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DIVISION OF WASTE MANAGEMENT
AND RADIATION CONTROL

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DRC-2022-018461

MEMORANDUM

TO: File

THROUGH: Phil Goble, Manager Phillip Goble 07/14/2022

FROM: Tom Rushing, P.G. 07/14/2022

DATE: July 14, 2022

SUBJECT: Review of the Energy Fuels Resources (USA) Inc. (EFR), White Mesa Uranium Mill, Blanding, Utah March 7, 2022, Source Assessment Report for Manganese and Sulfate in Monitoring Well MW-11
Ground Water Discharge Permit No. UGW370004 (Permit)

Summary

A March 7, 2022, Source Assessment Report ("SAR") for manganese and sulfate in Monitoring Well MW-11 at the White Mesa Uranium Mill (Mill) was submitted to the Director by Energy Fuels Resources (USA) Inc. ("EFR") and received by the Utah Division of Waste Management and Radiation Control on March 10, 2022. The SAR was submitted for review and approval of source assessment investigation findings and proposed revised Ground Water Compliance Limits (GWCLs) for uranium and selenium in the monitoring well.

Monitoring well MW-11 is located on the southern berm of the Mill Tailings Cell 3 and is hydraulically downgradient from portions of Cell 2, Cell 3, and from the Mill processing and storage areas (including ore storage).

Monitoring well MW-11 has been evaluated in recent EFR reports, studies, and other SAR's including a 2007 EFR Revised Background Groundwater Quality Report, a 2008 University of Utah groundwater isotopic study, a 2012 EFR Sitewide SAR, a 2012 EFR Sitewide pH Report and a 2019 EFR SAR. It is noted that the 2012 and 2019 EFR SAR's included investigation of manganese and revised GWCL's were approved in 2013 and 2019. Both manganese and sulfate were found to have increasing trends per the 2007 Revised Background Groundwater Quality Report and were attributed to natural fluctuations not associated with Mill activities. Evaluation of the current SAR is to ensure that previous findings regarding concentrations and sources are still evident.

SAR Review

The SAR is broken up into four primary sections: 1. Categories and approach for analysis; 2. Results of the analysis; 3. Statistical evaluation and calculation of revised GWCL's for trending constituents, and; 4. Conclusions and recommendations.

The figures below depict the time/concentration plot for manganese and sulfate in monitoring well MW-11 (data through the 4th Quarter 2021).

Figure – Manganese Data Plot of Historical Data at MW-11

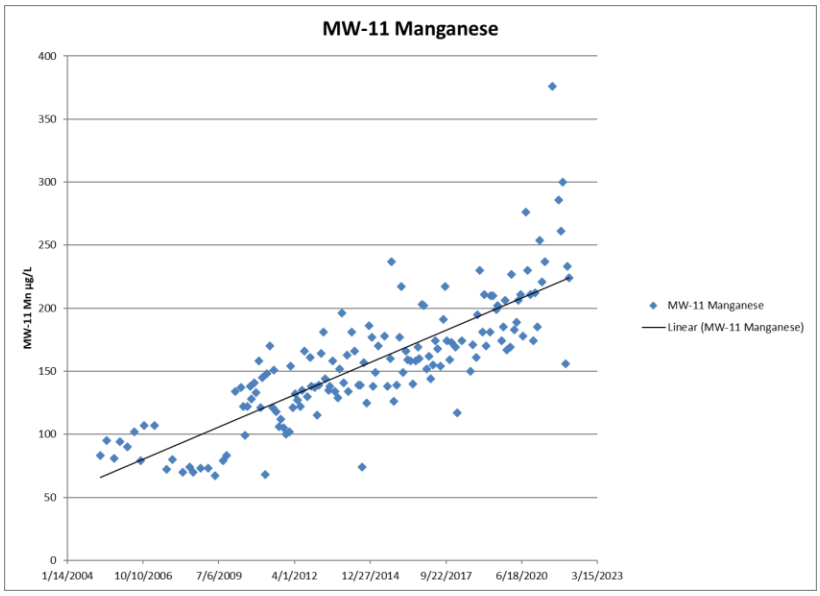
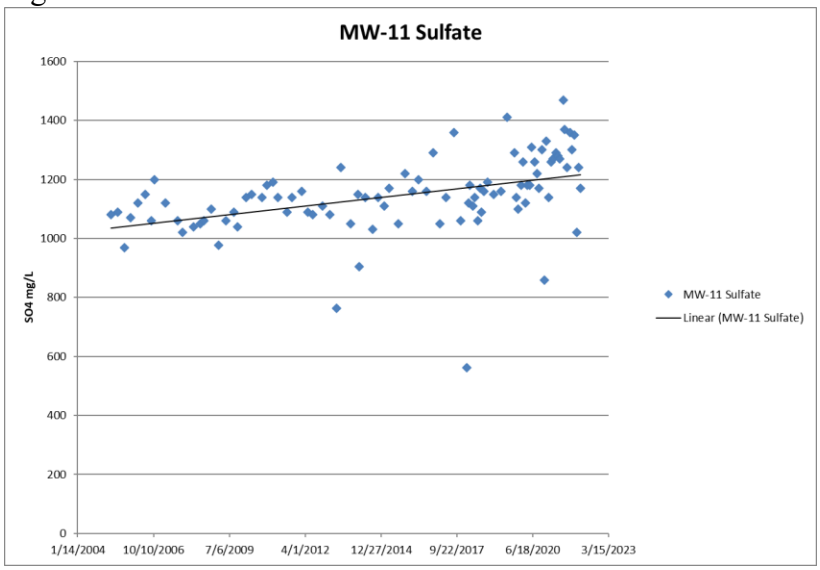


Figure – Sulfate Data Plot of Historical Data at MW-11



The manganese data set depicts a long-standing significant rising trend with recent high concentrations and most recent data points above the trend line, the sulfate data set depicts a long-standing increasing trend.

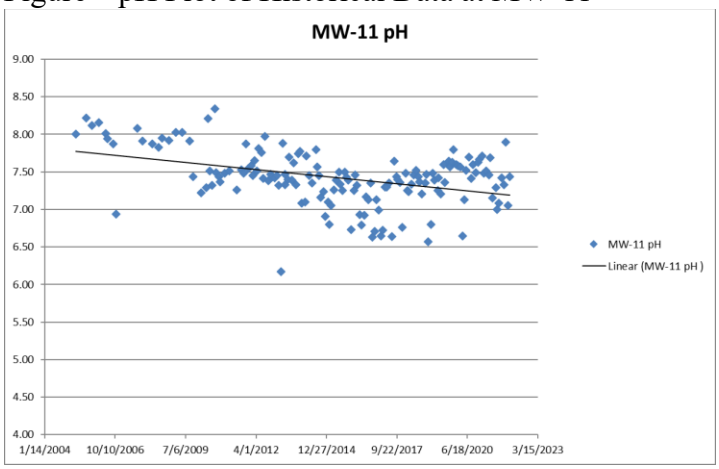
EFR Investigations of Potential Sources of Report Increasing Trends at Monitoring Well MW-11

1. Changes in Groundwater in MW-11

The SAR Section 3.2 discusses changes in groundwater in MW-11 for manganese and sulfate. It is noted that recent data for manganese is mostly above the trendline and is at significantly higher concentrations than historical results. This is also the case for indicator parameters chloride and uranium which show this same concentration pattern.

Manganese – Due to the high recent concentrations of manganese in MW-11 the data set is not normally or lognormally distributed and is increasing significantly. The SAR discusses that the trend is likely due to mobilization of naturally occurring manganese under changing pH and redox conditions. The SAR notes that pH at monitoring well MW-11 was decreasing significantly prior to 2016 which likely increased solubility associated with the previous increasing trend, however, the pH has been stable or increasing since then:

Figure – pH Plot of Historical Data at MW-11



Sulfate – Per the plot of historical sulfate concentrations, the concentrations have been increasing since the time of the Existing Wells Background Report. The SAR discusses natural processes for sulfate release into solution based on the long-term trend.

The SAR discusses that both sulfate and manganese have been increasing since the time of the Existing Wells Background Report and were also included in the University of Utah study which found that the concentration trends were not due to leakage from the tailings management system.

2. Tailings Solution Groundwater Indicator Parameters at Monitoring Well MW-11

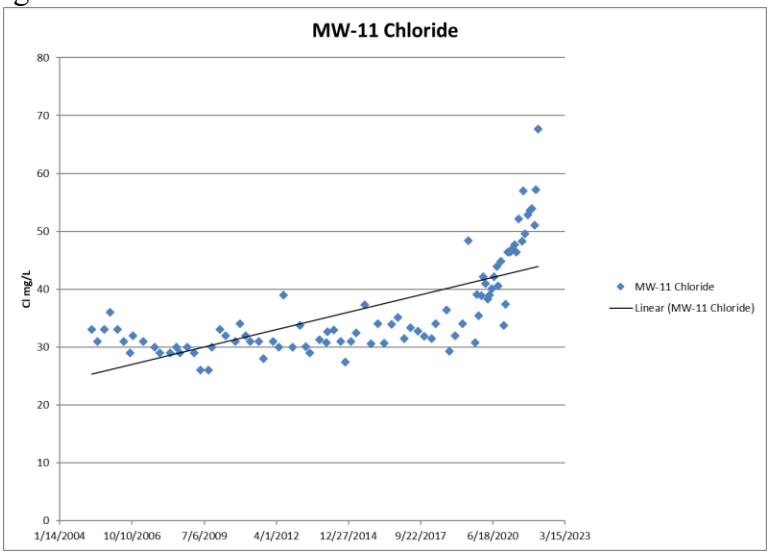
The SAR Section 3.3 discusses four primary indicator parameters (Chloride, Fluoride, Sulfate and Uranium) which would be detected in ground water in the event of a discharge from the Mill tailings cells.

Per the SAR it was noted "*indicator parameters chloride, sulfate and uranium exhibit significantly increasing trends, whereas indicator parameter fluoride exhibits a significantly decreasing trend (Figure 3). The decreasing fluoride indicates that MW-11 is not impacted by any potential seepage from the TMS.*"

Chloride

Per the SAR, the increase in chloride has occurred "*only since about 2018, correlates to an increase in nitrate and is de to the migration of the nitrate/chloride plume towards MW-11.*"

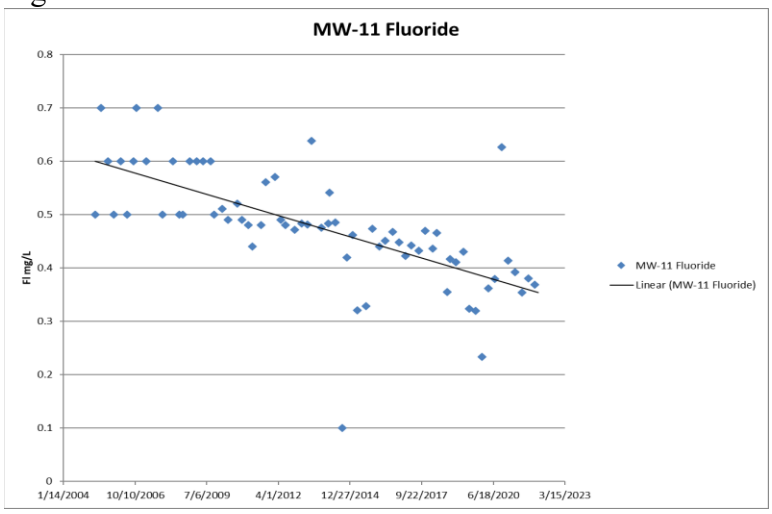
Figure – Chloride Plot of Historical Data at MW-11



Fluoride

Fluoride is highly concentrated in tailings wastewater and per literature and mill groundwater transport modeling has been shown to be highly mobile in the vadose zone and groundwater beneath the tailing cells. Per the figure below, fluoride is showing a decreasing concentration trend in MW-11.

Figure – Fluoride Plot of Historical Data at MW-11 – Decreasing Trend



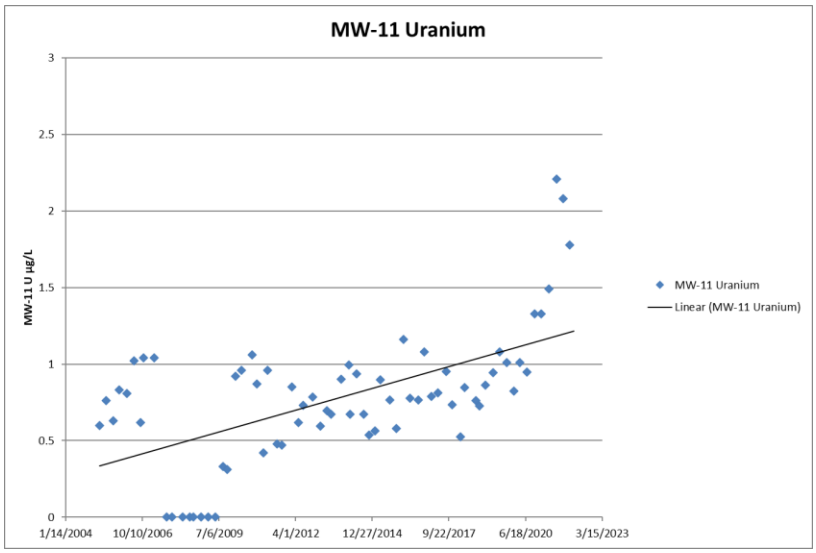
Sulfate

Sulfate concentrations in MW-11 are on the lower end in comparison with other nearby monitoring wells at the Mill. The average value of sulfate in MW-11 is 1,145 mg/L. This concentration is compared with highest historical values of other site monitoring wells (nearby MW-11) on the table below:

Monitoring Well No.	Location Relative to Tailings Cells	Average Sulfate Concentration (Complete Data Set) (mg/L)
MW-11	Downgradient Cell 2 and 3	1145
MW-1	Upgradient	837
MW-18	Upgradient	1,828
MW-19	Upgradient	669
MW-20	Far Downgradient	3,526
MW-03A	Far Downgradient	3,568
MW-29	Downgradient Cells 1 and 2	2704
MW-30	Downgradient Cell 2	784

Uranium

The SAR discusses that chloride nitrate and uranium show almost the same trend with respect to increasing concentrations. The SAR determines that these concentrations are caused by migration of the nitrate chloride plume to MW-11 based on the simultaneous increases. The SAR discusses that if the increases in uranium were caused by tailings solution, then it would be expected that uranium would lag chloride and nitrate based on higher Kd values for uranium and the more than 60 feet of vadose zone between the tailings management system and groundwater at MW-11.



3. Mass Balance Analysis

Section 3.4 of the SAR discusses mass balance analysis, noting that since 1990 the water levels at MW-11 have risen by more than 17 feet and the saturated thickness has increased from 29.8 to 47.1 feet. The SAR provides an evaluation of expected chloride concentrations (projecting a 37% tailings solution component) which would be expected if the rising levels were due to tailings solution. The expected concentration would be expected to exceed 10,000 mg/L, since the tailings solution is highly concentrated in chloride (average concentration 28,000 mg/l). However, current chloride concentrations at MW-11 are currently approximately 53 mg/L.

Similar evaluation of fluoride, another conservative tracer, indicate if a tailing source, then MW-11 concentrations should be on the order of 1,200 mg/L rather than the current concentration of approximately 0.38 mg/L. The sulfate concentration would exceed 69,000 mg/L rather than the current approximately 1,360 mg/L and uranium would exceed 148,000 µg/L rather than the current approximately 2.1 µg/L. Manganese concentration would exceed 244,000 µg/L rather than the current 286 µg/L.

4. University of Utah Study

Monitoring well MW-11 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). Based on groundwater age dating at monitoring well MW-30 [chlorofluorocarbon ("CFC") analysis], the groundwater was found to exhibit CFC recharge dates which predate the construction of the Mill in 1980. Data in general show that groundwater at the Mill is largely older than 50 years.

5. Source Assessment Conclusions

Per and in addition to those above, the SAR discussed several lines of evidence to support that mill activities are not the source of the selenium and uranium GWCL exceedances in monitoring

well MW-30, including 1. Decreasing pH effects on monitoring well geochemistry; 2. Evaluation of tailings solution indicator parameters (chloride, sulfate, fluoride, and uranium); 3. Mass balance calculations for chloride, fluoride, sulfate, uranium and manganese 3. Previous findings in the EFR Existing Wells Background Report that the SAR parameters showed long standing upward trends; 4. Potential effects of pyrite oxidation releasing selenium and other trace metals into solution; 5. Location of MW-11 within the nitrate/chloride plume, and 6. Findings of the 2007/2008 University of Utah Groundwater Study.

Per Section 3.5.2 of the SAR, EFRI finds that based on assessment and factors demonstrating that MW-11 has not been impacted by seepage from the tailings cell, that current changes in groundwater chemistry and uranium and selenium OOC at monitoring well MW-11 are due to groundwater background and impacts from the nitrate/chloride plume migration. The SAR includes discussion of the assessment and Section 3.5.2 lists the 8 factors supporting that EFRI conclusion. Specifically, per the SAR:

1. *"Key indicator parameter fluoride is decreasing.*
2. *pH has been stable to increasing since 2016.*
3. *Iron (which is the constituent having the highest concentration in the TMS) has been decreasing since the first quarter of 2012.*
4. *Statistically significant increasing trends in sulfate and manganese were present in MW-11 at the time of the Hurst and Solomon (2008) isotopic investigation report which included MW-11 in its analysis and that concluded there were no impacts to groundwater from the TMS, indicating that these trends are not the result of potential TMS seepage. Trends in both constituents are attributable to oxidation of naturally occurring pyrite at the site. In addition, manganese may be released from carbonate cement; and sulfate may be released by gypsum and anhydrite.*
5. *Although not within the plume, concurrently increasing chloride and nitrate at MW-1 since2018 result from the increasing influence of the nitrate/chloride plume. The increasing influence of the nitrate/chloride plume, which originates approximately 1,000 feet upgradient of the TMS, results from continued downgradient migration of the plume towards MW-11. One consequence of the increasing nitrate is mobilization of naturally occurring uranium at MW-11*
6. *Because uranium is substantially less mobile than nitrate or chloride at the near neutral pH conditions at MW-11, concurrently increasing uranium, nitrate, and chloride indicate geochemical changes in the immediate vicinity of MW-11 (cause in part by the increasing influence of the nitrate/chloride plume) rather than transport from a remote source such as the TMS.*
7. *Increasing water levels are expected to impact the MW-11 groundwater chemistry and contribute to trends in dissolved constituents.*
8. *Mass balance analysis indicates that water level increases at MW-11 are unrelated to potential TMS seepage."*

Per Division review of the SAR and historical data for MW-11, the out-of-compliance status for manganese and sulfate in monitoring well MW-11 does not appear to be associated with contamination from a tailing wastewater source or other Mill activities. Based on these findings it

is appropriate to adjust the Permit groundwater compliance limit for manganese and sulfate in MW-11, consistent with the currently Division approved groundwater data statistical process flow chart for the Mill and associated guidance.

Note that the evaluation of the comprehensive list of monitoring parameters and evaluation of data by EFR and the Division at monitoring well MW-11 is ongoing. Out-of-compliance status is being continuously monitored to ensure that a tailings source (or other Mill source) is not evident.

EFR Proposed Modified GWCL Statistical Evaluation of Data:

Based on Division review of the SAR statistical analysis it was noted that analysis was conducted for the complete historic data set for MW-11 and for a post January 1, 2016, data set. DWMRC notes that per the MW-11 pH concentration plot there is an apparent reversal in the pH trend from downward to neutral/upward at around 2016. Per SAR discussion, the pH changes are reflective of a shift in the data which warrants use of the modified data set as allowed by the U.S. Environmental Protection Agency Statistical Guidance[9]. A plot of historical data for pH in MW-11 is included above, the 2016 pH trend reversal is evident per review of the plot:

EFRI Statistical methods used in the SAR included: 1. Descriptive statistics for the complete and modified data sets; 2. Mean and Standard Deviation Calculation; 3. Shapiro-Wilk Test for normality; and 4. Mann-Kendall Trend Analysis (non-normally distributed data sets) and Linear Trend Analysis. Proposed GWCL's were calculated based on highest historical value (HHV) for manganese and Mean X 1.25 of the post January 1, 2016, data set for sulfate. The calculations and findings are summarized on a table in the SAR (Appendix A-1 of the SAR).

Per the SAR Section 4.2, EFRI proposed that GWCL's be adjusted according to HHV fir manganese and background (Mean X 1.25) for the post January 1, 2016, data set for sulfate. The Division approved statistical flow chart for the White Mesa Mill groundwater monitoring wells clarifies that if an upward trend is apparent for a constituent, then a modified approach should be considered. The modified approach should allow for a GWCL which considers the increasing concentrations.

The table below summarizes the EFR calculations and rationale for the proposed modified GWCL's.

Table of EFR Proposed Revised GWCL for Manganese and Sulfate at Monitoring Well MW-11:

Well Number	Parameter	Current GWCL	EFR Proposed GWCL Revision	Method to Determine GWCL	DWMRC Finding – Is Proposed GWCL in Conformance with the Statistical Flow Chart?
MW-11	Manganese	237 µg/L	376 µg/L	HHV	Increasing Trend allows for modified approach on Flow

Well Number	Parameter	Current GWCL	EFR Proposed GWCL Revision	Method to Determine GWCL	DWMRC Finding – Is Proposed GWCL in Conformance with the Statistical Flow Chart?
					Chart. The revised HHV Background value appears appropriate based on review of data.
MW-11	Sulfate	1309 mg/L	1493.6 mg/L	Mean X 1.25*	Increasing Trend allows for modified approach on Flow Chart. The revised Mean X 1.25 value appears appropriate based on review of data. This is in conformance with Utah Administrative Code R317-6-4.5. A post January 1, 2016 data set was used based on the reversal of the pH trend at that time (point of inflecton).

*Based on Mean X 1.25 of the Sulfate background data mean of the post January 1, 2016, data set for monitoring well MW-11

Conclusions:

Based on DWMRC review of the background statistics and confirmation that the proposed parameters for GWCL modifications are showing increasing trends not apparently associated with contamination from the Mill, it is appropriate to set GWCL's for these parameters at highest historical values. This review is consistent with the Director approved statistical flowchart which appreciates that a modified approach is appropriate for parameters showing upward trends.

Based on review a letter will be sent to EFR of initial approval of the modified GWCL's on the table below. The letter will include notification that the modifications are subject to public notice and public participation requirements, and that the modifications will not be effective until formal issuance of a modified Permit.

Well Number	Parameter	Current GWCL	Modified GWCL	Method of Analysis
MW-11	Manganese	237 µg/L	376 µg/L	HHV

MW-11	Sulfate	1309 mg/L	1493.6 mg/L*	Mean X 1.25*

*Based on Mean X 1.25 of the Sulfate background data mean of the post January 1, 2016 data set for monitoring well MW-11

References

[1] Energy Fuels Resources (USA) Inc., March 7, 2022, *Transmittal of Source Assessment Report for MW-11 White Mesa Mill Groundwater Discharge Permit UGW370004*

[2] Energy Fuels Resources (USA) Inc., August 15, 2017, *White Mesa Uranium Mill Ground Water Monitoring Quality Assurance Plan (QAP), Revision 7.4*

[3] Energy Fuels Resources (USA) Inc., October 12, 2012, *Source Assessment Report*, Prepared by Intera

[4] Energy Fuels Resources (USA) Inc., November 9, 2012, *pH Report*, Prepared by Intera

[5] Hurst, T.G., and Solomon, D.K. University of Utah, 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 Near Blanding,* Utah, Prepared by Department of Geology and Geophysics

[6] Hydro Geo Chem, December 7, 2012, *Pyrite Investigation Report*

[7] Intera. 2007, *Revised Background Groundwater Quality Report: Existing Wells for Denison Mines (USA) Corp.'s White Mesa Uranium Mill site, San Juan County, Utah.*

[8] Intera, 2007, *Groundwater Data Preparation and Statistical Process Flow for Calculating Groundwater Protection Standards, White Mesa Mill Site, San Juan County, Utah*

[9] United States Environmental Protection Agency, 2009, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance EPA530/R-09-007*

[10] Utah Department of Environmental Quality, January 19, 2018, Modified on March 19, 2019, *Utah Division of Radiation Control, Ground Water Discharge Permit, Permit No. UGW370004, Energy Fuels Resources (USA) Inc.*

[11] Utah Department of Environmental Quality, January 19, 2018, Modified on March 8, 2021, *Utah Division of Radiation Control, Ground Water Discharge Permit, Permit No. UGW370004, Energy Fuels Resources (USA) Inc.*