

## 1359 Final Status Survey Report Revision C

International Isotopes, Inc.  
1359 Commerce Way Facility  
NRC License Number SUB-1587

March 25, 2014

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## 1359 Final Status Survey Report Revision B

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*This 1359 Final Status Survey Report summarizes the results of the final status surveys conducted in Building 1359 following the removal of all depleted uranium and potentially contaminated equipment and components. Depleted uranium and potentially contaminated equipment will be stored at the 4137 Commerce Circle facility warehouse until it is either disposed of as radioactive waste, released for unrestricted use, or transferred to another license, such as SUB-1011 for future use.*

*Building 1359 was subdivided into 8 survey units as described in the 1359 Decommissioning Plan and surveyed in accordance with International Isotopes Inc. procedure OP-RSP-010, Facility Radiological Surveys. The maximum and average results of these surveys were found to be below the DCGL<sub>w</sub> of 1100 dpm/100 cm<sup>2</sup> of depleted uranium. Resulting dose to the public at the DCGL<sub>w</sub> is 20 mrem/year. The final status surveys demonstrate Building 1359 is free of residual radioactive material above the DCGL<sub>w</sub> and can be released for unrestricted use and removed from US NRC license SUB-1587.*

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## 1.0 FACILITY BACKGROUND

### Building History & Description

The 1359 facility is located in the St. Leon Business Park on the north side of Idaho Falls, Idaho. The building is constructed of expanded polymer block filled with approximately four inches of concrete. International Isotopes Inc. (INIS) became the sole leasing tenant (lease) of the facility in February 2004. Prior to the INIS lease the facility was occupied by Alliance Contractors, a vinyl siding and window distributor. There is no reason to believe radioactive materials were introduced into this facility by the prior occupant and this was the sole occupant prior to INIS's lease.

The 1359 facility is equipped with its own septic system that currently serves the restrooms and floor drains located in the restrooms and utility closet. There are no floor drains in the remainder of the building.

The facility is approximately 80 feet wide by 100 feet deep. Room numbers and functions are listed in the table below. Refer to the facility diagram enclosed with this plan.

Room	Function
101	Reception Area
102	Utility Hall Way
102A	Utility Closet
102B	Men's Restroom
102C	Women's Restroom
201	Second Floor Conference Room
301	Gas Production Skid
302	Analytical Laboratory
303	Count Room
304	Powder Handling (UF <sub>4</sub> , U <sub>3</sub> O <sub>8</sub> , GeO <sub>2</sub> , B <sub>2</sub> O <sub>3</sub> )
401	Process Floor Mezzanine
402	Count Room/DU Handling Room Mezzanine

Interior walls of the production area are constructed of steel siding. The production area floors are constructed of sealed concrete. There are no floor drains associated with the production area. Approximately 350 linear feet of ventilation ducting exists in the facility, only a small run of ventilation ducting has the potential for radiological contamination since it is upstream of an installed HEPA filter. Approximately 90% of the gas production system is located on a skid, that was contained within an enclosed ventilation controlled cabinet, and which can be removed from the facility utilizing a fork lift. The facility has been well maintained and routinely cleaned during the course of operations.



The following list describes the major pieces of equipment that have been used in the radiological work and fluorine gas production processes equipment.

*DUF<sub>4</sub>/DUOxide Stainless Steel Glove Box*: A stainless steel glove box had been used to transfer batches of UF<sub>4</sub> into the reaction tray. This glove box was used very infrequently because small batch sizes did not require the use of the glove box. The glove box was removed from Building 1359 and is currently stored in the 4137 Warehouse.

*DUF<sub>4</sub>/DUOxide Plexiglas Glove Box*: A small Plexiglas glove box has been utilized to transfer batches of UF<sub>4</sub> into the reaction tray. Low levels of residual depleted uranium are expected to be present in this glove box. The glove box was removed from Building 1359 and is currently stored in the 4137 Warehouse.

*DUF<sub>4</sub>/DUOxide Fume Hood*: A small Plexiglas fume hood has been utilized to perform visual inspections of the reacted depleted uranium and GeO<sub>2</sub> or B<sub>2</sub>O<sub>3</sub> following a batch run. Low levels of residual depleted uranium are expected to be present in this fume hood. The glove box was removed from Building 1359 and is currently stored in the 4137 Warehouse.

*Gas Production Fume Hood*: A fume hood approximately, 12 feet wide by 6 feet deep and 9 feet in height has been used to house the fluorine gas extraction system. This fume hood has not become contaminated during operations. This fume hood was disassembled and moved to the 4137 Warehouse for storage.

*ICP-MS Fume Hood*: A fume hood approximately, 12 feet wide by 6 feet deep and 9 feet in height was used to house the Perkin Elmer ICP-MS system. This fume hood has not become contaminated during operations. This fume hood was disassembled and moved to the 4137 Warehouse for storage.

*Perkin Elmer ICP-MS*: The Perkin Elmer ICP-MS is an automated trace element gas/liquid sampling system. The system was utilized to determine the impurity concentrations at the parts per trillion level of fluorine gas products. This unit was located in Room 302, Analytical Laboratory and has not become contaminated during operations. This piece of equipment was moved to the 4137 Warehouse for storage.

A list of other equipment removed from the 1359 facility is provided on the equipment disposition log, along with a copy of the radiological surveys supporting removal are included in this report. Original radiological surveys are maintained on file at the 4137 facility.

### Operational History

The facility operated in a research and development (R&D) mode from January 2006 until January 2013. Between January 23, 2006 and November 25, 2008 a total of 57 test runs using DUF<sub>4</sub> and GeO<sub>2</sub> to produce GeF<sub>4</sub> were completed. A total of 41.896 kg of DUF<sub>4</sub> was utilized in the GeF<sub>4</sub> production studies. The largest batch size consisted of 2.67 kg of DUF<sub>4</sub>.

R&D activities were curtailed between December 2008 and July 2010 to re-configure the gas production and collection system to support studies on the production and collection of BF<sub>3</sub>.

After configuration a total of 26 test runs were conducted commencing on July 12, 2010 and ending with the last run on December 12, 2012. A total of 11.368 kg of DUF<sub>4</sub> was utilized in the BF<sub>3</sub> production studies. In total, the R&D activities conducted at the 1359 facility under SUB-1587 utilized 53.264 kg of DUF<sub>4</sub>, refer to the table below.

Test Runs with GeO <sub>2</sub>					
Date	UF <sub>4</sub> (grams)	Date	UF <sub>4</sub> (grams)	Date	UF <sub>4</sub> (grams)
1/23/2006	135	3/12/2007	211	1/31/2008	211
5/15/2006	135	4/23/2007	212	2/4/2008	211
5/17/2006	135	5/2/2007	211	2/6/2008	212
6/21/2006	135	5/4/2007	211	3/11/2008	633
6/30/2006	801.3	5/9/2007	211	3/17/2008	638
7/20/2006	685	5/18/2007	211	3/19/2008	1329
7/26/2006	135	5/29/2007	213	3/27/2008	1330
8/1/2006	135	6/1/2007	213	4/7/2008	1334
8/3/2006	180	6/5/2007	211	4/10/2008	1367
11/17/2006	211.2	6/7/2007	222	4/14/2008	2658
11/22/2006	213	6/12/2007	211	4/16/2008	2660
11/28/2006	212	6/15/2007	211	4/18/2008	2660
11/30/2006	212	6/19/2007	211	6/19/2008	2660
12/5/2006	211	8/8/2007	211	6/26/2008	2263
12/7/2006	213	8/10/2007	211	6/27/2008	2532
12/15/2006	215	8/27/2007	211	6/30/2008	2670
12/19/2006	211	8/29/2007	209	8/29/2008	493.7
Total 2006	4174.5	10/1/2007	211	9/10/2008	1225.9
		10/2/2007	211	10/6/2008	1639.1
		Total 2007	4023	11/21/2008	2260
				11/25/2008	2712
				Total 2008	33698.7

Test Runs with B<sub>2</sub>O<sub>3</sub>

Date	UF <sub>4</sub> (grams)	Date	UF <sub>4</sub> (grams)	Date	UF <sub>4</sub> (grams)
7/12/2010	346	2/14/2011	386	6/12/2012	375
7/15/2010	380	5/26/2011	1854	6/20/2012	382
7/19/2010	386	9/30/2011	372	6/26/2012	380
9/23/2010	391	10/12/2011	376	7/16/2012	380
10/20/2010	386	10/18/2011	382	7/24/2012	380
11/15/2010	387	Total 2011	3370	9/4/2012	382
11/18/2010	388			9/25/2012	382
12/15/2010	386			10/23/2012	382
Total 2010	3050			11/13/2012	384
				11/17/2012	384
				11/29/2012	381
				12/5/2012	384
				12/12/2012	372
				Total 2012	4948

During operations depleted uranium compounds were only handled in glove boxes or fume hoods. Routine radiological surveys were conducted throughout the facility at weekly, monthly and quarterly frequencies and formed the basis of the area classifications and final status survey requirements.

Contamination was never identified outside of glove boxes or fume hoods used to handle depleted uranium compounds. Uranium contamination was never identified in the gas collection manifold outside of the reaction vessel or in the fluorine gas product. There was never any spill involving depleted uranium compounds in Building 1359. To prevent the accumulation of depleted uranium in the facility and to support a simplified decommissioning process, a license condition limited the total quantity of depleted uranium in the facility at any one time to 25 kilograms (approximately 10 mCi)

Individual's that worked at the 1359 facility were monitored for whole body and extremity exposures, dosimeters were exchanged on a quarterly basis. During this period of operations the highest whole body dose recorded was 14 mrem in one quarter. This was the only instance when a whole body dose exceeding the 10 mrem detection limit of the dosimeter was recorded.

Routine bioassay via urinalysis had been conducted as a precautionary measure from January 2006 until December 2008. The results of these bioassays, continuous air monitoring and grab air sampling indicated that the engineering controls implemented prevented the release of uranium contamination in the work place so routine bioassays were curtailed, while continuous air monitoring of the workplace continued. During the period of operations air monitoring samples and routing bioassay measurements failed to detect the presence of uranium.

## 2.0 DECOMMISSIONING PLAN

The scope of the decommissioning activity was limited to releasing Building 1359 for unrestricted use to remove Building 1359 from NRC license SUB-1587 and to revise the authorized licensed activities to possession and storage.

Consistent with NUREG-1757 Volume 2; Building 1359 facility was categorized as Decommissioning Group 2 based on the operational history of the facility, small quantities of depleted uranium handled and results of routine contamination and airborne radioactive surveys performed during operations and extended periods of shut-down.

Decommissioning of the 1359 Building was sub-divided into the following tasks:

1. Planning and Preparation
2. Facility Characterization
3. Decontamination/Dismantling
4. Packaging
5. Radioactive Material Disposition
6. Final Status Survey and Evaluation

### 2.1 PLANNING AND PREPARATION

The planning and preparation phase of this decommissioning activity consisted of developing a task sequence and schedule, identifying and acquiring as necessary the equipment needed to complete the project, ensuring this equipment is available, calibrated as needed, and operable, identifying disposition path for items to be removed from the facility including the identification of storage areas, identifying release requirements for items to be left behind in the facility.

Background survey measurements were conducted on the concrete floor of the Utility Room (Room 102A) and along the concrete slab along the north and south roll-up doors; these areas are considered non-impacted.

Instrumentation utilized during the R&D activities were utilized during the decommissioning process, these instruments are identified below:

Instrument	Serial Number	Calibration Due Date
Ludlum 3030	210766	07/18/2013
Ludlum 3030	210769	02/16/2013
Ludlum 2360 w/ 43-93 probe	202409/221513	08/07/2013
Ludlum 2360 w/ 43-93 probe	2024397/221514	10/9/2013

A disposition log was utilized to record equipment and components that were removed from the facility that may have been in contact with uncontained uranium. The disposition log identified the piece of equipment by name and serial number (as applicable), a brief description of the equipment, and type of disposition, i.e. storage for future use, storage for subsequent disposal as radioactive material, or unrestricted release. A copy of the log is included in this report.

## 2.2 FACILITY CHARACTERIZATION

Facility characterization was performed following the guidance provided in NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual*, (MARSSIM). Characterization typically consists of; historical site assessment followed by scoping and characterizations surveys, and remedial action surveys if necessary. Considering INIS has been the sole occupant to utilize radioactive materials at the 1359, characterization was conducted through a review of the routine surveys performed at the facility, which included weekly, monthly and quarterly contamination surveys and air sampling data. These surveys have been documented and maintained at the facility since the introduction of depleted uranium. It is important to note that during the course of depleted uranium operations the presence of uranium was never observed in any continuous air monitoring samples, in-line ventilation air samples, work coverage grab samples or in the fluorine gas production stream; and that contamination was never identified outside of any controlled area on building surfaces. The following definitions from the MARSSIM are included for clarity:

**Class 1 area:** An *area* that is projected to require a *Class 1 final status survey*.

**Class 1 survey:** A type of *final status survey* that applies to *areas* with the highest potential for contamination, and meet the following criteria: (1) *impacted*; (2) potential for delivering a dose above the *release criterion*; (3) potential for small *areas of elevated activity*; and (4) insufficient evidence to support reclassification as *Class 2* or *Class 3*.

**Class 2 area:** An *area* that is projected to require a *Class 2 final status survey*.

**Class 2 survey:** A type of *final status survey* that applies to *areas* that meet the following criteria: (1) *impacted*; (2) low potential for delivering a dose above the *release criterion*; and (3) little or no potential for small *areas of elevated activity*.

**Class 3 area:** An *area* that is projected to require a *Class 3 final status survey*.

**Class 3 survey:** A type of *final status survey* that applies to *areas* that meet the following criteria: (1) *impacted*; (2) little or no potential for delivering a dose above the *release criterion*; and (3) little or no potential for small *areas of elevated activity*.

**Impacted area:** Any *area* that is not *classified as non-impacted*. Areas with a possibility of containing *residual radioactivity* in excess of natural background or fallout levels.

**Non-impacted area:** Areas where there is no reasonable possibility (extremely low probability) of residual contamination.

Based on the operational history of the facility there are no Class 1 areas identified in the Building 1359 facility. Radioactive contamination was expected and confirmed in the ventilation duct that serviced the fume hood and glove boxes located in Room 304. The levels of contamination identified in the duct were less than 1,000 dpm over large area wipes. This portion of the duct work was sealed at both ends and transferred to the 4137 warehouse for subsequent disposal as radioactive waste. In-line air monitoring during operations downstream of the HEPA filters never identified the presence of uranium.

This section of duct was confirmed to be free of contamination downstream of the HEPA filters.

The facility areas have been classified based on the routine survey data and operational history. Area classifications are provided in the table below.

Area Description	Floor	Walls (≤ 8 ft)	Ceilings/Walls (> 8 ft.)
Reception Area Room 101	Class 3	Non-impacted	Non-impacted
Hallway 102	Class 3	Non-impacted	Non-impacted
Utility Room 102A	Non-impacted	Non-impacted	Non-impacted
Restrooms Rooms 102B & 102C	Class 3	Non-impacted	Non-impacted
2 <sup>nd</sup> Floor Conference Room 201	Non-impacted	Non-impacted	Non-impacted
Gas Production Room 301	Class 3	Non-impacted	Non-impacted
Analytical Laboratory Room 302	Class 3	Non-impacted	Non-impacted
Count Room 303	Class 2	Class 3	Non-impacted
DU Handling Room 304	Class 2	Class 3	Non-impacted
Remainder of Process Area	Class 3	Non-impacted	Non-impacted
401 Process floor Mezzanine	Class 3	N/A	Non-impacted
402 Count Room/DU Handling Room Mezzanine	Class 3	Non-impacted	Non-impacted
Building Exterior	Non-impacted	Non-impacted	Non-impacted
	Upstream Filter	Downstream Filter	
Room 304 Ventilation <sup>(1)</sup>	Class 1	Non-impacted	
Fluorine Gas Production Manifold <sup>(2)</sup>	Class 3	Non-impacted	
Notes: (1) HEPA Filter, (2) Metal Micron Filter			

## 2.3 DECONTAMINATION/ DISMANTLING

Decontamination and dismantling and removal of ventilation ducting, fume hoods and equipment was conducted prior to final status surveys. A list of equipment removed from the facility, along with a copy of the radiological surveys supporting the removal are provided in Attachments 1 and 2.

## 2.4 PACKAGING

Packaging of material has been conducted as follows:

The DUF<sub>4</sub> remaining in the facility has been packaged in a PVC bag and was placed in 1 gallon tin can and transferred to the 4137 warehouse. All other depleted uranium compounds (oxides and oxide/fluoride mixes) were packaged in a PVC bag and placed in a 1 gallon tin can and placed into radioactive waste storage at the 4137 warehouse.

Compactable waste, such as lab trash, swipes and PPE, were consolidated in double PVC bags for subsequent compaction at the 4137 facility.

Ventilation ducting was covered with PVC at the open ends and is stored in the radioactive waste cave in the 4137 warehouse. Two HEPA filters from the ventilation line have been packaged in PVC and are stored in the DU handling room in the 4137 warehouse.

The metal glove box, plexiglass glove box and small fume hood were sealed and transferred to the 4137 warehouse for storage. These items will be decontaminated as necessary and reutilized for other licensed operations.

## **2.5 RADIOACTIVE MATERIAL DISPOSITION**

Radioactive materials, including contaminated equipment have been transferred from the 1359 facility to the 4137 warehouse where it has been placed into storage until final disposition.

Unreacted  $\text{DUF}_4$  was returned to  $\text{DUF}_4$  inventory and is currently stored in the 4137 warehouse. Some, or all, of this inventory will either be transferred to International Isotopes Inc. NRC License SUB-1011 once the facility has been constructed or it will be disposed of at US Ecology's Richland, Washington waste disposal facility.

Reacted depleted uranium compounds have been transferred to the 4137 warehouse and were placed into radioactive waste storage to be disposed of at US Ecology's Richland, Washington waste disposal facility during the next waste disposal campaign.

Compactable radioactive waste that was located in the 1359 facility or had been generated during the decommissioning of the 1359 facility has been added compactable waste stream and will be compacted and subsequently disposed of at US Ecology's Richland, Washington waste disposal facility during the next waste disposal campaign.

Contaminated or potentially contaminated equipment/components that have no residual value have been packaged as described in section 2.4 above and were transferred to the 4137 warehouse for storage and subsequently disposed of at US Ecology's Richland, Washington waste disposal facility during the next waste disposal campaign. Information regarding the maximum quantity of uranium that could be disposed along with the chemical and physical form of the depleted uranium waste has been provided to US Ecology. The maximum quantity of depleted uranium waste that could be disposed at the US Ecology, 111.82 kg, is within the quantities of uranium remaining on the US Ecology State of Washington License, WN-I019-2. The maximum amount of uranium that would be disposed is listed in the table below:

	Mass	Activity
U238:	1109.6 kg	372.91 mCi
U235:	2.21 kg	4.78 mCi
U-234:	0.01kg	69.06 mCi

This information along with the chemical and physical form of the depleted uranium was provided to US Ecology, Richland who confirmed with the State of Washington that the quantity could be received for disposal under the current license.

Contaminated or potentially contaminated equipment/components that have residual value have been packaged as described in section 2.4 above and were transferred to the 4137 warehouse for storage and subsequent reuse or resale. Potentially contaminated equipment/components may be reused as is, if transferred to an authorized licensee. Potentially contaminated equipment/components would require decontamination prior to release for unrestricted use. Uncontaminated equipment/components of residual value were removed from the facility and placed into appropriate storage containers/locations until final disposition.

## 2.6 FINAL STATUS SURVEY

Final status surveys were performed in accordance with the MARSSIM. Prior to performing final status surveys the facility floors were swept of debris resulting from the dismantling efforts. The process floors and Rooms 301 and 302 were swept and cleaned using a Clarke® Encore 20L floor cleaner. The water collected from the cleaning was transferred to the evaporator in the 4137 Commerce Circle building. The floors were swept and cleaned with a Swiffer® Sweeper with the wet cloth prior to conducting final status surveys in Rooms 303, 304, 401 and. No cleaning was conducted on the walls of building 1359.

Final status surveys consisted of direct and removable contamination surveys conducted in the Class 2 and Class 3 areas identified in the building, note that there are no Class 1 areas located in Building 1359. Surveys exterior to the building as well as soil and building media samples, i.e. paint, piping insulation, or concrete were not considered to be necessary given the operating history of the facility and the physical and chemical form of the depleted uranium compounds handled during the brief operating history of the facility.

### 2.6.1 Survey Units

The Building 1359 facility had been divided into 8 survey units as follows:

Floor		Walls (≤ 8 ft)	Ceilings/Walls (> 8 ft.)
Survey Unit #1 – Class 3			
Stair way Conference Room 201	Random scan of area, Direct survey followed by swipe at highest scan location in each room		No survey  No Survey
	Location	Floor Area	
	Room 201	488 ft <sup>2</sup>	
Survey Unit #2 – Class 3			
Reception Area Room 101 Hallway 102 Restrooms 102B & 102C	Scan 5% of area, Direct survey followed by swipe at 5 highest scan locations in each room		No survey  No Survey
	Location	Floor Area	
	Room 101	273 ft <sup>2</sup>	
	Hallway 102	64 ft <sup>2</sup>	
	Restroom 102B	46 ft <sup>2</sup>	
	Restroom 102C	46 ft <sup>2</sup>	



Floor		Walls (≤ 8 ft)	Ceilings/Walls (> 8 ft.)	
Survey Unit #3 – Class 3				
Gas Production Room 301 Analytical Lab Room 302	Scan 5% of area, Direct survey followed by swipe at 5 highest scan locations in each room		No survey  No Survey	
	Location	Area (Ft <sup>2</sup> )		
	Room 301	350 ft <sup>2</sup>		
	Room 302	521 ft <sup>2</sup>		
Survey Unit #4 – Class 3				
401 Mezzanine 402 Mezzanine	Scan 5% of area, Direct survey followed by swipe at 5 highest scan locations in each area		No survey  No Survey	
	Location	Area (Ft <sup>2</sup> )		
	401 Mezzanine	1010 ft <sup>2</sup>		
	402 Mezzanine	391 ft <sup>2</sup>		
Survey Unit #5 – Class 3				
SE Quarter of Process Area SW Quarter of Process Area	Scan 5% of high traffic area and random scan remainder Direct survey 5 followed by swipe at highest scan locations in each quadrant		No survey  No Survey	
	Location	Area (Ft <sup>2</sup> )		
	SE Qtr of PA	1720 ft <sup>2</sup>		
	SW Qtr of PA	754 ft <sup>2</sup>		
Survey Unit #6 – Class 3				
NE Quarter of Process Area NW Quarter of Process Area	Scan 5% of high traffic area and random scan remainder Direct survey followed by swipe at 5 highest scan locations in each quadrant		No survey  No Survey	
	Location	Area (Ft <sup>2</sup> )		
	NE Qtr of PA	2114 ft <sup>2</sup>		
	NW Qtr of PA	2114 ft <sup>2</sup>		
Survey Unit #7 – Class 2				
DU Handling Room 304	Scan 25% of area. Direct survey followed by swipe at 10 highest scan locations		Scan 5% of area Direct survey, 2 highest scan locations each wall	Scan 100% of ceiling in 6 inch width along circumference of duct penetration Direct survey highest scan location
	Location	Area (Ft <sup>2</sup> )		
	Room 304	230 ft <sup>2</sup>		
Survey Unit #8 – Class 2				
Count Room 303	Scan 25% of area. Direct survey followed by swipe at 5 highest scan locations		Scan 5% of area Direct survey highest scan location each wall	No survey
	Location	Area (Ft <sup>2</sup> )		
	Room 303	105 ft <sup>2</sup>		

Final status surveys were documented on Forms F-33A Radiological Survey Report and F33-B, Radiological Survey Report Map.

Final status surveys were conducted by first performing scan surveys as indicated in the table above. The surveyor paused when an area of elevated counts was identified. This area was then scanned at a slower rate. A direct 1 minute count survey was then performed at the area of the highest scan location. After performing the direct survey a swipe survey over an area of approximately 100 cm<sup>2</sup> was performed to determine the extent of removable contamination.

## 2.6.2 DCGL<sub>w</sub> Development

Final US Nuclear Regulatory Commission's D and D Code, Version 2.1.0 was used to develop an average Derived Concentration Guideline Level (DCGL<sub>w</sub>) of 1100 dpm/100 cm<sup>2</sup> using the elemental ratios of U-238, U-234 and U-235 in depleted uranium.

	Mass Fraction	Activity Fraction	dpm/100cm <sup>2</sup>
U-238	99.8%	83.47%	918.19
U-235	0.199%	1.07%	11.77
U-234	0.001%	15.46%	170.04
DCGL <sub>w</sub> =			1100

The resulting TEDE = 2.0E+01 mRem was calculated using the default Building Occupancy parameters except that a resuspension factor (Rf) of 1E-6 m<sup>-2</sup> was utilized as recommended by NUREG-1720 *Re-evaluation of the Indoor Resuspension Factor for the Screening Analysis of the Building Occupancy Scenario for NRC's License Termination Rule*. The DandD report summary is provided as Attachment 3.

## 2.6.3 Reference Area Background

A reference area background for scan and direct survey measurements was developed by obtaining 20 direct survey measurements utilizing the Ludlum Model 2360 with Model 43-93 probe (serial numbers 202409/221513).

Ludlum 2360/43-93 (202409/221513) Calibration Due Date: 08/07/2013  
2 π Instrument Efficiency (E<sub>I</sub>): 21.89% Source Efficiency (E<sub>SRC</sub>): 25.0%

Location		Background		Location		Background	
		cpm 100cm <sup>2</sup>	dpm 100cm <sup>2</sup>			cpm 100cm <sup>2</sup>	dpm 100cm <sup>2</sup>
1	NW Roll-UP door	7	127.91	11	SE Roll-UP door	9	164.46
2	NW Roll-UP door	10	182.73	12	SE Roll-UP door	15	274.10
3	NW Roll-UP door	15	274.10	13	SE Roll-UP door	13	237.55
4	NW Roll-UP door	9	164.46	14	SE Roll-UP door	11	201.01
5	NW Roll-UP door	11	201.01	15	SE Roll-UP door	17	310.64
6	NE Roll-UP door	12	219.28	16	Room 102A	14	255.82
7	NE Roll-UP door	9	164.46	17	Room 102A	12	219.28
8	NE Roll-UP door	8	146.19	18	Room 102A	9	164.46
9	NE Roll-UP door	10	182.73	19	Room 102A	7	127.91
10	NE Roll-UP door	13	237.55	20	Room 102A	8	146.19

	cpm/100cm <sup>2</sup>		dpm/100cm <sup>2</sup>
Mean:	10.95	Mean:	200.09
Median:	10.5	Median:	191.9
σ:	2.86	σ:	52.18
Minimum:	7	Minimum:	127.9
Maximum:	17	Maximum:	310.6

The locations of reference area measurements 1 through 20 are identified on the map included as Figure 1. A mean reference area background of 10.95 cpm/100cm<sup>2</sup> with a standard deviation of 2.96 cpm/100cm<sup>2</sup> was determined for the survey units. Reference area background was converted to units of the DCGL<sub>w</sub> (dpm/100cm<sup>2</sup>).

The minimum detectable activity for a static 1 minute measurement using the Ludlum Model 2360 with 43-93 probe (serial numbers 202409/221513) was conservatively calculated by applying the 25% source efficiency from NUREG-1507 to the equation as 336.2 dpm/100 cm<sup>2</sup>, 30.5% of the DCGL<sub>w</sub> and within the recommended 50% MDA:DCGL ratio.

An equivalent average reference area background count rate of 7.85 cpm/100cm<sup>2</sup> (10.95 cpm/100cm<sup>2</sup> x (0.2189/0.3053)) was used for the Ludlum Model 2360 with 43-93 probe (serial numbers 2024397/221514) to calculate a minimum detectable activity for a static 1 minute measurement of 210.11 dpm/100 cm<sup>2</sup>, 19.1% of the DCGL<sub>w</sub> and within the recommended 50% MDA:DCGL ratio.

Assuming a human performance efficiency of 50% and a scan rate of 5 inches/second, a scanning MDA of 3285 dpm/100cm<sup>2</sup> would be observed for the Ludlum Model 2360 with 43-93 probe (serial numbers 202409/221513). During the scan it is assumed that the radiological technician would pause for a period of 10 seconds above an area that exhibited elevated count rates. The scanning MDA during the pause period is calculated at 689 dpm/100cm<sup>2</sup>.

Scan and pause MDAs for the Ludlum Model 2360 with 43-93 probe (serial numbers 2024397/221514) were calculated as 1994 and 418 dpm/100cm<sup>2</sup> respectively. The MDA and scanning MDA equations are provided below:

$$MDA = \frac{3 + 3.29 \sqrt{RbTs \left( 1 + \frac{Ts}{Tb} \right)}}{E_{SRC} \times E_I \times Ts \times \frac{\text{Probe Area (cm}^2\text{)}}{100}}$$

Where: Rb = Background countrate  
Ts = Sample count time (1 minute)  
Tb = Background count time (1 minute)  
E<sub>I</sub> = Instrument efficiency  
E<sub>SRC</sub> = Source efficiency (25%) default value from NUREG 1507

$$MDA_{scan} = \frac{3.29 \times \left[ \sqrt{\frac{Rb \times i}{60}} \times \frac{60}{\sqrt{p}} \right] \times \frac{60}{i}}{E_I \times E_{SRC} \times E_S \times \frac{\text{Probe Area (cm}^2\text{)}}{100}}$$

Where: Rb = Background count rate (10.95 cpm)  
i = Observation interval during scan (0.44 seconds)  
p = Performance efficiency (50%)  
E<sub>I</sub> = Instrument efficiency (21.89%)  
E<sub>S</sub> = Surface efficiency (100%)  
E<sub>SRC</sub> = Source efficiency (25%) default value from NUREG 1507

Note: The MDA scan equation during the 10 second pause period is the same as above, where i = 10 seconds.

As mentioned above, scan surveys and swipe surveys were conducted during the final status surveys. While the results of these surveys were not compared against the DCGL<sub>w</sub>, the scan survey was utilized to identify the locations to conduct direct surveys and the swipe surveys for removable contamination were performed to verify the facility was free of removable contamination to support the assumption that the removable fraction of contamination was no more than 10% of the total contamination which was used when developing the DCGL<sub>w</sub>.

#### 2.6.4 Scan and Swipe Survey Measurement Results

Results of the survey unit scan surveys and swipe surveys for removable contamination are provided in the tables below:

Survey Unit 1										
ID	Type	Serial #	Cal. Due	probe area (cm <sup>2</sup> )	E <sub>I</sub>	Bkg count rate (cpm) Rb	Sample count time (min) Ts	Bkg count time (min) Tb	MDA <sup>(2)</sup> (dpm)	Units
1	Ludlum 3030 <sup>(1)</sup>	210766	7/18/13	N/A	1	10	1	1	8.0	/swipe
2	Ludlum 3030 <sup>(1)</sup>	210769	2/25/14	N/A	1	10	1	1	8.0	/swipe
3	Ludlum 2360	202397	10/9/13	100	0.3053	7.85	1	1	1994.5	/100cm <sup>2</sup>

Note 1: Ludlum 3030 displays count rate in dpm

Observation interval (i): 0.44 sec

Note 2: Scan MDA calculated in accordance with NUREG-1575

Surveyor Eff. (p): 0.5

Survey No.	Type (D, S, L)	Inst ID	Location or Item Description	Gross count rate (cpm)	Net count rate (cpm)	Activity (dpm)	Units
1	D	3	Random Scan on of stairs	20	12.15	318	/100cm <sup>2</sup>
2	S	1	Swipe on highest scan on stairs	12	2	2	/swipe
3	D	3	Random Scan on floor room 201	20	12.15	318	/100cm <sup>2</sup>
4	S	2	Swipe on highest scan 201 floor	5	-5	-5	/swipe

Survey Unit 2										
ID	Type	Serial #	Cal. Due	probe area (cm <sup>2</sup> )	E <sub>i</sub>	Bkg count rate (cpm) Rb	Sample count time (min) T <sub>s</sub>	Bkg count time (min) T <sub>b</sub>	MDA <sup>(2)</sup> (dpm)	Units
1	Ludlum 3030 <sup>(1)</sup>	210766	7/18/13	N/A	1	10	1	1	8.0	/swipe
2	Ludlum 3030 <sup>(1)</sup>	210769	2/25/14	N/A	1	10	1	1	8.0	/swipe
3	Ludlum 2360	202397	10/9/13	100	0.3053	7.85	1	1	1994.5	/100cm <sup>2</sup>

Note 1: Ludlum 3030 displays count rate in dpm  
Note 2: Scan MDA calculated in accordance with NUREG-1575

Observation interval (i): 0.44 sec  
Surveyor Eff. (p): 0.5

Survey No.	Type (D, S, L)	Inst ID	Location or Item Description	Gross count rate (cpm)	Net count rate (cpm)	Activity (dpm)	Units
1	D	3	Scan on 5% of floor room 101	22	14.15	371	/100cm2
2	S	1	Swipe floor (1/5) highest scan rm 101	15	5	5	/swipe
3	S	2	Swipe floor (2/5) highest scan rm 101	8	-2	-2	/swipe
4	S	1	Swipe floor (3/5) highest scan rm 101	7	-3	-3	/swipe
5	S	2	Swipe floor (4/5) highest scan rm 101	2	-8	-8	/swipe
6	S	1	Swipe floor (5/5) highest scan rm 101	12	2	2	/swipe
7	D	3	Scan on 5% of floor hallway 102	10	2.15	56	/100cm2
8	S	2	Swipe floor (1/5) highest scan hlwy 102	0	-10	-10	/swipe
9	S	1	Swipe floor (2/5) highest scan hlwy 102	12	2	2	/swipe
10	S	2	Swipe floor (3/5) highest scan hlwy 102	8	-2	-2	/swipe
11	S	1	Swipe floor (4/5) highest scan hlwy 102	20	10	10	/swipe
12	S	2	Swipe floor (5/5) highest scan hlwy 102	8	-2	-2	/swipe
13	D	3	Scan on 5% of floor rm 102B	18	10.15	266	/100cm2
14	S	1	Swipe floor (1/5) highest scan rm 102B	20	10	10	/swipe
15	S	2	Swipe floor (2/5) highest scan rm 102B	5	-5	-5	/swipe
16	S	1	Swipe floor (3/5) highest scan rm 102B	15	5	5	/swipe
17	S	2	Swipe floor (4/5) highest scan rm 102B	2	-8	-8	/swipe
18	S	1	Swipe floor (5/5) highest scan rm 102B	10	0	0	/swipe
19	D	3	Scan on 5% of floor rm 102C	8	0.15	4	/100cm2
20	S	2	Swipe floor (1/5) highest scan rm 102C	8	-2	-2	/swipe
21	S	1	Swipe floor (2/5) highest scan rm 102C	15	5	5	/swipe
22	S	2	Swipe floor (3/5) highest scan rm 102C	2	-8	-8	/swipe
23	S	1	Swipe floor (4/5) highest scan rm 102C	20	10	10	/swipe
24	S	2	Swipe floor (5/5) highest scan rm 102C	13	3	3	/swipe

Survey Unit 3										
ID	Type	Serial #	Cal. Due	probe area (cm <sup>2</sup> )	E <sub>f</sub>	Bkg count rate (cpm) Rb	Sample count time (min) Ts	Bkg count time (min) Tb	MDA <sup>(2)</sup> (dpm)	Units
1	Ludlum 3030 <sup>(1)</sup>	210766	7/18/13	N/A	1	10	1	1	8.0	/swipe
2	Ludlum 3030 <sup>(1)</sup>	210769	2/25/14	N/A	1	10	1	1	8.0	/swipe
3	Ludlum 2360	202409	9/4/13	100	0.2189	10.95	1	1	3285.3	/100cm <sup>2</sup>

Note 1: Ludlum 3030 displays count rate in dpm

Observation interval (i): 0.44 sec

Note 2: Scan MDA calculated in accordance with NUREG-1575

Surveyor Eff. (p): 0.5

Survey No.	Type (D, S, L)	Inst ID	Location or Item Description	Gross count rate (cpm)	Net count rate (cpm)	Activity (dpm)	Units
1	D	4	Scan on 5% of floor room 301	20	9.05	331	/100cm <sup>2</sup>
2	S	1	Swipe floor (1/5) highest scan rm 301	17	10	10	/swipe
3	S	2	Swipe floor (2/5) highest scan rm 301	5	0	0	/swipe
4	S	1	Swipe floor (3/5) highest scan rm 301	7	0	0	/swipe
5	S	2	Swipe floor (4/5) highest scan rm 301	5	0	0	/swipe
6	S	1	Swipe floor (5/5) highest scan rm 301	5	-2	-2	/swipe
7	D	4	Scan on 5% of floor room 302	20	9.05	331	/100cm <sup>2</sup>
8	S	2	Swipe floor (1/5) highest scan rm 302	0	-5	-5	/swipe
9	S	1	Swipe floor (2/5) highest scan rm 302	7	0	0	/swipe
10	S	2	Swipe floor (2/5) highest scan rm 302	5	0	0	/swipe
11	S	1	Swipe floor (4/5) highest scan rm 302	5	-2	-2	/swipe
12	S	2	Swipe floor (5/5) highest scan rm 302	2	-3	-3	/swipe

Survey Unit 4										
ID	Type	Serial #	Cal. Due	probe area (cm <sup>2</sup> )	E <sub>i</sub>	Bkg count rate (cpm) Rb	Sample count time (min) T <sub>s</sub>	Bkg count time (min) T <sub>b</sub>	MDA <sup>(2)</sup> (dpm)	Units
1	Ludlum 3030 <sup>(1)</sup>	210766	7/18/13	N/A	1	10	1	1	8.0	/swipe
2	Ludlum 3030 <sup>(1)</sup>	210769	2/25/14	N/A	1	10	1	1	8.0	/swipe
3	Ludlum 2360	202409	9/4/13	100	0.2189	10.95	1	1	3285.3	/100cm <sup>2</sup>

Note 1: Ludlum 3030 displays count rate in dpm  
Note 2: Scan MDA calculated in accordance with NUREG-1575

Observation interval (i): 0.44 sec  
Surveyor Eff. (p): 0.5

Survey No.	Type (D, S, L)	Inst ID	Location or Item Description	Gross count rate (cpm)	Net count rate (cpm)	Activity (dpm)	Units
1	D	4	Scan on 5% of floor mezzanine 401	25	14.05	513	/100cm <sup>2</sup>
2	S	1	Swipe floor (1/5) highest scan mezz 401	12	5	5	/swipe
3	S	2	Swipe floor (2/5) highest scan mezz 401	8	3	3	/swipe
4	S	1	Swipe floor (3/5) highest scan mezz 401	15	8	8	/swipe
5	S	2	Swipe floor (4/5) highest scan mezz 401	5	0	0	/swipe
6	S	1	Swipe floor (5/5) highest scan mezz 401	12	5	5	/swipe
7	D	4	Scan on 5% of floor mezzanine 402	30	19.05	696	/100cm <sup>2</sup>
8	S	1	Swipe floor (1/5) highest scan mezz 402	17	10	10	/swipe
9	S	2	Swipe floor (2/5) highest scan mezz 402	5	0	0	/swipe
10	S	1	Swipe floor (3/5) highest scan mezz 402	10	3	3	/swipe
11	S	2	Swipe floor (4/5) highest scan mezz 402	5	0	0	/swipe
12	S	1	Swipe floor (5/5) highest scan mezz 402	10	3	3	/swipe

Survey Unit 5										
ID	Type	Serial #	Cal. Due	probe area (cm <sup>2</sup> )	E <sub>i</sub>	Bkg count rate (cpm) Rb	Sample count time (min) T <sub>s</sub>	Bkg count time (min) T <sub>b</sub>	MDA <sup>(2)</sup> (dpm)	Units
1	Ludlum 3030 <sup>(1)</sup>	210766	7/18/13	N/A	1	10	1	1	8.0	/swipe
2	Ludlum 3030 <sup>(1)</sup>	210769	2/25/14	N/A	1	10	1	1	8.0	/swipe
3	Ludlum 2360	202409	9/4/13	100	0.2189	10.95	1	1	3285.3	/100cm <sup>2</sup>

Note 1: Ludlum 3030 displays count rate in dpm  
Note 2: Scan MDA calculated in accordance with NUREG-1575

Observation interval (i): 0.44 sec  
Surveyor Eff. (p): 0.5

Survey No.	Type (D, S, L)	Inst ID	Location or Item Description	Gross count rate (cpm)	Net count rate (cpm)	Activity (dpm)	Units
1	D	4	Scan 5% of high traffic SE Process floor	25	14.05	513	/100cm <sup>2</sup>
2	D	4	Random Scan remainder SE Process floor	20	9.05	331	/100cm <sup>2</sup>
3	S	1	Swipe floor (1/5) highest scan SE floor	10	3	3	/swipe
4	S	2	Swipe floor (2/5) highest scan SE floor	5	0	0	/swipe
5	S	1	Swipe floor (3/5) highest scan SE floor	7	0	0	/swipe
6	S	2	Swipe floor (4/5) highest scan SE floor	5	0	0	/swipe
7	S	1	Swipe floor (5/5) highest scan SE floor	17	10	10	/swipe
8	D	4	Scan 5% of high traffic SW Process floor	25	14.05	513	/100cm <sup>2</sup>
9	D	4	Random Scan remainder SW Process floor	25	14.05	513	/100cm <sup>2</sup>
10	S	2	Swipe floor (1/5) highest scan SW floor	2	-3	-3	/swipe

Survey Unit 6										
ID	Type	Serial #	Cal. Due	probe area (cm <sup>2</sup> )	E <sub>i</sub>	Bkg count rate (cpm) Rb	Sample count time (min) Ts	Bkg count time (min) Tb	MDA <sup>(2)</sup> (dpm)	Units
1	Ludlum 3030 <sup>(1)</sup>	210766	7/18/13	N/A	1	10	1	1	8.0	/swipe
2	Ludlum 3030 <sup>(1)</sup>	210769	2/25/14	N/A	1	10	1	1	8.0	/swipe
3	Ludlum 2360	202409	9/4/13	100	0.2189	10.95	1	1	3285.3	/100cm <sup>2</sup>

Note 1: Ludlum 3030 displays count rate in dpm  
Note 2: Scan MDA calculated in accordance with NUREG-1575

Observation interval (i): 0.44 sec  
Surveyor Eff. (p): 0.5

Survey No.	Type (D, S, L)	Inst ID	Location or Item Description	Gross count rate (cpm)	Net count rate (cpm)	Activity (dpm)	Units
1	D	3	Scan 5% of high traffic NE Process floor	30	19.05	696	/100cm <sup>2</sup>
2	D	3	Random Scan remainder NE Process floor	20	9.05	331	/100cm <sup>2</sup>
3	S	1	Swipe floor (1/5) highest scan NE floor	11	4	4	/swipe
4	S	2	Swipe floor (2/5) highest scan NE floor	0	-5	-5	/swipe
5	S	1	Swipe floor (3/5) highest scan NE floor	15	8	8	/swipe
6	S	2	Swipe floor (4/5) highest scan NE floor	10	5	5	/swipe
7	S	1	Swipe floor (5/5) highest scan NE floor	10	3	3	/swipe
8	D	3	Scan 5% of high traffic NW Process floor	25	14.05	513	/100cm <sup>2</sup>
9	D	3	Random Scan remainder NW Process floor	25	14.05	513	/100cm <sup>2</sup>
10	S	2	Swipe floor (1/5) highest scan NW floor	5	0	0	/swipe



Survey Unit 7										
ID	Type	Serial #	Cal. Due	probe area (cm <sup>2</sup> )	E <sub>i</sub>	Bkg count rate (cpm) Rb	Sample count time (min) Ts	Bkg count time (min) Tb	MDA <sup>(2)</sup> (dpm)	Units
1	Ludlum 3030 <sup>(1)</sup>	210766	7/18/13	N/A	1	10	1	1	8.0	/swipe
2	Ludlum 3030 <sup>(1)</sup>	210769	2/25/14	N/A	1	10	1	1	8.0	/swipe
3	Ludlum 2360	202409	9/4/13	100	0.2189	10.95	1	1	3285.3	/100cm <sup>2</sup>

Note 1: Ludlum 3030 displays count rate in dpm

Observation interval (i): 0.44 sec

Note 2: Scan MDA calculated in accordance with NUREG-1575

Surveyor Eff. (p): 0.5

Survey No.	Type (D, S, L)	Inst ID	Location or Item Description	Gross count rate (cpm)	Net count rate (cpm)	Activity (dpm)	Units
1	D	4	304 floor scan 25% of sector 1	20	9.05	331	/100cm <sup>2</sup>
2	D	4	304 floor scan 25% of sector 2	20	9.05	331	/100cm <sup>2</sup>
3	D	4	304 floor scan 25% of sector 3	10	-0.95	-35	/100cm <sup>2</sup>
4	D	4	304 floor scan 25% of sector 4	10	-0.95	-35	/100cm <sup>2</sup>
5	D	4	304 floor scan 25% of sector 5	10	-0.95	-35	/100cm <sup>2</sup>
6	D	4	304 floor scan 25% of sector 6	30	19.05	696	/100cm <sup>2</sup>
7	D	4	304 floor scan 25% of sector 7	10	-0.95	-35	/100cm <sup>2</sup>
8	D	4	304 floor scan 25% of sector 8	10	-0.95	-35	/100cm <sup>2</sup>
9	D	4	304 floor scan 25% of sector 9	10	-0.95	-35	/100cm <sup>2</sup>
10	D	4	304 floor scan 25% of sector 10	10	-0.95	-35	/100cm <sup>2</sup>
11	D	4	304 floor scan 25% of sector 11	10	-0.95	-35	/100cm <sup>2</sup>
12	D	4	304 floor scan 25% of sector 12	10	-0.95	-35	/100cm <sup>2</sup>
13	D	4	304 floor scan 25% of sector 13	10	-0.95	-35	/100cm <sup>2</sup>
14	D	4	304 floor scan 25% of sector 14	20	9.05	331	/100cm <sup>2</sup>
15	D	4	304 floor scan 25% of sector 15	10	-0.95	-35	/100cm <sup>2</sup>
16	S	1	Swipe floor highest scan sector 6	10	-2	-2	/swipe
17	S	2	Swipe floor highest scan sector 1	7	2	2	/swipe
18	S	1	Swipe floor highest scan sector 2	0	-12	-12	/swipe
19	S	2	Swipe floor highest scan sector 14	7	2	2	/swipe
20	S	1	Swipe floor highest scan sector 5	10	-2	-2	/swipe
21	S	2	Swipe floor highest scan sector 12	12	7	7	/swipe
22	S	1	Swipe floor highest scan sector 11	2	-10	-10	/swipe
23	S	2	Swipe floor highest scan sector 8	7	2	2	/swipe
24	S	1	Swipe floor highest scan sector 4	2	-10	-10	/swipe
25	S	2	Swipe floor highest scan sector 10	0	-5	-5	/swipe
26	D	4	Scan on 5% of N. wall up to 8 ft.	20	9.05	331	/100cm <sup>2</sup>
27	D	4	Scan on 5% of E. wall up to 8 ft.	10	-0.95	-35	/100cm <sup>2</sup>
28	D	4	Scan on 5% of S. wall up to 8 ft.	20	9.05	331	/100cm <sup>2</sup>
29	D	4	Scan on 5% of W. wall up to 8 ft.	20	9.05	331	/100cm <sup>2</sup>
30	D	4	Scan ceiling 6 inch width around duct opening	10	-0.95	-35	/100cm <sup>2</sup>
31	S	1	Swipe highest scan around duct opening	2	-10	-10	/swipe

Survey Unit 8										
ID	Type	Serial #	Cal. Due	probe area (cm <sup>2</sup> )	E <sub>I</sub>	Bkg count rate (cpm) Rb	Sample count time (min) T <sub>s</sub>	Bkg count time (min) T <sub>b</sub>	MDA <sup>(2)</sup> (dpm)	Units
1	Ludlum 3030 <sup>(1)</sup>	210766	7/18/13	N/A	1	10	1	1	8.0	/swipe
2	Ludlum 3030 <sup>(1)</sup>	210769	2/25/14	N/A	1	10	1	1	8.0	/swipe
3	Ludlum 2360	202409	9/4/13	100	0.2189	10.95	1	1	3285.3	/100cm <sup>2</sup>

Note 1: Ludlum 3030 displays count rate in dpm

Observation interval (i): 0.44 sec

Note 2: Scan MDA calculated in accordance with NUREG-1575

Surveyor Eff. (p): 0.5

Survey No.	Type (D, S, L)	Inst ID	Location or Item Description	Gross count rate (cpm)	Net count rate (cpm)	Activity (dpm)	Units
1	D	4	303 floor scan 25% of sector 1	10	-0.95	-35	/100cm <sup>2</sup>
2	D	4	303 floor scan 25% of sector 2	10	-0.95	-35	/100cm <sup>2</sup>
3	D	4	303 floor scan 25% of sector 3	10	-0.95	-35	/100cm <sup>2</sup>
4	D	4	303 floor scan 25% of sector 4	20	9.05	331	/100cm <sup>2</sup>
5	D	4	303 floor scan 25% of sector 5	20	9.05	331	/100cm <sup>2</sup>
6	D	4	303 floor scan 25% of sector 6	10	-0.95	-35	/100cm <sup>2</sup>
7	S	1	Swipe floor highest scan sector 4	5	-7	-7	/swipe
8	S	2	Swipe floor highest scan sector 5	2	-3	-3	/swipe
9	S	1	Swipe floor highest scan sector 1	12	0	0	/swipe
10	S	2	Swipe floor highest scan sector 2	8	3	3	/swipe
11	S	1	Swipe floor highest scan sector 3	5	-7	-7	/swipe
12	D	4	Scan on 5% of N. wall up to 8 ft.	10	-0.95	-35	/100cm <sup>2</sup>
13	D	4	Scan on 5% of E. wall up to 8 ft.	20	9.05	331	/100cm <sup>2</sup>
14	D	4	Scan on 5% of S. wall up to 8 ft.	10	-0.95	-35	/100cm <sup>2</sup>
15	D	4	Scan on 5% of W. wall up to 8 ft.	10	-0.95	-35	/100cm <sup>2</sup>

## 2.6.5 Direct Survey Measurement Results

Direct surveys were conducted at the areas of the highest scan. The gross activity, as well as the maximum, average and minimum activities were compared against the DCGL<sub>w</sub>.

The maximum, average and minimum net activities were calculated as follows:

Maximum net activity = Gross activity – Minimum reference area background

Average net activity = Gross activity – Average reference area background

Minimum net activity = Gross activity – Maximum reference area background

Activity (dpm/100cm <sup>2</sup> )	Survey Unit					
	1&2	3	4	5&6	7	8
Maximum Gross Activity:	209.6	420.3	475.1	471.7	511.6	402.0
Average Gross Activity:	112.0	263.1	338.1	278.2	254.1	257.9
Maximum Net Activity:	81.7	292.4	347.2	343.8	383.7	274.1

No single gross activity measurement exceeded the Derived Concentration Guideline Level (DCGL<sub>w</sub>) of 1100 dpm/100 cm<sup>2</sup>. Based on the direct survey measurements the conclusion the survey unit meets the release criterion made.

While the survey measurement results indicate that the residual radioactivity is below the DCGL<sub>w</sub>, statistical tests on the data were conducted to confirm that the number of sampling points and measurement sensitivity is adequate. Section 3 provides the statistical analysis of the survey units.

# I<sup>3</sup> RADIOLOGICAL SURVEY REPORT

## Contamination Survey Instrument Data

ID	Type	Serial #	Cal. Due	probe area (cm <sup>2</sup> )	2 $\pi$ Eff	Background count rate (cpm)	MDA (dpm/100cm <sup>2</sup> )
3	Ludlum 2360	202397	10/9/2013	100	0.3053	7.85	210.1
4	Ludlum 2360	202409	9/4/2013	100	0.2189	10.95	336.2

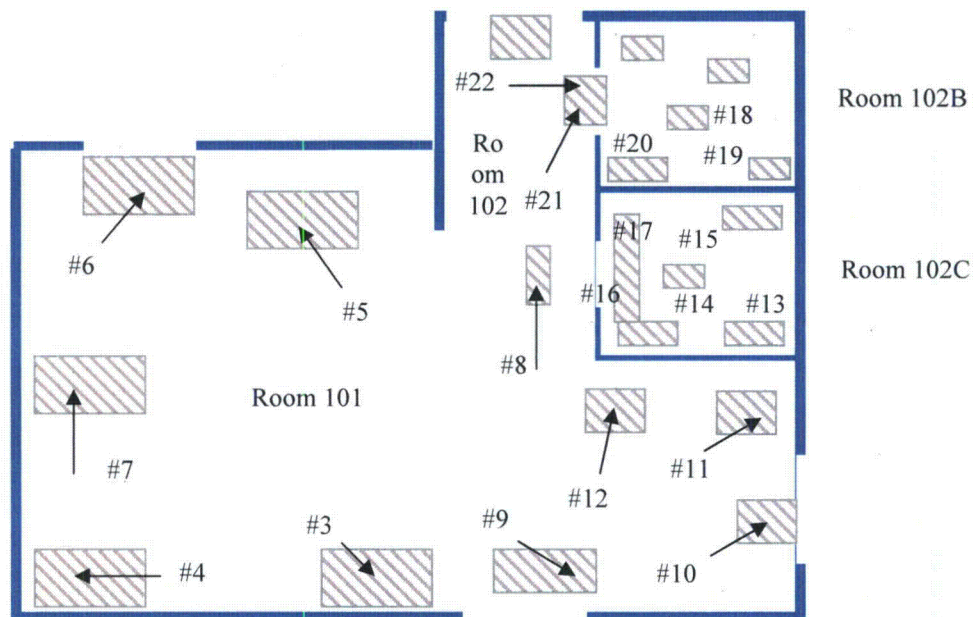
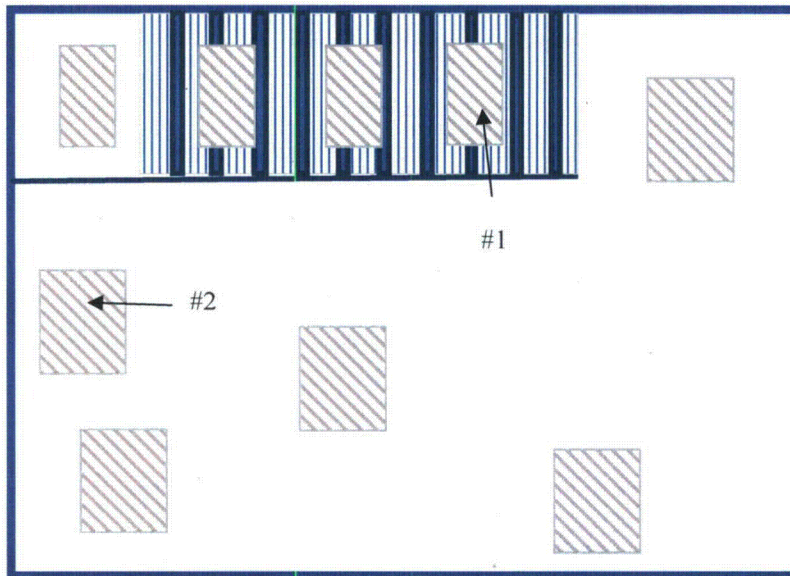
Eff<sub>source</sub>: 0.25


## Survey Units 1 & 2 – Class 3 Area (126.2 m<sup>2</sup>)

Survey No.	Type (D, S, L)	Inst. ID	Location or Item Description	Gross count rate (cpm/100 cm <sup>2</sup> )	Gross Activity (dpm/100cm <sup>2</sup> )
1	D	3	Direct Survey on highest scan on stairs	8	104.8
2	D	3	Direct Survey highest scan 201 floor	15	196.5
3	D	3	Direct Survey (1/5) highest scan rm 101	5	65.5
4	D	3	Direct Survey (2/5) highest scan rm 101	8	104.8
5	D	3	Direct Survey (3/5) highest scan rm 101	6	78.6
6	D	3	Direct Survey (4/5) highest scan rm 101	12	157.2
7	D	3	Direct Survey (5/5) highest scan rm 101	11	144.1
8	D	3	Direct Survey (1/5) highest scan hlwy 102	16	209.6
9	D	3	Direct Survey (2/5) highest scan hlwy 102	13	170.3
10	D	3	Direct Survey (3/5) highest scan hlwy 102	9	117.9
11	D	3	Direct Survey (4/5) highest scan hlwy 102	8	104.8
12	D	3	Direct Survey (5/5) highest scan hlwy 102	9	117.9
13	D	3	Direct Survey (1/5) highest scan rm 102B	9	117.9
14	D	3	Direct Survey (2/5) highest scan rm 102B	7	91.7
15	D	3	Direct Survey (3/5) highest scan rm 102B	6	78.6
16	D	3	Direct Survey (4/5) highest scan rm 102B	8	104.8
17	D	3	Direct Survey (5/5) highest scan rm 102B	7	91.7
18	D	3	Direct Survey (1/5) highest scan rm 102C	2	26.2
19	D	3	Direct Survey (2/5) highest scan rm 102C	9	117.9
20	D	3	Direct Survey (3/5) highest scan rm 102C	6	78.6
21	D	3	Direct Survey (4/5) highest scan rm 102C	7	91.7
22	D	3	Direct Survey (5/5) highest scan rm 102C	7	91.7

### Survey Unit #1 and #2 Direct Survey Measurement Map

Room 201



 = Scan Minimum 5% scan of each floor section

Direct survey measurements (# 1- #22) obtained at the highest scan locations.

Swipe survey performed at each direct survey measurement location.

Highest Scan measurements and swipe survey results provided in Section 2.6.4.

# I<sup>3</sup> RADIOLOGICAL SURVEY REPORT

## Contamination Survey Instrument Data

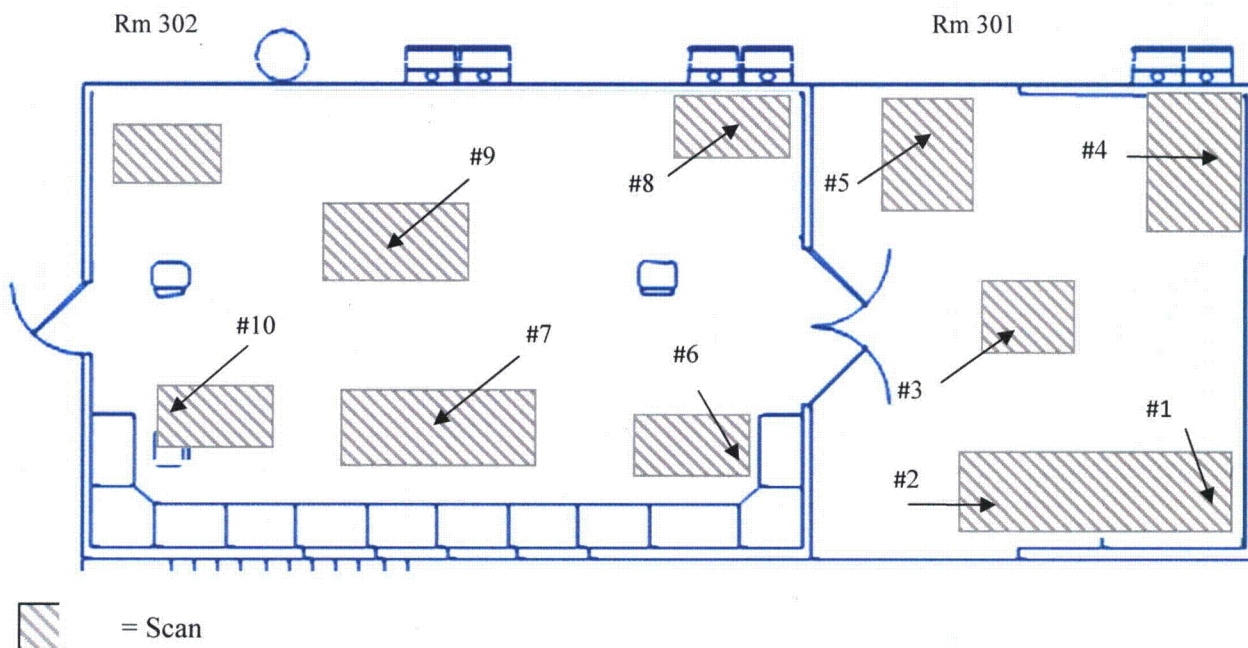
ID	Type	Serial #	Cal. Due	probe area (cm <sup>2</sup> )	2 $\pi$ Eff	Background count rate (cpm)	MDA (dpm/100cm <sup>2</sup> )
3	Ludlum 2360	202397	10/9/2013	100	0.3053	7.85	210.1
4	Ludlum 2360	202409	9/4/2013	100	0.2189	10.95	336.2

Eff<sub>source</sub>: 0.25

## Survey Unit 3 – Class 3 Area (80.9 m<sup>2</sup>)

Survey No.	Type (D, S, L)	Inst. ID	Location or Item Description	Gross count rate (cpm/100 cm <sup>2</sup> )	Gross Activity (dpm/100cm <sup>2</sup> )
1	D	4	Direct Survey (1/5) highest scan rm 301	23	420.3
2	D	4	Direct Survey (2/5) highest scan rm 301	22	402.0
3	D	4	Direct Survey (3/5) highest scan rm 301	17	310.6
4	D	4	Direct Survey (4/5) highest scan rm 301	11	201.0
5	D	4	Direct Survey (5/5) highest scan rm 301	12	219.3
6	D	4	Direct Survey (1/5) highest scan rm 302	12	219.3
7	D	4	Direct Survey (2/5) highest scan rm 302	8	146.2
8	D	4	Direct Survey (3/5) highest scan rm 302	13	237.6
9	D	4	Direct Survey (4/5) highest scan rm 302	14	255.8
10	D	4	Direct Survey (5/5) highest scan rm 302	12	219.3

## Survey Unit #3 Rooms 301 & 302 Direct Survey Measurement Map



Minimum 5% scan of Rooms 301 & 302

Direct survey measurements (#1- #10) obtained at the 5 highest scan locations in each room.

Swipe survey performed at each direct survey measurement location.

Highest Scan measurements and swipe survey results provided in Section 2.6.4.



# **I<sup>3</sup> RADIOLOGICAL SURVEY REPORT**

## **Contamination Survey Instrument Data**

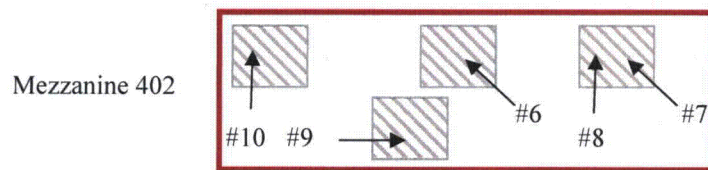
ID	Type	Serial #	Cal. Due	probe area (cm <sup>2</sup> )	2 $\pi$ Eff	Background count rate (cpm)	MDA (dpm/100cm <sup>2</sup> )
3	Ludlum 2360	202397	10/9/2013	100	0.3053	7.85	210.1
4	Ludlum 2360	202409	9/4/2013	100	0.2189	10.95	336.2

Eff<sub>source</sub>: 0.25

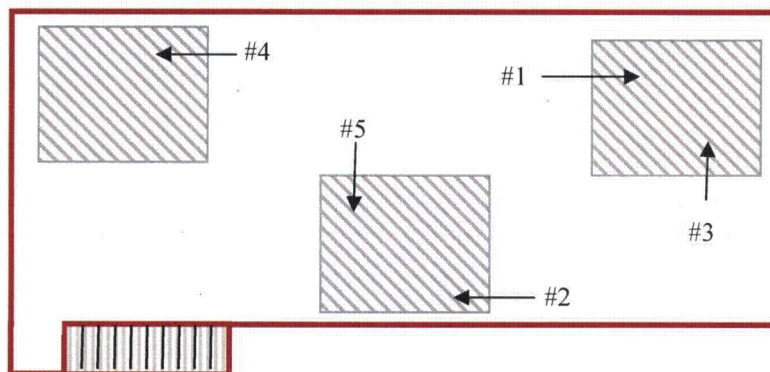
## **Survey Unit 4 – Class 3 Area (130.2 m<sup>2</sup>)**


Survey No.	Type (D, S, L)	Inst. ID	Location or Item Description	Gross count rate (cpm/100 cm <sup>2</sup> )	Gross Activity (dpm/100cm <sup>2</sup> )
1	D	4	Direct Survey (1/5) highest scan mezz 401	13	237.6
2	D	4	Direct Survey (2/5) highest scan mezz 401	15	274.1
3	D	4	Direct Survey (3/5) highest scan mezz 401	11	201.0
4	D	4	Direct Survey (4/5) highest scan mezz 401	25	456.8
5	D	4	Direct Survey (5/5) highest scan mezz 401	16	292.4
6	D	4	Direct Survey (1/5) highest scan mezz 402	17	310.6
7	D	4	Direct Survey (2/5) highest scan mezz 402	21	383.7
8	D	4	Direct Survey (3/5) highest scan mezz 402	26	475.1
9	D	4	Direct Survey (4/5) highest scan mezz 402	21	383.7
10	D	4	Direct Survey (5/5) highest scan mezz 402	20	365.5

### Survey Unit #4 Direct Survey Measurement Map



Mezzanine 401



 = Scan

Minimum 5% scan of each floor section

Direct survey measurements (# 1- #10) obtained at the highest scan locations.

Swipe survey performed at each direct survey measurement location.

Highest Scan measurements and swipe survey results provided in Section 2.6.4.



# I<sup>3</sup> RADIOLOGICAL SURVEY REPORT

## Contamination Survey Instrument Data

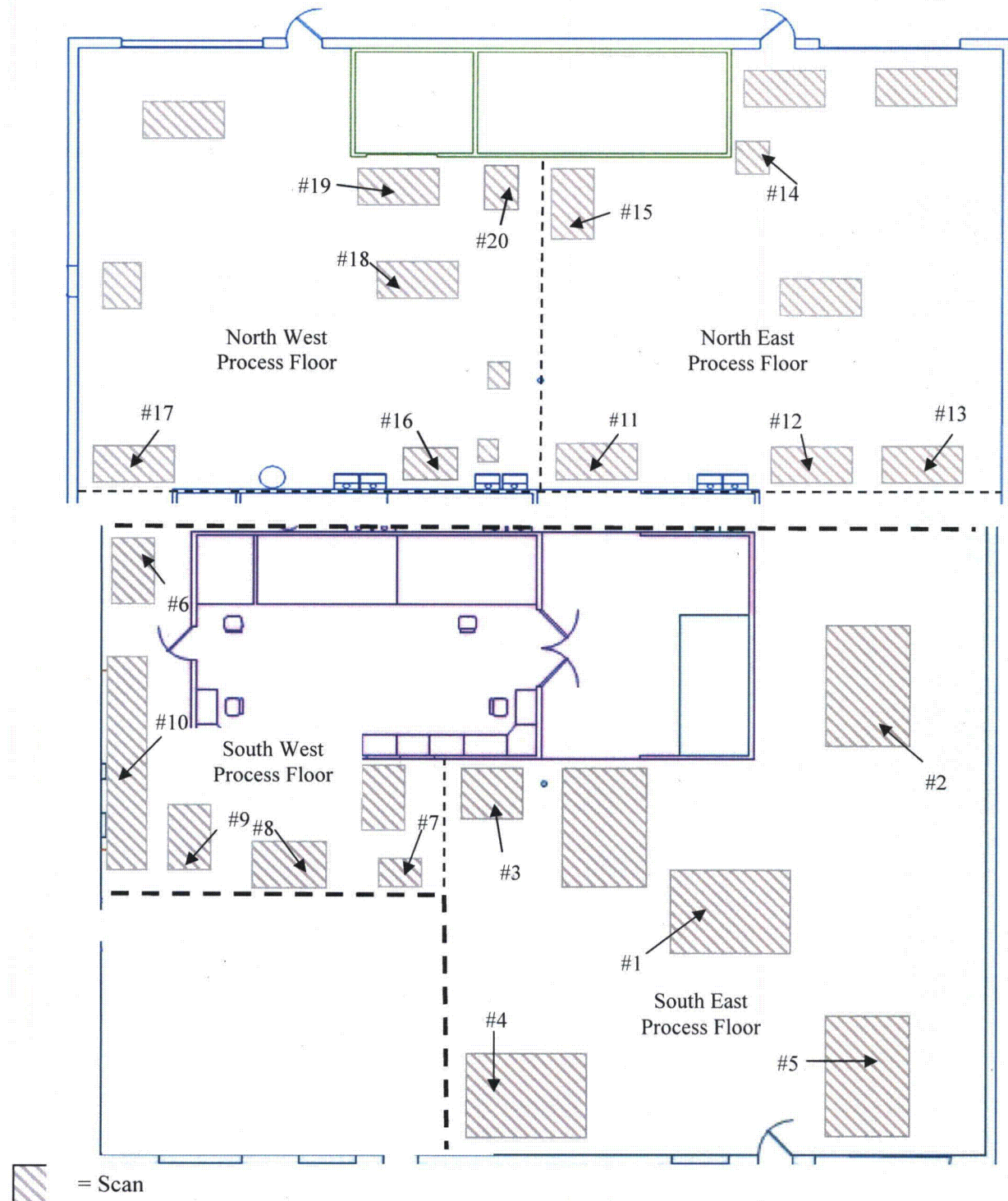
ID	Type	Serial #	Cal. Due	probe area (cm <sup>2</sup> )	2 $\pi$ Eff	Background count rate (cpm)	MDA (dpm/100cm <sup>2</sup> )
3	Ludlum 2360	202397	10/9/2013	100	0.3053	7.85	210.1
4	Ludlum 2360	202409	9/4/2013	100	0.2189	10.95	336.2

Eff<sub>source</sub>: 0.25

## Survey Units 5 & 6 – Class 3 Area (622.6 m<sup>2</sup>)

Survey No.	Type (D, S, L)	Inst. ID	Location or Item Description	Gross count rate (cpm/100 cm <sup>2</sup> )	Gross Activity (dpm/100cm <sup>2</sup> )
1	D	4	Direct Survey (1/5) highest scan SE floor	14	255.82
2	D	4	Direct Survey (2/5) highest scan SE floor	5	91.37
3	D	4	Direct Survey (3/5) highest scan SE floor	15	274.10
4	D	4	Direct Survey (4/5) highest scan SE floor	13	237.55
5	D	4	Direct Survey (5/5) highest scan SE floor	12	219.28
6	D	4	Direct Survey (1/5) highest scan SW floor	22	402.01
7	D	4	Direct Survey (2/5) highest scan SW floor	17	310.64
8	D	4	Direct Survey (3/5) highest scan SW floor	22	402.01
9	D	4	Direct Survey (4/5) highest scan SW floor	17	310.64
10	D	4	Direct Survey (5/5) highest scan SW floor	17	310.64
11	D	3	Direct Survey (1/5) highest scan NE floor	7	91.71
12	D	3	Direct Survey (2/5) highest scan NE floor	17	222.73
13	D	3	Direct Survey (3/5) highest scan NE floor	15	196.53
14	D	3	Direct Survey (4/5) highest scan NE floor	6	78.61
15	D	3	Direct Survey (5/5) highest scan NE floor	36	471.67
16	D	3	Direct Survey (1/5) highest scan NW floor	8	104.81
17	D	3	Direct Survey (2/5) highest scan NW floor	11	144.12
18	D	3	Direct Survey (3/5) highest scan NW floor	9	117.92
19	D	3	Direct Survey (4/5) highest scan NW floor	8	104.81
20	D	3	Direct Survey (5/5) highest scan NW floor	24	314.44

### Survey Unit #5 and #6 Direct Survey Measurement Map



Minimum 5% scan of each floor section

Direct survey measurements (# 1- #20) obtained at the highest scan locations.

Swipe survey performed at each direct survey measurement location.

Highest Scan measurements and swipe survey results provided in Section 2.6.4.

# I<sup>3</sup> RADIOLOGICAL SURVEY REPORT

## Contamination Survey Instrument Data

ID	Type	Serial #	Cal. Due	probe area (cm <sup>2</sup> )	2 $\pi$ Eff	Background count rate (cpm)	MDA (dpm/100cm <sup>2</sup> )
3	Ludlum 2360	202397	10/9/2013	100	0.3053	7.85	210.1
4	Ludlum 2360	202409	9/4/2013	100	0.2189	10.95	336.2

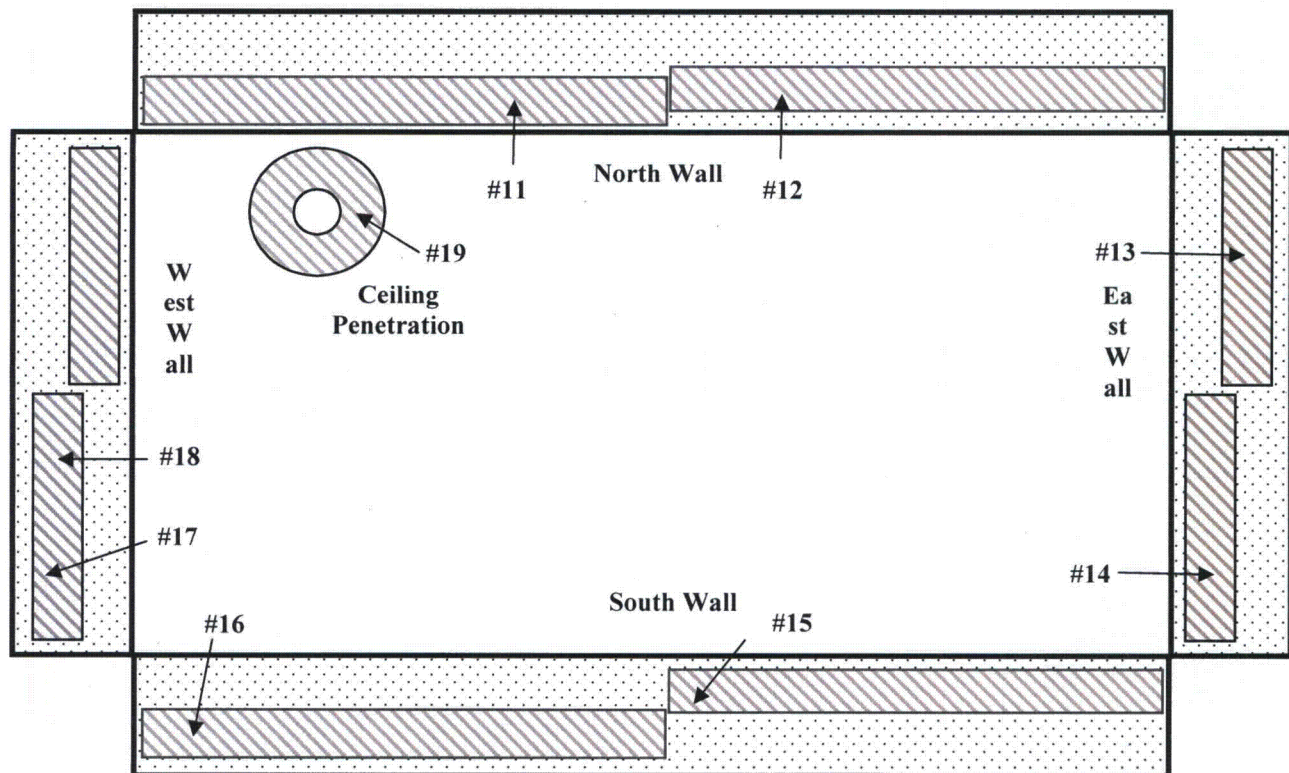
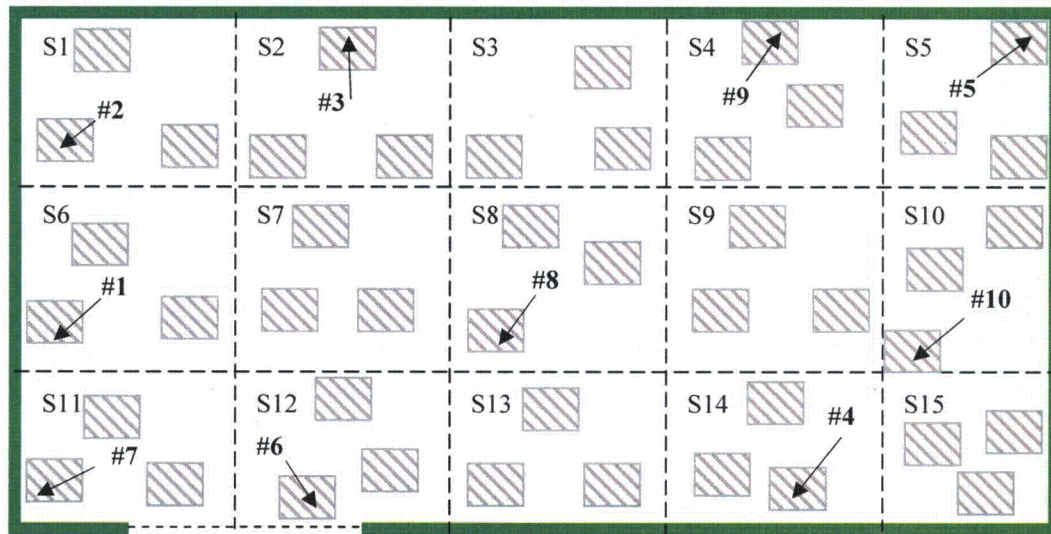
Eff<sub>source</sub>: 0.25


## Survey Unit 7– Class 2 Area (21.4 m<sup>2</sup>)

Survey No.	Type (D, S, L)	Inst. ID	Location or Item Description	Gross count rate (cpm/100 cm <sup>2</sup> )	Gross Activity (dpm/100cm <sup>2</sup> )
1	D	4	Direct Survey highest floor scan sector 6	28	511.65
2	D	4	Direct Survey highest floor scan sector 1	19	347.19
3	D	4	Direct Survey highest floor scan sector 2	15	274.10
4	D	4	Direct Survey highest floor scan sector 14	15	274.10
5	D	4	Direct Survey highest floor scan sector 5	19	347.19
6	D	4	Direct Survey highest floor scan sector 12	15	274.10
7	D	4	Direct Survey highest floor scan sector 11	21	383.74
8	D	4	Direct Survey highest floor scan sector 8	7	127.91
9	D	4	Direct Survey highest floor scan sector 4	19	347.19
10	D	4	Direct Survey highest floor scan sector 10	6	109.64
11	D	4	Direct Survey (1/2) highest scan N. wall	5	91.37
12	D	4	Direct Survey (2/2) highest scan N. wall	17	310.64
13	D	4	Direct Survey (1/2) highest scan E. wall	12	219.28
14	D	4	Direct Survey (2/2) highest scan E. wall	12	219.28
15	D	4	Direct Survey (1/2) highest scan S. wall	11	201.01
16	D	4	Direct Survey (2/2) highest scan S. wall	11	201.01
17	D	4	Direct Survey (1/2) highest scan W. wall	18	328.92
18	D	4	Direct Survey (2/2) highest scan W. wall	13	237.55
19	D	4	Direct Survey highest scan of duct opening	5	91.37



Survey Unit #7 Room 304 Direct Survey Measurement Map



 = Scan

Minimum 25% scan of each floor sector (S1 – S15), minimum 5% scan of each wall up to 8 feet, 100% scan 6 inch width around ceiling penetration.

Direct survey measurements (#11-#18) obtained at the 2 highest scan locations on each wall.

Direct survey measurement #19 obtained at the highest scan location around ceiling penetration.

Swipe survey performed at each direct survey measurement location.

Highest Scan measurements and swipe survey results provided in Section 2.6.4.

## I<sup>3</sup> RADIOLOGICAL SURVEY REPORT

### Contamination Survey Instrument Data

ID	Type	Serial #	Cal. Due	probe area (cm <sup>2</sup> )	2 $\pi$ Eff	Background count rate (cpm)	MDA (dpm/100cm <sup>2</sup> )
3	Ludlum 2360	202397	10/9/2013	100	0.3053	7.85	210.1
4	Ludlum 2360	202409	9/4/2013	100	0.2189	10.95	336.2

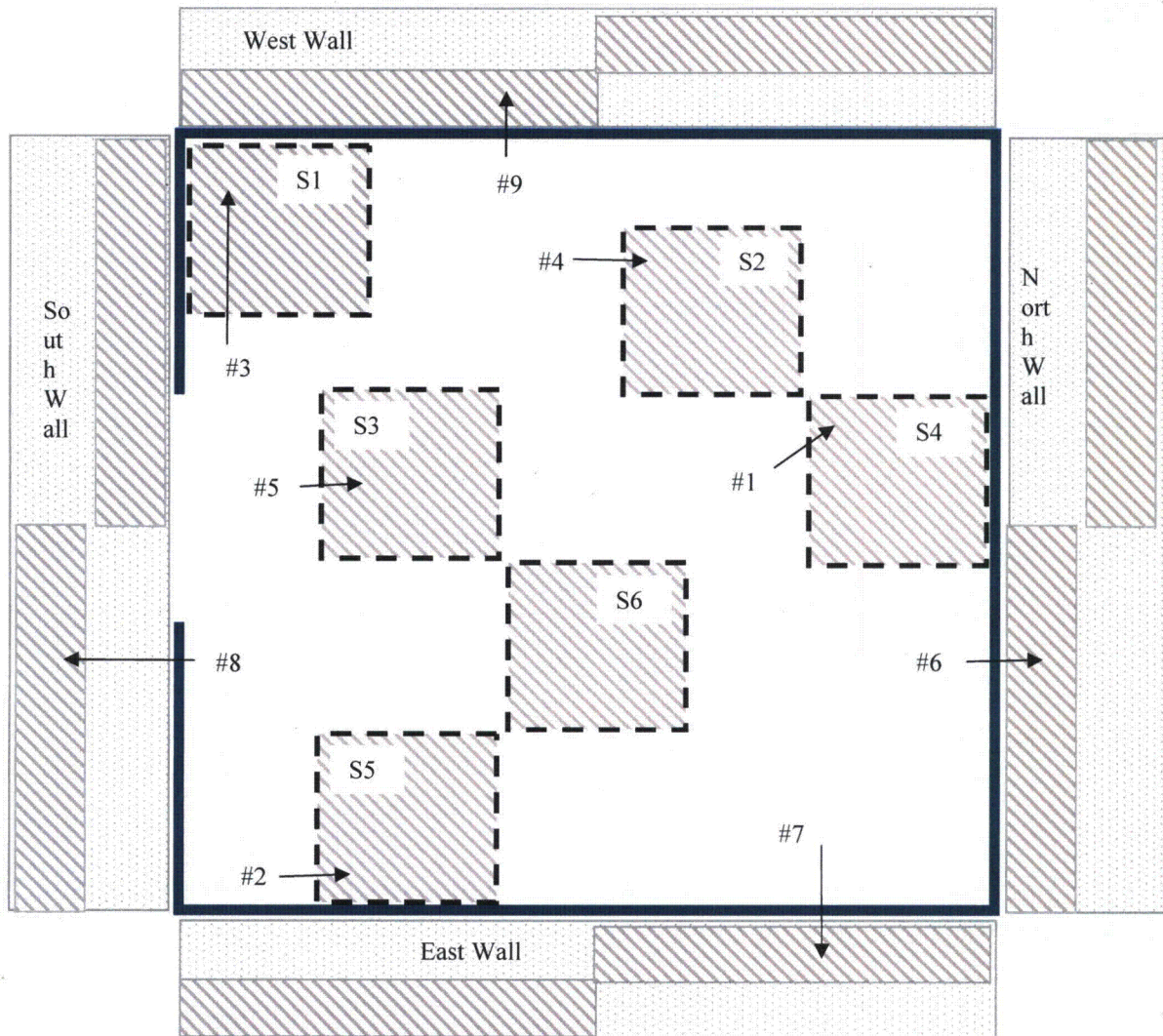
Eff<sub>source</sub>: 0.25


### Survey Unit 8 – Class 2 Area (9.7 m<sup>2</sup>)

Survey No.	Type (D, S, L)	Inst. ID	Location or Item Description	Gross count rate (cpm/100 cm <sup>2</sup> )	Gross Activity (dpm/100cm <sup>2</sup> )
1	D	4	Direct Survey highest floor scan sector 4	12	219.28
2	D	4	Direct Survey highest floor scan sector 5	17	310.64
3	D	4	Direct Survey highest floor scan sector 1	14	255.82
4	D	4	Direct Survey highest floor scan sector 2	16	292.37
5	D	4	Direct Survey highest floor scan sector 3	15	274.10
6	D	4	Direct Survey highest scan N. wall	10	182.73
7	D	4	Direct Survey highest scan E. wall	22	402.01
8	D	4	Direct Survey highest scan S. wall	10	182.73
9	D	4	Direct Survey highest scan W. wall	11	201.01



### Survey Unit #8 Room 303 Direct Survey Measurement Map



 = Scan

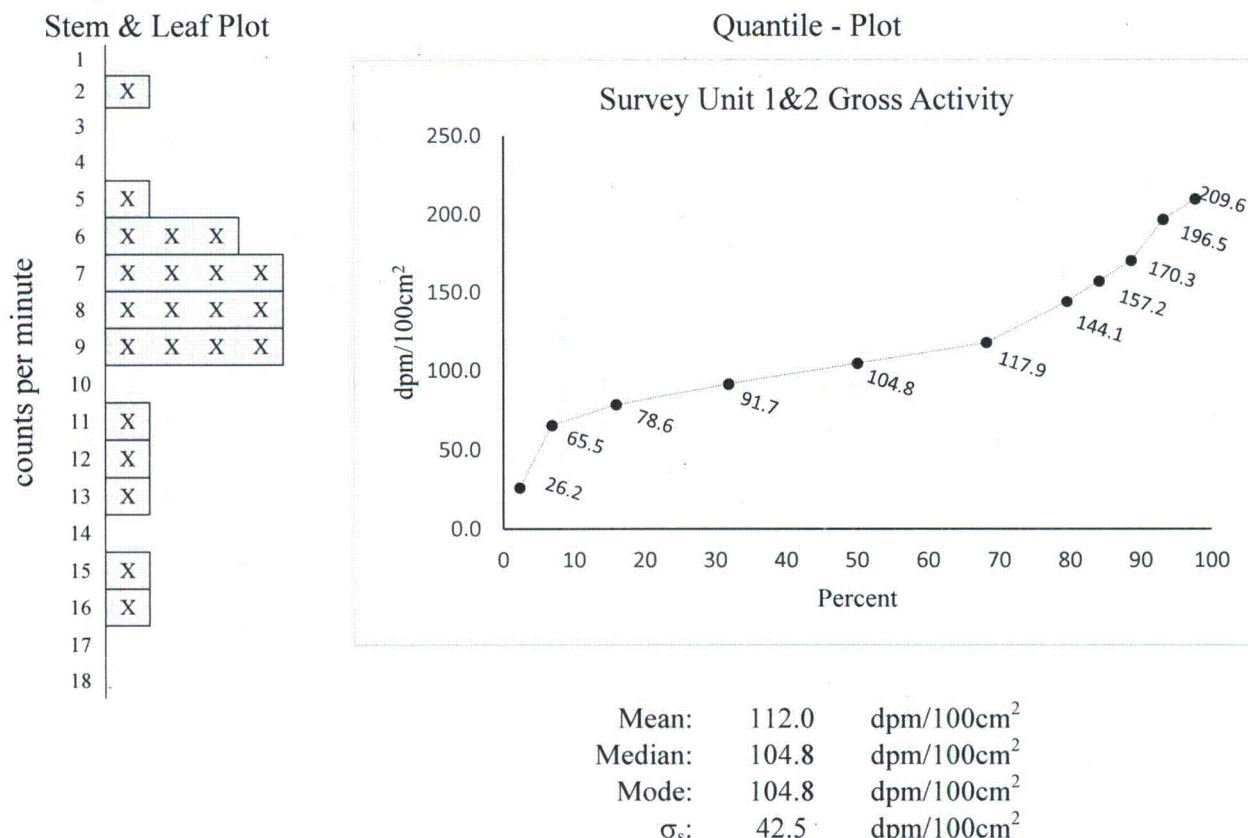
Minimum 25% scan of each floor sector (S1 – S5), minimum 5% scan of each wall up to 8 feet.  
Direct survey measurements (#1 – #5) obtained at the five highest scan locations.  
Direct survey measurements #6 – 9 obtained at the highest scan location on each wall.  
Swipe survey performed at each direct survey measurement location.  
Highest Scan measurements and swipe survey results provided in Section 2.6.4.

### 3.0 DATA ANALYSIS

Survey Units 1 and 2 - Class 3, Combined Area = 126.2 m<sup>2</sup>

Survey Units 1 and 2 were combined following the final status surveys because of their similarities in regards to use during operations and their potential for residual radioactivity exceeding the DCGL<sub>w</sub>. Survey Units 1 and 2 consist of the stairway, Conference Room 201, The hall way, (Room 102) restrooms (Rooms 102B and 102C), and the reception area (Room 101). Reference area background was not utilized for these survey units and the one sample sign test was conducted to evaluate the data.

Prior to conducting the one-sample statistical test a Stem & Leaf plot and Quantile Plot of the data was produced to provide a visual representation of the data set.



The data appears to be symmetrical, with the median and mode equal and the mean exceeds the median and mode by 0.17σ<sub>s</sub>.

In the case of Survey Units 1 & 2, all measurements are less than the DCGL<sub>w</sub> and therefore the survey units meets the release criterion.

The hypothesis tested by the Sign test is

Null Hypothesis

H<sub>0</sub>: The median concentration of residual radioactivity in the survey unit is greater than DCGL<sub>w</sub>

versus

Alternative Hypothesis

H<sub>a</sub>: The median concentration of residual radioactivity in the survey unit is less than the DCGL<sub>w</sub>

Sign Test Statistics Survey Units 1&2

	Data (dpm/100cm <sup>2</sup> )	DCGL <sub>w</sub> - Data (dpm/100cm <sup>2</sup> )	Sign
1	104.81	570.19	1
2	196.53	478.47	1
3	65.51	609.49	1
4	104.81	570.19	1
5	78.61	596.39	1
6	157.22	517.78	1
7	144.12	530.88	1
8	209.63	465.37	1
9	170.32	504.68	1
10	117.92	557.08	1
11	104.81	570.19	1
12	117.92	557.08	1
13	117.92	557.08	1
14	91.71	583.29	1
15	78.61	596.39	1
16	104.81	570.19	1
17	91.71	583.29	1
18	26.20	648.80	1
19	117.92	557.08	1
20	78.61	596.39	1
21	91.71	583.29	1
22	91.71	583.29	1

$\alpha$  : 0.025       $1-\alpha$  : 0.975  
 $\beta$  : 0.025       $1-\beta$  : 0.975  
DCGL: 1100      dpm/100cm<sup>2</sup>  
 $\sigma_s$ : 42.5      dpm/100cm<sup>2</sup>  
LBGR: 972.4      dpm/100cm<sup>2</sup>  
 $\Delta/\sigma$  : 3

$$N_{\text{required}} = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(\text{Sign P} - 0.5)^2}$$

$Z_{1-\alpha}$ : 1.96  
 $Z_{1-\beta}$ : 1.96  
Sign P: 0.99865  
 $N_{\text{required}}$  = 15.4  
+20% = 19

Adequate number of samples collected

Number of Positive differences S+ = 22  
Critical Value (N = 22 and  $\alpha$  = 0.025) = 16  
Accept H<sub>a</sub> the survey unit meets the release criterion

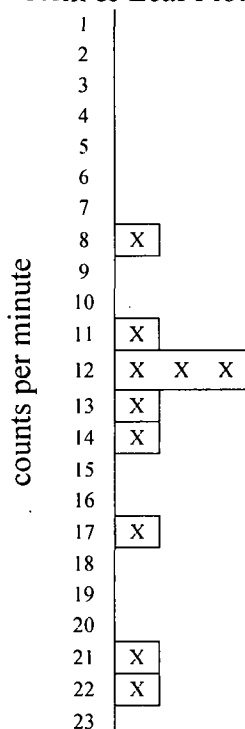


Survey Unit 3 – Class 3, Area = 80.9 m<sup>2</sup>

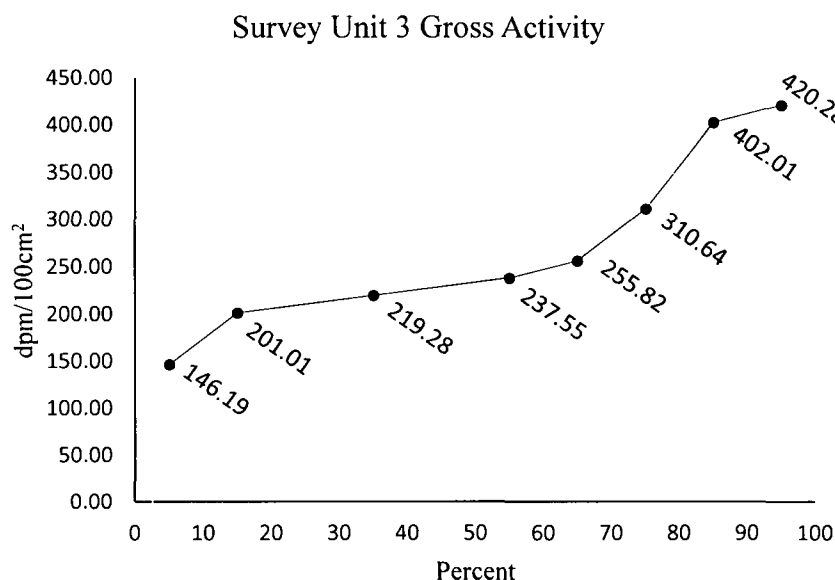
Survey Unit 3 consists of the Gas Production Room (301) and the analytical laboratory (302). Reference area background was subtracted from the results of the survey unit.

Prior to conducting the Wilcoxon Rank Sum statistical test a Stem & Leaf plot and Quantile Plot of the data was produced to provide a visual representation of the data set.

Stem & Leaf Plot



Quantile - Plot



DCGL <sub>w</sub> :	1100	dpm/100cm <sup>2</sup>	Mean:	263.13	dpm/100cm <sup>2</sup>
LBGR:	834.9	dpm/100cm <sup>2</sup>	Median:	228.41	dpm/100cm <sup>2</sup>
			Mode:	219.3	dpm/100cm <sup>2</sup>
			σ <sub>s</sub> :	88.4	dpm/100cm <sup>2</sup>

The data appears to be skewed slightly to the right, with the mean > median > mode, this spread is approximately ½ the σ<sub>s</sub>. It is likely that the upper 3 measurements identified residual radioactivity above the reference area background but these measurements are well below the DCGL<sub>w</sub> and no measurements exceeded the LBGR.

In the case of Survey Unit 3, the difference between the maximum survey unit measurement (420.28 dpm/100cm<sup>2</sup>) and smallest reference area measurement (127.9 dpm/100cm<sup>2</sup>) is less than the DCGL<sub>w</sub> and therefore the survey units meets the release criterion.

The WRS test was conducted to verify the survey parameters were adequate.

WRS Test Statistics Survey Unit 3

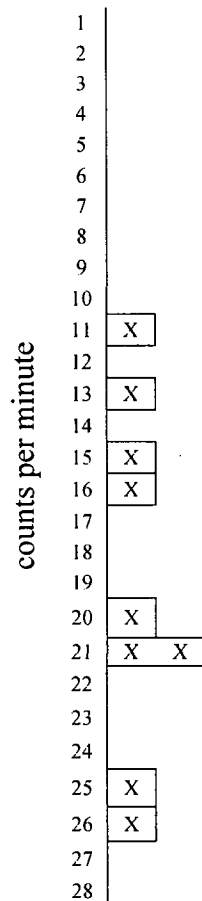
$\alpha =$	0.025				REFERENCE	DCGL <sub>w</sub> =	1100
$\beta =$	0.025		ADJUSTED		AREA	LBGR =	834.9
	DATA	AREA	DATA	RANKS	RANKS	$\sigma_s =$	88.35
						$\Delta/\sigma_s =$	3.00
						M =	20
						N =	10
						$N+M = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{3(P_r - 0.5)^2}$	
						$Z_{1-\alpha} =$	1.96
						$Z_{1-\beta} =$	1.96
						$P_r =$	0.98
						N+M =	22
						N+M+20% =	27
						20% met	TRUE
1	127.91	R	802.9	11.5	11.5		
2	182.73	R	857.7	19.5	19.5		
3	274.10	R	949.1	28.5	28.5		
4	164.46	R	839.5	16.5	16.5		
5	201.01	R	876.0	21.5	21.5		
6	219.28	R	894.3	23.5	23.5		
7	164.46	R	839.5	16.5	16.5		
8	146.19	R	821.2	13.5	13.5		
9	182.73	R	857.7	19.5	19.5		
10	237.55	R	912.6	25.5	25.5		
11	164.46	R	839.5	16.5	16.5		
12	274.10	R	949.1	28.5	28.5		
13	237.55	R	912.6	25.5	25.5		
14	201.01	R	876.0	21.5	21.5		
15	310.64	R	985.6	30	30		
16	255.82	R	930.8	27	27		
17	219.28	R	894.3	23.5	23.5		
18	164.46	R	839.5	16.5	16.5		
19	127.91	R	802.9	11.5	11.5		
20	146.19	R	821.2	13.5	13.5		
1	420.3	S	420.3	10	0		
2	402.0	S	402.0	9	0		
3	310.6	S	310.6	8	0		
4	201.0	S	201.0	2	0		
5	219.3	S	219.3	4	0		
6	219.3	S	219.3	4	0		
7	146.2	S	146.2	1	0		
8	237.6	S	237.6	6	0		
9	255.8	S	255.8	7	0		
10	219.3	S	219.3	4	0		
Sum =				465	410		
Critical Value =	354	Accept the alternative hypothesis; the median concentration in the survey unit exceeds that in the reference area by less than the DCGL					

Survey Unit 4 – Class 3, Area = 130.2 m<sup>2</sup>

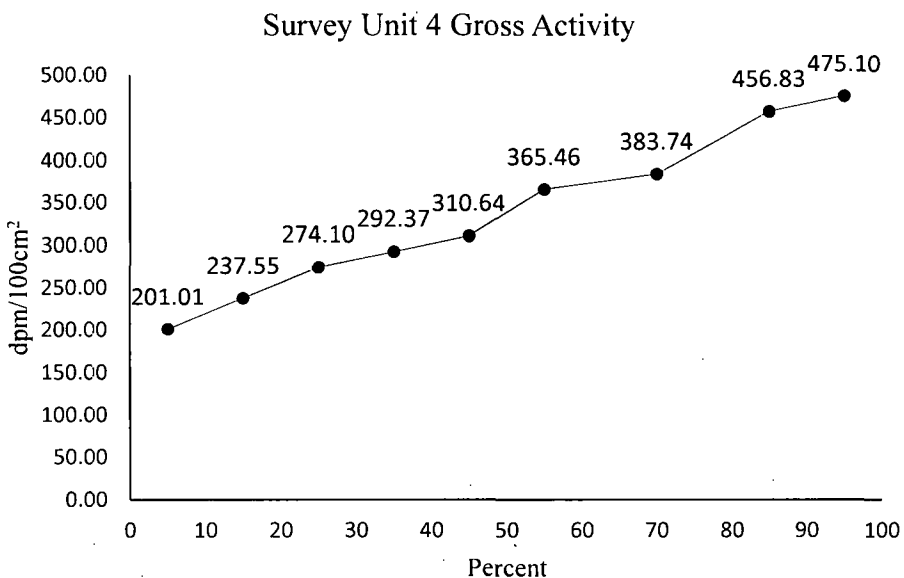
Survey Unit 4 consists of the mezzanines Rooms 401 and 402. Reference area background was subtracted from the results of the survey unit.

Prior to conducting the Wilcoxon Rank Sum statistical test a Stem & Leaf plot and Quantile Plot of the data was produced to provide a visual representation of the data set.

Stem & Leaf Plot



Quantile - Plot



Mean:	338.1	dpm/100cm <sup>2</sup>
Median:	338.1	dpm/100cm <sup>2</sup>
Mode:	383.7	dpm/100cm <sup>2</sup>
$\sigma_s$ :	90.45	dpm/100cm <sup>2</sup>
DCGL <sub>w</sub> :	1100	dpm/100cm <sup>2</sup>
LBGR:	828.7	dpm/100cm <sup>2</sup>

The data set is small and flat with the mean = median > mode, this spread is approximately ½ the  $\sigma_s$ . The two highest measurements are below the DCGL<sub>w</sub> and no measurements exceeding the LBGR.

In the case of Survey Unit 4, the difference between the maximum survey unit measurement (475.1 dpm/100cm<sup>2</sup>) and smallest reference area measurement (127.9 dpm/100cm<sup>2</sup>) is less than the DCGL<sub>w</sub> and therefore the survey units meets the release criterion.

The WRS test was conducted to verify the survey parameters were adequate.

WRS Test Statistics Survey Unit 4

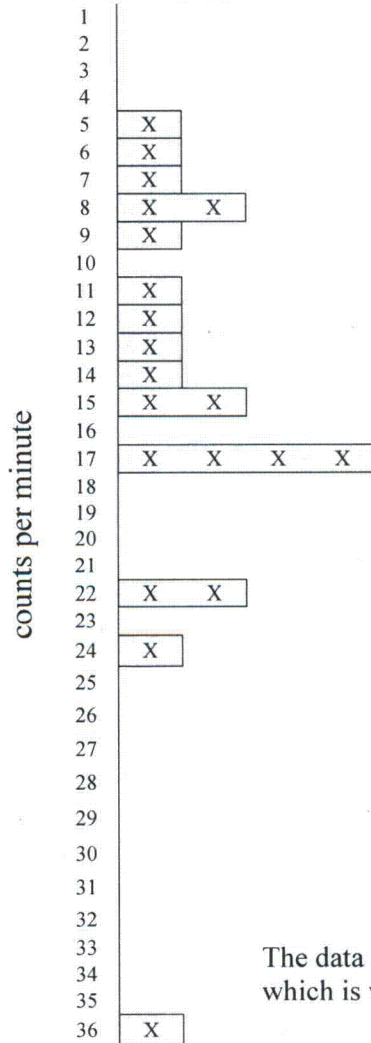
$\alpha =$	0.025				REFERENCE	DCGL <sub>w</sub> =	1100
$\beta =$	0.025		ADJUSTED		AREA	LBGR =	828.7
	DATA	AREA	DATA	RANKS	RANKS	$\sigma_s =$	90.45
						$\Delta/\sigma_s =$	3.00
						M =	20
						N =	10
						$N+M = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{3(P_r - 0.5)^2}$	
						$Z_{1-\alpha} =$	1.96
						$Z_{1-\beta} =$	1.96
						$P_r =$	0.98
						$N+M =$	22
						$N+M+20\% =$	27
						20% met	TRUE
1	127.91	R	802.9	11.5	11.5		
2	182.73	R	857.7	19.5	19.5		
3	274.10	R	949.1	28.5	28.5		
4	164.46	R	839.5	16.5	16.5		
5	201.01	R	876.0	21.5	21.5		
6	219.28	R	894.3	23.5	23.5		
7	164.46	R	839.5	16.5	16.5		
8	146.19	R	821.2	13.5	13.5		
9	182.73	R	857.7	19.5	19.5		
10	237.55	R	912.6	25.5	25.5		
11	164.46	R	839.5	16.5	16.5		
12	274.10	R	949.1	28.5	28.5		
13	237.55	R	912.6	25.5	25.5		
14	201.01	R	876.0	21.5	21.5		
15	310.64	R	985.6	30	30		
16	255.82	R	930.8	27	27		
17	219.28	R	894.3	23.5	23.5		
18	164.46	R	839.5	16.5	16.5		
19	127.91	R	802.9	11.5	11.5		
20	146.19	R	821.2	13.5	13.5		
1	237.6	S	237.6	2	0		
2	274.1	S	274.1	3	0		
3	201.0	S	201.0	1	0		
4	456.8	S	456.8	9	0		
5	292.4	S	292.4	4	0		
6	310.6	S	310.6	5	0		
7	383.7	S	383.7	7.5	0		
8	475.1	S	475.1	10	0		
9	383.7	S	383.7	7.5	0		
10	365.5	S	365.5	6	0		
			Sum =	465	410		
Critical Value =	354	Accept the alternative hypothesis; the median concentration in the survey unit exceeds that in the reference area by less than the DCGL					

Survey Units 5 & 6 – Class 3, Combined Area = 622.6 m<sup>2</sup>

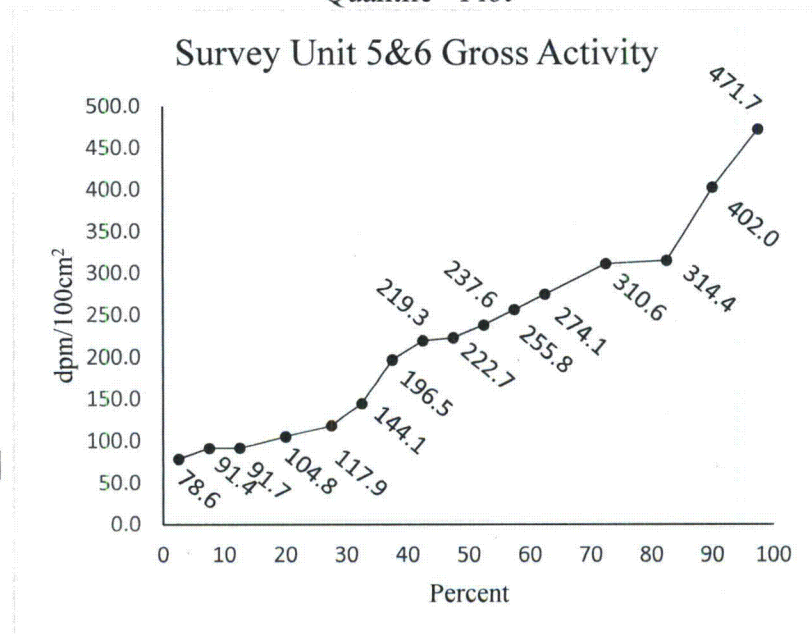
Survey Units 5 and 6 were combined following the final status surveys because of their similarities in regards to use during operations and their potential for residual radioactivity exceeding the DCGL<sub>w</sub>. Survey Units 5 and 6 consist of the general process area and was divided into quadrants, North-West, North-East, South-West and South-East. Reference area background was subtracted from the results of the survey unit.

Prior to conducting the Wilcoxon Rank Sum statistical test a Stem & Leaf plot and Quantile Plot of the data was produced to provide a visual representation of the data set.

Stem & Leaf Plot



Quantile - Plot



Mean:	233.1	dpm/100cm <sup>2</sup>
Median:	230.1	dpm/100cm <sup>2</sup>
Mode:	310.6	dpm/100cm <sup>2</sup>
σ <sub>s</sub> :	118.6	dpm/100cm <sup>2</sup>
DCGL <sub>w</sub> :	1100	dpm/100cm <sup>2</sup>
LBGR:	743.9	dpm/100cm <sup>2</sup>

The data appears to be skewed slightly to the right, with one obvious outlier, which is well below the DCGL<sub>w</sub> and is the only measurement above the LBGR.

In the case of Survey Units 5 & 6, the difference between the maximum survey unit measurement (471.7 dpm/100cm<sup>2</sup>) and smallest reference area measurement (127.9 dpm/100cm<sup>2</sup>) is less than the DCGL<sub>w</sub> and therefore the survey units meets the release criterion. No measurements exceeded the LBGR.

The WRS test was conducted to verify the survey parameters were adequate.

WRS Test Statistics Survey Units 5 & 6

$\alpha =$	0.025				REFERENCE	DCGL <sub>w</sub> =	1100
$\beta =$	0.025		ADJUSTED		AREA	LBGR =	743.9
	DATA	AREA	DATA	RANKS	RANKS	$\sigma_s =$	118.69
						$\Delta/\sigma_s =$	3.00
						M =	20
						N =	10
						$N+M = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{3(P_r - 0.5)^2}$	
						$Z_{1-\alpha} =$	1.96
						$Z_{1-\beta} =$	1.96
						$P_r =$	0.98
						N+M =	22
						N+M+20% =	27
						20% met	TRUE
1	127.91	R	802.9	20.5	20.5		
2	182.73	R	857.7	28.5	28.5		
3	274.10	R	949.1	37.5	37.5		
4	164.46	R	839.5	25.5	25.5		
5	201.01	R	876.0	30.5	30.5		
6	219.28	R	894.3	32.5	32.5		
7	164.46	R	839.5	25.5	25.5		
8	146.19	R	821.2	22.5	22.5		
9	182.73	R	857.7	28.5	28.5		
10	237.55	R	912.6	34.5	34.5		
11	164.46	R	839.5	25.5	25.5		
12	274.10	R	949.1	37.5	37.5		
13	237.55	R	912.6	34.5	34.5		
14	201.01	R	876.0	30.5	30.5		
15	310.64	R	985.6	39	39		
16	255.82	R	930.8	36	36		
17	219.28	R	894.3	32.5	32.5		
18	164.46	R	839.5	25.5	25.5		
19	127.91	R	802.9	20.5	20.5		
20	146.19	R	821.2	22.5	22.5		
1	255.82	S	255.8	12	0		
2	91.37	S	91.4	2	0		
3	274.10	S	274.1	13	0		
4	237.55	S	237.6	11	0		
5	219.28	S	219.3	9	0		
6	402.01	S	402.0	17.5	0		
7	310.64	S	310.6	15	0		
8	402.01	S	402.0	17.5	0		
9	310.64	S	310.6	15	0		
10	310.64	S	310.6	15	0		
11	91.71	S	91.7	3	0		
12	222.73	S	222.7	10	0		
13	196.53	S	196.5	8	0		
14	78.61	S	78.6	1	0		
15	471.67	S	471.7	19	0		
16	104.81	S	104.8	4.5	0		
17	144.12	S	144.1	7	0		
18	117.92	S	117.9	6	0		
19	104.81	S	104.8	4.5	0		
Sum =				780	590		

Critical Value = 469

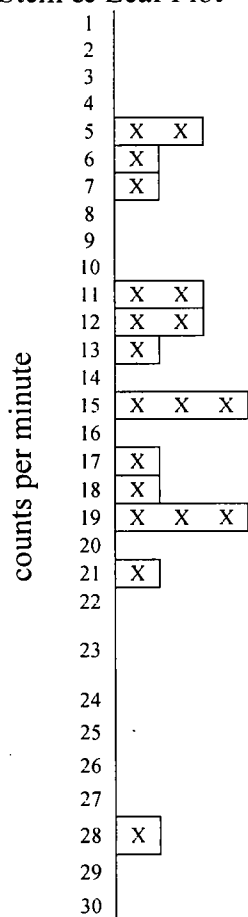
Accept the alternative hypothesis; the median concentration in the survey unit exceeds that in the reference area by less than the DCGL

Survey Unit 7 – Class 2, Area = 21.4 m<sup>2</sup>

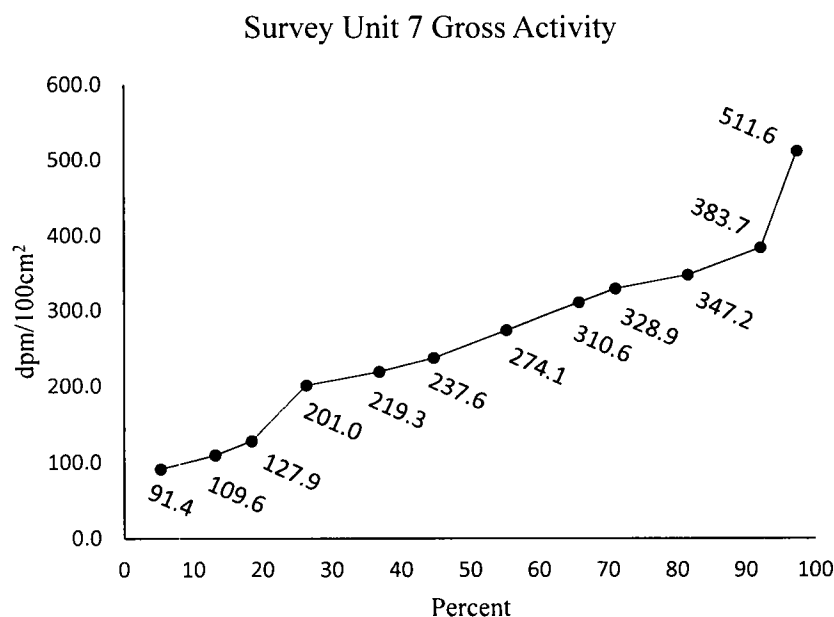
Survey Unit 7 consists of the Depleted Uranium Handling Room (304). Room 304 was considered the room with the most potential to identify residual radioactivity above the reference area but below the DCGL<sub>w</sub>. The survey unit was subdivided into 15 rectangular grids. Reference area background was subtracted from the results of the survey unit.

Prior to conducting the Wilcoxon Rank Sum statistical test a Stem & Leaf plot and Quantile Plot of the data was produced to provide a visual representation of the data set.

Stem & Leaf Plot



Quantile - Plot



Mean:	257.7	dpm/100cm <sup>2</sup>
Median:	274.1	dpm/100cm <sup>2</sup>
Mode:	274.1	dpm/100cm <sup>2</sup>
σ <sub>s</sub> :	109.8	dpm/100cm <sup>2</sup>
DCGL <sub>w</sub> :	1100	dpm/100cm <sup>2</sup>
LBGR:	770.6	dpm/100cm <sup>2</sup>

The data appears to flat with the maximum measurement 1.16 σ<sub>s</sub> greater than the next highest measurement. The mean < median = mode, this spread is approximately 0.15σ<sub>s</sub>. The highest measurement identified in the survey unit is slightly more than 1 standard deviation above the next highest and 2.3 standard deviations above the mean, this measurement is below the DCGL<sub>w</sub>, and no measurements exceeding the LBGR.

The difference between the maximum survey unit measurement (511.6 dpm/100cm<sup>2</sup>) and smallest reference area measurement (127.9 dpm/100cm<sup>2</sup>) is less than the DCGL<sub>w</sub> and therefore the survey units meets the release criterion. The WRS test was conducted to verify the survey parameters were adequate.

WRS Test Statistics Survey Unit 7

$\alpha = 0.025$

REFERENCE

DCGL<sub>w</sub> = 1100

$\beta = 0.025$

ADJUSTED

AREA

LBGR = 770.6

	DATA	AREA	DATA	RANKS	RANKS
1	127.91	R	802.9	20.5	20.5
2	182.73	R	857.7	28.5	28.5
3	274.10	R	949.1	37.5	37.5
4	164.46	R	839.5	25.5	25.5
5	201.01	R	876.0	30.5	30.5
6	219.28	R	894.3	32.5	32.5
7	164.46	R	839.5	25.5	25.5
8	146.19	R	821.2	22.5	22.5
9	182.73	R	857.7	28.5	28.5
10	237.55	R	912.6	34.5	34.5
11	164.46	R	839.5	25.5	25.5
12	274.10	R	949.1	37.5	37.5
13	237.55	R	912.6	34.5	34.5
14	201.01	R	876.0	30.5	30.5
15	310.64	R	985.6	39	39
16	255.82	R	930.8	36	36
17	219.28	R	894.3	32.5	32.5
18	164.46	R	839.5	25.5	25.5
19	127.91	R	802.9	20.5	20.5
20	146.19	R	821.2	22.5	22.5
1	511.65	S	511.6	19	0
2	347.19	S	347.2	16	0
3	274.10	S	274.1	11	0
4	274.10	S	274.1	11	0
5	347.19	S	347.2	16	0
6	274.10	S	274.1	11	0
7	383.74	S	383.7	18	0
8	127.91	S	127.9	4	0
9	347.19	S	347.2	16	0
10	109.64	S	109.6	3	0
11	91.37	S	91.4	1.5	0
12	310.64	S	310.6	13	0
13	219.28	S	219.3	7.5	0
14	219.28	S	219.3	7.5	0
15	201.01	S	201.0	5.5	0
16	201.01	S	201.0	5.5	0
17	328.92	S	328.9	14	0
18	237.55	S	237.6	9	0
19	91.37	S	91.4	1.5	0

Sum = 780

590

Critical Value = 469

Accept the alternative hypothesis; the median concentration in the survey unit exceeds that in the reference area by less than the DCGL

$\sigma_s = 109.8$

$\Delta/\sigma_s = 3.00$

M = 20

N = 10

$$N+M = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{3(P_r - 0.5)^2}$$

$Z_{1-\alpha} = 1.96$

$Z_{1-\beta} = 1.96$

$P_r = 0.98$

N+M = 22

N+M+20% = 27

20% met TRUE

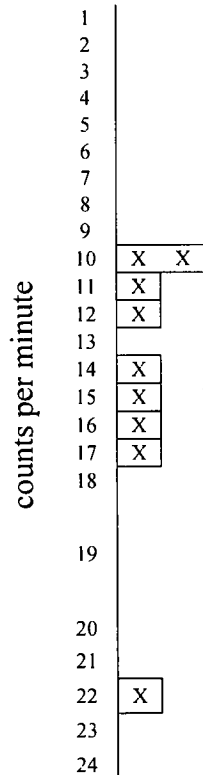


### Survey Unit 8 – Class 2, Area = 9.7 m<sup>2</sup>

Survey Unit 8 consists of the Counting Room (303). Room 303 is the smallest survey unit and was classified as a Class 2 Survey Unit because the room was used to analyze radiological samples, such as swipe surveys and air filters, therefore the potential exists for residual radioactivity above the reference area but below the DCGL<sub>w</sub>. The survey unit was subdivided into 5 rectangular grids. Reference area background was subtracted from the results of the survey unit.

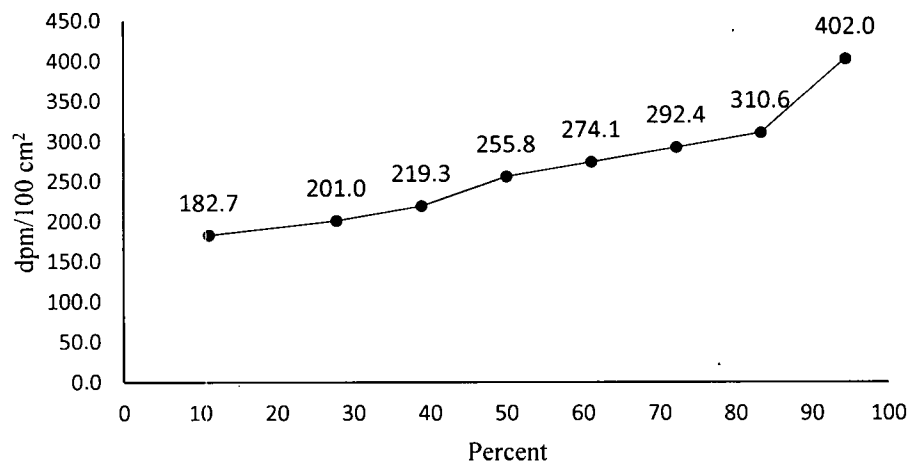
Prior to conducting the Wilcoxon Rank Sum statistical test a Stem & Leaf plot and Quantile Plot of the data was produced to provide a visual representation of the data set.

Stem & Leaf Plot



Quantile - Plot

Survey Unit 8 Gross Activity



Mean:	257.9	dpm/100cm <sup>2</sup>
Median:	255.8	dpm/100cm <sup>2</sup>
Mode:	182.7	dpm/100cm <sup>2</sup>
σ <sub>s</sub> :	71.6	dpm/100cm <sup>2</sup>
DCGL <sub>w</sub> :	1100	dpm/100cm <sup>2</sup>
LBGR:	885.1	dpm/100cm <sup>2</sup>

The data set is small due to the size of the survey unit. As a result the data set is flat however the mean and median are nearly equal. There are no measurement above the LBGR.

The difference between the maximum survey unit measurement (402.0 dpm/100cm<sup>2</sup>) and smallest reference area measurement (127.9 dpm/100cm<sup>2</sup>) is less than the DCGL<sub>w</sub> and therefore the survey units meets the release criterion.

The WRS test was conducted to verify the survey parameters were adequate.

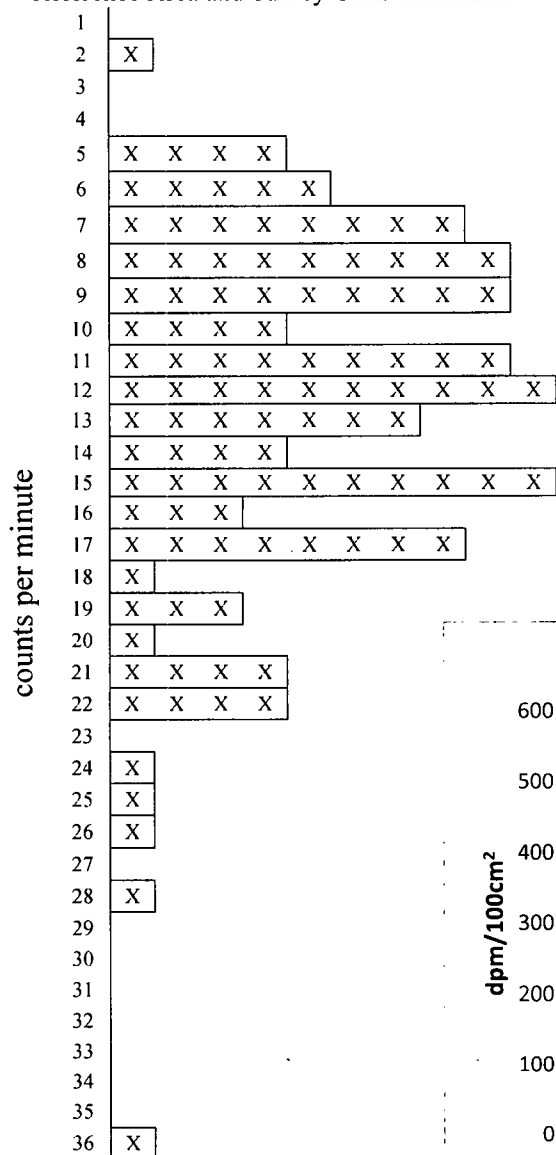
WRS Test Statistics Survey Unit 8

$\alpha =$	0.025	REFERENCE				DCGL <sub>w</sub> =	1100
$\beta =$	0.025	ADJUSTED				LBGR =	885.1
	DATA	AREA	DATA	RANKS	AREA RANKS	$\sigma_s =$	71.62
1	127.91	R	802.9	10.5	10.5	$\Delta/\sigma_s =$	3.00
2	182.73	R	857.7	18.5	18.5	M=	20
3	274.10	R	949.1	27.5	27.5	N=	10
4	164.46	R	839.5	15.5	15.5	N+M=	$\frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{3(P_r - 0.5)^2}$
5	201.01	R	876.0	20.5	20.5		
6	219.28	R	894.3	22.5	22.5	$Z_{1-\alpha} =$	1.96
7	164.46	R	839.5	15.5	15.5	$Z_{1-\beta} =$	1.96
8	146.19	R	821.2	12.5	12.5	$P_r =$	0.98
9	182.73	R	857.7	18.5	18.5	N+M=	22
10	237.55	R	912.6	24.5	24.5	N+M+20%=	27
11	164.46	R	839.5	15.5	15.5	20% met	TRUE
12	274.10	R	949.1	27.5	27.5		
13	237.55	R	912.6	24.5	24.5		
14	201.01	R	876.0	20.5	20.5		
15	310.64	R	985.6	29	29		
16	255.82	R	930.8	26	26		
17	219.28	R	894.3	22.5	22.5		
18	164.46	R	839.5	15.5	15.5		
19	127.91	R	802.9	10.5	10.5		
20	146.19	R	821.2	12.5	12.5		
1	219.28	S	219.3	4	0		
2	310.64	S	310.6	8	0		
3	255.82	S	255.8	5	0		
4	292.37	S	292.4	7	0		
5	274.10	S	274.1	6	0		
6	182.73	S	182.7	1.5	0		
7	402.01	S	402.0	9	0		
8	182.73	S	182.7	1.5	0		
9	201.01	S	201.0	3	0		
Sum =				435	390		
Accept the alternative hypothesis; the median concentration in the survey unit exceeds that in the reference area by less than the DCGL							
Critical Value =	341						

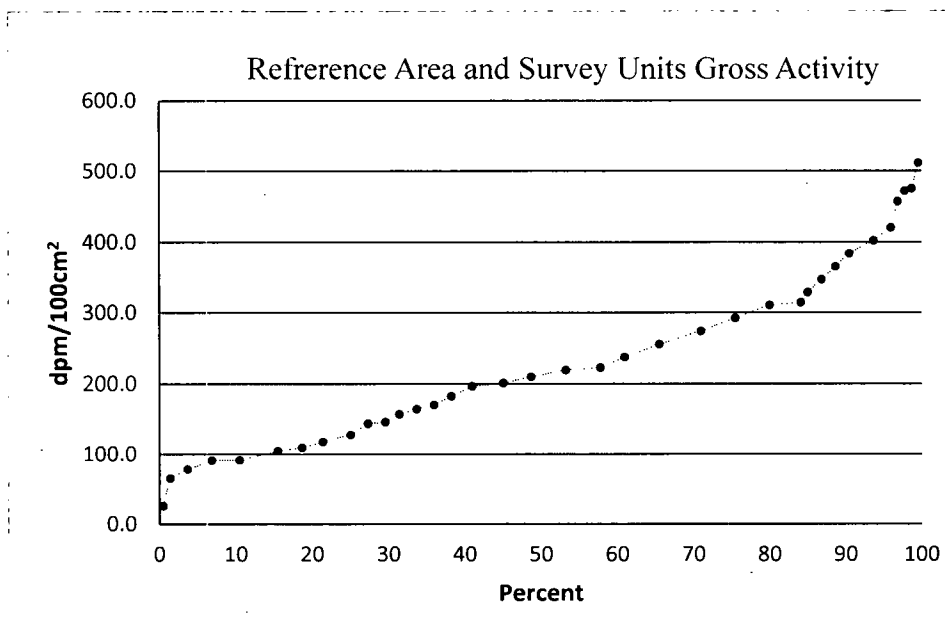
## Reference Area and Survey Units 1-8

A stem and leaf plot and quantile plot were constructed for all measurements obtained in the reference and survey units.

Reference Area and Survey Units Combined



Mean:	221.4	dpm/100cm <sup>2</sup>
Median:	219.3	dpm/100cm <sup>2</sup>
Mode:	219.3	dpm/100cm <sup>2</sup>
$\sigma_s$ :	103.4	dpm/100cm <sup>2</sup>
Minimum:	78.6	dpm/100cm <sup>2</sup>
Maximum:	511.6	dpm/100cm <sup>2</sup>



The complete data set is skewed slightly to the right with the mean > median = mode, this spread is only 2% of the  $\sigma_s$ . No gross measurement exceeds the DCGL<sub>w</sub>.

Survey Units 3-8, Class 2 & 3, 864.8 m<sup>2</sup> (Class 3 = 833.7 m<sup>2</sup> Class 2 = 31.1 m<sup>2</sup>)

The combined area of the survey units is below the recommended maximum 1000 m<sup>2</sup> area for a Class 2 Survey Unit. The data from Survey Units 3 through 8 were combined as a single data set to analysis using the Wilcoxon Rank Sum statistical test with  $\alpha$  and  $\beta$  set at 0.001.

WRS Test Statistics Survey Units 3 through 8

$\alpha =$	0.001				REFERENCE	DCGL <sub>w</sub> =	1100
$\beta =$	0.001		ADJUSTED		AREA	LBGR =	783.0
	DATA	AREA	DATA	RANKS	RANKS	$\sigma_s =$	105.7
1	127.91	R	802.9	20.5	20.5	$\Delta/\sigma_s =$	3.00
2	182.73	R	857.7	28.5	28.5	M =	20
3	274.10	R	949.1	37.5	37.5	N =	10
4	164.46	R	839.5	25.5	25.5	N+M =	$\frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{3(P_r - 0.5)^2}$
5	201.01	R	876.0	30.5	30.5		
6	219.28	R	894.3	32.5	32.5		
7	164.46	R	839.5	25.5	25.5	$Z_{1-\alpha} =$	3.09
8	146.19	R	821.2	22.5	22.5	$Z_{1-\beta} =$	3.09
9	182.73	R	857.7	28.5	28.5	$P_r =$	0.98
10	237.55	R	912.6	34.5	34.5	N+M =	54.6
11	164.46	R	839.5	25.5	25.5	N+M+20% =	66
12	274.10	R	949.1	37.5	37.5	20% met	TRUE
13	237.55	R	912.6	34.5	34.5		
14	201.01	R	876.0	30.5	30.5		
15	310.64	R	985.6	39	39		
16	255.82	R	930.8	36	36		
17	219.28	R	894.3	32.5	32.5		
18	164.46	R	839.5	25.5	25.5		
19	127.91	R	802.9	20.5	20.5		
20	146.19	R	821.2	22.5	22.5		
1	255.82	S	255.8	35	0		
2	91.37	S	91.4	3	0		
3	274.10	S	274.1	39.5	0		
4	237.55	S	237.6	31.5	0		
5	219.28	S	219.3	25	0		
6	402.01	S	402.0	61.5	0		
7	310.64	S	310.6	48	0		
8	402.01	S	402.0	61.5	0		
9	310.64	S	310.6	48	0		
10	310.64	S	310.6	48	0		
11	91.71	S	91.7	5	0		
12	222.73	S	222.7	29	0		
13	196.53	S	196.5	16	0		
14	78.61	S	78.6	1	0		
15	471.67	S	471.7	66	0		
16	104.81	S	104.8	6.5	0		
17	144.12	S	144.1	11	0		
18	117.92	S	117.9	9	0		
19	104.81	S	104.8	6.5	0		
20	420.28	S	420.3	64	0		
21	402.01	S	402.0	61.5	0		
22	310.64	S	310.6	48	0		
23	201.01	S	201.0	19	0		

					REFERENCE
			ADJUSTED		AREA
	DATA	AREA	DATA	RANKS	RANKS
24	219.28	S	219.3	25	0
25	219.28	S	219.3	25	0
26	146.19	S	146.2	12.5	0
27	237.55	S	237.6	31.5	0
28	255.82	S	255.8	35	0
29	219.28	S	219.3	25	0
30	237.55	S	237.6	31.5	0
31	274.10	S	274.1	39.5	0
32	201.01	S	201.0	19	0
33	456.83	S	456.8	65	0
34	292.37	S	292.4	43.5	0
35	310.64	S	310.6	48	0
36	383.74	S	383.7	58	0
37	475.10	S	475.1	67	0
38	383.74	S	383.7	58	0
39	365.46	S	365.5	56	0
40	146.19	S	146.2	12.5	0
41	511.65	S	511.6	68	0
42	347.19	S	347.2	54	0
43	274.10	S	274.1	39.5	0
44	274.10	S	274.1	39.5	0
45	347.19	S	347.2	54	0
46	274.10	S	274.1	39.5	0
47	383.74	S	383.7	58	0
48	127.91	S	127.9	10	0
49	347.19	S	347.2	54	0
50	109.64	S	109.6	8	0
51	91.37	S	91.4	3	0
52	310.64	S	310.6	48	0
53	219.28	S	219.3	25	0
54	219.28	S	219.3	25	0
55	201.01	S	201.0	19	0
56	201.01	S	201.0	19	0
57	328.92	S	328.9	52	0
58	237.55	S	237.6	31.5	0
59	91.37	S	91.4	3	0
60	219.28	S	219.3	25	0
61	310.64	S	310.6	48	0
62	255.82	S	255.8	35	0
63	292.37	S	292.4	43.5	0
64	274.10	S	274.1	39.5	0
65	182.73	S	182.7	14.5	0
66	402.01	S	402.0	61.5	0
67	182.73	S	182.7	14.5	0
68	201.01	S	201.0	19	0
Sum =				2121	1570
Accept the alternative hypothesis; the median concentration in the survey unit exceeds that in the reference area by less than the DCGL					
Critical Value =		1200			

#### 4.0 CONSLCUSION

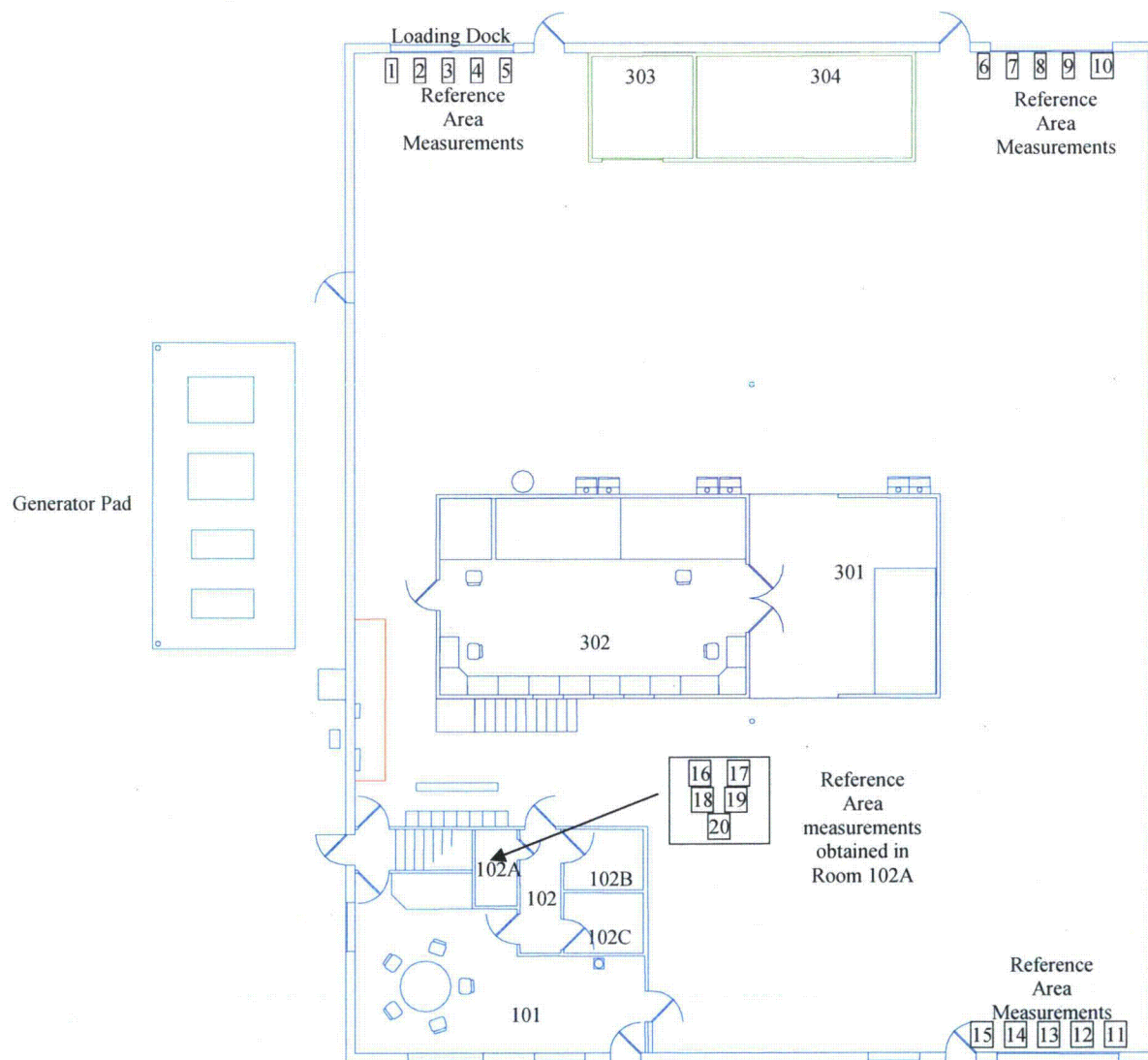
The results of the final status surveys have confirmed that the gross concentration of residual radioactive material associated with the survey units is below the DCGL<sub>w</sub> of 1100 dpm/100 cm<sup>2</sup>, which correlates to an annual dose of 20 mrem to a member of the public as modeled using the US NRC's DandD code. Statistical analysis of the final status surveys confirms the survey design as adequate. Based on the results of the final status surveys Building 1359 may be released for unrestricted.

#### 5.0 REFERENCES

- [1] NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual*, Washington D.C: Nuclear Regulatory Commission, December 1997
- [2] NUREG-1757, *Consolidated Decommissioning Guidance*, Volumes 1 & 2 Washington D.C: Nuclear Regulatory Commission, September 2006
- [3] NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Measurements for Various Contaminates and Field Conditions* Washington D.C.: Nuclear Regulatory Commission, August 1995 (Draft)
- [4] US Nuclear Regulatory Commission DandD Version 2.1.0
- [5] ORNL-6913, *Total Effective Dose Equivalent Associated with Fixed Uranium Surface Contamination*, Oak Ridge National Laboratory, Oak Ridge TN, April 1997

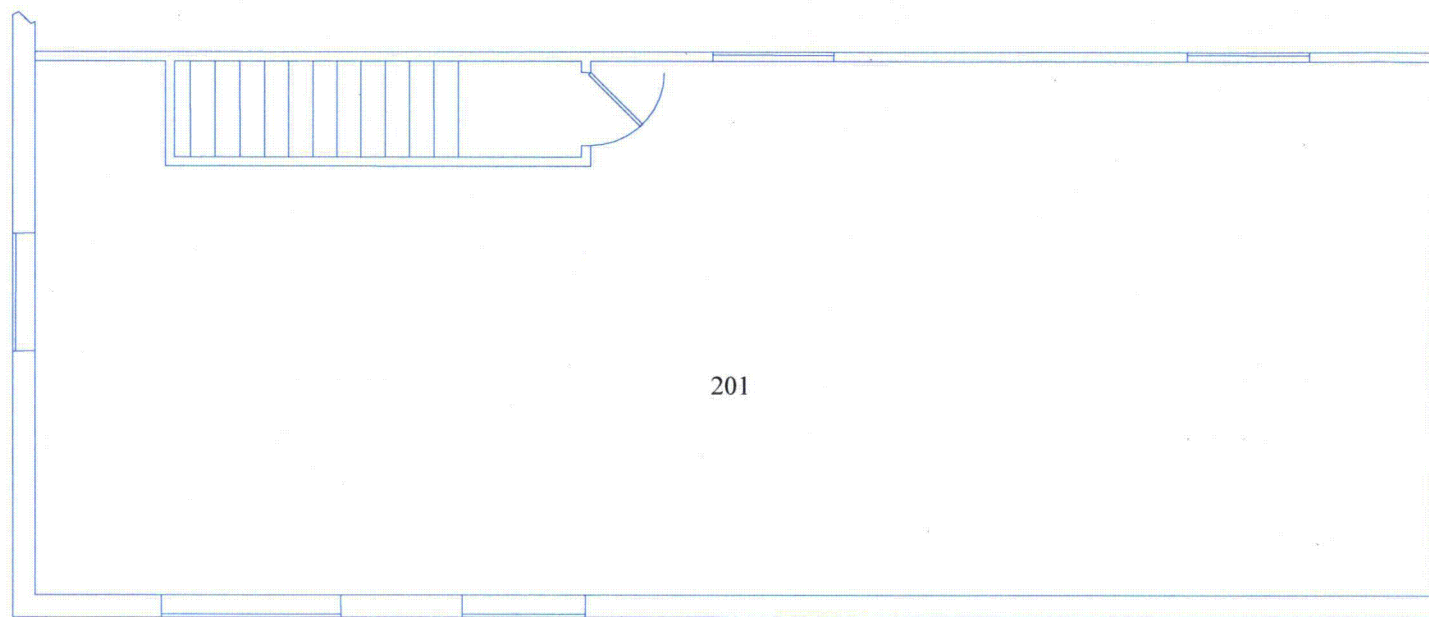
March 25, 2014

Figure 1. International Isotope Inc. FEP First Floor



March 25, 2014

Figure 2. International Isotope Inc. FEP Second Floor







**International Isotopes Inc.**

1359 Final Status Survey Report, Rev. C

March 25, 2014

Attachment 1 - Potentially Contaminated Equipment Disposition Log

Page 1 of 3

No.	Item Name or Description / Serial Number	Location Transferred to	Code <sup>(1)</sup>	Survey Attached
1	Fume Hood - EASTEC Monair / BFC10-04SLC / USA	4137 Warehouse	A	Y
2	Plexiglas glove box / FEP 0196	4137 Warehouse	A	Y
3	Air pump / sn 3109 / FEP 0199	4137 Warehouse	A	Y
4	Thermal Anemometer / FEP 0205	4137 Warehouse	C	Y
5	Alpha 7 continuous air monitor / sn 222	4137 Warehouse	A	Y
6	Chemical Reactor	4137 Warehouse	B	Y
7	Post Chemical Reactor filter vessel	4137 Warehouse	B	Y
8	Chair / FEP 0200	4137 Warehouse	C	Y
9	Foot Heat Sealer / #443 Singer Sealer	4137 Warehouse	C	Y
10	HEPA vacuum / sn 197913	4137 Warehouse	A	Y
11	Stool / FEP 0194	4137 Warehouse	C	Y
12	Old Flange and parts	4137 Warehouse	A	Y
13	Lab coats / 5 cloth coats	4137 Warehouse	C	Y
14	Wall Mounted Lock Box / FEP 0203	4137 Warehouse	C	Y
15	Lindberg Blue M Tube Furnace / sn R04P-504606-RP / FEP 0220	4137 Warehouse	A	Y
16	Tube Furnace Tube	4137 Warehouse	B	Y
17	Chemical Reactor Air Pressure Gauge and Tubing	4137 Warehouse	C	Y
18	Wall Mounted duct support braces	4137 Warehouse	C	Y
19	Lg Storage locker room 303 / FEP 0221	4137 Warehouse	C	Y
20	Movable cabinet with drawers & countertop / FEP 0188	4137 Warehouse	C	Y
21	55 gallon cold waste barrel	4137 Warehouse	C	Y
22	20 gallon waste can	4137 Warehouse	C	Y
23	Wall mounted shelf	4137 Warehouse	C	Y

Note (1): Code: (A) Storage for Future Use. (B) Storage for subsequent disposal as Radioactive Material. (C) Unrestricted Release

USE ADDITIONAL SHEETS AS NECESSARY



**International Isotopes Inc.**

1359 Final Status Survey Report, Rev. C

March 25, 2014

Attachment 1 - Potentially Contaminated Equipment Disposition Log

Page 2 of 3

No.	Item Name or Description / Serial Number	Location Transferred to	Code <sup>(1)</sup>	Survey Attached
24	Hoffman electric wire box & wire	4137 Warehouse	C	Y
25	Anti-contamination suits	4137 Warehouse	A	Y
26	Double bagged Contaminated 3' long Steel half pipe	4137 Warehouse	B	Y
27	Filling Cabinet room 303 / FEP 0218	4137 Warehouse	C	Y
28	Methanol bottle, Acetone bottle, and Empty plastic bottles	4137 Warehouse	C	Y
29	Clock	4137 Warehouse	C	Y
30	Scoop	4137 Warehouse	A	Y
31	Air duct upstream of HEPA Filter Unit	4137 Warehouse	B	Y
32	Probe inside duct upstream of HEPA Filter Unit	4137 Warehouse	B	Y
33	HEPA Filter Unit	4137 Warehouse	B	Y
34	Air duct downstream of HEPA Filter Unit	4137 Warehouse	C	Y
35	Room 304 air duct support braces	4137 Warehouse	C	Y
36	Room 303 Lg waste storage locker / FEP 0221	4137 Warehouse	C	Y
37	55 gallon hot waste barrel	4137 Warehouse	C	Y
38	Check source lock box / FEP 0212	4137 Warehouse	A	Y
39	Alpha Spectroscopy detector / FEP 0215	4137 Warehouse	A	Y
40	Computer / FEP 0217	4137 Warehouse	C	Y
41	Computer Monitor and Keyboard / FEP 216	4137 Warehouse	C	Y
42	Computer desk / FEP 0210	4137 Warehouse	C	Y
43	Alpha Spec vacuum Pump sn 0282	4137 Warehouse	A	Y
44	Count room steel Table / FEP 0013	4137 Warehouse	C	Y
45	Ludlum 3030 detector sn 210769 / FEP 0210	4137 Warehouse	A	Y

Note (1): Code: (A) Storage for Future Use. (B) Storage for subsequent disposal as Radioactive Material. (C) Unrestricted Release

USE ADDITIONAL SHEETS AS NECESSARY



March 25, 2014

Page 3 of 3

Note (1): Code: (A) Storage for Future Use. (B) Storage for subsequent disposal as Radioactive Material. (C) Unrestricted Release  
USE ADDITIONAL GREEN SHEETS AS NECESSARY

USE ADDITIONAL SHEETS AS NECESSARY

# I<sup>3</sup> RADIOLOGICAL SURVEY REPORT

## Contamination Survey Instrument Data

ID	Type	Serial #	Cal. Due	probe area (cm <sup>2</sup> )	Eff.	Bkg count rate (cpm) Rb	Sample count time (minute) Ts	Bkg count time (minute) Tb	MDA (pCi)	Units
1	Ludlum 3030	210766	7/18/2013	N/A	1	7.9	1	1	7.2	/swipe
2	Ludlum 3030	210769	2/25/2014	N/A	1	6.5	1	1	6.7	/swipe
3	Ludlum 2360	202397	10/9/2013	100	0.2	10.95	1	1	41.4	/100cm <sup>2</sup>
4	Ludlum 2360	202409	9/4/2013	100	0.2	10.95	1	1	41.4	/100cm <sup>2</sup>

## Radiation Survey Instrument Data

Type	Serial #	Cal. Due

$$MDA = \frac{3 + 3.29 \sqrt{RbTs \left(1 + \frac{T_s}{T_b}\right)}}{\text{efficiency} \times T_s \times \frac{\text{Probe Area (cm}^2\text{)}}{100}}$$

Survey No.	Type (D, S, L)	Inst. ID	Location or Item Description	Gross count rate (cpm)	Net count rate (cpm)	Activity (pCi)	Units
1	D	3	External of ASTEC Monair Fume Hood	4	-6.95	-16	/100cm <sup>2</sup>
2	D	3	External of Plexiglas Glove Box	10	-0.95	-2	/100cm <sup>2</sup>
3	L	3	External of Plexiglas Glove Box	6	-4.95	-11	/LAW
4	L	3	Air Pump / sn 3109 / FEP 0199	2	-8.95	-20	/LAW
5	D	3	Air Pump / sn 3109 / FEP 0199	3	-7.95	-18	/100cm <sup>2</sup>
6	L	3	Thermal Anemometer / FEP 0205	2	-8.95	-20	/LAW
7	D	3	Alpha 7 CAM / sn 222	15	4.05	9	/100cm <sup>2</sup>
8	S	1	External of Post Reactor Filter Vessel	2	-5.9	-3	/swipe
9	D	3	External of Post Reactor Filter Vessel	4	-6.95	-16	/100cm <sup>2</sup>
10	S	1	External of Chemical Reactor	12	4.1	2	/swipe
11	D	3	External of Chemical Reactor	14	3.05	7	/100cm <sup>2</sup>
12	S	1	External of Chemical Reactor	10	2.1	1	/swipe
13	S	1	External of Chemical Reactor	10	2.1	1	/swipe
14	L	3	External of Chemical Reactor	2	-8.95	-20	/LAW
15	L	3	Chair / FEP 0200	2	-8.95	-20	/LAW
16	L	3	Foot Heat Sealer / #443 Singer Sealer	5	-5.95	-13	/LAW
17	D	3	Foot Heat Sealer / #443 Singer Sealer	10	-0.95	-2	/100cm <sup>2</sup>
18	L	3	HEPA Vacuum / sn 197913	2	-8.95	-20	/LAW
19	D	3	HEPA Vacuum / sn 197913	10	-0.95	-2	/100cm <sup>2</sup>
20	L	2	Stool / FEP 0194	1	-5.5	-2	/LAW
21	D	3	Stool / FEP 0194	3	-7.95	-18	/100cm <sup>2</sup>

### Survey Types

**D** = Direct Scan

**S** = Swipe

**L** = Large Area Wipe (LAW)

### NOTES

1. Conversion Factor: **1 dpm = 0.45 pCi**
2. "Probe Area (cm<sup>2</sup>)/100 cm<sup>2</sup>" not used in MDA equation for Scalers.
3. A map is not required if sufficient detail can be included on this page.
4. Activity for direct (D) measurements corrected for probe area to 100 cm<sup>2</sup>.
5. Swipes obtained over 100 cm<sup>2</sup> when the accessible surface area an item exceeds 100cm<sup>2</sup>.
6. Ludlum 3030 instruments report results in units of dpm.
7. Notify RSO when contamination levels exceed 45 pCi/100cm<sup>2</sup> in uncontrolled areas.



# I<sup>3</sup> RADIOLOGICAL SURVEY REPORT CONTINUATION SHEET

Survey No.	Type (D, S, L)	Inst. ID	Location or Item Description	Gross count rate (cpm)	Net count rate (cpm)	Activity (μCi)	Units
22	D	3	Old Flange and parts	10	-0.95	-2	/100cm2
23	D	3	Lab coats / 5 cloth coats	20	9.05	20	/100cm2
24	S	1	Movable Cabinet / counter top	20	12.1	5	/swipe
25	S	1	Movable Cabinet / inside top drawer	7	-0.9	0	/swipe
26	S	1	Movable Cabinet / inside 2nd drawer	15	7.1	3	/swipe
27	S	2	Movable Cabinet / inside 3rd drawer	2	-4.5	-2	/swipe
28	S	1	Movable Cabinet / inside 4th drawer	25	17.1	8	/swipe
29	D	3	Movable Cabinet / external surfaces	10	-0.95	-2	/100cm2
30	D	3	Wall mounted lock box / FEP 0203	10	-0.95	-2	/100cm2
31	S	1	Wall mounted lock box / FEP 0203	10	2.1	1	/swipe
32	D	3	Tube Furnace / FEP 0220	20	9.05	20	/100cm2
33	S	1	External of Tube Furnace Tube / bottom	28	20.1	9	/swipe
34	S	2	External of Tube Furnace Tube / side	8	1.5	1	/swipe
35	S	1	External of Tube Furnace Tube / side	28	20.1	9	/swipe
36	S	2	External of Tube Furnace Tube / side	10	3.5	2	/swipe
37	S	1	External of Tube Furnace Tube / side	12	4.1	2	/swipe
38	S	2	External of Tube Furnace Tube / top	10	3.5	2	/swipe
39	S	1	External of Tube Furnace Tube / middle	5	-2.9	-1	/swipe
40	S	2	External of Tube Furnace Tube / top	2	-4.5	-2	/swipe
41	D	3	External of Tube Furnace Tube / bottom	80	69.05	155	/100cm2
42	D	3	External of Tube Furnace Tube / middle	10	-0.95	-2	/100cm2
43	D	3	Air Pressure gauge and tubing	15	4.05	9	/100cm2
44	D	3	Hoffman electric wire box & wire	10	-0.95	-2	/100cm2
45	D	3	20 gallon Waste can	15	4.05	9	/100cm2
46	S	1	20 gallon Waste can bottom outer surface	10	2.1	1	/swipe
47	S	2	20 gallon Waste can bottom inner surface	16	9.5	4	/swipe
48	S	1	20 gallon Waste can Side inner surface	10	2.1	1	/swipe
49	S	2	20 gallon Waste can Side outer surface	5	-1.5	-1	/swipe
50	D	3	Wall mounted shelf	3	-7.95	-18	/100cm2
51	D	3	Box and Anticontamination suits	10	-0.95	-2	/100cm2
52	S	1	Top double bagged 3 ft. Steel half pipe	0	-7.9	-4	/swipe
53	S	2	Middle double bagged 3 ft. Steel half pipe	5	-1.5	-1	/swipe
54	S	1	Bottom double bagged 3 ft. Steel half pipe	5	-2.9	-1	/swipe
55	D	4	Filling Cabinet / FEP 0218	5	-5.95	-13	/100cm2
56	S	1	Top of Filling Cabinet	7	-0.9	0	/swipe
57	S	2	Side of Filling Cabinet	5	-1.5	-1	/swipe
58	S	1	Top Drawer of Filling Cabinet	2	-5.9	-3	/swipe
59	S	2	Bottom Drawer of Filling Cabinet	8	1.5	1	/swipe
60	L	4	Methanol Bottle	10	-0.95	-2	/LAW
61	D	4	Methanol Bottle	5	-5.95	-13	/100cm2
62	D	4	Clock	8	-2.95	-7	/100cm2
63	L	4	Clock	5	-5.95	-13	/LAW
64	D	4	Office Supplies	5	-5.95	-13	/100cm2
65	L	4	Office Supplies	8	-2.95	-7	/LAW
66	D	4	Scoop	6	-4.95	-11	/100cm2

# I<sup>3</sup> RADIOLOGICAL SURVEY REPORT CONTINUATION SHEET

Survey No.	Type (D, S, L)	Inst. ID	Location or Item Description	Gross count rate (cpm)	Net count rate (cpm)	Activity (μCi)	Units
67	S	1	Scoop	10	2.1	1	/swipe
68	D	4	Acetone Bottle	10	-0.95	-2	/100cm2
69	D	4	Plastic Bottles	4	-6.95	-16	/100cm2
			Ventilation Duct in Room 304				
70	L	4	Inside East Section	120	109.05	245	/LAW
71	L	4	Inside West Section	60	49.05	110	/LAW
72	L	4	Outside East Section	10	-0.95	-2	/LAW
73	S	1	Inside East Section	221	213.1	96	/swipe
74	S	1	Outside Top Section	7	-0.9	0	/swipe
75	S	2	Inside Top section	338	331.5	149	/swipe
76	S	1	Outside bottom Section	15	7.1	3	/swipe
77	S	2	Inside Bottom Section	193	186.5	84	/swipe
78	S	1	East duct outside surface	12	4.1	2	/swipe
79	S	2	East duct outside surface	13	6.5	3	/swipe
80	S	1	East duct outside surface	5	-2.9	-1	/swipe
81	L	4	East duct outside surface	38	27.05	61	/LAW
82	D	4	West duct outside surface	20	9.05	20	/100cm2
83	S	1	West duct outside surface	5	-2.9	-1	/swipe
84	S	2	West duct outside surface	15	8.5	4	/swipe
85	S	1	West duct outside surface	5	-2.9	-1	/swipe
			Ventilation Duct on Mezzanine 402				
86	S	1	Inside Duct furthest from HEPA	160	152.1	68	/swipe
87	S	2	Inside Duct closest to HEPA	102	95.5	43	/swipe
88	S	1	Inside HEPA Unit ustream of filter	415	407.1	183	/swipe
89	S	2	Inside Duct closest to HEPA	150	143.5	65	/swipe
90	S	1	Inside HEPA Unit ustream of filter	612	604.1	272	/swipe
91	S	2	Probe inside Duct	155	148.5	67	/swipe
92	S	1	Floor Under HEPA	10	2.1	1	/swipe
93	S	2	Inside Duct downstream of HEPA filter	0	-6.5	-3	/swipe
94	S	1	Inside Duct downstream of HEPA filter	2	-5.9	-3	/swipe
95	D	4	Inside Duct downstream of HEPA filter	22	11.05	25	/100cm2
96	S	1	Inside Probe opening	5	-2.9	-1	/swipe
97	S	2	Deep inside probe opening	10	3.5	2	/swipe
98	S	1	Floor under probe opening	2	-5.9	-3	/swipe
99	D	4	Duct Braces	12	1.05	2	/100cm2
100	D	4	Lg storage locker / FEP 0221	12	1.05	2	/100cm2
101	D	4	55 gallon Hot Waste Barrel	28	17.05	38	/100cm2
102	S	1	55 gallon Hot Waste Barrel (outside)	15	7.1	3	/swipe
103	S	2	55 gallon Hot Waste Barrel (inside)	5	-1.5	-1	/swipe
104	S	1	55 gallon Hot Waste Barrel (bottom)	17	9.1	4	/swipe
105	D	4	55 gallon Cold Waste Barrel	12	1.05	2	/100cm2
106	S	1	55 gallon Cold Waste Barrel (outside)	12	4.1	2	/swipe
107	S	2	55 gallon Cold Waste Barrel (inside)	10	3.5	2	/swipe
108	S	1	55 gallon Cold Waste Barrel (bottom)	10	2.1	1	/swipe
109	D	4	Source Locke Box / FEP 0212	14	3.05	7	/100cm2
110	S	1	Source Locke Box / FEP 0212 (outside)	10	2.1	1	/swipe
111	S	2	Source Locke Box / FEP 0212 (inside)	2	-4.5	-2	/swipe



I<sup>3</sup> RADIOLOGICAL SURVEY REPORT CONTINUATION SHEET[illegible]



# DandD Building Occupancy Scenario

**DandD Version:** 2.1.0

**Run Date/Time:** 2/11/2014 11:55:47 AM

**Site Name:** 1359\_DU DCGL

**Description:** DCGL using ratio of U elements in DU

**FileName:** C:\Users\jjmiller\Documents\1359\_DU\_DCGL.mcd

## Options:

**Implicit progeny doses included with explicit parent doses Nuclide concentrations are NOT distributed among all progeny Number of simulations:** 100  
**Seed for Random Generation:** 8718721  
**Averages used for behavioral type parameters**

**External Pathway is**

**ON Inhalation**

**Pathway is ON**

**Secondary Ingestion Pathway is ON**

## Initial Activities:

Nuclide	Area of Contamination (m <sup>2</sup> )	Distribution
<b>234U</b>	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: U-234 fraction of 1100 dpm/100cm2 of DU		<u>Value</u> 1.70E+02
<b>235U</b>	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: U-235 fraction of 1100 dpm/100cm2 of DU		<u>Value</u> 1.18E+01
<b>238U</b>	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: U-238 fraction of 1100 dpm/100cm2 of DU		<u>Value</u> 9.18E+02



**Chain Data:**

Number of chains: 3

Chain No. 1: **234U**

Nuclides in chain: 7

Nuclide	Chain Position	Half Life	First Parent	Fractional Yield	Second Parent	Fractional Yield	Ingestion CEDE Factor (Sv/Bq)	Inhalation CEDE Factor (Sv/Bq)	Surface Dose Rate Factor	15 cm Dose Rate Factor
<b>234U</b>	1	8.92E+07					7.66E-08	3.58E-05	6.46E-14	1.85E-16
<b>230Th</b>	2	2.81E+07	1	1	0	0	1.48E-07	8.80E-05	6.48E-14	5.52E-16
<b>226Ra</b>	3	5.84E+05	2	1	0	0	3.58E-07	2.32E-06	5.56E-13	1.42E-14
<b>222Rn</b>	4	3.82E+00	3	1	0	0	0.00E+00	0.00E+00	3.41E-14	9.81E-16
<b>210Pb</b>	5	8.15E+03	4	1	0	0	1.45E-06	3.67E-06	2.14E-13	1.13E-15
<b>210Bi</b>	6	5.01E+00	5	1	0	0	1.73E-09	5.29E-08	9.06E-14	1.61E-15
<b>210Po</b>	7	1.38E+02	6	1	0	0	5.14E-07	2.54E-06	7.16E-16	2.11E-17

Chain No. 2: **235U**

Nuclides in chain: 6

Nuclide	Chain Position	Half Life	First Parent	Fractional Yield	Second Parent	Fractional Yield	Ingestion CEDE Factor (Sv/Bq)	Inhalation CEDE Factor (Sv/Bq)	Surface Dose Rate Factor ((Sv/d)/(Bq/m <sup>2</sup> ))	15 cm Dose Rate Factor ((Sv/d)/(Bq/m <sup>3</sup> ))
<b>235U</b>	1	2.57E+11					7.19E-08	3.32E-05	1.28E-11	3.24E-13
<b>231Th</b>	2	1.06E+00	1	1	0	0	3.65E-10	2.37E-10	1.60E-12	1.68E-14
<b>231Pa</b>	3	1.20E+07	2	1	0	0	2.86E-06	3.47E-04	3.52E-12	8.30E-14
<b>227Ac</b>	4	7.95E+03	3	1	0	0	3.80E-06	1.81E-03	1.36E-14	2.26E-16
<b>227Th</b>	5	1.87E+01	4	0.9862	0	0	1.03E-08	4.37E-06	8.94E-12	2.29E-13
<b>223Ra</b>	6	1.14E+01	5	1	4	0.0138	1.78E-07	2.12E-06	1.11E-11	2.67E-13

Chain No. 3: **238U**Nuclides in chain: **9**

<b>Nuclide</b>	<b>Chain Position</b>	<b>Half Life</b>	<b>First Parent</b>	<b>Fractional Yield</b>	<b>Second Parent</b>	<b>Fractional Yield</b>	<b>Ingestion CEDE Factor (Sv/Bq)</b>	<b>Inhalation CEDE Factor (Sv/Bq)</b>	<b>Surface Dose Rate Factor ((Sv/d)/(Bq/m<sup>2</sup>))</b>	<b>15 cm Dose Rate Factor ((Sv/d)/(Bq/m<sup>3</sup>))</b>
<b>238U</b>	1	1.63E+12					6.88E-08	3.20E-05	4.76E-14	4.76E-17
<b>234Th</b>	2	2.41E+01	1	1	0	0	3.69E-09	9.47E-09	7.18E-13	1.12E-14
<b>234U</b>	3	8.93E+07	2	1	0	0	7.66E-08	3.58E-05	6.46E-14	1.85E-16
<b>230Th</b>	4	2.81E+07	3	1	0	0	1.48E-07	8.80E-05	6.48E-14	5.52E-16
<b>226Ra</b>	5	5.84E+05	4	1	0	0	3.58E-07	2.32E-06	5.56E-13	1.42E-14
<b>222Rn</b>	6	3.82E+00	5	1	0	0	0.00E+00	0.00E+00	3.41E-14	9.81E-16
<b>210Pb</b>	7	8.15E+03	6	1	0	0	1.45E-06	3.67E-06	2.14E-13	1.13E-15
<b>210Bi</b>	8	5.01E+00	7	1	0	0	1.73E-09	5.29E-08	9.06E-14	1.61E-15
<b>210Po</b>	9	1.38E+02	8	1	0	0	5.14E-07	2.54E-06	7.16E-16	2.11E-17

**Initial Concentrations:**

**Note: All reported values are the upper bound of the symmetric 95% confidence interval for the 0.9 quantile value**

<b>Nuclide</b>	<b>Surface Concentration (dpm/100 cm**2)</b>
234U	1.70E+02
230Th	0.00E+00
226Ra	0.00E+00
222Rn	0.00E+00
210Pb	0.00E+00
210Bi	0.00E+00
210Po	0.00E+00
235U	1.18E+01
231Th	0.00E+00
231Pa	0.00E+00
227Ac	0.00E+00
227Th	0.00E+00
223Ra	0.00E+00
238U	9.18E+02
234Th	0.00E+00

## Model Parameters:

### General Parameters:

Parameter Name	Description	Distribution
<b>To:Time In Building</b>	The time in the building during the occupancy period	CONSTANT(hr/week)
<u>Default value used</u>		<u>Value</u> 4.50E+01
<b>Tto:Occupancy Period</b>	The duration of the occupancy exposure period	CONSTANT(days)
<u>Default value used</u>		<u>Value</u> 3.65E+02
<b>Vo:Breathing Rate</b>	The average volumetric breathing rate during building occupancy for an 8-hour work day	CONSTANT(m**3/hr)
<u>Default value used</u>		<u>Value</u> 1.40E+00
<b>RFo*:Resuspension Factor</b>	Effective resuspension factor during the occupancy period = $RFo * FI$	CONSTANT(1/m)
<u>Justification for modification:</u> As recommended in NUREG-1720		<u>Value</u> 1.00E-06
		<u>Default</u> DERIVED(1/m)
<b>GO*:Ingestion Rate</b>	Effective secondary ingestion transfer rate of removable surface activity from building surfaces to the mouth during building occupancy = $GO * FI$	DERIVED(m**2/hr)
<u>Default value used</u>		
<b>Tstart:Start Time</b>	The start time of the scenario in days	CONSTANT(days)
<u>Default value used</u>		<u>Value</u> 0.00E+00
<b>Tend:End Time</b>	The ending time of the scenario in days	CONSTANT(days)
<u>Default value used</u>		<u>Value</u> 3.65E+02
<b>dt:Time Step Size</b>	The time step size	CONSTANT(days)
<u>Default value used</u>		<u>Value</u> 3.65E+02
<b>Pstep:Print Step Size</b>	The time steps for the history file. Doses will be written to the history file every n time steps	CONSTANT(none)
<u>Default value used</u>		<u>Value</u> 1.00E+00
<b>AOExt:External Exposure Area</b>	Minimum surface area to which occupant is exposed via external radiation during occupancy period	CONSTANT(m**2)
<u>Default value used</u>		<u>Value</u> 1.00E+01
<b>AOInh:Inhalation Exposure Area</b>	Minimum surface area to which occupant is exposed via inhalation during occupancy period	CONSTANT(m**2)
<u>Default value used</u>		<u>Value</u> 1.00E+01

<b>AOIng:Secondary Ingestion Exposure Area</b>	Minimum surface area to which occupant is exposed via secondary ingestion during occupancy period	CONSTANT(m**2)
<u>Default value used</u>		<u>Value</u> 1.00E+01
<b>AO:Exposure Area</b>	Minimum surface area to which occupant is exposed during the occupancy period	DERIVED(m**2)
<u>Default value used</u>		
<b>FI:Loose Fraction</b>	Fraction of surface contamination available for resuspension and ingestion	CONSTANT(none)
<u>Default value used</u>		<u>Value</u> 1.00E-01
<b>Rfo:Loose Resuspension Factor</b>	Resuspension factor for loose contamination	CONTINUOUS LOGARITHMIC(1/m)
<u>Default value used</u>		<u>Value</u> <u>Probability</u>
		1.10E-04 7.67E-01
		1.46E-04 9.09E-01
		1.62E-04 9.50E-01
		1.85E-04 9.90E-01
		1.90E-04 1.00E+00
<b>GO:Loose Ingestion Rate</b>	The secondary ingestion transfer rate of loose removable surface activity from building surfaces to the mouth during building occupancy	CONSTANT(m**2/hr)
<u>Default value used</u>		<u>Value</u> 1.10E-04

**Correlation Coefficients:**None**Summary Results:**

90.00% of the 100 calculated TEDE values are < 2.00E+01 mrem/year .

The 95 % Confidence Interval for the 0.9 quantile value of TEDE is 2.00E+01 to 2.00E+01 mrem/year

## Detailed Results:

**Note:** All reported values are the upper bound of the symmetric 95% confidence interval for the 0.9 quantile value

### Concentration at Time of Peak Dose:

Nuclide	Surface Concentration (dpm/100 cm**2)
234U	1.70E+02
230Th	7.66E-04
226Ra	1.11E-07
222Rn	1.06E-07
210Pb	8.05E-10
210Bi	7.44E-10
210Po	2.02E-10
235U	1.18E+01
231Th	1.17E+01
231Pa	1.23E-04
227Ac	1.29E-06
227Th	1.03E-06
223Ra	9.10E-07
238U	9.18E+02
234Th	8.31E+02

### Pathway Dose from All Nuclides (mrem)

All Pathways Dose	External	Inhalation	Secondary Ingestion
2.00E+01	3.54E-02	1.96E+01	3.44E-01

**Radionuclide Dose through All Active Pathways (mrem)**

<b>Nuclide</b>	<b>All Pathways Dose</b>
234U	3.38E+00
230Th	3.73E-05
226Ra	3.11E-10
222Rn	2.46E-10
210Pb	6.62E-12
210Bi	2.81E-14
210Po	7.27E-13
235U	2.19E-01
231Th	3.25E-04
231Pa	2.48E-05
227Ac	1.30E-06
227Th	2.65E-09
223Ra	2.11E-09
238U	1.63E+01
234Th	4.92E-02
All Nuclides	2.00E+01

**Dose from Each Nuclide through Each Active Pathway (mrem)**

<b>Nuclide</b>	<b>External</b>	<b>Inhalation</b>	<b>Secondary Ingestion</b>
234U	1.78E-04	3.32E+00	5.59E-02
230Th	8.07E-10	3.68E-05	4.86E-07
226Ra	1.00E-12	1.40E-10	1.70E-10
222Rn	2.46E-10	2.25E-13	1.11E-13
210Pb	2.80E-15	1.61E-12	5.01E-12
210Bi	1.10E-15	2.15E-14	5.53E-15
210Po	2.36E-18	2.81E-13	4.46E-13
235U	2.45E-03	2.13E-01	3.63E-03
231Th	3.05E-04	1.52E-06	1.84E-05
231Pa	7.04E-09	2.33E-05	1.51E-06
227Ac	1.70E-12	1.28E-06	2.11E-08
227Th	1.50E-10	2.46E-09	4.55E-11
223Ra	3.63E-10	1.05E-09	6.96E-10
238U	7.10E-04	1.60E+01	2.71E-01
234Th	3.18E-02	4.30E-03	1.32E-02