National Emission Standards for Hazardous Air Pollutants 2006 Radon Flux Measurement Program **C-18 Repository** Gas Hills, Wyoming

Prepared for: Umetco Minerals Corporation 2754 Compass Drive, Suite 280 Grand Junction, Colorado 81506

Prepared by:

Tellco Environmental P.O. Box 3987 Grand Junction, Colorado 81502

TABLE OF CONTENTS

Pa	ige
1. INTRODUCTION	. 1
2. SITE HISTORY AND DESCRIPTION	. 1
3. REGULATORY REQUIREMENTS	. 1
4. SAMPLING METHODOLOGY	. 1
5. FIELD OPERATIONS	. 2
5.1 Equipment Preparation	. 2
5.2 Sample Locations, Identification, and Placement	. 2
5.3 Sample Retrieval	. 3
5.4 Environmental Conditions	. 3
6. SAMPLE ANALYSIS	. 3
6.1 Apparatus	. 3
6.2 Sample Inspection and Documentation	. 3
6.3 Background and Sample Counting	. 4
7. QUALITY CONTROL AND DATA VALIDATION	. 4
7.1 Sensitivity	. 4
7.2 Precision	. 4
7.3 Accuracy	. 5
7.4 Completeness	. 5
8. CALCULATIONS	. 5
9. RESULTS	. 6
9.1 Mean Radon Flux	. 6
9.2 Site Results	. 6
References	. 7
Figure 4-1	. 8

Appendix A. Charcoal Canister Analyses Support Documents

Appendix B. Recount Data Analyses

Appendix C. Radon Flux Sample Laboratory Data (Including Blanks)

Appendix D. Map, Figure D-1

1. INTRODUCTION

This report presents the final results of the National Emissions Standards for Hazardous Air Pollutants (NESHAPS) measurements for the C-18 Repository at the Gas Hills site in Natrona County, Wyoming. Umetco Minerals Corporation (Umetco) and Tellco Environmental, L.L.C. (Tellco) measured radon-222 releases at the former uranium processing facility. Final radon flux measurement sampling was performed on top of the final cover material at one hundred locations during September 06-07, 2006. The analytical results of these one hundred radon flux measurements were used to calculate the final mean radon flux for the C-18 Repository.

2. SITE HISTORY AND DESCRIPTION

The site is approximately 55 miles east of Riverton, Wyoming. Uranium was discovered in the area in 1953 and the mill began operating in 1960, with uranium processing at its peak in 1980. Tailings from milling operations were deposited in the C-18 Repository. Milling operations shut down in 1984 and the mill was decommissioned and dismantled in 1990. The C-18 Repository is a deep-burial repository with an area of approximately 24,174 square meters.

3. **REGULATORY REQUIREMENTS FOR THE GAS HILLS SITE**

Radon emissions from uranium mill tailings are regulated by the Nuclear Regulatory Commission (NRC) under generally applicable standards set by the Environmental Protection Agency (EPA). Applicable regulations are specified in 10 CFR Part 40, Criterion 6 and applicable technical procedures in 40 CFR Part 61, Appendix B. Radon-222 emissions from uranium mill tailings are limited to an average of 20 picoCuries per meter squared per second (pCi/m²-s) for each region. The sampling and analytical method used was in conformance with 40 CFR, Part 61, Appendix B, Method 115. The C-18 Repository at Gas Hills is subject to radon-emissions monitoring upon placement of the final cover.

4. SAMPLING METHODOLOGY

Radon emissions were measured using Large Area Activated Charcoal Canisters (canisters) in conformance with 40 CFR, Part 61, Appendix B, Method 115, Restrictions to Radon Flux Measurements, (EPA, 2001). These canisters are passive gas adsorption sampling devices used to determine the flux rate of radon-222 gas from a surface. The canisters were constructed using a 10-inch diameter PVC end cap for containing a bed of 180 grams of activated, granular charcoal. At the designated sample locations the prepared charcoal was placed in the canisters on a support grid on top of a ½ inch thick layer of foam and secured with a retaining ring under 1½ inches of foam (see Figure 4-1).

Each charged canister was placed directly onto the surface (open face down) and exposed to the surface for 24 hours. Radon gas adsorbed onto the charcoal and the subsequent radioactive decay of the entrained radon produced lead-214 and bismuth-214. These radon progeny isotopes emit characteristic gamma photons that can be detected through gamma spectroscopy. The original total activity of the adsorbed radon was calculated from these gamma ray measurements using calibration factors derived from cross-calibration of standard sources.

1

After 24 hours, the exposed charcoal was transferred to a sealed plastic sample container, and labeled showing exposure times/dates. Tellco personnel maintained custody of the samples from collection through delivery and analysis at the Tellco laboratory in Grand Junction, CO.

5. FIELD OPERATIONS

5.1 Equipment Preparation

All charcoal was dried at 110°C before use in the field. Aliquots of 180 grams of dried charcoal were placed in containers as follows:

- Proper balance operation was verified daily by checking a standard weight. The balance readout agreed with the known standard weight to within ± 0.1 percent. (see Appendix A, "Balance Operation Daily Check" form).
- After acceptable balance check, empty containers were individually placed on the balance and the scale was re-zeroed with the container on the balance. Unexposed and dried charcoal was placed in the container until the readout registered 180 grams. The lid was immediately placed on the container and sealed with plastic tape. The balance was checked for readout drift between readings.
- Sealed containers with unexposed charcoal were placed individually in the shielded counting well, with the bottom of the container centered over the detector and the background count rate was documented. If the background counts were too high to achieve an acceptable lower limit of detection (LLD), the entire charcoal batch was labeled non-conforming and recycled through the heating/drying process.

5.2 Sample Locations, Identification, and Placement

Designated sample point locations were surveyed and marked with pin flags or lath. An on-site weather station monitored minimum/maximum air temperatures and any rainfall occurrences to ensure compliance with the measurement criteria.

A sample identification number (ID) was assigned to every canister, using an alphanumeric system noting the charcoal batch followed by a sequential number indicating the location within the sampling grid (e.g., G05). This ID was recorded on an adhesive label and placed on top of the canister, and the sample ID, date, and time of placement were recorded on field data sheets.

The sampling locations were evenly spaced within the C-18 Repository. At each location, a canister was chosen and the retaining ring, screen, and foam pad were removed to expose the charcoal support grid. A pre-measured charcoal charge was selected from a batch, opened and distributed evenly across the support grid. The canister was reassembled and placed face down on the surface. Care was exercised not to push the device into the soil surface and the rim was "sealed" to the surface using local material.

Approximately five percent of the total number of canisters used for sampling were also charged with clean charcoal in the same manner as the radon flux samples, and were labeled as blanks. These blank canisters remained inside airtight plastic bags during the 24-hour testing period.

2

5.3 Sample Retrieval

At the end of the 24-hour sampling period, all canisters were disassembled and each sample was individually poured through a funnel into a container. Sample labels were transferred to the appropriate containers and the containers were sealed for transport. Retrieval date and time were recorded on the same data sheet used during placement. The blank samples were similarly processed.

5.4 Environmental Conditions

In accordance with 40 CFR, Part 61, Appendix B, Method 115:

- No measurements were initiated within 24 hours after rainfall. No rainfall occurred during the sampling.
- None of the seals around the rims were broken nor surrounded by water.
- No measurements presented in this report were performed during ambient air temperatures below 35°F nor on frozen ground. The minimum air temperature recorded at the site during radon flux sampling was 56°F.

6. SAMPLE ANALYSIS

6.1 Apparatus

The apparatus used for the analysis is as follows:

- Single- or multi-channel pulse height analysis system, Ludlum Model 2200 with a Teledyne 3" x 3" sodium iodide, thallium-activated (NaI (Tl)) detector.
- Lead shielded counting well approximately 40-centimeters (cm) deep with 5-cm lead walls, a 7-cm base, and 5-cm top.
- National Institute of Standards and Technology traceable calibration standard.
- Ohaus Model C501 balance with 0.1-gram sensitivity.

6.2 Sample Inspection and Documentation

The integrity of each sample container was verified in the laboratory by visual inspection.

The following items were verified:

- Container was sealed and undamaged.
- Data sheet was complete.

All of the sample containers were found to be properly sealed when received at the laboratory, documentation was completed, and no discrepancies were noted. After inspection, all containers were weighed and the gross weight (to the nearest 0.1 gram) was recorded.

6.3 Background and Sample Counting

The gamma ray counting system was checked daily, including background and calibration source measurements before and after sample counting each day. Three five-minute background counts were conducted for five containers selected at random to represent each "batch". Based on calibration statistics, (using blanks and a known source) background ranges in counts per minute (cpm) were established for the Ludlum/Teledyne counting system with shielded well (see Appendix A, "Charcoal Canister Analysis System" form).

Gamma ray counting of exposed charcoal samples included the following steps:

- The length of count time was selected by the activity of the sample being analyzed. A data quality objective of a minimum of 1,000 counts was selected for any given sample.
- Sample containers were centered on the NaI detector and the shielded well door was closed.
- The sample was counted over a pre-determined period and then the mid-sample count time date and counts were documented on the field data sheet and used in the calculations.
- The above steps were repeated for each sample.
- Approximately 10 percent of the containers counted were selected for recounting. These containers were recounted no sooner than one day, and no longer than three days after the original count for Quality Control (QC) and Data Validation.

7. QUALITY CONTROL AND DATA VALIDATION

Charcoal flux measurement QC samples included the following intra-laboratory analytical frequency objectives:

- Recounts, ten percent, and
- Blanks, five percent

All sample data were subjected to validation protocols that included assessments of sensitivity, precision, accuracy, and completeness. All method-required data quality objectives (EPA, 2001) were attained.

7.1 Sensitivity

A total of five blanks were analyzed by measuring the radon progeny activity in samples subjected to the measurement process, excepting exposure to the C-18 Repository. These blank sample measurements comprised five percent of the final field measurements. The blank sample analyses measured radon flux rates ranging from 0.01 to 0.04 pCi/m^2 -s, with an average of approximately 0.02 pCi/m^2 -s.

7.2 Precision

Ten recount measurements, distributed throughout the sample set, were performed by replicating analyses of individual field samples. These recount measurements comprised approximately 10 percent of the total number of samples analyzed. The precision of all recount measurements, expressed as relative percent difference (RPD), ranged from less than 1 percent to 5.9 percent with an overall average precision of approximately 2.3 percent (see Appendix B).

7.3 Accuracy

Accuracy of field measurements was assessed daily by counting two laboratory control samples. Accuracy of these lab control sample measurements, expressed as percent error, ranged from -1.3 percent to 1.7 percent. The arithmetic average error of all lab control sample measurements was 0.3 percent (see Appendix A, "Accuracy Appraisal Table").

7.4 Completeness

Method 115 specifies 100 samples to be collected from each region, with a completeness objective of 85 percent. All of the samples met technical criteria, representing 100% completeness.

8. CALCULATIONS

Radon flux rates were calculated for samples, using calibration factors derived from cross-calibration to two sources with known total activity and identical geometry as the charcoal containers. A yield efficiency factor was used to calculate the total activity of the sample charcoal containers.

A computer spreadsheet program calculated the individual radon flux rates. The algorithms used to reduce sample data collected this year were as follows:

Equation 1

pCi Rn-222/m²sec =
$$\frac{N}{[Ts^*A^*b^*0.5^{(d/91.75)}]}$$

where: N

Ts	= sample duration, seconds
b	= instrument calibration factor, cpm per pCi; values used:
	0.1718, for M-01/D-21 and 0.1716, for M-02/D-20
d	= decay time, elapsed hours between sample mid-time and count mid-time
91 75	= Rn-222 half life in hours

= net sample count rate, cpm under 220-662 keV peak

A = area of the collector, m^2

Equation 2

	Gross Sample, cpm	Background Sample, cpm	
$\mathbf{E}_{\mathbf{r}}$	SampleCount, t, min	Background Count, t, min	× Sample Concentration
$Li101, 20 - 2 \times 100$	Ne	et, cpm	× Sample Concentration

Equation 3

L

 $2.71 + (4.65)(S_{\rm b})$

LD =	[Ts*/	A*b*0.5 ^(d/91.75)]
where:	2.71	= constant
	4.65	= confidence interval
	Sb	= standard deviation of the background count rate
	Ts	= sample duration, seconds
	Ъ.	= instrument calibration factor, cpm per pCi; values used:
		0.1718, for M-01/D-21 and 0.1716, for M-02/D-20
	d	= decay time, elapsed hours between sample mid-time and count mid-time
	91.75	= Rn-222 half life in hours
	A	= area of the collector, m^2

9. **RESULTS**

9.1 Mean Radon Flux

 $\overline{\mathbf{x}} = \frac{\Sigma}{n}$

According to 40 CFR, Part 61, Appendix B, Method 115, Subsection 2.1.7, the mean radon flux for the C-18 Repository was calculated by summing all individual final flux measurements and dividing by the total number of measurements for the C-18 Repository. The mean radon flux for the C-18 Repository was calculated as follows:

Where:
$$\overline{x}$$
 = mean flux for the C-18 Repository (pCi/m²-s)
 Σ = sum of all individual flux measurements (pCi/m²-s)
n = total number of measurements

9.2 Site Results

The mean radon flux rate for the C-18 Repository was calculated at 5.2 pCi/m²-s, which is below the NRC and EPA standard of 20 pCi/m²-s. All of the requirements and the conditions specified in 40 CFR, Part 61, Appendix B, Method 115 were fulfilled.

Appendix C is a summary of individual measurement results, including blank canister analysis results. Sample locations are depicted on Figure D-1, which is included in Appendix D.

References

U. S. Environmental Protection Agency, Radon Flux Measurements on Gardinier and Royster Phosphogypsum Piles Near Tampa and Mulberry, Florida, EPA 520/5-85-029, NTIS #PB86-161874, January 1986.

U. S. Environmental Protection Agency, Title 40, Code of Federal Regulations, 2001.

- U. S. Nuclear Regulatory Commission, Radiological Effluent and Environmental Monitoring at Uranium Mills, Regulatory Guide 4.14, April 1980.
- U. S. Nuclear Regulatory Commission, Title 10, Code of Federal Regulations, Part 40, Appendix A, January 2001.

7





.

8

Appendix A

Charcoal Canister Analyses Support Documents

ACCURACY APPRAISAL TABLE

UMETCO MINERALS CORPORTION GAS HILLS, WYOMING FINAL 2006 NESHAPS RADON FLUX MEASUREMENTS C-18 REPOSITORY

SYSTEM	DATE	Bkg Cou	nts (1 min	. each)	Source Cou	ints (1 min. e	each)	AVG NET	YIELD	FOUND	SOURCE	KNOWN	% BIAS
I.D.		#1	#2	· #3	#1	#2	#3	cpm	cpm/pCi	pCi -	ID	pCi	
M-01/D-21	9/8/2006	136	124	139	10311	10133	10266	10104	0.1718	58811	GS-04	59300	-0.8%
M-01/D-21	9/8/2006	142	134	137	10307	10213	10259	10122	0.1718	58917	GS-04	59300	-0.6%
M-01/D-21	9/9/2006	149	159	140	10323	10200	10388	10154	0.1718	59106	GS-04	59300	-0.3%
M-01/D-21	9/9/2006	144	156	128	10415	10255	10323	10188	0.1718	59303	GS-04	59300	0.0%
M-01/D-21	9/8/2006	136	124	139	10292	10495	10246	10211	0.1718	59437	GS-05	59300	0.2%
M-01/D-21	9/8/2006	142	134	137	10232	10151	10207	10059	0.1718	58551	GS-05	59300	-1.3%
M-01/D-21	9/9/2006	149	159	140	10210	10388	. 10130	10093	0.1718	58750	GS-05	59300	-0.9%
M-01/D-21	9/9/2006	144	156	128	10057	10381	10406	10139	0.1718	59014	GS-05	59300	-0.5%
M-02/D-20	9/8/2006	125	125	133	10413	10488	10360	10293	0.1716	59981	GS-04	59300	1.1%
M-02/D-20	9/8/2006	132	131	132	10330	10301	10478	10238	0.1716	59662	GS-04	59300	0.6%
M-02/D-20	9/9/2006	125	127	128	10318	10383	10434	10252	0.1716	59742	<u>GS-04</u>	59300	0.7%
M-02/D-20	9/9/2006	134	121	139	10525	10442	10357	10310	0.1716	60082	GS-04	59300	1.3%
M-02/D-20	9/8/2006	125	125	133	10458	10571	10395	10347	0.1716	60297	GS-05	59300	1.7%
M-02/D-20	9/8/2006	132	131	132	10344	10555	10453	10319	0.1716	60134	GS-05	59300	1.4%
M-02/D-20	9/9/2006	125	127	128	10535	10314	10481	10317	0.1716	60120	GS-05	59300	1.4%
M-02/D-20	9/9/2006	134	121	139	10486	10570	10208	10290	0.1716	59965	GS-05	59300	1.1%

AVERAGE PERCENT BIAS FOR ALL ANALYTICAL SESSIONS:

0.3%

BALANCE OPERATION DAILY CHECK

Balance Model:	Ohqus	port-o-gram	
Standard Weight (g):_200.0	· · · · · · · · · · · · · · · · · · ·	

Date	Pre-check (g)	Post-check (g)	O.K. ± 0.1 % ?	Ву	
9/08/06	200.0	200,0	yes	DLCoop	
9/09/06	200.0	200,0	yes	Delog	
		•	•		
		· · ·	· · · · · · · · · · · · · · · · · · ·		
·					
			·		
			·		
		· ·			
	· · · · · · · · · · · · · · · · · · ·				

	e e				
				,	

SITE LOCATION: Gas Hills, Wyo,	
CLIENT: UMEtco Minerals Corp.	
Calibration Check Log	
System ID: $M - 01 / D - 21$ Calibration Date: $6/02/06$ Due Date:	6/02/07
Scaler S/N: <u>51572</u> High Voltage: <u>1050</u> Window: <u>4.42</u>	Thrshld: <u>2.20</u>
Detector S/N: 041533 Source ID/SN: $\frac{Rq^{224}/G^{5-04}}{G^{5-04}}$ Source Activ	vity: <u>59.3 KpCi</u>
Blank Canister Bkgd. Range, cpm: $2\sigma = 10\%$ to 173 $3\sigma = 92$	to189
Gross Source Range, cpm: $2\sigma = 10195$ to 10588 $3\sigma = 10084$	L to 10689
Technician: DL Coop	· · · ·

All counts times are one minute.

	Date	By	Backg	round Cou	ints (1 min	. each)	Source Counts (1 min. each)				
			#1	#2	#3	Avg.	#1	#2	#3	Average	Y/N
pre.	9/08/06	Decop	136	124	139	133	10311	10133	10266	10237	Y
P055	9/08/06	BLLowph	-142	134	137	138	10377	10213	10259	10260	Y.
pre	9/09/06	DLCoopen	149	159	40	149	10323	10200	10388	10304	Y.
post	9/09/06	RCoga	144	156	128	143	10415	10255	10323	10331	ý
•			,								
										•	
:											
	· · ·										
										· ·	
										·	
										· · ·	
			· ·					· · ·	•		
									<u> </u>	L	L

Y/N: Y = average background and source cpm falls within the control limits.

N = average background and source cpm does not fall within the control limits.

				CH	ARCOAL	CANISTE	R ANALYSI	S SYSTEM	· · ·		
	SITE LOCA	TION:	Gra	25 H;	115,1	Nyo	· .				
	CLIENT:	Um	etco	> M.	inéra	als	Corp.	· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·		• •
			,		. <u>(</u>	Calibration	Check Log				
	System ID: _	M-0	>1/D	-21	c	alibration	Date: _ 6/0	2106	Due Date:	02/07	
	Scaler S/N: _	519	572		High	Voltage: _	1050	Window:	<u>4.42</u> T	hrshld: <u>2.20</u>	
	Detector S/N	041	533		Sourc	e ID/SN:	Razz6 /	65-04	Source Activit	<u>у: 59,3 Кра</u>	<u> </u>
	Blank Caniste	er Bkgd.	Range, cp	m: $2\sigma = $	(0	B to	173	3 σ =	92	to 189)
	Gross Source	Range, c	pm:	2 σ = _	100	35 to	10511	3 σ =	9916	to 1062	9
				Techn	ician:	D_{i}	1 000	<u>z-</u>	- -		
	All cou	nts times	are one m	inute.							
	Date	By	Backg	round Cou	ints (1 min	. each)		Source Count	ts (1 min. each) · · ·	ok?
			#1	#2	#3	Avg.	#1	#2	#3	Average	Y/N
pre.	9/08/06	Piloga	136	124	139	133	10292	10495	10246	10344	<u>y</u>
post	9/08/06	Deloge	142	134	137	138	10232	10151	10207	10197	<u>Ι ΄γ</u>
pre	9/09/06	DLCooper	149	139	140	149	10210	103 88	10130	10243	<u>Y</u>
post	9/09/06	PLCooph	144	156	128	143	10057	10381	10406	10281	Ι¥-
							•			· · · · · · · · · · · · · · · · · · ·	
	1									1	

Y/N: Y = average background and source cpm falls within the control limits.

N = average background and source cpm does not fall within the control limits.

CHARCOAL CANISTER ANALYSIS SYSTEM	· · ·
SITE LOCATION: Gas Hills, WYD	
CLIENT: Umetco Minerals Corp.	
Calibration Check Log	•
System ID: $M-02/D-20$ Calibration Date: $6/02/06$ Due Date:	6/02/07
Scaler S/N: 51563 High Voltage: 1000 Window: 4.42	Thrshld: <u>2.20</u>
Detector S/N: 041532 Source ID/SN: $Rq^{226}/G5 \cdot 04$ Source Activ	vity: <u>59.3 KpCi</u>
Blank Canister Bkgd. Range, cpm: $2\sigma = 100$ to 164 $3\sigma = 84$	to180
Gross Source Range, cpm: $2\sigma = 1010B$ to $1064Z$ $3\sigma = 9975$	to10775
Technician: DL Cogn	

All counts times are one minute.

	Date	By	Backg	round Cou	nts (1 min	. each)	Source Counts (1 min. each)						
			#1	#2	#3	Avg.	#1	#2	#3	Average	Y/N		
pre	9/08/06	DLCoop	125	125	(33	128	10413	10488	10360	10420	X		
Post	9108/06	DLCoge	132	131	132	132	10330	10301	10478	10370	Y		
pre	9109106	LCoop	125	127	128	127	10318	0383	10434	10378	'y		
post	9109106	DLCoop	. 134	121	139	131	10525	10442	10357	10441	Ý		
•													
	·												
									····	·			
	w									· · · · · · · · · · · · · · · · · · ·			
	· · · ·			•									
· .													
		·						·					
					· · · · ·		·						
			·										
		· · · · ·								· · · · ·			
											{		
			· · ·										
										· · · · · · · · · · · · · · · · · · ·			
		· · ·											
								· · ·	ļ	L			

Y/N: Y = average background and source cpm falls within the control limits.

N = average background and source cpm does not fall within the control limits.

CHARCOAL	CANISTER	ANALYSIS	SYSTEM

SITE LOCATION: Gas Hills, Wyo.	· · ·
CLIENT: Umetco Minerals corp.	an a
Calibration Check Log	· .
System ID: $M - 02/D - 20$ Calibration Date: $6/02/06$ Due Date:	6/02/07
Scaler S/N: 51563 High Voltage: 1000 Window: 4.42	Thrshld: <u>2.20</u>
Detector S/N: 041532 Source ID/SN: Rq^{22b}/GS^{-04} Source Activ	rity: <u>59.3 KpCi</u>
Blank Canister Bkgd. Range, cpm: $2\sigma = 100$ to 164 $3\sigma = 34$	_to_180
Gross Source Range, cpm: $2\sigma = \frac{9915}{10572}$ to 10572 $3\sigma = \frac{9751}{10572}$	to10736
Technician: DL Cooper	
	· · · ·

	All counts times are one minute.													
	Date	By	Backg	round Cou	nts (1 min	. each)		Source Count	s (1 min. each)	ok?			
			#1	#2	#3	Avg.	#1	#2	#3	Average	Y/N			
Pre	9/08/06	DL Coope	-125	125	133	128	10458	10571	10395	10475	Y			
P05+	9108106	Dicoopt	- 132	131	132	132	10344	10555	10453	10451	Ý			
pre	9/09/06	DLCoopen	125	127	128	127	10535	10314	10481	10443	ly_			
post	9/09/06	DLCoopy	134	121	139	131	10486	10570	lozoB	10421				
										:	,			
											:			
	-													
						··· .								
-											1			
	· · · · · · · · · · · · · · · · · · ·													
•														

Y/N: Y = average background and source cpm falls within the control limits.

N = average background and source cpm does not fall within the control limits.

Appendix B

Recount Data Analyses

	1	 · · ·	
			· ·

CLIENT: UMETCO	PROJECT: RADON FLUX MEASUREMENTS, GAS HILLS, WY PR											PROJECT NO.:						
PILE: C-18 AREA: COVER D FIELD TECHNICIAN COUNTING SYSTEM	BATCH: G DEPLOYED: IS: Craig She M I.D.: M01/[9 erwood, D21, MC	SURFA 6 David 02/D20	ACE: SC 6 Cooper	dil Retri Cal.	eved: Cou Due: 6	NTED 5/02/0	9) BY: [7	AIR TI 7 DLC	EMP Mi 6 DAT	IN: 56°F Charco/ `A Entry B`	AL BKG: Y: DLC	WEATHEF 149	R: NO RAIN cpm	Wt. Out: TARE WEIGHT:	180.0 29.2	g. g.	· ·
RECOUNT CANIST	ER ANALYS	SIS:																
GRID LOCATION	SAMPLE		.OY MIN	RETF HR	RIV MIN	ANAI MO	.YSI: DA	S YR	MID-	TIME MIN	CNT (MIN)	GROSS		pCi/m	DN ± I²s pCi/m²s	LLD pCi/m ² s	PRE	CISION % RPD
C-18 NS-10 RECOUNT	G10 G10	10 10	42 42	10 10	40 40	9 9	8 9	6 6	17 9	17 17	1 1	2169 1847	218.3 218.3	3.5 3.3	0.4 0.3	0.03 0.04		5.98
C-18 NS-20 RECOUNT	G20 G20	10 10	34 34	10 10	34 34	9 9	8 9	- 6 6	17 9	28 17	1 1	293 9 2717	217.4 217.4	4.8 5.0	0.5 0.5	0.03 0.04		4.1%
C-18 NS-30 RECOUNT	G30 G30	11 11	30 30	11 11	30 30	9	8 9	6 6	17 9	38 19	1 1	2842 2573	216.1 216.1	4.6 4.7	0.5 0.5	0.03 0.04		2.28
C-18 NS-40 RECOUNT	G40 G40	11 11	32 32	11 11	32 32	9 9	8 9	6 6	17 9	49 19	· 1 1	6250 5535	216.5 216.5	10.5 10.4	1.1 1.0	0.03		1.0%
C-18 NS-50 RECOUNT	650 650	11 11	9 9	11 11	10 10	9 9	8 9	6 6	18 9	0 21	1 1	1871 1675	215.5 215.5	3.0 3.0	0.3 0.3	0.03 0.04		0.08
C-18 NS-60 RECOUNT	G60 G60	11 11	25 25	11 11	25 25	9 9	8 9	6 6	18 9	10 21	1 1	2429 2188	214.8 214.8	3.9 3.9	0.4	0.03 0.04		0.0%
C-18 NS-70 RECOUNT	G70 G70	11 11	48 48	11 11	48 48	9 9	8 9	6 6	18 9	22 23	1 1	2862 2546	218,3 218,3	4.7 4.6	0.5 0.5	0.03 0.04		2.28
C-18 NS-80 RECOUNT	G80 G80	11 11	45 45	11 11	45 45	9 9	8 9	6 6	18 9	33 23	1 1	2505 2189	221.7 221.7	4.1 3.9	0.4 0.4	0.03 0.04	•	5.0%
C-18 NS-90 RECOUNT	G90 G90	11 11	51 51	11 11	50 50	9 9	8 9	6	18 9	44 25	1 1	6543 5828	215,3 215,3	11.1 11.0	1.1 1.1	0.03 0.04		0.9%
C-18 NS-100 RECOUNT	G100 G100	12 12	1 1	12 12	1 1	9 9	8	6 6	19 . 9	1 25	1 1	7048 6304	215.3 215.3	11.9 11.9	1.2	0.03 0.04		0.0%
			AVE	RAGE	PERC	CENT	PRE	CISI	ON F	OR TI	HE C-18 P	IT COVER	RED REG	ION:				2.3%

Appendix C

Radon Flux Sample Laboratory Data (including Blanks)

CLIENT: UMETCO MINERALS PROJECT: RADON FLUX MEASUREMENTS, GAS HILLS, WY

PROJECT NO.: 06003.01

PILE: C-18 BATCH: G SURFACE: SOIL AIR TEMP MIN: 56°F WEATHER: NO RAIN 9 6 6 AREA: COVER DEPLOYED: RETRIEVED: 7 6 CHARCOAL BKG: 149 9 cpm Wt. Out: 180.0 FIELD TECHNICIANS: Craig Sherwood, David Cooper COUNTED BY: DLC DATA ENTRY BY: DLC TARE WEIGHT: 29.2 a. COUNTING SYSTEM I.D.: M01/D21, M02/D20 CAL. DUE: 6/02/07

LOCATION I. D. HR MIN HR MIN MO DA YR HR MIN (MIN) COUNTS WT IN pCi/m²s pCi/m²s	AMENTS:
C-18 NS-01 G01 10 32 10 32 9 8 6 17 8 1 2148 216.3 3.5 0.3 0.03 C-18 NS-02 G02 10 45 10 45 9 8 6 17 8 1 3156 215.9 5.2 0.5 0.03 C-18 NS-03 G03 10 46 10 46 9 8 6 17 1 3539 216.1 5.8 0.6 0.03	
C-18 NS-02 G02 10 45 10 45 9 8 6 17 8 1 3156 215.9 5.2 0.5 0.03 C-18 NS-03 G03 10 46 10 46 9 8 6 17 1 3156 215.9 5.2 0.5 0.03	
C-18 NS-03 G03 10 46 10 46 9 8 6 17 10 1 3539 216.1 5.8 0.6 0.03	
C-18 NS-04 G04 10 47 10 47 9 8 6 17 10 1 2789 216.2 4.5 0.5 0.03	
C-18 NS-05 G05 10 48 10 48 9 8 6 17 12 1 1361 226 7 2.1 0.2 0.03	
C-18 NS-06 G06 10 51 10 51 9 8 6 17 12 1 1669 220.4 2.6 0.3 0.03	
C-18 NS-07 G07 10 52 10 52 9 8 6 17 14 1 4125 217.8 6.9 0.7 0.03	
C-18 NS-08 G08 10 38 10 38 9 8 6 17 15 1 1875 228.0 3.0 0.3 0.03	
C-18 NS-09 G09 10 31 10 31 9 8 6 17 17 1 1836 211.9 2.9 0.3 0.03	
C-18 NS-10 G10 10 42 10 40 9 8 6 17 17 1 2169 218.3 3.5 0.3 0.03	
C-18 NS-11 G11 10 44 10 45 9 8 6 17 19 1 2761 214.5 4.5 0.5 0.03	
C-18 NS-12 G12 10 48 10 48 9 8 6 17 19 1 3037 216.6 5.0 0.5 0.03	
C-18 NS-13 G13 10 49 10 49 9 8 6 17 21 1 1598 218.6 2.5 0.3 0.03	
C-18 NS-14 G14 10 53 10 53 9 8 6 17 21 1 3662 217 0 6 0 0.6 0.03	
C-18 NS-15 G15 10 54 10 54 9 8 6 17 23 1 4023 218.4 6.7 0.7 0.03	
C-18 NS-16 G16 10 57 10 57 9 8 6 17 23 1 6374 219.0 10.7 1.1 0.03	
C-18 NS-17 G17 10 39 10 39 9 8 6 17 26 1 1520 229 3 2.4 0.2 0.03	
C-18 NS-18 G18 10 40 10 39 9 8 6 17 25 1 3966 214 1 6.6 07 0.03	
C-18 NS-19 G19 10 30 10 30 9 8 6 17 28 1 1489 216.7 2.3 0.2 0.03	
C-18 NS-20 G20 10 34 10 34 9 8 6 17 28 1 2939 217.4 4.8 0.5 0.03	anahananananana
C-18 NS-21 C21 10 35 10 35 9 8 6 17 30 1 1981 2193 32 03 0.03	
C-18 NS-22 G22 10 49 10 49 9 8 6 17 30 1 1539 2209 2.4 0.2 0.03	
C-18 NS-23 G23 10 50 10 50 9 8 6 17 32 1 4408 215.6 7.4 0.7 0.03	
C-18 NS-24 G24 10 55 10 55 9 8 6 17 32 1 4351 217.4 7.2 0.7 0.03	
C-18 NS-25 G25 10 56 10 56 9 8 6 17 34 1 3363 220 5 5 6 0.6 0.03	
C-18 NS-26 G26 10 58 10 57 9 8 6 17 34 1 6321 220 / 10.6 11 0.03	
C-18 NS-27 G27 10 59 10 58 9 8 6 17 36 1 331/ 216.3 5.5 0.5 0.03	
C-18 NS-28 G28 10 33 10 33 9 8 6 17 36 1 6218 214.2 10.5 1.0 0.03	
C-18 NS-29 G29 10 31 10 31 9 8 6 17 38 1 3089 212.8 51 0.5 0.03	

Page 1 of 4

CLIENT: UMETCO MINERALS	PROJECT:	RADON FLUX MEASUREMENTS, GAS HILLS, WY	

PROJECT NO.: 06003.01

PILE: C-18	BATCH: G	:	SUR	FACE	SOIL		AIR 1	EMP	MIN: 56°F	WEATHE	R: NO RAIN			
AREA: COVER	DEPLOYED:	9	6	6	RETRIEVED:	9	7	6	CHARCOAL BKG:	149	cpm	Wt. Out:	180.0	g.
FIELD TECHNICIANS: Craig Sherwood, David Cooper COUNT							DLC	DA	ATA ENTRY BY: DLC			TARE WEIGHT:	29.2	g.
COUNTING SYS	TEM I.D.: M01/D21	, M 0	2/D2	0	CAL. DUE: 6/02/	/07								

4.4.9	GRID	SAMPLE	DEP	LOY	RET	RIV	ANA	LYSI	S	MID-	TIME	CNT	GROSS	GROSS	RADON	ren an	ELD 🚬	
	LOCATION	I.D.	HR	MIN	HR	MIN	MO	DA	YR	HR	MIN	(MIN)	COUNTS	WT IN	pCi/m²s	pCi/m²s	pCi/m²s	COMMENTS:
	C-18 NS-31	G31	10	30	10	30	9	8	6	17	40	1	2806	217.8	4.6	0.5	0.03	
	C-18 NS-32	G32	10	36	10	36	9	8	6	17	40	<u> </u>	5503	220.9	9.3	0.9	0.03	
	C-18 NS-33	G33	10	37	10	35	9	8	6	17	43	1	1863	216.7	3.0	0.3	0.03	
	C-18 NS-34	G34	11	21	11	21	9	8	6	17	42	1	4936	218.3	8.3	0.8	0.03	
	C-18 NS-35	G35	11	.23	11	22	9	8	6	17	45	1	5093	219.3	8.5	0.8	0.03	· .
	C-18 NS-36	G36	. 11	14	11	14	9	8	6	17	45	1	3685	216.7	6.1	0.6	0.03	
	C-18 NS-37	G37	11	15	11	15	9	8	6	17	47	1	1685	217.2	2.6	0,3	0.03	
	C-18 NS-38	G38	11	0	11	0	9	8	6	17	47	1	5587	215.6	9.4	0.9	0.03	
	C-18 NS-39	G39	11	1	11	1	9	8 -	6	17	49	- 1	6922	212.8	11.7	1.2	0.03	••
	C-18 NS-40	G40	11	32	11	32	9	8	6	17	49	1	6250	216.5	10.5	1.1	0.03	
	C-18 NS-41	G41	11	31	11	31	9	8	6	17	51	1	3859	217.0	6.4	0.6	0.03	
-	C-18 NS-42	G42	11	29	11	29	9	8	6	17	51	1	3777	211.4	6.2	0.6	0.03	
	C-18 NS-43	G43	11	28	11	28	9	8	6	17	54	1	1674	221.2	2.6	0.3	0.03	
	C-18 NS-44	G44	11	27	11	27	9	8	6	17	53	1	4827	219.3	8.0	0.8	0.03	
-	C-18 NS-45	G45	11	26	11	26	9	8	6	17	56	1	2469	221.6	4.0	0.4	0.03	
	C-18 NS-46	G46	11	19	11	20	9	8	6	17	56	1	2201	218.2	35	0.4	0.03	
	C-18 NS-47	G47	11	20	11	21	9	8	6	17	58	1	3323	216.2	5.5	0.5	0.03	
	C-18 NS-48	G48	11	12	11	12	9	8	6	17	58	1	2726	218.5	4.4	0.4	0.03	
	C-18 NS-49	G49	11	13	11	13	9	8	6	18	0	1	2070	218.7	3.3	0.3	0.03	
	C-18 NS-50	G50	11	9	11	10	9	8	6	18	0	1	1871	215 5	3.0	0.3	0.03	
	C-18 NS-51	G51	. 11	1	11	2	9	8	6	18	2	, 1	3412	215.8	5.6	0.6	0.03	
	C-18 NS-52	G52	11	2	11	3	. 9	8	6	. 18	2	1	5835	216.7	9.8	1.0	0.03	
	C-18 NS-53	G53	- 11	39	11		9	8	6	18	4	1	6530	219.8	11.0	1.1	0.03	
-	C-18 NS-54	G54	11	38	11	37	9	8	6	18	4	1	5005	215.5	8.4	0.8	0.03	
	C-18 NS-55	G55	11	36	11	36	9	8	6	18	6	·· 1	4929	218.4	8.2	0.8	0.03	
	C-18 NS-56	G56	11	35	11	35	9	8	6	18	6	1.	2777	217.2	4.5	0.5	0.03	
	C-18 NS-57	G57	11	34	11	34	9	8	6	18	8	1	1403	218.3	2.2	0.2	0.03	
	C-18 NS-58	G58	11	33	11	- 33	9	8	6	18	8	1	2484	224.6	4.0	0.4	0.03	
	C-18 NS-59	G59	11	24	11	24	-9	8	6	18	10	1	1647	219.2	2.6	0.3	0.03	
	C-18 NS-60	G60	11	25	11	25	9	8	6	18	10	1	2429	214.8	3,9	0.4	0.03	

Page 2 of 4

CLIENT: UMETCO MINERALS PROJECT: RADON FLUX MEASUREMENTS, GAS HILLS, WY PROJECT NO.: 06003.01

PILE: C-18	BATCH: G		SUR	FACE	E: SOIL	OIL AIR TEMP MIN: 56°F						N					
AREA: COVER	DEPLOYED:	9	6	6	RETRIEVED:	9	7	6	CHARCOAL BKG:	149	cpm	Wt. Out:	180.0	g.			
FIELD TECHNIC	d Coo	oper COUNTE	ed by: I	DLC	D	ATA ENTRY BY: DLC			TARE WEIGHT:	29.2	g.						
COUNTING SYS	TEM I.D.: M01/D21	I, MC	2/D2	0	CAL. DUE: 6/02	/07				•							

GRID	SAMPLE	DEF	LOY	RET	RIV	ANA	LYS	IS	MID-	TIME	CNT	GROSS	GROSS	RADON		ing LLD	
LOCATION	I. D.	HR	MIN	HR	MIN	MO	DA	YR	HR	MIN	(MIN)	COUNTS	WT IN	pCi/m²s	pCi/m²s	pCi/m²s	COMMENTS:
C-18 NS-61	G61	11	16	11	16	9	8	6	18	12	1	2758	218.7	4.5	0.5	0.03	
C-18 NS-62	G62	11	18	11	17	9	8	6	18	12	1	2125	219.0	3,4	0.3	0,03	
C-18 NS-63	G63	11	11	11	11	9	8	6	18	14	1	1672	223.2	2.6	0.3	0.03	
C-18 NS-64	G64	11	5	11	4	9	8	6	18	14	1	1620	216.8	2.5	0.3	0.03	
C-18 NS-65	G65	11		11	9	9	8	6	18	17	2	1711	215.1	12	0.1	0.03	
C-18 NS-66	G66	11	40	11	40	9	8	6	18	18	3	1355	217.3	0.5	0.1	0,03	
C-18 NS-67	G67	11	. 41	11	41	9	8	6	18	20	1.	5082	228.8	8.5	0.9	0.03	
C-18 NS-68	G68	11	42	11	42	9	8	6	18	20	1	4056	228.4	6.7	0.7	0.03	•
C-18 NS-69	G69	11	47	11	47	9	- 8	6	18	23	2	1574	227.3	1.1	0.1	0.03	
C-18 NS-70	G70	11	48	11	48	9	8	6	18	22	1	2862	218.3	4,7	0.5	0.03	
C-18 NS-71	G71	11 ·	52	11	52	9	8	6	18	25	1	2306	216.6	3.7	0.4	0.03	
C-18 NS-72	G72	11	53	11	53	9	8	6	18	25	1	2750	215.8	4.5	0.4	0.03	
C-18 NS-73	G73	11	55	11	55	9	8	6	18	27		3050	217.3	5.0	0.5	0.03	
C-18 NS-74	G74	11	56	11	56	9	- 8	6	18	27	1	2609	219.1	4.2	0.4	0.03	
C-18 NS-75	G75	11	58	11	58	9	8	6	18	29	1	2792	216.1	4.5	0.5	0.03	
C-18 NS-76	G76	11	59	11	59	9	8	6	18	29	1	2675	217.9	4.4	0.4	0.03	
C-18 NS-77	G77	12	Ö	12	Ō	9	8	6	18	31	1	3557	216.9	5.9	0.6	0.03	
C-18 NS-78	G78	11	43	11	43	9	8	6	18	31		3706	214.2	6,2	0.6	0.03	
C-18 NS-79	G79	11	44	11	44	9	8	6	18	33	1	3182	218.3	5.2	0.5	0.03	
C-18 NS-80	G80	11	45	11	45	9	8	6	18	33	1	2505	221.7	4.1	0.4	0.03	
C-18 NS-81	G81	11	49	11	49	9	8	6	18	- 36	1	1952	222.6	3.1	0.3	0.03	
C-18 NS-82	G82	11	50	11	50	9	8	6	18	36		1565	221.4	2.4	0.2	0.03	
C-18 NS-83	G83	11	53	11	53	9	8	6	18	38	1	4749	217.7	7.9	0.8	0.03	
C-18 NS-84	G84	11	54	11	54	9	8	6	18	38	1	2182	218.8	3.5	0.4	0.03	
C-18 NS-85	G85	11	57	11	56	9	8	6	18	40	1	4648	218.4	7.8	0.8	0.03	
C-18 NS-86	G86	11	57	11	57	9	8	6	18	40		2707	216.5	44	0.4	0.03	
C-18 NS-87	G87	11	- 59	11	59	9	8	6	18	42	1	3238	215.0	5.3	0.5	0.03	
C-18 NS-88	G88	12	0	12	0	9	8	6	18	42	1	2383	216.8	3.9	0.4	0.03	
C-18 NS-89	G89	11	46	11	46	9	8	6	18	44	1	2773	215.2	4.5	0.5	0.03	
C-18 NS-90	G90	11	51	11	50	9	8	6	18	44	1	6543	215,3	11.1	1,1	0.03	

Page 3 of 4

CLIENT: UMETCO MINERALS PROJECT: RADON FLUX MEASUREMENTS, GAS HILLS, WY PROJECT NO.: 06003.01

PILE: C-18 BATCH: G WEATHER: NO RAIN SURFACE: SOIL AIR TEMP MIN: 56°F DEPLOYED: AREA: COVER 9 6 6 **RETRIEVED**: 76 CHARCOAL BKG: 149 cpm 9 Wt. Out: 180.0 q. FIELD TECHNICIANS: Craig Sherwood, David Cooper COUNTED BY: DLC DATA ENTRY BY: DLC TARE WEIGHT: 29.2 g. COUNTING SYSTEM I.D.: M01/D21, M02/D20 CAL. DUE: 6/02/07

GRID	SAMPLE	DEP	LOY	RET	RIV	ANA	ALYS	IS	MID-	TIME	CNT	GROSS	GROSS	RADON	da se t er se	LLD 🦾	
LOCATION	1. D.	HR	MIN	HR	MIN	MO	DA	YR	HR	MIN	(MIN)	COUNTS	WT IN	pCi/m²s	pCi/m²s	pCi/m²s	COMMENTS:
C-18 NS-91	G91	11	52	11	51	9	8	6	18	46	1	1210	217.5	1.8	0.2	0.03	
C-18 NS-92	G92	11	54	11	54	9	8	6	18	46	1	1669	217.0	2.6	0.3	0.03	
C-18 NS-93	G93	11	55	11	55	9	8	6	. 18	48	1	3315	215.7	5.5	0.5	0.03	
C-18 NS-94	G94	11	57	11	57	9	8	6	18	50	1	2189	208.6	3.5	0.4	0.03	
C-18 NS-95	G95	11	58	11	58	9	8	6	-18	52	1	2101	221.1	3.4	0.3	0.03	· *
C-18 NS-96	G96	12	1	12	1	9 ,	8	6	18	54	1.	1765	219.0	2.8	0.3	0.03	
C-18 NS-97	G97	12	3	12	3	9	8	6	18	56	1	3867	216.5	6.4	0.6	0.03	
C-18 NS-98	G98	12	2	12	2	9	8	6	18	58	1	3405	219.6	5.6	0.6	0.03	
C-18 NS-99	G99	12	2	12	2	9	8	6	19	0	- 1	3708	220.5	6.1	0.6	0.03	
C-18 NS-100	G100	12	1	12	1	9	8	6	19	1	1	7048	215.3	11.9	1.2	0.03	
			AVE	RAGE	RAD	ON F	LUX	FOR	THE	C-18 F	PIT COVE	ERED REGI	ON:	5.2	pCi/m²s	· · · · · ·	
·														0.5	pCi/m²s	MIN	
														11.9	pCi/m²s	MAX	•

11.9 pCi/m²s

BLANK CANISTER ANALYSIS:

GRID	SAMPLE	DEP	LOÝ	RET	RIV.	ANA	LYSI	S	MID-	TIME	CNT	GROSS	GROSS	RADON	ng 🖆 n 🖓	LLD	
LOCATION	َ ا. D.	HR	MIN	HR	MIN	MO	DA	YR	HR	MIN	(MIN)	COUNTS	WT IN	pCi/m²s	pCi/m²s	pCi/m²s	COMMENTS:
BLANK	G blank 1	10	22	12	12	9	8	6	14	20	10	1720	209.0	0.04	0.02	0.03	CONTROL
BLANK	G blank 2	10	22	12	12	9	8	6	14	20	10	1533	209.5	0.01	0.02	0.03	CONTROL
BLANK	G blank 3	10	22	12	12	9	8	6	14	35	10	1699	208.3	0.03	0.02	0.03	CONTROL
BLANK	G blank 4	10	22	12	12	9	8	6	14	35	10	1544	212.3	0.01	0.02	0.03	CONTROL
BLANK	G blank 5	10	22	12	12	9	8	6	14	50	10	1552	210.7	0.01	0.02	0.03	CONTROL
AVERAGE BL	ANK CANIS	TER	ANAL	YSIS	FOR ⁻	THIS	SAM	PLE	SET:			· ·		0.02	pCi/m²s		

Appendix D Map, Figure D-1



C-18 Pit NESHAPS 2006.DWG