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April 30, 2019

Ms. Elizabeth A. Connell
Associate Principal Deputy Assistant
Secretary for Regulatory Policy Affairs
DOE, OEM
1000 Independence Ave., SW
Washington, DC 20585

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION ON THE DRAFT WASTE INCIDENTAL TO REPROCESSING EVALUATION FOR CLOSURE OF WASTE MANAGEMENT AREA C AT THE HANFORD SITE

Dear Ms. Connell:

The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed the "Draft Waste Incidental to Reprocessing Evaluation for Closure of Waste Management Area C at the Hanford Site" dated March 2018, the "Performance Assessment of Waste Management Area C, Hanford Site, Washington" dated September 2016 and associated documentation provided by the U.S. Department of Energy (DOE). This independent review was conducted in accordance with an Interagency Agreement between the DOE and the NRC. This agreement requests the NRC's consultative technical review to determine if the draft Waste Incidental to Reprocessing (WIR) evaluation meets DOE Manual 435.1-1 criteria for Waste Management Area (WMA) C WIR to be managed as low-level waste. In the agreement, DOE requests NRC consultative emphasis on DOE M 435.1-1 criterion 2 regarding meeting safety standards comparable to the performance objectives set out in 10 CFR Part 61 Subpart C, over DOE M 435.1-1 criterion 1 regarding the removal of key radionuclides. Additionally, the DOE requests consultation pertaining to reasonable expectation of compliance with the performance objectives for a compliance period of 1,000 years.

The draft WIR evaluation addresses the stabilized residuals which will remain in the WMA C waste tanks and ancillary structures at the time of WMA C closure. This evaluation, and the NRC staff review, do not address other facilities or systems, waste removed from the waste tanks and ancillary structures, or the contaminated soil and groundwater from previous leaks or unplanned or planned releases.

NRC has attached a Request for Additional Information (RAI), which is a list of comments for which the NRC staff needs responses from the DOE before the NRC can complete its review. This RAI is based on our risk-informed review of the draft WIR evaluation and supporting documentation. NRC evaluated DOE's intruder and performance assessment results, including sensitivity cases in developing the risk insights used to inform the review. The NRC staff reviewed DOE's performance assessment model developed with the software package GoldSim. The NRC staff modified DOE's model and examined alternate cases to develop additional risk insights.

As NRC continues its review of DOE documents and RAI responses, NRC may develop additional comments for which NRC will need a response from DOE. Other technical comments, which the NRC staff does not consider to be risk significant for the draft WMA C WIR evaluation review, but could be significant for other facility reviews, will be noted in a technical evaluation report that documents the NRC's findings and conclusions.

To meet the current schedule and complete the review by November 31, 2019, NRC requests responses to the RAI on or before August 1, 2019. If it would be useful to DOE, NRC would be willing to meet with DOE to discuss the RAI or DOE's responses.

In accordance with 10 CFR 2.390 of the NRC's "Agency Rules of Practice and Procedure," a copy of this letter will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html.

If you have any questions related to this letter, please contact Lloyd Desotell, Project Manager in the Division of Decommissioning, Uranium Recovery, and Waste Programs at 301-415-5969 or by e-mail at Lloyd.Desotell@nrc.gov.

Sincerely,

/RA/

Chris McKenney, Branch Chief
Risk and Technical Analysis Branch
Division of Decommissioning, Uranium Recovery
and Waste Programs
Office of Nuclear Material Safety
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Enclosure: Request for Additional Information

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION ON THE DRAFT WASTE INCIDENTAL TO REPROCESSING EVALUATION FOR CLOSURE OF WASTE MANAGEMENT AREA C AT THE HANFORD SITE **DATE: April 30, 2019**

DISTRIBUTION: M. Heath DUWP D. Esh DUWP

ADAMS Accession No. 19112A091

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Request for Additional Information
Draft Waste Incidental to Reprocessing Evaluation for Closure of Waste Management Area C at the Hanford Site

Structure of Comments

The U.S. Nuclear Regulatory Commission (NRC) staff's review comments are separated into categories based on the Department of Energy (DOE) Manual 435.1-1 evaluation process criteria to determine if Waste Incidental to Reprocessing (WIR) can be managed as low-level waste. DOE Manual 435.1-1 states that WIR can be managed as low-level waste if an evaluation shows that the following criteria are met:

1. Have been processed, or will be processed, to remove key radionuclides to the maximum extent that is technically and economically practical; and

2. Will be managed to meet safety requirements comparable to the performance objectives set out in 10 CFR Part 61, Subpart C, *Performance Objectives*; and

3. Are to be managed, pursuant to DOE's authority under the *Atomic Energy Act of 1954*, as amended, and in accordance with the provisions of Chapter IV of this Manual, provided the waste will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C low-level waste as set out in 10 CFR 61.55, *Waste Classification*; or will meet alternative requirements for waste classification and characterization as DOE may authorize.

The path forward provided for each comment is one recommended approach to resolution; the NRC staff understands that there may be more than one method for adequately addressing the technical issues raised in the comments. Appropriate responses to some comments may depend on the nature of the resolution of other comments. A sub-topic is presented parenthetically after each Request for Additional Information (RAI) number.

RAI 1-1 (Removal of Key Radionuclides to the Maximum Extent Practicable)

Comment

An insufficient basis was provided that removal of waste from plugged pipelines is not necessary in order to satisfy removal of key radionuclides to the maximum extent that is technically and economically practical.

Basis

DOE indicated it would not be technical practical to remove additional waste and key radionuclides from ancillary structures. The basis for this statement was not provided for plugged pipelines. Plugged pipelines represent one of the highest risks from all of the potential structures proposed to be left in place. Removal would seem to be a viable option for plugged pipelines unless it is not technically and economically viable to do so. DOE has spent approximately $750 million dollars to remove waste from the tank farm at WMA C (NRC's Agencywide Documents Access and Management System [ADAMS] Accession No. ML18337A404). According to DOE's "Draft Waste Incidental to Reprocessing Evaluation for Closure of Waste Management Area C at the Hanford Site" (DOE/ORP-2018-01), [Draft WIR Evaluation], they will have removed approximately 96% of the waste from the tank farm at closure. The "Performance Assessment of Waste Management Area C, Hanford Site" (RPP-

Enclosure

ENV-58782) [WMA C PA] shows that the waste residuals result in a dose to a member of the public of approximately 0.166 mrem/year within the sensitivity analysis period (Figure 8-22, WMA C PA) and a dose to a hypothetical acute inadvertent intruder of approximately 4 mrem (averaged over sixteen 100- and 200- series tanks). The average amount spent on removing waste from an average tank (life-cycle) would be approximately $47 million. By comparison, DOE indicated that the dose to a chronic intruder (rural pasture exposure scenario) from a plugged pipeline is 160 mrem/year at 100 years. The actual inventory in plugged pipelines is unknown and assumed (see following request for additional information). In addition, it is not clear why the rural pasture exposure scenario would be the most limiting intruder dose result for a plugged pipeline when for every other source type the suburban gardener exposure scenario is the most limiting result of the chronic intruder exposure scenarios. The acute driller dose impacts are larger than the chronic dose impacts by a factor of 2.5 to 3.8 for other sources with similar waste composition.

DOE has performed various activities to access contaminated structures (including buried pipelines) at Hanford, the experience from those activities may be used to provide cost and other information.

Path Forward
Please provide a basis that it is not technically and economically practical to remove and dispose of plugged pipelines.

<u>RAI 1-2</u> (Removal of Key Radionuclides to the Maximum Extent Practicable)

Comment
An insufficient basis was provided for terminating waste removal activities for some tanks.

Basis
Section 4 of the Draft WIR Evaluation steps through the waste removal processes used for each tank and component in WMA C. For the 100-series tanks, two thirds of the retrieval campaigns did not achieve their goal. For the 200-series tanks, all the retrieval campaigns achieved their goal. A variety of different processes and technologies were deployed to remove waste from the tanks. The DOE approach to removing waste focused on bulk waste removal. For most of the 100-series tanks charts were provided showing the asymptotic approach of the amount of waste removed to a threshold value, demonstrating that the limits of that particular technology were being approached. However, charts were not provided for C-105, C-106, C-109, C-111, and C-112.

DOE stated on page 4-68 of the Draft WIR Evaluation that removal of 96% of the waste volume has also resulted in removal of 96% of the radioactivity in the tanks from pre- to post-retrieval. The solids (sludge) generally have higher concentrations of radioactivity and are more difficult to remove, therefore it would be anticipated that a higher percentage of radioactivity would remain. The removal efficiencies for key radionuclides were not provided.

Additional observations associated with waste removal include:

- For Tank C-104 an obstruction was encountered which limited pump placement and waste removal. It is not clear why the obstruction couldn't be cleared or additional access provided. For some tanks, risers have been modified or new risers installed.
- For Tank C-108 the waste was stated as being insoluble in DST AN-106 supernate. Information was not provided as to why other supernate couldn't be used and how it was determined that other supernate would not be effective.
- For Tank C-108, Figure 4-17 of the Draft WIR Evaluation shows waste removal is primarily limited by access locations. It is not clear why additional access could not be provided or if providing additional access locations was evaluated.
- For Tank C-109, Figure 4-22 does not appear to shown decreasing effectiveness of the technology with time. The flouride concentration increases with circulation time. Longer circulation time should correspond to more waste removal.
- For Tank C-110, Figure 4-27 shows very effective performance of the FoldTrak MRT system. The system was stopped due to a component failure. It is not clear why the component could not be repaired or replaced to continue removal. In addition, owing to its effective and efficient performance it is not clear why it could not be deployed on other tanks for which retrieval goals were not met.

Path Forward
Please provide removal efficiency charts for tanks C-105, C-106, C-109, C-111, and C-112. Provide the removal efficiencies of key radionuclides Cs-137, Sr-90, I-129, Tc-99, U-isotopes, Pu-isotopes, Am-241, Np-237, and C-14, non-decay corrected. Address the additional observations noted above associated with particular tank cleaning campaigns

RAI 1-3 (Removal of Key Radionuclides to the Maximum Extent Practicable)

Comment
An insufficient basis was provided in the Draft WIR Evaluation that pits, diversion boxes and pipelines were well-flushed, thereby removing waste containing key radionuclides to the maximum extent technically and economically practical.

Basis
DOE indicated that operational practices were to flush components after use. DOE stated that additional removal of waste from ancillary equipment was not necessary because the equipment was well-flushed. However, some components were, based on available records, clearly not flushed. For instance, cascade lines were gravity drained and in some cases the source of leaks from long-term overfilling conditions. Diversion boxes (e.g., 152-CR, 151-C) experienced significant leaks. It is not clear how the material that may reside in the leak pathway from the interior to the exterior of the box would have been flushed. There are numerous records of piping that "failed" and was taken out of service. The report RPP-RPT-38152 identified 11 pipes that failed. It is not clear how the piping was flushed if it failed.

Path Forward
Please provide the records available that indicate which components were flushed at the time they were taken out of service. Provide present radiation level measurements inside the diversion boxes and pits, including which radionuclides are the source of the radiation (if known). For ancillary equipment that was not well-flushed, provide information that key radionuclides have been removed to the maximum extent technically and economically practical.

RAI 2-1 (General Technical Analyses Considerations)

Comment
An insufficient basis was provided that demonstrates that procedures were effectively implemented to ensure proper quality assurance (QA) of the Draft WIR Evaluation and supporting analyses.

Basis
During the review process, staff identified discrepancies or inconsistencies in documentation, inputs, or other aspects of the calculations. These observations include:

- The inventory assigned for the C-301 tank and 244-CR vault in Table 3-15a of the WMA C PA do not match the values provided in Table 4-3 of the same document or Table 2-5 of the Draft WIR Evaluation.
- There is a portion of the WMA C source term that was inadvertently modeled as not being covered by the final closure cap, resulting in faster transport to the water table for a portion of the residual waste.
- The modeling of water fluxes uses a point below the center of the tank that is subject to a significant "tank shadow" effect, but is applied to all releases from the tank. Water flow and saturation at the periphery of an intact tank would be expected to be much higher.
- The intruder dose results for the pipelines 5% full of waste could not be verified. DOE estimated the dose to the acute intruder from drilling through a 0.137 meter (m) thick layer in tank C-301 as 21.1 mrem. DOE estimated the dose to the acute intruder from drilling through a 0.0253 m thick layer in the 244-CR vault as 3.91 mrem. The doses are directly proportional to the thickness of the waste layer. DOE estimated the dose from drilling through a 5% full pipeline as 36.0 mrem. The 5% full pipeline has a diameter of 7.62 centimeter (cm) and so an equivalent waste layer thickness of <0.5 cm. Since the composition of the waste is the same in each of these components it is not clear why the dose would be 36.0 mrem.
- The minimum value for the Pu distribution coefficient (Kd) provided in Table 6-5 of the WMA C PA does not agree with the value used in the model (7.1E5 vs. 7.14E5). GoldSim is the software package used to develop the WMA C PA model.
- Table 6-16 on page 6-111 of the WMA C PA indicated that the H2 sand layer has a middle portion consisting of 20 cells but the GoldSim model has 80 cells.

- The WMA C PA model lists the isotope Pb-210 but no inventory assigned to it. Parent radionuclides are present that would have expected to produce Pb-210 during the ~70 years of operations. During pre-RAI interactions DOE explained (ADAMS Accession No. ML18275A207) why Pb-210 was not included but that explanation was not provided in the WMA C PA documentation.
- The porosity of the soil backfill is not assigned a value of 1. DOE indicated that the porosity of other materials are assigned a value of 1 because porosity is included in the tortuosity parameter and the approach is conservative.
- The value for longitudinal dispersivity provided for 100 series tanks is 4 m multiplied by the SZ_dispersivity_multiplier parameter whereas the value use for the 200 series tanks is 10 m multiplied by the SZ_dispersivity_multiplier parameter.
- Relative aqueous permeability parameters are contained in the STOMP input file that were not provided in the WMA C PA documentation.
- The Henry's Law constant for tritium appears to be very large and inconsistent with values commonly used. If all the tritium ends up in the air pathway and the air pathway has large dilution factors, this approach would be non-conservative.

The NRC staff has performed a risk-informed review of the Draft WIR Evaluation and Performance Assessment. In order for the risk-informed process to be effective, there should be high confidence in the results of the calculations. Staff acknowledges that development of the analyses and documentation is a large effort involving many different people and groups. This amplifies the importance of applying strict quality assurance procedures and verifying that the procedures have been implemented effectively. Most of the discrepancies listed above are not believed to have a significant impact on the decisions. However they were pervasive enough to warrant a request for additional information to ensure the results of the calculations have been properly verified. These discrepancies were not limited to the highest-level documents reviewed (e.g., the Draft WIR Evaluation and WMA C PA), but were also found in the supporting documents (e.g., inventory reports) where errors were identified and values were updated in new versions of reports.

Path Forward
Please provide the QA procedures that were applied to development of the Draft WIR Evaluation, the WMA C PA, and supporting documents and models. Provide a qualitative description of how analyses are reviewed and checked, including how much time is afforded to the reviewers. Provide examples of records (e.g., environmental model calculation files) demonstrating how the performance assessment analyses were reviewed and checked. Describe the process for evaluating and resolving errors identified in analyses that were previously approved.

<u>RAI 2-2</u> (Future Scenarios and Conceptual Models)

Comment
The description of how viable alternative conceptual models or alternative future scenarios are identified is insufficient. DOE's current safety function methodology would not appear to be able

to identify interdependencies and interrelationships between features, events, and processes (FEPs) that could result in plausible alternative conceptual models or alternative future scenarios.

Basis

Conceptual models (different ways a disposal system might behave) and future scenarios (usually associated with a major event such as an igneous or climate event) can be a source of great uncertainty. DOE's WMA C PA has evaluated alternative conceptual models such as the alternative geological model II and the heterogeneous media model. While DOE has stated, and NRC staff agrees, that the two alternative conceptual models are plausible, the methodology by which these alternative conceptual models were derived is not clear although the alternative geological model II appears to have been evaluated at the request of stakeholders. DOE has stated that viable alternative conceptual models or alternative future scenarios are considered based on an evaluation of safety functions and their relationship to FEPs; however, results in the WMA C PA uncertainty and sensitivity analysis appear to indicate that many of the identified specific functions are not especially relevant to the performance.

DOE identified and documented an extensive list of relevant FEPs as would be done in a bottom-up approach to identifying alternative models and scenarios. In addition, safety functions were included as part of a top-down approach to identifying conditions that need to be evaluated in the WMA C PA. After the safety functions are identified, FEPs are identified that may degrade or modify the performance of a safety function in some way. However, in this hybrid approach, there appears to be no analysis of how the safety functions influence one another or if there are interdependencies and interrelationships between the identified features and processes. The one-at-a-time sensitivity analysis used in the WMA C PA does not lend itself to identifying risk-significant interdependencies and interrelationships between FEPs.

The uncertainty analysis appears to be focused on the evaluating the range of variability of the input parameter values for the base case and is not able to identify plausible alternative conceptual models. An assumption that there is only one plausible future scenario (i.e., no alternative future scenarios) with a non-dynamic environment for 10,000 year requires a rigorous technical basis. Results of analyses should evaluate the interdependencies and interrelationships between components of the system and provide supporting evidence of plausible alternative scenarios or conceptual models.

While plausible models and scenarios would be evaluated in the WMA C PA, these analyses would also provide the basis for determining which "what-if" models and scenarios are not plausible and require no further examination. This would remove any confusion about which conceptual model should be included the WMA C PA.

For example, in a previous technical review related to a Hanford tank closure, NRC staff provided eight examples of features, events, and processes that may be sufficiently plausible and significant as to require an alternative conceptual model or alternative future scenario to be considered (ADAMS Accession No. ML090090030).

Path Forward
Please provide a description of the approach to identifying plausible alternative conceptual models or alternative future scenarios used in development of the WMA C PA, or clarify how DOE's current safety function methodology would identify interdependencies and interrelationships that may lead to plausible alternative models or scenarios.

In addition, describe the process by which the safety functions were identified. If some safety functions are redundant barriers, DOE should demonstrate, as stated in Appendix H, how a safety function is a feature of the system that provides a specific function that is relevant to the performance (or safety) of the facility. The safety concept is considered to be a set of safety functions acting together in concert to provide the required safety. Provide a description of the how the safety functions act together.

RAI 2-3 (Radionuclide Inventory and Release Rates)

Comment
An insufficient basis was provided for the inventory assigned to the C-301 Catch Tank. Assumptions regarding residual inventories are not consistent with operational history.

Basis
DOE summarized in Section 4.3.5 of the Draft WIR Evaluation that ancillary structures included within the scope of the assessment include the C-301 Catch Tank, the 244-CR Process Vault (with four small tanks), pipelines, and diversion boxes. DOE indicated that it planned to characterize the C-301 Catch Tank, but for the purpose of the Draft WIR Evaluation the WMA C PA assumes that 90 percent of the waste will be retrieved. It was also assumed that the inventory in the C-301 Catch Tank was comparable to the residual waste inventory in the tank farm.

The C-301 Catch Tank received drainage from four diversion boxes (241-C-151, 241-C-152, 241-C-153, 241-C-252). At least two of these diversion boxes experienced leaks of waste. According to RPP-RPT-45723, the C-301 Catch Tank contained a layer of solids (sludge) approximately 1.17 m thick as of June 3, 1985. The sludge contents of the tank appear to be largely uncharacterized, though liquid samples have been evaluated in 1974 with Cs-137 concentrations of 1E4 to 2.55E4 µCi/gallon (3.8E1 to 9.7E1 µCi/m^3). As a result of partitioning, the Cs-137 concentrations in sludge would be anticipated to be considerably higher. Additionally, the thickness of the waste layer is likely to be much larger than other components due to the geometry of the catch tank. Thicker waste layers combined with higher concentrations could be significant to evaluating the impacts to the inadvertent intruder.

Path Forward
Please provide a basis for the estimated radioactivity concentrations in sludge in tank C-301. If the inventory for the C-301 Catch Tank is revised, then the C-301 Catch Tank would need to be classified consistent with RAI 3-2 and an intruder dose assessment should be performed consistent with RAI 2-16.

<u>RAI 2-4</u> (Radionuclide Inventory and Release Rates)

Comment
An insufficient basis for the inventory assigned to the 244-CR Process Vault (with four small tanks) was provided. Assumptions regarding residual inventories are not consistent with operational history. Characterization data of ancillary equipment has not been provided.

Basis
DOE summarized in Section 4.3.5 of the Draft WIR Evaluation that ancillary structures included within the scope of the assessment include the C-301 Catch Tank, the 244-CR Process Vault (with four small tanks), pipelines, and diversion boxes. DOE indicated that it planned to characterize the 244-CR Process Vault. For the purpose of the Draft WIR Evaluation and in the analyses of the WMA C PA DOE assumes that 90 percent of the waste will be retrieved. It was also assumed that the concentration of radioactivity in that system was comparable to the residual waste inventory in the tank farm.

The 244-CR Vault was used for scavenging Cs-137 from tributyl phosphate (TBP)-based waste. The 244-CR Vault and associated tanks and cells were used as the uranium sludge recovery and distribution vault for C-Farm. The 244-CR Vault was also used for the interim storage and transfer of waste from B Plant, PUREX and Hot Semiworks. The 244-CR Vault had the capacity to add chemicals, mix solutions and cool the tank contents. Waste was also received from the Hot Semiworks Facility. The 244-CR-003 tank in the 244-CR Vault was used for the interim storage of saltwell waste from C-Farm.

As shown Figure ES-1 from RPP-RPT-24257, the waste in the tanks consists of a high percentage of sludge. In addition, the figure shows waste in the cells outside of the tanks. Based on the complex operational history, the use of present day average tank farm facility waste concentrations to estimate the sludge concentrations in the 244-CR tanks (vaults) may not be reliable or protective. In addition, even after retrieval the remaining waste layer will likely be considerably thicker than that remaining in the 100- and 200-series tanks. Precipitation processes and lessor amounts of mixing could contribute to significantly higher concentrations of radioactivity in the 244-CR vaults than would be estimated using average tank farm concentrations.

Thicker waste layers combined with higher concentrations could be significant to evaluating the impacts to the inadvertent intruder.

Path Forward
Please provide any historical characterization data available for the 244-CR Vault including the four tanks. If no data is available, provide the sampling and characterization plan that will be used to verify the inventory assumptions prior to closure. After the inventory estimate for the CR-244 Vault has been revised, then the components would need to be classified consistent with RAI 3-2 and intruder dose assessment performed consistent with RAI 2-16.

<u>RAI 2-5</u> (Radionuclide Inventory and Release Rates)

Comment
An insufficient basis for the inventory of plugged pipelines was provided. The dose from intrusion into a plugged pipeline may be higher than the dose from intrusion into any other ancillary component or tank.

Basis
Pipelines failed or plugged over time as a result of complex phenomena associated with waste transfers. An earlier report (RPP-RPT-46879 Rev. 2) indicated that approximately 21 pipelines are documented to have been plugged within WMA C. The report RPP-25113 identified ten waste transfer lines that failed at some point due to plugging. The Draft WIR Evaluation has assumed one pipeline is plugged. Intrusion into a plugged pipeline represents one of the highest risk exposure scenarios associated with closure of WMA C. From the documentation provided, it is not clear exactly how many lines are plugged within WMA C and how many lines that were plugged at one point were verified quantitatively to be unplugged prior to being no longer used. The plugging process is unlikely to be discrete and can result from gradual buildup of material in the pipeline.

The line(s) plugged at various times in the past. The waste in the line today would be a decayed version of what was in the line at the time of plugging. The Draft WIR Evaluation assigned average concentrations of the waste in the tank farm today to represent that in the plugged pipeline(s). The waste in the plugged lines could be much more concentrated (e.g., first-cycle extraction type wastes) than assumed in the sensitivity case for the WMA C PA. Report RPP-25113 attempted to identify what transfers were occurring at the time of plugging. Without characterization data, a conservative approach should be taken to ensure public health and safety would be protected from leaving in place plugged pipelines.

The Draft WIR Evaluation and WMA C PA only evaluated plugged pipelines as a sensitivity case, stating that the amount of plugged pipelines represents only 2% of the total pipeline length. At ~ 11 kilometer (km) of pipeline this would represent over 200 m of piping. The 2% argument is a form of risk dilution. If the plugged pipelines were exhumed, they would have to be characterized prior to disposal and then shown to meet the performance objectives of the disposal facility. According to the Draft WIR Evaluation, DOE does not have plans to characterize the lines nor are they considered part of the base case technical analyses. While intrusion into a non-plugged line is more likely, the risk associated with a plugged line, if plugged lines are within the scope of the evaluation, should be calculated as part of the assessment. An acute intruder dose for plugged pipelines with inventory estimated at the time of plugging was not provided in the WMA C PA.

Path Forward
Please provide sufficient basis for the plugged pipelines inventory, taking into account when the pipeline plugged. Perform characterization or provide a characterization plan for determining the inventory of plugged pipelines. After the inventory for the plugged pipelines has been revised, then the pipelines would need to be classified consistent with RAI 3-2 and intruder dose assessment performed consistent with RAI 2-16.

RAI 2-6 (Radionuclide Inventory and Release Rates)

Comment
Some pipelines were taken out of service or replaced during operations, but the documents do not indicate what happened to a line when it was replaced during operations. The total amount of piping within the scope of the Draft WIR Evaluation has not been sufficiently established.

Basis
The WMA C system has an estimated ~11 km of waste transfer piping in C Farm according to the WMA C PA, though other reports indicate different values (ranging from 6.4 km and 119 pipes to 12.9 km and 230 pipes) (RPP-PLAN-47559). Problems with piping systems occurred and sometimes the lines were abandoned or replaced. For example, RPP-RPT-29191 stated "because of two apparent leaks in this line it has been abandoned as being unusable." Report RPP-RPT-38152 indicated that numerous piping changes involving the 244-CR vault ocurred.

The reports don't indicate what efforts DOE took to develop the inventory of piping that will be left in place under the Draft WIR Evaluation, or if a database of replaced and abandoned pipelines has been maintained. Various reports provide different estimates. It is not clear if when problems with piping occurred, that the replaced piping was tracked and has been included in the inventory of piping considered within the scope of the Draft WIR Evaluation.

Path Forward
Please describe the operational history of pipelines that were abandoned or replaced, including when they were taken out of service, if they were left in place, if they were included in the WMA C pipeline inventory, their construction materials, and their geometrical properties. Provide historical records associated with abandoned pipelines in WMA C.

RAI 2-7 (Radionuclide Inventory and Release Rates)

Comment
The inventory of waste assigned to pipelines is represented by two assumptions that have insufficient technical basis. First, pipelines are assumed to be 5% full of waste. Second, the piping is assumed to be represented by 7.6 cm diameter lines. Some piping is contained in encasements that can contain much larger amounts of radioactivity than would remain in the pipes themselves, but encasements were not evaluated. The DOE inadvertent intruder analyses for pipelines provides inadequate basis to support limiting the analyses to the 7.6 cm diameter lines and residual inventories based on 5% of the pipeline volume.

Basis
The assumption of 5% waste remaining in the transfer piping is based loosely on observations for much larger diameter piping described in DOE/RL-2003-11. The amount of residual waste in pipelines is likely to be highly variable based on the size of the pipe, the corrosion state of the pipe, and the amounts and types of waste transfers that occurred through the pipes. Pipelines that are "unplugged" today could readily transmit waste under a prescribed head but have a substantial loss in cross sectional area due to build-up of waste. Without characterization data the amount of waste remaining in the piping system is highly uncertain. Characterization work

of piping that was done for the plutonium finishing plant noted that build-up of solids in front of the camera eventually prohibited further observation of the piping system (PNNL-14144).

The Hanford piping has a variety of diameters ranging from ~ 4 cm to more than 15 cm with an average diameter of 10.8 cm (RPP-PLAN-47559; Sec. 4.1.5). The amount of residual waste in a 7.6 cm line would only be 25% of the amount of waste in a 15 cm line given the same fractional area of waste. While the 7.6 cm diameter line is most common, sufficient basis was not provided for limiting the evaluation to a single diameter line.

Some piping at Hanford is direct buried while others are encased. The encasements can be substantially larger than the pipe itself. Some of the trough-type encasements contain many pipes in the same encasement, such that multiple pipes could be intersected at once by an intruder. The trough-type encasements have 10 cm berms on either side and can be more than 100 cm wide. One report noted an encasement of 20 cm diameter for a 7.6 cm diameter line (RPP-ENV-33418). Piping has leaked at Hanford and it would not be unexpected that piping has leaked within the encasements of some pipes. Report RPP-RPT-38152 notes an encasement that likely contains waste. At an upper bound, a 7.6 cm diameter pipe that is 5% full of waste would represent only about 0.8% of the waste that would be inside one 20 cm diameter casing (outside of the pipe but inside the casing). Report RPP-RPT-29191 noted a leak that likely transported down an encasement and eventually entered C-101, C-102, and C-103.

The pipeline inventory is an important variable for evaluation of dose impacts to the inadvertent intruder.

Path Forward
Please provide additional basis for the 5% waste volume in the piping, or provide plans to characterize piping (even analogous piping removed from other decommissioned facilities) to verify the waste volume percent assumption for piping. Provide DOE's plans to verify the 5% assumption. Evaluate intruder impacts to larger diameter piping that may remain in the system. Provide a description of all encasements used for piping in WMA C. Provide characterization data for inventory that may have been released to piping encasements. Evaluate the potential impacts to intruders from waste remaining in pipe encasements.

RAI 2-8 (Flow and Transport in the Unsaturated Zone)

Comment
The amount, type, and impact of chelating agents in waste residuals were not provided.

Basis
Sorption of radionuclides to vadose zone and aquifer materials is a key process to limiting the risk to members of the public from residual wastes remaining in WMA C. Chelating agents have the potential to significantly alter expected radionuclide transport.

Organic compounds are present in waste and most were introduced as chelating agents (DOE, 1987). Some of the chelating agents used include hydroxyacetic acid, citric acid, hydroxyethyl ethylene diamine triacetic acid (HEDTA) and ethylene diamine tetraacetic acid (EDTA). Most of the organics and their degradation products are found in organic complexant waste.

NRC's low-level waste regulations (10 CFR Part 61) as well as waste acceptance criteria for DOE disposal facilities (e.g., The Environmental Restoration Disposal Facility Waste Acceptance Criteria [DOE, 2015]) explicitly prohibits most chelating agents in waste because of the potential impacts on system performance.

Observations from a low-level waste disposal facility found the in-situ Kd's for Co, Ru, and Sb isotopes were found to be significantly lower than published Kd's based on laboratory measurements (Fruchter, 1985). Complexes with both natural and manmade organic compounds in the groundwater were implicated, particularly with Co-60 (Fruchter, 1985).

Path Forward
Please provide the total quantity of each type of chelating agent present in WMA C wastes. Provide any experimental measurements at Hanford to quantify chelating agents concentrations and total organic content of waste residuals. Provide any experimental data generated at Hanford to assess the impact of chelating agents and organic wastes on radionuclide transport and grout durability, with particular emphasis on setting and curing. Discuss or demonstrate how the presence of chelating agents have been adequately incorporated into the WMA C PA.

RAI 2-9 (Flow and Transport in the Unsaturated Zone)

Comment
An insufficient basis is provided for the assignment of the H2 sand hydraulic properties to the degraded grout infill for the grout infill degradation sensitivity case analyses

Basis
For its base case, DOE has assumed that the grout infill within the waste tanks at closure remains intact and impermeable to flow throughout the 10,000-year analysis period. DOE conducted four sensitivity analyses to assess the impact of degradation of the grout infill that would allow advective flow of net infiltration through the degraded grout infill at 0, 500, 1,000 and 5,000 years post closure.

In these sensitivity case simulations, the grout infill is assumed be impermeable until the assumed failure time is met. Once the failure time is met, the grout infill is assigned the same hydraulic properties that are used for the H2 sand.

The modeling results for these sensitivity cases indicate that the assignment of the H2 sand hydraulic properties to the grout infill results in a contrast of hydraulic properties between the failed grout infill and the surrounding materials such that the flow of net infiltration is largely diverted around the tank waste residuals that underlie the grout infill. This may be a modeling artifact based on the contrast in properties. These results therefore suggest that the dose at the receptor location may be underestimated if the assumed hydraulic properties of the degraded grout infill are not accurate.

Path forward
Please provide additional support for the assignment of the H2 sand hydraulic properties to the failed grout infill or alternatively, conduct simulations that assign hydraulic properties to the failed grout that do not result in flow being diverted around the tank waste residuals. Provide the net infiltration depth profiles for these simulations.

RAI 2-10 (Flow and Transport in the Saturated Zone)

Comment
Additional information is needed to support a technical basis for using a relatively high hydraulic conductivity value for the unconfined aquifer.

Basis
The saturated hydraulic conductivity and the hydraulic gradient of an aquifer are important parameters for determining the degree of contaminant mixing and dilution in that aquifer. The amount of dilution in the aquifer is a key safety function with respect to protection of offsite members of the public. Section 8 in the WMA C PA shows that the saturated zone Darcy flux is an important parameter.

The scale used to determine the input parameter value can have a large influence on the final parameter value. DOE provided a figure in the WMA C PA (Figure C-1) which illustrates this fact for hydraulic conductivity values. DOE stated that, "Measurements of hydraulic conductivity appear to be dependent on the test scale, and increase as the scale increases, particularly in heterogeneous media." DOE further states that individual well-based slug and pump tests provide information at a relatively small-scale while the effects of large-scale heterogeneity on flow and determination of media properties can therefore be inferred most effectively by using regional scale groundwater.

DOE relied on a large-scale pump or treatability test, documented in DOE/RL-2015-75, and the calibrated values from the Central Plateau Groundwater (CPGW) model (CP-47631). The treatability test, as described in DOE/RL-2015-75, evaluated whether 189 and 379 liter per minute pumping rates could be sustained in the unconfined aquifer near the B Complex northeast of WMA C. The derived hydraulic properties from this treatability test were used to update part of a Central Plateau to Columbia River model. The distances of the particle pathlines within the simulated capture zone were generally well over a kilometer long. The model domain of the CPGW model encompasses much of the Hanford Site and is well over 20 km long and 10 km wide. The scale of interest for this WMA C PA are the points of calculations 100 m downgradient from WMA C. It is not clear why DOE decided that the hydraulic conductivities derived from a calibrated model on the scale of kilometers are regarded as more reliable than direct measurements by slug test or pump tests. In addition, there are differences in the conceptual hydrogeological models of the CPGW model and the STOMP model as discussed in RAI 2-13 which makes a direct comparison between the Hanford Site model and the WMA C model questionable.

Section 6 in the CPGW model document (CPP-47631, Rev. 2) discusses limitations of that model. Two of these limitations included:

- "The flow model is regional in nature. Hydraulic property variation is generally recognized at the scale of HSUs [hydrostratigraphic units] (km to 10s of km horizontally). At the scale of the HSUs down to the model grid scale (100 m), the eastern portion of the model is geologically more complex than the western portion of the model. Especially in the eastern portion of the model domain, these limitations of the scale at which variation is represented limits the scale that simulated results should be considered reliable as evidenced by two observations:
    - Model calibrations indicate that there are some regions of kilometer scale, such as the northeast corner of the model domain, where flow is not well-represented.
    - Review of flow simulations in the 200 East Area, at less than a kilometer scale, have revealed very poor agreement with interpreted flow directions.
- The model grid represents the aquifer with cells of dimension 100 by 100 m. It is expected that the model is most suitable for making predictions of heads, hydraulic gradients, and groundwater flow rates over areas that comprise many model cells, and that predictions of these quantities on scales smaller than 100 m are not reliable except in circumstances of uniform hydraulic gradients."

As shown in Figure C-6 of the WMA C PA, until recently, most DOE documents and sources provided a range of hydraulic conductivity values that were lower than the current average WMA C PA value of 11,000 meters per day (m/d). Previously, RPP- RPT-46088, Revisions 0, 1, and 2 (in Section 5) had given the general range of saturated hydraulic conductivity values for the unconfined aquifer as between 1000 to 3000 m/d with a recommended parameter value of 3000 m/d and using a recommended minimum and maximum of 100 m/d and 7000 m/d, respectively (RPT-46088, Rev. 1).

The Darcy flux sensitivity analysis in the WMA C PA uses a minimum value (4200 m/d) that is above the hydraulic conductivity values that were being recommended until recently. The uncertainty analysis uses minimum values that go down to 1000 m/d; however, the values used do not encompass a range that would capture the uncertainty associated with the saturated zone Darcy flux.

Path Forward
Please provide additional information to support the technical basis for the hydraulic conductivity value used for the unconfined aquifer beneath WMA C, or increase the range of parameter values for the saturated zone hydraulic conductivity in the uncertainty and sensitivity analysis so as to encompass the range of estimated or recommended values from recent WMA C saturated zone documents.

RAI 2-11 (Biosphere Characteristics and Dose Assessment)

Comment
The mass loading and soil ingestion parameters assigned to the acute intruder exposure scenarios may not be appropriate for the Hanford site.

Basis
DOE used a mass loading value of 6.66E-5 grams per cubic meter (g/m^3) based on NCRP Report No. 129. It is not clear that this value is appropriate for an arid environment where construction-type activities are taking place. For comparison, in development of the waste classification tables found in 10 CFR Part 61 NRC used a value of 5.65E-4 g/m^3 for a humid southeastern site to represent an acute intruder (NRC, 1981). The value NRC used for a chronic intruder was comparable to the value used by DOE. Chronic values tend to be lower due to the longer time periods without disturbances. In an arid environment soils are more easily suspended in the air and can be inhaled. Some drilling technologies are very "dusty" when limited drilling fluids are used. Likewise, the soil ingestion rate used was 100 milligrams per day based on OSWER Directive 9285.6-03. DOE used a larger soil ingestion rate for the offsite receptor.

Inhalation is an important exposure pathway for the inadvertent intruder.

Path Forward
Please provide additional technical basis that the mass loading and incidental soil ingestion rates are appropriate for the acute intruder exposure scenario at Hanford. Provide any relevant and available measurements from Hanford or analog locations to support the mass loading and soil ingestion values used in the WMA C PA.

<u>RAI 2-12</u> (Numerical Model Development and Assessment)

Comment
An insufficient basis was provided to demonstrate that the WMA C PA model is a valid representation of the system. It has not been demonstrated that the simplified WMA C PA model includes the real-world features in a sufficient or conservative manner to support decision-making.

Basis
The NRC staff has performed a risk-informed review of the Draft WIR Evaluation and WMA C PA. In order for the risk-informed process to be effective, the WMA C PA model should sufficiently represent the system. This RAI has two main components: simplification of real-world features and demonstration that the WMA C PA model is capable of generating results consistent with real-world observations, especially from past leaks and releases. Staff acknowledges that traditional model validation is generally not possible for performance assessment models, however model support is a necessary component of the assessment process.

Various reports document in-leakage (advection) to the tanks during past operations and that in-leakage continues into the present day (RPP-RPT-29191). Though the tanks are to be filled with grout for closure, the paths of in-leakage are not going to be specifically sealed. One of the most poorly-sealed parts of the systems appear to be the spare inlet ports (RPP-PLAN-47559, Rev. 0, Table 3-1) which in some cases are sealed with wood. The report RPP-RPT-29191 indicates that waste entered tanks from an external leak via tank pump pits. It appears that there are numerous advective pathways that are active in the systems that are not modeled as part of the base case, making the base case potentially insufficiently supported. Advective pathways combined with phenomena such as grout shrinkage may lead to release processes different and more rapid than the 1-D vertical diffusion simulated by DOE.

A number of past leaks and spills have occurred at WMA C. For example, Figure 4-5 of RPP-ENV-33418 Rev. 3 shows depth profiles of Co-60, Cs-137, and Eu-154. Model support for flow and contaminant transport may be developed by simulating past leaks and spills with the WMA C PA. The WMA C PA model, with modification to prescribe operational infiltration rates, should be able to generally replicate the observed transport profiles (relative transport of each isotope) over the observed timeframe. The WMA C PA model generally produces doses only from Tc-99 under ambient recharge conditions. Under select cases uranium isotopes can also produce impacts. The WMA C PA model should be able to roughly generate the observed vadose and saturated zone plumes when adjusting for recharge history but with minimal other changes.

The report RPP-CALC-60793 documents WMA C flow and contaminant transport model simulations supporting scoping analysis and future projected impacts of past waste releases. The simulations in this report were developed in an attempt to match observed temporal and spatial contamination and to obtain a reasonable approximation of the timing and magnitude of Tc-99 arrival in most of the monitoring wells surrounding WMA C. The results showed that the 10th percentile aquifer flux and the transient aquifer conditions with a counterclockwise rotation of the hydraulic gradient provided a reasonable approximation of the timing and magnitude of Tc-99 arrival in most of the monitoring wells surrounding WMA C.

Path Forward
Please provide additional model support for the WMA C PA model. Provide comparisons of key intermediate model outputs to observations of system performance made during the approximately 70 years of operations. For example, comparisons could be made to observed vs. simulated in-leakage to tanks and the 244-CR vault (i.e., compare the Darcy fluxes through and below the waste layer in the base and degraded cases to in-tank and in-vault leakage rates consistent with water level changes). The report RPP-ENV-33418, Rev. 3 provides subsurface contaminant characterization data that may be used to develop model support for the WMA C PA model, especially contaminant transport.

RAI 2-13 (Numerical Model Development and Assessment)

Comment
Differences in the conceptual hydrogeological models near WMA C between the regional CPGW model and the WMA C STOMP model are considerable and some of the techniques for abstracting information and data from the CPGW model to the STOMP model require additional information. Additional information is needed on the calculated groundwater flux into the STOMP model and on the water budget from that model.

Basis
The saturated hydraulic conductivity and the hydraulic gradient of an aquifer are important parameters for determining the degree of contaminant mixing and dilution in that aquifer. The amount of dilution in the aquifer is a key safety function with respect to protection of offsite

members of the public. WMA C PA Section 8 shows that the saturated zone Darcy flux is an important uncertain parameter.

The Darcy flux is obtained by multiplying the hydraulic conductivity of the hydrostratigraphic unit by the hydraulic gradient. The CPGW model provides calibrated hydraulic conductivity estimates for the hydrostratigraphic units present within the saturated zone (CP-47631) and the STOMP model obtains its parameter values by applying the equivalent homogeneous medium (EHM) approach to the calibrated CPGW model values so that the STOMP saturated zone is represented with the weighted average hydraulic conductivity values (Table C-1 in the WMA C PA) from the CPGW model. The CPGW model and the STOMP model, however, have different hydrostratigraphic units representing the saturated zone under WMA C. The hydrogeology for the base case in the WMA C PA assumes the existence of a paleochannel and an unconfined aquifer composed of undifferentiated gravels. The CPGW model assumes that distinct layers with different hydraulic properties (Figure C-9 in the WMA C PA) are present. It is not clear how the calibrated hydraulic conductivity values of the CPGW model would have changed if the STOMP stratigraphy had be used in CPGW model near WMA C. The number of cells in the CPGW model layers 6 and 7 are evenly divided and represented by the Ringold A formation, the Cold Creek unit, and the coarse-grained Hanford formation at WMA C. Since DOE is relying on the calibrated hydraulic conductivity values from the CPGW model, it is not clear to NRC staff why the distinct hydrostratigraphy of the CPGW model was not adopted in the WMA C PA. In addition, it is not clear if the entire upper 5 m of the CPGW model aquifer is located in Hanford formation at the points of calculations 100 m downgradient from WMA C.

The calibrated hydraulic conductivities of the Cold Creek unit (400 m/d) and the Ringold A formation (4.8 m/d) from the CPGW model (CP-47631) are considerably less than the calibrated Hanford formation values. Calculations of the weighted average hydraulic conductivity values change the original CPGW model values of both these units to an equivalent hydraulic conductivity for the entire layers to 5802 m/d. The upper aquifer layers (layers 4 and 5) of the CPGW model include the Cold Creek unit with a calibrated value of 400 m/d. The resulting equivalent hydraulic conductivities for those layers are 5,933 to 14,233 m/d.

Additional information is needed on the approach for deriving groundwater flux for use in the STOMP model. By evaluating the water budget in the CPGW model through a planar rectangular window similar to the WMA C flow domain over the unconfined aquifer thickness, a Darcy flux is estimated. This CPGW model volumetric flux calculation window does not align with the orientation of the northern boundary of the WMA C STOMP model used in the WMA C PA (Figure C-5 in the WMA C PA). It is not clear how much this misalignment influences the groundwater flux estimate since the greater the angle of misalignment the less realistic the flow estimate will become.

Additional information is needed on the approach whereby the original prescribed upgradient flux (saturated hydraulic conductivity x hydraulic gradient) for the northwest boundary condition in STOMP is increased by 53% to account for a thickening of the unconfined aquifer along the flowpath due to the uneven elevation of the top of the basalt from the northwest to southeast STOMP boundaries. Since dose is directly influenced by the degree of groundwater dilution, and the approach increases the groundwater flux, a technical basis for the approach is required. Although WMA C PA Section D4.1.1 and Table 6-12 discuss and demonstrate the mechanics of the approach, references pertaining to the applicability the approach or as its use as standard practice were not provided.

The WMA C PA did not provide water budget tables for the STOMP model at intermediate and steady states. The balance between the inflow and outflow, or the imbalance between the two, can be a good indicator for potential numerical difficulties.

Path Forward
Please provide information demonstrating that the EHM approach for obtaining saturated hydraulic conductivity values in the STOMP model does not result in excess aquifer dilution. Provide information demonstrating that the misalignment between the CPGW model volumetric flux calculation window and the northern boundary of the WMA C STOMP model does not significantly affect performance.

Provide a technical basis for the applicability of the approach that increased the Darcy flux into the STOMP model by 53% over that provided by the CPGW model. Provide a water budget table for the STOMP model at intermediate and steady states, or at different time steps, that includes inflow at the surface and inflow/outflow at the five aquifer boundaries whereby three boundaries are assumed to be no-flow.

RAI 2-14 (Sensitivity and Uncertainty Analyses)

Comment
The approach to sensitivity and uncertainty analyses does not provide a complete assessment of uncertainty and variability.

Basis
DOE developed a deterministic base case model which uses the code STOMP for flow and contaminant transport. Best estimate parameter values were used in the deterministic base case model. The performance assessment model was developed with the software package GoldSim to integrate the STOMP results and produce radiological dose estimates. The base case model was supplemented with a probabilistic system model (developed in GoldSim) to evaluate parameter uncertainty. In addition, alternate cases were evaluated to examine other sensitivities.

There are a large number of uncertainties that are not reflected in the base case, limiting its usefulness for decision-making. Some of these include but are not limited to:

- Long-term infiltration rates (e.g., sand dune formation, plant evolution)
- Performance of the yet to be designed engineered cover
- Erosion performance of the engineered cover
- In-leakage to systems and advective release
- Lateral diffusion from the source term
- Grout shrinkage of the yet to be designed grout
- Organics impacts on waste release and retention of radionuclides

- Sulfate impacts on grout
- Presence of chelating agents in the waste
- Corrosion of penetrating steel
- Integrity of the basemat concrete
- Seismic impacts on performance
- The representativeness of tank sampling
- The uncertainty in the inventory modeling systems
- The uncertainty in the saturated zone hydraulic conductivity

The DOE sensitivity analysis was primarily focused on parameter variability and to a lesser extent epistemic uncertainty. The sensitivity cases were generally one-at-a-time evaluations to look at specific uncertainties, such as grout performance. Because the Hanford site is complex and there are a large number of uncertainties (both parameter and model/conceptual), this approach may not identify key combinations of uncertainties that are risk-significant. Uncertainties and variabilities normally can't be evaluated in isolation in a system model. For example, the sensitivity case presented in WMA C PA Figure 8-49 examined the impact from the amount of Tc-99 released from the waste instantaneously. The response should scale almost linearly with the release fraction, however there is no impact going from 6% to 100%. This is because the Tc-99 that has been released from the waste and is available for transport must diffuse out of the system. With no advection assumed there is no impact on the results. Any uncertainties associated with advective flow in the system would potentially be additive with the uncertainties on the Tc-99 release fraction, but they wouldn't be identified unless the uncertainties are evaluated in combination.

Path Forward
Please perform a global sensitivity analysis combining both parameter and model/conceptual uncertainty. A full probabilistic uncertainty analysis including model uncertainty would provide key risk insights without compounding conservative assumptions. NRC staff understands the computational limitations associated with performing probabilistic simulations with the STOMP model. The global sensitivity analysis could be performed with the GoldSim system model.

RAI 2-15 (Sensitivity and Uncertainty Analyses)

Comment
The approach to inventory uncertainty does not reflect all important sources of uncertainty in the estimates of radionuclide inventory remaining in waste residuals.

Basis
DOE propagated variability in measured concentrations, densities, and volume to derive the uncertainty distributions in waste inventories, but did not include any uncertainty associated with the representativeness of waste tank sampling or uncertainty associated with use of the Hanford Tank Waste Operation Simulator and the Hanford Defined Waste (HDW) models (Higley, 2004).

In most cases, approximately two samples were obtained from each tank. Those samples reflect material that is removable and accessible by tank sampling equipment. Approximately

30% of the waste is fixed to the walls and stiffener rings. DOE indicated that they attempted to sample different types of waste residuals based on color, but that obstructions and reach of the sampling equipment created limitations. DOE is assuming that the samples obtained are completely representative of the waste residuals without any additional uncertainty propagation. The material on the walls may represent material strongly influenced by chemical and physical processes resulting from the temperature gradients on the tank boundaries.

The HDW model is used to provide inventory values for ~20 radionuclides. Comparison of pre-sampling waste radionuclide concentration estimates from HDW with post-sampling waste concentrations from measurements show high uncertainty associated with use of HDW estimates, for some isotopes orders of magnitude. That uncertainty has not been included in the uncertainty analysis. The amount of uncertainty in DOE's approach is much lower.

DOE has developed estimates of the inventory of key radionuclides in WMA C over the past two decades. Those estimates show relatively high volatility.

Path Forward
Please provide a full uncertainty evaluation for radionuclide inventory that includes the representativeness of the tank samples and use of the HDW model. Provide sampling results of material from other tank farms or removed equipment or piping that supports the assumption that the composition of waste sampled is representative of material that can't be sampled, such as material hardened onto walls at the operational interface between the waste layer and the void space. Examination of the time series of estimates of key radionuclide concentrations in WMA C waste residuals may provide insights of the temporal uncertainty in inventory estimates.

RAI 2-16 (Inadvertent Intrusion)

Comment
DOE did not provide the acute intruder doses from disturbance of a plugged pipeline, or from intrusion into diversion boxes. The thickness of waste used to assess the inadvertent intruder in the 244-CR Vault appears to be too low. Intruder dose calculations may need to be revised pending resolution of other requests for additional information.

Basis
DOE indicated that the dose to a chronic intruder (rural pasture exposure scenario) is 160 mrem/year at 100 years from intrusion into a plugged pipeline. DOE did not provide any results for impacts to the acute intruder. It is not clear why the rural pasture exposure scenario would be most limiting exposure scenario when for every other source type the suburban gardener exposure scenario is the most limiting of the chronic exposure scenarios. The acute driller dose impacts are larger than the chronic dose impacts by a factor of 2.5 to 3.8.

The evaluation of the 244-CR vault assigned an area of 162.4 m^2 which results in an average waste layer thickness of 2.5 cm. The waste layer in tank CR-011 inside the 244-CR vault is much thicker and at the assumed 90% waste removal would be anticipated to be much thicker than 2.5 cm used in the analysis.

Path Forward
Please provide the acute intruder dose impacts from disturbance of a plugged pipeline. Explain why the rural pasture exposure scenario is most limiting. Revise the thickness of the waste layer inside the 244-CR vault to show the different impacts depending on where the drilling could occur. Revise all intruder dose calculations following resolution of other issues raised by NRC.

<u>**RAI 3-1**</u> (Assessment of Waste Concentration and Classification)

Comment
DOE's basis for concluding that the waste will be incorporated into a solid physical form is insufficient.

Basis
Some wastes, such as residuals remaining in tanks or other ancillary equipment, are in liquid form. DOE plans to fill the tank structures with an as yet to be determined grout formulation to fill the void space. DOE did not discuss how their closure plans will ensure liquids are incorporated into a solid physical form.

Path Forward
Please describe the amount of liquids expected to be present in each tank and ancillary equipment at closure. Provide DOE's basis that residual liquids will be incorporated into a solid physical form.

<u>**RAI 3-2**</u> (Assessment of Waste Concentration and Classification)

Comment
DOE's calculations that demonstrate the waste residuals do not exceed the applicable concentration limits for Class C low-level waste as set out in 10 CFR 61.55 were incomplete. All components remaining in WMA C were not classified.

Basis
DOE used site-specific averaging factors to estimate the concentration of radionuclides remaining in the system to compare against Class C limits. In Section 6 of the Draft WIR Evaluation DOE did a good job describing the approach they used, based off the information provided in NUREG-1854 (NRC, 2005). As described on page 6-9, they used a ratio of the concentrations found in 10 CFR 61.55 to the waste concentrations after drilling by the intruder multiplied by the ratio of their estimated intruder dose to 500 mrem.

The NRC had developed an approach for staff to use to review DOE waste determinations that accounts for the differences in disposal configuration of the waste (i.e. deeper and possibly less accessible) as well as the use of modern dosimetry. The 10 CFR 61.55 concentrations are based on ICRP-2 dose methodology and limiting organ doses, as well as a large number of other assumptions. In the approach provided by NRC in Appendix B of NUREG-1854, the guidance is not clear.

Whereas the output concentrations of the NRC analysis performed in 1981 corresponded to limiting organ doses (e.g., 500 mrem whole body, 1500 mrem liver), those concentrations had a variety of modifications based on public comment and other technical considerations (NRC, 1982). For example, it was assumed that not all the waste that is disposed in a low-level waste facility would be at the Class limit. As a result allowable concentrations were increased by a factor of 10. While these modifications are embedded in the factors discussed and known to NRC staff, they are generally not as well known by external stakeholders. In other words, some of those assumptions should be "backed out" for the approach used by DOE.

The simplest approach would be for DOE to use the concentration of each radionuclide in each residual waste layer and calculate the ratio to the Class A limits, then use a sum of fractions approach. The Class A limits assumed access at 100 years. The difference between the Class A values and the Class C values are primarily an extra 400 years of decay. However as previously noted, the Class C values were also increased from what was calculated to take credit for the assumptions that not all the waste would be at the class limit and the waste would be more inaccessible. Next, DOE could account for the different dilution factor and accessibility of the waste by calculating the drilling dilution factor (for example a 2.5 cm waste layer divided by a 79 m aquifer depth would be a factor of 0.00032) divided by the product of the two dilution factors embedded in the Part 61 calculations (0.254*0.5 = 0.127) (NUREG/CR-1759 Vol. 3). Finally, for waste that is more inaccessible DOE could calculate the radioactive decay from 100 to 500 years for each radionuclide, followed by a sum of fractions on the results.

DOE did not provide classification calculations for diversion boxes, pits, and plugged pipelines. Because the intruder calculations for the 244-CR vault used an average waste thickness, each tank within the 244-CR vault should be classified using known waste thicknesses and not the average over the whole area of the vault.

Path Forward
Please revise the waste classification calculations to properly account for the assumptions embedded within the original Part 61 calculations. Provide the classification of the diversion boxes, pits, and plugged pipelines. Revise the classification calculations for the 244-CR vault.

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