March 28, 2016

Mr. Richard Bush
UMTRCA Program Manager
U.S. Department of Energy
Office of Legacy Management
2597 Legacy Way
Grand Junction, CO 81503

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION STAFF COMMENTS ON THE U.S. DEPARTMENT OF ENERGY REPORT ENTITLED "DRAFT GROUNDWATER FLOW MODEL FOR THE TUBA CITY, ARIZONA, DISPOSAL SITE" DATED FEBRUARY 2016 (DOCKET NO. WM-0073)

Dear Mr. Bush:

The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed the U.S. Department of Energy (DOE) report entitled "Draft Groundwater Flow Model for the Tuba City, Arizona, Disposal Site" dated February 2016 (Agencywide Documents Access and Management System (ADAMS) Accession Number ML16053A017). Based on our review, we have several comments and questions about the draft report.

As discussed in the report the objectives of the calibrated ground water flow model were to: 1) evaluate ground water flow patterns; 2) estimate travel times from the Tuba City disposal site to Moenkopi Wash, and, 3) simulate extraction system pumping with, and without, the injection of treated ground water. However, the report contains little hydrogeological data for the area north of Highway 160 and for the area south of Well 107. As such, the usefulness of any ground water travel time predictions from the Tuba City disposal site to Moenkopi Wash would be questionable. In addition, ground water flow paths are expected to be highly variable because of the complex bedding structure and contrasts in hydraulic conductivity and there is the possibility that fracture-controlled flow influences ground water flow and solute transport. Sensitivity analyses would provide more insight on the effect that specific parameter values have on the ground water flow model travel times.

In summary, the NRC staff agrees that the ground water flow model includes sufficient data about the area around the Tuba City disposal site to be able to use the model to simulate extraction system pumping with, and without, the injection of treated ground water and to evaluate ground water flow patterns in the upper model layers in and around the Tuba City disposal site. However, the NRC staff does not agree that there are sufficient data to evaluate ground water flow patterns away from the Tuba City disposal site, nor does the NRC staff agree that the model can reliably estimate ground water travel times from the Tuba City disposal site to Moenkopi Wash. The NRC staff suggests that sensitivity analyses be performed on various model parameters and boundary condition assumptions so as to determine which factors are the key drivers and to better understand how the ground water flow system works within the model domain.

In addition, on June 23, 2014, the NRC staff provided the DOE with comments on the draft ground water modeling work plan (ML14163A663). A number of the comments on the work plan included in our letter remain open because the draft ground water model report does not contain information relevant to those comments. Our comments and questions on the draft ground water model report and the previous comments on the work plan that have not been addressed are enclosed. We look forward to reviewing the revised report that addresses our comments.

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 ADAMS. ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html.

If you have any questions please contact me at (301) 415-6749 or by email at Dominick.Orlando@nrc.gov.

Sincerely,

/RA/

Dominick A. Orlando, Senior Project Manager
Materials Decommissioning Branch
Division of Decommissioning, Uranium Recovery
and Waste Programs
Office of Nuclear Material Safety
and Safeguards

Enclosure:
Staff Comments on
"Draft Groundwater Flow Model for
the Tuba City, Arizona, Disposal Site"

cc: Tuba City Distribution List

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Enclosure:
Staff Comments on
"Draft Groundwater Flow Model for
the Tuba City, Arizona, Disposal Site"

cc: Tuba City Distribution List

<u>DISTRIBUTION</u>: R. Evans, RI J. Whitten, RIV

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**NRC Staff Comments on the
"Draft Groundwater Flow Model
for the Tuba City, Arizona, Disposal Site" dated February 2016**

General Comments:

1. The purpose of sensitivity analyses are to quantify the effect of uncertainty in the estimates of boundary conditions and of parameter values associated with features and processes on the model results. Sensitivity analyses are an essential step in all modeling applications. This is especially true for the current ground water flow model, which suffers from data deficiencies in many areas. The Nuclear Regulatory Commission (NRC) staff suggests that the Department of Energy (DOE) perform sensitivity analyses of various model parameters so as to determine which parameters significantly influence model outcomes.

2. In addition to the data deficiencies, there are uncertainties related to future precipitation/temperature changes and to the conceptual model of flow and transport as presented in Sections 5 and 6 of the report. There may be alternative conceptual flow models that are as valid as the one presented in the report. Uncertainty analyses that evaluate possible future precipitation/temperature changes and alternative conceptual models would provide more confidence in the model's results.

3. On June 23, 2014, the NRC staff provided the DOE with comments on the draft ground water modeling work plan. A number of the comments on the work plan included in our June 23, 2014, letter remain open because the draft ground water model report does not contain information relevant to those comments. These comments are summarized below:

    a. Initial parameter values may be difficult to obtain for the less permeable zones of the aquifer vs. the zones of preferential flow. Information in previous ground water reports for the Tuba City disposal site have shown evidence of a possible fracture-dominated hydraulic connection between the disposal cell area and the lower terrace. Although such a feature could appreciably change the results of flow and transport model runs to the wash, this uncertainty was not analyzed in the 2016 ground water model report.

    b. Ground water inflow at the model's northern boundary parameter values may be difficult to obtain since the hydraulic conductivity may be unknown in the Kayenta-Navajo Transition Zone (KNTZ). The 2016 ground water model report stated that, "A remedial investigation in 2013 determined that local groundwater flow north and west of the site converges to Pasture Canyon (AMEC 2013). This observation supports the concept that a local groundwater divide coincides with the surface water divide north of the site." The NRC staff were not able to obtain or review this report to confirm this assumption.

    c. The base of the N-aquifer, (i.e., both the Navajo Sandstone and the KNTZ), is unknown, especially near the Moenkopi Wash so that it is unclear if all the ground water discharges at or near the wash.

    d. It is not clear if information exists on vertical anisotropy for the KNTZ because Table 8 on Page 35 of the 2016 ground water model report does not include information on vertical anisotropy below aquifer Horizon C.

Enclosure

It is possible that many of these parameters may not be critical for the intended purpose of the model outcomes, however the sufficiency of data, or the lack of data, should be discussed in the report.

Specific Comments

1. **Appendix B, Table B-1; Section 3.1, Page 10, and Figure 6, Page 15:**

   Very little information is known about the KNTZ and even less is known about the Kayenta Formation. Five wells (well numbers 253-257) that were decommissioned in 2005 were deeper than all other wells. Well numbers 253, 255, and 257 were deeper than aquifer Horizon M and reached the Kayenta Formation. Any additional information on the KNTZ and the Kayenta Formation obtained from these wells on stratigraphic composition, hydraulic properties, water chemistry, or water table levels measured within the screened interval could be valuable data for the ground water flow model and should be included in the model report. If information concerning these wells is no longer available or useful, that should also be briefly discussed in the report.

   In addition, Figure 6 (Page15) shows well numbers 968 and 971 with screen intervals from aquifer Horizon B down to greater than Horizon M. These deep wells, with potentially valuable information, are not discussed nor are they included in Tables B-1 and B-2 in the current report.

2. **Section 3.2.1, Page 15; Section 7.3.1, Page 65; and Plate 1**:

   This section states that, “East of the topographical divide, a portion of the watershed slopes toward a dry lake bed referred to as Greasewood Lake. Surface water runoff occasionally collects temporarily in this closed basin in wet seasons. There is no perennial inflow to or outflow from Greasewood Lake.” The majority of the Greasewood Lake watershed that lies outside of the model domain appears to flow into the Greasewood Lake and since this depression has no outflow, and no vegetation (see Section 7.3.1, Page 66), it is very probable that standing water would enter the model domain as recharge and increase the current water budget of the model. Section 7.3.1 states that, “Infiltration of runoff received by this depression is expected to flow southeast toward Moenkopi Wash.” Therefore, there may be an impact to the water budget and this should be evaluated.

3. **Section 3.2.1, Page 15; Section 7.3.1, Page 65; and Plate 1**:

   Plate 1 indicates that there is a topographical divide between the Greasewood Lake and Moenkopi Wash watersheds and it is not clear why the surface water divide between these two watersheds does not have the same effect on the ground water as the surface water divide between the Greasewood Lake watershed and the Pasture Canyon watershed. It is not clear why the report does not discuss the impacts of a ground water divide separating the Greasewood Lake and the Moenkopi Wash areas.

4. **Section 3.0, Page 9; Section 4.2.1, Page 32; and Table 6, Page 33**:

   Section 3 on Page 9 states that within the KNTZ, the classic Navajo Sandstone dune deposits become interbedded at depth with fine-grained, horizontally bedded alluvium more typical of the deeper Kayenta Formation. The Kayenta formation is considered to be an aquiclude. This would indicate that hydraulic conductivities should be less for the KNTZ than it would be for the Navajo Sandstone and Table 6 appears to show that this is the case. However, it does not appear that an effort was made to match the properties of the model with this hydrogeological insight and it was not considered during the model calibration process.

5. **Section 4.3.2, Page 40**:

   This section states that, "Recharge to the aquifer in the model domain is estimated as the difference between average annual precipitation, applied uniformly over the model domain, and estimated ET within the various delineated vegetation zones." Average annual precipitation rates are important parameter values since this is the most significant contributor to inflow for the model. However, no references or source materials are discussed when presenting the precipitation rates used for the model domain nor are seasonal or annual variabilities discussed that may influence recharge.

6. **Section 4.3.2.3, Page 41 and Table 20, Page 95**:

   Table 20 on Page 95 shows that the calculated recharge to Zone 1 (upland north of Highway 160) represents almost 50 percent of the water budget input, yet there is no discussion of this significant vegetation zone in Section 4.3.2.3. Such a discussion is especially important considering that Zone 1 was apparently not included in the original February 2015 evapotranspiration study (DOE (U.S. Department of Energy), 2015. Evapotranspiration within the Groundwater Model Domain of the Tuba City, Arizona, Disposal Site, Interim Report, LMS/TUB/S12694, Office of Legacy Management, Grand Junction, Colorado).

7. **Section 4.4.2.1, Page 45 and Table 13, Page 48**:

   The precipitation and evapotranspiration rates used in the water budget presented in Table 13 on Page 48 are mean annual rates, presumably taken over an entire year and multiple years, while the information on aquifer discharge to the wash appears to be based on three measurements and thus is not a mean annual rate. Due to the variability during the growing vs. non-growing season and of the regional meteorology, the amount of water discharging could vary depending on the season of the year and the weather pattern over a range of years. Therefore, a sensitivity analysis, or more data on the discharge to the wash, would improve the model output.

8. **Section 4.4.2.1, Page 45**:

   Section 4.4.2.1 states, "The stream gain is attributed to groundwater discharge from the Navajo Sandstone aquifer because no tributary sources are observed, and is assumed to occur from both sides of the wash in equal proportion."

   a. No hydrogeological information is presented on the upland area south of the Moenkopi Wash. Therefore, the assumption that ground water discharge is occurring equally from both sides of the banks of the Moenkopi Wash is not justified. A sensitivity analysis would help to determine if additional justification is needed to support this assumption.

   b. The KNTZ is not discussed although this is the unit that probably was meant instead of the "Navajo Sandstone aquifer." It is not clear that all the regional ground water empties into the Moenkopi Wash. If regional ground water continues to flow under, or bypasses, the wash, this would affect the water budget of the model. Relevant information supporting the current conceptual model of outflow to the wash should be discussed.

9. **Section 4.5, Page 47**:

   Section 4.5 states that, "The analysis indicates that the total rate of groundwater flow through the model domain is about 150 gallons per minute (gpm). This volumetric rate is approximately one-half of that presented in the [Site Observational Work Plan] SOWP (DOE 1998)." It is not clear why the current water budget is 50 percent less than that presented in the SOWP and an explanation of this difference would be useful.

10. **Section 5.0, Page 57**:

    Major assumptions are associated with several components of the conceptual model but supporting data is lacking. These components include:

    a. The site is located in a local hydrologic basin that is bounded by an up gradient ground water flow divide. (See comment general 2.b);

    b. Ground water flow from north of the divide is discharged westward to Pasture Canyon. (See general comment 2.b);

    c. The hydrologic basin is bounded downgradient by Moenkopi Wash. There is no ground water flow beneath the wash. (See specific comment 10.b);

    d. The local flow system does not extend into the Kayenta Formation; and

    e. All ground water within the hydrologic basin originates from precipitation within the basin. (See specific comment 2)

11. **Section 6.0, Page 59**:

    Section 6.0 states that, "LM is evaluating how these processes may affect contaminant transport at the site." These evaluations could have important ramifications on the results of future iterations of the model, and LM should discuss how the results of the evaluations will be incorporated into the final ground water flow model.

12. **Section 7.2.2, Page 63; Figure 30, Page 65 and Figure 6, Page 15**:

    Although no data was presented to support the location of the KNTZ/Kayenta interface, Figure 6 on Page 15 shows the interface rising several hundred feet from one end of the model domain north of Highway 160 to the other end of the model domain at the Moenkopi Wash. However, Figure 30 indicates that the model was constructed using a horizontal line to represent that interface. A sensitivity analysis may be needed to demonstrate how the difference in the bottom boundary condition might influence the output of the model.

13. **Section 7.3.2, Page 66**:

    It would be helpful if a flownet is presented to demonstrate that the "model domain is oriented such that the eastern and western boundaries are parallel to the predominant direction of ground water flow that occurs southeast of the flow divide."

14. **Section 7.4.2, Page 73 and Figure 36, Page 79**:

    Figure 36 on Page 79 shows the dearth of calibration points for this model south of the Greasewood area. The area around the disposal site appears to be well represented. However, this cannot be said for the area between the disposal site and Moenkopi Wash. This may pose a problem for meeting the stated objective of estimating the ground water travel times from the Tuba City disposal site to Moenkopi Wash. As Section 7.4.2 discusses, pilot points were used, however they cannot replace real data. In addition, the pilot points are assigned expected "typical" values rather than hydraulic conductivity values closer to the minimum and maximum extremes, although more water will flow within an area with interconnected maximum hydraulic conductivity values compared to an area with typical hydraulic conductivity values.

15. **Section 7.4.2, Page 71, Figures 5,6,30, 40 and 48 (numerous pages) and Section 3.2, Page 13**:

    a. Figures 40 and 48 show that model layer 1 was assigned higher hydraulic conductivity values in the floodplain and riparian zone along the Moenkopi Wash. Figures 5 and 6 indicate that the terrace alluvium is relatively thin and that model layer 1 in this area is basically representing the Navajo Sandstone (Aquifer Horizons A, B, and C) as shown in Figure 30. It is not clear why the sandstone should have such a high hydraulic conductivity value.

    b. Section 7.4.2, Page 74 states that, "Pilot points were not used to constrain the spatial distribution of hydraulic conductivity of the Moenkopi Wash floodplain alluvium. These sediments were assigned a homogeneous hydraulic conductivity of 100 ft/day." However, Section 3.2 states that, "terrace alluvium and dune deposits are not saturated." It is not clear why the high hydraulic conductivity values were assigned to a unit that is basically dry (and very thin).

16. **Section 8.1.3, Page 78**:

    The use of censor targets as shown in Figure 38 may be indicative of a calibration problem. If so, a discussion would be helpful on why this would not significantly affect the outcome of the model's results.

17. **Tables 16, 17 and 18, Pages 87, 92 and 93**:

    It is not clear why the model layer 1 hydraulic conductivity values in Table 18 are different than the model layer 1 values found in Tables 16 and 17.

18. **Section 8.2.4, Page 95**:

    It is not clear why the "Disposal cell drainage" inflow (0.6 gpm) in Table 20 is different than the "Disposal Cell: 1990 to 2001" inflow component (6 gpm) in Table 13.

19. **Figure 60, Page 100**:

    Figure 60 shows the equipotential lines of the calibrated model (the assumption is that the units are in feet). However, the lines intersect the ground water divide adjoining the Pasture Canyon watershed at almost right angles. This conflicts with the assertion that this line represents a ground water divide. If it is a divide, the water table map should show ground water flowing away from the divide since the divide represents a relative high point (or water table ridge) in the area.

20. **Section 8.4.1, Page 111**:

    Section 8.4.1 states that, "… because of the large number of particles (9,235) used in the evaluation individual particle traces are not visible, but instead the particle traces blend together to produce a "plume" of particle traces." It is not clear why fewer particles could not be used to better show the relative contribution from each model layer. It would be useful to show how much ground water is flowing in each model layer as it makes its way to the wash.

21. **Section 9.0, Page 115**:

    This section states that, "With regard to modeling objectives, the calibrated model can be used to evaluate groundwater flow patterns, to estimate travel times from the Tuba City disposal site to Moenkopi Wash, and to simulate extraction system pumping with and without injection of treated groundwater." The NRC staff agrees that the calibrated model could possibly be used to simulate extraction system pumping with and without injection of treated ground water, however the staff does not agree with the other two statements. Only the information around the disposal site is sufficient to be able to use this model for prediction of ground water flow because very little hydrogeological data is present for the area north of the Highway 160 and to the area south of Well number 107 (with the exception of well numbers 904 and 902). This gap between the disposal site and Moenkopi Wash is evident in Figure 36 on Page 79 and, as such, the usefulness of any travel time predictions from the Tuba City disposal site to Moenkopi Wash would be questionable.

22. **Section 11.0, Page 133**:

The second bullet under “Results” states, “Complex groundwater flow paths, arising from a wide range in hydraulic conductivity and vertical hydraulic gradients, account for the wide range in predicted groundwater travel time.” However, figures 40-46 and figures 49-54 do not show a wide range in hydraulic conductivities (with the exception of the disposal site area and near the wash). In addition, calibrated vertical gradients were not shown in the report.

23. **Section 11.0, Page 134**:

The last sentence in Section 11.0 states “It is therefore suitable as a supporting tool for evaluating future options for the groundwater remediation strategy at the Tuba City site.” The last 2 bullets in the section entitled “Conceptual Model of Solute Transport” on Page 58 state:

> “Groundwater flow paths are expected to be highly variable because of the complex bedding structure and contrasts in hydraulic conductivity.” and,
>
> “……The likeliness that fracture-controlled flow has no influence on ground water flow and solute transport at the site cannot be dismissed; however, the significance of this process has not been evaluated in detail.”

These factors can significantly speed up, or slow down, travel time to the wash. Sensitivity analyses would provide more insight as to the effect of these processes on ground water travel times from the disposal site to the wash.