UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 2, 2016

Mr. Robert Compernolle
President, FMRI
FMRI, Inc.
Number 10 Tantalum Place
Muskogee, OK 74403

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION REGARDING THE JUNE 10, 2016 SUBMITTAL FOR DERIVED CONCENTRATION GUIDELINE LEVELS

Dear Mr. Compernolle:

On June 10, 2016, FMRI, Inc. (FMRI) submitted a revision (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16166A041) to the information required by Condition 5A of the August 17, 2015 Forbearance Agreement (FA). Condition 5A of the August 17, 2015 FA stated:

> "FMRI shall submit to the NRC by December 31, 2015, revised Derived Concentration Guideline Level ("DCGL") values for the Muskogee site. The revised values shall address deficiencies identified in the NRC's Safety Evaluation Report ("SER") on the July 24, 2003 Decommissioning Plan (Agencywide Documents Access and Management System ("ADAMS") Accession No. ML033250083). If FMRI has not reached agreement with the NRC on the DCGLs by April 15, 2016, the NRC will determine the final DCGLs and amend FMRI's license accordingly."

While the above condition required FMRI to provide revised DCGLs that address deficiencies identified by the U.S. Nuclear Regulatory Commission (NRC) in the 2003 SER, FMRI did not acceptably address the deficiencies in its previous submittals dated December 14, 2015 (ADAMS Accession No. ML15351A474) and February 3, 2016 (ADAMS Accession No. ML16036A035). The NRC responded to this effect in correspondence dated January 19, 2016 (ADAMS Accession No. ML16013A020) and March 30, 2016 (ADAMS Accession No. ML16069A084). On April 11, 2016, FMRI requested an extension of the time requirements with regards to Condition 5A (ADAMS Accession No. ML16133A038). While the NRC did not previously respond to that request, FMRI should consider this correspondence as granting an extension of the time referenced in Condition 5A for 60 days after the issuance of this letter.

The June 10, 2016 submittal has been reviewed by NRC technical staff who require additional information to complete the evaluation. There are two Requests for Additional Information (RAIs) staff have identified at this time.

RAI-1

Regulatory requirement: Title 10 of the *Code of Federal Regulations* (10 CFR) Part 20.1402 states, in part, that a site will be considered acceptable for unrestricted use "... if the residual radioactivity that is distinguishable from background radiation results in a TEDE to an average member of the critical group that does not exceed 25 mrem (0.25 mSv) per year, including that from groundwater sources of drinking water, and the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA)."

Comment: Revised DGCLs for Elevated Measurement Comparisons ($DCGL_{EMC}$) are needed for soils and sediments incorporating changes made to the FMRI RESRAD model since the 2003 Decommissioning Plan (DP) was drafted, including any changes made in response to RAI-2. FMRI should either provide revised $DCGL_{EMC}$'s or provide adequate justification as to why this is not needed.

Basis: Licensees commonly use DCGL values during decommissioning to achieve the regulatory requirement of 10 CFR 21.1402. As indicated in the NRC Consolidated Decommissioning Guidance (NUREG-1757) Volume 2, Revision 1, Section 4.1, in general, licensees should provide values applicable to survey unit average concentrations (called $DCGL_W$ values), and values for small areas of elevated concentrations (called $DCGL_{EMC}$ values). Both $DCGL_W$ and $DCGL_{EMC}$ values[1] were included in the FMRI 2003 Decommissioning Plan (DP). The FMRI June 10, 2016 submittal included revised $DCGL_W$ values for soils and sediments but did not include revised $DCGL_{EMC}$ values for soils and sediments. However, the $DCGL_{EMC}$ values included in the 2003 DP are inconsistent with the revised $DCGL_W$ values in the June 10, 2016 submittal.

The ratio of the $DCGL_{EMC}$ value for a radionuclide to the $DCGL_W$ for that radionuclide is referred to as an area factor. Area factors are typically calculated by recalculating DCGL values for areas smaller than the area applicable for the $DCGL_W$. This process was documented in Section 5.2.1.4.3 and Appendix 5-2 of the FMRI 2003 DP. NRC staff used the $DCGL_{EMC}$ values in Tables 1 through 11 of Appendix 5-2 of the 2003 DP to back-calculate the area factors underlying the FMRI 2003 $DCGL_{EMC}$ values. NRC staff also independently calculated area factors relevant to the 2016 model by modifying the contaminated area in the FMRI revised (2016) RESRAD model. NRC staff then compared the two sets of area factors to determine whether the area factors underlying the $DCGL_{EMC}$ values in the 2003 DP were still applicable. However, the area factors underlying the 2003 $DCGL_{EMC}$ values were inconsistent with the area factors staff independently generated with FMRI's revised model. This outcome is expected because of the multiple parameter changes made between the 2003 DP and the June 10, 2016 submittal, which would be expected to change the area factors. Because the $DCGL_{EMC}$ values developed in the 2003 DP are no longer applicable, revised values should be submitted to NRC.

RAI-2

Regulatory requirement: 10 CFR 20.1402 states, in part, that a site will be considered acceptable for unrestricted use "...if the residual radioactivity that is distinguishable from

[1] $DCGL_{EMC}$ values are provided in Tables 1 through 11 of Appendix 5-2 of the FMRI 2003 DP.

background radiation results in a TEDE to an average member of the critical group that does not exceed 25 mrem (0.25 mSv) per year, including that from groundwater sources of drinking water, and the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA)."

Comment: To meet the 10 CFR 20.1402 regulatory requirement, additional revisions to the FMRI RESRAD model are needed to adequately consider the groundwater pathway. Additional sensitivity analyses should include sorption coefficients (Kd values) for the contaminated, unsaturated and saturated zones as well as the thicknesses of the contaminated and unsaturated zones and the well pump intake depth (screened thickness of the saturated zone). The range for the thickness of the unsaturated zone should account for excavated areas and variations in the depth of contamination. Either conservative or site-specific values should be used for parameters to which the dose is sensitive, in accord with the NRC Consolidated Decommissioning Guidance (NUREG-1757, Volume 2, Revision 1, Appendix I). FMRI should provide the noted revisions or provide adequate justification as to why the revisions are not needed.

Basis: To ensure that the residual radioactivity that is distinguishable from background radiation results in a total effective dose equivalent (TEDE) to an average member of the critical group that does not exceed 25 mrem (0.25 mSv) per year, FMRI developed concentration limits (CLs) for groundwater, DCGLs for soils and sediments, and DCGLs for equipment and building surfaces (FMRI, 2016). FMRI committed to applying the CLs for groundwater, DCGLs for soils and sediments, and DCGLs for equipment and building surfaces with a sum-of-fractions approach, such that the dose through all pathways and all applicable media does not exceed 25 mrem (0.25 mSv) per year. The CL values address existing groundwater contamination. To address the groundwater contamination that could occur from radionuclides leaching from contaminated soil and sediment, FMRI revised the RESRAD model for the soil and sediment DCGLs to include the drinking water pathway.

To accommodate the drinking water pathway, FMRI had to define or revise many parameters related to modeling groundwater. In the FMRI June 10, 2016 letter, FMRI indicated that it had not found adequate justification for several of the parameters used in the FMRI 2003 DP and proposed revisions of those values. In some cases, FMRI appears to have replaced values based on site-specific data with generic values from NUREG/CR-6697 (NRC, 2000) even though site-specific data typically are preferable to generic values. For example, FMRI changed the hydraulic conductivity of the contaminated zone, unsaturated zone, and saturated zone to 9.9 m/yr based on a mean value for generic soils given in NUREG/CF-6697 although this value is much lower than values given in Section 3.7.2.1 of the 2003 DP. In this case, FMRI tested the sensitivity of the projected peak dose to the hydraulic conductivity of the contaminated zone and saturated zone and found the parameter does not have a significant effect on dose. NRC staff confirmed that using the value from the 2003 DP did not significantly affect dose and also tested the hydraulic conductivity of the unsaturated zone with the same result. Therefore no additional information is needed about this parameter.

However, not all parameters relevant to the groundwater pathway were included in the FMRI sensitivity analysis included with the June 10, 2016 letter. FMRI excluded parameters relevant to the unsaturated zone from the sensitivity analysis on the basis that they only affect the time

until exposure and do not affect the projected dose. NRC staff finds this justification to be unacceptable because a significant factor reducing the projected dose within 1000 years of site release is the delay in contamination from the soil reaching the groundwater. NRC staff independently tested the sensitivity of dose to unsaturated zone parameters and did not find a significant effect of changing the density, total porosity, effective porosity, hydraulic conductivity, or b parameter of the unsaturated zone. Therefore, additional information is not needed for these parameters. However, more information is needed on the variation expected in the unsaturated zone thickness.

FMRI changed the modeled thickness of the unsaturated zone from the site-specific value of 9.1 m (30 ft) reported in the 2003 DP to the RESRAD default value 4 m (13 ft). As explained in NUREG-1757, Volume 2, Revision 1, Appendix I, Section I.6.4.4, the RESRAD deterministic default values are placeholders to allow the code to run and are not sufficient justification for a parameter value. In this case, NRC staff analysis showed that using the site-specific 9.1 m (30 ft) value had little effect on the DCGL values proposed in the FMRI June 10, 2016 submittal. Thinner unsaturated zones, however, did have an effect on the projected peak dose. Therefore, FMRI should justify whether the generic value is justified for the entire site or if a thinner unsaturated zone could be present (e.g., in excavated areas). The range of thicknesses of the unsaturated zone also should account for variations in the depth of contamination, since the uncontaminated unsaturated zone will be thinner if the soil is contaminated to a greater depth. The FRMI DP acknowledges that sections of the site have contamination deeper than 0.85 m (the value used in the FMRI RESRAD model) but states that the DCGLs are not sensitive to contamination depth. Section 5.2.1.3.3 of the FMRI 2003 DP states:

> "The sensitivity analysis results presented in Section 5.2.2.5 indicate that increases in either thickness or area of residual radioactivity do not substantially affect the peak annual TEDE to the average member of the critical group under an industrial use scenario. This is primarily because the external exposure pathway limits dose from residual radioactivity in soil at the Fansteel site."

Thus, if the dominant dose pathway were not external radiation, the sensitivity of dose to the thickness of the contaminated zone could be expected to change. This sensitivity is therefore important to re-evaluate when new exposure pathways, such as the drinking water pathway, are included in the analysis.

Like the unsaturated zone thickness, FMRI based the well pump intake depth (screened thickness of the saturated zone) on the RESRAD deterministic default value and excluded the parameter from its sensitivity analysis. Although the projected dose had not been sensitive to the parameter when the drinking water pathway was excluded from the analysis, the parameter could have more of an effect on dose when the drinking water pathway is included.

When the NRC staff conducted a sensitivity analysis using the FMRI model with alternate Kd values (see Table 2), the projected peak dose changed moderately with changes in the thickness of the contaminated zone, unsaturated zone, and well pump intake depth (screened thickness of the saturated zone). For each of these parameters, changes of approximately a factor of three yielded changes of approximately 50 percent in the projected peak dose. However, it is not clear if changes of a factor of three to these parameters are applicable to the FMRI site. Therefore, FMRI should include these parameters in a sensitivity analysis with a

range of values applicable to the FMRI site and choose conservative values for these parameters if the dose is sensitive to changes in these parameters, in accord with the guidance in NUREG-1757 Volume 2, Revision 1, Appendix I, Section I.6.4.4. Sensitivity analyses for these parameters should use appropriate Kd values, as discussed below.

In the 2003 DP, no references were provided for the Kd values used (see Table 5-5 of the FMRI 2003 DP). Therefore, FMRI based revised K_d values on generic guidance in NUREG/CR-6697 (NRC, 2000). FMRI used the geometric means of the distributions given in NUREG/CR-6697 Table 3.9-1 for generic soil. Some of the changes were significant (Table 1). NRC staff did not discuss the Kd values in the 2003 SER, presumably because the groundwater pathway was not included in the dose analysis. However, the Kd values are relevant to the concern NRC staff expressed in its March 30, 2016 letter indicating that parameter values may need to be re-evaluated to be justified for a scenario in which groundwater ingestion is included. Kd values can have a significant effect on DCGL values if groundwater ingestion is considered because they affect the rate of transfer of contamination from soils to groundwater.

Table 1. Soil-to-water partition coefficients (Kd values) used in the 2003 Decommissioning Plan and June 10, 2016 submittal.

Element	2003	June 2016	2016 value divided by 2003 value
U	2.18	126	58
Th	119	5884	49
Ra	3530	3533	1.0
Pb	2380	2392	1.0
Pa	4.8	380	79
Ac	1739	825	0.47

FMRI excluded the Kd values from the sensitivity analysis on the basis that: (1) the best available data were used; and (2) NRC found the groundwater pathway not to have a significant impact in its 2003 SER. NRC staff finds these justification to be unacceptable. The first justification is unacceptable because generic data were used and there is typically large uncertainty in generic Kd values. Therefore, the quality of this data is not a basis for excluding it from a sensitivity analysis. Furthermore, it does not appear that FMRI used the available site-specific information about soil texture to inform its choices about Kd values. Section 3.5.2 of the FMRI 2003 DP characterizes the site soil as predominantly "…silty and sandy clay, silt, fine sand, and coarse sand." Sandy soils often have lower Kd values than mean values for generic soils (see, e.g., Thibault et al., 1990). The second basis is unacceptable because, as NRC staff explained in the NRC March 30, 2016 letter, doses from the groundwater pathway were artificially lowered by unrealistic parameter selections used in the 2003 RESRAD model, such as an unsupported evapotranspiration coefficient of 0.99 which diverted almost all of the precipitation on site from reaching the groundwater. Therefore, the insensitivity of projected peak dose to groundwater in the 2003 model is not a sufficient basis for excluding parameters

related to groundwater dose from the 2016 revised model, especially given that the model is being revised specifically to include the groundwater pathway.

Because FMRI excluded Kd values from its sensitivity analysis, NRC staff performed sensitivity analyses for the Kd values. First, NRC staff used the Kd values that FMRI used in the 2003 DP (see Table 1) and found that DCGL values were not affected for isotopes of Ac, Th, Ra, and Pb. However, DCGL values were significantly lower (i.e., ranging from 0.3% to 3% of the values proposed in the June 10, 2016 submittal) for isotopes of U and Pa. This large difference in DCGL values occurred because the lower Kd values used for U and Pa in the 2003 DP allowed soil contamination to reach groundwater within 1000 years of site release, increasing the projected dose. Because no justification was given for the Kd values FMRI reported in the 2003 DP, it is unclear to NRC staff if these values are appropriate. Therefore, NRC staff conducted additional sensitivity analyses for the Kd values.

The NRC consolidated decommissioning guidance, NUREG-1757 Volume 2, Revision 1, Appendix I, Section I.6.4.4 states that it is appropriate to use the generic distributions provided in NUREG/CR-6697 as inputs to a sensitivity analysis. The decommissioning guidance (Section I.6.4.4) then states:

> "…if higher Kd values result in the larger dose, an input Kd value should be selected from the upper quartile of the distribution, or if lower Kd values result in the larger dose, an input Kd value should be selected from the lower quartile of the distribution. For those isotopes where the Kd does not have a significant impact on the dose assessment (i.e., Kd is not a sensitive parameter), the median value within the range is an acceptable input parameter."

Because FMRI excluded Kd values from the sensitivity analysis, it did not identify them as parameters to which the projected dose is sensitive. However, using the 25^{th} and 75^{th} percentile values of the generic distributions in NUREG/CR-6697 as input to a sensitivity analysis, NRC staff found that the projected dose is sensitive to the Kd values for isotopes of U and Pa. As shown in Table 2, choosing the more conservative of the 25^{th} or 75^{th} percentile values from NUREG/CR-6697 has a significant effect on the DCGL values for isotopes of U and Pa, and has very little effect on other radionuclides. Therefore, according to the NUREG-1757 guidance quoted above, median values would be acceptable for the other radionuclides but conservative values should be chosen for U and Pa. Alternately, site-specific values could be used.

Table 2. Soil and sediment DCGL values based on selection of 25th or 75th percentile values from NUREG/CR-6697

Radionuclide	25th or 75th Percentile Kd value based on Table 3.9-1 NUREG/CR-6697 (mL/g) (percentile)	DCGL value based on 25th percentile Kd values (pCi/g)	DCGL proposed in June 2016 submittal (pCi/g)
U-238 (Th-234, Pa-234m, Pa-234)	15 (25th)	56.0	1058
U-234	15 (25th)	53.4	2880
U-235 (Th-231)	15 (25th)	39.4	285
Pa-231	45 (25th)	7.91	34.2
Ac-227 (Th-227 to stable Pb-207)	90 (25th)	39.0	39.0
Th-232	70,000 (75th)	13.8	13.8
Th-230	70,000 (25th)	57.2	59.0
Th-228 (Ra-224 to stable Pb-208)	70,000 (75th)	27.5	27.5
Ra-226 (Rn-222 to Po-210)	11,000 (75th)	21.3	21.2
Ra-228 (Ac-228)	11,000 (75th)	24.5	24.5
Pb-210 (Bi-201 to stable Pb-206)	14,000 (75th)	780	780

References

NRC, 2000. Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes. U.S. Nuclear Regulatory Commission. NUREG/CR-6697.

NRC, 2006. Consolidated Decommissioning Guidance Characterization, Survey, and Determination of Radiological Criteria. U.S. Nuclear Regulatory Commission. NUREG-1757 Volume 2, Rev. 1.

Thibault, D.H., Sheppard M.I. and Smith P.A. 1990. A Critical Compilation and Review of Default Soil Solid/Liquid Partition Coefficients, Kd, for Use in Environmental Assessments. Atomic Energy of Canada, Limited.

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Please contact Mr. Greg Chapman if you have any questions concerning the above. He can be reached at (301) 415-8718 or via e-mail at Gregory.Chapman@nrc.gov.

Sincerely,

/RA/

Matthew Meyer, Acting Chief
Materials Decommissioning Branch
Division of Decommissioning, Uranium
Recovery, and Waste Programs
Office of Nuclear Material Safety
and Safeguards

Docket No. 40-7580
License No. SMB-911

cc: Christina England, NRC/OGC
Pam Dizikes, Oklahoma Department of
Environmental Quality
Richard Gladstein, Department of Justice

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Please contact Mr. Greg Chapman if you have any questions concerning the above. He can be reached at (301) 415-8718 or via e-mail at Gregory.Chapman@nrc.gov.

Sincerely,

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