DEPARTMENT OF DEFENSE
HEADQUARTERS, FORT BELVOIR COMMUNITY HOSPITAL
9300 DEWITT LOOP
FORT BELVOIR, VIRGINIA 22060-5901

Reply to
Attention of

June 12, 2012

Health Physics Service

Nuclear Regulatory Commission, Region 1
ATTN: Mr. Dennis Lawyer
2100 Renaissance Boulevard, Suite 100
King of Prussia, PA 19406-2713

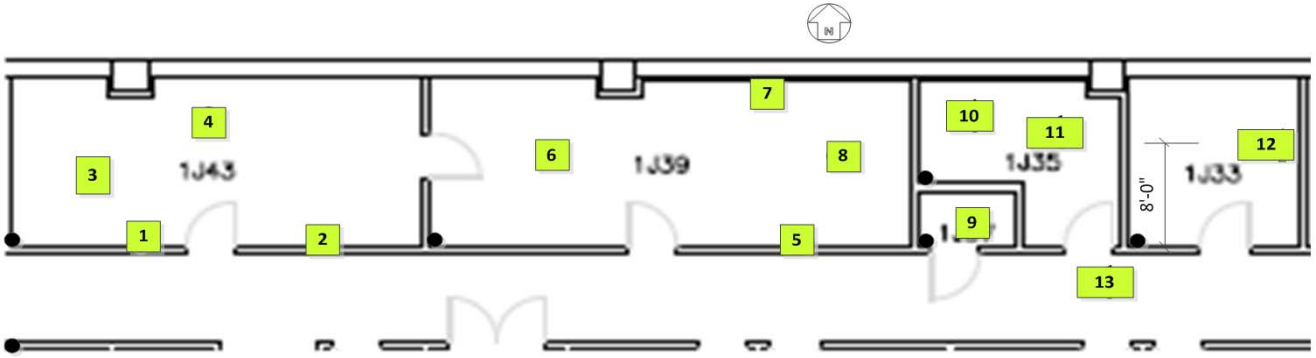
Dear Sir,

In response to your electronic mail message requesting additional information or clarification of the Final Status Survey report submitted for the Walter Reed Army Medical Center main campus, dated May 9th, 2012, please see our electronic mail response and associated attachments.

For additional clarification or information, please contact Lieutenant Colonel Francis M. Fota, Radiation Safety Officer at (571) 231-4034 or email francis.fota@us.army.mil and/or Colonel Casmere H. Taylor, JTF-CAPMED Radiation Hygiene Consultant at (301) 400-2539 or email casmere.taylor@med.navy.mil.

Sincerely

Francis M. Fota
Lieutenant Colonel
U.S. Army



Building 2					
First					
SU	Room	X,Y Locations			
2-1-2	1J43	S 22,3	S 7,2	5,4	14,9
	1J39	S 26,1	7,8	23,12	28,7
	1J37	3,2			
	1J35	3,5	10,4		
	1J33	11,8			
	Hall	76,5			

SURVEY UNITS LEGEND

Class 3

\# Measurement Number

Origin

Survey Unit Identifier

SU2-1-2

B-Building
F-Floor
B-Basement
G-Ground
1-1st; etc.
N- SU# for Floor

No Scale

Building 2 First Floor

Date: 1-18-12
Project: WRAMC Main Post
Prepared by: C. Wiblin

Summary of Random H3 Static Measurements

Building: 2
Survey Unit: SU2-1-2
Survey Date: 12/28/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm²) Activity	Net (dpm/100 cm²) Uncertainty (2σ)
Floor						
1	Drywall	77	106	19	264	90
2	Door	87	126	19	314	100
3	White Tile	70	92	19	229	90
4	White Tile	76	104	19	259	90
5	Refrigerator	58	68	18	170	90
6	Linoleum	85	122	19	304	90
7	Linoleum	92	136	20	339	100
8	Linoleum	94	140	20	349	100
9	White Tile	85	122	19	304	90
10	Tan Tile	103	158	20	394	100
11	Tan Tile	84	120	19	299	90
12	White Tile	70	92	19	229	90
13	Gray Tile	100	152	20	379	100
				Maximum:	394	
				Average:	295	
				STDEV:	64	

Instrument Data and Analysis Parameters

	Model	Serial No			
			Reference Material:	Tile Floor	
Instrument:	2360	141321	Background (cpm):	47.8	cpm
Detector:	44-110	PR-258430	Background σ (cpm):	14.35	cpm
Probe Area:	126	cm^2	Sample Analysis Time:	0.5	min

Total Efficiency:	0.319	cpm/dpm
Total Efficiency Uncertainty:	0.001	cpm/dpm
MDC:	206	dpm/100 cm^2

Summary of Biased H3 Static Measurements

Building: 2
Survey Unit: SU2-1-2
Survey Date: 12/28/2012

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	Table Top	64	80	18	200	90
2	Black Hood Drain	66	84	18	209	90
3	Black Lab Sink	75	102	19	254	90
4	Drywall	56	64	18	160	90
				Maximum:	254	
				Average:	206	
				STDEV:	39	

Instrument Data and Analysis Parameters

	Model	Serial No			
			Reference Material:	Tile Floor	
Instrument:	2360	184935	Background (cpm):	47.8	
Detector:	43-68	PR-181739	Background σ (cpm):	14.35	
Probe Area:	126	cm^2	Sample Analysis Time:	0.5	min

Total Efficiency:	0.319	cpm/dpm
Total Efficiency Uncertainty:	0.001	cpm/dpm
MDC:	206	dpm/100 cm^2

Summary of Random Beta Static Measurements

Building: 2
Survey Unit: SU2-1-2
Survey Date: 12/28/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	Drywall	93	0	9	-1	280
2	Door	88	-3	9	-40	270
3	White Tile	77	-8	9	-126	260
4	White Tile	88	-3	9	-40	270
5	Refrigerator	94	0	9	6	280
6	Linoleum	84	-5	9	-71	270
7	Linoleum	97	2	9	30	280
8	Linoleum	91	-1	9	-17	280
9	White Tile	97	2	9	30	280
10	Tan Tile	107	7	9	108	290
11	Tan Tile	100	3	9	53	280
12	White Tile	106	6	9	100	290
13	Gray Tile	94	0	9	6	280

Maximum: 108
Average: 3
STDEV: 65

Instrument Data and Analysis Parameters

	Model	Serial No		
Instrument:	2360	253237	Reference Material:	Tile Floor
Detector:	43-68	PR-216834	Background (cpm):	46.59
Probe Area:	126	cm^2	Background σ (cpm):	6.05
			Sample Analysis Time:	2 min

Total Efficiency: 0.051 cpm/dpm
Total Efficiency Uncertainty: 0.001 cpm/dpm
MDC: 773 dpm/100 cm^2

Summary of Biased Beta Static Measurements

Building: 2
Survey Unit: SU2-1-2
Survey Date: 12/28/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	Table Top	66	-1	7	-19	220
2	Black Hood Drain	63	-3	7	-42	210
3	Black Lab Sink	64	-2	7	-35	220
				Maximum:	-19	
				Average:	-32	
				STDEV:	12	

Instrument Data and Analysis Parameters

	Model	Serial No			
			Reference Material:	Metal	
Instrument:	2360	253237	Background (cpm):	34.23	
Detector:	43-68	PR-216834	Background σ (cpm):	4.21	
Probe Area:	126	cm^2	Sample Analysis Time:	2	min

Total Efficiency:	0.051	cpm/dpm
Total Efficiency Uncertainty:	0.001	cpm/dpm
MDC:	773	dpm/100 cm^2

Summary of Random Alpha Static Measurements

Building: 2
Survey Unit: SU2-1-2
Survey Date: 12/28/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	Drywall	5	2	2	16	30
2	Door	2	0	1	3	20
3	White Tile	0	-1	1	-5	10
4	White Tile	3	1	1	8	20
5	Refrigerator	2	0	1	3	20
6	Linoleum	1	0	1	-1	10
7	Linoleum	1	0	1	-1	10
8	Linoleum	0	-1	1	-5	10
9	White Tile	2	0	1	3	20
10	Tan Tile	1	0	1	-1	10
11	Tan Tile	1	0	1	-1	10
12	White Tile	3	1	1	8	20
13	Gray Tile	2	0	1	3	20

Maximum: 16
Average: 2
STDEV: 6

Instrument Data and Analysis Parameters

	Model	Serial No		
Instrument:	2360	253237	Reference Material:	Tile Floor
Detector:	43-68	PR-216834	Background (cpm):	0.59
Probe Area:	126	cm^2	Background σ (cpm):	0.51
			Sample Analysis Time:	2 min

Total Efficiency: 0.096 cpm/dpm
Total Efficiency Uncertainty: 0.001 cpm/dpm
MDC: 59 dpm/100 cm^2

Summary of Biased Alpha Static Measurements

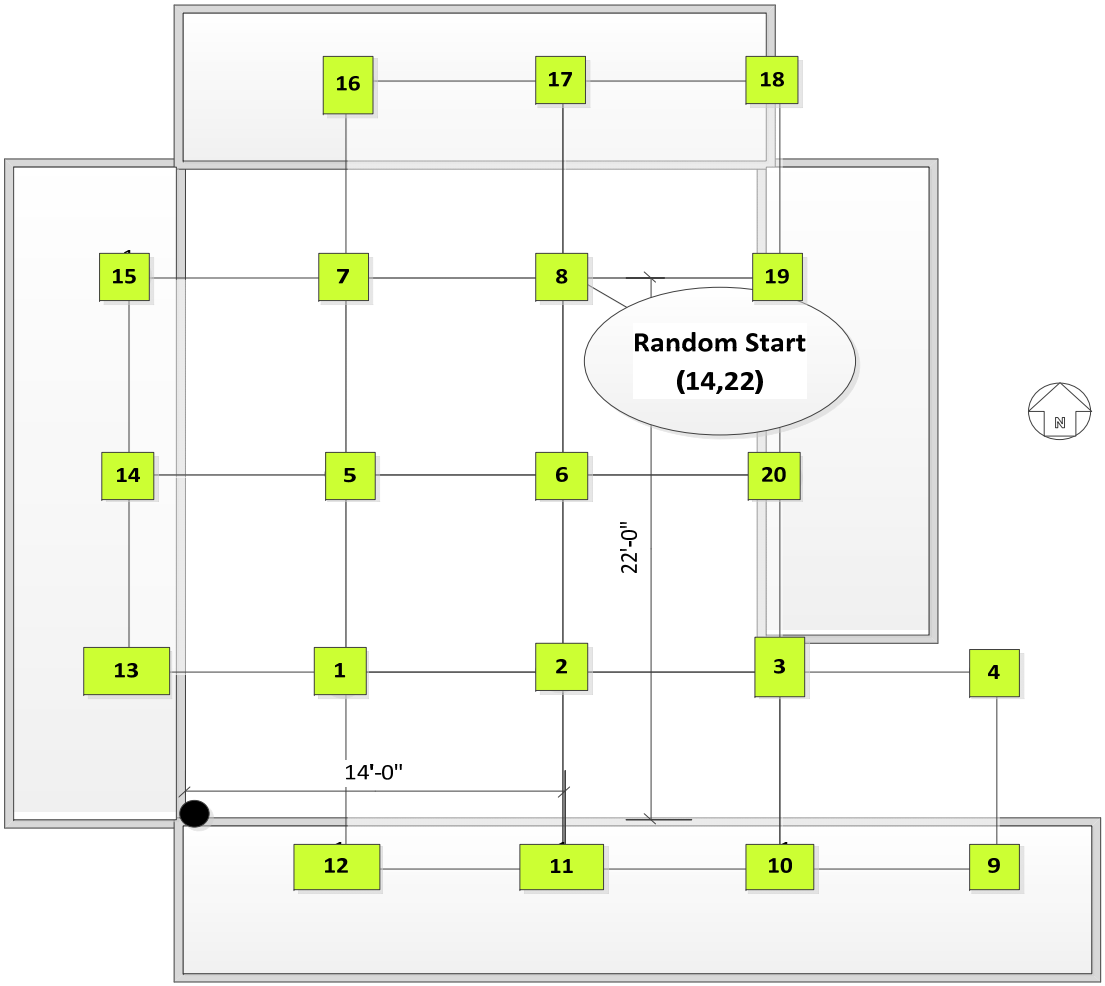
Building: 2
Survey Unit: SU2-1-2
Survey Date: 12/28/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	Table Top	2	0	1	3	20
2	Black Hood Drain	2	0	1	3	20
3	Black Lab Sink	2	0	1	3	20
				Maximum:	3	
				Average:	3	
				STDEV:	0	

Instrument Data and Analysis Parameters

	Model	Serial No			
			Reference Material:	Tile Floor	
Instrument:	2360	253237	Background (cpm):	0.59	
Detector:	43-68	PR-216834	Background σ (cpm):	0.51	
Probe Area:	126	cm^2	Sample Analysis Time:	2	min

Total Efficiency:	0.096	cpm/dpm
Total Efficiency Uncertainty:	0.001	cpm/dpm
MDC:	59	dpm/100 cm^2



SURVEY UNITS LEGEND

Class 1

\# Measurement Number

Origin

Survey Unit Identifier

SU2-1-3

B-Building
F-Floor
B-Basement
G-Ground
1-1st; etc.
N- SU# for Floor

No Scale

Building 2 First Floor

Date: 1-18-12
Project: WRAMC Main Post
Prepared by: C. Wiblin

Summary of Random H3 Static Measurements

Building: 2
Survey Unit: SU2-1-3
Survey Date: 12/28/2012

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	Wood Floor	51	25	14	62	70
2	Wood Floor	67	57	15	141	70
3	Wood Floor	64	51	15	126	70
4	Wood Floor	52	27	14	67	70
5	Wood Floor	70	63	16	156	80
6	Wood Floor	55	33	15	82	70
7	Wood Floor	58	39	15	97	70
8	Wood Floor	70	63	16	156	80
9	Drywall	55	33	15	82	70
10	Drywall	51	25	14	62	70
11	Drywall	45	13	14	32	70
12	Drywall	30	-17	13	-43	60
13	Cabinet Face	47	17	14	42	70
14	Cabinet Face	48	19	14	47	70
15	Cabinet Face	38	-1	13	-3	70
16	Drywall	48	19	14	47	70
17	Drywall	47	17	14	42	70
18	Drywall	46	15	14	37	70
19	Drywall	70	63	16	156	80
20	Cabinet Face	44	11	14	27	70
QC4	Wood Floor	45	13	14	32	70
		52.42857143		**Maximum:**	156	
				Average:	82	
				STDEV:	56	

Instrument Data and Analysis Parameters

	Model	Serial No		
Instrument:	2360	141321	Reference Material:	Wood Composite
Detector:	44-110	PR-258430	Background (cpm):	77.2
Probe Area:	126	cm^2	Background σ (cpm):	10.11
			Sample Analysis Time:	0.5 min

Total Efficiency:	0.319	cpm/dpm
Total Efficiency Uncertainty:	0.001	cpm/dpm
MDC:	206	dpm/100 cm^2

Summary of Biased H3 Static Measurements

Building: 2
Survey Unit: SU2-1-3
Survey Date: 12/28/2012

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	Wooden Plate	53	29	14	72	70
2	Steel Plate	44	11	14	27	70
				Maximum:	72	
				Average:	49	
				STDEV:	32	

Instrument Data and Analysis Parameters

	Model	Serial No			
Instrument:	2360	184935	Reference Material:	Tile Floor	
Detector:	43-68	PR-181739	Background (cpm):	77.2	
Probe Area:	126	cm^2	Background σ (cpm):	10.11	
			Sample Analysis Time:	0.5	min

Total Efficiency:	0.319	cpm/dpm
Total Efficiency Uncertainty:	0.001	cpm/dpm
MDC:	206	dpm/100 cm^2

Summary of Random Beta Static Measurements

Building: 2
Survey Unit: SU2-1-3
Survey Date: 12/28/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	Wood Floor	37	-8	17	-128	510
2	Wood Floor	39	-7	17	-112	510
3	Wood Floor	43	-5	17	-81	510
4	Wood Floor	92	19	17	300	530
5	Wood Floor	68	7	17	113	520
6	Wood Floor	54	0	17	4	520
7	Wood Floor	43	-5	17	-81	510
8	Wood Floor	93	20	17	308	530
9	Drywall	50	-2	17	-27	510
10	Drywall	54	0	17	4	520
11	Drywall	61	4	17	59	520
12	Drywall	57	2	17	28	520
13	Cabinet Face	33	-10	17	-159	510
14	Cabinet Face	50	-2	17	-27	510
15	Cabinet Face	56	1	17	20	520
16	Drywall	59	3	17	43	520
17	Drywall	42	-6	17	-89	510
18	Drywall	38	-8	17	-120	510
19	Drywall	49	-2	17	-35	510
20	Cabinet Face	51	-1	17	-19	510

Maximum: 308
Average: 17
STDEV: 149

Instrument Data and Analysis Parameters

	Model	Serial No
Instrument:	2360	253237
Detector:	43-68	PR-216834
Probe Area:	126	cm^2

Reference Material: Tile Floor
Background (cpm): 26.73
Background σ (cpm): 16.10
Sample Analysis Time: 2 min

Total Efficiency: 0.051 cpm/dpm
Total Efficiency Uncertainty: 0.001 cpm/dpm
MDC: 773 dpm/100 cm^2

Summary of Biased Beta Static Measurements

Building: 2
Survey Unit: SU2-1-3
Survey Date: 12/28/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	Wooden Plate	28	-13	17	-198	500
2	Steel Plate	36	-9	17	-136	510
				Maximum:	-136	
				Average:	-167	
				STDEV:	44	

Instrument Data and Analysis Parameters

	Model	Serial No			
			Reference Material:	Tile Floor	
Instrument:	2360	253237	Background (cpm):	26.73	
Detector:	43-68	PR-216834	Background σ (cpm):	16.10	
Probe Area:	126	cm^2	Sample Analysis Time:	2	min

Total Efficiency:	0.051	cpm/dpm
Total Efficiency Uncertainty:	0.001	cpm/dpm
MDC:	773	dpm/100 cm^2

Summary of Random Alpha Static Measurements

Building: 2
Survey Unit: SU2-1-3
Survey Date: 12/28/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	Wood Floor	2	0	1	4	20
2	Wood Floor	0	-1	1	-5	10
3	Wood Floor	3	1	1	8	20
4	Wood Floor	11	5	2	41	40
5	Wood Floor	1	0	1	0	20
6	Wood Floor	6	2	2	20	30
7	Wood Floor	6	2	2	20	30
8	Wood Floor	4	1	2	12	30
9	Drywall	4	1	2	12	30
10	Drywall	2	0	1	4	20
11	Drywall	0	-1	1	-5	10
12	Drywall	2	0	1	4	20
13	Cabinet Face	2	0	1	4	20
14	Cabinet Face	4	1	2	12	30
15	Cabinet Face	3	1	1	8	20
16	Drywall	3	1	1	8	20
17	Drywall	5	2	2	16	30
18	Drywall	1	0	1	0	20
19	Drywall	6	2	2	20	30
20	Cabinet Face	3	1	1	8	20

Maximum: 41
Average: 9
STDEV: 12

Instrument Data and Analysis Parameters

	Model	Serial No
Instrument:	2360	253237
Detector:	43-68	PR-216834
Probe Area:	126	cm^2

Reference Material: Wood Composite
Background (cpm): 0.55
Background σ (cpm): 0.8
Sample Analysis Time: 2 min

Total Efficiency: 0.096 cpm/dpm
Total Efficiency Uncertainty: 0.001 cpm/dpm
MDC: 59 dpm/100 cm^2

Summary of Biased Alpha Static Measurements

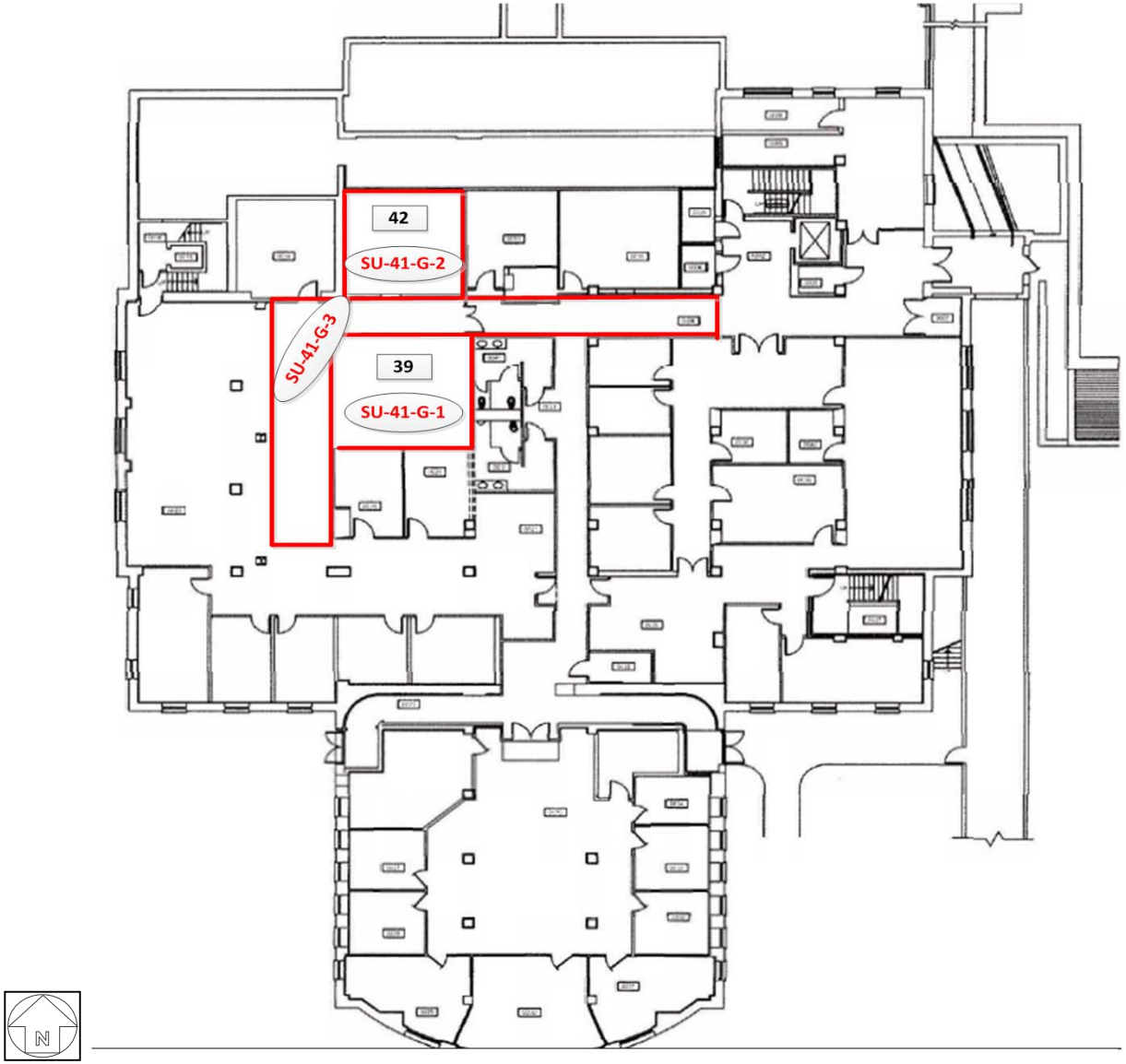
Building: 2
Survey Unit: SU2-1-3
Survey Date: 12/28/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	Wooden Plate	1	0	1	0	20
2	Steel Plate	4	1	2	12	30
				Maximum:	12	
				Average:	6	
				STDEV:	9	

Instrument Data and Analysis Parameters

	Model	Serial No			
			Reference Material:	Wood Composite	
Instrument:	2360	253237	Background (cpm):	0.55	
Detector:	43-68	PR-216834	Background σ (cpm):	0.8	
Probe Area:	126	cm^2	Sample Analysis Time:	2	min

Total Efficiency:	0.096	cpm/dpm
Total Efficiency Uncertainty:	0.001	cpm/dpm
MDC:	59	dpm/100 cm^2



SURVEY UNITS LEGEND

Survey Unit Identifier

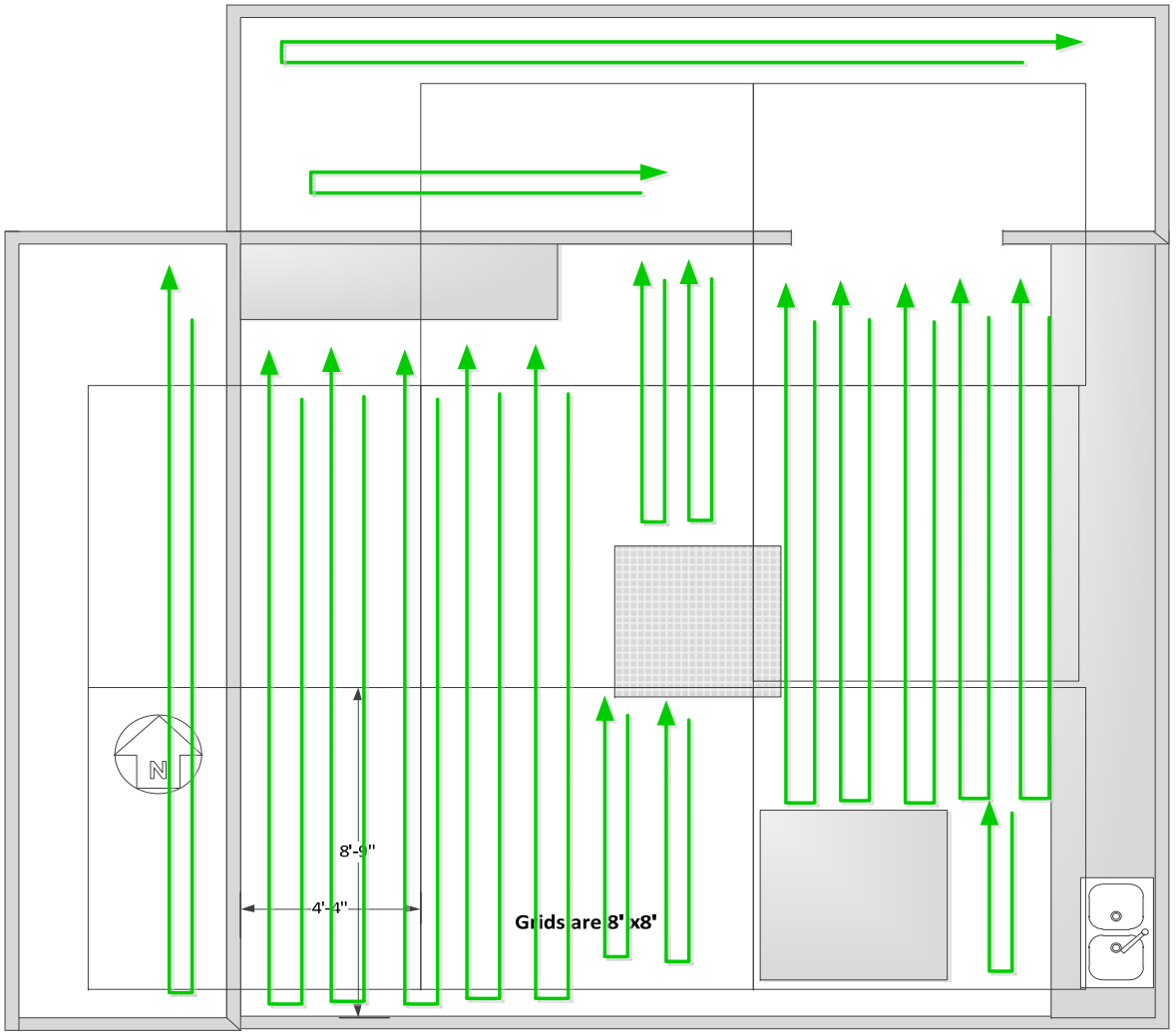
SU-B-F-N

B-Building
F-Floor
B-Basement
G-Ground
1-1st; etc.
N- SU# for Floor

No Scale

Building 41 Ground Floor

Date: 1-15-12
Project: WRAMC Main Post
Prepared by: C. Wiblin



SURVEY UNITS
LEGEND

Class 2

Scan Path

Survey Unit Identifier

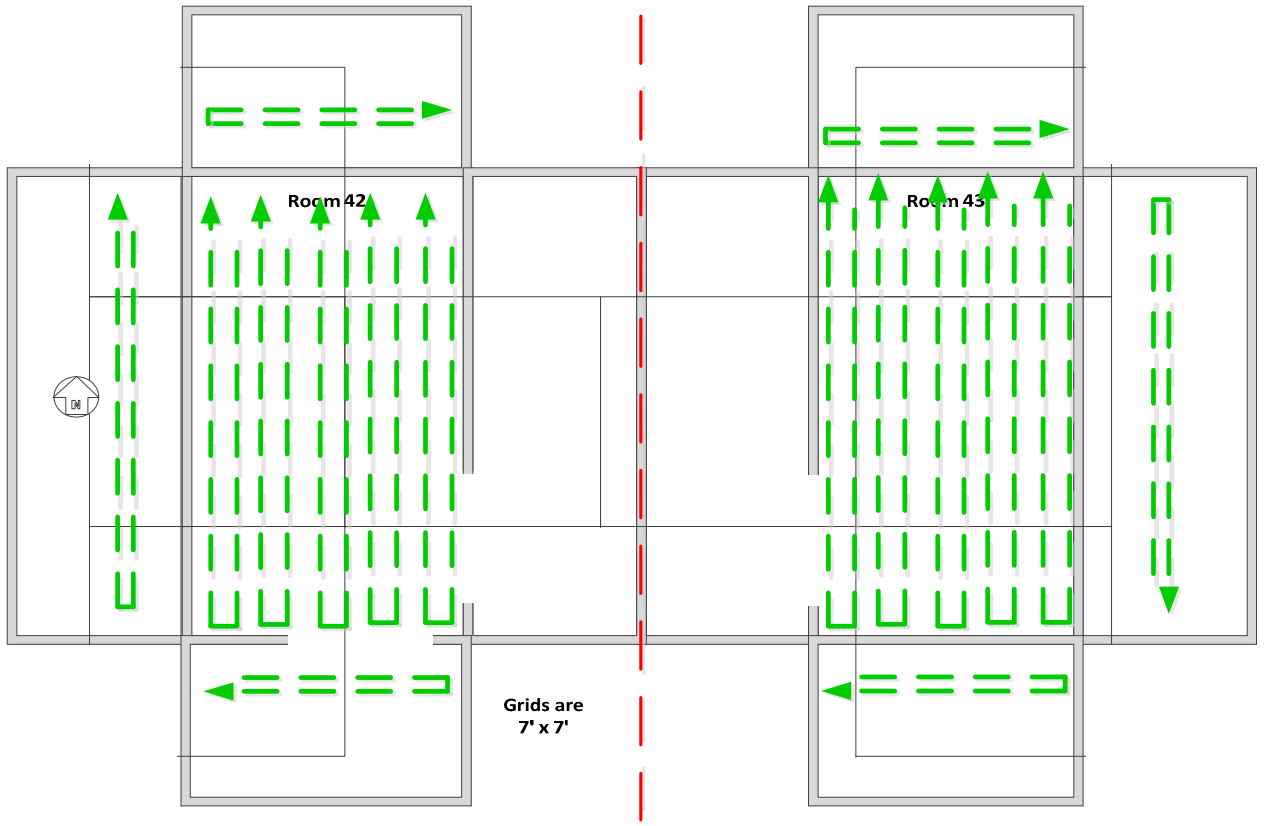
SU-41-G-1

B-Building
F-Floor
B-Basement
G-Ground
1-1st; etc.
N- SU# for Floor

No Scale

Building 41 Ground Floor
Room 39

Date: 1-15-12
Project: WRAMC Main Post
Prepared by: C. Wiblin



SURVEY UNITS
LEGEND

Class 2

Scan Path

Survey Unit Identifier

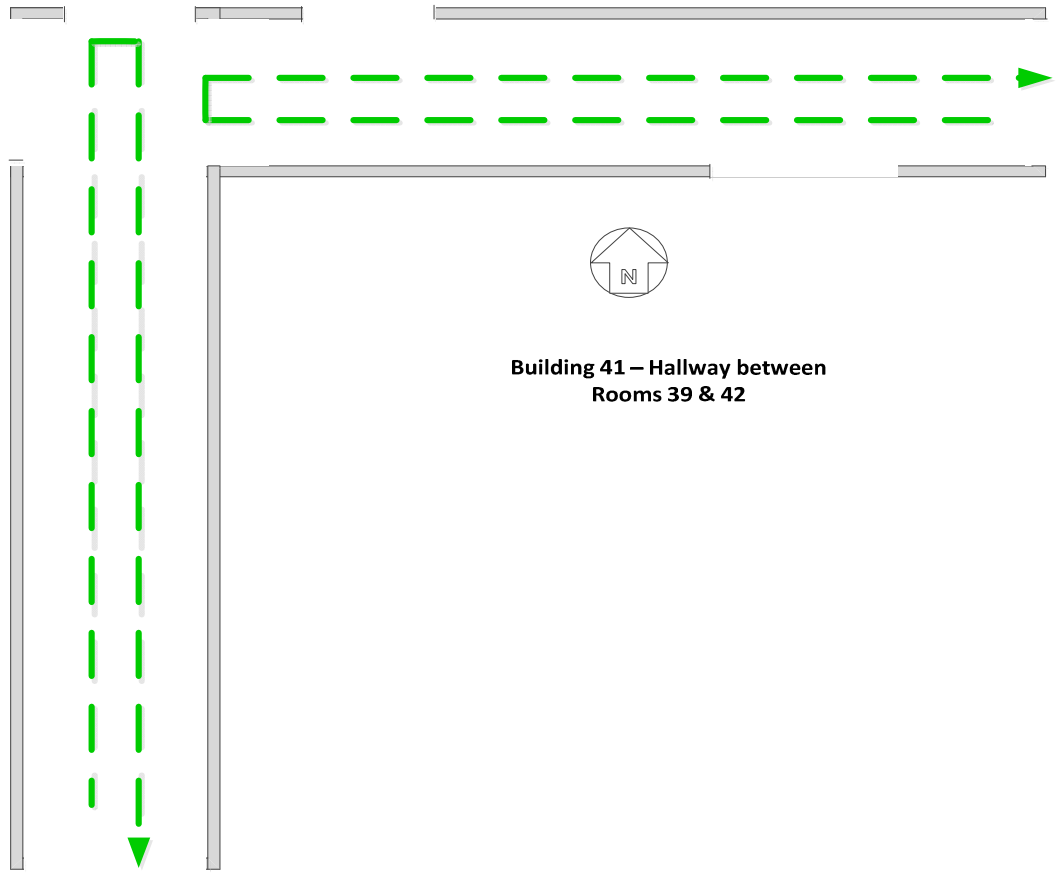
SU-41-G-2

B-Building
F-Floor
B-Basement
G-Ground
1-1st; etc.
N- SU# for Floor

No Scale

Building 41 Ground Floor
Rooms 42 and 43

Date: 1-15-12
Project: WRAMC Main Post
Prepared by: C. Wiblin



Building 41 – Hallway between Rooms 39 & 42

SURVEY UNITS LEGEND

Class 3

Scan Path

Survey Unit Identifier

SU-41-G-3

B-Building
F-Floor
B-Basement
G-Ground
1-1st; etc.
N- SU# for Floor

No Scale

Building 41 Ground Floor Hallway

Date: 1-15-12
Project: WRAMC Main Post
Prepared by: C. Wiblin

Summary of Scan Results - Beta

Location: Building 41 Ground Level

		Gross CPM				Activity (dpm/100cm^2)			
Location	**Number of records**	**Minimum**	**Maximum**	**Average**	**STDEV**	**Minimum**	**Maximum**	**Average**	**STDEV**
SU41-G-1	544	111	326	198	36	-61	576	197	107
SU41-G-2	556	51	277	146	45	-239	431	43	133
SU41-G-3	633	69	257	155	33	-186	371	69	99

Area Scanned (ft^2) 1086

Instrument Data and Analysis Parameters

	Model	Serial No
Instrument:	2360	253258
Detector:	43-37	265544
Probe Area:	582	cm^2

Reference Material: Tile Floor
Background: 132 cpm
Background σ: 32.21 cpm
Scan speed: 1 detector width / 2 sec
Observation interval: 1 recorded measurement / 2 sec

Total Efficiency: 0.058 cpm/dpm
Total Efficiency Uncertainty: 0.001 cpm/dpm
MDC_{scan}: 363 dpm/100 cm^2

Summary of Scan Results - Alpha

Location: Building 41 Ground Level

Location	Number of records	Gross CPM Minimum	Gross CPM Maximum	Gross CPM Average	Gross CPM STDEV	Activity (dpm/100cm^2) Minimum	Activity (dpm/100cm^2) Maximum	Activity (dpm/100cm^2) Average	Activity (dpm/100cm^2) STDEV
SU41-G-1	544	0	26	3	4	-5	41	0	8
SU41-G-2	556	0	37	5	6	-5	61	3	11
SU41-G-3	633	0	46	12	9	-5	77	16	15

Area Scanned (ft^2) 1086

Instrument Data and Analysis Parameters

	Model	Serial No
Instrument:	2360	253258
Detector:	43-37	265544
Probe Area:	582	cm^2

Reference Material: Tile Floor
Background: 3 cpm
Background σ: 7.32 cpm
Scan speed: 1 detector width / 8sec
Observation interval: 1 recorded measurement / 2 sec

Total Efficiency: 0.096 cpm/dpm
Total Efficiency Uncertainty: 0.001 cpm/dpm
MDC_{scan}: 720 dpm/100 cm^2

Summary of Scan Results - Beta

Location: Building 41 Ground Level

Non-Floor Items

Location	Number of records	Gross CPM Minimum	Gross CPM Maximum	Gross CPM Average	Gross CPM STDEV	Activity (dpm/100cm$^{2)}$ Minimum	Activity (dpm/100cm$^{2)}$ Maximum	Activity (dpm/100cm$^{2)}$ Average	Activity (dpm/100cm$^{2)}$ STDEV
SU-41-G-1	433	22	137	69	19	-80	1821	699	319

Area Scanned (ft^2) 59

Instrument Data and Analysis Parameters

	Model	Serial No
Instrument:	2360	253258
Detector:	43-68	148454
Probe Area:	126	cm^2

Reference Material: Counter
Background: 27 cpm
Background σ: 5.95 cpm
Scan speed: 1 detector width / 2 sec
Observation interval: 1 recorded measurement / 2 sec

Total Efficiency: 0.048 cpm/dpm
Total Efficiency Uncertainty: 0.001 cpm/dpm
MDC_{scan}: 916 dpm/100 cm^2

Summary of Scan Results - Alpha

Location: Building 41 Ground Level

Non-Floor Items

Location	Number of records	Gross CPM Minimum	Gross CPM Maximum	Gross CPM Average	Gross CPM STDEV	Activity (dpm/100cm$^{2)}$ Minimum	Activity (dpm/100cm$^{2)}$ Maximum	Activity (dpm/100cm$^{2)}$ Average	Activity (dpm/100cm$^{2)}$ STDEV
SU-41-G-1	433	0	18	3	4	-4.45	141.32	15.91	31.51

Area Scanned (ft^2) 59

Instrument Data and Analysis Parameters

	Model	Serial No
Instrument:	2360	253258
Detector:	43-68	148454
Probe Area:	126	cm2

Reference Material: Counter
Background: 1 cpm
Background σ: 0.8 cpm
Scan speed: 1 detector width / 2sec
Observation interval: 1 recorded measurement / 2 sec

Total Efficiency: 0.098 cpm/dpm
Total Efficiency Uncertainty: 0.001 cpm/dpm
MDC_{scan}: 705 dpm/100 cm^2

Summary of Exposure Rate Measurements

Location: Building 41

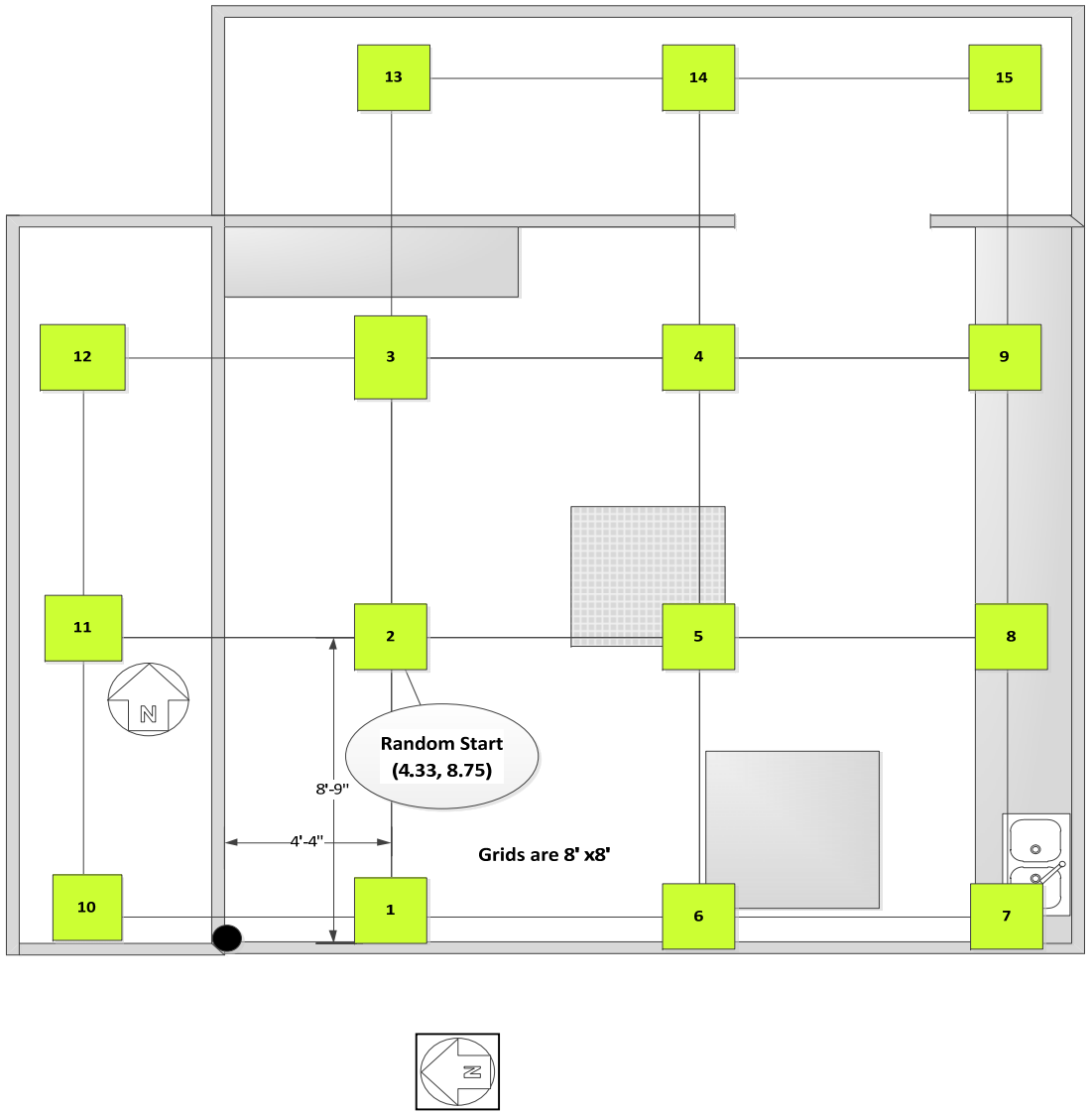
All measu

Date: 12/15/2011

Location	41-G-1	41-G-2	41-G-3
1	6	10	11
2	7	11	9
3	8	9	7
4	6	8	5
5	5	7	5
6	7	5	9
7	5	8	8
8	8	10	5
9	7	6	8
10	8	6	6
11	10	5	11
12	10	11	8
13	7	6	8
14	8		
15	8		
16	5		
17			
18			

Instrument Data and Analysis Parameters

Model	Serial No	Cal. Due
L19	180302	11/14/2012
L19	156479	5/24/2012



SURVEY UNITS LEGEND

Class 2

\# Measurement Number

Origin

Survey Unit Identifier

SU-41-G-1

B-Building
F-Floor
B-Basement
G-Ground
1-1st; etc.
N- SU# for Floor

No Scale

Building 41 Ground Floor
Room 39

Date: 1-15-12
Project: WRAMC Main Post
Prepared by: C. Wiblin

Summary of Random H3 Static Measurements

Building: 41
Survey Unit: 41-G-1
Survey Date: 12/21/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	White Tile	106	164	16	409	80
2	White Tile	132	216	18	538	90
3	White Tile	120	192	17	478	80
4	White Tile	127	206	17	513	80
5	Formica Counter Top	93	138	15	344	70
6	White Tile	115	182	17	453	80
7	Drywall	115	145	17	360	80
8	Counter	118	188	17	468	80
9	Counter	104	160	16	399	80
10	Drywall	115	145	17	360	80
11	Drywall	118	151	17	375	80
12	Drywall	94	103	15	256	70
13	Drywall	94	103	15	256	70
14	Door	109	170	16	423	80
15	Drywall	109	133	16	331	80
				Maximum:	538	
				Average:	401	
				STDEV:	88	

Instrument Data and Analysis Parameters

	Model	Serial No		Reference Material:	Tile Floor	Drywall
Instrument:	2360	141321		Background (cpm):	47.8	85.2
Detector:	44-110	PR-258430		Background σ (cpm):	6.66	10.86
Probe Area:	126	cm^2		Sample Analysis Time:	0.5	min

Total Efficiency: 0.319 cpm/dpm
Total Efficiency Uncertainty: 0.001 cpm/dpm
MDC: 206 dpm/100 cm^2

Summary of Biased H3 Static Measurements

Building: 41
Survey Unit: 41-G-1
Survey Date: 12/21/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	Stainless Steel Sink	103	143	17	356	80
2	Copper Shield	61	59	14	147	70
				Maximum:	356	
				Average:	251	
				STDEV:	148	

Instrument Data and Analysis Parameters

	Model	Serial No			
			Reference Material:	Metal	
Instrument:	2360	184935	Background (cpm):	63.1	
Detector:	43-68	PR-181739	Background σ (cpm):	8.52	
Probe Area:	126	cm^2	Sample Analysis Time:	0.5	min

Total Efficiency:	0.319	cpm/dpm
Total Efficiency Uncertainty:	0.001	cpm/dpm
MDC:	206	dpm/100 cm^2

Summary of Random Beta Static Measurements

Building: 41
Survey Unit: 41-G-1
Survey Date: 12/15/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	White Tile	1567	6	9	88	290
2	White Tile	1604	7	9	107	290
3	White Tile	1438	1	9	21	280
4	White Tile	1506	4	9	56	280
5	Formica Counter Top	1286	-4	9	-58	270
6	White Tile	1501	3	9	54	280
7	Drywall	1326	-10	9	-153	270
8	Counter	1268	-4	9	-67	270
9	Counter	1199	-7	9	-103	270
10	Drywall	1434	-6	9	-96	280
11	Drywall	--				
12	Drywall	1416	-7	9	-106	280
13	Drywall	1356	-9	9	-137	280

Maximum: 107
Average: -33
STDEV: 92

Instrument Data and Analysis Parameters

	Model	Serial No
Instrument:	2360	253237
Detector:	43-68	PR-216834
Probe Area:	126	cm^2

Reference Material:	Tile Floor	Drywall
Background (cpm):	46.59	54.0
Background σ (cpm):	6.05	6.86
Sample Analysis Time:	30	min

Total Efficiency:	0.051	cpm/dpm
Total Efficiency Uncertainty:	0.001	cpm/dpm
MDC:	195	dpm/100 cm^2

Summary of Biased Beta Static Measurements

Building: 41
Survey Unit: 41-G-1
Survey Date: 12/15/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	Stainless Steel Sink	1194	6	8	87	230
2	Copper Shield	419	-20	6	-315	170
				Maximum:	87	
				Average:	-114	
				STDEV:	284	

Instrument Data and Analysis Parameters

	Model	Serial No			
			Reference Material:	Metal	
Instrument:	2360	253237	Background (cpm):	34.23	
Detector:	43-68	PR-216834	Background σ (cpm):	4.21	
Probe Area:	126	cm^2	Sample Analysis Time:	30	min

Total Efficiency:	0.051	cpm/dpm
Total Efficiency Uncertainty:	0.001	cpm/dpm
MDC:	195	dpm/100 cm^2

Summary of Random Alpha Static Measurements

Building: 41
Survey Unit: 41-G-1
Survey Date: 12/15/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	White Tile	36	1	1	5	20
2	White Tile	86	2	2	19	30
3	White Tile	51	1	1	9	20
4	White Tile	67	2	2	14	30
5	Formica Counter Top	43	1	1	7	20
6	White Tile	52	1	1	9	20
7	Drywall	51	0	1	4	20
8	Counter	75	2	2	16	30
9	Counter	25	0	1	2	20
10	Drywall	35	0	1	-1	20
11	Drywall	45	0	1	2	20
12	Drywall	49	0	1	3	20
13	Drywall	33	0	1	-1	20

Maximum: 19
Average: 7
STDEV: 6

Instrument Data and Analysis Parameters

	Model	Serial No
Instrument:	2360	253237
Detector:	43-68	PR-216834
Probe Area:	126	cm^2

Reference Material:	Tile Floor	Drywall
Background (cpm):	0.59	1.27
Background σ (cpm):	0.51	1.26
Sample Analysis Time:	30	

Total Efficiency: 0.096 cpm/dpm
Total Efficiency Uncertainty: 0.001 cpm/dpm
MDC: 13 dpm/100 cm^2

Summary of Biased Alpha Static Measurements

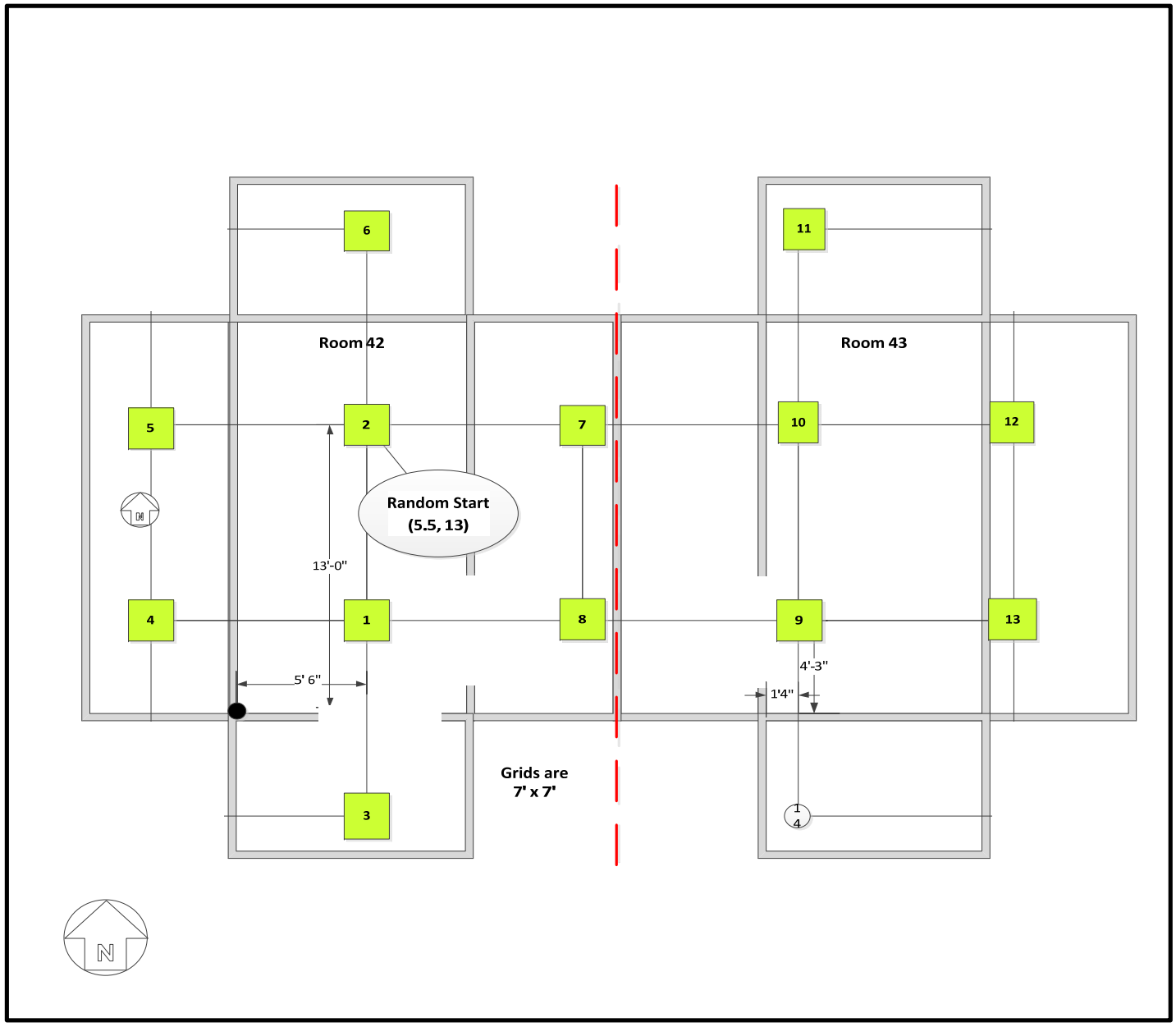
Building: 41
Survey Unit: 41-G-1
Survey Date: 12/15/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	Stainless Steel Sink	21	0	1	0	20
2	Copper Shield	21	0	1	0	20
				Maximum:	0	
				Average:	0	
				STDEV:	0	

Instrument Data and Analysis Parameters

	Model	Serial No		
Instrument:	2360	253237	Reference Material:	Metal
Detector:	43-68	PR-216834	Background (cpm):	0.64
Probe Area:	126	cm^2	Background σ (cpm):	0.73
			Sample Analysis Time:	30

Total Efficiency:	0.096	cpm/dpm
Total Efficiency Uncertainty:	0.001	cpm/dpm
MDC:	13	dpm/100 cm^2



SURVEY UNITS LEGEND

Class 2

\# Measurement Number

Origin

Survey Unit Identifier

SU-41-G-2

B-Building
F-Floor
B-Basement
G-Ground
1-1st; etc.
N- SU# for Floor

No Scale

Building 41 Ground Floor
Rooms 42 and 43

Date: 1-15-12
Project: WRAMC Main Post
Prepared by: C. Wiblin

Summary of Random H3 Static Measurements

Building: 41
Survey Unit: 41-G-2
Survey Date: 12/21/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	White Tile	143	238	18	593	90
2	White Tile	73	98	14	244	70
3	White Tile	121	194	17	483	80
4	White Tile	95	142	15	354	70
5	White Tile	87	126	15	314	70
6	White Tile	55	62	12	155	60
7	White Tile	91	134	15	334	70
8	White Tile	64	80	13	200	60
9	White Tile	51	54	12	135	60
10	White Tile	60	72	13	180	60
11	White Tile	63	78	13	195	60
12	White Tile	89	130	15	324	70
13	White Tile	52	56	12	140	60
				Maximum:	593	
				Average:	281	
				STDEV:	139	

Instrument Data and Analysis Parameters

	Model	Serial No		
Instrument:	2360	141321	Reference Material:	Tile Floor
Detector:	44-110	PR-258430	Background (cpm):	47.8
Probe Area:	126	cm^2	Background σ (cpm):	6.66
			Sample Analysis Time:	0.5

Total Efficiency:	0.319	cpm/dpm
Total Efficiency Uncertainty:	0.003	cpm/dpm
MDC:	206	dpm/100 cm^2

Summary of Random Beta Static Measurements

Building: 41
Survey Unit: 41-G-2
Survey Date: 12/19/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	White Tile	332	26	11	400	330
2	White Tile	232	1	10	11	300
3	White Tile	245	4	10	61	300
4	White Tile	212	-4	9	-67	290
5	White Tile	246	4	10	65	300
6	White Tile	254	6	10	96	310
7	White Tile	221	-2	10	-32	290
8	White Tile	179	-13	9	-195	280
9	White Tile	237	2	10	30	300
10	White Tile	224	-1	10	-20	290
11	White Tile	201	-7	9	-110	290
12	White Tile	208	-5	9	-82	290
13	White Tile	193	-9	9	-141	280

Maximum: 400
Average: 1
STDEV: 147

Instrument Data and Analysis Parameters

	Model	Serial No
Instrument:	2360	253237
Detector:	43-68	PR-216834
Probe Area:	126	cm^2

Reference Material: Tile Floor
Background (cpm): 57.30
Background σ (cpm): 6.10
Sample Analysis Time: 4 min

Total Efficiency: 0.051 cpm/dpm
Total Efficiency Uncertainty: 0.001 cpm/dpm
MDC: 542 dpm/100 cm^2

Summary of Random Alpha Static Measurements

Building: 41
Survey Unit: 41-G-2
Survey Date: 12/19/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	White Tile	39	2	3	16	60
2	White Tile	37	1	3	12	60
3	White Tile	37	1	3	12	60
4	White Tile	23	-2	3	-17	50
5	White Tile	28	-1	3	-7	50
6	White Tile	41	2	4	20	60
7	White Tile	33	0	3	4	50
8	White Tile	21	-3	3	-21	50
9	White Tile	27	-1	3	-9	50
10	White Tile	40	2	4	18	60
11	White Tile	36	1	3	10	50
12	White Tile	21	-3	3	-21	50
13	White Tile	19	-3	3	-25	40

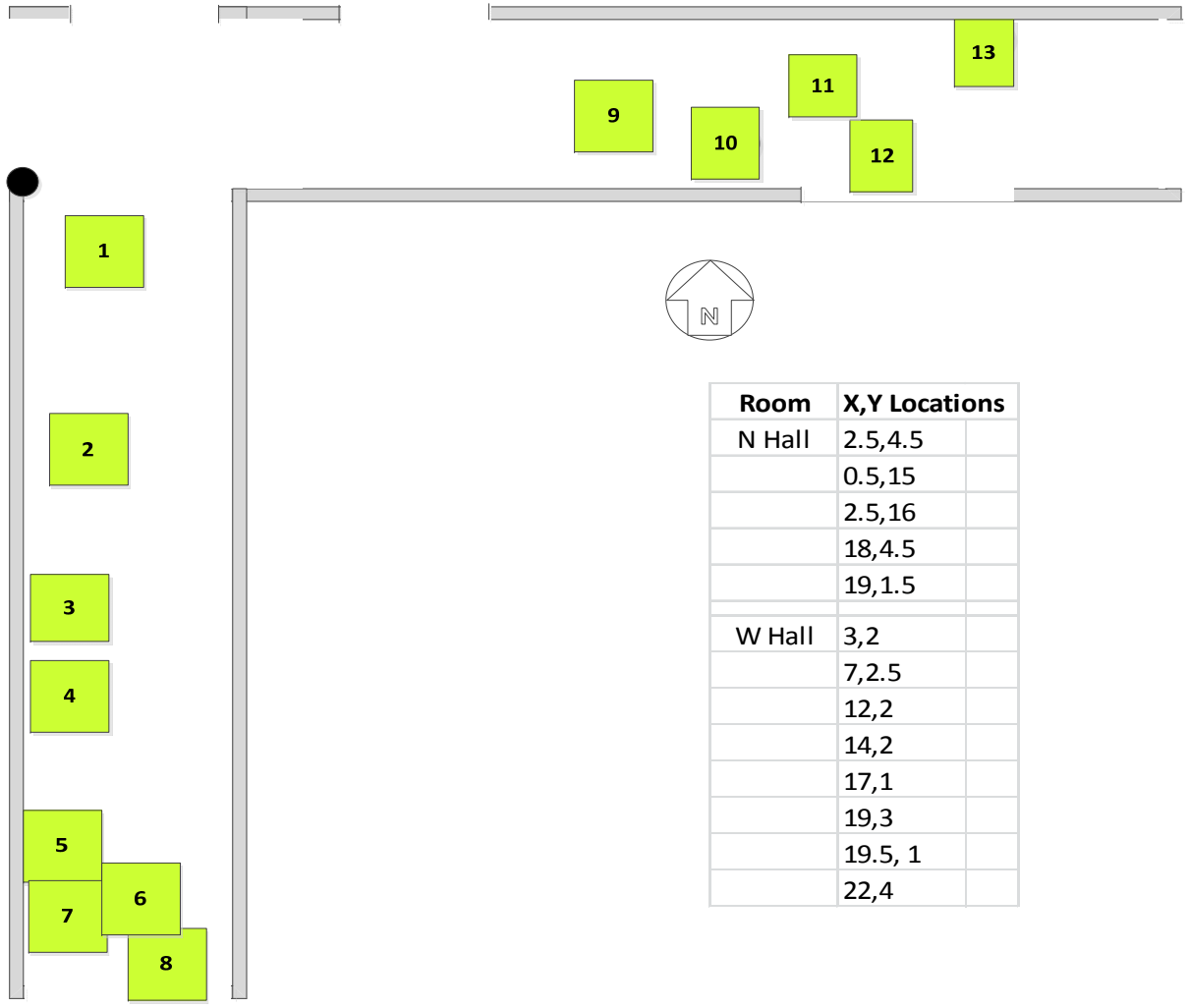
Maximum: 20
Average: -1
STDEV: 17

Instrument Data and Analysis Parameters

	Model	Serial No
Instrument:	2360	253237
Detector:	43-68	PR-216834
Probe Area:	126	cm^2

Reference Material: Waxed Tile
Background (cpm): 7.80
Background σ (cpm): 1.57
Sample Analysis Time: 4 min

Total Efficiency: 0.096 cpm/dpm
Total Efficiency Uncertainty: 0.001 cpm/dpm
MDC: 39 dpm/100 cm^2



Room	X,Y Locations	
N Hall	2.5,4.5	
	0.5,15	
	2.5,16	
	18,4.5	
	19,1.5	
W Hall	3,2	
	7,2.5	
	12,2	
	14,2	
	17,1	
	19,3	
	19.5, 1	
	22,4	

SURVEY UNITS LEGEND

Class 3

Measurement Number

Survey Unit Identifier

SU-41-G-3

B-Building
F-Floor
B-Basement
G-Ground
1-1st; etc.
N- SU# for Floor

No Scale

Building 41 Ground Floor Hallway

Date: 1-15-12
Project: WRAMC Main Post
Prepared by: C. Wiblin

Summary of Random Beta Static Measurements

Building: 41
Survey Unit: 41-G-3
Survey Date: 12/19/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	Carpet Over Concrete	144	-5	9	-81	270
2	Carpet Over Concrete	172	2	9	28	280
3	Carpet Over Concrete	133	-8	9	-124	260
4	Carpet Over Concrete	171	2	9	24	280
5	Carpet Over Concrete	186	5	9	82	280
6	Carpet Over Concrete	140	-6	9	-96	260
7	Carpet Over Concrete	167	1	9	9	280
8	Carpet Over Concrete	182	4	9	67	280
9	Carpet Over Concrete	137	-7	9	-108	260
10	Carpet Over Concrete	143	-5	9	-85	260
11	Carpet Over Concrete	143	-5	9	-85	260
12	Carpet Over Concrete	79	-21	8	-334	240
13	Carpet Over Concrete	162	-1	9	-11	270

Maximum: 82
Average: -55
STDEV: 109

Instrument Data and Analysis Parameters

	Model	Serial No
Instrument:	2360	253237
Detector:	43-68	PR-216834
Probe Area:	126	cm^2

Reference Material: Mastic Concrete
Background (cpm): 41.20
Background σ (cpm): 6.30
Sample Analysis Time: 4 min

Total Efficiency: 0.051 cpm/dpm
Total Efficiency Uncertainty: 0.001 cpm/dpm
MDC: 542 dpm/100 cm^2

Summary of Random Alpha Static Measurements

Building: 41
Survey Unit: 41-G-3
Survey Date: 12/19/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	Carpet Over Concrete	20	2	2	7	20
2	Carpet Over Concrete	19	1	2	6	20
3	Carpet Over Concrete	14	0	2	0	20
4	Carpet Over Concrete	11	-1	2	-3	20
5	Carpet Over Concrete	9	-1	2	-5	20
6	Carpet Over Concrete	8	-1	2	-6	20
7	Carpet Over Concrete	16	1	2	2	20
8	Carpet Over Concrete	11	-1	2	-3	20
9	Carpet Over Concrete	7	-2	2	-7	10
10	Carpet Over Concrete	11	-1	2	-3	20
11	Carpet Over Concrete	9	-1	2	-5	20
12	Carpet Over Concrete	4	-2	1	-11	10
13	Carpet Over Concrete	6	-2	2	-9	10

Soruce efficiency from NUREG-1507 was applied.

Maximum: 7
Average: -3
STDEV: 5

Instrument Data and Analysis Parameters

	Model	Serial No
Instrument:	2360	253237
Detector:	43-68	PR-216834
Probe Area:	126	cm^2

Reference Material: Mastic Concrete
Background (cpm): 3.45
Background σ (cpm): 1.04
Sample Analysis Time: 4 min

Total Efficiency: 0.181 cpm/dpm
Total Efficiency Uncertainty: 0.002 cpm/dpm
MDC: 39 dpm/100 cm^2

Summary of Biased Alpha Static Measurements

Building: 54
Survey Unit: 54-B-2
Survey Date: 11/16/2011 2/3/2012

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm²) Activity	Net (dpm/100 cm²) Uncertainty (2σ)
Floor						
1	Peg Board Ceiling	5	1	1	6	20
2	Stainless Steel Sink*	5	1	1	3	20
3	Peg Board Ceiling	3	0	1	2	20
4	Stainless Steel Under Sink*	4	0	1	1	20
5	Metal Air Duct*	12	2	2	10	30
6	Floor Tile	5	1	1	5	20
7	Red Ceramic Tile	4	0	1	1	20
8	Stainless Steel Sink*	4	0	1	1	20
9	Drywall Ceiling	2	-1	1	-6	20
10	Floor Tile	6	1	2	8	20
11	Red Ceramic Tile	7	1	2	8	30
12	Stainless Steel Sink*	7	1	2	5	20
13	Water Stained Concrete	9	1	2	6	30
14	Stainless Steel Sink*	7	1	2	5	20
15	Red Ceramic Tile	12	2	2	18	30
16	Red Ceramic Tile	7	1	2	8	30
17	Matte Black Hood	5	1	1	6	20
18	Stainless Steel Hood*	5	1	1	3	20
19	Stainless Steel Sink*	7	1	2	5	20
20	Rusted Under Sink	7	1	2	9	20
21	Painted Hood	7	1	2	9	20
22	Black Lab Sink	4	0	1	4	20
23	Floor Tile	6	1	2	8	20
24	Stainless Steel Sink*	7	1	2	5	20
25	Mirror	12	: No reference material		--	--
26	Stainless Steel Sink*	6	1	1	4	20
27	Stainless Steel Hood*	12	2	2	10	30
28	Stainless Steel Under Sink*	5	1	1	3	20
29	Stainless Steel Sink*	2	0	1	-1	20
30	Stainless Steel Hood*	11	2	2	9	30
31	Stainless Steel Under Sink*	4	0	1	1	20
32	Stainless Steel Sink*	3	0	1	0	20
33	Stainless Steel Hood*	4	0	1	1	20
34	Stainless Steel Sink*	5	1	1	3	20
35	Stainless Steel Hood*	11	2	2	9	30
36	Autopsy Drain (Stainless)*	10	2	2	8	30
37	Black Lab Sink	5	1	1	6	20
38	Rusted Under Sink	9	2	2	13	30
39	Stainless Steel Under Sink*	9	2	2	7	30
40	Concrete*	3	0	1	0	20

* Source efficiencies were applied from NUREG-1507.

Maximum: 18
Average: 5
STDEV: 4

Instrument Data and Analysis Parameters

	Model	Serial No
Instrument:	2360	253237
Detector:	43-68	PR-216834
Probe Area:	126	cm^2

Reference Material: Floor Tile
Background (cpm): 0.6 cpm
Background σ (cpm): 0.91 cpm
Sample Analysis Time: 4 min

	Metal	Composite	Concrete	Drywall	Red Ceramic
	0.6	0.6	0.8	1.3	0.8
	0.73	0.8	1.17	1.27	0.87

Total Efficiency: 0.096 cpm/dpm
Total Efficiency Uncertainty: 0.001 cpm/dpm
MDC: 39 dpm/100 cm^2

RAI 6

TECHNICAL MEMORANDUM

SCANNING CAPABILITY ASSESSMENT

FOR DEPLETED URANIUM AS EMBEDDED FRAGMENTS

May 2012

Table of Contents

Tables

Figure

ACRONYMS, ABBREVIATIONS, AND SYMBOLS

$(\mu/\rho)_{NaI}$	mass attenuation coefficient for NaI
μR/hr	microReontgen per hour
%	Percent
bgs	below ground surface
cm	Centimeter
COC	contaminant of concern
cpm	counts per minute
DU	Depleted Uranium
Eff_{total}	Total detector efficiency
FIDLER	Field Instrument for the Detection of Low Energy Radiation
FRER	fluence rate to exposure rate
m	Meter
MARSAME	Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	minimum detectable activity
MDC	minimum detectable concentration
MDCR	Minimum detectable count rate
$MDCR_{surveyor}$	Minimum detectable count rate for surveyor
MDER	minimum detectable exposure rate
MicroShield	Modeling Software manufactured by Grove Engineering
NaI	Sodium iodide
P	Probability
RDR	Relative Detector Response

SCANNING CAPABILITY ASSESSMENT
FOR DEPLETED URANIUM (DU) AS EMBEDDED FRAGMENTS

1.0 INTRODUCTION

The anecdotal accounts of use of Depleted Uranium (DU) in a firing range indicated that there could a potential for the presence of small DU fragments. The firing range was physically located in the basement of Building 54 and was part of the Survey Unit (SU) 54-B-3. The entire survey unit was routinely handled per standard MARSSIM survey technique as reported in the Final Status Survey Report (FSSR) with accompanying data and maps in the FSSR Appendix C. During this survey it was determined that the actual firing range (line of fire) location by rifle to target was a small portion of the overall survey unit and on the eastern side of the building. Two walls were removed to allow access to the area, east of B030A and from the southeast corner of B030B. Firing would have occurred in a north to south direction as shown in the illustration below.

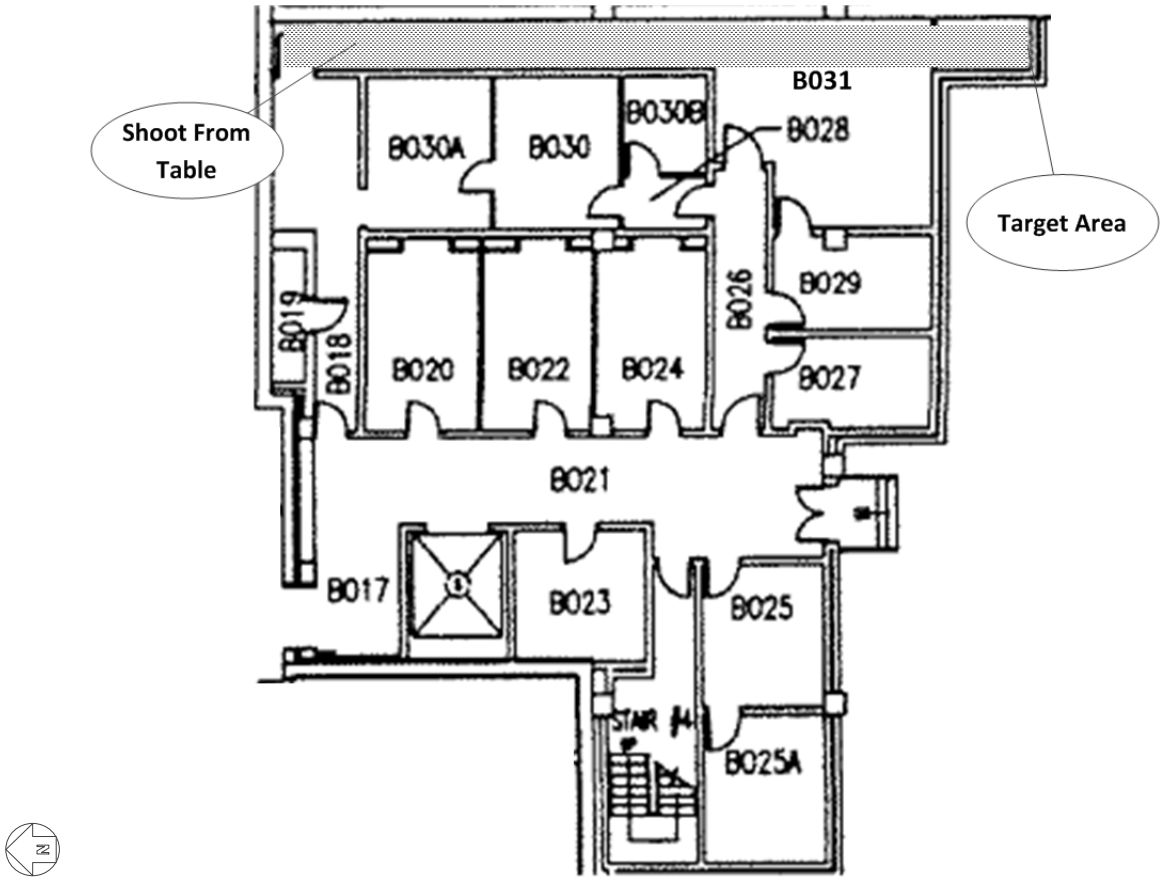


Figure 1. Location of Firing Range

The most obvious locations for any residual DU would be in the target area which is where a 100% scan was performed as well as on the nearby (adjacent) wall, floor, and ceiling locations.

For the scanning activities described in this Technical Memorandum (TM), the Field Instrument for the Detection of Low Energy Radiation (FIDLER) was used. Scan surveys were performed indoors at an average distance of 5 cm (~2") using the detectors coupled with a data logger rate-meter/scaler.

MARSSIM Section 6.7.2.1 describes the methodology used to calculate the Scan Minimum Detectable Concentrations (MDCs) for land areas that are delineated in MARSSIM Table 6.7. The ScanMDCs determined in this TM are based on a scan speed of one detector width per second. As will be detailed in Section 4, the scan required a total of three hours and twenty-five minutes to complete for a total scanned area of 2,080 square feet. These parameters permitted a 100% scan of all areas from the target back to approximately 65 feet.

The basic method for performing a gamma scan survey was to scan along a straight path while holding the detector within 2" of the building surface. As the scan speed was one detector width per second, the observation interval will be 1 second. The rate-meter/scaler used for this work plan was configured to output directly to a data collection PDA unit.

2.0 DETERMINATION OF EFFICIENCY (cpm/pCi/g)

This document utilizes the methodology and approach documented in MARSSIM Section 6.7.2.2, Table 6.7 and also from MARSAME Section 7.11. MARSSIM calculations are based on USNRC NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions* (USNRC 1997). MARSSIM Table 6.7 provides data for soil concentrations but does not provide scan MDCs for DU fragments; thus, scan MDCs are derived using MARSAME/MARSSIM methods. Factors included in this analysis are the surveyor scan efficiency, index of sensitivity, the natural background of the surveyed area, scan rate, detector to source geometry, and energy and yield of gamma emissions.

Modeling (using MicroShield® Version 8.02) for a one gram DU fragment is used to determine the net exposure rate produced at a distance 5 cm (~2") above the source. This position is selected because it relates to the average height of the scintillation detector face above the building surface during scanning. The objective is to determine the size of the fragment that is correlated to the minimum detectable net exposure rate.

The factors considered in the modeling include:

- radionuclide of interest (considering all gamma emitters for decay chains)
- expected activity of the radionuclide of interest
- areal dimensions of the area of elevated activity
- depth of the area of elevated activity
- location of dose point (scintillation detector height above the surface)
- density of potential covering material (wall plaster)
- the thickness of the FIDLER NaI layer

The computer code MicroShield® was used to model the presence of a normalized 1 gram of DU with the assumption that the volume was a sphere. As the firing range had been repaired with wall plaster or grout, a 0.5 cm (0.2 in) of covering was assumed. This is consistent with

MARSSIM methodology and provides for a count rate to exposure ratio (cpm/μR/hr) to be calculated.

Activity concentrations must be entered into MicroShield® in units of μCi/cm^3 with consideration to the density of DU at 19.1 g/cm^3. A 1 g source would have a radius of 0.2321 cm. Activity concentrations for DU were entered into MicroShield® as per values found in Table 1 and 60 years of decay time to permit daughter ingrowth was applied. The mass abundances and specific activities shown in Table 1 are from NUREG-1717, *Systematic Radiological Assessment of Exemptions for Source and Byproduct Material.*

Table 1. Activity of Uranium Isotopes in DU

Isotope	Mass Abundance	Specific Activity (μCi/g)	Activity (μCi/cc)
U-238	0.9975	3.35E-01	6.38
U-235	0.0025	2.16E+00	0.10
U-234	0.000005	6.24E+03	0.60

MicroShield® presents an output in units of mR/hour with buildup for each standard energy indice. The MicroShield® exposure rate outputs are included as an attachment. There are several steps to converting these outputs into cpm anticipated by the detector. These steps follow.

2.1 Fluence Rate to Exposure Rate (FRER)

The fluence rate to exposure rate (FRER) may be approximated by:

$$FRER \approx \frac{1\mu R/hr}{(E_\gamma)(\mu_{en}/\rho)_{air}}$$

Where:

E_γ = energy of the gamma photon of concern, keV

(μ_{en}/ρ) = the mass energy absorption coefficient for air, cm^2/g

This can be represented in tabular form, as in Table 2.

2.2 Probability of Interaction (P) Through Detector End for a Given Energy

The probability, P, of a gamma ray interaction in the NaI scintillation crystal entering through the end of the crystal is given by:

$$P = 1 - e^{-(\mu/\rho)_{NaI}(X)(\rho_{NaI})}$$

Where:

$(\mu/\rho)_{NaI}$ = the mass attenuation coefficient for NaI

X = the thickness through the end of the NaI crystal, 0.166 cm for the FIDLER and 5.1 cm for the Ludlum 44-10

(ρ_{NaI}) = the density of the NaI crystal, 3.67 g/cm^3

This can be represented in tabular form, as in Table 2.

2.3 Relative Detector Response (RDR)

The Relative Detector Response (RDR) as a function of energy is determined by multiplying the relative fluence rate to exposure rate (FRER) by the probability (P) of an interaction and is given by:

$$RDR = (FRER)(P)$$

This can be represented in tabular form, as in Table 2.

2.4 Determination of cpm per μR/hr as a Function of Energy

The equivalent FRER, P, and finally RDR may be calculated for the NaI scintillation detector at the Cesium-137 (^{137}Cs) energy of 662 keV. MARSAME gives the estimated FIDLER G-5 (12.7cm diameter x 0.166 cm thick NaI) response for ^{137}Cs as 1287 cpm/μR/hr. [Note that MARSAME uses a slightly less thickness of 0.16 cm.) The manufacturer provides a 900 cpm/μR/hr for the 44-10 NaI detector. This point allows one to determine the cpm per μR/hr and ultimately activity concentration and minimum detection sensitivity level in terms of pCi/g for a specific instrument.

Based on the manufacturer's response specification, and using the same methodology as shown in the tables above, the FRER, P, and RDR are calculated. The mass energy absorption coefficient for air and the mass attenuation coefficient for NaI are interpolated from tables in the Radiological Health Handbook, Revised Edition January 1970, pages 139 and 140 similar to the technique used in NUREG-1507 while MARSAME uses the NIST XCOM program.

FRER = 0.0514

$Energy_{\gamma}$, keV = 662

$(\mu_{en}/\rho)_{air}$, cm^2/g = 0.0294

$(\mu_{en}/\rho)_{NaI}$, cm^2/g = 0.0780

P = 0.89

Cs-137 RDR (662 keV) = 0.0023 for the FIDLER

The detector response (cpm) to other energies is based upon the ratio of the RDR at a specific energy to the known Cs-137 energy RDR:

$$CPM/\mu R/hr, E_i = \frac{(CPM/\mu R/hr_{Cs-137})(RDR_{E_i})}{(RDR_{Cs-137})}$$

This can be represented in tabular form, as in Table 2 for the FIDLER.

The Microshield run and the weighted cpm per µR/h for 1 g of DU are summarized in Tables 2 and 3. For the FIDLER, about 92% of anticipated responses fall in the 60 keV to 200 keV energy indices.

Table 2. Tabulation of FRER, P, RDR and CPM per microR/hr for the FIDLER

Energy (keV)	Mass Attenuation Coefficient - Air (cm^2/g)	FRER	Mass Attenuation Coefficient - NaI (cm^2/g)	P	RDR	CPM per microR/hr	R_i (µR/h)	WS_i (cpm per µR/h)
15	1.29	0.0517	47.4	1.00	0.0517	28915	6.75E-06	0
20	0.516	0.0969	22.3	1.00	0.0969	54216	5.02E-11	0
30	0.147	0.2268	7.45	0.99	0.2239	125276	1.87E-05	3
40	0.064	0.3906	19.3	1.00	0.3906	218558	6.85E-8	0
50	0.0384	0.5208	10.7	1.00	0.5199	290869	7.12E-06	2
60	0.0292	0.5708	6.62	0.98	0.5591	312810	3.95E-03	1382
80	0.0236	0.5297	3.12	0.84	0.4449	248912	7.98E-04	222
100	0.0231	0.4329	1.72	0.64	0.2752	153994	3.41E-02	5885
150	0.0251	0.2656	0.625	0.31	0.0816	45651	3.11E-03	159
200	0.0268	0.1866	0.334	0.18	0.0332	18590	2.19E-02	455
300	0.0288	0.1157	0.167	0.09	0.0108	6049	9.00E-04	6
400	0.0296	0.0845	0.117	0.07	0.0056	3138	1.52E-03	5
500	0.0297	0.0673	0.0955	0.05	0.0037	2055	3.41E-03	8
600	0.0296	0.0563	0.0826	0.05	0.0027	1492	1.87E-02	31
662	0.0294	0.0514	0.078	0.04	0.0023	1287		
800	0.0289	0.0433	0.0676	0.04	0.0017	942	1.53E-01	161
1000	0.028	0.0357	0.0586	0.03	0.0012	676	6.29E-01	476
1500	0.0255	0.0261	0.0469	0.03	0.0007	397	1.92E-02	9
2000	0.0234	0.0214	0.0413	0.02	0.0005	286	3.13E-03	1
3000	0.0205	0.0163	0.0366	0.02	0.0003	193		
						Total	**8.93E-01**	**8807**

3.0 MINIMUM DETECTABLE CONCENTRATIONS

3.1 Scan Minimum Detectable Count Rate

The minimum detectable number of net source counts in the interval is given by s_i . Therefore, for an ideal observer, the number of source counts required for a specified level of performance can be arrived at by multiplying the square root of the number of background counts by the detectability value associated with the desired performance (as reflected in *d'*) as shown in MARSSIM Equation 6-8 which parallels the MARSSIM page 6-45 analysis as follows:

$$s_i = d'\sqrt{b_i}$$

Where the value of d' is selected from MARSSIM Table 6.5 based on the required true positive and false positive rates and b_i is the number of background counts in the interval. The value of d' represents the rate of detections at 95% and a false positive rate of 60% and is set at 1.38.

In the extremely shielded sub-basement areas of Building 54 where the firing range was located, the background rates for the FIDLER was approximately 2350 cpm.

The average number of background counts in a one second interval, b_i = cpm/60

$$\text{FIDLER } b_i = 2{,}350 \text{ cpm}/60 \sim 39.2 \text{ cps}$$

The MDCR is therefore calculated as:

$$MDCR = (d')(b_i)^{0.5}(60\text{sec}/1\text{min})$$

$$MDCR_{FIDLER} = (1.38)(39.2)^{0.5}(60) = 518 \text{ cpm}$$

The MDCR for the surveyor is given as:

$$MDCR_{surveyor} = MDCR / (P)^{0.5}$$

Where P is the surveyor efficiency equal to 0.5 to 0.75 as given by NUREG-1507. P = 0.5 was chosen to parallel MARSSIM/MARSAME examples and

$$\text{FIDLER } MDCR_{surveyor} = 518 / (0.5)^{0.5} = 732 \text{ cpm}$$

3.2 Estimate of Scan MDC for DU Fragment

The minimum detectable scan rate from DU is obtained from the $MDCR_{surveyor}$ divided by the total weighted count rate from Tables 2 which is 8,807 cpm/g. The scan MDC is then equal to the ratio of the $MDCR_{surveyor}$ to the weighted count rate per g.

$$ScanMDC = \frac{\left(MDCR_{surveyor}\right)}{\left(WeightedCountRate/g\right)}$$

$ScanMDC_{FIDLER}$ = 732 cpm/(8,807 cpm per g) = 0.08 g

4.0 SURVEY RESULTS AND CONCLUSIONS

Results of the survey are presented in Table 3.

Table 3. FIDLER Scan Results for Building 54 Firing Range

Date:	20, 2011				
SU:	54-B-3				
		Gross CPM			
Location	**Number of records**	**Minimum**	**Maximum**	**Average**	**STDEV**
SU54-Firing Range	6160	1127	5612	2583	515
Area Scanned (ft^2):	2080				
Total Scan Time (mi	205				
Instrument Data and Analysis Parameters					
	Model	Serial No			
Instrument:	URSA II	200130			
Detector:	FIDLER	050307AZ1			
Probe Area:	0.17	ft^2			

There were nine recorded measurements greater than 5000 cpm which appeared to be anomalies and were not reproducible upon rescan.

No fragments were detected as being larger than the survey design of 0.08 g which is a small fragment. This was a scan in support of the total negative conclusions identified in the FSSR for this SU.

MicroShield 8.02
Microsoft (8.02-0000)

Date	By	Checked

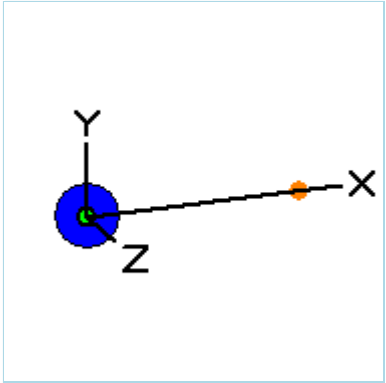
Filename	Run Date	Run Time	Duration
DU Fragment With Shield.msd	May 28, 2012	7:49:34 PM	00:00:00

Project Info	
Case Title	DU Fragment
Description	1 gm DU Fragment With Wall Plaster Shield
Geometry	6 - Sphere

Source Dimensions	
Radius	0.232 cm (0.1 in)

Dose Points			
A	**X**	**Y**	**Z**
#1	5.0 cm (2.0 in)	0.0 cm (0 in)	0.0 cm (0 in)

Shields			
Shield N	**Dimension**	**Material**	**Density**
Source	.052 cm³	Uranium	19.1
Shield 1	.5 cm	Mixed ->	1.40122
		Air	0.00122
		Concrete	1.4
Transition		Air	0.00122
Air Gap		Air	0.00122



Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Included
Library: Grove

Nuclide	Ci	Bq	µCi/cm³	Bq/cm³
Ac-227	3.6798e-012	1.3615e-001	7.0287e-005	2.6006e+000
Bi-210	9.0506e-014	3.3487e-003	1.7288e-006	6.3964e-002
Bi-211	3.6686e-012	1.3574e-001	7.0074e-005	2.5927e+000
Bi-214	2.1853e-013	8.0855e-003	4.1741e-006	1.5444e-001
Fr-223	5.0781e-014	1.8789e-003	9.6996e-007	3.5889e-002
Pa-231	6.6416e-012	2.4574e-001	1.2686e-004	4.6938e+000
Pa-234	5.3442e-010	1.9774e+001	1.0208e-002	3.7770e+002
Pa-234m	3.3402e-007	1.2359e+004	6.3800e+000	2.3606e+005
Pb-210	9.0585e-014	3.3517e-003	1.7303e-006	6.4020e-002
Pb-211	3.6686e-012	1.3574e-001	7.0074e-005	2.5927e+000
Pb-214	2.1853e-013	8.0855e-003	4.1741e-006	1.5444e-001
Po-210	8.8361e-014	3.2694e-003	1.6878e-006	6.2448e-002
Po-211	1.0015e-014	3.7057e-004	1.9130e-007	7.0782e-003

Po-214	2.1848e-013	8.0838e-003	4.1732e-006	1.5441e-001
Po-215	3.6686e-012	1.3574e-001	7.0075e-005	2.5928e+000
Po-218	2.1857e-013	8.0872e-003	4.1749e-006	1.5447e-001
Ra-223	3.6686e-012	1.3574e-001	7.0075e-005	2.5928e+000
Ra-226	2.1868e-013	8.0912e-003	4.1770e-006	1.5455e-001
Rn-219	3.6686e-012	1.3574e-001	7.0075e-005	2.5928e+000
Rn-222	2.1857e-013	8.0872e-003	4.1749e-006	1.5447e-001
Th-227	3.6221e-012	1.3402e-001	6.9186e-005	2.5599e+000
Th-230	1.6975e-011	6.2809e-001	3.2425e-004	1.1997e+001
Th-231	5.2353e-009	1.9371e+002	1.0000e-001	3.7000e+003
Th-234	3.3402e-007	1.2359e+004	6.3800e+000	2.3606e+005
Tl-207	3.6586e-012	1.3537e-001	6.9883e-005	2.5857e+000
U-234	3.1463e-008	1.1641e+003	6.0098e-001	2.2236e+004
U-235	5.2353e-009	1.9371e+002	1.0000e-001	3.7000e+003
U-238	3.3402e-007	1.2359e+004	6.3800e+000	2.3606e+005

Buildup: The material reference is Source **Integration Parameters**	
Rho (Radial)	10
Angle	10

Results					
Energy (MeV)	**Activity (Photons/sec)**	**Fluence Rate MeV/cm²/sec No Buildup**	**Fluence Rate MeV/cm²/sec With Buildup**	**Exposure Rate mR/hr No Buildup**	**Exposure Rate mR/hr With Buildup**
0.015	2.678e+03	7.872e-08	7.872e-08	6.752e-09	6.752e-09
0.02	1.142e-03	1.450e-12	1.450e-12	5.022e-14	5.022e-14
0.03	2.841e+01	1.871e-06	1.886e-06	1.854e-08	1.870e-08
0.04	2.488e-02	1.529e-08	1.548e-08	6.760e-11	6.846e-11
0.05	1.387e+00	2.624e-06	2.671e-06	6.991e-09	7.116e-09
0.06	4.847e+02	1.944e-03	1.987e-03	3.862e-06	3.947e-06
0.08	4.036e+01	4.859e-04	5.040e-04	7.690e-07	7.975e-07
0.1	7.793e+02	2.120e-02	2.232e-02	3.244e-05	3.414e-05
0.15	3.642e+01	1.063e-03	1.889e-03	1.750e-06	3.111e-06
0.2	1.237e+02	9.683e-03	1.240e-02	1.709e-05	2.188e-05
0.3	1.528e+00	4.203e-04	4.746e-04	7.973e-07	9.002e-07
0.4	1.253e+00	6.998e-04	7.788e-04	1.363e-06	1.517e-06
0.5	1.804e+00	1.564e-03	1.736e-03	3.070e-06	3.407e-06
0.6	7.372e+00	8.679e-03	9.568e-03	1.694e-05	1.867e-05
0.8	4.104e+01	7.337e-02	8.049e-02	1.396e-04	1.531e-04
1.0	1.312e+02	3.135e-01	3.415e-01	5.779e-04	6.294e-04
1.5	2.769e+00	1.068e-02	1.142e-02	1.798e-05	1.921e-05
2.0	3.592e-01	1.896e-03	2.023e-03	2.932e-06	3.128e-06
Totals	**4.360e+03**	**4.452e-01**	**4.871e-01**	**8.165e-04**	**8.933e-04**

Summary of Biased Alpha Static Measurements

Building: 54
Survey Unit: 54-G-4
Survey Date: 11/22/2011 2/3/2012

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)	Net (dpm/100 cm^2) Activity	Net (dpm/100 cm^2) Uncertainty (2σ)
Floor						
1	Black Hood Sink	2	0	1	0	20
2	Black Hood	2	0	1	0	20
3	Black Lab Sink	4	0	1	4	20
4	Painted Concrete	2	0	1	-3	20
5	Stainless Sink	3	0	1	1	20
6	Rusted Paint Under Sink	2	0	1	-1	20
7	Tan Air Duct	5	1	1	5	20
8	Black Lab Sink	10	2	2	16	30
9	Painted Concrete	2	0	1	-3	20
				Maximum:	16	
				Average:	0	
				STDEV:	0	

Instrument Data and Analysis Parameters

	Model	Serial No	Reference Material:	Composite	Concrete	Metal
Instrument:	2360	253237	Background (cpm):	1	1	1
Detector:	43-68	PR-216834	Background σ (cpm):	0.8	1.17	0.73
Probe Area:	126	cm^2	Sample Analysis Time:	4	min	

Total Efficiency: 0.096 cpm/dpm
Total Efficiency Uncertainty: 0.001 cpm/dpm
MDC: 39 dpm/100 cm^2

Room	X,Y Locations		
5100	2,1	8,3	9,8
5101	6,2	6,8	
5104	1,1		
5102	4,1		
5105	3,2	6,6	
5107	2,5	9,2	
5112	8,4	10,2	

SURVEY UNITS LEGEND

Class 3

[#] Measurement Number

No Scale

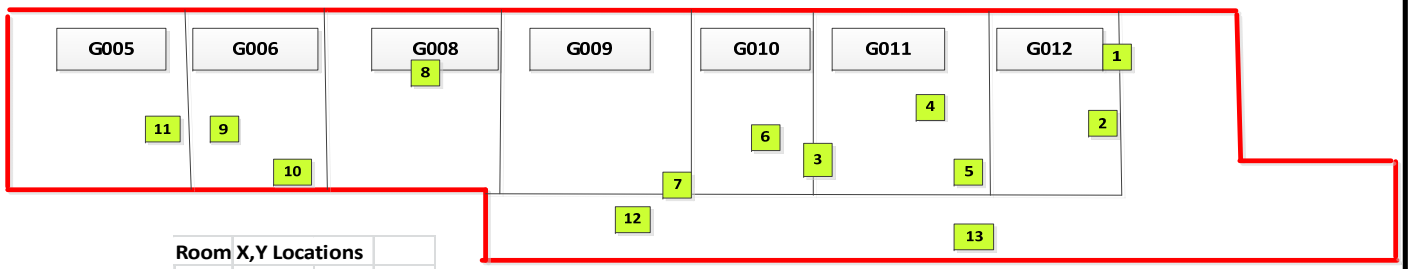
Survey Unit Identifier

SU54-5-1

B-Building
F-Floor
B-Basement
G-Ground
1-1st; etc.
N- SU# for Floor

Building 54 Fifth Floor

Date: 1-18-12
Project: WRAMC Main Post
Prepared by: C. Wiblin



Room	X,Y Locations		
G012	E-4,4	15,8	
G011	W-3,3	10,9	12,1
G010	9,6		
G009	S-1,4		
G008	9,12		
G006	3,7	11,1	
G005	12,7		
Hall	23,2	13,5	

SURVEY UNITS
LEGEND

Class 3

[#] Data Point

Survey Unit Identifier

SU-92-G-2

B-Building
F-Floor
B-Basement
G-Ground
1-1st; etc.
N- SU# for Floor

No Scale

Building 92 Ground Floor

Date: 1-15-12
Project: WRAMC Main Post
Prepared by: C. Wiblin

Table 1. Summary of Scan Results - NaI 2X2

Location: Building 2, 1st Level

RAI 10

Location	Number of records	Gross CPM Minimum	Gross CPM Maximum	Gross CPM Average	Gross CPM STDEV	Exposure Rate Equivalent µR/hr Minimum	Exposure Rate Equivalent µR/hr Maximum	Exposure Rate Equivalent µR/hr Average	Exposure Rate Equivalent µR/hr STDEV
SU-2-1H25	730	1218	2483	1694	226	1	3	2	0
SU-2-1H27	765	1007	2560	1564	289	1	3	2	0
SU-2-1H33	2073	1579	3853	2437	360	2	4	3	0
SU-2-1H33 South wall	597	2051	4269	3390	407	2	5	4	0
Area Scanned (ft^2)	13740								

Instrument Data

	Model	Serial No
Instrument:	URSA II	200124
Detector:	44-10	186962
Estimated Probe View:	4	ft^2

Table 2. Summary of Scan Results - FIDLER

Location: Building 2, 1st Level

Location	Number of records	Gross CPM Minimum	Gross CPM Maximum	Gross CPM Average	Gross CPM STDEV	Exposure Rate Equivalent μR/hr Minimum	Exposure Rate Equivalent μR/hr Maximum	Exposure Rate Equivalent μR/hr Average	Exposure Rate Equivalent μR/hr STDEV
SU-2-1H25	506	2517	4745	3411	329	3	5	4	0
SU-2-1H27	769	742	5652	2243	376	1	6	2	0
SU-2-1H33	642	1492	3785	2759	426	2	4	3	0
SU-2-1H33 South wall	1055	2572	5961	4473	608	3	7	5	1
Area Scanned (ft^2)	11888								

Instrument Data and Analysis Parameters

	Model	Serial No
Instrument:	URSA II	200130
Detector:	FIDLER	050307AZ1
Estimated Probe View:	4	ft^2

Table 3. Summary of Biased Beta Static Measurements

Building: 2
Survey Unit: 2-1-1 Rm 1H25
Survey Date: 12/27/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)
Varian Clinac 600c				
1	Ambient	1078	490	24
2	Ambient	978	440	23

Instrument Data and Analysis Parameters

	Model	Serial No			
Instrument:	2360	253237	Reference Material:	Ambient	
Detector:	43-68	PR-216834	Background (cpm):	49	
Probe Area:	126	cm^2	Background σ (cpm):	7	
			Sample Analysis Time:	2	min

Table 4. Summary of Biased Alpha Static Measurements

Building: 2
Survey Unit: 2-1-1 Rm 1H25
Survey Date: 12/27/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)
Varian Clinac 600c				
1	Ambient	1	-1	1
2	Ambient	1	-1	1

Instrument Data and Analysis Parameters

	Model	Serial No			
Instrument:	2360	253237	Reference Material:	Ambient	
Detector:	43-68	PR-216834	Background (cpm):	1	
Probe Area:	126	cm^2	Background σ (cpm):	1.27	
			Sample Analysis Time:	2	min

Table 5. Summary of Biased Beta Static Measurements

Building: 2
Survey Unit: 2-1-1 Rm 1H27
Survey Date: 12/27/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)
Varian Clinac 2100				
1	Ambient	1064	483	24
2	Ambient	1180	541	25

Instrument Data and Analysis Parameters

	Model	Serial No			
Instrument:	2360	253237	Reference Material:	Ambient	
Detector:	43-68	PR-216834	Background (cpm):	49	
Probe Area:	126	cm^2	Background σ (cpm):	7	
			Sample Analysis Time:	2	min

Table 6. Summary of Biased Alpha Static Measurements

Building: 2
Survey Unit: 2-1-1 Rm 1H27
Survey Date: 12/27/2011

Location	Material	Gross (counts)	NCPM	NCPM Uncertainty (1σ)
Varian Clinac 2100				
1	Ambient	1	-1	1
2	Ambient	0	-1	1

Instrument Data and Analysis Parameters

	Model	Serial No			
Instrument:	2360	253237	Reference Material:	Ambient	
Detector:	43-68	PR-216834	Background (cpm):	1	
Probe Area:	126	cm^2	Background σ (cpm):	1.27	
			Sample Analysis Time:	2	min

Radiation Safety
Routine Operability of Field Instruments

DAILY INSTRUMENT RESPONSE CHECK
Form RS-013.0-3

SITE: **WRAMC** **Date:** **11/9/2011** **For Month of: Nov/Dec**

Instrument Information	
Type/Serial #:	L2360/141321
Probe/Serial #:	44-110/258430
Calibration Due Date:	23-Oct-12

Source Information		
Isotope	H-3	Fe-55
Serial Number	TY 849	N/A
2π emission rate	N/A	N/A

DATE	TIME	BACKGROUND CPM		SOURCE CPM		COMMENTS	Tech Initials
		Alpha	Beta	H-3	Fe-55		
11/25/2011	6:30	N/A	203	5839	738131	Initial Set up	ALR
11/28/2011	6:30	N/A	188	6424	676716		ALR
11/29/2011	6:30	N/A	177	4944	607079		ALR
11/30/2011	6:30	N/A	204	6303	767316		ALR
12/1/2011	6:30	N/A	233	6605	804321		ALR
12/2/2011	6:30	N/A	215	6053	760542		ALR
12/5/2011	6:30	N/A	221	5984	712057		ALR
12/6/2011	6:30	N/A	196	4935	646817		ALR
12/7/2011	6:30	N/A	232	6287	678190		ALR
12/8/2011	6:30	N/A	203	4755	738675		ALR
12/9/2011	6:30	N/A	173	6027	760641		ALR
12/12/2011	6:30	N/A	191	6390	746916		ALR
12/13/2011	6:30	N/A	175	6138	733530		ALR
12/14/2011	6:30	N/A	173	6145	668898		ALR
12/15/2011	6:30	N/A	221	4825	830987		ALR
12/16/2011	6:30	N/A	209	5563	599930		ALR
12/19/2011	6:30	N/A	226	5951	631588		ALR
12/20/2011	6:30	N/A	220	4604	854717		ALR
12/21/2011	6:30	N/A	219	5375	743574		ALR
12/22/2011	6:30	N/A	224	5573	770727		ALR
12/23/2011	6:30	N/A	197	5709	641661		ALR
12/27/2011	6:30	N/A	188	4875	676063		ALR
12/28/2011	6:30	N/A	202	4823	696020		ALR
12/29/2011	6:30	N/A	233	5520	754679		ALR
2/3/2012	5:30	N/A	194	4522	783291		ALR

Mean from form RS-013.0-1
Background 202.75 Beta

Mean from form RS-013.0-1
Source 738130.9 Fe-55 (5535.1 H-3)

Background Acceptance Limits				
M-20%	162	M+20%	243	Beta

Source Acceptance Limits				
M-20%	4428.08	M+20%	6642.12	H-3
M-20%	590505	M+20%	885757	Fe-55

Reviewed by:  Date: 2/3/2012

Radiation Safety
Routine Operability of Field Instruments

DAILY INSTRUMENT RESPONSE CHECK
Form RS-013.0-3

SITE: **WRAMC** **Date:** **11/9/2011** **For Month of: Nov/Dec**

Instrument Information	
Type/Serial #:	L2360/253237
Probe/Serial #:	43-68/216834
Calibration Due Date:	23-Oct-12

Source Information		
Isotope	Th-230	Tc-99
Serial Number	A2-743	A2-771
2π emission rate	N/A	N/A

DATE	TIME	BACKGROUND CPM		SOURCE CPM		COMMENTS	Tech Initials
		Alpha	Beta	Alpha	Beta		
11/9/2011	6:30	1	59	5016	7674	Initial Set up	ALR
11/10/2011	6:30	0	51	4818	8316		ALR
11/14/2011	6:30	1	65	4695	7009		ALR
11/15/2011	6:30	1	48	5238	7115		ALR
11/16/2011	6:30	0	68	4751	6687		ALR
11/17/2011	6:30	1	68	4348	8587		ALR
11/18/2011	6:30	1	68	3875	6340		ALR
11/21/2011	6:30	1	67	3956	7016		ALR
11/22/2011	6:30	1	63	5510	7993		ALR
11/23/2011	6:30	1	55	4998	6499		ALR
11/25/2011	6:30	0	63	4776	7155		ALR
11/28/2011	6:30	1	50	5352	8564		ALR
11/29/2011	6:30	1	65	4683	7525		ALR
11/30/2011	6:30	1	70	4871	6857		ALR
12/1/2011	6:30	1	60	4257	7676		ALR
12/2/2011	6:30	2	49	5218	6511		ALR
12/5/2011	6:30	2	62	5515	8094		ALR
12/6/2011	6:30	1	60	5034	6273		ALR
12/7/2011	6:30	1	63	5193	5957		ALR
12/8/2011	6:30	1	70	4324	7783		ALR
12/9/2011	6:30	1	51	4862	6948		ALR
12/12/2011	6:30	2	51	4909	6544		ALR
12/13/2011	6:30	1	51	3869	8591		ALR
12/14/2011	6:30	0	54	4851	6783		ALR
12/15/2011	6:30	1	62	5220	7822		ALR

Mean from form RS-013.0-1	0.6	Alpha	Mean from form RS-013.0-1	4672	Alpha
Background	59.35	Beta	Source	7338.4	Beta

Background Acceptance Limits				
M-2s	-0.76	M+2s	1.96	Alpha
M-20%	47	M+20%	71	Beta

Source Acceptance Limits				
M-20%	3738	M+20%	5606	Alpha
M-20%	5871	M+20%	8806	Beta

Reviewed by:  Date: 12/15/2011

Radiation Safety
Routine Operability of Field Instruments

DAILY INSTRUMENT RESPONSE CHECK
Form RS-013.0-3

SITE: **WRAMC** **Date:** **11/9/2011** **For Month of: Nov/Dec**

Instrument Information	
Type/Serial #:	L2360/253237
Probe/Serial #:	43-68/216834
Calibration Due Date:	23-Oct-12

Source Information		
Isotope	Th-230	Tc-99
Serial Number	A2-743	A2-771
2π emission rate	N/A	N/A

DATE	TIME	BACKGROUND CPM		SOURCE CPM		COMMENTS	Tech Initials
		Alpha	Beta	Alpha	Beta		
12/16/2011	6:30	0	66	5044	7286		ALR
12/19/2011	6:30	0	62	4416	6485		ALR
12/20/2011	6:30	1	64	5176	8212		ALR
12/21/2011	6:30	0	48	4899	8558		ALR
12/22/2011	6:30	0	68	3999	8083		ALR
12/23/2011	6:30	0	54	3755	8556		ALR
12/27/2011	6:30	1	69	3982	6195		ALR
12/28/2011	6:30	0	59	5380	6804		ALR
12/29/2011	6:30	0	54	4539	7081		ALR
2/3/2012	5:30	0	63	5274	6778		ALR

Mean from form RS-013.0-1	0.6	Alpha		Mean from form RS-013.0-1	4671.95	Alpha	
Background	59.35	Beta		Source	7338.35	Beta	

Background Acceptance Limits				
M-2s	-0.76	M+2s	1.96	Alpha
M-20%	47	M+20%	71	Beta

Source Acceptance Limits				
M-20%	3738	M+20%	5606	Alpha
M-20%	5871	M+20%	8806	Beta

Reviewed by:  Date: 2/3/2012

Radiation Safety
Routine Operability of Field Instruments

DAILY INSTRUMENT RESPONSE CHECK
Form RS-013.0-3

SITE: **WRAMC** **Date:** **11/9/2011** **For Month of: Nov/Dec**

Instrument Information	
Type/Serial #:	L2360/253258
Probe/Serial #:	43-37/265544
Calibration Due Date:	23-Oct-12

Source Information		
Isotope	Th-230	Tc-99
Serial Number	A2-743	A2-771
2π emission rate	N/A	N/A

DATE	TIME	BACKGROUND CPM		SOURCE CPM		COMMENTS	Tech Initials
		Alpha	Beta	Alpha	Beta		
11/9/2011	6:30	12	254.5	3784.7	5492.6	Initial Set up	ALR
11/10/2011	6:30	10	236	3620	5922		ALR
11/14/2011	6:30	14	269	4134	4549		ALR
11/15/2011	6:30	7	227	3939	5622		ALR
11/16/2011	6:30	7	279	3636	5515		ALR
11/17/2011	6:30	9	283	3704	5367		ALR
11/18/2011	6:30	12	234	3535	5673		ALR
11/21/2011	6:30	11	254	3498	5672		ALR
11/22/2011	6:30	17	266	3543	5653		ALR
11/23/2011	6:30	15	227	3521	5793		ALR
11/28/2011	6:30	10	279	3825	5539		ALR
11/29/2011	6:30	5	237	3602	6165		ALR
11/30/2011	6:30	6	246	3743	6416		ALR
12/1/2011	6:30	17	287	4358	6180		ALR
12/2/2011	6:30	9	265	3613	4973		ALR
12/5/2011	6:30	7	296	3404	6342		ALR
12/6/2011	6:30	15	292	3398	5669		ALR
12/7/2011	6:30	15	262	3937	6109		ALR
12/8/2011	6:30	10	229	3300	4609		ALR
12/9/2011	6:30	15	252	4314	4800		ALR
12/12/2011	6:30	8	290	3764	5285		ALR
12/13/2011	6:30	9	234	3141	6377		ALR
12/14/2011	6:30	6	281	3242	5998		ALR
12/15/2011	6:30	9	267	4116	6424		ALR
12/16/2011	6:30	14	292	4302	5051		ALR

Mean from form RS-013.0-1 Background	12	Alpha	Mean from form RS-013.0-1 Source	3784.7	Alpha
	254.5	Beta		5492.6	Beta

Background Acceptance Limits				
M-20%	4.69	M+20%	19.31	Alpha
M-20%	204	M+20%	305	Beta

Source Acceptance Limits				
M-20%	3028	M+20%	4542	Alpha
M-20%	4394	M+20%	6591	Beta

Reviewed by: Date: 12/16/2011

Radiation Safety
Routine Operability of Field Instruments

DAILY INSTRUMENT RESPONSE CHECK
Form RS-013.0-3

SITE: **WRAMC** **Date:** **11/9/2011** **For Month of: Nov/Dec**

Instrument Information	
Type/Serial #:	L2360/253258
Probe/Serial #:	43-37/265544
Calibration Due Date:	23-Oct-12

Source Information		
Isotope	Th-230	Tc-99
Serial Number	A2-743	A2-771
2π emission rate	N/A	N/A

DATE	TIME	BACKGROUND CPM		SOURCE CPM		COMMENTS		Tech Initials
		Alpha	Beta	Alpha	Beta			
12/19/2011	6:30	15	226	3521	5047			ALR
12/20/2011	6:30	18	237	3138	6443			ALR
12/21/2011	6:30	12	225	3728	6449			ALR
12/22/2011	6:30	7	289	4098	5636			ALR
12/23/2011	6:30	6	248	4184	5929			ALR
12/27/2011	6:30	9	284	3165	5083			ALR
12/28/2011	6:30	16	291	3536	5994			ALR
12/29/2011	6:30	18	267	3230	4665			ALR
2/3/2012	5:30	5	263	3640	5415			ALR

Mean from form RS-013.0-1 Background	12	Alpha	
	254.5	Beta	
Mean from form RS-013.0-1 Source	3784.7	Alpha	
	5492.6	Beta	

Background Acceptance Limits				
M-20%	4.69	M+20%	19.31	Alpha
M-20%	204	M+20%	305	Beta

Source Acceptance Limits				
M-20%	3028	M+20%	4542	Alpha
M-20%	4394	M+20%	6591	Beta

Reviewed by: Date: 2/3/2012

Radiation Safety
Routine Operability of Field Instruments

DAILY INSTRUMENT RESPONSE CHECK
Form RS-013.0-3

SITE: **WRAMC** **Date:** **11/9/2011** **For Month of: Nov/Dec**

Instrument Information	
Type/Serial #:	L2360/253258
Probe/Serial #:	43-68/148454
Calibration Due Date:	23-Oct-12

Source Information		
Isotope	Th-230	Tc-99
Serial Number	A2-743	A2-771
2π emission rate	N/A	N/A

DATE	TIME	BACKGROUND CPM		SOURCE CPM		COMMENTS	Tech Initials
		Alpha	Beta	Alpha	Beta		
11/9/2011	6:30	0.9	111	4746	9236	Initial Set up	ALR
11/10/2011	6:30	1	131	5187	9680		ALR
11/14/2011	6:30	0	108	4490	9907		ALR
11/15/2011	6:30	1	107	4664	10465		ALR
11/16/2011	6:30	1	123	3858	7584		ALR
11/17/2011	6:30	0	103	5587	9368		ALR
11/18/2011	6:30	0	91	5288	9152		ALR
11/21/2011	6:30	1	93	4936	9852		ALR
11/22/2011	6:30	2	122	5201	9681		ALR
11/23/2011	6:30	1	130	4922	8902		ALR
11/25/2011	6:30	0	116	3903	10367		ALR
11/28/2011	6:30	1	126	5159	9748		ALR
11/29/2011	6:30	1	115	4707	9028		ALR
11/30/2011	6:30	0	118	5012	9089		ALR
12/1/2011	6:30	0	120	5673	7912		ALR
12/2/2011	6:30	1	113	5659	9938		ALR
12/5/2011	6:30	1	103	3975	8627		ALR
12/6/2011	6:30	0	123	4932	9877		ALR
12/7/2011	6:30	2	99	5127	8521		ALR
12/8/2011	6:30	0	117	3967	7414		ALR
12/9/2011	6:30	1	114	4221	10136		ALR
12/12/2011	6:30	1	101	5482	10641		ALR
12/13/2011	6:30	0	112	3981	9348		ALR
12/14/2011	6:30	0	123	5223	9032		ALR
12/15/2011	6:30	0	109	4987	8216		ALR

Mean from form RS-013.0-1 Background			Mean from form RS-013.0-1 Source		
0.9	Alpha		4745.55	Alpha	
110.55	Beta		9235.85	Beta	

Background Acceptance Limits				
M-2σ	-0.80	M+2σ	2.60	Alpha
M-20%	88	M+20%	133	Beta

Source Acceptance Limits				
M-20%	3796	M+20%	5695	Alpha
M-20%	7389	M+20%	11083	Beta

Reviewed by: Date: 2/15/2011

Radiation Safety
Routine Operability of Field Instruments

DAILY INSTRUMENT RESPONSE CHECK
Form RS-013.0-3

SITE: **WRAMC** **Date:** **11/9/2011** **For Month of: Nov/Dec**

Instrument Information	
Type/Serial #:	L2360/253258
Probe/Serial #:	43-68/148454
Calibration Due Date:	23-Oct-12

Source Information		
Isotope	Th-230	Tc-99
Serial Number	A2-743	A2-771
2π emission rate	N/A	N/A

DATE	TIME	BACKGROUND CPM		SOURCE CPM		COMMENTS	Tech Initials
		Alpha	Beta	Alpha	Beta		
12/19/2011	6:30	0	88	4528	9739		ALR
12/20/2011	6:30	0	117	5064	7571		ALR
12/21/2011	6:30	0	101	4370	9387		ALR
12/22/2011	6:30	1	122	4683	7839		ALR
12/23/2011	6:30	0	121	4702	10260		ALR
12/27/2011	6:30	1	121	5113	10153		ALR
12/28/2011	6:30	0	105	4632	9220		ALR
12/29/2011	6:30	0	97	4783	8321		ALR
2/3/2012	5:30	1	103	5042	9768		ALR

Mean from form RS-013.0-1	0.9	Alpha		Mean from form RS-013.0-1	4745.55	Alpha	
Background	110.55	Beta		Source	9235.85	Beta	

Background Acceptance Limits					Source Acceptance Limits				
M-2σ	-0.80	M+2s	2.60	Alpha	M-20%	3796	M+20%	5695	Alpha
M-20%	88	M+20%	133	Beta	M-20%	7389	M+20%	11083	Beta

Reviewed by: Date: 2/3/2012

TECHNICAL MEMORANDUM

EFFICIENCY DETERMINATION FOR INSTRUMENTS USED AT WRAMC MAIN POST SURVEY

May 2012

Table of Contents

Tables

ACRONYMS, ABBREVIATIONS, AND SYMBOLS

α	alpha
β	beta
C-14	Carbon-14
cm	centimeter
cpm	counts per minute
DCGL	Derived Concentration Guideline Level
dpm	disintegrations per minute
ε_T	total efficiency
ε_i	instrument efficiency
ε_s	source efficiency
FSSR	Final Status Survey Report
GM	Geiger Mueller
H-3	Tritium
ISO	Internal Standards Organization
max	maximum
MARSSIM	NUREG-1575, Rev. 1, *Multi-Agency Radiological Survey and Site Investigation Manual*
MeV	Mega electron Volt;1.602×10−13 J
ROC	Radionuclide of concern
Tc-99	Technecium-99
Th-230	Thorium-230
TM	Technical Memorandum
WRAMC	Walter Reed Army Medical Center
ZnS	Zinc Sulfide

EFFICIENCY DETERMINATION FOR INSTRUMENTS USED AT WRAMC MAIN POST SURVEY

1.0 Introduction

The purpose of this Technical Memorandum (TM) is to describe the determination of efficiencies for radiological survey instrumentation used during the final status survey at Walter Reed Army Medical Center (WRAMC) Main Post, Washington. DC. The goal of determining instrument efficiency was to be very conservative in the calculation of potential residual radioactivity and using more realistic assumptions when reasonable to do so. For example, the efficiency for C-14 is very low compared to Tc-99 but it was nearly universally applied to most beta measurements; the exception being when C-14 was not a radionuclide of concern (ROC) and the results were deemed to be artificially high from using the low efficiency. As will be shown, there is a small menu of conservative efficiencies which may be used to demonstrate a reasonable determination of residual radioactivity.

The generally accepted industry practices for evaluation of radioactive surface contamination were used - which are described in NUREG-1575, Rev. 1, *Multi-Agency Radiological Survey and Site Investigation Manual (MARSSIM)* and NUREG-1507, *Minimum Detectable Concentrations With Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*. Both of these documents refer to ISO 7503-1 *Evaluation of Surface Contamination – Part 1: Beta Emitters and Alpha Emitters.* Instrument efficiencies have two components where ε_T is the total efficiency of the instrument in counts per disintegration, effectively the product of the instrument efficiency (ε_i) and the source efficiency (ε_s). Application and determination of both components are provided here. While NUREG-1507 describes both ε_i and ε_s as unitless, their product ε_T must have units of cpm/dpm. To achieve unit analysis balance, ε_i may be presented with units of cpm per emissions per minute and ε_s may be presented with units of emissions per minute per dpm.

ISO-7503-1 states that as a result of plausible and conservative assumptions, the values for source efficiency (ε_s) should be used in the absence of more precisely known values:

- ε_s =0.5 [beta emitters ($E_{\beta max} \geq 0.4$ MeV)]
- ε_s =0.25 [all alpha emitters and beta emitters (0.15 MeV < $E_{\beta max}$< 0.4 MeV)]

MARSSIM acknowledges that source efficiencies for some common surface materials and overlaying material are provided in NUREG-1507.

The source efficiencies described above are not applicable to H-3 with beta energies of 0.0186 MeV max and 0.0056 MeV average. Neither are they applicable to Ni-63 with beta energies of 0.066 Mev max and 0.017 MeV average. Because of emitters like these, ISO developed ISO-7503-2*, Evaluation of Surface Contamination -- Part 2: Tritium Surface Contamination* specifically for tritium and ISO-7503-3 *Evaluation of Surface Contamination -- Part 3: Isomeric Transition and Electron Capture Emitters, Low Energy Beta-emitters (E bêtamax less than 0.15 MeV)* for other low beta-emitters ($E_{\beta max}$< 0.15 MeV).

ISO-7503-2 applies to the evaluation of tritium contamination on surfaces of equipment and facilities, containers of radioactive materials and sealed sources.

- Tritium surface contamination is defined as the total activity of tritium adsorbed upon and absorbed into the surface.
- Directly measurable tritium is defined as the fraction of the tritium surface contamination available for direct measurement.
- The removable tritium surface contamination is defined as the fraction of tritium surface contamination which is removable or transferable under normal working conditions.

ISO-7503-2 provides both a caution and position regarding tritium measurements: "The total surface contamination cannot be accurately evaluated by direct or indirect methods. Direct measurements are carried out with contamination-measuring instruments which will not respond to all activity absorbed below the surface. Indirect measurements performed by wet smear tests generally provide a reasonable estimate of the removable surface contamination at the time of collection...smear test evaluation is an adequate method of assessing the actual radiological hazard arising from incorporation in the course of contact with surfaces by tritium."

ISO-7503-3 indicates that adequate instruments for direct measurement of Ni-63 include a windowless gas flow proportional counter and for indirect (smear) detection includes liquid scintillation counters. As neither ISO-7503-2 nor -3 provide a suggested source efficiency for direct measurements, one option is to use a total (4π) efficiency factor provided with the calibration of the instrument.

Sections 2, 3, and 4 of this TM deal with survey instruments applicable to gas flow proportional detectors with windows such as the Ludlum 43-68 and the Ludlum 43-37. Section 5 addresses the use of the windowless gas flow detector used for tritium detection or other very low energy betas.

The daily instrument performance checks and associated check sources is not a calibration of the instrument in the field and the assumed activity of the check sources cannot be verified; therefore, these log sheets are resubmitted without activity noted. Two of the sources were at least 10 years old and obviously well used; the activity on them is not required to be known - just the radionuclide and type of emission.

2.0 Determination of Instrument Efficiency (ε_i) of Survey Instruments for ISO-7503-1 Described Alpha and Beta Emitters

The efficiencies for the various instruments are reported on the certificates as 4π (cpm/dpm) and must be converted to instrument efficiency (ε_i) for use in contamination evaluations using MARSSIM techniques. Per MARSSIM, the instrument efficiency is defined as the ratio of the net count rate of the instrument and the surface emission rate of a source for a specified geometry. The surface emission rate is defined as the number of particles of a given type above a given energy emerging from the front face of the source per unit time. The surface emission rate is the 2π particle fluence that embodies both the absorption and scattering processes that effect the radiation emitted from the source. Thus, the instrument efficiency is determined by the ratio of the net count rate and the surface emission rate. Ludlum provided the specific nuclide, individual detector backgrounds, activity of the sources, and the instrument response for this conversion. These values and the calculated instrument efficiency (ε_i) are presented in Table 1. This technique is not applicable to windowless gas flow instrumentation for low energy beta emitters ($E_{\beta max}$< 0.15 MeV).

Table 1. Instrument Efficiencies Determined for WRAMC Instrumentation

Meter Serial Number	Probe Type	Probe Serial No.	Nuclide	Back-ground (cpm)	Calibration Source Surface Rate (emissions per minute)	Instrument Response (1 minute count)	Instrument Efficiency, ε_i (cpm/epm)
141321	43-68	148456	Th-230	2	10100	3996	0.395
			Tc-99	209	58300	27278	0.464
			C-14	209	114883	23670	0.204
	43-37	265540	Th-230	4	10100	3695	0.365
			Tc-99	800	58300	28857	0.481
			C-14	800	114883	23005	0.193
253237	43-68	216834	Th-230	2	10100	3864	0.382
			Tc-99	147	58300	27869	0.476
			C-14	147	114883	23792	0.206
	43-37	128625	Th-230	2	10100	3999	0.396
			Tc-99	679	58300	29777	0.499
			C-14	679	114883	25798	0.219
253258	43-68	148454	Th-230	5	10100	3957	0.391
			Tc-99	262	58300	29394	0.500
			C-14	262	114883	22331	0.192
	43-37	265544	Th-230	4	10100	3879	0.384
			Tc-99	462	58300	28860	0.487
			C-14	462	114883	26959	0.231

3.0 Determination of Source Efficiency (ε_s)

"The International Organization for Standardization recommends the use of factors to correct for alpha and beta self-absorption losses when determining the surface activity. Specifically, the recommendation is to use a source efficiency of 0.5 for maximum beta energies exceeding 0.4 MeV, and to use a source efficiency of 0.25 for maximum beta energies between 0.15 and 0.4 MeV. For alpha-emitters; these values 'should be used in the absence of more precisely known values'(ISO-7503-1)" (NUREG-1507). Note that source efficiencies are not stated for tritium and other very low beta energy emitters.

NUREG-1507 states that source efficiencies must be experimentally determined for a given surface type and coating. However, Tables 5.4 and 5.5 in NUREG-1507 present experimental data on source efficiencies for several common surface types and are reproduced below as Tables 2 and 3. Source efficiencies from NUREG-1507 were periodically applied (1) to assure no measurement in a Class 3 survey unit exceeded a small fraction of the $DCGL_w$ SOR of 1; and (2) to assure no measurement in a Class 1 or 2 survey units exceeded the DCGL. When

source efficiencies from NUREG-1507 were used, an annotation was made on the applicable results page in Appendix C of the FSSR.

Table 2. Source Efficiency for Tc-99 Distributed on Various Surfaces (NUREG 1507 Table 5.4)

Surface Material	Source Efficiency [a,b]		
	Gas Proportional		
	β Only	α + β	GM
Point Source [c]			
Sealed Concrete[d]	0.703 ± 0.079[e]	0.694±0.063	0.630±0.076
Stainless Steel	0.755±0.096	0.761±0.076	0.773±0.091
Untreated Wood	0.53±0.11	0.504±0.03	0.512±0.061
Distributed Source [f]			
Sealed Concrete	0.299± 0.096	0.20±0.12	0.19±0.18
Stainless Steel	0.81±0.13	0.73±0.11	---[g]
Treated Wood	0.66±0.11	0.551±0.088	0.61±0.52

[a] Source efficiency determined by dividing total efficiency by the instrument efficiency.
[b] The instrument efficiencies for point source geometry were 0.25, 0.45, and 0.28, respectively, for the β only, α+β, and GM detectors. Instrument efficiencies for the distributed source geometry were 0.2, 0.38, and 0.2, respectively, for the β only, α+β, and GM detectors.
[c] The Tc-99 activity (2828±91 dpm) was dispensed over an area less than 5 cm^2.
[d] For sealed concrete, the Tc-99 activity (5,660±110 dpm) was dispensed over an area of approximately 4 cm^2.
[e] Uncertainties represent the 95% confidence interval, based on propagating the errors in pipetting, volumetric measurements, calibration source activity, and in counting statistics.
[f] The Tc-99 activity (2830±100 dpm) was evenly distributed over an area of 126 cm^2.
[g] Measurement not performed.

Table 3. Source Efficiency for Th-230 Distribued on Various Surfaces (NUREG 1507 Table 5.5)

Surface Material	Source Efficiency [a,b]	
	Gas Proportional (α only)	ZnS
Point Source [c]		
Scabbled Concrete	0.276 ± 0.013[d]	0.288±0.026
Stainless Steel	0.499±0.028	0.555±0.043
Untreated Wood	0.194±0.023	0.185±0.025
Distributed Source [e]		
Sealed Concrete	0.473± 0.053	0.428±0.054
Carbon Steel	0.250±0.042	0.216± 0.031
Treated Wood	0.527±0.057	0.539±0.065

[a] Source efficiency determined by dividing total efficiency by the instrument efficiency.
[b] The instrument efficiencies for point source geometry were 0.50 and 0.33, respectively, for the α-only and ZnS detectors. Instrument efficiencies for the distributed source geometry were 0.4 and 0.3, respectively, for the α-only and ZnS detectors.
[c] The Th-230 activity (4,595 ± 79 dpm) was dispensed over an area less than 10 cm^2.
[d] Uncertainties represent the 95% confidence interval, based on propagating the errors in pipetting, volumetric measurements, calibration source activity, and in counting statistics.
[e] The Th-230 activity (4,600±170 dpm) was evenly distributed over an area of 126 cm^2.

Initially and for conservatism, the instrument efficiency for C-14 betas was generally used and a Sum-of-Ratios (SOR) for the various components of the release criteria of less than 0.2 was achieved. If a SOR of less than 0.2 was not achievable at this conservative level, an approach was taken to select the most probable ROC and the corresponding higher efficiency to demonstrate that SOR results were less than 0.2. Conservatism was maintained as the most restrictive DCGL was used. Regardless of the efficiency selected (most conservative or probable), a SOR of 1 was never exceeded. All efficiencies used in calculations were presented in Appendix C of the FSSR; annotations were made when a source efficiency was selected from Tables 2 and 3.

All survey instruments were calibrated by the manufacturer, Ludlum Measurements, Inc., and certificates of calibration are provided in Appendix E of the Final Status Survey Report (FSSR).

4.0 Determination of Total Efficiency (ε_T)

As indicated, instrument efficiencies have two components where ε_T is the total efficiency of the instrument in counts per disintegration, effectively the product of the instrument efficiency (ε_i) and the source efficiency (ε_s).

An example is provided from NUREG-1757 Section 5.4.2, Measurement of Various Surface Coatings: "Assume that a GM detector is calibrated to a Tc-99 point source, resulting in an ε_i equal to 0.278. It is determined that surface activity measurements will be performed on a concrete surface-refer to Table 5.4 to obtain ε_s equal to 0.630. Therefore, the total efficiency is calculated by multiplying ε_i by ε_s,(equals 0.175)."

When source efficiencies from NUREG-1507 were used, an annotation was made on the applicable results page in Appendix C of the FSSR.

5.0 Efficiency for Windowless Gas Flow Proportional Detectors

Instrumentation and techniques proposed at WRAMC for measurement of low energy beta surface contamination utilize a windowless gas flow proportional detector (Ludlum 44-110) and wetted smears for analysis by liquid scintillation techniques. The ε_T as a 4π value in cpm/dpm was provided by the manufacturer and used in calculations for low energy beta emitters such as tritium and Ni-63. Indirect measurements (smears) were also made as a quality control technique at routine locations; smear results were insignificant as the highest smear result was 178 dpm/100 cm^2 when compared to the release criteria of 1.2E8 dpm/100cm^2. With very low smear results, actual comparisons between smear and direct measurements could not be made

and very low direct measurement results were anticipated and obtained when compared to the release criteria.

The Ludlum 44-110 detector was calibrated by the manufacturer with a H-3 source and the overall or total efficiency was provided by the manufacturer as 0.319 cpm/dpm; ISO-7503-2 does not provide recommendations regarding surface efficiency for H-3. The results summary of the FSSR shows that tritium measurements were very low such they could not exceed the DCGL even if a surface efficiency was applied as low as 8.5E-6. This value for surface efficiency was obtained by dividing the highest measured ncpm result by the instrument efficiency of 0.639 and then by the release criteria for h-3 of 1.2E8 dpm/100cm^2. A review of detection techniques and requirements for betas at the H-3 low energy level was presented in Appendix B of the FSSR. Certificates of calibration were provided in Appendix E.

6.0 References

1 *Evaluation of Surface Contamination-Part1, Beta Emitters (maximum beta energy greater than 0.15 MeV) and Alpha Emitters* (ISO 7503-1), International Organization for Standardization, 1988.

2 *Evaluation of Surface Contamination-Part2, Tritium surface contamination* (ISO 7503-2), International Organization for Standardization, 1988.

3 *Evaluation of Surface Contamination-Part3, Isomeric transition and electron capture emitters, low energy beta-emitters ($E_{\beta max}$ < 0.15 MeV)* (ISO 7503-3), International Organization for Standardization, 1996.

4 *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*, NUREG 1507, US NRC, June, 1998.

5 *Multi-Agency Radiation Survey and Site Investigation Manual*, EPA/402/R-97-016, Revision 1. NUREG-1575, US NRC, August, 2000.

6 *Consolidated NMSS Decommissioning Guidance,* NUREG-1757 Volumes 1 and 2, US NRC, 2003.

RAI 13

12 June 2012

MEMORANDUM FOR RECORD

SUBJECT: Declassification of FOUO Information, Final Site Survey Information submitted by Walter Reed Army Medical Center, Washington, DC.

1. Reference: See attachment enclosed; email dated 24 May 2012 from Mr. Dennis Lawyer; subject: Department of the Army, Request for Additional Information Concerning Application for a License Amendment, Control 577436.

2. Discussion: The Nuclear Regulatory Commission (NRC) specifically requested the following " In Appendix E to Appendix H was an electronic file 36 MS RP Inventory pp 1-247.pdf and a subset of the file 42 MS RP Inventory p197-247.pdf which was marked as "Official Use Only." Information which is marked must be processed in accordance with 10 CFR 2.390. If during our review as stated in 10 CFR 2.390 that this information is not sensitive, we will release this information. You may request the document be withdrawn or destroyed prior to that review. Alternately, you could supply more information to why this document was labeled as "Official Use Only."

3. Conclusion:

a. The information provided within the Final Site Survey(FSS) submitted to the NRC for review was classified FOUO/Do Not Distribute because WRAMC was still in operation as one of the largest DoD. Medical Treatment Facilities within the National Capital Region. WRAMC officially closed as of August 2011 and the information submitted within the WRAMC, FSS to the NRC can now be "DECLASSIFIED" and the information contained in the documents are releasable for public knowledge, effective August 2011.

b. This decision was approved by the undersigned, Mr. Elbert Lewis, MEDCOM Security Manager and Mr. Randy Treiber, Walter Reed Caretaker team Manager, Assistant Chief of Staff for Installation Management.

4. Point of contact is the undersigned at (301) 400-2539.

CASMERE H. TAYLOR
COL, MS
JTF-CaPMed Radiation Consultant

RAI	Response
1. On page 76, Building 2: SU2-1-1 states the survey unit consisted of room 1H23 and others. On the map it appears that the room 1H25 was surveyed and room 1H23 does not appear to have been surveyed. Please explain why 1H23 does not appear to be a part of the survey.	1H23 was incorrectly stated in the FSSR as it was an office. 1H25 was the room surveyed.
2. On page 76, Building 2: SU2-1-2 and on page 77, Building 2: SU 2-1-3 stated the summary of the results of the surveys for these rooms. The specific survey results were not located within the submitted information. Please submit the specific survey data for these two survey units.	These were inadvertently omitted and are submitted.
3. Page 84, Building 2: SU2-7-4 section of the report did not include an assertion from the licensee that the results rejected the null hypothesis. Please provide the statements as written for other survey units.	The following statements are provided: "The measurement results were less than the DCGLs. Results from exposure rate, scan, static and smear measurements indicate the survey unit meets the criteria for unrestricted release by rejecting the null hypothesis which assumes contamination is present above the limit. As no individual result exceeded the release criteria, no additional statistical test was needed."
4. Pages 96-99, summarizes the survey results for Building 41. The specific survey results were not located within the submitted information. Please submit the specific survey results.	These were inadvertently omitted and are submitted. In the summary for SU 41-G-1, a minor correction is submitted: For MARSSIM required measurements, the average betas in the H-3 energy range should read as 401 not 398 dpm/100cm^2; respectively. In the summary for 41-G-1, a minor correction is submitted: For MARSSIM required measurements, the average and maximum integrated direct measurements for gross beta was -33 not -30 dpm/100cm^2. In the Summary for 41-G-2, a minor correction is submitted: The average floor scan results for gross beta and gross alpha were "43 and 3" not "154 and 6" dpm/100cm^2; respectively.
5. On page 101, Building 54: SU54-B-2 summarizes the survey results and gives the highest gross alpha measurement as 13 disintegrations per minute (dpm) per 100 square centimeters. On page C-313, shows two bias surveys over the alpha DCGL of 100 dpm per 100 square centimeters and one reading at the limit. No additional actions, surveys or explanations are given associated with these results. Please evaluate these readings and provide further evaluations like post decontamination surveys, quantified areas hot spot, increase of Class.	Our staff made the same observation causing a return to the site for the retake of several of these measurements on Feb. 3, 2012. We neglected to provide the revised data and the revised data sheet is enclosed. The apparent elevated data was reviewed for potential influences from radon decay, source efficiency, and background reference material. For bias alpha measurements, the highest measurement was 18 not 13 dpm/100cm2.
6. On page 102, Building 54: SU54-B-3 more information about the survey and range locations is needed. Since this area was suspected to be used as a depleted uranium firing range, it was difficult from the maps to discern which area had the actually firing of the weapons and target. The survey unit was developed to be large enough that is appears that maybe only one fixed point was obtained in the actual firing range. The bias readings are not marked to the specific locations and thus may not represent an check in the firing range. Scan surveys have a MDC of 7 times the derived adequate concentration guideline level and would be insufficient without appropriate fixed readings. Please review this survey unit for appropriate sizing of the survey unit given the potential and appropriate bias surveys. Please give detailed information about the room purposes and locations of all fixed readings including bias surveys.	As the firing range area and target area were repaired/renovated to office quality, no residual radioactivity was anticipated on the various surfaces. These were subjected to a 100% scan survey for very small embedded fragments with a FIDLER probe with negative results. Due to the extensive repair and remodeling, additional directs were not deemed warranted; these areas were part of a larger Class 3 survey unit. See the attached Technical Memorandum for details regarding the range location and survey details.
7. On page 106, Building 54:SU54-G-4, the summary report states the highest alpha bias reading was 16 dpm per 100 square centimeters. On page C-565, there was a bias survey of 92 dpm per 100 square centimeters which is not above the DCGL but is statistically approximately the DCGL. Please review this survey point or perform more surveys of the Tan air duct to determine if DCGL is exceeded or the reason for the elevated survey.	Our staff made the same observation causing a return to the site for the retake of several of these measurements on Feb. 3, 2012. We neglected to provide the revised data and the revised data sheet is enclosed. The apparent elevated data was reviewed for potential influences from radon decay, source efficiency, and background reference material.

RAI	Response
8. On page 119, Building 54: SU:54-5-1 gives the summary of the survey results. The map on page C-499 appears to be SU:54-4-4 instead of results. The map on page C-499 appears to be SU:54-4-4 instead of SU:54-5-1. Please submit the correct map and scan locations.	The map onpage C-499 appears to be correct. Upon review, we discovered that page C-507 had the incorrect map for the static locations of SU:54-5-1 which we have corrected and a copy is attached.
9. On page 126, Building 92: SU92-G-2 gives the summary of the survey results. The map for this location was not submitted. It appears that the map for SU92-G-1 was placed in the appendix twice instead. Please submit a map for SU92-G-2.	The requested map is enclosed.
10. Appendix G, Evaluation of Varian CLINACs did not include the tables. Please include the tables.	Enclosed.
11. The instrument efficiencies used in the report were not supported by the documents in the report. Please send in method of determining efficiencies of the instrumentation and documentation supporting the instrument efficiencies.	See attached Technical Memorandum for this RAI. Performance check log sheets have been revised to remove reference to source emission rates as performance checks were not meant to be substituted asfield calibrations.
12. In the historical site assessment the following rooms were included that did not appear to be included in the Final Status Survey: Building 2, rooms 1847, 1848, 1849; Building 7, room G-42; and Building 54 rooms 5007, 5044, and 5050. Please state why these surveys were not included, were included but not explicitly stated, or were included and where they are included in the survey.	The Building 2 rooms 1847, 1848, and 1849 appear to be from an earlier room numbering system and cannot now be identified; however, functionality of rooms did not appear to change through the years regardless of the numbering system. The rooms are believed to be part of the those rooms surveyed in SU:2-1-2.
	Building 7, Room G-42 was surveyed as SU:7-B-1, see pages C-157 through C-163.
	The HSA indicated that close out surveys by the HPO were performed at an earlier time which implied that these rooms would not be more than MARSSIM Class 3; however, Building 54 Rooms 5007, 5044, and 5050 were not identifiable. It was not known if they were absorbed into other rooms thorugh remodeling or if room numbers were changed. The entire floor was divided into three survey units as a reasonable attempt to assure that these rooms were included regardless of the current room number designation.
13. In Appendix E to Appendix H was an electronic file 36 MS RP Inventory pp 1-247.pdf and a subset of the file 42 MS RP Inventory p197-247.pdf which was marked as "Official Use Only." Information which is marked must be processed in accordance with 10 CFR 2.390. If during our review as stated in 10 CFR 2.390 that this information is not sensitive, we will release this information. You may request the document be withdrawn or destroyed prior to that review. Alternately, you could supply more information to why this document was labeled as "Official Use Only."	Army Walter Reed representatives believe that since Walter Reed is no longer operational that these documents marked as FOUO should not be considered sensitive information and are acceptable for release to the public. Please see email attachments for record of this decision.

This Errata sheet is a record of final revisions deemed necessary to the FSSR subsequent to NRC submittal.

Section	Issue	Clarification
1.3.2 Building 2	As reads: "Rooms 7544 and 7545 were used by the HPO for temporary short-lived radioactive waste storage." These were historically used as iodinization rooms.	Change to "Rooms 7544 and 7545 were used historically for iodinizations but during closeout activities they were used by the HPO for temporary short-lived radioactive waste storage."
Tables 1-4, 1-5, and 1-6.	As reads for Pd-103 $T_{1/2}$ "13.6 h"	Change to "16.99 d"; there is no impact on survey technique or results.
Table 1-7	Building 41 was omitted.	Add column for Building 41 with "X" for all radionuclides.
Table 1-9	This table has a misleading title and needs some clarification	Retitle as: Table 1-9 ROC Half-lives, Decay Type, and Principal Beta/Alpha Energy
		Added footnote for Cs-137 and Co-60: [g] These also have a significant gamma emission; see Table 1-10.
		Added footnote for Zn-65: [h] Actual decay is by electron capture.
3.1.4.3 Temporal Boundaries of the Decision Statement	The time frame to which the decision applies should be clarified. As is: "The lower temporal bound for this investigation was 1957, when radioactive materials were used pursuant to an Atomic Energy Commission license. The upper temporal bound was December 2011 following termination of facility operations and all known licensed material was removed.	Change to read: The lower temporal bound for licensed activities for this investigation was 1957, when radioactive materials were authorized pursuant to an Atomic Energy Commission license. The initial use date of naturally occurring radium which was not required to be licensed was probably in the 1940s but the time is not critical as any hazardous residuals would be detectable today. The upper temporal bound was December 2011 following termination of facility operations and all known licensed material was removed.
6.3.5 MARSSIM Survey Unit Results	Clarity required regarding whether or not background was subtracted from exposure rate measurements.	Sentence added: "Background exposure rate levels were not subtracted from any measurement shown in this report."