Draft

ADVISORY BOARD ON RADIATION AND WORKER HEALTH

National Institute for Occupational Safety and Health

SC&A RESPONSE TO NIOSH'S COMMENTARY ON FINDINGS REGARDING THE SITE PROFILE FOR DUPONT DEEPWATER WORKS

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0 (Draft)	06/06/2013	Initial issue

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ABBREVIATIONS AND ACRONYMS

Advisory Board	Advisory Board on Radiation and Worker Health
AEC	Atomic Energy Commission
AWE	Atomic Weapons Employer
cSv	cubic sievert
DCAS	Division of Compensation Analysis and Support
DOL	Department of Labor
GM	geometric mean
GSD	geometric standard deviation
hr	hour
IREP	Interactive Radio-Epidemiological Program
MCNP	Monte Carlo N-Particle
keV	kilo-electron volt
MED	Manhattan Engineer District
mg/day	milligrams per day
mR	milliroentgen
mrad	millirad
mrep/hr	millirep per hour
NIH	National Institutes of Health
NIOSH	National Institute for Occupational Safety and Health
OCAS	Office of Compensation Analysis and Support
POC or PC	probability of causation
rem	roentgen equivalent man
SC&A	S. Cohen and Associates (SC&A, Inc.)
SRDB	Site Research Database
TBD	technical basis document
TIB	technical information bulletin
U	uranium
UF_4	uranium tetrafluoride
U_3O_8	uranium oxide
yr	year

1.0 INTRODUCTION

On August 12, 2011, SC&A delivered to the National Institute for Occupational Safety and Heath (NIOSH) and the Advisory Board on Radiation and Worker Health (Advisory Board) its review of the site profile for DuPont Deepwater Works (SC&A 2011). In accordance with a request made by the AWE (Atomic Weapons Employer) Work Group during its September 7, 2012, meeting, NIOSH responded to SC&A's findings in a white paper dated March 18, 2013 (Neton 2013) . This report is provided in response to that white paper.

It has become common practice to provide these types of point-counterpoint exchanges of information in a running issues matrix, which is then used as the basis for discussion at work group meetings, in this case the AWE Work Group under the Chairmanship of Dr. Henry Anderson. However, in this case, we elected to prepare our responses in more of a narrative form, as was used by SC&A in its original review of the site profile and also used by NIOSH in its white paper dated March 18, 2013. We felt that this narrative approach will make it easier for all participants to follow the exchange of information and the rationale for any conclusions. At any time, these white papers can be converted into an exposure matrix format.

In order to prepare our response, we are using the same approach adopted by NIOSH in its white paper. First, we reiterate each of SC&A's original findings (in bold), followed in some cases by some additional explanatory material regarding the finding. This material is followed by a summary of NIOSH's commentary on SC&A's findings as provided in NIOSH's March 18, 2013, white paper. We then provide SC&A's response to that commentary, either agreeing or disagreeing with NIOSH's position and providing SC&A's rationale for its position. We hope all parties find this format useful and informative.

1.1 SC&A'S ORIGINAL FINDING 1

Finding 1: The site profile should discuss the degree to which the air sampling data, which were collected in 1944 and 1945, can be used to reasonably bound doses in the earlier years of operation (e.g., 1942–1943).

This is an issue that SC&A has encountered on many occasions when reviewing site profiles for old facilities, especially AWE facilities. What has often occurred in these situations is the Atomic Energy Commission (AEC) or, prior to the AEC, the Manhattan Engineer District (MED), hired a private company to perform some specialized metallurgical work due to that company's experience related to the handling of metals. At that time, the nation was just learning about the properties and safe handling of uranium in its various forms, and it was not until later in the 1940s and early 1950s that improved radiation protection practices became widely employed at these types of facilities. Hence, uranium work performed in the early 1940s was often performed with minimal health safety controls. Thus, we are concerned with extrapolating data collected in 1944 and 1945 to exposures that might have occurred in 1942 and 1943.

1.1.1 NIOSH's Response

In its March 18, 2013, response to SC&A's findings, NIOSH pointed out that the air sampling data collected during the 1944–1945 time periods were likely bounding as applied to the 1942–1943 time frame because uranium activities were very limited during the early years. In its response, NIOSH refers the reader to two Site Research Database (SRDB) reports (i.e., SRDB 16272 [Chambers Works 1945] and page 16 of DuPont 1946) as the basis for this conclusion.

1.1.2 SC&A Response

Chambers Works (1945), *History, Chambers Works Special Construction*, identifies the pre-operational phase as December 1942 to early January 1943, where temporary offices and structures were established for the projects outlined in Table 1 of NIOSH's response. The earliest start-up date for the first equipment required by operations for Project 9595 was April 11, 1943, and a test run made in May 1943. Projects 9634, 9757, 9233 and 9803 had start-up dates that ranged from mid-1943 through mid-1944. Chambers Works (1945) does state that the "advice of physical completion" was not issued until April 15, 1944. The start of full-scale operation is not indicated in Chambers Works (1945), but can be assumed to be after the advice of physical completion was issued, and that full-scale operations were not being conducted during 1942–1943. On this basis, we concur with NIOSH's response and recommend that this finding be **closed**.

1.2 SC&A'S ORIGINAL FINDING 2

Finding 2: We would request that the site profile discuss the levels of surface contamination at the facility and explain that, at these levels, the default ingestion rate of 0.5 mg/day, which is inherent to TIB-009 [OCAS 2004], applies to this facility. NIOSH should also describe how the ingestion intake in Table 1 was calculated.

1.2.1 NIOSH Response

NIOSH explains that, "This finding pertains to the quantification of ingestion intakes which was transferred to the Procedures Subcommittee. The subcommittee appears to have completed its work and has concluded that no changes are necessary to TIB-009. However, in its response to this finding, NIOSH states that the implementation of TIB-009 in the residual period has been misinterpreted in the DuPont Deepwater works. These values will be revised in keeping with the discussions held in the Procedures Subcommittee."

1.2.2 SC&A Response

SC&A concurs that the methods recommended in OCAS-TIB-009 apply to this case. However, it appears that NIOSH agrees that a revision is needed to the analysis as provided in the site profile with respect to this matter. SC&A will review the revised analysis when it becomes available. SC&A recommends that this item remain **open** until NIOSH's revised analysis is provided and discussed with the Work Group.

1.3 SC&A'S ORIGINAL FINDING 3

It appears that uranium metal was produced at the site using the UF_4 to U magnesium bomb reduction process, which, because of the Putzier effect, could have produced uranium ingots that were associated with external beta radiation fields that were 10 to 20 times greater than those adopted in the site profile.

1.3.1 NIOSH Response

In its response, NIOSH points out that the Putzier effect only applies when an ingot is recast for the purpose of further purification, and recasting did not occur at DuPont Deepwater. Hence, NIOSH concludes that the Putzier effect did not likely occur at this facility.

1.3.2 SC&A Response

SC&A concurs with NIOSH, and we recommend that this finding be **closed**.

1.4 SC&A'S ORIGINAL FINDINGS 4 AND 5

These two findings are combined because NIOSH's responses to these findings are combined.

Finding 4: There seems to be a substantial disparity between the explanation of how the annual photon doses to operators were derived and the actual values employed in the site profile.

Finding 5: There seems to be a substantial disparity between the explanation of how the annual contact doses to operators were derived and the actual values employed in the site profile. In addition, justification should be provided as to why TBD-6000 default values should not be used at DuPont, since no site data are available for external exposure during the operating period.

1.4.1 NIOSH Response

NIOSH understands that SC&A calculated an annual photon exposure of 1,920 mR/yr by making the following assumptions:

- An exposure rate of 1.3 mR/hr at 1 foot from either a slab of natural uranium or a 55-gallon drum of U_3O_8
- An exposure rate of 0.3 mR/hr at 1 meter from either a slab of natural uranium or a 55-gallon drum of U_3O_8
- A total exposure duration of 2,400 hours per year, half of which is spent at 1 foot and half of which is spent at 1 meter from the source of uranium.

NIOSH explains, however, that it did not use the 1.3 mR/hr and the 0.3 mR/hr exposure rates at 1 foot and 1 meter from a 55-gallon drum of uranium oxide (values which were derived by

NIOSH using MCNP and reported in Table 6 of the site profile, and with which SC&A agrees). Instead, NIOSH explains that it assumed that the MCNP-derived values were in fact the average exposure rates at these distances, and then proceeded to derive the geometric mean (GM) of these exposure rates assuming that the exposure rates at these distances are lognormally distributed with a geometric standard deviation (GSD) of 5. This results in a GM of 0.22 mR/hr for 2,400 hours per year, yielding an annual exposure of 529 mR/yr (NIOSH actually estimated an annual exposure of 519 mR/yr, a value that is slightly lower than the value SC&A derived using NIOSH's approach.)

The white paper also explains that the difference in extremity doses as derived by NIOSH and SC&A is also a result of the application of what we will refer to as the statistical method, as described above with respect to photon doses. Specifically, NIOSH understands that the assumptions SC&A used to derive its extremity dose of 121,800 mrad per year are based on the following assumptions:

- An assumed contact dose rate of 203 mrad/hr to skin in direct contact with a slab of natural uranium
- A total exposure duration of 2,400 hours per year, but only 25% of the time in direct contact with the uranium

NIOSH explains that the dose rate of 203 mrad/hr is assumed to be the average contact dose rate to the skin, and then derived the GM of the dose rate by assuming that the contact dose rate is lognormally distributed with a GSD of 5. The outcome of this exercise is provided in Table 7 of the site profile. Specifically, assuming that the hands and forearms are in contact with pure unshielded uranium metal 25% of the time, the exposure rate would be 58.75 mrad/hr (we estimate a slightly lower value of 50.75 mrad/hr). Then, using the same statistical process described above, NIOSH estimates that the GM is 16.09 mrad/hr with a GSD of 5. Assuming skin contact 25% of the time, the annual dose to hands and forearms for operators is estimated by NIOSH to have a GM of 38,614 mrad/yr and a GSD of 5.

NIOSH explains that this approach to deriving doses, and subsequently the probability of causation (POC), is more claimant favorable than the "non-statistical" approach used by SC&A because of the fact that using a GSD of 5 on the GM creates a distribution that, when inserted into IREP, results in a POC at the 99% confidence level that is higher than what would be obtained if a single fixed value is used as input to IREP, even though the fixed input value is substantially higher (by about a factor of 4) than the GM value used by NIOSH. NIOSH explains that this occurs because the POC is reported at the 99th percentile level, and a GSD of 5 results in a higher POC, even though the GM is substantially lower than a fixed value for the organ dose. NIOSH demonstrates the validity of this argument in Attachment 1 in its March 18, 2013, white paper.

1.4.2 SC&A's Response

The assumptions and statistical method used by NIOSH to arrive at its annual exposures seem quite "strained," in that NIOSH is employing a complex statistical manipulation of the numbers that, in the end, effectively means that the worker spent 2,400 hours per year about 1 meter from

a filled 55-gallon drum. We are troubled by the statistical manipulation of the numbers, and would have preferred that NIOSH simply choose a claimant-favorable distance from the drum and exposure duration; i.e., keep it simple. However, as described above, NIOSH argues that their approach actually results in a higher POC. In addition, when viewed from the simple perspective used by SC&A, NIOSH is effectively assuming that the worker is spending 2,400 hours per year about 1 meter from a filled drum; an outcome that seems intuitively reasonable. On this basis alone, SC&A sees no problem recommending that this finding could be closed, but would like it to remain open until we can discuss this strategy a little further**.** Specifically, we are interested in exploring whether we agree that the "statistical approach" actually results in a higher POC than the approach SC&A employed, and that the statistical approach makes sense in this application.

SC&A ran IREP to evaluate NIOSH's conclusions. We first ran IREP using a fixed annual dose to a selected organ and a set of default assumptions regarding the other IREP input parameters to determine a POC. We then ran IREP using the same set of input parameters, except we assumed that the dose was lognormally distributed with a GM that is ¼ the fixed dose and with a GSD of 5. Our results confirm NIOSH's conclusions that the statistical approach results in a higher POC. See Attachment 1 for the sample calculation we performed.

The following summarizes the IREP calculation and our findings:

John Doe was born in 1942.
Diagnosed with lung cancer in 2002.
White non-Hispanic, never smoked.
One year (1982) of dose, which is 20 years prior to cancer diagnosis.

Dose distribution #1 (lognormal): 50% 30–250 keV; 50% >250 keV (Chronic Exposure Rate) or 0.240 rem GM with a GSD of 5.0 for each energy range.
POC at 99th percentile = **12.60%**

Dose distribution #2 (constant): 50% 30–250 keV; 50% >250 keV (Chronic Exposure Rate) or 0.960 rem
POC at 99th percentile = **6.48%**

Notwithstanding these results, the statistical approach as used here does not appear to be a coherent strategy. By "coherent" we mean that it seems illogical to assume a known exposure rate at a point in space that has essentially no uncertainty is assumed to have a very large degree of uncertainty. Perhaps NIOSH is attempting to account for uncertainty in worker placement relative to the source by applying an uncertainty term to the source dose rate. In any case, this subject needs further discussion. We recommend that Findings 4 and 5 be kept **open** until we have an opportunity to discuss this matter with the Work Group.

1.5 SC&A ORIGINAL FINDING 6

Finding 6: Assuming 50% of the beta/gamma dose rate measured at 3 feet from a surface is 50% from gamma and 50% from beta does not appear to be appropriate. In addition, beta dose cannot contribute significantly to whole body dose.

It is important to point out that this finding pertains to the residual period, and that SC&A's concern has to do with the method used by NIOSH to derive the penetrating and non-penetrating dose rates at 3 feet from surfaces that had residual uranium contamination.

1.5.1 NIOSH Response

The method used by NIOSH to derive the doses begins with gross beta/gamma measurements taken 3 feet above the floor at the locations surveyed in Building 708 and Building 845 after decontamination in 1948, where dose rates of 0.05 and 0.03 mrep/hr, respectively, were observed. A subsequent survey in 1977 indicated that contact doses on the walls and floors were typically about 0.1 mrad per hour. In order to cover the full range of possible contact dose measurements, NIOSH favorably assumed that the contact dose (beta/gamma) was 0.2 mrad/hr. Using a factor of 5 for the dose reduction between the surface and 3 feet, the site profile assumes that all workers experienced external whole body beta plus gamma dose rates of 0.04 mrad/hr, and that 50% is due to photons and 50% is due to electrons. As stated in the site profile, "Therefore, this appendix will assume the 0.04 mrad/hr is composed of a whole body gamma dose rate of 0.02 mR/hr and a beta **whole body** dose rate of 0.02 mrad/hr" (DCAS 2011a, p. 13, emphasis added). However, in its response, NIOSH agrees that the use of a one-to-one beta/gamma ratio is likely inappropriate, and a 10:1 ratio should be applied.

1.5.2 SC&A Response

In response to this finding, NIOSH makes a number of good points regarding the nature of the residual uranium contamination and how that thin layer of contamination, which is partly commingled in a thin veneer of concrete, would affect the beta radiation field above the surface in a complex manner. SC&A agrees with this discussion, but would like to explore this issue a little further. Specifically, Table 3.10 of TBD-6000 (DCAS 2011b) shows that beta **non-penetrating** dose rates 1 meter above a concrete floor with a thin residue of uranium contamination would be about 100 times higher than the photon exposure rates at the same location. It is noteworthy that, in its response to this issue, NIOSH concludes the following:

> *However, NIOSH agrees that the use of a one to one beta/gamma ratio is likely inappropriate. NIOSH states that a 10 to 1 ratio is used in TBD-6000, and during discussions in the TBD-6000 work group; it was shown that this ratio appears to be favorable for volume sources (uranium metal, uranium products in tanks, etc.). NIOSH recommends changing this assumption to a 10 to 1 ratio.*

As described above, we believe that Table 3.10 of TBD-6000 recommends a 100-to-1 ratio, not 10-to-1, as stated in NIOSH's response, for this type of exposure situation. In this case, NIOSH argues that it might be appropriate to use a 10:1 ratio for two reasons. First, given that the

starting point for this calculation is a measured beta/gamma dose rate of 0.04 mrep/hr at 3 feet, a 10:1 beta/gamma ratio would be claimant favorable for assigning penetrating doses, but not for assigning skin dose. In addition, a 10:1 beta/gamma ratio might be appropriate in this situation if the residual uranium is somewhat imbedded in the top layer of concrete. This would attenuate the beta somewhat, thereby reducing the beta/gamma ratio.

It appears that NIOSH plans to revise the dose reconstruction protocol in a manner that the gross beta/gamma dose rate at 3 feet from the surface is 0.04 mrad/hr, and that the beta-to-gamma ratio will be 10:1. We would like to investigate this further. First, it appears that Table 3.10 in TBD-6000 was developed specifically for this type of exposure scenario, and changing the ratio from 100:1 to 10:1 seems somewhat arbitrary. Nevertheless, a 10:1 beta/gamma ratio in this case would be more claimant favorable when reconstructing deep doses. In fact, using a 1:1 ratio would be even more claimant favorable, but perhaps unrealistic. With respect to skin dose, the ratio really doesn't matter, since 0.04 mrad/hr would be assigned either way (the only difference would be how much of this dose is assumed to be beta and how much is assumed to be photon). In light of this, we would suggest that a 10:1 ratio be used for reconstructing penetrating dose, but a ratio of 100:1 be used for reconstructing the non-penetrating dose. This would seem to be a more realistic but claimant-favorable strategy.

We believe that we are converging on a resolution to Finding 6, but recommend that it remain **open** until we have an opportunity to discuss it with the Work Group.

1.6 SC&A'S ORIGINAL FINDING 7

Finding 7: The development of the photon dose is convoluted and not scientifically sound. A simpler approach would be to assume that the deep dose rate was 0.05 mrad/hr based on measurements at 3 feet from contaminated surfaces, and pro-rate this dose rate between beta and gamma based on Table 3.10 of TBD-6000.

In reviewing this finding, we believe we made an error. We believe that the 0.05 mrad/hr number would certainly be a bounding deep dose, especially if the 0.05 mrep/hr measurement was an open window measurement that included both beta and photon exposures at 3 feet from contaminated surfaces. As discussed above in our discussion of Finding 6, perhaps a more realistic but claimant-favorable approach would be to assume a 10:1 beta gamma ratio.

1.6.1 NIOSH Response

NIOSH explains that a dose rate of 0.04 mrep/hr be used.

1.6.2 SC&A Response

SC&A agrees with NIOSH, but recommends keeping this finding **open** until we have an opportunity to discuss this matter with the Work Group.

2.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the above review, we have the following conclusions and recommendations:

Finding	Conclusions	SC&A Recommendations
1	SC&A agrees with NIOSH's position that the air sampling data collected in 1944 and 1945 can be used to reconstruct doses in 1942–1943	Close this finding
2	SC&A agrees with NIOSH that some revision is required to the site profile with respect to this finding	Remain open until the Work Group has an opportunity to review NIOSH's revision to this part of the site profile
3	SC&A agrees with NIOSH that the Putzier effect does not apply to this facility	Close this finding
4 and 5	SC&A understands the rationale for NIOSH's position on this matter and agrees that it is claimant favorable, but we believe the approach raises some scientific questions that need to be discussed with the Work Group	Remain open until the Work Group has an opportunity to discuss NIOSH's approach to this class of problem
6	We are converging on a solution, but there remains a need for additional discussion	Remain open until we have an opportunity to discuss this issue with the Work Group
7	We are converging on a solution, but there remains a need for additional discussion	Remain open until we have an opportunity to discuss this issue with the Work Group

2.1 REFERENCES

Chambers Works 1945. Report: *History Chambers Works Special Construction*. February 9, 1945. Ref ID 16272.

DCAS 2011a. *Technical Basis Document for the DuPont Deepwater Works, Deepwater, New Jersey.* DCAS-TKBS-0006, Rev. 00. National Institute for Occupational Safety and Health (NIOSH) Division of Compensation Analysis and Support (DCAS), Cincinnati, Ohio. March 8, 2011.

DCAS 2011b. *Site Profiles for Atomic Weapons Employers that Worked Uranium Metals*. Battelle-TBD-6000. Rev. 1. National Institute for Occupational Health and Safety (NIOSH), Division of Compensation Analysis and Support (DCAS), Cincinnati, Ohio. June 17, 2011.

OCAS 2004. *Estimation of Ingestion Intakes*. OCAS-OTIB-009, Rev. 0. National Institute for Occupational Health and Safety (NIOSH), Office of Compensation Analysis and Support (OCAS), Cincinnati, Ohio. April 13, 2004.

Neton, J., 2013. DuPont Deepwater Works, NIOSH's Response to Findings in SC&A's Review, Dated August 12, 2011. National Institute for Occupational Health and Safety (NIOSH), Cincinnati, Ohio. March 18, 2013.

SC&A 2011. *Review of the NIOSH Site Profile for Dupont Chambers Works, Deepwater, NJ,* Document No. SCA-TR-SP2011-0035, Rev. 0. SC&A, Inc., Vienna, Virginia. August 12, 2011.

DuPont 1946. *Design and Procurement History of Chambers Works Special Projects*. E.I. du Pont Denemours and Company. March 1946. Ref ID 89139.

ATTACHMENT 1: SAMPLE IREP CALCULATIONS

NIOSH-Interactive RadioEpidemiological Program
Probability of Causation Results

Uploaded file: **N/A**
Date of Run: 5/28/2013
Time of Run: 11:15:46 AM
NIOSH ID #: 123456
Claimant Name: John Q. Doe

DOL District Office: CL
NIOSH-IREP version: 5.7
Analytica/ADE version: 3.0
DOL Case No: 123-45-6789

Claimant Cancer Diagnoses:

Primary Cancer #1: N/A — Date of Diagnosis: N/A
Primary Cancer #2: N/A — Date of Diagnosis: N/A
Primary Cancer #3: N/A — Date of Diagnosis: N/A
Secondary Cancer #1: N/A — Date of Diagnosis: N/A
Secondary Cancer #2: N/A — Date of Diagnosis: N/A
Secondary Cancer #3: N/A — Date of Diagnosis: N/A

Claimant Information Used In Probability of Causation Calculation:

Gender: Male
Race (skin cancer only): N/A
Birth Year: 1942
Year of Diagnosis: 2002
Cancer Model: Lung (162)
Should alternate cancer model be run?: No
Smoking history (trachea, bronchus, or lung cancer only): Never smoked

NIOSH-IREP Assumptions and Settings:

User Defined Uncertainty Distribution: Lognormal(1,1)
Number of Iterations: 2000
Random Number Seed: 99

General Exposure Information:

#	Exp. Year	Organ Dose (cSv)	Exp. Rate	Radiation Type
1	1982	Lognormal (0.24, 5)	chronic	photons E=30-250keV
2	1982	Lognormal (0.24, 5)	chronic	photons E>250keV

Radon Exposure Information:

N/A (applies only to cases of Lung Cancer with Radon Exposures)

Probability of Causation (PC) *

1st percentile	0.01 %
5th percentile	0.04 %
50th percentile	0.38 %
95th percentile	4.93 %
99th percentile	12.60 %

* NIOSH-IREP is programmed with two different lung cancer risk models. Under current guidelines, each lung cancer claim is run separately using both risk models and the higher PC will determine the outcome of the claim. The results displayed above are derived from the **NIOSH-IREP lung model**, which is the model that produced the higher PC at the 99th percentile for this particular claim. The lower PC at the 99th percentile, derived from the NIH-IREP lung model, is 7.53 %. This lower PC value is reported here for information only and will have no bearing on the claim outcome.

NIOSH-Interactive RadioEpidemiological Program
Probability of Causation Results

Uploaded file: **N/A**
Date of Run: 4/18/2013
Time of Run: 11:47:16 AM
NIOSH ID #: 123456
Claimant Name: John Q. Doe

DOL District Office: CL
NIOSH-IREP version: 5.7
Analytica/ADE version: 3.0
DOL Case No: 123-45-6789

Claimant Cancer Diagnoses:

Primary Cancer #1: N/A — Date of Diagnosis: N/A
Primary Cancer #2: N/A — Date of Diagnosis: N/A
Primary Cancer #3: N/A — Date of Diagnosis: N/A
Secondary Cancer #1: N/A — Date of Diagnosis: N/A
Secondary Cancer #2: N/A — Date of Diagnosis: N/A
Secondary Cancer #3: N/A — Date of Diagnosis: N/A

Claimant Information Used In Probability of Causation Calculation:

Gender: Male
Birth Year: 1942
Cancer Model: Lung (162)

Race (skin cancer only): N/A
Year of Diagnosis: 2002
Should alternate cancer model be run?: No

Smoking history (trachea, bronchus, or lung cancer only): Never smoked

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NIOSH-IREP Assumptions and Settings:

User Defined Uncertainty Distribution: Lognormal(1,1)

Number of Iterations: 2000 Random Number Seed: 99

General Exposure Information:

#	Exp. Year	Organ Dose (cSv)	Exp. Rate	Radiation Type
1	1982	Constant (0.96)	chronic	photons E=30-250keV
2	1982	Constant (0.96)	chronic	photons E>250keV

Radon Exposure Information:

N/A (applies only to cases of Lung Cancer with Radon Exposures)

Probability of Causation (PC) *

1st percentile	0.09 %
5th percentile	0.24 %
50th percentile	1.04 %
95th percentile	4.07 %
99th percentile	6.48 %

* NIOSH-IREP is programmed with two different lung cancer risk models. Under current guidelines, each lung cancer claim is run separately using both risk models and the higher PC will determine the outcome of the claim. The results displayed above are derived from the **NIOSH-IREP lung model**, which is the model that produced the higher PC at the 99th percentile for this particular claim. The lower PC at the 99th percentile, derived from the NIH-IREP lung model, is 2.79 %. This lower PC value is reported here for information only and will have no bearing on the claim outcome.