ORAU TEAM Dose Reconstruction Project for NIOSH

Oak Ridge Associated Universities | Dade Moeller | MJW Technical Services

DOE Review Release 03/18/2013

Document Title:	Document Number:	ORAUT-RPRT-0057
A Method for Estimating Stable Metal Tritide Exposures to Tritium Ancillary Workers Based on Swipe Data in Rooms SW-8, SW-13, SW-150 and R-108 at the Mound Laboratory 1968 to 1989	Revision:	00
	Effective Date:	03/07/2013
	Type of Document:	Report
	Supersedes:	None

Subject Expert(s): Karin A. Jessen, Samuel L. T. Chu, Robert L. Morris, Leo G. Faust, Melton H. Chew, Eugene W. Potter, Billy Smith

Approval:	Signature on File Karin A. Jessen, Document Owner	Approval Date:	03/05/2013
Concurrence:	Signature on File Daniel H. Stempfley, Objective 4 Representative	Concurrence Date:	03/06/2013
Concurrence:	Vickie S. Short Signature on File for Kate Kimpan, Project Director	Concurrence Date:	03/06/2013
Approval:	Signature on File James W. Neton, Associate Director for Science	Approval Date:	03/07/2013

☒ New ☐ Total Rewrite ☐ Revision ☐ Page Change

FOR DOCUMENTS MARKED AS A TOTAL REWRITE, REVISION, OR PAGE CHANGE, REPLACE THE PRIOR REVISION AND DISCARD / DESTROY ALL COPIES OF THE PRIOR REVISION.

PUBLICATION RECORD

EFFECTIVE DATE	REVISION NUMBER	DESCRIPTION
03/07/2013	00	This report defines a dose reconstruction method for Mound workers who may have been incidentally exposed to stable metal tritide (SMT) compounds in the SW/R Tritium Complex (SRTC), but who were not assigned to directly handle SMTs. SMTs are type S tritium compounds that are insoluble in lung fluids. The method defines an annual intake of SMTs based on a claimant-favorable estimate of removable tritium surface contamination, a chronic resuspension factor (5 ×10-5 m-1) that modifies the surface contamination level resulting in an airborne radioactivity concentration, and full-time worker occupancy (2000 hr/yr) in the contaminated area. The method is applicable for the period March 6, 1980 through December 31, 1999. March 5, 1980 is the date when SEC-00171, which covers every potentially-exposed tritium worker, ends. December 31, 1999 is the date when there is confidence that the dosimetric problems associated with SMT exposure were adequately addressed by the Mound radiation safety staff. The method may also be useful for reconstruction of doses associated with non-presumptive cancers during the SEC-00171 period. Incorporates formal internal and NIOSH review comments. Training required: As determined by the Objective Manager. Initiated by Karin A. Jessen.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

ABRWH	Advisory Board on Radiation and Worker Health
AMAD	activity median aerodynamic diameter
cm	centimeter
cpm	counts per minute
DCAS	Division of Compensation Analysis and Support
DCF	dose conversion factor
DE	dose equivalent
DOE	U.S. Department of Energy
dpm	disintegrations per minute
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
GM	geometric mean
GSD	geometric standard deviation
hr	hour
IMBA	Integrated Modules for Bioassay Analysis
LN(TH)	trachea, bronchi, bronchioles, alveolar ducts, and sacs
LS	liquid scintillation
m	meter
MAE	minimum absolute error
NIOSH	National Institute for Occupational Safety and Health
NRC	Nuclear Regulatory Commission
ORAU	Oak Ridge Associated Universities
ORAUT	Oak Ridge Associated Universities Team
R	Research
RF	resuspension factor
SEC	Special Exposure Cohort
SMT	stable metal tritide
SRDB Ref ID	Site Research Database Reference Identification number
SRTC	SW/R Tritium Complex
SW	Semi-Works
WG	Working Group
yr	year
μCi	microcurie
μm	micrometer

1.0 EXECUTIVE SUMMARY

The report defines a dose reconstruction method for Mound workers who may have been incidentally exposed to stable metal tritide (SMT) compounds in the SW/R Tritium Complex (SRTC), but who were not assigned to directly handle SMTs. SMTs are type S tritium compounds that are insoluble in lung fluids. The method defines an annual intake of SMTs based on a claimant-favorable estimate of removable tritium surface contamination, a chronic resuspension factor (5×10^{-5} m^{-1}) that modifies the surface contamination level resulting in an airborne radioactivity concentration, and full-time worker occupancy (2000 hr/yr) in the contaminated area.

The method is applicable for the period March 6, 1980 through December 31, 1999. March 5, 1980 is the date when SEC-00171, which covers every potentially-exposed tritium worker, ends. December 31, 1999 is the date when there is confidence that the dosimetric problems associated with SMT exposure were adequately addressed by the Mound radiation safety staff. The method may also be useful for reconstruction of doses associated with non-presumptive cancers during the SEC-00171 period.

The estimate of removable tritium surface contamination is based on analysis of more than 60,000 tritium swipe results taken in Rooms SW-150, SW-13, R-108 and SW-8. In some periods all of the surface contamination data for a period of time and specific location are available. In those cases the full set of data are fit to lognormal distributions and the 95th percentile values are used. For other periods only “high, low, and average” trend data are available. In those cases the geometric mean (GM) of the high data are used. For some years the results must be combined on a time-weighted basis, with preference given to 95th percentile values when they are available.

The following recommendations are provided to dose reconstructors:

1. For workers who are known to have worked directly with SMT (a list identifying SMT workers exists):

   - Calculate SMT dose to the organ of interest assuming all of the tritium measured in urine bioassay samples is the result of SMT intakes.

   - Calculate dose to the organ of interest assuming the tritium excreted in urine is entirely associated with exposure to soluble tritium compounds, such as tritiated water.

2. Select the result that provides the highest dose to the organ of interest.

3. For all other workers who were monitored for tritium:

   - Calculate dose to the organ of interest assuming the tritium excreted in urine is entirely associated with exposure to soluble tritium compounds, such as tritiated water.

   - Calculate SMT dose to the organ of interest using the method specified in this report.

   - Add both quantities to determine the dose to the organ of interest.

2.0 INTRODUCTION

Most of the tritium exposure at Mound was associated with tritiated water which is soluble in biological fluids, is quickly excreted, and is readily measured using urine bioassay. This kind of tritium exposure is amenable to dose reconstruction using ordinary methods (ORAUT 2007). In contrast, some metal tritide compounds are insoluble and are retained in the lung and other respiratory tissues for long times, potentially causing high doses to the respiratory tract and much small doses to all other organs or tissues. Consequently a different approach to dose reconstruction is required in situations where exposure to insoluble metal tritides may have occurred. These insoluble metal tritide compounds are often called “stable metal tritides” (SMTs).

This report documents a method for SMT dose reconstruction that may be used at Mound. The method requires knowledge of the tritium contamination levels present in the work place and includes assumptions about a chronic resuspension of workplace contamination, occupancy times in the contaminated workplace, and breathing rate of the worker.

By the late 1990s D&D was underway at Mound and the problems associated with dosimetry of SMTs were recognized and adequately addressed. The Mound Internal Dosimetry TBD that first addressed SMTs was published in January 2000 (BWXT 2000). Consequently this dose reconstruction method is not necessary after December 31, 1999.

SEC-00171 (HSS 2010) has been approved for all Mound workers who had a tritium bioassay between March 1, 1959 and March 5, 1980. Tritium workers were identified as being coincident with workers who may have been exposed to elevated and unmonitored levels of occupationally enhanced radon, which was the basis for the SEC. In effect everyone who could have been exposed to SMT prior to March 6, 1980 is already in an SEC Class.

The dose reconstruction method described in this report is intended for use as a “best estimate” method for SMT exposures for workers who did not directly handle SMTs. This guidance is applicable for exposures that may have occurred after March 5, 1980 and before 2000. It may also be useful for dose reconstruction for non-presumptive cancers at earlier dates.

Guidance for dose reconstruction for the specifically identified people who directly handled SMT is also provided.

Although this report is applicable only at the Mound site, the approach defined in this report may be applied at any site where SMT exposure may have occurred if sufficient contamination survey data are available.

3.0 WORKPLACE DESCRIPTION

Tritium research, development, analytical recovery, enrichment, and surveillance activities occurred in the SW/R Tritium Complex (SRTC) on the Mound Laboratory site. The SW/R Tritium Complex consisted of the Semi-Works (SW) Building and two rows of rooms in the adjacent Research (R) Building that were converted to tritium operations. Figure 1 shows the floor plan layouts of the SRTC. SRTC tritium operations started in these rooms in the 1960s and continued beyond the 1980s.

The focus of this report is the following four rooms in the SRTC:

- SW-150, which housed the gas synthesis, high pressure gas loading, pinch weld, gas tungsten arc welding, and component functional testing systems.
- SW-13, which housed the gas synthesis system, the tritiated water synthesis and sampling system, and the metallurgical analysis processes.
- R-108, which housed and tritium recovery operations that included solid tritiated metal compounds, gas recovery, and purification from other tritium-handling processes.

- SW-8, which housed the effluent removal system and was involved in tritium enrichment, recovery process technology, and the processing and containment of tritium-contaminated scrap from Mound activities as well as scrap generated at other DOE sites.

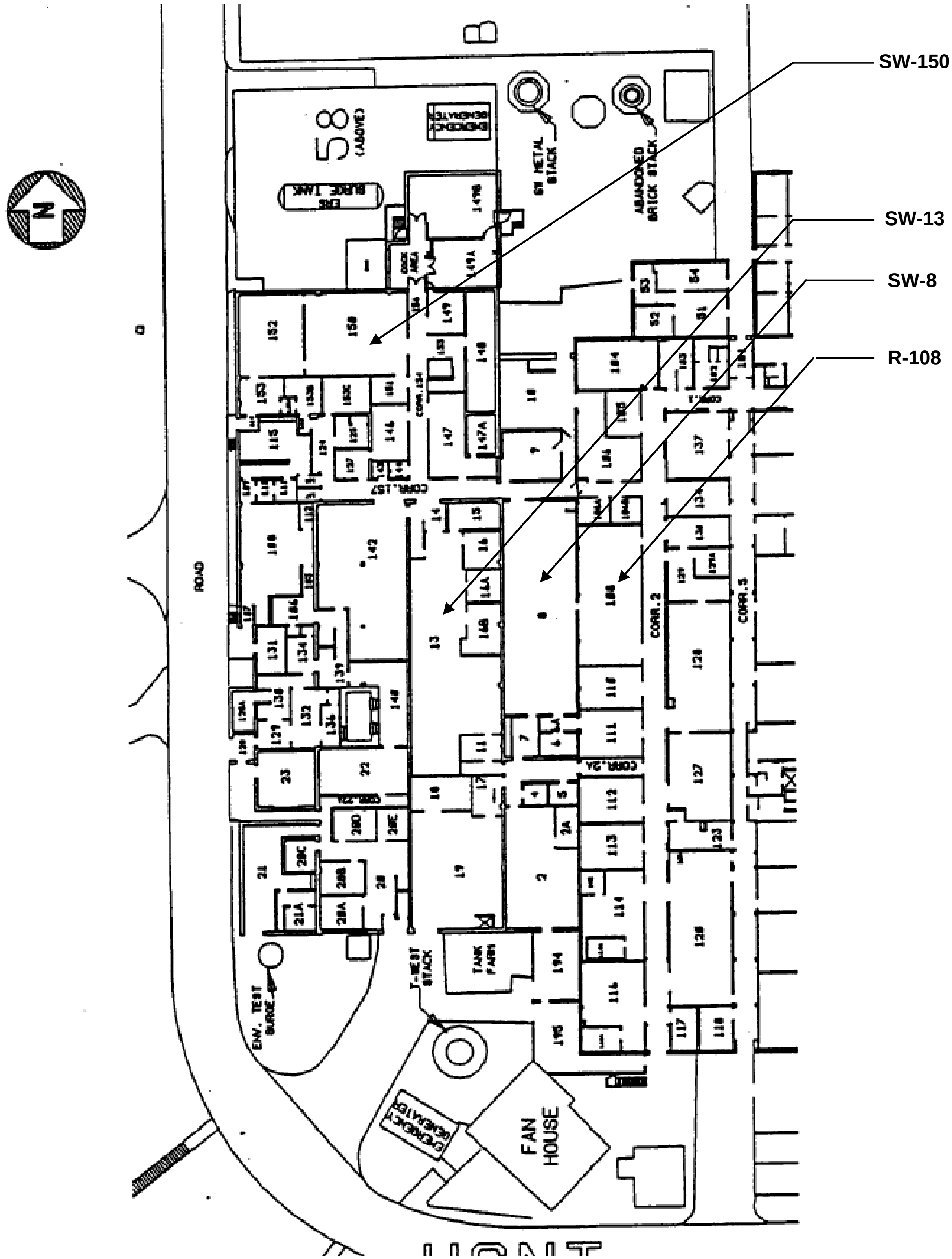


Figure 1. SW/R Complex layout – first floor (SRDB Ref ID 26833).

Mound had a comprehensive tritium urinalysis program. Workers who entered these rooms participated in this program.

The identities of the small number of primary SMT workers who were involved with the direct handling and processing of SMTs are known (Chew et al 2012). Urine bioassay results for these specifically identified workers should be interpreted as though they were entirely associated with exposure to SMT if the organ of interest is in the respiratory tract. Digestive tract organs and tissues should also be evaluated as it is possible that the dose to these organs may be larger if the exposure is evaluated as an insoluble form as opposed to a soluble form of tritium.

Unlike the primary SMT workers, the only plausible mechanism for SMT intake for support and ancillary workers was via resuspended removable surface contamination. Under this circumstance, the urinalysis program could fail to detect SMT intakes with adequate sensitivity.

4.0 SURVEY DATA AND CONTAMINATION LEVELS

4.1 SURVEY DATA

The routine contamination swipe data used in this report were obtained from a set of Building Contamination Surveys (Wipe Samples) Reports for the R and SW Buildings. More than 10,900 SRDB documents and more than 220,000 pages were reviewed. Twenty-nine (29) of those reports contained swipe data reported on a routine basis for Rooms SW-150, SW-13, R-108, and SW-8 for the period between 1968 and 1989 (Caldwell 1991). Additional citation information for the source documents is in the Reference section identified as author “Unk.”. Typical locations in the rooms where swipe samples were taken are shown in Figure 2, Figure 3, Figure 4 and Figure 5.

In general, when only the high, low and average swipe values were reported, as shown in Figure 6, the high value, each of which is an independent data point, was used as discussed in Section 4.3.

Figure 7 shows the yearly swipe sample populations of the four rooms in the 22-year period. A total of 60,264 swipe data values were used for all four rooms.

4.2 DATA GAPS

Figure 7 shows swipe sample data availability for the rooms during the operational period from 1968 to 1989. Gaps exist in the swipe data. The gap periods could be an entire year or could be several months within a given year. This raises the question of what work or incident (if any) had occurred during the data gap periods that could cause anomalies of the trending on either side of the gap.

The developmental and production work with the SMTs occurred primarily in SW-150 and SW-13 in the SW/R Tritium Complex. This work was done throughout the period from 1968 through 1989 (SRDB Ref ID 107797). The developmental and production work was well defined and would not deviate from the functionality of the equipment housed in the rooms. Incidents that cause a SMT release are reportable and dose assessments would have been performed for the personnel that were exposed. For these rooms, the swipe results on either side of the gap periods can be used to extrapolate data in the gap periods.

The tritium scrap recovery work in R-108 was the primary work during the intermittent gap periods beginning in the 1980s. The recovery of SMT contaminated scraps occurred in 1984 (SRDB Ref IDs 107797, 116978 and 116979). SW-8, which housed the effluent removal system and was involved in the processing and containment of tritium-contaminated scrap from Mound activities as well as scrap generated at other DOE sites. These rooms are susceptible to “off-spec” scrap materials that could have impacted the contamination level within the data gap periods.

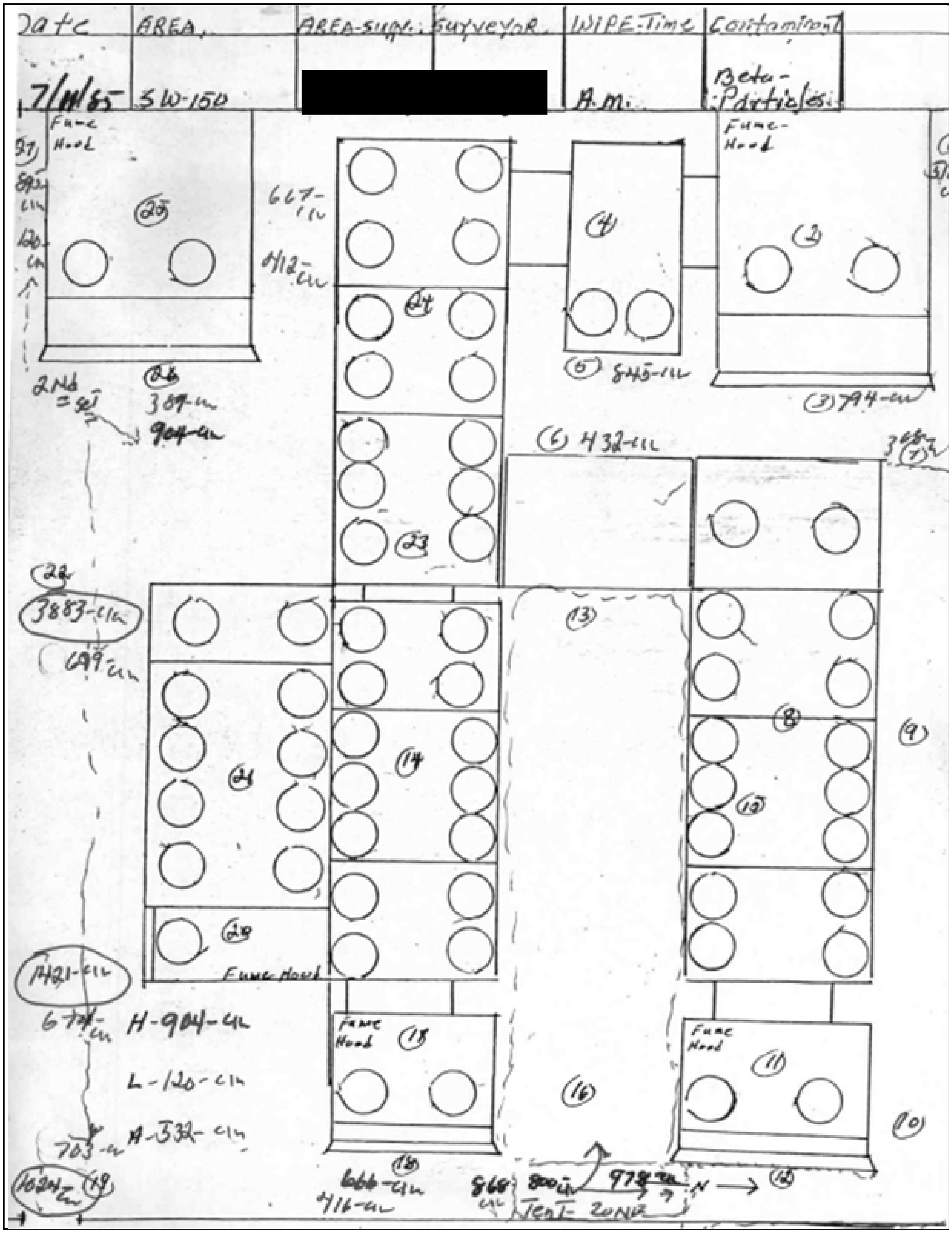


Figure 2. Typical contamination swipe locations in Room SW-150.

The trending of tritium doses to workers as determined through urine analyses can serve as an indicator of unspecified high activity operations in any given time period. Figure 8 shows the relationship between the swipes and the average worker tritium dose, by period, for Room 108 from 1983 to 1989. Figure 9 shows the relationship between the swipes and average worker tritium dose, by period, for Room SW-8 for years 1980 to 1989. The average doses were the average dose for the

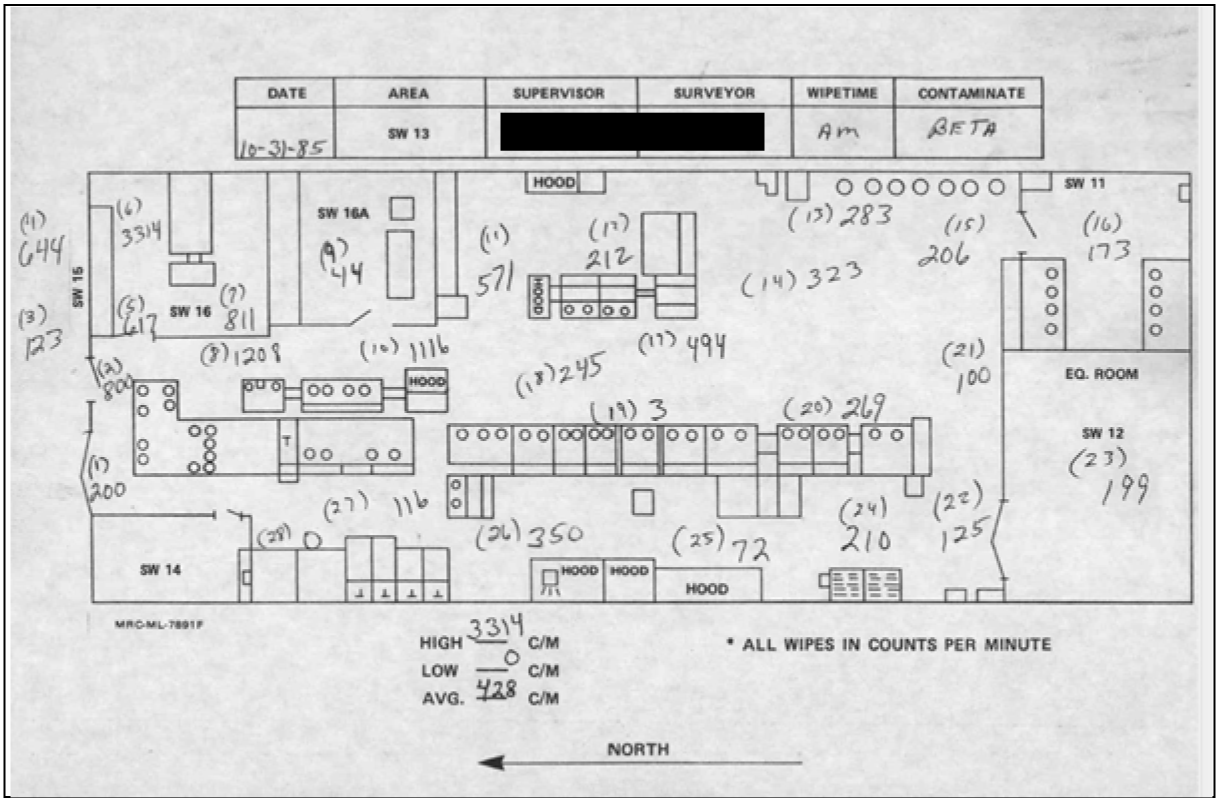


Figure 3. Typical contamination swipe locations in Room SW-13.

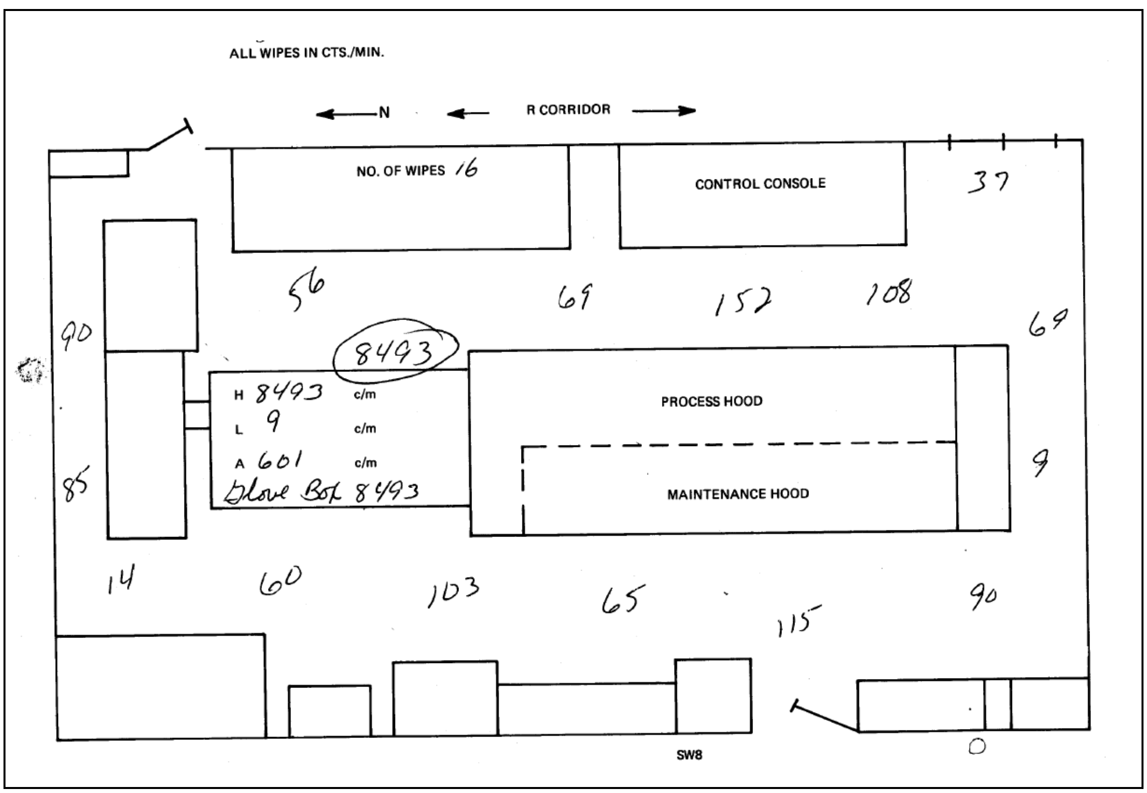


Figure 4. Typical contamination swipe locations in Room R-108.

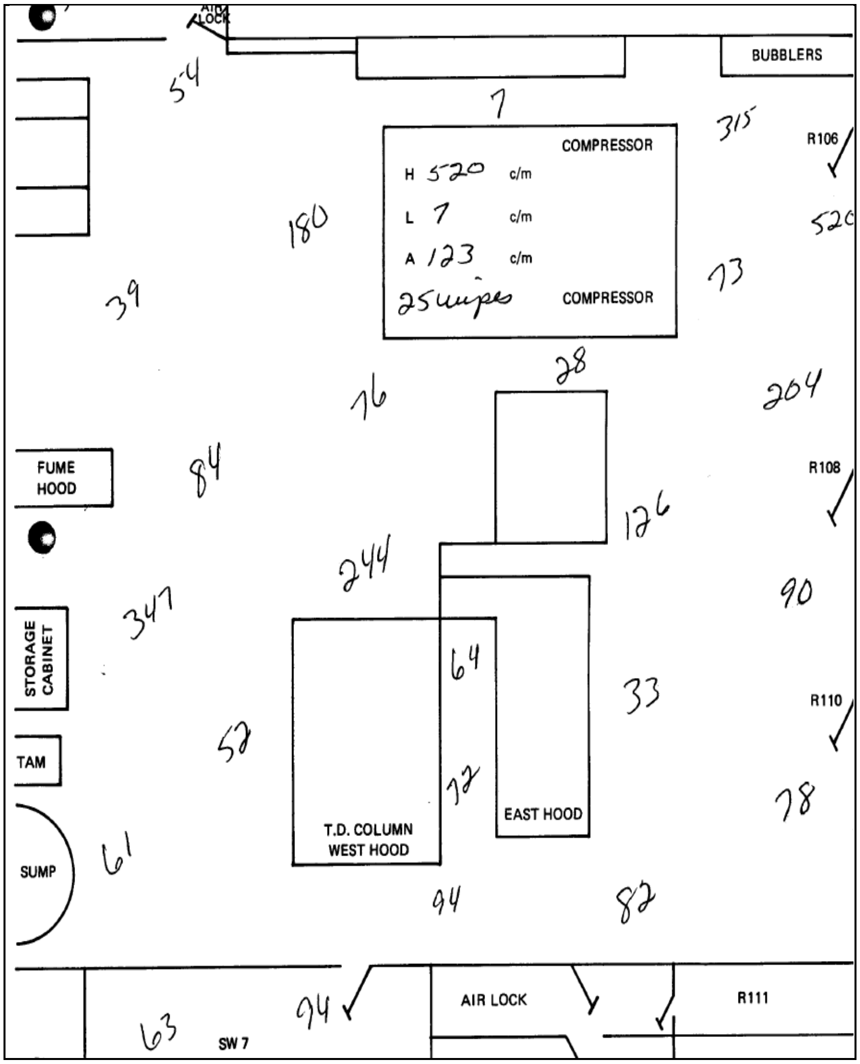


Figure 5. Typical contamination swipe locations in Room SW-8.

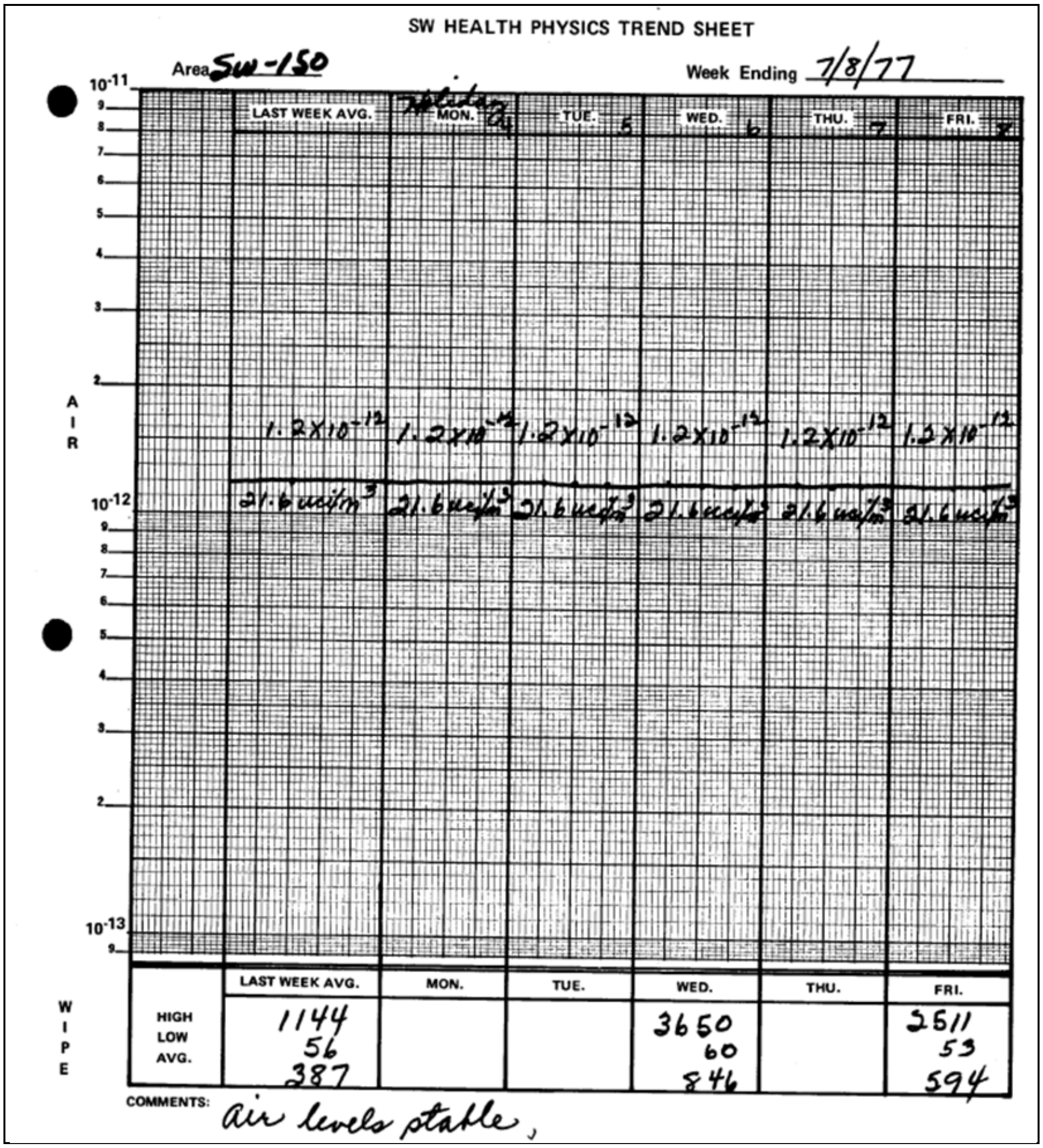
top 50% of annual doses obtained from the HP_TRITIUM Table in the MESH database (Chew et al 2012). The dose value trending is overlaid onto the data gap periods in both Figures.

Both of these graphs indicate that the doses were not trending upward as a result of unusual high activity during operations or scrap recovery that could result in increased uptakes during the gap periods. This supports the position that the swipe results on either side of the gap periods can be used to extrapolate data in the gap periods for R-108 and SW-8.

4.3 FITTING CONTAMINATION DATA TO LOGNORMAL DISTRIBUTIONS AND ESTABLISHING A FAVORABLE ESTIMATE OF CONTAMINATION LEVELS

For some periods of time the entire contamination swipe data set measured for a particular room is available. In other periods only “high, low and average” trend data (see Figure 6) are available. And for some periods no swipe data are available as discussed in Section 4.1. When full data sets and trend data are available for the same period, full data sets are preferred.

When all measured swipe values for a period are available these data are fit to a lognormal distribution to define the 95th-percentile contamination levels for that period of time, using the following approach.



SW HEALTH PHYSICS TREND SHEET

Area SW-150 Week Ending 7/8/77

LAST WEEK AVG.	MON. 4	TUE. 5	WED. 6	THU. 7	FRI. 8
1.2×10^{-12}	1.2×10^{-12}	1.2×10^{-12}	1.2×10^{-12}	1.2×10^{-12}	1.2×10^{-12}
21.6 uci/m^3	21.6 uci/m^3	21.6 uci/m^3	21.6 uci/m^3	21.6 uci/m^3	21.6 uci/m^3

AIR

WIPE

	LAST WEEK AVG.	MON.	TUE.	WED.	THU.	FRI.
HIGH	1144			3650		2511
LOW	56			60		53
AVG.	387			846		594

COMMENTS: air levels stable.

Figure 6. Typical high, low, and average swipe values reported on the health physics trend sheets.

The 95th-percentile contamination values are developed by: (1) plotting the “z scores” of the data on the x axis and the natural logs of the data on the y axis; and (2) using the plotted data to determine a linear equation and the associated fit parameter, R^2 (ORAUT 2006). The linear equation is in the form of Equation 1:

$$y = mx + b \qquad (1)$$

Where:

- *y* = *natural log of the data*
- *m* = *slope of the line*
- *x* = *z-score*
- *b* = *Y axis intercept*

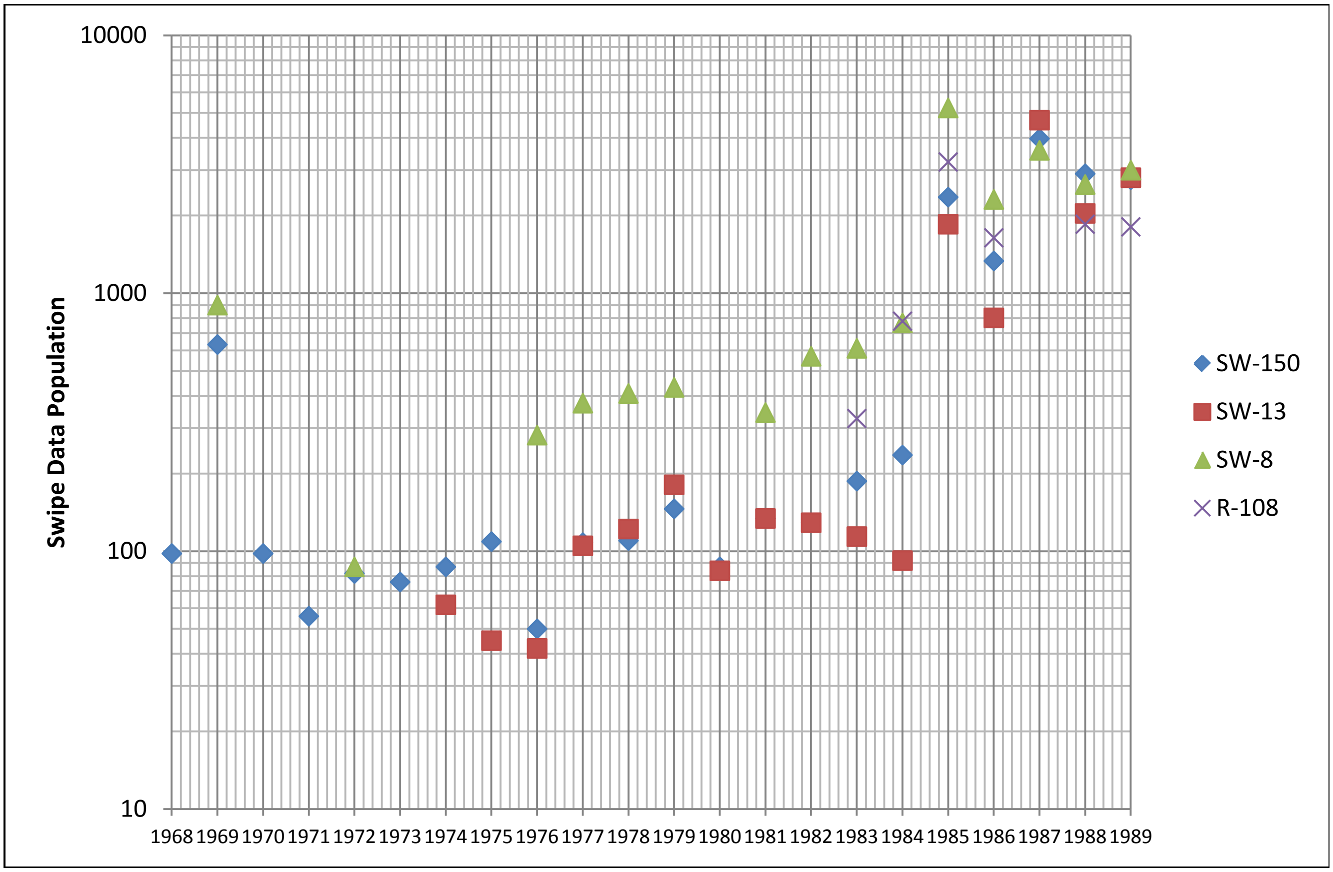


Figure 7. Available swipe sample populations (Chu 2013).

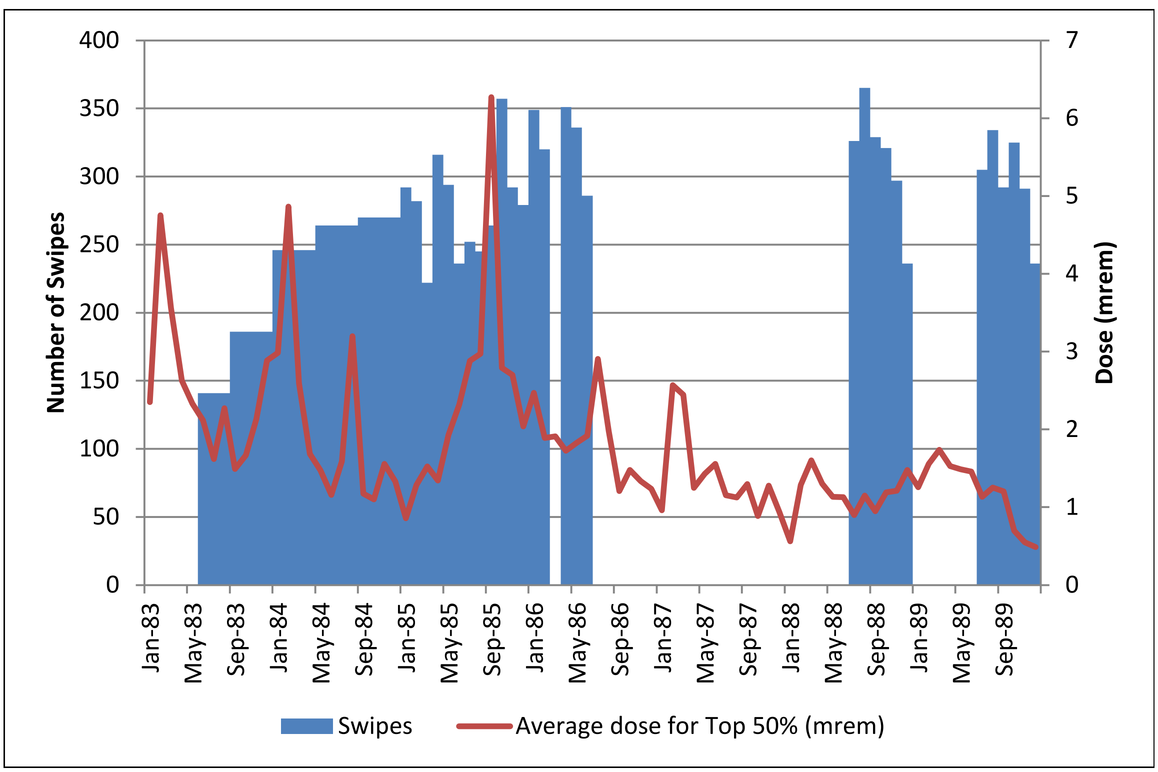


Figure 8. Swipes and average worker tritium dose by period for Room R-108, 1983 to 1989 (Chew et al 2012).

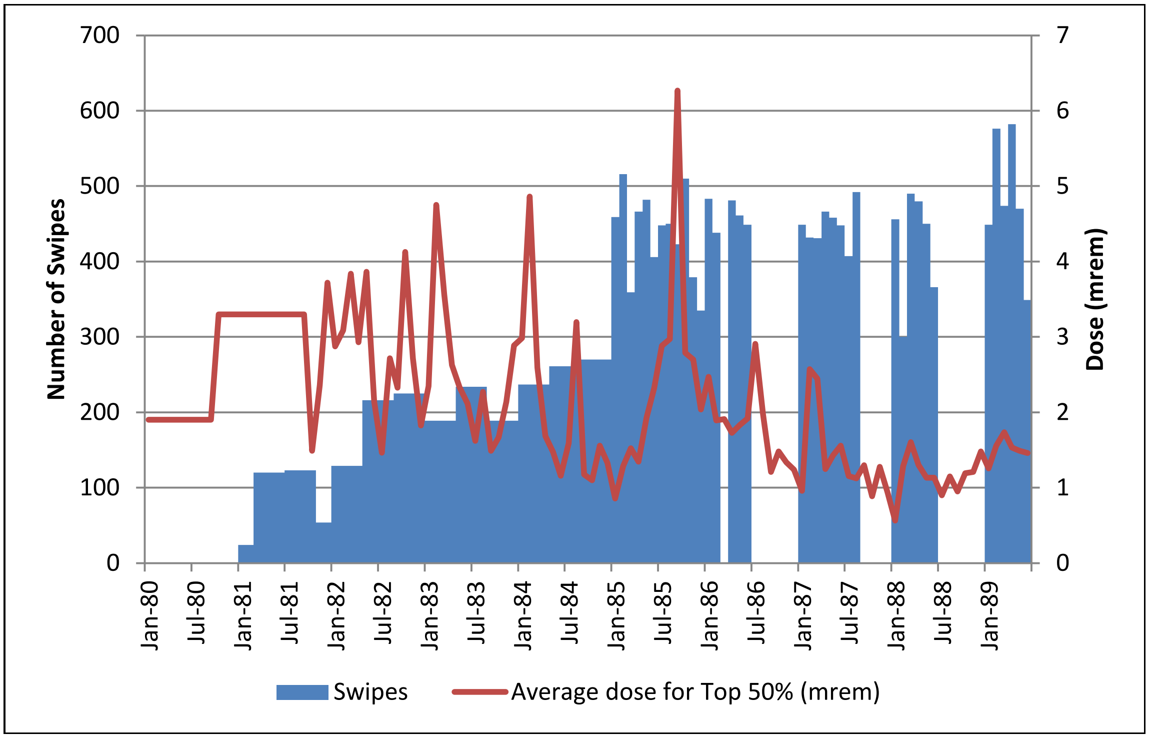


Figure 9. Swipes and average worker tritium dose by period for Room SW-8, 1980 to 1989 (Chew et al 2013).

For a lognormal distribution, the geometric mean (GM), which is also the 50th percentile, is equal e^b; the geometric standard deviation (GSD) is equal to e^m; and the 95th percentile is equal to $GM * GSD^{1.645}$.

When only trend data are available, a reasonable assumption of contamination level for that period is obtained by calculating the GM value of the “high” values reported in the trend data, as described above. For years in which both trend data and 95th percentile data must be combined, this is done by time-weighted averaging of the values.

Figure 10 shows the resulting “high estimate” swipe contamination activity levels values for the rooms that were used to calculate the airborne contamination. Depending on the availability of data, Figure 10 represents 95th percentile of swipe data, or the GM of high trend data, or the higher of the two when a combination of the two are used.

4.4 Conversion of Survey Data Into Units of Activity

Nuclear Measurements Corporation PC-5 windowless gas flow proportional counters were generally used to count tritium contamination control swipes at Mound prior to August 1993. The PC-5 is a “gross beta” counter with variable beta particle detection efficiency that is proportional to the energy of the beta emission. High energy beta emitters, such as strontium-90, are typically counted with greater than 50% efficiency and the efficiency is reduced as the energy of the beta emissions decreases. The PC-5 used at Mound exhibited some low, but undefined, counting efficiency for tritium beta particles. Consequently, the PC-5 data are reported in counts per minute (cpm). In order for a PC-5 counter result to be quantitative and be reported in units of disintegrations per minute (dpm), a calibration factor must be determined.

By 1990, the Packard “Tricarb” liquid scintillation (LS) counter was introduced at Mound for quantitative measurement of tritium on contamination control swipes. For tritium compounds, (e.g.,

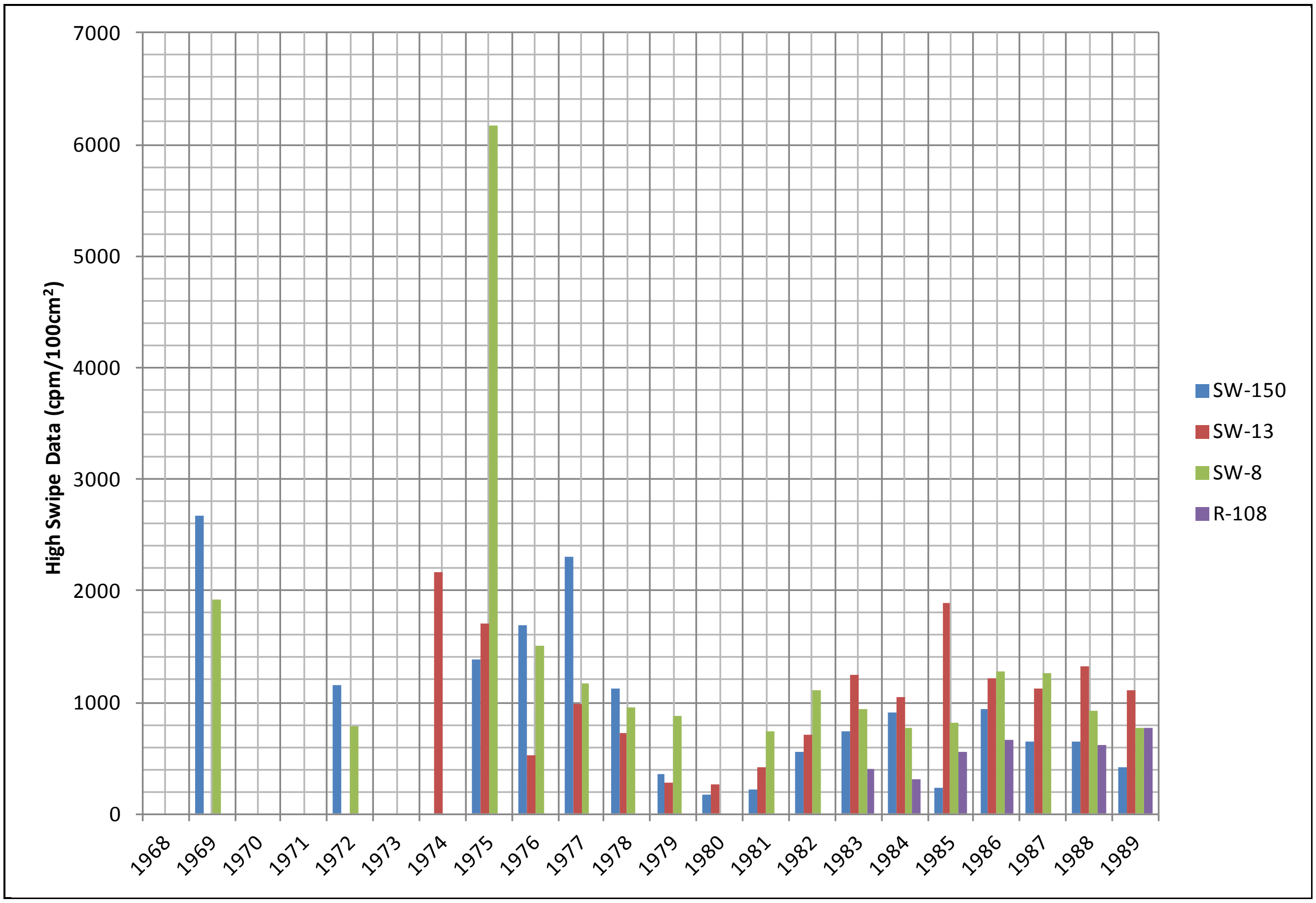


Figure 10. Estimate (i.e. 95th percentile of all data or GM of “high” trend data or the higher of the two for combined data sets) of swipe sample counts in four rooms at Mound (Chu and Potter 2013).

tritiated water) that completely dissolve in the counting cocktail, LS systems are able to provide quantitative results – the “actual activity” because the factors that affect counting efficiency are measured and compensated using the transformed spectral index of the external standard quench parameter called tSIE.

Some SMTs are insoluble so the assumption of complete solubility is not valid. The energy from beta rays originating inside a SMT particle can be absorbed inside the particle before reaching the particle surface where it becomes available for measurement, or for delivery of dose to the surrounding tissue. For low energy beta rays (average 5.7 keV) emitted during the decay of tritium, self-absorption can approach 100% when the particles are large (> 10 µm) because only the energy from betas emitted from the particle surface are available for measurement.

The problem of SMT activity quantization has been addressed authoritatively in DOE-HDBK-1129-2008 Appendix E (DOE 2008). The term “observed activity” is introduced for radiation protection and dosimetry purposes. Observed activity is the activity that is detected by the analytical method. Therefore the LS counter data in dpm reports the observed activity of a contamination control swipe. DOE-HDBK-1129-2008 Appendix E demonstrates that individual dose calculations can be made using observed activity data without the need to determine actual activity.

Tritium swipe counting records are available documenting the results of swipes counted on both an LS counter and on a PC-5 system (SRDB Ref IDs: 81787, pdf pp. 8-247; 81788, pdf pp. 2-628; 81907, pdf pp. 425-700; 81908, pdf pp. 58-62; 81909, pdf pp. 2-692). A sample of 356 of these data pairs were transcribed for evaluation in a spreadsheet titled “Mound LSC & PC5 Comparison” (SRDB

Ref IDs: 81787, pdf pp. 28-38, 44, 50, 60, 70, 80, 90, 100, 110; 81788, pdf pp. 2, 20). The PC-5 counting efficiency value for each paired sample (discussed below) is calculated by dividing the PC-5 count rate in cpm by the observed activity in dpm, as measured by the LS counter. The sample of 356 pairs was reduced to 133 pairs. This was done by eliminating the 14 instances in which the PC-5 counting efficiency was undefined, which means the LS observed activity equaled zero. Others were eliminated because the PC-5 efficiency was judged to be implausibly high for tritium (i.e., > 10%).

A linear regression analysis of the 133 data pairs was performed using Statgraphics Centurion XV to obtain the slope of the calibration model as represented in Figure 11. Recognizing that outliers could significantly impact the analysis the "minimum absolute error" (MAE) analysis method was used instead of the more common "least squares" method. The MAE method is more robust and lowers the impact of outliers on the regression analysis. This regression analysis reveals the slope of the line to be 0.054. So the PC-5 observed counting efficiency for tritium is nominally 5%. The counting efficiency factor is assumed to be accurate to one significant figure.

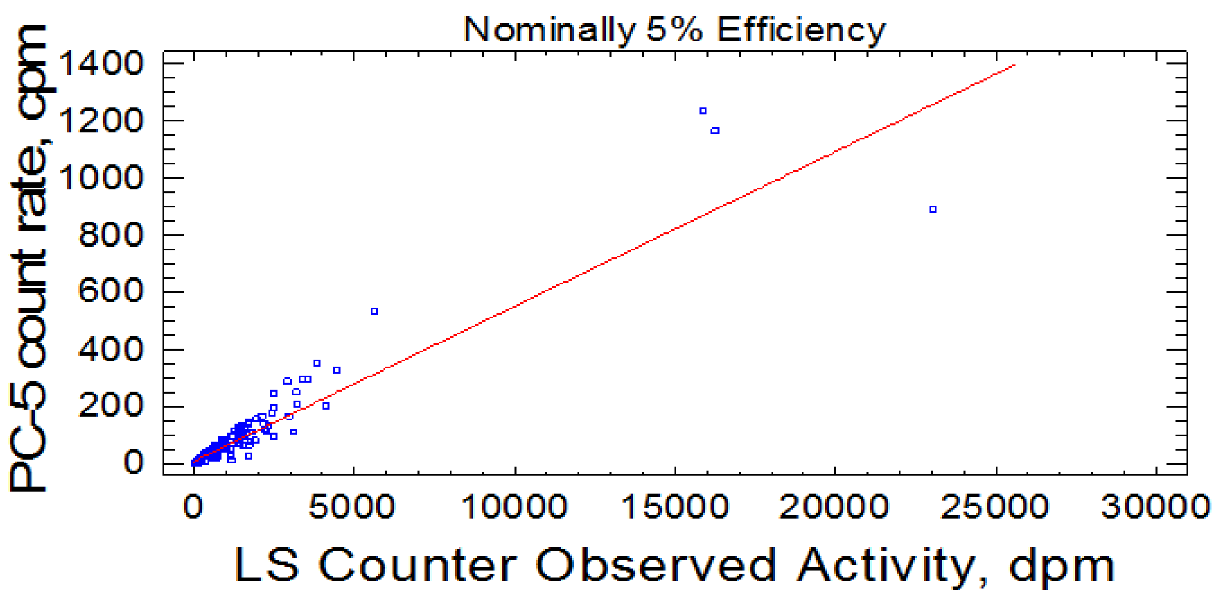


Figure 11. Calibration of PC-5 based on paired LSC counts.

5.0 RESUSPENTION FACTOR

A resuspension factor (RF) is the ratio of the radionuclide airborne concentration per unit air volume divided by the surface contamination level per unit area and is generally reported in units of m-1. ORAUT-OTIB-0070, Rev. 01, *Dose Reconstruction During Residual Radioactivity Periods at Atomic Weapons Employer Facilities* (ORAUT 2012) includes a summary of literature reviews pertaining to RF. The U.S. Nuclear Regulatory Commission (NRC) literature review is given emphasis in OTIB-0070. The median RF value developed in that review, 5×10^{-5} m^{-1}, is used in this dose reconstruction method. The resuspension factor is assumed to be accurate to one significant figure.

6.0 BREATHING RATE, OCCUPANCY FACTOR AND PARTICLE SIZE

6.1 BREATHING RATE

The standard ICRP 66 (ICRP 1994a) occupational breathing rate,1.2 m^3/hr, is assumed in this dose reconstruction method.

6.2 OCCUPANCY FACTOR

Full time occupancy, 2000 h per year, is assumed for this dose reconstruction method. This value may be proportionally adjusted to account for partial year exposures.

6.3 PARTICLE SIZE

The standard particle size distribution, 5-µm AMAD, is assumed for this dose reconstruction method.

7.0 CALCUATION OF ANNUAL INTAKE

7.1 CALCULATION OF ANNUAL INTAKE

Intake rate is calculated as shown in Equation 2:

$$I = \left\{ \left[\left(C_{PC\text{-}5} \times \left(Eff_{PC\text{-}5} \right)^{-1} \right) \times CF \right] \times 100 \times RF \right\} \times Br \times T \qquad (2)$$

Where:

I	=	*SMT intake quantity (µCi)*
$C_{PC\text{-}5}$	=	Contamination swipe data as counted by a PC-5 proportional counter (cpm/100 cm^2).
$Eff_{PC\text{-}5}$	=	Counter efficiency (cpm/dpm)
CF	=	Conversion Factor of 4.505×10^{-7} µCi/dpm
100	=	Constant that converts 100 cm^2 to m^2
RF	=	Resuspension Factor (m^{-1})
Br	=	Worker's breathing rate of 1.2 m^3/hr (ICRP 1994a)
T	=	Exposure time of 2,000 working hr/yr.

7.2 TABULATION OF ANNUAL INTAKE

The intake rate of SMT for each year, 1969 through 1989, is shown in Table 7-1 to one significant figure. The data and calculations used to produce this table are available in a spreadsheet (Chu and Potter 2013). For years 1990 through 1999, data for 1990 are assumed.

Table 7-1. Annual intakes in µCi.

Year	Room SW 150 (µCi/year)	Room SW 13 (µCi/year)	Room R 108 (µCi/year)	Room SW 8 (µCi/year)
1969	3E-01	NA	NA	3E+00
1970	NA	NA	NA	NA
1971	NA	NA	NA	NA
1972[a]	1E-01	NA	NA	9E-02
1973	NA	NA	NA	NA
1974	NA	2E-01	NA	NA
1975[a]	1E-01	2E-01	NA	7E-01
1976	2E-01	6E-02	NA	2E-01
1977	2E-01	1E-01	NA	1E-01
1978	1E-01	8E-02	NA	1E-01
1979	4E-02	3E-02	NA	1E-01
1980	2E-02	3E-02	NA	1E-01
1981	2E-02	4E-02	NA	8E-02

Year	Room SW 150 (µCi/year)	Room SW 13 (µCi/year)	Room R 108 (µCi/year)	Room SW 8 (µCi/year)
1982	6E-02	8E-02	NA	1E-01
1983	8E-02	1E-01	4E-02	4E-05
1984	1E-01	1E-01	3E-02	8E-02
1985	2E-01	2E-01	6E-02	9E-02
1986	1E-01	1E-01	7E-02	1E-01
1987	7E-02	1E-01	8E-02	1E-01
1988	7E-02	1E-01	1E-01	2E-01
1989	5E-02	1E-01	8E-02	7E-02
1990–1999	5E-02	1E-01	8E-02	7E-02

a. Data for SW-150 are very limited in 1972 and 1975; and for SW-8 in 1975

8.0 CALCULATION OF ORGAN DOSE

The NIOSH approach for calculating SMT intakes and doses from urine bioassay data is provided in ORAUT-OTIB-0066 (ORAUT 2007). ORAUT-OTIB-0066 implements the ICRP Publication 71 recommendations for SMT aerosols. In this instance the SMT intakes are calculated based on air concentrations rather than urine bioassay, so the modifications to the urine bioassay model discussed in ORAUT-OTIB-0066 Appendix A are not necessary.

Table 7-1 lists the intake rates for the calculation of doses from SMTs for the organs of interest. Enter intake rates into IMBA as normal and organ doses will be calculated.

9.0 INTAKE DURING THE SEC-00171 PERIOD AND AFTER 1989

9.1 INTAKE BEFORE MARCH 6,1980, THE SEC-000171 PERIOD

As discussed in Section 2.0, all workers who may have been exposed to SMT prior to March 6, 1980 may also have been exposed to unmonitored radon and consequently are members of the SEC-00171 class.

Although NIOSH found that it is not possible to completely reconstruct radiation doses for the SEC-00171 class, HHS stated in the July 14, 2010 designation of the class (HSS 2010) that any internal monitoring data that may become available for an individual claim that can be interpreted using existing NIOSH dose reconstruction processes or procedures will be used.

Therefore, dose reconstructions for individuals who were monitored for tritium at the Mound Plant during the period from March 1, 1959 through March 5, 1980, but who do not qualify for inclusion in SEC-00171 class, due to having a non-presumptive cancer or due to a short employment duration, may be performed using the annual intake data and method in this report to the extent appropriate.

9.2 INTAKE AFTER 1989

SMT intakes after 1989, the last year when survey data were analyzed, are expected to be the same as the intake in 1989, because no additional SMT was introduced into the workplace until the D&D period began. By the late 1990s D&D was underway at Mound and the problems associated with dosimetry of SMTs was recognized and adequately addressed. The Mound Internal Dosimetry TBD that first addressed SMTs was published in 2000 (BWXT 2000).

Therefore the annual intake established for 1989 should be applied to years 1990 through 1999, and this method is not applicable after December 31, 1999.

10.0 GUIDANCE TO DOSE RECONSTRUCTORS

Apply the following guidance to complete SMT dose reconstruction for Mound workers monitored for tritium exposure at any time during the period March 6, 1980 through December 31, 1999.

1. For workers who are known to have worked directly with SMT (a list identifying SMT workers exists):

    - Calculate SMT dose to the organ of interest assuming all of the tritium measured in urine bioassay samples is the result of SMT intakes.
    - Calculate dose to the organ of interest assuming the tritium excreted in urine is entirely associated with exposure to soluble tritium compounds, such as tritiated water.
    - Select the result that provides the highest dose to the organ of interest.

2. For all other workers who were monitored for tritium:

    - Calculate dose to the organ of interest assuming the tritium excreted in urine is entirely associated with exposure to soluble tritium compounds, such as tritiated water.
    - Calculate SMT dose to the organ of interest using the method specified in this report.
    - Add both quantities to determine the dose to the organ of interest.

REFERENCES

Birchall, A. and James, A.C., 2005, Integrated Modules for Bioassay Analysis (IMBA) Expert™ ORAU-Edition, Version 4.0.9, updated May 2005.

BWXT of Ohio, Inc., 2000, Mound Technical Basis Document for Stable Tritiated Particles and Organically Bound Tritium, MD-10516, January 24. [SRDB Ref ID: 32921].

Caldwell, J.L., Health Physics Data Sheets, SW Building tritium Results 1991. [SRDB Ref ID: 84788]

Chew, M. H., Smith, B., Rich, B., 2012, Responses to Action Items Introduced During the Mound Work Group Meeting of June 5, 2012, M. H. Chew & Associates, Inc., August 22. [SRDB Ref ID: 122695]

Chu, S. and Potter, E. W., 2013, Excel Spreadsheets, R-108 SW-8 pre 1980, R-108 SW-8 in 1980s, SW-13 SW-150 1960s-1990s and Report calc backups, M. H. Chew & Associates, Inc. [SRDB Ref IDs: 122684, 122685, 122686, 122687]

Cook, S. A., Health Physics Data Sheets, SW Building Tritium Wipe Results 1991. [SRDB Ref ID: 81787]

Department of Energy, 2008, DOE Handbook Tritium Handling and Safe Storage, DOE-HDBK-1129, December 2008.

EG&G Mound Applied Technologies,1994, Final Safety Analysis Report for the SW/R Tritium Complex, Rev.1, August 1994. [SRDB Ref ID: 26833]

HHS, 2010, Health and Human Services Designation of Additional Members of the Special Exposure Cohort under the Energy Employees Occupational Illness Compensation Program Act of 2000, Designating a Class of Employees from Mound Plant Miamisburg, Ohio, www.cdc.gov/niosh/ocas/pdfs/sec/mound/mounddes-171.pdf.

ICRP (International Commission on Radiological Protection), 1994a, *Human Respiratory Tract Model for Radiological Protection*, Publication 66, Annals of the ICRP, Vol. 24/1-3, Pergamon Press, Oxford. [SRDB Ref ID: 22732]

ICRP (International Commission on Radiological Protection), Publication 68b, Dose Coefficients for Intakes of Radionuclides by Workers,1994, Pergamon Press, Oxford, England.

ICRP (International Commission on Radiological Protection), Publication 71, Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 4 Inhalation Dose Coefficients, 1995, Pergamon Press, Oxford, England.

ORAUT (Oak Ridge Associated Universities Team), 2006, *Generating Summary Statistics for Coworker Bioassay Data,* ORAUT-PROC-0095, Rev. 00, Oak Ridge Tennessee, June 5.

ORAUT (Oak Ridge Associated Universities Team), 2007, *Calculation of Dose from Intakes of Special Tritium Compounds*, ORAUT-OTIB-0066, Rev. 00, Oak Ridge Tennessee, April 26.

ORAUT (Oak Ridge Associated Universities Team), 2012, *Dose Reconstruction During Residual Radioactivity Periods at Atomic Weapons Employer Facilities*, ORAUT-OTIB-0070, Rev. 01, Oak Ridge Tennessee, March 5.

Ulsh, B., Notes on Interviews Conducted on April 6, 2010 with [redacted], [redacted], [redacted], [redacted] and [redacted], April 2010. [SRDB Ref ID: 107797]

Unk., Documented Communication with [redacted]on Mound Tritium Issues, July 2012. [SRDB Ref ID: 116978]

Unk., Documented Communication with [redacted]on Mound Tritium Issues, July 2012. [SRDB Ref ID: 116979]

Unk., SW & R Building Material, Personnel, and Job Specific Contamination Surveys with Tritium results, 1990. [SRDB Ref ID: 81908]

Unk., SW&R building Material, Personnel, and Job Specific Contamination Surveys with Tritium results, 1990. [SRDB Ref ID: 81909]

Unk., SW Building Monitoring Profile, Air Sample and Smear Data 1972. [SRDB Ref ID: 42977]

Unk., SW Health Physics Trend Sheets, Jan 27-Aug 20 1978. [SRDB Ref ID: 59271]

Unk., SW Health Physic’s Trend Sheet’s, July 21-December 29 1978. [SRDB Ref ID: 59272]

Unk., SW Health Physics Trend Sheets, Feb 1-Jul 15, 1979. [SRDB Ref ID: 59273]

Unk., SW Health Physics Trend Sheets, Aug 13 1978-Dec 28, 1979. [SRDB Ref ID: 59275]

Unk., SW Health Physics Trend Sheets, Jan 4-Dec 26, 1980v. [SRDB Ref ID: 59276]

Unk., SW Building Surveys, Wipe Samples 1989. [SRDB Ref ID: 81503]

Unk., SW Building Surveys, Wipe Samples September and October 1989. [SRDB Ref ID: 81504]

Unk., SW Building Surveys, Wipe Samples December 1989. [SRDB Ref ID: 81506]

Unk., SW and R Building Contamination Survey 1988. [SRDB Ref ID: 81789]

Unk., SW and R Building Contamination Survey 1988. [SRDB Ref ID: 81801]

Unk., SW Building Contamination Surveys 1985. [SRDB Ref ID: 81809]

Unk., SW Building Contamination Surveys 1985. [SRDB Ref ID: 81816]

Unk., SW Building Contamination Surveys 1986. [SRDB Ref ID: 81820]

Unk., SW Building Contamination Surveys 1986. [SRDB Ref ID: 81824]

Unk., Counting Room Monthly Totals 1969. [SRDB Ref ID: 81874]

Unk., SW Building contamination Surveys 1969. [SRDB Ref ID: 81875]

Unk., SW Building Contamination Surveys 1985. [SRDB Ref ID: 81876]

Unk., SW Building Contamination Surveys 1985. [SRDB Ref ID: 81878]

Unk., Daily 8-Hour Air Samples H, R, SW Buildings 1977. [SRDB Ref ID: 81896]

Unk., SW Building Contamination Surveys 1987. [SRDB Ref ID: 81910]

Unk., SW Building Contamination Surveys 1987. [SRDB Ref ID: 81911]

Unk., SW Building Contamination Surveys 1987. [SRDB Ref ID: 81912]

Unk., SW Health Physics Trend Sheets 1975. [SRDB Ref ID: 90026]

Unk., SW and R Building Health Physics Trend Sheets 1982-1983. [SRDB Ref ID: 90092]

Unk., SW and R Building Health Physics Trend Sheets Jan-Dec 1984. [SRDB Ref ID: 90096]

Unk., SW and R Building Health Physics Trend Sheets July-December 1985. [SRDB Ref ID: 90098]

Unk., SW Building Tritium Wipe Results 1991. [SRDB Ref ID: 81788]

Unk., SW and R Buildings Surveys with Tritium Survey Results 1990. [SRDB Ref ID: 81907]