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McClellan Nuclear Research Center
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(916)-614-6200

March 30th, 2022

US Nuclear Regulatory Commission
11555 Rockville Pike
MS 12-D3
Rockville, MD 20852-2738

SUBJECT: UC Davis MNRC Response to NRC Staff Request for Additional Information Regarding Licensing Renewal Application Letter Issued February 8th, 2022.

Enclosed are the UC Davis MNRC responses to the 5 requests for additional information regarding historical Ar-41 effluence and dose modeling issued by the NRC staff on February 8th 2022.

I have reviewed this submission and found it to be truthful and accurate. If there are any questions or concerns, please contact me directly.

I declare under penalty of perjury that the foregoing is true and correct executed on March 30th, 2022.

Sincerely,

Wesley Frey PhD
Facility Director

1. Provide an explanation of the first column of the CY 2020 Annual Report, Table 1, "Summary of Airborne Effluents," including if the Ar-41 quantity is estimated, as indicated in the title, or measured as a release, as described in Section 8.0, "Radioactive Effluents," preceding the Table 1.

Although the table for airborne effluences in the CY 2020 Annual Report (and over the past 20 years) lists the total quantity of Ar-41 released as estimated, the quantity is in fact a measured quantity. Ar-41 effluence is measured via a continuous air monitor that samples from the facility's stack. Negative air is drawn in all areas of Ar-41 production (radiography bays and reactor room) such that all Ar-41 produced is ultimately drawn up the stack and quantified as it is released. The stack CAM is maintained and calibrated in accordance with the MNRC technical specifications.

2. In the remaining six columns in the CY 2020 Annual Report, Table 1, for each column:

a. indicate if the column titles accurately describe the information listed in each column, and

Column 1 "Total Est. Quan. Ar-41 Released" should be "Total Measured Quantity Ar-41 Released" as the Ar-41 is measured by the MNRC stack continuous air monitor before it is effluenced.

Column 2 "Est Max. Avg. Conc. Of Ar-41 in Unrestricted Area" should be "Est Max. Avg. Conc. Of Ar-41 in Restricted Area".

Column 3 "Fraction of Applicable 10 CFR 20 Ar-41 Conc. Limit for Unrestricted Area" is highly misleading and will not be included in future annual reports. It is calculated by taking the maximum concentration of Ar-41 in the unrestricted area (not included in this table) and dividing that value by 10 CFR 20 appendix B limit for Ar-41 released to the unrestricted area.

Column 4 "Est Dose From Ar-41 for Unrestricted Area" is the dose estimate if that month concentration's of Ar-41 to the unrestricted area were to be released for 12 continuous months. This calculation uses our historical dose conversion factor of 2.3E-10 uCi/ml continuous exposure for one year equaling 1.4 mrem. Future annual reports will not include this column, only the total annual dose to the maximum exposed individual will be included in the annual report.

Column 5 "Fraction of Applicable 10CFR20 Dose Constraint for Unrestricted Area" is the dose calculated in column 4 divided by the 10 mrem per year ALARA dose limit. Future annual reports will not include this column.

Column 6 and 7 are listed correctly.

b. provide an example of any calculations used for the numerical values provided.

Column 2 values are calculated by taking the total Ar-41 released in the month divided by the total volume of air effluenced in that month out of the MNRC stack. This air flow is measured annually and used throughout the year in these monthly calculations.

For example, in January of 2020:

$3.04\ Ci/(31\ days*24\ hours/day*60\ min/hr*1.70*10^{8}\ ml/min)=4.01*10^{-7}\ uCi/ml$

Column 3 values are calculated by taking the Ar-41 concentration in the restricted area (i.e. stack exit) from column 2, dividing by the MNRC specific dilution factor then dividing by the 10 CFR 20 appendix B value for the Ar-41 limit to an unrestricted area (1E-8 uCi/ml).

For example, in January:

(4.01*10-7 uCi/ml)/(2272*1e-8 uCi/ml)=1.8%

It is unclear why a dilution factor of 2272 was used instead of the 4640 dilution factor that has been typically used. A review of historical calculations back to 2002 show that this dilution factors appears to oscillate between two values (2272 and 4640). It should be noted the 2272 value is more conservative. Moving away from the use of these dilution factors for future reporting is discussed more in RAI response 4b. **Future annual reports will not include this column and will not use this dilution factor to calculate dose to the public.**

Column 4 first calculates the Ar-41 concentration to the unrestricted area using the MNRC specific dilution factor. Then uses the historical dose conversion factor of 2.3E-10 uCi/ml continuous exposure for one year equals 1.4 mrem. **Future annual reports will not include this column and will use the 10 CFR Appendix B dose conversion factor for Ar-41.**

For example, in January:

(4.01E-7 uCi/ml)/(2272)=1.76E-10 uCi/ml

(1.76E-10 uCi/ml)*(1.4 mrem)/(2.3E-10 uCi/ml)= 1.08 mrem.

Note this calculation is also highly misleading because this monthly dose would only be achieved if the monthly effluence for Ar-41 occurred for 12 consecutive months.

Column 5 “Fraction of Applicable 10CFR20 Dose Constraint for Unrestricted Area” is the dose from column 4 divided by the 10 mrem per year ALARA dose limit. Future annual reports will not include this column.

For example, in January:

1.08 mrem/10mrem= 10.8% (10.75%)

Note this calculation is also highly misleading because this fraction of the ALARA does limit would only be achieved if the monthly effluence for Ar-41 occurred for 12 consecutive months.

3. For annual reports for CYs 2009 through 2020, provide updated "Summary of Airborne Effluents," tables.

Note all tables have been updated using the more conservative methodology outline in RAI response 4b. Even using this more conservative methodology MNRC has never exceed the 10 mrem dose limit to the maximum exposed individual in the unrestricted area.

2009

	Total Measured Ar-41 Released	Calculated Avg. Conc. Of Ar-41 Released from Stack (uCi/ml)	Calculated Avg. Conc. Of Ar-41 Released to Unrestricted Area (uCi/ml)	Calculated Dose From Ar-41 for Unresitriced Area (mrem)	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days
JAN	2.32	3.45E-07	2.33E-10	0.10	None	None
FEB	1.72	2.56E-07	1.73E-10	0.07	None	None
MAR	2.19	3.25E-07	2.20E-10	0.09	None	None
APR	2	2.97E-07	2.01E-10	0.08	None	None
MAY	2.09	3.11E-07	2.10E-10	0.09	None	None
JUN	2.89	4.29E-07	2.90E-10	0.12	None	None
JUL	3.13	4.65E-07	3.14E-10	0.13	None	None
AUG	3.14	4.67E-07	3.15E-10	0.13	None	None
SEP	2.43	3.61E-07	2.44E-10	0.10	None	None
OCT	2.62	3.89E-07	2.63E-10	0.11	None	None
NOV	2.34	3.48E-07	2.35E-10	0.10	None	None
DEC	0.51	7.58E-08	5.12E-11	0.02	None	None
Average		**3.39E-07**	**2.29E-10**			
Total	**27.38**			**1.14**		

2010

	Total Measured Ar-41 Released (Ci)	Calculated Avg. Conc. Of Ar-41 Released from Stack (uCi/ml)	Calculated Avg. Conc. Of Ar-41 Released to Unrestricted Area (uCi/ml)	Calculated Dose From Ar-41 for Unrestricted Area (mrem)	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days
JAN	0.50	7.43E-08	5.02E-11	0.02	None	None
FEB	1.47	2.18E-07	1.47E-10	0.06	None	None
MAR	0.43	6.39E-08	4.31E-11	0.02	None	None
APR	0.78	1.16E-07	7.82E-11	0.03	None	None
MAY	0.69	1.03E-07	6.92E-11	0.03	None	None
JUN	1.31	1.95E-07	1.31E-10	0.05	None	None
JUL	2.01	2.99E-07	2.02E-10	0.08	None	None
AUG	2.37	3.52E-07	2.38E-10	0.10	None	None
SEP	2.20	3.27E-07	2.21E-10	0.09	None	None
OCT	2.09	3.11E-07	2.10E-10	0.09	None	None
NOV	2.64	3.92E-07	2.65E-10	0.11	None	None
DEC	0.71	1.05E-07	7.12E-11	0.03	None	None
Average		**2.13E-07**	**1.44E-10**			
Total	**17.2**			**0.72**		

2011

	Total Measured Ar-41 Released (Ci)	Calculated Avg. Conc. Of Ar-41 Released from Stack (uCi/ml)	Calculated Avg. Conc. Of Ar-41 Released to Unrestricted Area (uCi/ml)	Calculated Dose From Ar-41 for Unrestricted Area (mrem)	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days
JAN	1.12	1.66E-07	1.12E-10	0.05	None	None
FEB	1.08	1.60E-07	1.08E-10	0.05	None	None
MAR	1.61	2.39E-07	1.62E-10	0.07	None	None
APR	1.47	2.18E-07	1.47E-10	0.06	None	None
MAY	1.07	1.59E-07	1.07E-10	0.04	None	None
JUN	1.12	1.66E-07	1.12E-10	0.05	None	None
JUL	1.19	1.77E-07	1.19E-10	0.05	None	None
AUG	1.21	1.80E-07	1.21E-10	0.05	None	None
SEP	1.15	1.71E-07	1.15E-10	0.05	None	None
OCT	1.13	1.68E-07	1.13E-10	0.05	None	None
NOV	1.39	2.07E-07	1.39E-10	0.06	None	None
DEC	0.96	1.43E-07	9.63E-11	0.04	None	None
Average		**1.80E-07**	**1.21E-10**			
Total	**14.5**			**0.61**		

2012

	Total Measured Ar-41 Released (Ci)	Calculated Avg. Conc. Of Ar-41 Released from Stack (uCi/ml)	Calculated Avg. Conc. Of Ar-41 Released to Unrestricted Area (uCi/ml)	Calculated Dose From Ar-41 for Unrestricted Area (mrem)	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days
JAN	3.94	5.85E-07	3.95E-10	0.16	None	None
FEB	1.73	2.57E-07	1.74E-10	0.07	None	None
MAR	1.75	2.60E-07	1.76E-10	0.07	None	None
APR	1.82	2.70E-07	1.83E-10	0.08	None	None
MAY	1.00	1.49E-07	1.00E-10	0.04	None	None
JUN	1.52	2.26E-07	1.52E-10	0.06	None	None
JUL	1.25	1.86E-07	1.25E-10	0.05	None	None
AUG	1.14	1.69E-07	1.14E-10	0.05	None	None
SEP	0.78	1.16E-07	7.82E-11	0.03	None	None
OCT	0.77	1.14E-07	7.72E-11	0.03	None	None
NOV	0.93	1.38E-07	9.33E-11	0.04	None	None
DEC	0.34	5.05E-08	3.41E-11	0.01	None	None
Average		**2.10E-07**	**1.42E-10**			
Total	**16.97**			**0.71**		

2013

	Total Measured Ar-41 Released (Ci)	Calculated Avg. Conc. Of Ar-41 Released from Stack (uCi/ml)	Calculated Avg. Conc. Of Ar-41 Released to Unrestricted Area (uCi/ml)	Calculated Dose From Ar-41 for Unrestricted Area (mrem)	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days
JAN	0.87	1.29E-07	8.73E-11	0.04	None	None
FEB	0.61	9.06E-08	6.12E-11	0.03	None	None
MAR	0.94	1.40E-07	9.43E-11	0.04	None	None
APR	1.27	1.89E-07	1.27E-10	0.05	None	None
MAY	1.14	1.69E-07	1.14E-10	0.05	None	None
JUN	1.06	1.58E-07	1.06E-10	0.04	None	None
JUL	1.01	1.50E-07	1.01E-10	0.04	None	None
AUG	0.96	1.43E-07	9.63E-11	0.04	None	None
SEP	1.07	1.59E-07	1.07E-10	0.04	None	None
OCT	0.78	1.16E-07	7.82E-11	0.03	None	None
NOV	0.85	1.26E-07	8.53E-11	0.04	None	None
DEC	0.22	3.27E-08	2.21E-11	0.01	None	None
Average		**1.33E-07**	**9.01E-11**			
Total	**10.78**			**0.45**		

2014

	Total Measured Ar-41 Released (Ci)	Calculated Avg. Conc. Of Ar-41 Released from Stack (uCi/ml)	Calculated Avg. Conc. Of Ar-41 Released to Unrestricted Area (uCi/ml)	Calculated Dose From Ar-41 for Unrestricted Area (mrem)	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days
JAN	1.7	2.53E-07	1.71E-10	0.07	None	None
FEB	0.83	1.23E-07	8.33E-11	0.03	None	None
MAR	0.76	1.13E-07	7.62E-11	0.03	None	None
APR	0.64	9.51E-08	6.42E-11	0.03	None	None
MAY	0.66	9.81E-08	6.62E-11	0.03	None	None
JUN	1.16	1.72E-07	1.16E-10	0.05	None	None
JUL	1.6	2.38E-07	1.61E-10	0.07	None	None
AUG	1.00	1.49E-07	1.00E-10	0.04	None	None
SEP	1.2	1.78E-07	1.20E-10	0.05	None	None
OCT	1.2	1.78E-07	1.20E-10	0.05	None	None
NOV	1.99	2.96E-07	2.00E-10	0.08	None	None
DEC	1.47	2.18E-07	1.47E-10	0.06	None	None
Average		**1.76E-07**	**1.19E-10**			
Total	**14.21**			**0.59**		

2015

	Total Measured Ar-41 Released (Ci)	Calculated Avg. Conc. Of Ar-41 Released from Stack (uCi/ml)	Calculated Avg. Conc. Of Ar-41 Released to Unrestricted Area (uCi/ml)	Calculated Dose From Ar-41 for Unrestricted Area (mrem)	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days
JAN	2.18	3.24E-07	2.19E-10	0.09	None	None
FEB	1.97	2.93E-07	1.98E-10	0.08	None	None
MAR	1.8	2.67E-07	1.81E-10	0.08	None	None
APR	1.84	2.73E-07	1.85E-10	0.08	None	None
MAY	1.11	1.65E-07	1.11E-10	0.05	None	None
JUN	1.65	2.45E-07	1.66E-10	0.07	None	None
JUL	1.92	2.85E-07	1.93E-10	0.08	None	None
AUG	0.93	1.38E-07	9.33E-11	0.04	None	None
SEP	1.2	1.78E-07	1.20E-10	0.05	None	None
OCT	1.82	2.70E-07	1.83E-10	0.08	None	None
NOV	1.02	1.52E-07	1.02E-10	0.04	None	None
DEC	1.07	1.59E-07	1.07E-10	0.04	None	None
Average		**2.29E-07**	**1.55E-10**			
Total	**18.51**			**0.77**		

2016

	Total Measured Ar-41 Released (Ci)	Calculated Avg. Conc. Of Ar-41 Released from Stack (uCi/ml)	Calculated Avg. Conc. Of Ar-41 Released to Unrestricted Area (uCi/ml)	Calculated Dose From Ar-41 for Unrestricted Area (mrem)	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days
JAN	0.7	1.04E-07	7.02E-11	0.03	None	None
FEB	1.06	1.58E-07	1.06E-10	0.04	None	None
MAR	3.93	5.84E-07	3.94E-10	0.16	None	None
APR	1.64	2.44E-07	1.65E-10	0.07	None	None
MAY	0.89	1.32E-07	8.93E-11	0.04	None	None
JUN	1.91	2.84E-07	1.92E-10	0.08	None	None
JUL	1.79	2.66E-07	1.80E-10	0.07	None	None
AUG	1.2	1.78E-07	1.20E-10	0.05	None	None
SEP	1.14	1.69E-07	1.14E-10	0.05	None	None
OCT	1.97	2.93E-07	1.98E-10	0.08	None	None
NOV	2.06	3.06E-07	2.07E-10	0.09	None	None
DEC	0.98	1.46E-07	9.83E-11	0.04	None	None
Average		**2.39E-07**	**1.61E-10**			
Total	**19.27**			**0.81**		

2017

	Total Measured Ar-41 Released (Ci)	Calculated Avg. Conc. Of Ar-41 Released from Stack (uCi/ml)	Calculated Avg. Conc. Of Ar-41 Released to Unrestricted Area (uCi/ml)	Calculated Dose From Ar-41 for Unrestricted Area (mrem)	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days
JAN	1.50	2.23E-07	1.50E-10	0.06	None	None
FEB	1.12	1.66E-07	1.12E-10	0.05	None	None
MAR	1.29	1.92E-07	1.29E-10	0.05	None	None
APR	1.68	2.50E-07	1.69E-10	0.07	None	None
MAY	1.29	1.92E-07	1.29E-10	0.05	None	None
JUN	0.93	1.38E-07	9.33E-11	0.04	None	None
JUL	3.04	4.52E-07	3.05E-10	0.13	None	None
AUG	1.39	2.07E-07	1.39E-10	0.06	None	None
SEP	1.73	2.57E-07	1.74E-10	0.07	None	None
OCT	1.94	2.88E-07	1.95E-10	0.08	None	None
NOV	2.69	4.00E-07	2.70E-10	0.11	None	None
DEC	0.51	7.58E-08	5.12E-11	0.02	None	None
Average		**2.37E-07**	**1.60E-10**			
Total	**19.11**			**0.80**		

2018

	Total Measured Ar-41 Released (Ci)	Calculated Avg. Conc. Of Ar-41 Released from Stack (uCi/ml)	Calculated Avg. Conc. Of Ar-41 Released to Unrestricted Area (uCi/ml)	Calculated Dose From Ar-41 for Unrestricted Area (mrem)	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days
JAN	2.44	3.63E-07	2.45E-10	0.10	None	None
FEB	2.18	3.24E-07	2.19E-10	0.09	None	None
MAR	2.49	3.70E-07	2.50E-10	0.10	None	None
APR	2.19	3.25E-07	2.20E-10	0.09	None	None
MAY	1.71	2.54E-07	1.72E-10	0.07	None	None
JUN	1.67	2.48E-07	1.68E-10	0.07	None	None
JUL	1.53	2.27E-07	1.53E-10	0.06	None	None
AUG	2.15	3.19E-07	2.16E-10	0.09	None	None
SEP	1.78	2.64E-07	1.79E-10	0.07	None	None
OCT	3.13	4.65E-07	3.14E-10	0.13	None	None
NOV	2.16	3.21E-07	2.17E-10	0.09	None	None
DEC	1.45	2.15E-07	1.45E-10	0.06	None	None
Average		**3.08E-07**	**2.08E-10**			
Total	**24.88**			**1.04**		

2019

	Total Measured Ar-41 Released (Ci)	Calculated Avg. Conc. Of Ar-41 Released from Stack (uCi/ml)	Calculated Avg. Conc. Of Ar-41 Released to Unrestricted Area (uCi/ml)	Calculated Dose From Ar-41 for Unrestricted Area (mrem)	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days
JAN	2.57	3.82E-07	2.58E-10	0.11	None	None
FEB	1.73	2.57E-07	1.74E-10	0.07	None	None
MAR	2.54	3.77E-07	2.55E-10	0.11	None	None
APR	2.63	3.91E-07	2.64E-10	0.11	None	None
MAY	1.56	2.32E-07	1.56E-10	0.07	None	None
JUN	1.32	1.96E-07	1.32E-10	0.06	None	None
JUL	1.72	2.56E-07	1.73E-10	0.07	None	None
AUG	1.62	2.41E-07	1.63E-10	0.07	None	None
SEP	1.97	2.93E-07	1.98E-10	0.08	None	None
OCT	3.21	4.77E-07	3.22E-10	0.13	None	None
NOV	4.85	7.21E-07	4.87E-10	0.20	None	None
DEC	1.87	2.78E-07	1.88E-10	0.08	None	None
Average		**3.42E-07**	**2.31E-10**			
Total	**27.59**			**1.15**		

2020

	Total Measured Ar-41 Released (Ci)	Calculated Avg. Conc. Of Ar-41 Released from Stack (uCi/ml)	Calculated Avg. Conc. Of Ar-41 Released to Unrestricted Area (uCi/ml)	Calculated Dose From Ar-41 for Unrestricted Area (mrem)	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days	Total Measured Quantity of Particulate Effluence with Half-Life >8 Days
JAN	3.04	4.52E-07	3.05E-10	0.13	None	None
FEB	3.02	4.49E-07	3.03E-10	0.13	None	None
MAR	3.17	4.71E-07	3.18E-10	0.13	None	None
APR	4.72	7.01E-07	4.74E-10	0.20	None	None
MAY	2.14	3.18E-07	2.15E-10	0.09	None	None
JUN	3.99	5.93E-07	4.00E-10	0.17	None	None
JUL	3.24	4.81E-07	3.25E-10	0.14	None	None
AUG	2.35	3.49E-07	2.36E-10	0.10	None	None
SEP	3.30	4.90E-07	3.31E-10	0.14	None	None
OCT	3.35	4.98E-07	3.36E-10	0.14	None	None
NOV	2.36	3.51E-07	2.37E-10	0.10	None	None
DEC	1.22	1.81E-07	1.22E-10	0.05	None	None
Average		**4.45E-07**	**3.00E-10**			
Total	**35.9**			**1.50**		

4. Provide the calculational methodology used in the 2020 UCD LRA SAR Appendix A, for determination of the:

a. Ar-41 effluent concentration of 2.0E-06 µCi/ml;

MNRC operated for 1,430 hours at 1 MW in 2019 and produced 27.6 Ci of Ar-41 as measured by the stack continuous air monitor. This corresponds to an emission rate of 5.4 uCi/s while operating at 1 MW. Based on a typical stack flow rate (measured annually) of 5678 CFM (2.68 x 10^6 cm^3 /sec) a concentration of 2.0E-6 µCi/ml is released during 1 MW operations. This emission rate is relatively constant from year to year as the mode of Ar-41 production at MNRC does not change. This is the concentration of Ar-41 released from the stack and it is a restricted area. The concentrations of Ar-41 released from the stack to the restricted area given in the response to RAI question 3 are less than this 2.0E-6 uCi/ml because the MNRC reactor does not operated continuously at 1 MW (typically operating 30-35 MWhrs per week).

b. Delusion [Dilution] factor of 4640; and

MNRC will no longer be utilizing the dilution factor to calculate ground level Ar-41 concentrations and doses in the unrestricted area. Instead, the following Gaussian Plume model equation is used to determine the maximum Ar-41 concentration in the unrestricted area in order to compare the results to the regulatory limit of 1E-8 uCi/ml (equivalent to 50 mrem for a one year exposure).

The calculational methodology below is provided to demonstrate that even when operating continuously for the entire year MNRC will not exceed the 10 mrem dose limit to the unrestricted area (maximum exposed individual). Though the Ar-41 is already diluted to some extent, when it exits the stack, in the following calculations it is assumed that the Ar-41 is a continuous point source release. This simplifies the calculations greatly and is conservative. Sigma y and sigma z values were determined based on the formulas provided in the HotSpot user manual. The distance to the maximum dose location is calculated in HotSpot using the parameters below. For these calculations no credit for plume rise and a below average wind speed of 2 m/s is used to be conservative. The maximum concentration of Ar-41 for the maximum exposed individual for various atmospheric conditions is given in the table below based on the equation below.

$$\chi_{(max,0)} = \frac{Q}{\pi u \sigma_z \sigma_y} exp\left(-\frac{1}{2}\frac{H^2}{\sigma_z^2}\right) = \frac{Ci}{m^3} = \frac{\mu Ci}{cm^3};$$

where:

Q = Emission Rate (5.4 uCi/s) as discussed in RAI response 4a
H = Physical stack height (18.2m)
u = Mean Wind Speed (2 m/s);
σ_y = diffusion coefficient in the y-axis
σ_z = diffusion coefficient in the z-axis

Atmospheric Stability Classification	$Sigma\ y$ (m)	Sigma z (m)	χ_{max} ($\mu Ci/cm^3$)	Distance to Max Dose (m)	Maximum Dose per Year (mrem)
Very Unstable (A)	13.8	12.6	1.74×10^{-9}	63	8.7
Moderately Unstable (B)	15.9	12	1.43×10^{-9}	100	7.1
Slightly Unstable (C)	17.5	12.6	1.37×10^{-9}	160	6.9
Neutral (D)	19.0	12.3	1.23×10^{-9}	240	6.2
Slightly Stable (E)	27.0	12.1	8.49×10^{-9}	460	4.2
Moderately Stable (F)	36.3	11.8	6.2×10^{-10}	950	3.1

The table above assumes continuous 24/7 operation and shows that MNRC cannot exceed any dose limits to the public from Ar-41 effluence while operating at 1 MW under any atmospheric conditions and taking no credit for plume rise.

Moving forward, MNRC will calculate dose to the maximum exposed individual based on the methodology provided above. Due to the fact that over the last 15 years the MNRC has operated during a single daytime shift, atmospheric conditions are selected to represent slightly unfavorable daytime conditions of atmospheric stability class B with a 2 m/s wind speed. Historically MNRC has selected stability class C, which is not necessarily representative of average daytime conditions and likely resulted in a slight underestimation of Ar-41 dose to the public.

The calculations above assume 5.4 uCi/s is released to the public continuously for one year. This corresponds to 168 Ci of Ar-41 being release during one year of continuous operation at 1MW. Selecting atmospheric class B, no plume rise, and using the 10 CFR 20 appendix B Ar-41 dose conversion factor one arrives at a final conversion factor of: for every 23.7 Ci of Ar-41 released, the dose to the public is 1 mrem. It is this factor that will be used to calculate future Ar-41 dose to the public based on the measured Ar-41 being effluenced up the stack.

c. Ar-41 concentration to dose relationship described in the 2020 Annual Report, Table 1, Note (2), of 2.3E-10 µCi/ml continuous for one year equals 1.4 mrem.

The conversion factor of 2.3E-10 uCi/ml continuous exposure for 1 year equates to 1.4 mrem (1.6E-10 uCi/ml continuous exposure for 1 year equates to 1.0 mrem) is based on an older reference from the 1980s that cannot be reproduced. **Moving forward the MNRC will use the Ar-41 dose conversion factor based on the 10 CFR 20 appendix B of 1E-8 uCi/ml continuous exposure for 1 year equaling 50 mrem.** Note that tables in RAI response 3 have been updated to reflect this updated DCF. The previous DCF factor appears to have slightly overestimated doses from Ar-41 effluence and is therefore conservative.

5. Explain the apparent discrepancy for the dose from Ar-41 between the UCD LRA Environmental Report, Figure 20 and the CY 2005 Annual Report of 0.2 mrem and 2.19 mrem, respectively. Provide updated Figure 20.

The annual dose to the unrestricted area was reported as 0.182 mrem instead of 2.19 mrem. It appears that the monthly dose average was reported instead of the annual dose. 2.19 mrem is the correct dose to the maximum exposed individual for CY 2005. Note that 2.19 mrem is well below any regulatory limit. Furthermore, the CY 2004 annual report has been located (this data point was originally left blank in the UCD LRA Environmental Report). The CY 2004 dose to the maximum exposed individual was 4.09 mrem, also below any regulatory limit.

The updated chart below provides historical Ar-41 doses to the unrestricted area using the updated methodology outlined in RAI response number 4b. These doses are higher relative to the previous methodology due to the usage of more conservative assumptions. Specifically, not taking any credit for plume rise and using a less stable atmospheric classification of class B to reflect daytime operation.