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MEMORANDUM

TO: File

THROUGH: Phil Goble, Manager

FROM: Tom Rushing, P.G.

DATE: February 16, 2016

SUBJECT: Review of the Energy Fuels Resources (USA) Inc. Source Assessment Report for Monitoring Well MW-31, White Mesa Uranium Mill
Ground Water Permit No. UGW370004

I. Review Summary:

A December 9, 2015 Source Assessment Report ('SAR") for Selenium, Sulfate, TDS and pH in Monitoring Well MW-31was submitted to the Director by Energy Fuels Resources (USA) Inc. ("EFR"), received by the Utah Division of Waste Management and Radiation Control ("DWMRC") on December 11, 2015. The SAR was submitted for review and approval of proposed revised Ground Water Compliance Limits ("GWCL's") in the White Mesa Uranium Mill Groundwater Discharge Permit, Permit No. UGW-370004.

SAR's for Selenium, Sulfate and TDS in monitoring well MW-31 were also submitted to DWMRC by EFR in 2012 and 2013. Per DWMRC review of those SAR's it was recognized that increasing concentration trends were present for those analytes in monitoring well MW-31, of varying degrees. Specifically, it was noted that increasing concentrations of sulfate and TDS could be attributed to the location of monitoring well MW-31 within the nitrate/chloride contaminant plume. Per discussions between DWMRC and EFR at that time it was recognized that GWCL's for those parameters would likely exceed any modified GWCL's and that the parameters would need be reanalyzed to reflect continuing monitoring concentrations (statistics would need to reflect continuing concentrations) in order to cross check recent data. The basis of the DWMRC review of potential tailings solution release to the groundwater is the same, however, it was agreed that continuing review was necessary to ensure that none of the criteria had changed and that no additional information was generated to potentially refute the original findings. DWMRC notes that pH is also included in the December 9, 2015 Source Assessment, this parameter was noted to have a slight decreasing trend in past source assessment reports, and has been potentially associated with site wide decreases in pH measurements.

The SAR is broken up into two primary sections, 1. Analysis of potential sources of the contamination, and, 2. Statistical evaluation and calculation of proposed modified GWCL's. EFR states generally in the

SAR that "*Sulfate, and by extension TDS, are expected at increased concentrations due to the proximity of the nitrate/chloride plume. The pH is decreasing site –wide, likely due to oxidation of pyrite*."

EFR uses categories of potential source analysis as has been used in past reports as follows:

1. Constituents in wells with previously identified rising trends.
2. Constituents in pumping wells.
3. Constituents potentially impacted by decreasing trends in pH.
4. Newly installed wells with interim GWCL's.
5. Other constituents and wells.

Per the SAR, current exceedances in monitoring well MW-31 fall into categories 3 and 5 and the approach for analysis was guided by these criteria. Per the SAR, EFR has used the historical data to evaluate the behavior of the constituents in the well.

II. Investigations of Potential Sources of Contamination at Monitoring Well MW-31

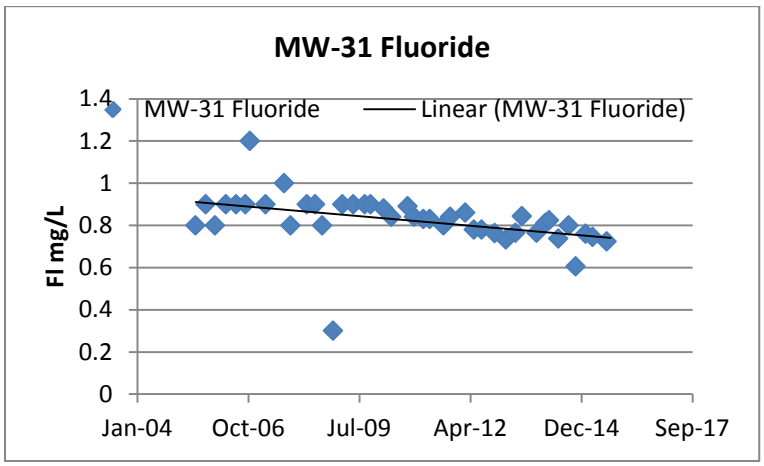
1. Discussion of Tailings Solution Groundwater Indicator Parameters at Monitoring Well MW-31

The SAR Section 2.1 discusses indicator parameters which would be detected in ground water in the event of discharge from the Mill tailings Cell 1 and reliable indications which would be detected specifically at monitoring well MW-31.

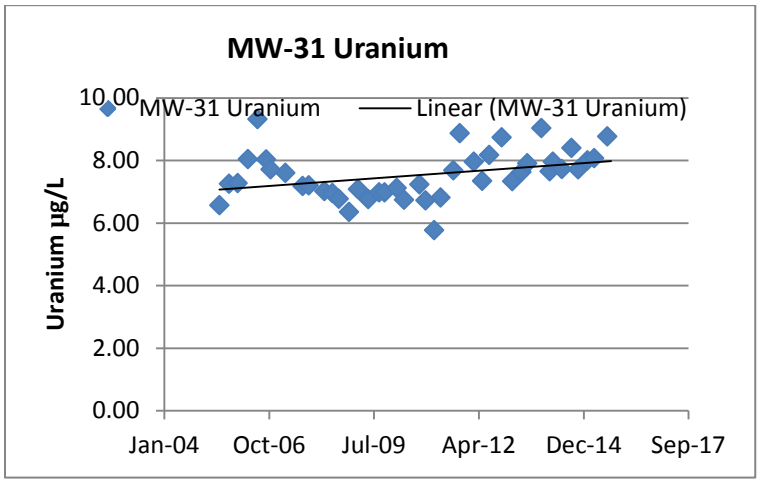
Per the SAR, the indicator parameters in the case of monitoring well MW-31 are complicated by the fact that monitoring well MW-31 is screened within the recognized nitrate/chloride plume, and chloride is therefore not a reliable indicator of cell leakage (would normally be the primary indicator parameter based on high concentrations in Cell 1 and chloride contaminant mobility in groundwater). Sulfate is also not a reliable indicator parameter at monitoring well MW-31 since the sulfate concentrations in the well are among the lowest at the site and are highly variable due to natural background fluctuations site-wide. Therefore, in the case of monitoring well MW-31, Fluoride and Uranium are considered the most reliable indicators of potential tailings cell leakage.

The discussion and figures below depict the concentration trends of the primary indicator parameters used for the evaluation of potential tailings solution contamination in monitoring well MW-31 (Fl and U).

a. Fluoride is the fastest-moving available indicator parameter of tailings seepage at monitoring well MW-31. Average concentrations of Fluoride in tailings cell 1 solution is approximately 457 mg/L. Therefore, as an indicator of tailings solution release EFR calculates that Fluoride concentrations at monitoring well MW-31 should be at least 3.8 mg/L in conjunction with the current selenium concentrations. However, per concentrations in monitoring well MW-31, as depicted on the figure below, have been primarily at concentrations less than 1 mg/L. Additionally, fluoride concentrations at the monitoring well are displaying a decreasing trend in concentration.



b. Uranium – Uranium concentrations in monitoring well MW-31 are low for the site, in the 6 µL to 9 µL range and are not exhibiting a significant upward trend. It is noted that based on contaminant distribution coefficients for Fluoride and Uranium, it would be expected that an increasing trend in fluoride concentrations at monitoring well MW-31 would be expected before an increasing trend in uranium. A plot including all available historical data available for uranium at monitoring well MW-31 is included in the figure below.



2. *University of Utah Study*

Monitoring well MW-31 was included in a University of Utah study conducted at the White Mesa Uranium Mill during 2007 (Final Report of Study Findings Dated May, 2008). The current data trends were noted prior to the University of Utah Study. Based on groundwater age dating at monitoring well MW-31 [chlorofluorocarbon ("CFC") analysis], the groundwater was found to exhibit CFC recharge dates which predate the construction of the Mill in 1980, indicating that the identified data trend were due to factors other than establishment of the White Mesa Mill.

Additionally, tritium concentrations in monitoring well MW-31 were found to be non-detect. If ground water in monitoring well MW-31 had a surface infiltration source post 1950's (time period of atmospheric

injection of tritium during above-ground thermonuclear weapons testing) then tritium concentrations would be expected in ground water samples in monitoring well MW-31.

Based on review of the U of U Report and specific data results for monitoring well MW-31 age dating of groundwater at the well indicates that the MW-31 groundwater predates Mill construction. These finding are consistent with previous source assessment reviews conducted by DWMRC for monitoring well MW-31.

3. Source Assessment Conclusions

The SAR contaminant investigation concludes that, "*The mass balance and mixing calculations demonstrate that neither the concentrations of SAR constituents and indicator parameters present in MW-31, nor the ratios at which they are present in MW-31 and Cell 1, are consistent with potential tailings system seepage impacts. This conclusion is consistent with the previous work by Hurst and Solomon (2008) using results from MW-31 and other wells as part of the University of Utah study to evaluate whether seepage from the tailings system was affecting groundwater conditions. As discussed in Section 2.3 of the report, Hurst and Solomon (2008) found that stable isotope fingerprints do not suggest contamination of groundwater by tailings cell seepage, evidence that is corroborated by trace metal concentrations similar to historically observed concentrations*."

Based on DWMRC review of the EFR SAR, there is no clear indication that tailings solution is causing the parameter exceedances and increasing concentration trends. This is based on review of the indicator parameters, review of site data, review of the University of Utah Report, and review of the EFR SAR. DWMRC agrees that review of the monitoring well MW-31 data and modification of the GWCL's is appropriate in order to avoid additional compliance actions associated with the exceedances.

III. <u>EFR Proposed Modified Groundwater Compliance Limits</u>

1. EFR Proposed Approach for Modified GWCL's at Monitoring Well MW-31

EFR proposes a modified approach to setting GWCL's for the affected parameters. Per the SAR, "*In this approach, the complete data set, which exhibits an increasing trend over the history of the well record, is divided into subsets of data based on identification of a point of inflection where the results appear more stable…The fact that sulfate, selenium, and uranium now exhibit significant long-term trends in MW-31 is not a complete representation of conditions in this well; such long-term trends do not indicate current trends. As a result it is more appropriate to focus on the recent stable results and to recalculate GWCL's for those constituents based on that data*."

Per DWMRC review of the SAR, EFR proposes to modify the data sets for the SAR parameters to reflect current conditions at monitoring well MW-31 which has been variable in concentrations and appears to reflect rises in concentration and an apparent stabilization. Note that GWCL's are set site wide based on intrawell statistics. In the SAR, EFR provides a scatter plot of data for each constituent in the SAR and includes vertical lines indicating the date when certain activities occurred, specifically 1. Date that monthly sampling was initiated, 2. Date when sitewide monitoring well redevelopment took place, 3. Date when the analytical laboratory was changed, and, 4. Date reflecting the peak groundwater elevation at the monitoring well. Per DWMRC review, recognizing changes in procedures, as included in the SAR, is discussed in the United States Environmental Protection Agency, 2009, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance, EPA 530/R-09-007* ("EPA Guidance").

According to DWMRC review of the EPA guidance it was noted that a periodic review of background data for facilities is recommended. In general the EPA guidance notes that in cases when site wide interwell statistics are being used and where upgradient monitoring wells indicate a data shift, the facility is recommended to change to intrawell statistics to ensure that the data sets used are reflective of all site wells. In cases of intrawell review, the EPA guidance notes procedural changes, such as changes in sample collection and analytical procedures, could create a difference (EPA, 2009 p. 4-2), including the types of changes that were provided in the SAR. In this case the EPA guidance recommends that the data be analyzed for shifts in concentrations and whether analysis indicates that the concentrations have stabilized at a different concentration based on recent results.

The DWMRC reviewed the currently approved statistical flow chart, used to insure that data evaluation is consistent, to determine if the EFR modified approach was in conformance with agreed upon procedures. Based on DWMRC review of the Director approved statistical flow chart and the EPA guidance it was noted that EFR did not appear to include comparative tests:

- The EPA guidance prescribes that when data are not normally or log normally distributed based on routine statistical tests then other methods should be employed to normalize the data using a system termed the "ladder of powers" (EPA 2009 p. 3.6 and 3.8 *refers to Helsel and Hirsch, 2002*). Attempts to normalize the data by these methods were not included in the EFR Report.
- In cases where data sets cannot be represented to follow a normal distribution, the EPA guidance specifies that non-parametric tests should be used to weight data points (EPA 2009 multiple references). This process is also specified by the Director approved flow chart. Non-parametric tests do not appear to have been included in the SAR for data sets with non-normal distribution.
- The EPA Guidance notes that when choosing a data set within historical data, tests should be performed to ensure that the observed data sets are representative, "*A significant t-test or Wilcoxon rank-sum result should spur a closer investigation and review of the background sample, in order to determine which observations are most representative of the current groundwater conditions*."

These issues were discussed with EFR during a telephone conference on February 11, 2016 and it was discussed that the methods should be included with future requests for GWCL modifications. However, per review of the EFR SAR, DWMRC notes that the SAR includes the following methods of calculating proposed modifications to the GWCL's; 1. Modified Approach; 2. Highest Historic Value; and 3. Mean + 2σ. DWMRC notes that, although the data sets for Selenium and Sulfate were not normally distributed per the evaluation, all proposed GWCL's were relatively similar. Per DWMRC review of the historical data for these parameters in monitoring well MW-31 it was noted that the reported values for highest historical concentration were not outliers and appeared reasonable. DWMRC concluded that the modified approach did not appear to be significantly different than those listed by the other methods, and in most cases the modified approach calculated GWCL's that were lower than the other methods. Per this comparison review, the modified approach results were valuable in order to verify the analysis of the non-normally distributed historical data sets. The table below summarizes the EFR calculations and background rationale for the MW-31 proposed modified GWCL's.

Table of EFR Proposed Revised GWCL's for Monitoring Well MW-31:

Well Number	Parameter	Location	Current GWCL (mg/L)	EFR Proposed GWCL Revision Modified Approach	Highest Historic Value	Calculated Mean + 2σ	DRC Finding – Is Proposed GWCL in Conformance with the Statistical Flow Chart?
MW-31	Selenium (µg/L)	Downgradient Cells 1 and 2	79	84.00	85.4	86.81	Not log normal, Increasing Trend See Discussion
MW-31	Sulfate (mg/L)	Downgradient Cells 1 and 2	552	691.00	691.0	697.60	
MW-31	pH (S.U.)	Downgradient Cells 1 and 2	6.57-8.5	6.19	6.23 (LHV)	6.40	Log Normal Increasing Trend See Discussion
MW-31	TDS (mg/L)	Downgradient Cells 1 and 2	1410.57	1674.73	1700	1613.78	

Per review and discussion with EFR regarding past source assessment reports and approvals, it has been the DWMRC policy to use full data sets when calculating GWCL's. DWMRC has generally not approved use of partial data sets or rolling data assessments using control charts. DWMRC has advocated separate reviews of source assessments and comprehensive reviews of all data when compliance issues with GWCL's arise, even when an increasing trend is apparent. This process ensures that data are consistently re-assessed which is important when evaluating potential releases of contaminants to the environment. DWMRC recognizes that groundwater in the vicinity of the White Mesa Uranium Mill is variable.

Per the February 11, 2016 telephone conference with EFR, it was discussed that in the case of the EFR Source Assessment, the GWCL's would be reset according to EFR calculations based on either mean + 2σ or the highest historical value. The calculations which were based on the modified approach, partial data sets, are valuable as a comparative tool to validate the calculations. It was discussed that for future GWCL calculations, DWMRC would like to see additional tests, as prescribed by the approved flow chart, discussed above. If the data still do not show a normal distribution then parametric statistics should be used in conformance with the EPA guidance. DWMRC also discussed that in some cases the EFR modified approach may be used to reset GWCL's or used as a comparison tool to validate other calculations as reviewed on a case by case basis.

Based on review of the statistical calculations, telephone conference with EFR, and consistent with the Director approved flow chart for the White Mesa Uranium Mill, DWMRC staff recommends that the GWCL's for monitoring well MW-31 be modified as summarized on the table below:

Recommended Changes to GWCL's

Well Number	Parameter/units	Current GWCL	Modified GWCL	Method of Analysis
MW-31	Selenium (µg/L)	79	86.81	Mean + 2σ
MW-31	Sulfate (mg/L)	552	697.60	Mean + 2σ
MW-31	pH (standard units)	6.57 – 8.5	6.23 – 8.5	Lowest Historic Value
MW-31	TDS (mg/L)	1410.57	1700	Highest Historic Value

4. **References**

[1] Energy Fuels Resources (USA) Inc., December 9, 2015, *Source Assessment Report for MW-31*, Prepared by Intera

[2] Energy Fuels Resources (USA) Inc., June 6, 2012, *White Mesa Uranium Mill Ground Water Monitoring Quality Assurance Plan (QAP), Revision 7.2.*

[3] United States Environmental Protection Agency (USEPA), 2009, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance, EPA 530/R-09-007*

[4] INTERA Incorporated, 2007, *Revised Background Groundwater Quality Report: Existing Wells for Dension Mines (USA) Corp.'s White Mesa Uranium Mill Site, San Juan County, Utah.*

[5] INTERA Incorporated, 2007, *Background Groundwater Quality Report: New Wells for Denison Mines (USA) Corp.'s White Mesa Uranium Mill Site, San Juan County, Utah.*

[6] Hurst, T.G., and Solomon, D.K., 2008. *Summary of Work Completed, Data Results, Interpretations and Recommendations for the July 2007 Sampling Event at the Denison Mines, USA, White Mesa Uranium Mill located near Blanding Utah.* Prepared by University of Utah Department of Geology and Geophysics.

[7] Utah Department of Environmental Quality, August 24, 2012, *Utah Ground Water Discharge Permit, Permit No. UGW370004 issued for the Energy Fuels Resources (USA) Inc. White Mesa Uranium Mill.*