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August 5, 2015

Mr. Charles W. Maguire, Division Director
Radioactive Materials Division
Office of Waste
Texas Commission on Environmental Quality
P.O. Box 13087
Austin, TX 78711-3087

SUBJECT: PEER REVIEW COMMENTS ON THE WASTE CONTROL SPECIALISTS LLC PERFORMANCE ASSESSMENT

Dear Mr. Maguire:

In our discussions, you requested a peer review of a preliminary performance assessment prepared by Waste Control Specialists LLC (WCS) of potential radiological impacts from the proposed disposal of Greater Than Class C (GTCC) low-level radioactive waste.

While no conclusions have been made, the U.S. Nuclear Regulatory Commission (NRC) staff provides these comments in the enclosure to provide NRC technical insight on the WCS preliminary performance assessment to the Texas Commission on Environmental Quality (TCEQ).

Please note that this letter is not responding to your January 31, 2015 letter, “Authority and Jurisdiction re Greater-Than-Class C (GTCC) type of waste streams”. The questions you asked in the January 31, 2015 letter are currently before the Commission (SECY-15-0094) on whether the State of Texas should be allowed to exercise its authority (through Commission approval via 10 CFR 61.55(a)(2)(iv)). The NRC will respond to that letter separately.

Should you have any questions concerning this response, please contact Melanie Wong at (301) 415-2432.

Sincerely,

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Larry W. Camper, Director
Division of Decommissioning, Uranium Recovery,
and Waste Programs.
Office of Nuclear Material Safety
and Safeguards

Enclosure:
Comments to the Performance Assessment

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Enclosure:
Comments to the Performance Assessment

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**Preliminary Peer Review of Waste Control Specialists LLC (WCS) Performance Assessment of Greater-Than-Class C (GTCC) Disposal**

**Overview:**

Texas Commission on Environmental Quality (TCEQ) requested that the U.S. Nuclear Regulatory Commission (NRC) staff perform a peer review of the model submitted to TCEQ by its licensee, Waste Control Specialists LLC (WCS) for the purpose of evaluating the safety of Greater-Than-Class C (GTCC) disposal at the Andrews County, Texas site. The model was developed in GoldSim[1], a software application for conducting dynamic, probabilistic simulations to support management and decision-making in business, engineering and science. TCEQ staff provided to the NRC staff the model that was developed in GoldSim (hereafter referred to as the GoldSim model), and at a later date, documents describing the licensee's model (NRC's Agencywide Documents Access and Management System (ADAMS) Accession No.: ML15180A321). The NRC staff reviewed the GoldSim model and associated documents provided by TCEQ staff.

Because the model is large and staff did not have access to all of the supporting licensing documentation, the results that follow should be considered to be limited and may be subject to revision if additional review by the NRC staff is requested. In addition, if the concerns documented here are addressed, that does not necessarily mean the model is sufficient to support licensing decisions. The regulatory authority for disposal of GTCC waste has the responsibility to perform the technical review of the model and determine its adequacy for decision making.

**Process Recommendation:**

The licensing process should be as transparent as possible. If not prohibited, for example because information is proprietary, the licensee's basis for the licensing decision should be publically available as well as TCEQ's safety analysis of the licensee's information. TCEQ may want to perform their own independent analysis to verify the licensee's calculations. In addition, TCEQ should test and evaluate the licensee's model by running their own scenarios.

**Technical Recommendations:**

1) The model file provided to the NRC staff (WCS Site Model v0.205.gsm) is clearly identified as a preliminary model under active development. The contractor who developed the model (Neptune and Company, Inc.) provided very clear disclaimers in the model file that the results are not certified or finalized, that the model is a preliminary version, and nothing should be considered definitive or predictive. Therefore, the quality assurance status of the model appears to be unqualified.

   ***Recommendation: The results of the model should be qualified by WCS and the qualified results reviewed by TCEQ prior to making any licensing decisions. License conditions can be used to verify assumptions or verify data, but cannot generally be used to address quality assurance or completeness issues unless independent information can be used to make a safety determination.***

[1] GoldSim is a registered trademark of the GoldSim Technology Group LLC.

2) The documentation of the model is incomplete. For instance there is not a discussion of the inventory that is being evaluated in the model and how it was developed (e.g. waste streams, composition, volumes). The documentation does not provide a discussion of the scenario analysis process. Though a variety of different receptor scenarios are included, the scenarios for evolution of the disposal system and site are not presented, for instance, with respect to erosion or other disruptive processes and events (such as seismic events). Please see comment #13 for more specific examples with respect to evolution of the engineered system.
   ***Recommendation: Ensure the licensee provides a complete set of documentation describing the model, data sources, assumptions, uncertainties, and model support. The licensee should describe their scenario development process and provide a basis for eliminating features, events, and processes that are generally relevant to low-level waste disposal.***

3) A large number of parameters in the model are clearly identified within the model file as "placeholder" inputs (e.g., Radon_EP_Ratio, Alpha_Residence, numerous biosphere parameters, distribution coefficients [Kd], solubilities). For many of the placeholder inputs however, no reference is provided to the source of the data.
   ***Recommendation: The licensee should verify all placeholder inputs and provide a reference to the data sources for TCEQ to review. Licensing decisions should not be based on the model containing placeholder inputs unless the licensee or TCEQ can demonstrate that the parameters are appropriate or the cumulative impact on the results is not significant.***

4) The cement transition times are calculated using a mass balance approach based on the number of pore volumes of water that reaches the concrete. The infiltration rates are from HYDRUS modeling and are 0 mm/yr for 100,000 years under the base scenario. Therefore, the calculated cement transition times are greater than $1 \times 10^{35}$ years. The only concrete degradation mechanism represented in the calculation is leaching. The basis for not including any other degradation mechanisms is not provided (e.g., carbonation, sulfate attack, radiation damage, seismic events, and biologic corrosion).

   The cement transition times should be estimated considering the reactive pathways of the fluids, not the whole volume of the concrete in the system. It is likely that flow will be in areas of higher relative permeability. Depending on the geometry of the system, infiltration can be focused into a single fracture. Therefore, only a portion of the concrete in the system provides active buffering capacity and the transition times estimated can be much shorter. Model support for the estimated transition times is needed. Also, there is no model support for the man-made concrete persisting for an indefinite period in nature. Our concern with the approach to modeling the geochemical impacts of the concrete on the retention of radionuclides was expressed to TCEQ staff during the 2014 Integrated Materials Performance Evaluation Program (IMPEP) review.

***Recommendation: Other degradation mechanisms should be evaluated to estimate the geochemical performance of the cement. Considering the lack of model support for the very long term results, more conservative modeling approaches should be considered. The significance of the modeling approach should be clearly understood, especially the dimensionality of the problem and the potential presence of discrete features. In general, a one-dimensional approach using the total volume of cement is not adequate.***

5) The uncertainty for some aspects of the model are not represented. Some stochastic distributions are set as discrete values as a placeholder for a future probability distribution. The model and documentation does not describe the overall approach to consideration of uncertainty (i.e. why some parameters are assigned distributions and others are not). For example, the unsaturated properties of the system appear to be assigned deterministically with no consideration of uncertainty. Unsaturated properties are typically inferred from a variety of measurements, and are commonly quite uncertain. ***Recommendation: The licensee should provide a description of the approach to characterizing and representing uncertainty in the model. The local and global impact of uncertainty should be discussed, including both parameter and model uncertainty. Areas with little model support should either be demonstrably conservative or include a large amount of uncertainty.***

6) The approach to modeling air pathway doses uses a box model approach with an average annual wind speed of 3.1 m/s. This approach does not account for the variation in wind speed (e.g., hourly, daily, and seasonal). With a large area source, the concentrations in the air for an onsite individual are dominated by the calm periods of wind and not by the periods of high flow. The flux rates from the surface can be impacted by wind speed but are not directly connected in the model. The approach used is generally significantly non-conservative for moderately windy locations. The box model approach with mean annual wind speed combined with the very low values assigned to resuspension flux rates, result in soil mass loading concentrations of approximately $1 \times 10^{-7}$ g/m$^3$. In an arid environment, soil mass loadings are generally much larger by orders of magnitude. The concern with the approach to modeling the atmospheric concentrations of radionuclides was expressed to TCEQ staff during the 2014 IMPEP review.

   ***Recommendation: If the air pathway is a significant contributor to dose, the box model approach should be justified or otherwise not be used. In addition, the soil mass loading values should be carefully evaluated to determine if they are representative for an arid Southwestern site under current and future climate conditions and land use practices.***

7) An approach to consider the probability of an intruder is provided in the main control panel for the model. However, the probability of an intruder is already implicitly accounted for in NRC's regulations by assigning a higher annual dose limit to the intruder (500 mrem [5 mSv]) for the calculations used to derive the waste classification system compared to the annual dose limit required to protect a general member of the public (25 mrem/yr [0.25 mSv]).

   ***Recommendation: Ensure that credit is not taken for the probability of intrusion. If it is, then use the probability of intrusion in combination with a (25 mrem/yr [0.25 mSv]) dose limit***.

8) As noted in Concern #3 above, the infiltration rate that penetrates to the waste (i.e., recharge) assigned in the base scenario is 0 mm/yr for 100,000 years. This is based in part on HYDRUS[2] modeling. Zero net advective flux is the most optimistic result as liquid phase advection does not occur in either direction (up or down). The model is constructed to use liquid saturations and recharge rates from HYDRUS simulations. Therefore, the ability to test sensitivity of the model results to changes in infiltration rates is limited because assignment of a proper liquid saturation profile is technically challenging without running HYDRUS.
   The NRC staff did not have access to the licensing basis for the assigned infiltration rates. Quite a bit of research has been performed using a variety of techniques to estimate recharge rates in arid environments. Scanlon (2006), Phillips (1988), and Knowlton (1989) provide some of this information. Isotopic studies have observed that tritium has traveled more rapidly than chlorine-36, and a variety of explanations have been proposed. Irrespective of the uncertainty in the correct interpretation, it is clear that vapor phase transport (water) plays some role.

   Scanlon (2006) performed a survey or a large number of studies and estimated that recharge generally spans 0.1 to 5 percent of precipitation and 1 to 25 percent of irrigation in arid locations. These results could be considered to be analog information. It appears the model uses the 0 mm/yr recharge rate for all future land uses. Calculation of liquid and vapor fluxes can be non-unique when inferred from observations of liquid saturations and moisture potentials, particularly in very arid environments. The primary method to provide support is to use long-term isotopic studies combined with analog information. Isotopic studies should be performed with and without native plant species present. If plants are important, then the modeling process needs to be changed significantly.

   ***Recommendation: The licensee should provide technical basis for the long-term infiltration rates, including model support. If the natural recharge rates are anticipated to be zero or extremely low, then features, events, and processes that may result in modification to the engineered and natural barriers should be considered (e.g. abandoned wells). The licensee should perform sensitivity***

[2] HYDRUS is a suite of Windows-based modeling software that can be used for analysis of water flow, heat and solute transport in variably saturated porous media (e.g., soils).

***analysis of the PA results to changes in infiltration rates, especially to ranges consistent with analog information. The infiltration rates and liquid saturation profiles should be consistent with the land use for each scenario (e.g. infiltration rates generally increase during farming).***

9) The GoldSim modeling uses some unique modifications to simulate diffusion in unsaturated media. For example, in most cases the diffusive lengths assigned are much larger than the thickness of the layers themselves. This could be a source of confusion for some stakeholders. The discretization of the large number of layers in the system is provided, with an attempt to provide a somewhat uniform cell thickness. It is not clear from the documentation how the appropriateness of the discretization of the system in the GoldSim model was determined. For example, the model is a one-dimensional representation and important phenomena with respect to infiltration may be two- or three-dimensional. The dimensionality of the system could be important for a process like radon (Rn) diffusion. If a typical house were modeled with a one-dimensional layer cake model, the estimated Rn concentrations would be significantly underestimated; the discrete pathways (e.g. fractures) control the results in most cases.

With no liquid advection, the diffusion calculations could be very important. Some results in the diffusion profiles are not intuitive. For example, C-14 in the evapotranspiration layer near the land surface peaks in only 35 years, but the very thin 1-cm topsoil layer over the evapotranspiration layer takes 40 more years to achieve peak concentration and when a peak is achieved it is approximately 150 percent less than in the evapotranspiration layer. Furthermore, decreasing the topsoil layer to 0.001 cm increases the observed concentration drop between the layers. It is not clear if the current implementation creates an artificial drop in the flux rates.

Furthermore, when the saturation profile is modified based on the change to naturalized properties, the projected concentrations throughout the profile instantaneously change. This is a non-physical result as it should take quite some time for the concentration profile to adjust to the new state of the system. When the properties of the cover change the concentrations in the concrete deep within the system should not change immediately.

Uncertainty in the tortuosity models is not propagated in the calculations, and page 7 of the groundwater modeling report (Neptune and Company, 2013) shows that even varying the different models does not preserve the large variabilities in observed tortuosity.

***Recommendation: The licensee should provide verification of the diffusion profile results, in light of the technical concerns mentioned above. Model support for the diffusion rates and fluxes should be provided. Technical basis for the dimensionality and discretization of the GoldSim model should be provided. Sensitivity analysis may be considered. The approach to tortuosity should preserve the observed variability in the data.***

10) The stochastic element, **CuttingsSurfaceDispersionArea,** is potentially quite large (20,000 $m^2$). This parameter is set equal to the Compact Waste Facility (CWF) area at the maximum, but is also applied to the Federal Waste Facility (FWF) and Resource Conservation and Recovery Act (RCRA) facilities even though they have different areas. ***Recommendation: The CuttingsSurfaceDispersionArea parameter should be verified and a technical basis for the parameter distribution consistent with the projected land uses should be provided.***

11) The model employs a discretization of the simulation time. ***Recommendation: The licensee should provide sensitivity analysis that demonstrates the results are not sensitive to changes in the temporal discretization of the model.***

12) All distribution coefficients (Kd) and solubilities are identified as generic/placeholders. The geochemical properties can have many orders of magnitude variability. The particular values that are appropriate for a specific site will be determined by a variety of factors.

    The geochemical modeling report states that it is assumed that the concrete may fail mechanically but will still provide geochemical control. This is true but only to an extent; it depends on where the waste is in relation to the concrete as well as the particular flow rate of water and pattern of water flow and its interaction with the concrete. Flow generally occurs around concrete and not through it if a more highly permeable path is available. The number of pore volumes used to estimate changes in geochemical conditions, citing U.S Department of Energy reports as the basis, is quite uncertain. The NRC staff has had numerous comments about those reports that should be considered.[3]

    Distribution coefficients for some radionuclides were developed by averaging values from different experimental studies. While this approach may preserve the range of observed values, the likelihood of a particular value within the range may be difficult to define when only a few studies are available. Differences between studies can be a result of a large number of factors. The value that is appropriate to estimate the “mean” risk from the site is likely not to be the simple average of the studies, unless it has been determined that the quality of each study was appropriate and the measurements from each study can be translated to the site-specific conditions. The approach described for developing Kd distributions is not appropriate if 1) site-specific measurements are not

[3] ML12212A192, *U.S. Nuclear Regulatory Commission Plan for Monitoring Disposal Actions Taken by the U.S. Department of Energy at the Savannah River Site F-Area Tank Farm Facility in Accordance With the National Defense Authorization Act for Fiscal Year 2005*, U.S Nuclear Regulatory Commission, Washington DC, January 2013.
ML13100A113, *U.S. Nuclear Regulatory Commission Plan for Monitoring Disposal Actions Taken by the U.S. Department of Energy at the Savannah River Site Saltstone Facility in Accordance with the National Defense Authorization Act for Fiscal Year 2005*, U.S. Nuclear Regulatory Commission, Washington, DC, Rev. 1, September 2013.

available 2) deterministic analysis is used for the licensing basis and 3) the results are sensitive to the assigned distribution coefficients. License conditions could be used to mitigate this uncertainty.

Technetium (Tc) solubility for reducing conditions is used in the model. Likewise, the solubility for chlorine is based on the potential presence of Ag-108m. Finally, the solubility for species in water or cement water is set to be the same, which may be in error. Some elements are more soluble under alkaline, high ionic strength solutions.

***Recommendation: The licensee should explain why generic geochemical values are representative for the site-specific application. Sensitivity analyses should be performed to demonstrate the impact of variability in the parameters. If the variability in Kds is propagated through the calculation, some values may need to be correlated to each other. The appropriateness of averaging the results of different studies for use in a deterministic analysis should be provided. If TCEQ does not have a license condition for the use of reducing cement, and technical basis for the persistence of the reducing conditions is not provided, then Tc solubility associated with reducing conditions should not be used.***

13) The scenarios of evolution of the site, while traditional, may need to be expanded for the unique types of wastes being considered for disposal. The presence of the disposal system, due to its size, may modify the natural system resulting in changes to future performance compared to past characterization studies. The temperature and moisture regime, especially relating to vapor flow and condensation, may be altered from the present natural system. In addition, it may not be conservative to assume engineered barriers fail. If barrier performance times are uncertain and estimated, the sequence of how barriers fail and when they fail may become important. The high-density polyethylene (HDPE) liner system may be more durable and effective than the infiltration cover, resulting in the potential for some “bath-tubbing” type of phenomena. Past projective analysis of disposal system performance at other locations have resulted in significant errors because the natural system can remain more impermeable than the altered area of the disposal facility, including the final cover system.

Because of the presence of a very thick cover, the risk from Rn-222 from depleted uranium is greatly reduced. However, this makes the results sensitive to things that could violate the cover system. Since oil and gas development is taking place in the region and those wells only have a defined development period or may not be economical, it may be informative to consider an abandoned well scenario. Even though the area of the well is small in relation to the cover the flux from one abandoned well can actually be larger than the flux from the whole cover. The doses from alternate scenarios should be understood.

***Recommendation: The licensee should evaluate the sensitivity of the results to alternative evolutions of the disposal system. The significance of the sequence of engineered barrier failure times should be evaluated. Model support should be provided for engineered barrier failure times.***

14) A number of parameters are defined in the model as stochastic.  It is not clear how the sensitivity of the model results to those parameters can be readily determined, as many of those parameters are embedded within localized containers.

***Recommendation:  The licensee should provide the results (sampled values) of all stochastic parameters in the model, such as by writing them to an output file or to an output element within GoldSim.  This will allow TCEQ to perform independent sensitivity analysis or to review the licensee's analysis.***

References:

Scanlon, B.R. et al, "Global synthesis of groundwater recharge in semiarid and arid regions," Hydrological Processes, **20**, 3335-3370, John Wiley and Sons, Ltd., 2006.

Philips, F.M., "Chlorine-36 Dating of Old Groundwater," New Mexico Institute of Mining and Technology, Socorro, NM, 1998.

Knowlton, R.G, F.M. Phillips, and A.R. Campbell, "A Stable-Isotope Investigation of Vapor Transport During Ground-Water Recharge in New Mexico," New Mexico Institute of Mining and Technology, Project Number 1345644, 1989.