metric is individual dose.	Discussed October 11, 2018. This was discussed in the briefings. The farmer is assumed to draw contaminated surface water for irrigation and to support livestock from Bear Creek at the point where most of the contaminated groundwater is predicted to discharge. This ~~limited~~ use of surface water for irrigation of crops is consistent with the use of water on farms in the area that have access to surface water. Section 3.2.4.2 of the PA provides additional justification for assuming surface water use for agriculture.. ~~Also see the corrective action for LFRG PA Key Issue EMDF-K05-PA12-02 for information that will be added to the revised PA to justify the use of surface water for irrigation and livestock support.~~
24	Slide 8	Were the more-current transfer factor values from Yu et al (2015) used in the RESRAD calculations?	Discussed October 11, 2018. ~~Default RESRAD-OFFSITE transfer factors were used for the RESRAD modeling. These plant transfer factors are the NCRP (1999)~~RESRAD-OFFSITE default values (Wang et al. 1993, YU et al. 2015) ~~values for I-129 and Tc-99~~ which are supported by NCRP 1999. ~~Table 6.3.10 (Yu et al. 2015) presents various plant transfer factors including values from Staven et al. (2003). A comparison of available meat transfer factors is presented in Table 6.4.2 (Yu et al. 2015). C-14 plant and meat transfer factors are calculated by RESRAD-OFFSITE using the carbon submodule.~~ Refer to Sect. 3.4.5.1 of the PA for description of the basis for transfer factors used in the dose analysis. ~~the corrective action for LFRG PA Key Issue EMDF-K05-PA12-02 describing how the EMDF PA will be~~Both the meat ingestion rate and the transfer

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			factors were revised to implicitly account for receptor consumption of beef, poultry, and eggs. Also, see response to Comment no. 26.
25	Slides 10 - 12	A low annual fish ingestion rate was used for a recreational angler. If subsistence fishing is potentially the most important exposure pathway, why was this scenario not evaluated?	Discussed September 20, 2018. Subsistence fishing is not possible in Bear Creek. Fish consumption was informed by determinations for Solid Waste Storage Area (SWSA) 6 and EMWMF as well as site conditions. The initial SWSA 6 PA did not include fish consumption and the updated SWSA 6 PA did not include fish consumption because the doses from consuming contaminated biota (including fish) are much less than the performance objective for low-level waste (LLW) disposal. EMWMF did not consider fish consumption (actually removed it during the final waste acceptance criteria development) because at the Bear Creek/NT-5 location the water flow is not a steady flow condition so the fish pathway is not a viable food supply source. Recent calculations performed for potential surface water discharge limits recognized that fish consumption in Bear Creek is extremely limited.
26	Slides 14 and 15	Were the poultry TFs used in the base case? If not, why? This pertains to the appropriate definition of exposure scenarios, which is also the subject of comments on slides 6 and 10-12. The base case calculations should not address only a single scenario (resident farmer) when it is clear that other scenarios could result in higher doses to a hypothetical individual. Multiple potential future exposure scenarios should be considered, including a resident with garden and livestock irrigated with well water, and a subsistence angler.	Discussed September 20, 2018. The consumption of poultry has been discussed in the briefings. The EMDF PA has been revised to implicitly account for receptor consumption of beef, poultry, and eggs. ~~as detailed in the corrective action to LFRG PA Key Issue EMDF-K05-PA12-02~~ The other pathways are either not viable in Bear Creek (subsistence angler) or are covered by more conservative scenarios (residential gardener).

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<tr><th>Comment No.</th><th>Presentation Slide</th><th>Comment/Suggested Change/Rationale</th><th>Response</th></tr>
<tr><td>27</td><td>Slides 15 and 16</td><td>TFs are only considered for Tc99, not I129 or others. What is the basis for assuming I129 and others behaves the same way?</td><td>Discussed September 20, 2018.

As performed for Tc-99, additional simulations have been completed with varying transfer factors for I-129. Results are presented below.
Refer to Sect. 3.4.5.1 of the revised PA for description of the basis for transfer factors used in the final dose analysis.

<table>
<tr><th>Transfer Factor</th><th>Maximum Total Dose, Compliance Period (mrem/yr)</th><th>Maximum Total Dose, 10,000 yrs (mrem/yr)</th></tr>
<tr><td>I-129 Meat TF: 7.00E-03 (Base Case)</td><td>0.36</td><td>4.21</td></tr>
<tr><td>I-129 Meat TF: 5.00E-02 (Poultry)</td><td>0.36</td><td>4.23</td></tr>
<tr><td>I-129 Meat TF: 4.00E-02 (Beef)</td><td>0.36</td><td>4.23</td></tr>
<tr><td>I-129 Meat TF: 4.4 (Eggs)</td><td>0.36</td><td>6.21</td></tr>
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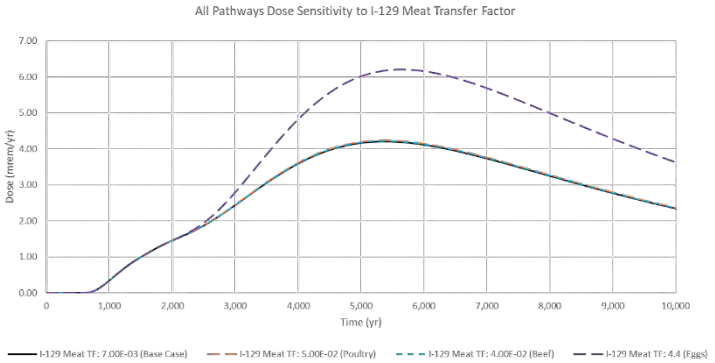
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28	**Presentation 3b -** Slide 3	What is the basis for the lowest Tc Kd being 0.5 mL/g, rather than zero?	Discussed September 20, 2018 and October 11, 2018. The Tc Kds ~~will be~~were revised in response to PA Key Issue EMDF-K02-PA11-02 from LFRG. As discussed in that corrective action, the base case assessment ~~will~~ ~~u~~uses a Kd of 0.72 ml/g for the vadose and saturated zones. A Kd of 0.36 ml/g (one-half of the vadose and saturated zones Kd) ~~will be~~was used for the waste zone. ~~Note that using a Kd of zero would mean that a significant amount (or all) of the Tc-99 would leach from the waste during operations and would not be available for inclusion in this post-closure assessment of the performance of the EMDF.~~For the revised uncertainty analysis, the lower limit of the Tc-99 Kd value is zero.
29	**Presentation 3c**	Was catastrophic failure of the berm considered if water builds up behind it? This would be like failure of an earthen dam and not an unreasonable scenario.	No. This is not considered a reasonable scenario. The landfill and its berms are not the same as an earthen dam and dam failure often occurs due to piping from flowing water. The facility is protected by the cover system that prevents the sudden change in water infiltration rate. The bathtub scenario is hypothetical only. However, during final design, the berm stability will be quantitatively assessed from various potential future scenarios.
30	Slide 8	Why is there no accounting for the upward movement of radon parents, like Ra?	Net flow is assumed to be downward. Thus, liquid phase upward diffusion is assumed to be insignificant. Only radon in gas form can move up and the waste source mass (average thickness) was considered in the calculation. The clay and the synthetic liner in the cover will also serve as a significant deterrent to upward migration.
31	Slide 10	Rn222 E/P ratio is only 0.25 "for fine-grained materials". RESRAD indicates it could be as high as 0.8. Why was the higher value not considered?	The default value approximately represents the conditions in a silty loam soil with a low moisture content (i.e., not dry) as stated in the Appendix H. Disposed waste (either soil or debris) will be surrounded by filled-in soil to meet the waste compaction requirement. Therefore, the default value for the expected conditions is considered more appropriate than selecting a worst case literature value. Also see the response to Comment #74.
32	**Presentation 4a –** Slides 6 and 7	RESRAD-OFFSITE has probabilistic capability, but in this case, distributions for only 44 parameters were specified because of very long run times. Why were software limitations allowed to restrict the scope and value of the uncertainty analysis (UA)?	The identified parameters included in the probabilistic analysis were selected based on previous model simulation results as well as sensitivity analysis simulation results. The number of parameters included in the uncertainty simulations was not specifically limited by computer run time limitations.

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33	Slide 8	Since UA analysis was limited to C14, I129, and Tc99, does this infer there is no probability that Kd values for any other radionuclides could be low enough to allow meaningful solubility and transport? Was uncertainty in future pH and redox conditions and their potential impacts on Kd values considered? Why have observations of elevated uranium in groundwater elsewhere in BCV not been used to inform the possibility of mobile forms of uranium?	Discussed November 8, 2018. The uncertainty analysis for the first revision was limited to those radionuclides because they were the primary contributors to the total dose during the 1,000-year compliance period. Under expected solubility and transport conditions, the other radionuclides would not contribute to the total dose during the compliance period. For the revision 2 PA, the 10,000 year probabilistic analysis includes isotopes of plutonium and uranium. The last question in this comment is addressed in the response to Comment #41.
34	Slides 9 and 10	Why was the leach rate specified as an input to the RESRAD model, using the RESRAD equation, versus allowing RESRAD to calculate the leach rate directly? Permitting RESRAD to calculate the leach rate directly would allow for a complete probabilistic analysis of infiltration and leaching.	Discussed October 11, 2018. Specifying a variable infiltration rate is not possible within the computer code. To capture the variation of infiltration contacting waste and leaching contaminants, the first order leach rate was specified. Another important consideration is that when the equilibrium sorption/desorption source release is specified, the concentration profile over the thickness of the primary contamination is not computed. The concentration profile over the thickness of the primary contamination is necessary to compute dose from direct exposure from the primary contamination or onsite exposure. Note that the source release model in RESRAD-OFFSITE ~~will be~~has been changed from first order rate-controlled release with transport to instantaneous equilibrium desorption in the revised PA. ~~in response to LFRG PA Key Issue EMDF_K03_PA11_03.~~
35	Slide 19	This peak dose evaluation should be developed for the 0 – 1,000-year compliance period, as well as the 0 – 10,000-year period, and both should be included in the PA.	Discussed November 8, 2018. The suggested compliance period peak dose evaluation has been performed and results were presented to DOE during the onsite meeting. Figure 4.~~22~~ 21 in the ~~current~~ revision 2 PA indicates the isotope specific base case 0 to 1000-year dose results.
36	**Presentation 4b –** Slides 3 and 5	An irrigation well is identified on this slide, along with a presumed garden. If this is the case, why was groundwater use excluded in the exposure pathways? The external dose to a	The rationale for the scenarios for the inadvertent intruder was discussed in the briefings. The purpose of the inadvertent human intrusion (IHI) evaluation is to estimate doses from a hypothetical

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		resident would be directly proportional to the difference in exposure time (80 hours for the excavator versus ~8,000 hours for a resident). Why is the residential scenario excluded from the IHI analysis? This is inconsistent with the 1986 NRC guidance that describes the discovery, drilling, and residential scenarios (NUREG/CR-4370, *Update of Part 61 Impacts Analysis Methodology*) used in the EMDF PA.	exposure to exhumed waste under scenarios after the loss of institutional control and compare those doses to either a chronic dose or an acute dose performance measure in the DOE Manual 435.1-1 (see Section 2.2.8 of DOE-STD-5002-2017). An irrigation well is depicted on these slides because one scenario estimates the dose from direct exposure to the waste in the drill cuttings during the activity of drilling the well. The garden is depicted because one scenario assumes the drill cuttings (including the waste) are placed in the garden. The gardener is then exposed to the waste while he/she works in the garden. The base case assessment evaluates the residential exposure scenario in accordance with the DOE Order. Alternate IHI exposure scenarios are not considered credible because of the total thickness of the cover, which is completely consistent with the DOE Order.
37	Slide 7	Why is the well assumed to collect water through 80 feet of the saturated zone?	Discussed November 8, 2018. Section 3.4.2 of the PA states that local water wells in the area range in depth from less than 100 to more than 300 feet deep. The total depth of the assumed well in this exposure scenario is 204 feet, about the midpoint in that range. This depth was assumed rather than a shallower depth because the predominately shale Conasauga formation would be expected to be "tight" and not a reliable source of groundwater (characterized as an "aquitard" by Solomon et al 1992). The assumed screened length of 80 feet would make it a more reliable source of water, especially during dry periods. Refer to the corrective action for LFRG PA Key Issue EMDF-K05-PA12-02 for additional information that ~~will be~~was included in the revised PA concerning well depth assumptions. For the intruder analyses in the revision 2 PA, the penetration of the borehole into the saturated zone has been increased to 131 ft (40 m) for consistency with the all-pathways base case exposure scenario.
38	Slide 13	The water ingestion pathway is not considered; the presenter indicated that applicable guidance does not require this. Please cite the guidance used for this determination.	See response to Comment 36 above.

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39	**Presentation 4c 4d -** Slide 5	What is the practical difference between "business impacting software" QA and safety impacting software QA? Why would software used to assess potential future exposure and health effects not be categorized as software pertaining to safety?	This is UCOR terminology for nuclear safety issues and does not apply to potential future exposure and health effects. Refer to the new performance modeling Quality Assurance (QA) report for additional detail on corporate QA protocols and software QA requirements.
40	Slide 8	The presenter indicated that uncertainty in radiological inventory was not represented, but that this uncertainty would be resolved moving forward. Please provide a description of the process for incorporating new inventory information, updating the PA, and revising the waste acceptance criteria.	Any discussion of how the PA will be maintained will be part of the future PA/CA Maintenance Plan. A sensitivity evaluation on assumed inventories of C-14, Tc-99, and I-129 has been added to the RESRAD-OFFSITE model sensitivity analysis.

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41	**CA Presentation** - Slides 19 and 27	These slides identify uranium isotopes measured in groundwater and being transported to surface water as impacts related to other existing sources in the BCV. Inventories at Y-12 and the EMWMF, and buried wastes originating from Y-12 operations, are also cited as a basis for evaluating uranium isotopes in the CA. However, the uranium K_d of 50 ml/g applied in the EMDF PA results in negligible leaching and transport of uranium in EMDF wastes throughout the modeling period. Why is the EMDF PA K_d for uranium valid given evidence that uranium is migrating in water within BCV, particularly since the EMDF PA identifies waste streams containing uranium isotopes from Y-12 remediation projects as a major contributor to the EMDF?	Discussed October 11 and November 8, 2018. Process knowledge on the wastes disposed in the other existing Bear Creek Valley (BCV) sources [e.g. Bear Creek Burial Grounds (BCBG), S-3 ponds] indicate that the waste forms and methods of waste disposal were different from the waste expected to be disposed in the EMDF. Records indicate that liquid wastes such as mop water contaminated with uranium was disposed. Records also indicate that pure uranium filings were disposed. It is believed that these and other wastes were buried in shallow trenches directly in the groundwater or just above the water table and were subject to direct and repeated exposure to rainwater and groundwater for decades. These two waste streams are not expected to be eligible for direct disposal in the EMDF. Additionally, these wastes were not disposed in a facility such as EMDF that is designed and constructed to effectively minimize infiltration into the waste and minimize the infiltration of the contaminated water from the bottom of the facility. Seeley and Kelmers 1984 evaluated the sorption and solubility behavior of uranium when trench water from an actual waste facility was used in place of a synthetic site groundwater. Uranium sorption was decreased by more than two orders of magnitude. Note that as part of the corrective action for LFRG PA Key Issue EMDF-K02-PA11-02, an evaluation of the Kd values for uranium (and all other radionuclides included in the PA) in the waste, the vadose zone, and the saturated zone was conducted. The results of this evaluation ~~will be~~are reflected in a revised table of Kd values and an explanation of the logic used to determine the Kd values in the revised PA.
42	Slides 20 and 23	Both the EMWMF and EMDF source terms are comprised of radioactive LLW, RCRA hazardous waste, TSCA PCB wastes, and mixtures of these wastes. Modeling for the EMWMF CA addressed both chemical and radiological constituents, and waste acceptance criteria were defined in terms of lifetime cancer risk, rather than radiological dose, since cancer risks are presented by both certain chemical wastes and radiological	Discussed October 11, 2018. For EMWMF, much of the work to support DOE Order compliance was being conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) which addresses both chemical and radiological constituents and then crosswalked to the DOE Order. Because the two regulatory

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		waste. Why does the CA for the EMWMF and EMDF address only radiological dose? What has changed in the regulatory landscape underlying composite analyses at Oak Ridge between when the EMWMF CA was published in 1999 and today that supports the change from evaluation of chemical and radiological cancer risk to evaluation of radiological dose?	authority documents were integrated more, the results addressed both types of constituents. For EMDF, the full DOE Order 435.1 process is being conducted independently from CERCLA in a separate set of documents. This order is for assessing the performance of landfills for radiological constituents only. The CERCLA documents address both sets of constituents but there is no requirement under CERCLA for a CA.
43	Slide 26	According to discussions during the presentation, the EMDF PA considers the fish ingestion pathway, but the CA does not. Why is this pathway not considered in the CA?	Discussed October 11, 2018. Fish ingestion is considered in the exposure scenarios in the CA.
44	Slides 32 through 40	All transport and exposure pathways for the CA are based on leaching of buried wastes and transport of dissolved contamination in groundwater and surface water. The contaminant fate and transport models for the CA therefore assume with 100% confidence that the physical integrity of the engineered systems for the different source areas (EMWMF, Bear Creek Burial Ground, EMDF) will not be compromised during the performance period. This critical assumption should be supported by evaluation of analog sites and study of regional landscape evolution (as extensively discussed in Section 3.5.3 of NUREG-1757, Volume 2). For example, the recent application of LiDAR in archeology has allowed evaluation of the evolution of natural and modified landscapes in hilly and forested terrain that could be applicable to the assessment of long-term performance of engineered disposal systems such as the EMDF. Landscape evolution models, such as the Channel-Hillslope Integrated Landscape Development model, supported by terrain and age dating analyses, could be used to evaluate the long-term risks posed by Bear Creek and Pine Ridge tributary erosional processes.	Discussed November 8, 2018. It is believed that the physical integrity of the engineered systems will not be compromised during the compliance period due to incorporation of stringent performance requirements into the design. If the physical integrity is compromised to the point that the risks in any of the approved Records of Decision (RODs) are exceeded, DOE will take measures to reduce those risks or renegotiate the RODs with the regulators.
45	Slide 34	In discussing slide 34 of the presentation, the presenter was asked if there is a contaminant transport model that shows mass balance of contaminants. The modeler at the meeting responded, “No.” It is possible that communication was confused with many people talking, so in order to confirm the response on this important point – is there a contaminant	Discussed October 11, 2018. For the EMDF site, a site-specific groundwater flow and transport model was developed during the PA. The fate-transport model was used to quantify the mass balance of the contaminants and its relations in groundwater and surface water. See PA Appendix F – groundwater fate-transport model.

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		transport model for the EMDF site that shows mass balance of contaminants?	
46	General Comment 1	As noted in slides 22 and 30, and discussed during the presentation, the CA relies on an assumption of effective perpetual institutional control (IC) as the basis for the contribution of risk (dose) from the EMWMF and other existing Bear Creek Valley (BCV) sources. Reliance on active IC to mitigate releases or exposures in the distant future is unrealistic. No analysis is required to understand that the existence or maintenance of any human institutions or legal instruments cannot be indefinitely assumed with complete confidence. All sources of contamination within the BCV should be included in the simulations of contaminant release, transport, and exposure. Additionally, the possibility that parts of BCV will return to agrarian use, including farming directly on the EMDF and EMWMF, should be considered. Although the CA assumed perpetual IC, the presenter also stated the CA assumed unrestricted access to the site. These are contradictory assumptions and need to be reconciled.	Discussed October 11, 2018. The CA does not rely on active institutional control as the basis for the risk from the EMWMF and the other existing BCV sources. The codified risks from those sources assume the release of contamination from those sources to a hypothetical resident farmer in an area of unrestricted land use. There is insufficient information (that is, records of inventories that were disposed) for the other existing sources in BCV to develop a defensible source term and model contaminant release from that source term in the CA. For that reason, the CA used the codified risk in the BCV ROD and the current concentrations of radionuclides in Bear Creek to arrive at doses in the CA in various scenarios. If future concentrations in Bear Creek increase, the effect on the results of the CA will be evaluated as a part of the maintenance of the CA that is required by the DOE Order. These evaluations will be performed using PROC-EMDF-001. It is believed that the exposure scenarios evaluated in the CA constitute a set of credible scenarios that meet the requirements and intent of the DOE order and the CERCLA process. Additional conservatism is applied by DOE with the land transfer requirements in DOE Order 458.1 and by the Federal Facility Act under CERCLA (with the required five-year reviews).
47	General Comment 2	Use of individual sensitivity analyses related to a deterministic "base case" is inadequate to gauge uncertainty in the long-term performance of the BCV disposal systems and associated health risks. A multivariate sensitivity analysis based on a probabilistic simulation of release and transport for all BCV facilities with parameter distributions that are defended both scientifically and statistically is necessary to identify those inputs that are most critical to understanding long-term system performance. Multiple possible future receptor scenarios, including subsistence fishing, should be evaluated.	Discussed November 8, 2018. The LFRG reviewers did not indicate that evaluating individual sensitivity analyses in the CA was not adequate. The approach that was used was intended to focus on those factors most likely to influence the results. Therefore, no change is being evaluated as suggested in the comment.

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48	General Question 1	How was it determined that the POA at BCK 7.73 was the location corresponding to the highest dose to a member of the public (MOP)? How was it determined that the following alternative downstream POAs, all of which include contamination from the EMDF and EMWMF, presented lower doses than the chosen POA? • At East Fork of Poplar Creek (EFPC) immediately downstream of the mouth of Bear Creek. Sources in the EFPC watershed would include those at Y-12. • At the mouth of Poplar Creek, downstream of the confluence of EFPC. Sources would include those in the EFPC watershed, as well as additional sources in the Poplar Creek watershed (likely limited to contamination in the ETTP). • On the right bank of the Clinch River, downstream of the mouth of Poplar Creek. This would include sources from upstream White Oak Creek, including all of Bethel and Melton Valleys.	Discussed October 11, 2018. CA Section 1.2.2 explains the selection of Bear Creek kilometer (BCK) 7.73 as the CA POA. It is the closest point to the EMDF in which a hypothetical receptor can also receive a dose from the other two upstream CA source terms (EMWMF and the other existing BCV sources). As the POA is hypothetically moved downstream, the composite dose from the three sources would decrease because of increased flow in Bear Creek from uncontaminated groundwater and uncontaminated surface water. This is demonstrated by the sensitivity analysis that evaluated relocating the POA to the confluence of NT-14 and Bear Creek. The Oak Ridge Reservation-wide sensitivity analysis looked at the contribution from the three BCV sources if the POA was moved to the confluence of Poplar Creek and the Clinch River. It was determined that the contribution would be less than 7.4E-04 ~~0.00036~~ mrem/yr or 0.01 pCi/L. The range of analyses (the base case plus the sensitivity analyses) is believed to adequately define the expected composite doses if an EMDF is constructed in BCV.
49	General Question 2	How will an expected lifetime cancer risk (ELCR) of 10^{-5} be achieved at BCK 9.2? The EMWMF was represented by contributions developed for its 1999 CA, which does not consider its current state of disposal and documented releases into BC. This representation needs to be brought up to date (under CA maintenance) so that it is consistent with the projected future state of the EMWMF, which is different from projections made in 1999. Additionally, inventories for other contributing facilities, including the Burial Grounds, S-3 ponds, and Boneyard/Burnyard, were not considered beyond the ELCR goal of 10^{-5} in the BCV ROD. Without a plan or decision for cleanup of these facilities to achieve this goal, the CA should assume it has not been met. A contaminant transport analysis from these contaminant sources should be performed and added to the contamination expected to emanate from the EMWMF and EMDF at the POA. *Actual* dose and risk should not be based on the ROD *goal*.	Discussed October 11, 2018. The 1E-05 risk at BCK 9.2 is codified in a CERCLA ROD. Some of the remediation of the sources in BCV is specified in this ROD. The remediation of the BCBG is not. However, the risk commitment in the ROD has been agreed to by the DOE, Environmental Protection Agency (EPA), and Tennessee Department of Environment and Conservation and has to be met when remediation in BCV has been completed. DOE guidance allows for plans under CERCLA to be used in CAs. The same is true for the EMWMF (and there are no documented releases of contamination from the EMWMF). However, this was the subject of the LFRG CA Key Issue EMDF-K01-CA16. The corrective action for that Key Issue requires that the base case assessment in the revised CA be structured as summarized in the following:

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			1) The source term for the EMDF will continue to be defined by the PA. This is not a change for this source term from the draft CA. 2) The source term for the EMWMF ~~will be~~has been defined assuming the final waste inventory will be the waste disposed in the EMDF to-date (with regard to isotopic concentrations) to appropriately forecast at closure of the facility (e.g. with mass increased to 100%). This is a change in this source term from the version of the CA reviewed by the LFRG. The revised CA used a 17-year average contaminant concentrations in Bear Creek, adjusted the concentrations assuming remediation in Bear Creek had been completed and was in compliance with the ROD, and then performed a conversion to dose (Sect 2.5.1 in the CA). 3) The basis for the source term for "other existing Bear Creek Valley sources" ~~will~~ continues to be the remediation goals defined in the BCV Phase 1 ROD at the Integration Point (BCK 9.2) identified in the BCV ROD. The dose from these three sources ~~will then be~~was totaled at the CA POA (BCK 7.73) considering mixing in Bear Creek. See the corrective action for LFRG CA Key Issue EMDF-K01-CA16 for the details of the restructured base case assessment.
50	General Question 3	Assuming it is acceptable to assign a risk value at BCK 9.2, how is this converted to doses from specific radionuclides?	Discussed October 11, 2018. The ILCR risk value (1E-05) at BCK 9.2 is converted to dose based on a total radionuclide dose used EPA guidance (EPA 1999) as discussed in Section 3.1 of the draft CA. It is not based on the individual radionuclides. That is why the sensitivity analysis that looked at radionuclides that were expected to be the primary contributors to the risks at the EMWMF and the other existing BCV sources in Section 5.8 was performed. Also see the response to the above comment.

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51	General Question 4	How has residual contamination remaining in the subsurface from cleanup of the S-3 Ponds, Boneyard/Burnyard, and similar facilities been accounted for? Although the bulk of the contamination present in these facilities has been removed, there is residual contamination that should be accounted for as source terms that have migrated from these facilities, but which have not yet reached the POA.	Discussed October 11, 2018. All of the existing sources in BCV are considered in the CA analysis. These sources are grouped together as a single source term that has to meet the risk criteria at BCK 9.2 as required by the Bear Creek ROD (1E-05). This assumption was applied in all relevant scenarios during the CA.
52	General Question 5	RESRAD-OFFSITE was used to perform the majority of the PA and CA analysis. RESRAD-OFFSITE is widely accepted as a suitable screening tool for gaining preliminary insight into what risks might be present, but is not considered capable of running a sufficiently sophisticated model for fully evaluating the risks from the complex radiological sites in the complex terrain of BCV. Additionally, PATHRAE was used, which was originally developed in 1986 as a screening tool and appears to no longer be supported or maintained by its developers. Recognizing the limitations of these programs for making critical decisions, are there any plans for migrating the EMDF (and the EMWMF) preliminary analyses using these programs to a more sophisticated modeling platform that can fully account for all contaminant transport and human exposure pathways?	Discussed November 8, 2018. Alternate models to RESRAD-OFFSITE were considered prior to initiating the performance modeling for the EMDF and it was determined that RESRAD-OFFSITE was adequate. The PA development team received positive feedback from the LFRG review on the use of RESRAD-OFFSITE. DOE ~~will~~ continues to rely on PATHRAE for the EMWMF modeling in the CA because the results continue to be valid, and support the existing waste acceptance criteria (see the response to CA Secondary Issue EMDF-S04-CA15-01). A final PA will be developed for EMWMF upon closure, and the model used will be re-evaluated at that time.
53	General Question 6	The EMWMF CA was stated to serve as the template for the EMDF CA. Every PA and CA has a maintenance plan for continued development and is part of the DAS for the site. However, the presenter indicated he had no knowledge of any maintenance done for the EMWMF CA. Can information be provided regarding maintenance that has been performed on the EMWMF CA since its first submittal, and if or how any changes to this analysis were incorporated into the EMDF CA?	Discussed October 11, 2018. There have been no new sources or changes in the remediation approach identified for BCV. Therefore, there were no changes to the EMWMF CA. Identification of the potential new source from the EMDF required a revision to the CA, now a combined EMWMF and EMDF CA. This combined CA reflects the updated conditions in BCV.
54	Comment-9/24 through 9/26 LFRG on-site review	The EMDF PA, in § 4.1, assumes that the average depth to the water table is 20 to 25 ft from the "disposal cell floor" (p. 166). Recent groundwater elevation measurements, as presented on September 24, indicate that this assumption would not be the case given the currently proposed design. The current design assumes the groundwater level will lower	Discussed October 11, 2018. Recent site-specific characterization information was incorporated into the groundwater modeling during the development of the Preliminary Design of the EMDF. The Preliminary Design ~~will be~~was incorporated into the revised PA. There is very little potential

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		itself under the landfill, since the cover would act to reduce and divert infiltration. This does not consider that a great deal of groundwater flow is lateral, with the potential to flow under and up into the landfill. Studies have shown that water can move around the edge of landfill covers and get sucked upward into the waste through capillary action. **Question 1**: How will recent site-specific characterization data be used to update the EMDF design?	for lateral groundwater flow to enter the EMDF area once it is built and eventually closed given the waste will be disposed above the surrounding natural and engineered surface water features. More information about the post-construction water table will be provided as the design progresses. Additional detail on EMDF groundwater flow model for preliminary design was included in the second part of the Oct 15, 2019 presentation to EPA and TDEC. Calibration of the Central Bear Creek Valley groundwater flow model (pre-construction conditions model) is presented in detail in Sect. D.3.3 of Appendix D.
55	Comment-9/24 through 9/26 LFRG on-site review	**Comment 1**: Solid/water partition coefficients (K_ds) were presented using outdated references for these parameters, such as Baes et al. (1984) and Sheppard and Thibault (1990). A variety of materials were modeled using the same K_d values, which is not in keeping with common practice. Even these older references provide different values for different materials. Further, the selection of K_d values for the elements H, I, and Tc is at odds with the literature, and distributions for these values should always include values of zero. The calculation of an effective K_d of 40,000 mL/g for uranium (U) from the EMWMF, based on the ratio of leachate to what was disposed, does not demonstrate what the solid/water partition coefficient represents. As a starting point, more recent Kd values from EPA (EPA 1999a, 1999b, 2004) need to be considered.	Two PA Key Issues concerned the selection/justification of partition coefficients following the LFRG review of the PA (EMDF-K01-PA11-01 and EMDF-K02-PA11-02). See the corrective actions for those two Key Issues as well as the resolution to related Comments #28 (Tc-99) and #41 (Uranium) above. As part of the resolution of Kd values, Dan Kaplan, a geological chemist with vast experience on testing and determination of partition coefficients, has reviewed the ORR references used and participated in the corrective action plan for assumed Kd base values. For the revised uncertainty analysis the lower limit of the Tc-99 and I-129 Kd values is zero.
56	Comment-9/24 through 9/26 LFRG on-site review	The analysis presented does not adequately address the source estimation and contaminant transport of U in Bear Creek Valley (BCV). During the September 24 meeting, the following was noted: • The S-3 Ponds are unlined lagoons with large amounts of technetium (Tc), U, and nitrate (NO_3^-). There are large plumes of U and nitrate east and west of the groundwater divide, which extend for “a couple of miles”.	See responses to Comments #41, #46, and #49.

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		• The Bear Creek Burial Grounds (BCBG) contain large amounts of uranium metal turnings. These include the walk-in pits, which contain unstable pyrophoric and shock-sensitive materials. • The U chip pits in burial grounds C and D west, are the source of approximately 40% of the U in Bear Creek (BC). These were capped in the 1980s and 1990s, but are still in contact with groundwater, especially during the "wet season", which is December through April – any time during leaf-off, essentially. These chips and turnings are still dissolving into the groundwater. • Raw nitric acid was placed in the S-3 Ponds for 30 years, has and it migrated into the residuum below the ponds. Although the ponds themselves were neutralized and backfilled in 1980, U is still migrating into the residuum and rocks of the Nolichucky and Maynardville formations. • In response to the question, "How does the large mobility of U square with the high K_d used in the assessment?", it was explained that water moves in the fractures, and therefore the contaminants are less subject to retardation by adsorption. Batch K_d tests do not apply to the BC environment. • Weekly U flux data are available for BC. • U concentrations in the water should not be modeled as being dependent on K_d, since contaminants are transported mostly in fracture flow, where there is little interaction with the matrix. This suggests that groundwater concentrations of U would not be subject to retardation in the BCV system. • About 40% of the U at BCK 9.2 is from the burial grounds, based on annual calculations performed for the Remediation Effectiveness Report (RER.) There is no way to estimate what is in the transport pathway	

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		vs what is still in the trenches. It was stated that there is no groundwater monitoring in that area. Question 2: Given this important information about sources of U in BCV, some of which will be difficult to remediate fully, how will the assessment of long-term doses and toxicity risks from uranium be modified, given its extremely long half-life?	
57	Comment-9/24 through 9/26 LFRG on-site review	A similar question pertains to the assessment of risks from mercury, which was not addressed in the presentations to LFRG, since it is not radioactive. If one considers mercury to have an infinite half-life (e.g. it is stable), then it also presents long term risks, and should follow a similar fate and transport analysis to that of uranium. Question 3: How will the contaminant transport and chemical risk assessment (required by CERCLA) for U and Hg be completed?	Discussed October 11, 2018. The assessment of mercury is outside the scope of DOE Order 435.1, which requires addressing potential radiological sources. Chemicals are addressed through compliance with other laws such as Resource Conservation and Recovery Act or Toxic Substances Control Act.
58	Comment-9/24 through 9/26 LFRG on-site review	Infiltration rates through the engineered cover are initially low, and increase to a value of 1 inch/year (in/yr) at 1,000 years post-closure. **Question 4:** What modeling supports the selection of this infiltration rate? The infiltration rate of 1 in/yr at 1,000 years is carried forward indefinitely, implying that degradation of the cover ceases at 1,000 years. **Question 5:** What modeling supports this assumption?	Discussed November 8, 2018. The infiltration rates used in the PA resulted from the HELP modeling. The infiltration rate at 1,000 years (the end of the "compliance period") is carried forward through the periods of time required for this PA. It is believed that the assumed long-term infiltration already addresses substantial accelerated degradation of the cover, and is thus already pessimistically biased as a reasonable bound for infiltration. Rather that assuming degradation ends, it is assumed that substantial degradation (that is not expected) occurs early during the 1,000-year compliance period.. Please also refer to the email sent by Roger Seitz on 11/5/18 to Brad Stephenson regarding infiltration (this value is greater than the reasonable upper bound identified by Dr. Benson). The cover is not identical to that evaluated by Dr. Benson, but Dr. Benson's work suggests that engineered covers in conditions very similar to Oak Ridge are likely to maintain effective performance for very long times, well in excess of assumed degradation times and rates assumed for these analyses.
59	Comment-9/24 through 9/26 LFRG on-site review	Cover degradation occurs from a variety of processes, including intrusion by tree roots. In the fullness of time, the biointrusion layer will also succumb to degradation and will cease to function as such. As stated during the September 24	Discussed November 8, 2018. It is believed that the statement regarding the depth of tree roots assumed natural conditions. Although the disposal facility cover

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		meeting, local excavations have found tree roots at depths up to 12 ft below ground surface. **Question 6:** How will cover degradation by tree roots and other biotic processes be accounted for?	includes natural materials, it does not mimic natural conditions (for example, the biointrusion layer). The infiltration rates considered in the performance modeling (including the sensitivity analyses) are believed to represent pessimistic assumptions for degradation of the cover over the period of compliance and the other time periods that require evaluation under the DOE Order under a variety of causes. The individual causes of degradation (such as tree roots) are not addressed separately. See also the discussion for Comment #58 above. Long-term maintenance of the cover is required and any erosional features will be corrected under CERCLA.
60	Comment-9/24 through 9/26 LFRG on-site review	Another set of cover degradation processes arises from erosion. The PA/CA addresses surface sheet erosion by application of the Revised Universal Soil Loss Equation (RUSLE), but does not address erosion at the edges of the facility from gully formation and hillslope failure. These processes will eventually undermine any engineered cover design, leaving wastes exposed at the ground surface (Alonso et al. 2002; Bennett 1999; Bennett and Casalí 2001; Boothroyd et al. 1979; Hancock et al. 2014; McKinney 1986; Poesen et al. 2011; Shipers 1989; Smith and Benson 2016; Smith et al. 1997; Tucker and Doty 2018; Waugh and Richardson 1997; Willgoose and Hancock 2011). **Question 7:** How will these processes be considered in future modeling?	Discussed November 8, 2018. Commenter clarified that exposing waste via gullies is not an infiltration question. The multi-layer cover system has been designed to support the performance measures using engineered layers and a sloped cover. Drainage layers in the cover and the biointrusion layer are designed to prevent erosion and prevent damage from the root systems of trees. The radiating nature of the cover encourages flow from the top of the cover toward the edges and away from the facility without developing gullies. Finally, the cover has been designed with slopes that minimize the chance of hillslope failure. The infiltration rates considered in the performance modeling (including the sensitivity analyses) are believed to represent the pessimistic assumptions for degradation of the cover over the period of compliance and the other time periods that require evaluation under the DOE Order through a variety of causes. The individual causes of degradation (such as erosion on the edges of the facility) are not addressed separately. Also see the response to Comment #58. Long-term maintenance of the cover is required and any erosional features will be corrected under CERCLA.

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61	Comment-9/24 through 9/26 LFRG on-site review	The CA for EMDF uses a risk goal from the BCV interim ROD to represent upstream contributions of radionuclides in BC. The LFRG review team made a strong point that this approach is insufficient, and that the dose from contributing sources, calculated from concentrations in BC estimated by contaminant transport modeling, would be the accepted approach. It was agreed that dose should be calculated instead of risk, although it would be appropriate to convert the calculated dose for evaluating risk under CERCLA. **Question 7:** How will the fate and transport of radionuclides from upstream sources into BC into the long-term future be modeled to support a more representative CA?	Discussed November 8, 2018. See the corrective action for the LFRG CA Key Issue EMDF-K01-CA16 and the response to Comment #49. The corrective action to CA Secondary Issue EMDF-S01-CA02 addresses the consideration of future radionuclide concentrations in Bear Creek in the CA.
62	Comment-9/24 through 9/26 LFRG on-site review	The LFRG review team asked why STOMP was not run in 3-D, as it has been at other sites around the DOE complex. The response was that the system would be “un-modelable”. Modelability is a criterion for site selection of radioactive waste facilities (CFR 2014). **Question 8:** Given the extreme challenges in modeling the environmental behavior of sites in BCV, and on the ORR in general, why would a site that could be better supported through contemporary modeling techniques not be preferred?	Discussed November 8, 2018. There are many factors that go into selecting a site, not just the challenges of modeling the site.. Oak Ridge is accepting the challenges of modeling this proposed site because of other benefits of onsite disposal in BCV. The STOMP model was used in the PA to provide only a more detailed understanding of the fate and transport of the contaminants in the source zone and unsaturated zone. The 2-D model provided sufficient information for that application (see the corrective action for LFRG PA Secondary Issue EMDF S12-PA13-02).
63	Comment-9/24 through 9/26 LFRG on-site review	RESRAD, the screening-level model that was used for EMDF compliance assessment, supports the exposure pathways related to human consumption of poultry and eggs. The model presented does not include the chicken and egg ingestion pathways, instead combining all meat ingestion into a single pathway for beef. This results in a potentially significant underestimation of dose from ingestion pathways, since the transfer factors for chicken and eggs are generally higher than those for beef, and chickens are exposed to greater amounts of direct soil ingestion per body mass than are cattle. Further, deer and other wild game are likely sources of food for rural residents in this region. **Question 9:** How will meat-ingestion pathways in future modeling be separated?	See the response to Comment #26 and the corrective action for LFRG PA Key Issue EMDF-K05-PA12-02. RESRAD-OFFSITE 3.2 does not accommodate separate animal food ingestion pathways. Both the meat ingestion rate and the transfer factors were revised to implicitly account for receptor consumption of beef, poultry, and eggs.

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64	Comment-9/24 through 9/26 LFRG on-site review	The RESRAD modeling assesses irrigation using water concentrations developed using long-term average surface water flows. Irrigation in this region, however, would be done principally during drier seasons, which correspond to lower creek flows. This in turn results in higher contaminant concentrations in the creeks, and therefore in irrigation water. **Question 10:** How will this be accounted for in future modeling?	Discussed November 8, 2018. A detailed response for this comment regarding flow rates in Bear Creek is found in the corrective action to LFRG CA Secondary Issue EMDF-S03-CA14. Lower flow in Bear Creek due to less precipitation does not necessarily result in higher contaminant concentrations in Bear Creek because less precipitation would result in less leaching from the contaminant sources.
65	Comment-9/24 through 9/26 LFRG on-site review	Groundwater protection should be evaluated against maximum contaminant levels (MCLs,) as stated in the PA (p. xxv). These would use an equivalence of a dose of 4 mrem in a year. Instead, EPA's PRG calculator and DCFs from DOE-STD-1196-2011 were used, though the LFRG review team objected strongly to the use of both of these programs. **Question 11:** How will comparisons to the MCLs for protection of groundwater be addressed?	Discussed October 11 and November 8, 2018. Groundwater protection is evaluated in the current PA against the 4 mrem/yr maximum concentration level (MCL) requirement. MCL values for individual isotopes in the PA ~~will be~~are those provided by EPA. This comparison ~~will be~~has been made more clearly in the text of the revised PA.
66	Comment-9/24 through 9/26 LFRG on-site review	Calculations of doses from present-day radionuclide concentrations in BC exceed the 4-mrem in a year protection standard. **Question 12:** Given that radionuclide concentrations will increase in the future due to the large inventories of uranium and ingrowth of progeny, how can the protection standards be demonstrably met in the future?	Discussed November 8, 2018. The 4 mrem/yr protection standard is the groundwater protection standard, and is the MCL for drinking water. The groundwater at the EMDF site location is not contaminated by uranium from the BCBG. Uranium in Bear Creek surface water does exceed the 10-5 risk set by the ROD; however, the remediation of BCV has not been completed. Remediation of the BCV will meet the 10-5 risk goal and thus will meet the surface water protection standard of 24% of the Derived Conservation Standard.
67	Comment-9/24 through 9/26 LFRG on-site review	**Question 13:** Since surface water protection standards in BCV are currently exceeded, and will likely rise in the future, for the reasons stated above, what is the rationale for the addition of radioactive materials to BCV?	Discussed November 8, 2018. Surface water protection standards are exceeded in Bear Creek because the remediation of the BCV has not yet been completed. Once that remediation is implemented, the risk posed by the water will be reduced to acceptable limits. The CA is used to look at composite risk posed at an integration point. Since that composite risk is acceptable (from all potential sources) the proposed facility for disposal of additional LLW in the valley is acceptable, as will be evidenced by receiving a Disposal Authorization Statement.

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68	Comment-9/24 through 9/26 LFRG on-site review	Engineered clay layers in the EMDF design will degrade, producing "bounding" infiltration rates of up to 12 in/yr, as stated by the modelers. The base case of the PA assumes only 1 in/yr as a maximum value, and the one-at-a-time (OAT) sensitivity analysis (SA) for infiltration rates considered rates only up to 7 in/yr. It was agreed that this is not bounding. **Question 14:** Will the OAT SA for infiltration be revised to include the 12-in/yr value?	Discussed November 8, 2018. None of the PA team recalls discussing infiltration rates of up to 12 in./yr. MODFLOW simulations indicate a regional recharge rate (outside of the proposed cell footprint) of 6-8 in./yr, which is likely to be the maximum expected given any cell cap degradation. 12 in./yr ~~will~~ is not ~~be~~ used.
69	Comment-9/24 through 9/26 LFRG on-site review	Another OAT SA was performed to assess the influence of K_d values alone. This SA varied K_ds by a factor of 5 for all radioelements. **Question 15:** What is the basis for the factor of 5?	Discussed November 8, 2018. The factor of 5 represented an approximation of the expected plausible range of Kd values given site data, materials, and site conditions. The specified values of Kd are being revised for the base case and OAT SA simulations based on corrective actions for LFRG PA Key Issues EMDF-K01-PA11-01 and EMDF-K02-PA11-02.
70	Comment-9/24 through 9/26 LFRG on-site review	OAT SA evaluates the effects on performance metrics by variation of single pre-selected model parameters. This methodology is flawed in that it does not assess the combined effects of varying more than a single parameter, and it is limited by the modeler's preconceptions of what parameters might be significant. A global SA, on the other hand, evaluates the combined effects of varying all input parameters (which should nearly all be stochastic) and evaluates the effects of each one. This method is the only way to reveal other parameters that may be more significant than those preselected by the modeler. **Question 16:** Will global SA be implemented in future modeling?	Discussed November 8, 2018. Iterative simulations consisting of OAT SA and probabilistic simulations were performed to assess how model conclusions may be affected given changes in parameters. A global SA, which consists of identifying and simulating stochastic distributions for greater than 400 model parameters, is not planned.
71	Comment-9/24 through 9/26 LFRG on-site review	RESRAD-OFFSITE has limited probabilistic capability, and in this case, distributions for only 44 parameters were specified because of very long run times. **Question 17:** Why were software limitations allowed to restrict the scope and value of the uncertainty analysis (UA)?	Discussed November 8, 2018. As discussed at the onsite meeting, the selected 44 parameters were not determined by "software limitations." Iterative simulations consisting of OAT SA and probabilistic simulations were performed to assess how model conclusions may be affected given changes in parameters.

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72	Comment-9/24 through 9/26 LFRG on-site review	Distributional forms like uniform, triangular, and log-triangular are applied inappropriately to this modeling, since these do not represent the uncertainty inherent in the subject phenomena (i.e. leach rates or adsorption coefficients). Some are truncated at seemingly arbitrary values, such as the 10th and 90th percentiles, without justification. Further, no spatial or temporal scaling seems to have been applied in the distribution development. **Question 18:** How will the development of input distributions for those parameters that were selected for sensitivity cases be updated, as well as for other input parameters?	It is respectfully requested that specific instances of suggested parameter distribution changes be provided. Attachment G.3 of Appendix G of the revision 2 PA provides additional detail on the basis for the selected input parameter distributions. Section. G.6.3.2.1 provides a general description of the approach to selecting probability distributions for input parameters.
73	Comment-9/24 through 9/26 LFRG on-site review	Radon flux at the ground surface, a DOE M 435.1 performance metric, was calculated in isolation using an NRC methodology dating from the 1980s (NRC 1989; Rogers et al. 1984). This methodology was developed for the design of uranium mill tailings covers, and its application to the EMDF is not supported. Improved methods are available, such as a detailed modeling of air diffusion through the porous media, based on first principles in porous media transport (Ho 2008; Neptune 2015; Nielson and Sandquist 2011). **Question 19:** Would using such a more realistic and defensible approach be considered?	Discussed November 8, 2018. The Nuclear Regulatory Commission method provides detailed mathematical equations that can be applied to various conditions and cover designs, including EMDF design. The method has been used for the recently approved DOE PA (DOE Portsmouth 2016). No other modeling approach for radon flux at the surface of the disposal facility ~~will be~~is used.
74	Comment-9/24 through 9/26 LFRG on-site review	In the calculation of radon flux, the PA assumes a radon escape-to-production (E/P) ratio of 0.2. The E/P ratio defines the fraction of decaying parent (radium) that produces radon that is free to migrate in the immediate environment, and can range from 0 to 1. A value of 0.2 may apply to wastes that contain radium within their matrix, but once radium has migrated into the environment (through leaching and release from the waste form), the E/P ratio should be 1. That is, different E/P ratios should be applied in the waste matrix and in the environment. **Question 20:** Will the radon flux analysis be revisited using more realistic E/P ratios?	Discussed November 8, 2018. See response to above Comment #73. The escape-to-production (E/P) ratio, or radon emanation coefficient in the radon flux calculation, applies to only the source waste zone. A radon emanation coefficient of 0.25 for Rn-222, the default value in the RESRAD model (Yu et al. 2015), was selected. This default value approximately represents the conditions in a silty loam soil with low moisture content (that is, not dry). This value is on the higher end of the reported radon emanation coefficients for Rn-222 in various soils (Yu el al., 2015, Section 4.2.2, Page 122), which typically range from less than 0.01 to 0.30). Relationships in the literature illustrate the emanation coefficient increases as moisture content increases, but none of these references imply that a value of 1 should be used. A value of 1 for the

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			emanation coefficient would assume that no radon atoms would end up in solids, which is an absolute worst case. In general, the use of worst case assumptions in the models that support decision-making has been avoided. Note that if a higher moisture content is used (and higher emanation coefficient), the gas diffusion rate will decrease, so there are trade-offs for the upward migration of radon (higher moisture -> higher emanation coefficient –> reduced gas diffusion, lower moisture -> reduced emanation coefficient -> higher gas diffusion). The radon flux analysis will not be revisited because it is believed that the radon emanation coefficient used in the calculation is appropriate and the LFRG did not question the value of that coefficient.
75	Comment-9/24 through 9/26 LFRG on-site review	A side effect of radon migration into surrounding porous media is that it results in enrichment of those media, including surface soils, in decay products of radon. Significant buildup of these progeny, such as Pb-210 and Po-210 from Rn-222, can contribute to doses by several exposure pathways. External doses from contaminated surface soils need to include contributions from Rn222 and its progeny in soils (not, as specified in DOE M 435.1, in air). Soil contamination also feeds into exposure pathways from growing crops, fodder, and livestock. The currently-modeled exposure pathways are therefore incomplete. **Question 21:** Will modeling be revised to include contaminant transport and exposure pathways related to these mechanisms?	Discussed November 8, 2018. See response to above Comment #73.

76	Comment-9/24 through 9/26 LFRG on-site review	Diffusion of radionuclides in pore air seems to have been omitted from the contaminant transport modeling used to support the PA and CA of the EMDF. Since the modeled radionuclides H, C, I, and Rn all have volatile phases, air-phase diffusive transport should be considered as a potentially significant process. **Question 22:** Will adding this contaminant transport process to future modeling be considered?	Discussed November 8, 2018. Volatile phases of H-3, C-14, and Rn are simulated within RESRAD-OFFSITE. Regarding I-129, atmospheric releases of iodine are screened because of the low potential for volatilization, combined with the relatively large moisture content and the downward flux of water that would tend to limit atmospheric transport, even if volatile phases were to occur. Some discussion of the potential for volatilization is provided below. **General conditions needed for iodine volatilization to occur:** Iodine volatilization occurs in the natural environment under very specific conditions. The ideal conditions where iodine volatilization occurs are in rice paddies and in marine systems, especially above beds of kelp. In terrestrial systems, iodine volatilization is a microbial process that occurs under primarily acidic conditions where the soil has little capability to build strong bonds with the iodine (e.g., in the presence of organic matter or low pH/high iron oxide environments). The iodine volatilizes as methyl iodine (CH_3-I), with very little I_2 (gas) formed. For I_2 (gas) to form, extremely high concentrations with respect to typical environmental levels must be present as iodide (I^-) under acidic conditions pH<~4.5. Finally, the greater the total iodine concentrations (i.e., both stable -I-127 plus radioactive I-129 concentrations), the greater likelihood of volatilization. There has been very little research into iodine volatilization in soil/vadose zone under environmentally relevant conditions. Whitehead (1983) concluded from a survey of 27 soils: "In general, it appears that surface soils with a content of organic C greater than about 2.5 per cent and a pH above 5 are unlikely to induce any appreciable volatilization, but that, with lower contents of organic C, and particularly under stronger acid conditions, volatilization may be substantial." **Environmental conditions expected in the EMDF:** Rothschild et al. (1984) reported that from 15 soil samples from the Solid Waste Storage Area 7 on the Oak Ridge Reservation, that the average pH was 5.0 ± 0.5 and that the organic matter concentration was 3.31 ± 1.2 %. Davis et al. (1984) reported an average pH of 4.4 ± 0.3 and organic concentrations of 0.37 ± 0.41 % for 24 soils collected from the Solid Waste Storage Area 6. These soils are

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			similar to soils that would be used for clean fill at EMDF. However, leachate from EMWMF, which reflects the presence of waste (including concrete debris) has consistently tested as circumneutral rather than acidic conditions. These circumneutral conditions should be more reflective of the EMDF waste zone. **Expectation of iodine volatilization in EMDF:** The average soil collected by Rothschild et al. (1984) would not be expected to generate volatile iodine, but those described by Davis et al. (1984) would be expected to generate some volatile iodine. Under circumneutral conditions observed at EMWMF, which includes the presence of waste mixed with the soil, iodine would not be expected to be volatile. (One unknown is the concentrations of the stable I-127 concentrations, the dominant isotope expected at the site, which can increase the likelihood of volatilization under acidic conditions.) The revision 2 of the PA includes improved conceptual justification and quantitative basis for screening vapor phase release and/or biointrusive transport to cover surface, and added a quantitative estimate of potential radionuclide release through the cover. The RESRAD-OFFSITE screening model was used to bound the dose resulting from release of potentially volatile radionuclides.
77	Comment-9/24 through 9/26 LFRG on-site review	Diffusion of radionuclides in groundwater seems to have been omitted from the contaminant transport modeling used to support the PA and CA of the EMDF. The exclusion of diffusive properties in groundwater is justified in common hydrogeological practice based on a calculation of the Péclet number, but no such calculation is presented in the PA or CA. This would be especially important in the modeling of contaminant transport in clays, which are of high saturation and low hydraulic conductivity and could therefore be dominated by diffusion. **Question 23:** Could the Péclet number calculation for various media in the modeling, as justification for omitting water-phase diffusion, be provided?	Discussed November 8, 2018. Because predicted peak dose magnitude and timing are the primary drivers for compliance, it is not feasible for diffusion phenomenon to increase concentrations below the waste such that advective processes are not dominant. However, modeling ~~will be~~has been repeated using Peclet number calculations and the results evaluated.
78	Comment-9/24 through	**Comment 2:** The RESRAD modeler stated that dispersivity in the saprolite (layer UZ5) is correlated to groundwater velocity,	Discussed November 8, 2018.

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	9/26 LFRG on-site review	and that RESRAD has no method for implementing that relationship. This is incorrect; dispersivities have been correlated to the length of the region of interest (Charbeneau 2000; Gelhar et al. 1992), and not to water velocity.	It is correct that dispersivities have been correlated to length and not water velocity. The statement regarding relation between dispersive phenomenon and water velocity was meant to be regarding dispersion, not dispersivity.
79	Comment-9/24 through 9/26 LFRG on-site review	It seems that the EMDF CA depends, in part, on previous modeling performed with PATHRAE for the EMWMF. This computer program, first developed by Gary Merrell and Vern Rogers of Rogers and Associates Engineering (Merrell et al. 1986; Rogers and Merrell 1986), is quite dated. Gary Merrell (personal communication) has said that it has not been maintained, and would not meet contemporary quality assurance standards. The EMWMF modeling that used PATHRAE should have been updated as part of the EMWMF Maintenance Plan. **Question 24:** When will this modeling, in the context of the EMDF and EMWMF CA, be updated?	Discussed November 8, 2018. DOE ~~will~~ continues to rely on PATHRAE for the EMWMF modeling in the CA because the results continue to be valid and support the existing waste acceptance criteria (see corrective action for LFRG CA Secondary Issue EMDF-S04-CA15-01). A final PA will be developed for EMWMF upon closure, and the model used will be re-evaluated at that time.