

# **NIOSH Response to SCA-TR-2016-SEC009: Review of Petition Evaluation Report for SEC-00224 Regarding the Use of General Area Air Sampling for Internal Dose Assessment**

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**Advisory Board on Radiation and Worker Health, 159<sup>th</sup> Meeting**

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# Overview

- Argonne National Laboratory-West (ANL-W) Site Background & Description
- SEC-00224 Petition Information
- SEC-00224 Evaluation Report
- “Areas of Concern” raised in SCA-TR-2016-SEC009, *Review of SEC-00224 regarding Use of General Area Air Sampling for Internal Dose Assessment*
- ORAUT-RPRT-0089, *Evaluation of Issues in the Use of General Area Air Sampling for Argonne National Laboratory-West Internal Dose Assessment*
- NIOSH Responses to “Areas of Concern” in SCA-TR-2016-SEC009

# ANL-W Site Background & Description



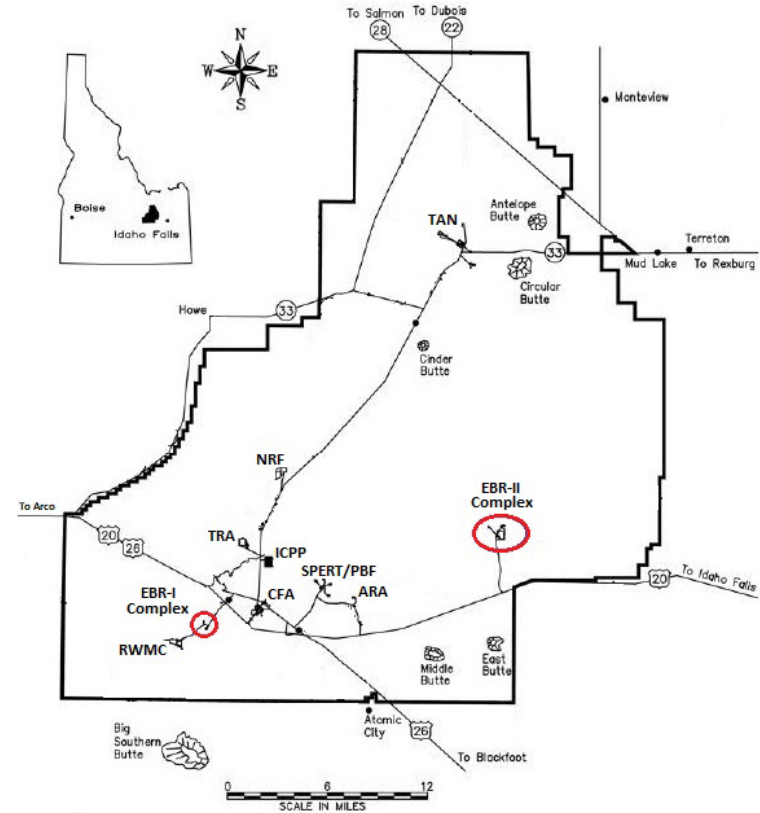
Aerial photo of the EBR-I Complex

# Background

- **1949-February 2005:** operated by the University of Chicago under the AEC/ERDA/DOE Chicago Operations Office
- **February 2005:** merged with Idaho National Laboratory (INL) and remaining operational facilities collectively named the Materials and Fuels Complex (MFC)
- Reactor testing, including breeder reactor theory, and experimental measurements.

# Site Description

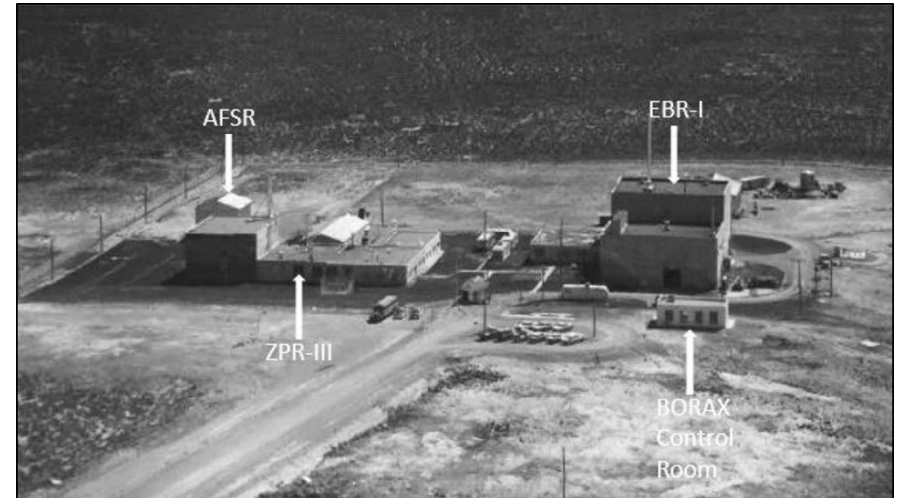
- Located on the INL site
- Two primary areas:
  1. Experimental Breeder Reactor-I (EBR-I) Complex
  2. EBR-II Complex



INL Site Map Depicting the Locations of the ANL-W Facilities

# EBR-I Complex

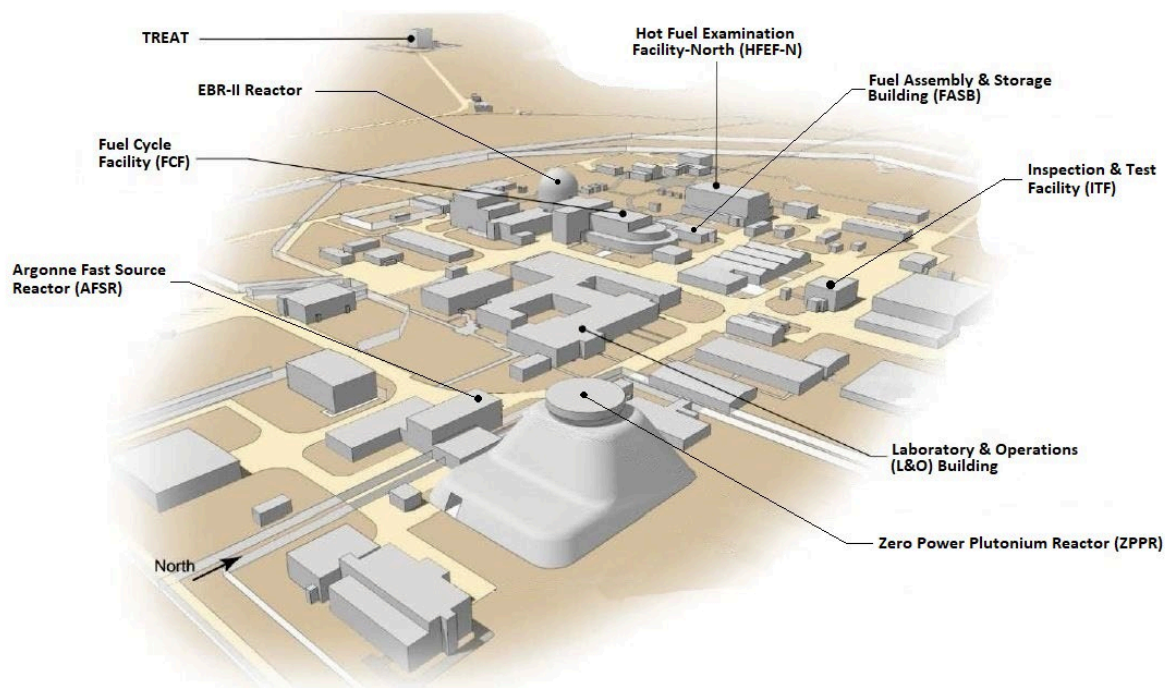
1. Argonne Fast Source Reactor (AFSR) first location
2. EBR-I
3. Boiling Water Reactor Experiments I-V (BORAX I-V)
4. Zero Power Reactor-III (ZPR-III)



Main Part of the EBR Complex

# EBR-II Complex

During Time Period for Class Evaluated by NIOSH



# SEC-00224 Petition Information



Light Bulbs Powered by the EBR-I Reactor



# SEC-00224 Petition

- **Received December 4, 2014**
  - **Requested Class:** *All workers who worked in any work location at the ANL-W from January 1, 1949 through December 31, 1995.*
  - **F.1 Basis:** *Inadequate monitoring for Pu, Np, and fission products*
- **Qualified on March 13, 2015**
  - **Class Evaluated by NIOSH:** *All workers who worked in any location of the ANL-W from April 10, 1951 through December 31, 1979.*
    - Start date based on first radiological operation
    - End date modified because large number of Pu bioassay analyses available beginning in 1980
- **Evaluation Report (ER) sent to ABRWH on February 24, 2016**

# SEC-00224 Petition ER



Aerial Photo of the EBR-II Complex

# NIOSH-Proposed Class and HHS-Designated Class

“All employees of the Department of Energy, its predecessor agencies, and their contractors and subcontractors who worked at the Argonne National Laboratory-West between April 10, 1951 and December 31, 1957...”

- Not feasible to estimate internal and external exposures for this class due to the lack of personnel monitoring data
- Personnel monitoring data for mixed fission product (MFP) internal exposures and external exposures beginning in 1958

# NIOSH-Proposed Method for Bounding Internal Doses- With MFP Present

- Continue with current method for unmonitored actinide intakes given in ANL-W/INL Internal Dose TBD
  - ORAUT-TKBS-0007-5, Section 5.5.2
- Estimate Sr-90 or Cs-137 intakes from bioassay measurements
- Tables 5-22 (Sr-90) and 5-23 (Cs-137) provide ratios to assign the actinide intakes for different reactor fuel types

# NIOSH-Proposed Method for Bounding Internal Doses- Actinide-only Areas Identified in ER using 10% MPC

Exposure Location	Years	Exposure
EBR-I	After 1957	U
EBR-II: ZPPR	After 1957	U
EBR-II: FCF, ITF, FASB	08/1967 – 06/1983	U
EBR-II: FCF	08/1963 – 11/1967	Th
EBR-II: ZPPR	After 1957*	Pu
EBR-II: FCF	04/1970 – 12/1972	Pu

*\*no timeline given in ER; assumption is methodology would apply after the SEC class*

**SC&A Review of Petition Evaluation  
Report for SEC-00224, Argonne National  
Laboratory-West Regarding the Use of  
General Area Air Sampling for Internal  
Dose Assessment**

SCA-TR-2016-SEC009, Revision 0

# SC&A Area of Concern 1

- Use of GA samples with low airflow rates, led to sampling times of up to 4 days
- Reasonable assumption is:
  - Working hours air concentration >> non-working hours air concentration
- Measured airborne activity divided by total volume sampled (including air sampled during non-work hours) to yield average air concentration
- Potential for “sample dilution”

## SC&A Area of Concern 2

- Other nuclear fuel processing facilities have found lack of parity between air concentration results measured by GA samplers and those measured by lapel samplers
- Section 3.2 of SCA-TR-2016-SEC009 recommended multiplying the GA air samples results by a factor of 10 to resolve the lack of parity



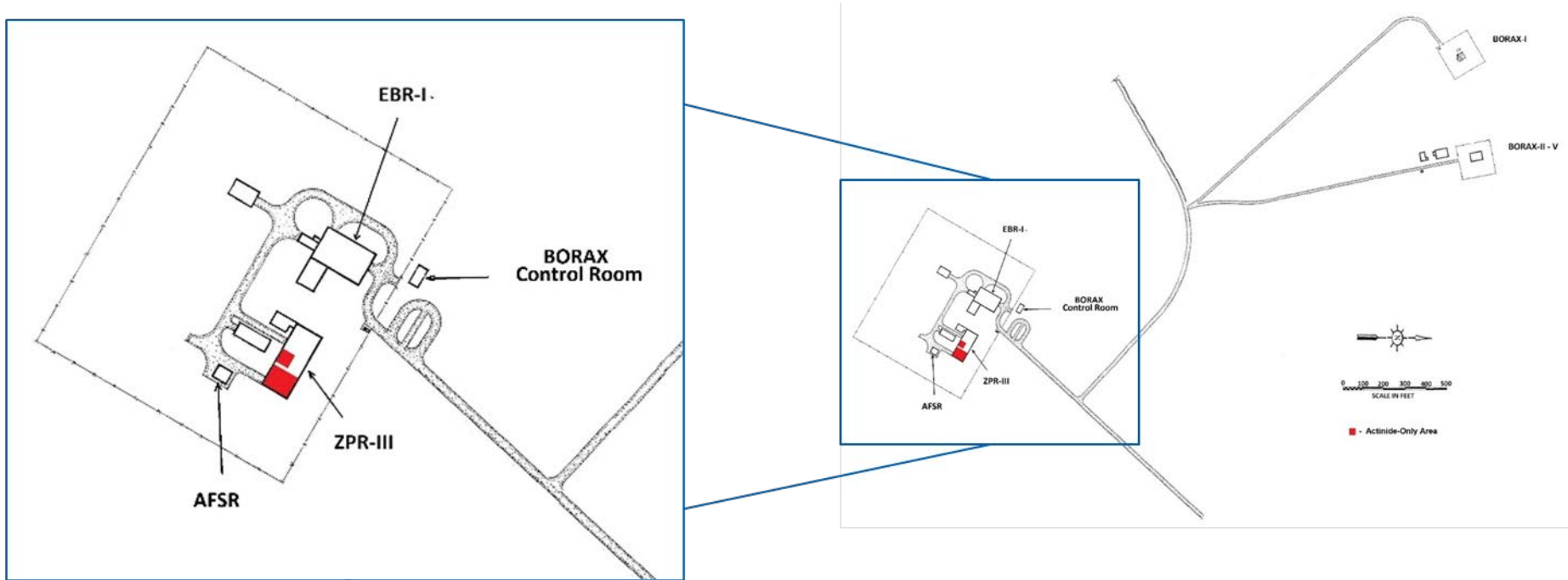
# **Evaluation of Issues in the Use of General Area Air Sampling for Argonne National Laboratory- West Internal Dose Assessment**

ORAUT-RPRT-0089

# Purpose of ORAUT-RPRT-0089

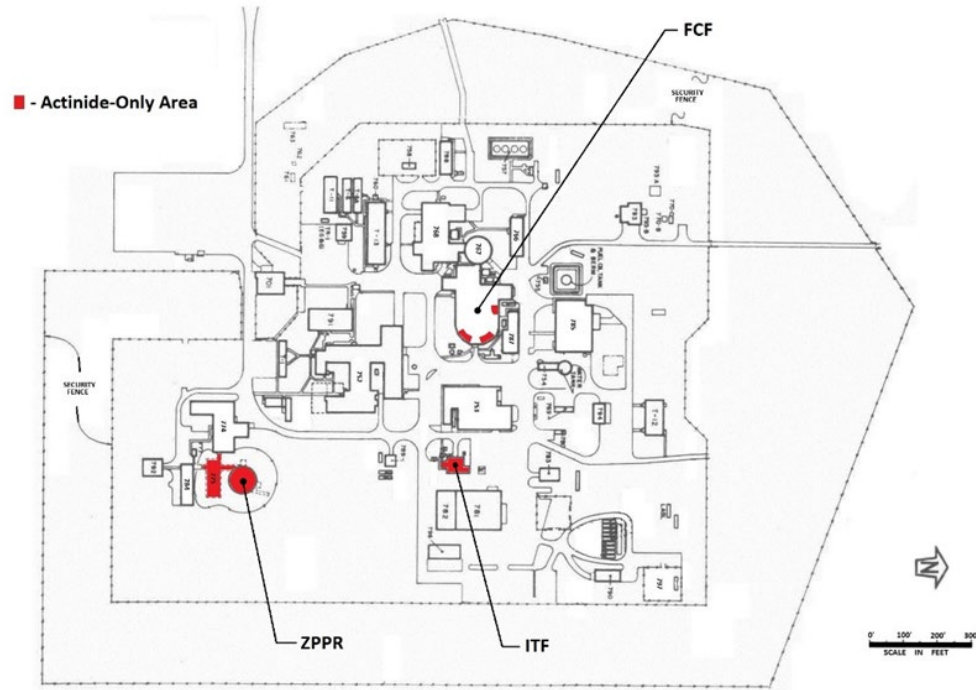
- Address two areas of concern raised in Section 4.0 of SCA-TR-2016-SEC009
- Provide additional details about the calculation of the unmonitored actinide intakes at ANL-W including:
  - Evaluation of ANL-W air sampling data
  - Date ranges for potential intake periods not already defined
  - Bases for deviations from the ER proposed methods

# EBR-I Complex Actinide-Only Areas



# EBR-II Complex Actinide-Only Areas

- **FCF:** Th, U, and Pu
- **ITF:** U
- **ZPPR:** Pu



# Exposure Potential By Area

Exposure Location	Years	Exposure
EBR-I	01/01/1958 – 06/13/1975	U
EBR-II: FCF, ITF	08/01/1967 – 06/30/1976	U
EBR-II: FCF	08/01/1963 – 11/30/1967	Th
EBR-II: ZPPR	09/01/1970 – 07/31/1975	Pu
EBR-II: FCF	04/01/1970 – 04/30/1973	Pu

# Air Sampling in ANL-W Actinide Only Areas

- Types of Sampling:
  - Fixed General Area (GA)
  - Portable GA
  - Fixed Breathing Zone (BZ)
  - Portable BZ
- Actinides measured by gross alpha
- Due to radon, ANL-W generally recounted sample until results dropped below level of concern (i.e., 10% or 1% MPC)
- 3 Types of Data Sheets over the Time Period

# Exposure Potential By Area + Bounding Method

Location	Exposure	Timeframe	Intake Assessment Method
EBR-I	U	01/01/1958 – 06/13/1975	10% MPC
EBR-II: FCF, ITF	U	08/01/1967 – 06/30/1976	Measured Air Concentrations
EBR-II: FCF	Th	08/01/1963 – 11/30/1967	Measured Air Concentrations
EBR-II: ZPPR	Pu	09/01/1970 – 07/31/1975	10% MPC
<b>EBR-II: FCF</b>	Pu	04/01/1970 – 04/30/1973	Measured Air Concentrations

*Shaded rows denote 10% MPC air concentration values.*

# Evaluation of Measured Air Sample Data (Step 1)

- **Compiled Air Sample Data Based on Exposure (4 datasets)**
- Data Adjustments
- Determined GA Air Concentration Distribution (GM, GSD)
- Adjusted GA Air Concentration to BZ Air Concentration (RPRT-0097)



# Example of Type 1 Air Sample Data

- Single air sample
- Significant amount of sample collection and analysis information

AIR SAMPLE DATA															
Date	Time on	Time off	Run Time	Suspected Activity			Protection Worn		First Count Factor		$\frac{88}{5}$				
10-18-63	1459	1157	1278 min	MPC(40) 132 dpm/M <sup>3</sup>			Supplied Air	<input type="checkbox"/>	Final Count						
Room	Flow Rate			MPC(40) 6600 dpm/M <sup>3</sup>			Assault Masks	<input type="checkbox"/>	Fraction of MPC						
25	— M <sup>3</sup> /hr ÷ 60						Respirators	<input type="checkbox"/>	>1X		<input checked="" type="checkbox"/> <input type="checkbox"/>				
Bldg.	— cfm ÷ 35.4						None	<input checked="" type="checkbox"/>	>10%		<input type="checkbox"/> <input type="checkbox"/>				
FCF									<10%		<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>				
Operation Code	Sampler Type	Volume													
Routine	Filtration	36.1 M <sup>3</sup>													
Filter Media	Counter(s) Used			Conversion Factor											
Gelman Glass E	RIOL Proportional			d/m/M <sup>3</sup> x 4.55 x 10 <sup>-43</sup> = µc/cm <sup>3</sup>											
Sampled By:	Counted By:		Self-Absorption Factor:												
Redacted	Redacted		α, 1.3 X												
Remarks: $\frac{1 \times 1278}{35.4} = 36.1 \text{ M}^3$															
Date and Time of Count	Total Count	GROSS COUNT				BKGD NET		Counter Yield	Self-Absorption Factor	Disintegrations Per Minute	d/m/M <sup>3</sup>	Percent of MPC	Type of Activity Counted	Decay Time	Initials
		Count Time in Minutes	Counts per Minute	Background Counts per Minute	Counts per Minute	Counts per Minute	Counts per Minute								
10-18-63 1205	2370	5	454	1	453	25	1.3	2356	65	49	<	8 min	PH		
1211	3093	5	619	43	566	19.1	—	2911	81	1.2	PH	14 min	PH		
1520	1412	5	282	43	239	19.1	—	1257	37	<1	PH	203 min	PH		
1525	828	5	166	1	165	25	1.3	856	24	18	<	208 min	PH		
10-24-63/1520	11	5	2	1	1	24.8	1.3	5	<1	<1	<	4253 min	PH		

Figure 4-1. Example of radioactive decay on an FCF air sample (ORAUT 2018a).

# Example of Type 2 Air Sample Data

- November 1973 Air Sample Data sheet was modified
- Multiple samples
- Focus on sample analysis information

AIR SAMPLE DATA																	
FORMULA $\frac{DPM}{t \cdot S} \times 1.59 \times 10^{-11} = \text{Ci/cc}$										RCG-40 $\rightarrow = 3 \times 10^{-9} \text{ Ci/cc - UNIDENTIFIED}$							
SAMPLER TYPE										$= 2 \times 10^{-12} \text{ Ci/cc - Pu}$							
COUNTER TYPE										$= 5 \times 10^{-11} \text{ Ci/cc - UNIDENTIFIED}$							
DATE & TIME	LOCATION	CFM	RUN TIME	VOL. FT. 3	ARS. FACTOR	COUNT TIME	GROSS COUNT	BKG.	NET CPM	YIELD	DPM	Ci/cc	RATIO	DECAY TIME	% RCG	INIT.	REMARKS
4/3/75 1115 hrs	Rm 26	1	10370	10370	-	5min	717	87	56	33%	168	$2.57 \times 10^{-13}$	3	5525	<10		on 1026 hrs 5/20/75 off 1510 hrs. 5/30/75
4/10/75 1020	Rm 26	1	10080	10080	-	5min	120	88	32	33%	96	$1.52 \times 10^{-13}$	5.9	5455	<10	KP	on 5/20/75 1510 hrs off 6/4/75 1510 hrs
4/19/75 0930	Rm 26	1	14000	14000	-	5min	1072	91	121	34%	350.9	$4.61 \times 10^{-13}$	3	1650	<10		on 4/6/75 off 6/16/75
4/27/75 0940	Rm 20	1	436	436	-	5min	1167	81	152	33	456	$1.6 \times 10^{-13}$	3.1	1100	<1		
4/27/75 1340	Rm 20	1	436	436	-	5min	635	81	46	33	138	$5.16 \times 10^{-14}$	3	1850	<1	KP	Account of above air sample
7/11/75	R 20	1	2394	2394	-	5min	693	85	51	38	103	$6.88 \times 10^{-14}$	2.2	35min	<1		
7/11/75	R 20	1	2394	2394	-	5min	86	2.0	15	31	46.5	$3.11 \times 10^{-13}$	1	40min	<1	KP	
7/11/75	Rm 26	1	19160	19160	-	5min	1915	85	298	33	894	$7.44 \times 10^{-13}$	3.5	45	<1		
7/18/75	Rm 26	1	19160	19160	-	5min	420	2.0	82	31	287.2	$2.12 \times 10^{-13}$	1	50	<1	KP	
7/18/75	Rm 26	1	10081	10081	-	5min	2633	85	142	38	412	$6.54 \times 10^{-13}$	1.1	195min	<1		
7/18/75	Rm 26	1	11081	10081	-	5min	690	2.0	136	34	395	$6.27 \times 10^{-13}$	1	190min	<1	KP	

Figure 4-5. Example of a post-April 1975 air sample record (ORAUT 2018b).

# Example of Type 3 Air Sample Data

- EBR-II Uranium data set for 1967-1969
- Routine (monthly) and non-routine health physics reports
- Reported number of air samples above, below, or at a given percentage of the MPC or RCG

## EBR-II (Cold Line - Fuel Cycle Facility and Inspection Test Facility)

There were 45 routine and special health physics surveys performed during the month. All air samples taken during the 13 openings of the Injection Casting furnace showed < 10% RCG(40)  $\alpha$ ,  $\beta\gamma$ .

A contamination survey of a vacuum pump that was removed from the Injection Casting furnace system to be repaired showed up to 900 dis/min/100 cm<sup>2</sup>  $\alpha$  in the interior on 12-19-67. An air sample taken during the removal and replacement of the pump showed < 10% RCG(40)  $\alpha$ ,  $\beta\gamma$ . The pump was repaired in the FCF basement without spread of contamination.

Alpha contamination was removed from W. Hurum's shoe after it was detected on the  $\alpha$  hand and foot monitor at the entrance to FCF Room 20 on 12-13-67. The monitor had alarmed at 500 counts/min. A survey of room 20 showed the floor to be  $\alpha$  contaminated up to > 500 counts/min/100 cm<sup>2</sup> between the hoods. Room 20 was posted as a shoe cover area. No  $\beta\gamma$  contamination was detected.

# Evaluation of Measured Air Sample Data (Step 2)

- Compiled Air Sample Data Based on Exposure (4 datasets)
- **Data Adjustments**
  - Applied alpha self-absorption factor 1.3
    - Except when documented it was accounted for in data
  - Adjusted for potential sample dilution
    - Except short duration samples
- Determined GA Air Concentration Distribution (GM, GSD)
- Adjusted GA Air Concentration to BZ Air Concentration (RPRT-0097)

# Data Adjustments – Sample Dilution

## Type 1

- Calculate the average air concentration using operational time during the sampling period
- Assumes airborne radioactivity drops to 0 during non-operational times

## Type 2 Data

- Calculate the average air concentration with total sampler run-time
- Assume workers exposed to average air concentrations around the clock

**Type 3 Data** assumed to be short duration samples; not adjusted for sample dilution

# Evaluation of Measured Air Sample Data (Step 3)

- Compiled Air Sample Data Based on Exposure (4 datasets)
- Data Adjustments
- **Determined GA Air Concentration Distribution (GM, GSD)**
- Adjusted GA Air Concentration to BZ Air Concentration (RPRT-0097)

# Statistical Evaluation to Determine the GA Air Concentration Distribution

- Regression on order statistics
- 0 dpm/m<sup>3</sup> results evaluated with censoring level of <0.01 dpm/m<sup>3</sup>
- Some reported results included other censoring levels imposed by ANL-W
  - <1% of MPC, <10% of MPC
- Weighted linear regression with sampling time as the weight
  - Except May 1975 through June 1976 uranium data had a better fit using an unweighted regression

# EBR-II Uranium Air Monitoring Data

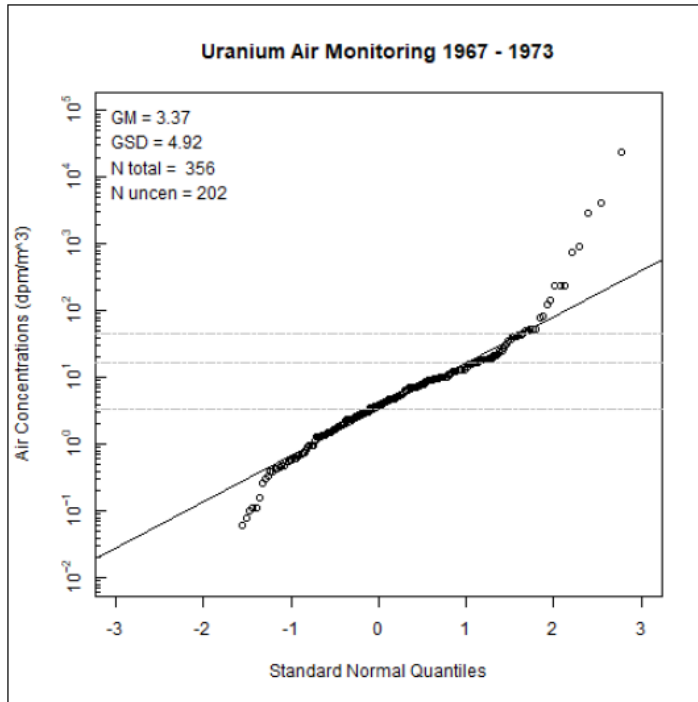


Figure A-2. FCF Cold-Line air data, August 1967 to March 1973 (ORAUT 2021g).

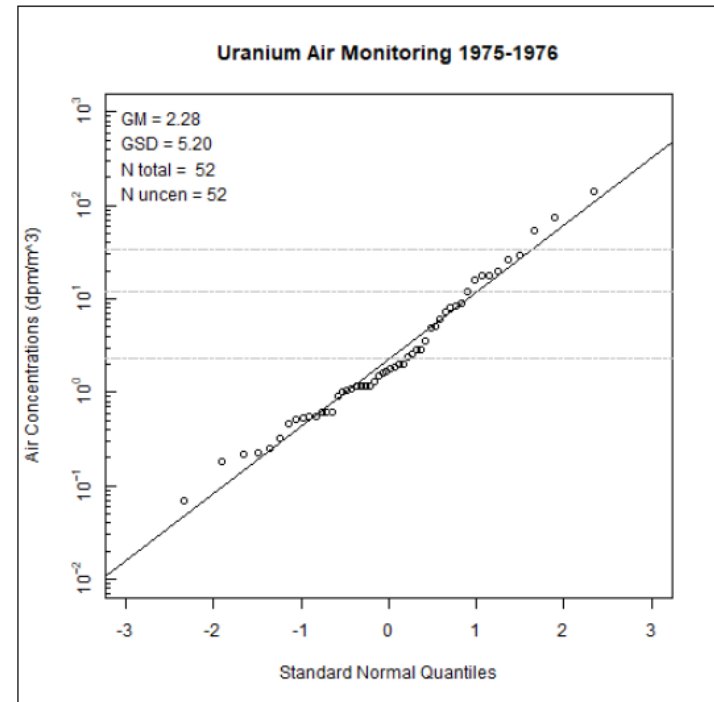


Figure A-3. FCF Cold-Line air data, May 1975 to June 1976 (ORAUT 2021g).



# EBR-II Thorium Air Monitoring Data

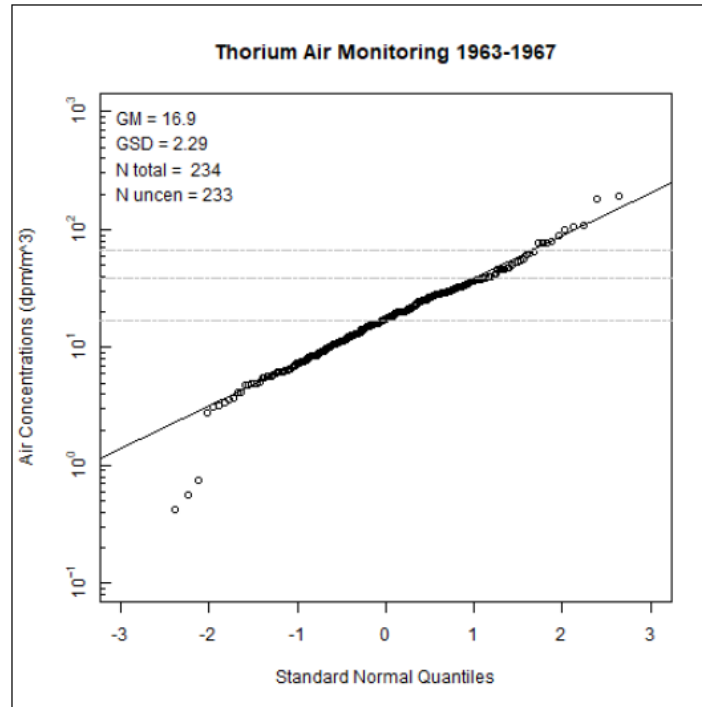


Figure A-1. FCF Room 25 (thoria room) air data, August 1963 to November 1967 (ORAUT 2021g).

# EBR-II Non-ZPPR Plutonium Air Monitoring Data

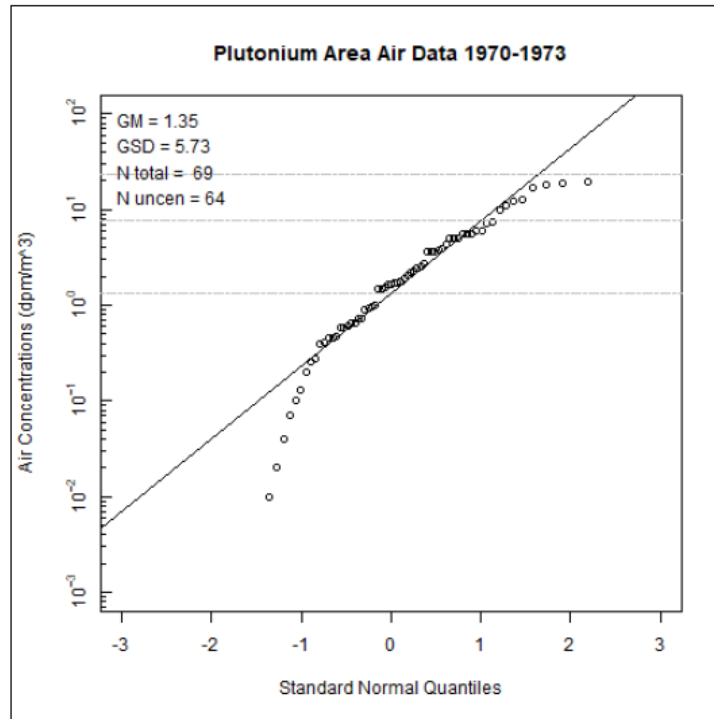


Figure A-4. FCF RAS-TREAT sodium-loop air data, April 1970 to April 1973 (ORAUT 2021g).

# Determination of Air Concentration for the 10% MPC

- MPC from available air sampling data sheets
- Converted from % MPC to air concentration in dpm/m<sup>3</sup>

# Evaluation of Measured Air Sample Data & 10% MPC (Step 4)

- Compiled Air Sample Data Based on Exposure (4 datasets)
- Data Adjustments
- Determined GA Air Concentration Distribution (GM, GSD)
- **Adjusted GA Air Concentration to BZ Air Concentration (RPRT-0097)**

# Adjusting GA Air Concentrations to BZ Air Concentrations (ORAUT-RPRT-0097)

- All air measurements assumed to be GA
- 10% MPC and measured air concentrations were adjusted using factors in ORAUT-RPRT-0097
- Use of adjustment factors from ORAUT-RPRT-0097 must be justified for use at particular sites

# Justifying Application of ORAUT-RPRT-0097 at ANL-W

## 1. Room Size (24.0 to 105.0 m<sup>2</sup>)

- Table 6-1 shows actinide-only areas generally  $\leq 92.3$  m<sup>2</sup>

## 2. Particle Size Distribution (respirable)

- No indication of particle size measurements at ANL-W, nor that samplers removed non-respirable particles
- ANL-W samples likely include non-respirable particles (result in overestimate of intake)

Process Area (actinide)	Total Area (m <sup>2</sup> )
FCF Rm 20 (U)	62.4
FCF Rm 22 (U)	62.4
FCF Rm 23 (U)	49.1
FCF Rm 25 (Th)	34.3
FCF Rm 26 (U)	53.7
FCF Rm 27 (Pu)	20.6
FCF Rm 28 (Pu)	44.5
FCF Rm 29 (Pu)	92.3
ITF Low Bay Area (U)	Unknown
ZPR-III Workroom (U)	28.1
ZPPR Workroom (Pu)	154.4

# Justifying Application of ORAUT-RPRT-0097 at ANL-W (cont.)

## 3. Ventilation Rate (6 to 90 AC/hr)

- Not known for ANL-W
- It is unlikely ANL-W AC rates would fall outside of the range

## 4. Room Complexity

- Available floor plans for ANL-W (Attachment B) depict they are comparable to the room complexity and ventilation flow patterns in RPRT-0097

## 5. Dominant Particles

- No indication of airborne dominant particles at ANL-W in the records

# RPRT-0097 Scenario Applicable to ANL-W Actinide Only Areas

- **Scenario 1: Worker always at same location as release**
  - 2 subgroups based on room configuration: open in the middle and obstructions in the middle
- **Scenario 2: Worker not necessarily located at same location as release**
- **Scenario 2 (GM = 1.08, GSD = 4.02) most appropriate for ANL-W because**
  - Unmonitored intakes assessed as chronic exposures
  - Most actinide-only workrooms have multiple workstations
  - Intermittent nature of work means workers would have moved around



# Intake Assumptions

- **10% MPC and Type 1 Measured Air Concentrations (adjusted for sample dilution)**
  - 2,000h per year exposure time
  - 1.2 m<sup>3</sup>/h breathing rate
  - Convert to intake per calendar day
- **Type 2 Measured Air Concentrations (intake adjusted for sample dilution)**
  - Calculate intake per calendar day assuming 24h exposure
- **Ingestion calculated following OCAS-TIB-009 guidance**
  - Type 2 data- calculate the equivalent to the adjusted BZ air concentration

# Intake Assignment

Location & Exposure	Time Period	Air Conc. (dpm/m <sup>3</sup> )	Inh Intake (pCi/d)	Ing Intake (pCi/d)	GSD
<b>EBR-I: U</b>	01/01/1958 – 07/31/1961	7.0	20.7	0.430	4.02
	08/01/1961 – 06/13/1975	13.2	39.1	0.810	4.02
<b>EBR-II: U</b>	08/01/1967 – 12/31/1974	(3.37, 4.92)	10.8	0.223	8.29
	01/01/1975 – 06/30/1976	(2.28, 5.20)	31.9	0.662	8.65
<b>EBR-II: Th</b>	08/01/1963 – 11/30/1967	(16.9, 2.29)	54.1	1.12	5.05
<b>EBR-II: ZPPR Pu</b>	09/01/1970 – 07/31/1975	0.44	1.4	0.029	4.02
<b>EBR-II: Non-ZPPR Pu</b>	04/01/1970 – 04/30/1973	(1.35, 5.73)	4.32	0.0828	9.32

*Shaded rows denote 10% MPC air concentration values. Measured air concentration data reported as (GM, GSD).*

**NIOSH Response to Areas of Concern from  
SCA-TR-2016-SEC009 regarding Use of  
General Area Air Sampling for Internal  
Dose Assessment**

# Reminder: SC&A Area of Concern 1

- Use of GA samples with low airflow rates, led to sampling times of up to 4 days
- Reasonable assumption:
  - Working hours air concentration >> non-working hours air concentration
- Measured airborne activity divided by total volume sampled (including air sampled during non-work hours) to yield average air concentration
- Potential for “sample dilution”

# NIOSH Response

## Area of Concern 1

- **NIOSH agrees sample dilution is a concern and performed an evaluation of the data for the actinide only areas**
- **NIOSH adjusted air concentrations or intakes to account for sample dilution**
  - Air concentrations adjusted using operational time to calculate average air concentration
  - Intakes adjusted by assuming worker was exposed to unadjusted average concentration 24h/d 365d/year

## Reminder: SC&A Area of Concern 2

- Other nuclear fuel processing facilities have found lack of parity between air concentration results measured by GA samplers and those measured by lapel samplers
- Section 3.2 of SCA-TR-2016-SEC009 recommended multiplying the GA air samples results by a factor of 10 to resolve the lack of parity

# NIOSH Response

## Area of Concern 2: Factor of 10

- **Factor of 10 based on data from only two studies completed in 1967**
  - Brunskill and Holt at NUMEC
  - Caldwell, Potter, and Schnell at UK Works Sites
- **Studies completed before significant sources of error with lapel sampling were known**
  - Including lapel samplers sampling contamination from protective clothes and non-respirable size particles, as well as the presence of dominant particles
- **NIOSH disagrees with applying a factor of 10 and instead further investigated the lack of parity**

# NIOSH Response

## Area of Concern 2, Part 1: Lack of Parity

- **Lack of parity between air concentrations measured by GA and lapel samplers is a common discussion for many EEOICPA covered sites**
- **ORAUT-RPRT-0097: Breathing Zone to General Area Air Concentration Ratios in Small Workrooms**
  - “When the median of the BZ:GA ratio distribution becomes significantly greater than 1 or the GSD becomes large, GA concentrations should be adjusted to make them equivalent to BZ air concentrations”
  - Provides default adjustment factors and approach for determining applicability at specific sites



# NIOSH Response

## Area of Concern 2, Part 1: Lack of Parity, Continued

- **NIOSH adjusted the GA air concentrations for ANL-W by applying RPRT-0097, Scenario 2 BZ:GA ratio distribution**
  - GM = 1.08, GSD = 4.02
- **Application of the BZ:GA ratio distribution:**
  - adjusts the GA air concentrations to be equivalent to BZ air concentrations
  - accounts for the increased uncertainty in the BZ air concentrations
- **SCPR review of RPRT-0097 resulted in 2 observations**
  - Observations were closed at the November 2023 meeting
  - SCPR interested in RPRT-0089 because first application of RPRT-0097

# Questions?

