The Jerome N. Frank Legal Services Organization

YALE LAW SCHOOL

November 2020

Re: Evidence supporting claim for service-connected disability compensation for potentially radiogenic condition related to service at Palomares, Spain.

Enclosed here is information regarding radiation exposure of veterans of the 1966 nuclear cleanup operation at Palomares, Spain. The information was compiled as part of *Skaar v. Wilkie,* No. 17-2574, a class action challenging Department of Veterans Affairs (VA) methodologies used to establish radiation exposure. The information was assembled by counsel for the class of Palomares veterans certified[1] in that case to provide the VA with information on which to adjudicate related claims. It is intended to support an application for disability compensation for radiation-related conditions arising out of service at Palomares, Spain in 1966.

This letter and attachments provide evidence for a legal conclusion that the dose estimate methodologies currently relied upon by the Secretary to assess claims of Palomares veterans seeking service-connected disability benefits for potentially radiogenic conditions do not constitute "sound scientific evidence" as defined in 38 C.F.R. § 3.311(c)(3), and as required by *Hilkert v. West*, 12 Vet. App. 145, 149 (1999). This letter further includes an overview of the Palomares incident and the VA's subsequent failure to provide disability benefits to veterans exposed to radiation during the cleanup operation. It also explains the relevance of the 35 documents attached here, and listed at the end of the cover letter, to show that the VA has improperly conducted evaluations of Palomares veterans' benefits claims.

This packet was prepared by class counsel in *Skaar v. Wilkie*, the Jerome N. Frank Legal Services Organization. It is intended to compile pertinent evidence for class members in their individual claims for disability benefits for radiation-related conditions developed in connection with service at Palomares, Spain in 1966. Class counsel does not represent class members in their individual applications or appeals and does not represent claimants who are not members of the class (unless expressly indicated elsewhere). Class counsel makes no claims as to the merits of the claims of veterans they do not individually represent, nor expresses any opinion as to the claimant's membership in the *Skaar* class.

Factual Background

In January 1966, two U.S. Air Force planes collided over Palomares, Spain, releasing four nuclear bombs. Ex. 6 at 4. Two of these bombs conventionally exploded after landing, dispersing dangerously high amounts of alpha radiation in the surrounding countryside. Approximately 1,400 servicemembers were sent to the site as part of the U.S. military's clean-up effort in Palomares, in

---

[1] The Court of Appeals certified a class in *Skaar v. Wilkie* consisting of:

> All U.S. veterans who were present at the 1966 cleanup of plutonium dust at Palomares, Spain, and whose application for service-connected disability compensation based on exposure to ionizing radiation VA has denied or will deny by relying, at least in part, on the findings of dose estimates requested under 38 C.F.R. § 3.311, except those whose claims have been denied and relevant appeal windows of those denials have expired, or those whose claims have been denied solely based on dose estimates obtained before 2001.

Ex. 6 at 36.

an operation known as "Broken Arrow." U.S. military responders were exposed to high radiation levels, measured by their clothing and urine and nasal samples. *Id.* The U.S. sampled some, but not all, personnel, and collected only one sample from most of those tested, violating accepted bioassay protocol. Ex. 7 at 4, 27.

The U.S. provided full-body counters – which can detect plutonium in lungs, the organ most likely to harbor plutonium – to the Spanish to test Palomares residents, but it never did so for U.S. servicemembers. Ex. 14. Instead, researchers selected just 26 Palomares responders (misleadingly called the "high 26") for lifetime monitoring of urine samples. Ex. 6 at 4; Ex. 1 at 1. Air Force medical officers concluded that a longitudinal, expansive treatment program was necessary to supplement the urinalysis data. However, the U.S. government chose to halt all monitoring after less than a year. *Id.* Indeed, the U.S. government sought to downplay the health hazard of the Palomares "Broken Arrow" operation from the beginning. Exs. 9, 10. U.S. Officials made initial assessments of risk based on "intuition" and the preliminary readings of only a few working alpha radiation counters. Ex. 9 at 304, 305, 3113. The U.S. told its troops there was no health risk, gave them little to no safety gear, and forced them to eat irradiated tomatoes for their meals. Exs. 9, 11.

Legal Standard

Many Palomares veterans have developed medical conditions related to their radiation exposure, some as young men. Some Palomares-related conditions are already considered presumptively radiogenic under 38 C.F.R. § 3.309 and § 3.311 when developed after other radiation exposure events, but Palomares veterans do not receive the benefit of these presumptions. Exs. 6, 11. This means that, for example, a veteran of underground nuclear tests at Amchitka Island, Alaska, who developed lung cancer would receive presumptive service connection, but a veteran of the nuclear cleanup at Palomares who developed the same cancer would not receive presumptive service connection. *See* 38 C.F.R. § 3.309(d)(2)(xx); (d)(3)(ii). The Air Force denied any expected ill health effects for Palomares personnel and made many false statements regarding Palomares exposure. Exs. 19C, 19D, 19E. Instead of notifying Palomares veterans of their radiation exposure and adding testing details to their medical records, the U.S. affirmatively decided to withhold veterans' exposure data from their medical records, in large part to avoid potential legal liability. Exs. 9, 11.

The VA has used dosimetry methodology of questionable scientific validity when estimating ionizing radiation doses for Palomares veterans. Exs. 1, 2. The methodology is the subject of litigation under consideration by the Court of Appeals for Veterans Claims in *Skaar v. Wilkie,* No. 17-2574, a class action lawsuit in which applicants for disability benefits claims may be class members. Since 2001, the VA has unlawfully relied on radiation dose estimates derived from a scientifically unsound report produced by a privately-contracted litigation support company, Labat-Anderson, Inc., in adjudicating benefits for Palomares veterans' claims under 38 C.F.R. § 3.311. Ex. 16.

In determining whether a condition is "at least as likely as not" to have resulted from exposure to radiation in service, the VA must rely on "sound scientific evidence," defined as "observations, findings, or conclusions which are statistically and epidemiologically valid, are statistically significant, are capable of replication, and withstand peer review." *Id*. § 3.311(c)(3). The VA is "bound to follow its own regulations as long as they are in force." *Snyder v. Principi*, 15 Vet. App. 285, 29 (2001). The Under Secretary for Benefits must rely on "sound scientific evidence" when determining service connection for claims related to ionizing radiation. *Hilkert v. West*, 12 Vet. App. at 149.

Legal Opinion

The dose estimates that the VA has relied on to deny Palomares veterans' claims do not meet the "sound scientific evidence" standard required by § 3.311. In 1998, the Air Force contracted Labat-Anderson to create a report on Palomares exposure (the "LA Report"). Ex. 7 at 11. As Princeton nuclear physicist Dr. Frank von Hippel explains, the LA Report provides two dose estimate ranges for Palomares veterans. Exs. 1, 2. The first is based on plutonium excretion in urine samples collected from Palomares veterans, but with the highest dose measurements improperly excluded. Excluding the highest measurements makes the total range of samples artificially low. This means that estimates calculated from this model may show levels of radiation exposure lower than what veterans actually experienced. The second is also based on those samples, but is "reconciled" with environmental data collected months or years after the clean-up ended. Exs. 1 at 1, 2, 3, 4, 7 at 10, 16. In other words, the estimate produced from this model do not accurately reflect the radiation levels at the time of the cleanup.

From the completion of the Report in 2001 to 2013, the VA relied on doses constructed under the LA Report's second set of ranges to adjudicate claims of Palomares veterans seeking service-connected disability benefits for radiogenic conditions under 38 C.F.R. § 3.311. After Congress challenged that methodology in 2013, the Air Force told the VA that it would begin calculating dose estimates using the first set of ranges from the LA Report. Exs. 15, 19C-G. Neither the first nor the second set of ranges, however, are based in "sound scientific evidence," a term specifically defined in VA regulation at 38 C.F.R. § 3.311(c)(3).

Labat-Anderson conceded in 2001 that its dose methodology analysis was "preliminary," and explicitly cautioned that additional bioassay data collection, research, and analysis was required. Exs. 7 at 10-11, 19I. As in 1967, however, the Air Force refused to perform additional analysis. Exs. 15, 19I. As Dr. von Hippel explains, the LA Report is not only preliminary but is also fundamentally flawed on a methodological level. Exs. 1, 2. First, the Report excludes the highest radiation exposures measured from its analysis without scientific basis, which violates the VA requirement that "exposure at the highest level of the dose range reported" be presumed. 38 C.F.R. § 3.311(a); Ex. 1 at 13-14. The LA Report then unreasonably adjusts, or "reconciles," the dose estimate ranges downward using air sampling data collected at least two months after the cleanup ended. Ex. 14. Further, it arbitrarily sets a ceiling for Palomares veterans' exposure based on the lower measurements of the "high 26," despite the fact that veterans not in that group had higher exposures measured. Exs. 15, 16. The dose estimates derived from the LA Report fail to constitute "sound scientific evidence," and the VA's continued reliance on them is also arbitrary and capricious, violating 38 U.S.C. § 7261(a)(3)(A). In sum, the VA should not use dose estimates produced from the LA Report's faulty methodology in its disability benefits adjudications.

"Sound scientific evidence"—or proper calculation methods—for Palomares veterans' dose estimates could take two forms. First, the VA could offer new radiation exposure testing for Palomares veteran claimants using current technology. Ex. 7 at 11. Alternatively, as Dr. von Hippel explains, the VA could require that the Air Force use a methodology that uses all bioassay data collected, including the highest doses measured, and building scientifically appropriate uncertainty into the model and dose ranges. Ex. 1 at 15-16. The evidence attached to this letter requires a finding that the VA's reliance on dose estimates derived from the LA Report does not meet the standard for "sound scientific evidence." 38 C.F.R. § 3.311(c)(3); *Hilkert v. West*, 12 Vet. App. 145, 149 (1999). Accordingly, the VA cannot make disability benefits decisions based on dose estimates arising from the LA Report methodology, as are the estimates currently supplied by the Air Force.

INDEX OF EVIDENCE

1. Dr. Frank von Hippel, Program on Science and Global Security Working Paper 1 (Dec. 7, 2017) (explaining why dose estimate methodologies based on the Labat-Anderson Report are scientifically unsound and flawed).

2. Dr. Jan Beyea and Dr. Frank von Hippel History of Dose, Risk, and Compensation Assessments for US Veterans of the 1966 Plutonium Cleanup in Palomares, Spain (July 24, 2019), Health Physics 117(6): 625–636 (outlining problems with obtaining dose estimates based on the Labat-Anderson Report due to its scientific flaws).

3. Biography, Dr. Frank von Hippel (2019).

4. Curriculum Vitae, Dr. Frank Niels von Hippel (updated Jan. 1, 2019).

5. U.S. Nuclear Regulatory Commission, Plutonium Backgrounder (Mar. 2017).

6. Class Certification Order, *Skaar v. Wilkie*, 17-2574 (Dec. 6, 2019) (certifying a class of Palomares veterans to challenge the VA's dose estimate methodology).

The VA Relies on Flawed Dose Estimate Methodologies Based on the Labat-Anderson Report

7. Labat-Anderson Inc., Palomares Nuclear Weapons Accident: Revised Dose Evaluation Report (Apr. 2001) (questionable preliminary report using unsound scientific methods and flawed assumptions on which VA dose estimate methodology is based; prepared by unnamed litigation support specialists and not subjected to a review process).

8. Labat-Anderson Inc., Palomares Nuclear Weapons Accident: Revised Dose Evaluation Report, Appendix C (Apr. 2001) (containing dose estimate data).

The U.S. Government Failed to Collect Complete Bioassay Data at Palomares and After

9. L.T. Odland, Air Force Logistics Command, Wright-Patterson AFB, Plutonium Deposition Registry Board, Proceedings, First Annual Meeting (Oct. 26-28, 1966) at 5, 6, 20-21 (initial Air Force plan to aggressively monitor exposure at Palomares, as "small amount of Plutonium-239 detectable in the urine; i.e., amounts less than acceptable body burden, are of biological significance, since permissible body burdens as assayed by urinalysis may only vaguely indicate the amount of the isotope which may be deposited in the lungs"; discussing withholding exposure results from veterans to avoid legal liability).

10. Notes on Phone Conversation with Col. Odland (Apr. 5, 1967) (referencing the "sleeping dog" policy that halted follow-up monitoring of radiation-exposed Palomares veterans rather than monitoring their health as initially recommended).

11. Dave Philipps, *Decades Later, Sickness Among Airmen After a Hydrogen Bomb Accident*, N.Y. TIMES (June 19, 2016) (Col. Odland states that he "never got accurate results from hundreds of men who may have been contaminated" by plutonium exposure and that he acknowledged at the time that "plutonium lodged in the lungs could not always be detected in veterans' urine," such that "men with clean samples might still be contaminated").

12. Dave Philipps, *Legal Win Is Too Late for Many Who Got Cancer After Nuclear Clean-Up*, N.Y. TIMES (Feb. 11, 2020) ("For decades, the Air Force has cited urine samples taken in the field in 1966 to support its claim that the cleanup troops were not harmed, even after its own analysis raised alarms about the data.").

The U.S. Government Minimized the Appearance of Hazardous Exposure at Palomares

13. Friday Afternoon Session (Oct. 6, 1967) at 296, 304, 305, 313 (transcript of conversation led by Dr. Wright Langham, head of hazardous materials response at Palomares, explaining that the only value of the surgical masks provided to responders was psychological; that the alpha radiation counters at the site often did not work; that exposure risk assessment was based on "intuition"; and that acceptable post-cleanup radiation levels were negotiated with the Spanish without direct reference to human health).

14. U.S. Dep't of State, Nuclear Accidents at Palomares, Spain in 1966 and Thule, Greenland, in 1968 at 5 (describing eagerness of Spanish and U.S. governments to downplay risk of exposure).

15. Department of the Air Force, Memorandum for the House Armed Services Committee Regarding Report on Implementation of the Recommendations of the Palomares Nuclear Weapons Accident Revised Dose Evaluation Report (Dec. 6, 2013) (discussing review of data leading to partial revision of dose estimate methodologies).

16. Department of the Air Force, Memorandum for Department of Veterans Affairs Regarding Radiation Exposure Estimates for USAF Nuclear Weapon Accident Responders – Palomares, Spain (Dec. 6, 2013) (describing review of dose assessment process which

found inconsistencies leading the office to adopt questionable methodologies based on the misnamed "high 26" doses, which methodologies should be revised as set out in *Skaar v. Wilkie*).

17. U.S. Department of Veterans Affairs, Aircraft Collision Cleanup at Palomares, Spain (website providing overview and discussing health risks according to flawed methodology).

Declarations from Palomares Veterans and Substitute Claimant

18. Declaration of Victor B. Skaar (Feb. 19, 2019).

19. Declaration of Nona Watson, Survivor of Nolan Watson (Feb. 26, 2019).

    a. Handwritten Statement of Nolan Watson (regarding his experience at Palomares).

    b. Letter from Rep. Broun to Chairman McKeon (regarding issue of Palomares).

    c. Letter from Maj. Gen. Robinson to Rep. Broun (regarding the Air Force's handling of Palomares-related issues) (May 21, 2012).

    d. Letter from Rep. Broun to Maj. Gen. Robinson (pointing out numerous discrepancies in the May 21, 2012 Air Force letter).

    e. Letter from Col. Goggin to Rep. Broun (responding to Rep. Broun's letter, stating that "responders were not expected to experience any health effects") (July 12, 2012).

    f. Letter from Rep. Broun to Nolan Watson (explaining amendment to H.R. 1960 requiring the Air Force to submit a report on Palomares) (June 13, 2013).

    g. Memo. from USAF Medical Support Agency/SG3PB to Dep't of Veterans Affairs, Jackson, MS on Radiation Exposure Estimates for USAF Nuclear Weapon Accident Responders – Palomares, Spain (Dec. 6, 2013).

    h. Memorandum from Nona Watson to Rep. Broun (including questions propounded to the Air Force regarding its Palomares dose evaluation report) (Mar. 21, 2014).

    i. Letter from Rep. Broun to Nona Watson (including the Air Force responses to the March 21, 2014 questions regarding its Palomares dose evaluation report) (May 14, 2014).

    j. Medical records of Nolan Watson (including his physician's conclusion that "it is as likely as not that his renal cell carcinoma was caused by his active duty radiation exposure") (Nov. 29, 2010).

k. Statement by Peter Ricard, Palomares veteran, in email to Nona Watson (Aug. 22, 2012).

l. Statement by Ronald McCutchen, Palomares veteran, in email to Nona Watson (Oct. 25, 2010).

20. Declaration of John Garman (Feb. 15, 2019).

21. Declaration of Virgil McDaniel (Feb. 21, 2019).

22. Declaration of Travis Quinn (Feb. 25, 2019).

23. Declaration of Anthony Maloni (Feb. 26, 2019).

Exhibit 1

Assessment of the U.S. Air Force's estimates of the radiation doses received by the veterans of the cleanup of plutonium from two nuclear bombs that fell on Palomares, Spain in 1966

Frank von Hippel,* 7 December 2017

Summary

1. About 1600 U.S. military men – mostly Air Force – participated in a cleanup of plutonium contamination in the Spanish village of Palomares in 1966. The contamination resulted from chemical explosions in two nuclear bombs that had fallen from a collision of a U.S. B-52 bomber with its aerial refueling tanker. The young men were ordered to work for up to three months shoveling contaminated earth into barrels for shipment to the United States. They worked without protection against plutonium-contaminated particles because their supervisors did not wish to alarm the Spanish citizens and officials observing the cleanup.
2. Under 38CFR3.311, "Claims based on exposure to ionizing radiation," veterans are entitled to compensation if they developed a radiogenic disease after their service and if they received a radiation dose to the diseased organ large enough so that the "evidence supports the conclusion it is at least as likely as not the veteran's disease resulted from exposure to radiation in service." Since such dose estimates have an uncertainty range, the veteran is given the benefit of the uncertainty and the highest level is presumed under the law.
3. Between 2001 and 2013 (35 to 47 years after the accident) the Air Force based its estimates of the veterans' doses on measurements of airborne plutonium *after* the cleanup. These theoretical exposures had no relationship to the actual amount of plutonium inhaled by the veterans during the cleanup, when the concentration of airborne plutonium is likely to have been much higher.
4. In 2013 (47 years after the cleanup) the Air Force changed to the assumption that 26 veterans in a "high dose" group, for which good measurements of urine contamination were available, had inhaled the amount of plutonium estimated in a 2001 reanalysis of that data and that the remainder of the group of about 1600 had received lower doses. Although the remaining group had lower-quality measurements of the plutonium in their urine, estimates based on those measurements indicated that a significant fraction could have had much higher doses than the lowest dose to the "High 26" – and some could have had much higher doses than the highest of the "High 26".
5. The dose estimation process for the "High 26" also was flawed by the fact that the

* Frank von Hippel is a Senior Research Physicist and Professor of Public and International Affairs emeritus in Princeton University. During 1993-4, he served as Assistant Director for National Security in the White House Office of Science and Technology Policy. He has published numerous peer-reviewed articles on the health consequences of nuclear accidents, including one hypothetical case involving plutonium dispersal. In 1993, he was awarded a MacArthur "genius" prize fellowship.

plutonium excretion rates declined with time instead of being relatively stable after the first ten days, as predicted by the biological model used. The analysis done for the Air Force dealt with this problem by dropping the early highest urine measurements. This significantly reduced the resulting dose estimates, whereas a proper treatment would have used that data to increase the maximum of the dose uncertainty range.

6. Based on the above, it appears that the uncertainties in the dose estimates currently being used to determine the veterans' benefits have been grossly underestimated and that the upper end of the uncertain ranges for many of them may be multiple factors of ten higher than the Air Force is advising.

Background

A June 2016 *New York Times* article describes the frustrations of a group of Air Force veterans in their efforts to obtain Department of Veterans Affairs (VA) assistance for health problems they attributed to their participation 50 years earlier, without significant protection against plutonium inhalation, in the removal of plutonium-contaminated earth from areas in the Mediterranean village of Palomares, Spain.[1] Four U.S. nuclear bombs fell there on 17 January 1966 as a result of a U.S. bomber colliding with its refueling tanker. Three of the bombs struck the ground near the village of Palomares and, in two, the chemical explosives detonated and dispersed their plutonium in a fine dust of plutonium oxide.

A similar event occurred two years later when another B-52 loaded with bombs crashed on the ice off of Thule, Greenland. In the Thule cleanup, however, a serious effort was made to protect personnel involved the cleanup from plutonium inhalation and contamination.[2]

After these and other accidents, the U.S. abandoned its policy of keeping nuclear-armed bombers in the air at all times.

About sixteen hundred U.S. military personnel – mostly Air Force but including 107 Army, 37 Navy and 38 other individuals[3] –participated in the Palomares cleanup over a period of approximately three months (17 January to 11 April 1966) for a period of two to three weeks each, on average. They were afforded little protection from contamination or inhalation. Wright Langham, the Los Alamos National Laboratory expert who advised on the protection of the men during the operation later told his colleagues, "[t]he manual says you will dress up in coveralls, booties, cover your hair, wear a respirator, wear gloves," but explained that none of that was done because of concerns about alarming the local population[4]

---

[1] Dave Philipps, "Decades Later, Sickness Among Airmen After a Hydrogen Bomb Accident," *New York Times,* 19 June 2016, http://www.nytimes.com/2016/06/20/us/decades-later-sickness-among-airmen-after-a-hydrogen-bomb-accident.html?_r=1

[2] For a description of the Thule crash and cleanup, see, *Project Crested Ice, The Thule Nuclear Accident* (Strategic Air Command Historical Study 113 (1969), http://nsarchive.gwu.edu/nukevault/ebb267/03.pdf.

[3] L.T. Odland, R.L. Farr, K.E. Blackburn and A.J. Clay, "Industrial Medical Experience Associated with the Palomares Nuclear Incident," *Journal of Occupational Medicine,* Vol. 10 (1968) pp. 356-362.

[4] https://www.documentcloud.org/documents/2797062-xxplutonium-1967-DOE-secret-briefing.html, p. 296.

"Most of the respirators were surgical masks, and if it did something for your psychology to wear one, you are privileged to wear one. It wouldn't do you any good in the way of protection but if you felt better, we let you wear it. We ran into such psychological problems. The manual says you will dress up in coveralls, booties, cover your hair, wear a respirator, wear gloves. That's what the manual says. So, some people tried to do this where you could find something that resembled this type of equipment and before long you found this caused consternation in the village. They said, 'How come you dress up like that and you let us walk around in the village with our street clothes on?' And so even little things like that that I never even thought of before becomes a problem psychologically. Why shouldn't we be protecting them if we were doing all of this protection in the area? So, most of the time it would hardly meet the standards of the health physics manuals the way this operation was done, and I think it's fine because I think there was not anything wrong with this operation. I think it seems wrong with the manual,"

An initial assessment was made of the quantities of plutonium the men inhaled[5] ("body burdens") based on a formula Langham had devised to relate plutonium excreted in urine samples to body burden.[6] On this basis, it was concluded that, of 1586 on-site samples, 20 indicated body burdens of more than the then specified maximum permissible body burden (MPBB) of 0.044 μCi (44,000 pCi or 1630 Bq][7] of plutonium-239 and 422 samples indicated between 9% and 99% of an MPBB.[8] Later off-site urine samples from about 20% of the cleanup personnel resulted in much lower estimates. Of 373 cleanup personnel, only 6 were concluded to have inhaled more than 10% of the MPBB.[9] Of those resampled, 26 provided three urine samples over a year.[10] Their urinary excretion dropped much more rapidly than predicted by Langham's formula, however, raising questions about the validity of the formula.

The Air Force established a Plutonium Deposition Registry Board to advise it on follow-up. That group met only once in October 1966 and advised against entering the

---

[5] Inhalation was assumed to be the dominant route of intake. The body does not absorb most chemical forms of ingested plutonium.

[6] Wright H. Langham, "Determination of Internally Deposited Radioactive Isotopes from Excretion Analysis," *Industrial Hygiene Quarterly,* September 1956, pp. 305-318. The formula is $D = 435U*t^{0.78}$ where D is the body burden, U is the amount excreted daily in urine and t is measured in days. This formula assumes that the exposure happens during a short period at t = 0. The data was obtained from human injection experiments coordinated by Langham that later became infamous because an absence of informed consent.

[7] These units of radioactivity relate to the number of nuclear disintegrations per second. A Curie (Ci) is the radioactivity of a gram of radium, $3.7x10^{10}$ disintegrations per second. A μCi (millionth of a Curie) is 37,000 disintegrations per second. A pCi (trillionth of a Curie) is 0.037 disintegrations per second. A Becquerel (Bq) is one disintegration per second.

[8] L.T. Odland, *et al*, "Industrial Medical Experience Associated with the Palomares Nuclear Incident," *op. cit*. An earlier version was published as L.T. Odland, R.G. Thomas, J.C. Taschner, H.R. Kaufman and R.E. Benson "Bioassay experiences in support of field operations associated with widespread dispersion of plutonium" in H. Kornberg and W. Norwood (eds), *Diagnosis and Treatment of Deposited Radionuclides. Symposium. XVIII: Amsterdam, the Netherlands* (Monographs on Nuclear Medicine and Biology Series, No. 1., 1968) pp. 256-265.

[9] Plutonium Deposition Registry Board, *Proceedings, First Annual Meeting, 26-28 Oct. 1966* (Dept. of the Air Force, Air Force Logistics Command, Wright-Patterson Air Force Base, Ohio) p. 19.

[10] L.T. Odland *et al*, "Industrial Medical Experience Associated with the Palomares Nuclear Incident," *op. cit.*

plutonium body-burden estimates into the medical records of the veterans but rather to send the data "to the appropriate [Service] Surgeon General for deposition and recording, as he saw fit."[11] After that, there was no further monitoring.[12]

Many of the men have suffered cancers and other conditions that they attribute to their exposure to plutonium and some have applied for benefits.

Determination of Benefits

Establishing whether or not a veteran is entitled to benefits is a two-step process laid out in 38CFR3.311, "Claims based on exposure to ionizing radiation":[13]

1. The veteran's disease must be "radiogenic," i.e. to have been shown by epidemiologic data to be caused by ionizing radiation; and
2. Since the probability of ionizing radiation causing the disease increases with dose, the veteran must have received a dose large enough so that "it is at least as likely as not the veteran's disease resulted from exposure to radiation in service."

Usually the dependence of risk on dose (d) is expressed as a Relative Risk [RR(d)], i.e. the factor by which the risk of a radiogenic disease is increased over the baseline in the absence of radiation exposure beyond that received by the average population. The criterion in Section 3.311 is therefore defined through the formula $[RR(d) – 1]/RR(d) \geq 0.5$. The boundary is set at a dose where radiation has doubled or more than doubled the risk relative to a control population of the same sex, age and race. This boundary is taken to be the point at which the probability of disease causation (assigned share) due to radiation is 50% or more.

The National Cancer Institute has established a website where the "probability of causation" (PC) or "assigned share" can be calculated, using the IREP interactive program.[14] Excess risk for 19 cancers known to be radiogenic can be calculated in the IREP program's online calculator, including an uncertainty range, as a function of estimated dose and converted into the PC.

Handling uncertainty in the relationship between a dose and disease is a key element of IREP. Under VA rules, the 50% criterion need only be met at the upper 99% credibility range for the overall uncertainty.[15] The range of uncertainty of the PCs calculated by

---

[11] Plutonium Deposition Registry Board, *Proceedings, op. cit.* p. 21.
[12] "Palomares Broken Arrow--Report on Medical Follow-up Program" (Air Force Logistics Command, Wright Patterson Air Force Base, Ohio) 16 Jan 1968.
[13] https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=1&SID=256a630c4acdb9cb26393c9c5531b0f7&ty=HTML&h=L&mc=true&r=SECTION&n=se38.1.3_1311
[14] https://www.niosh-irep.com/irep_niosh/ The analyses behind the original version of this calculator are discussed in David C. Kocher et al, "Interactive Radio-epidemiological Program (IREP): A Web-Based Tool for Estimating Probability of Causation/Assigned Share of Radiogenic Cancers," *Health Physics* Vol. 95(1) pp. 119-147. See also: https://radiationcalculators.cancer.gov/.
[15] "The Department of Veterans Affairs (VA), in their application of the 1985 radio epidemiological tables, uses the value at the upper 99 percent credibility limit of the probability of causation estimate," *User's Guide for the Interactive Radio Epidemiological Program (NIOSH-IREP)* https://www.niosh-irep.com/irep_niosh/Help/irepug.pdf, p. 3.

IREP can be performed for a single (e.g., a maximum) dose or, if the uncertainty in dose can be expressed in terms of a standard statistical distribution, for a range of doses.

Establishing the organ doses a veteran received – and their uncertainty ranges – is therefore critical to the determination of eligibility for benefits. When the dose is uncertain, section 3.311 gives the veteran the benefit of the doubt,

> "When dose estimates provided pursuant to paragraph (a)(2) of this section are reported as a range of doses to which a veteran may have been exposed, exposure at the highest level of the dose range reported will be presumed."

As will be seen below, the dose estimates that have been made for the Palomares veterans are extremely uncertain and, in many cases, the maximum doses have been grossly underestimated.

Estimating the doses received

For other classes of "atomic veterans," doses were primarily from penetrating gamma rays and neutrons – either directly from a nuclear explosion or from ground contaminated by fission products from a nuclear explosion. Such doses can be measured by a dosimeter worn as a badge.

The doses incurred by the Palomares veterans were different. They did not come from outside the body. They came from inside from inhaled particles of plutonium.

A second difference in the radiation doses incurred by these veterans is the short range of the radiation emitted by plutonium. Gamma rays and neutrons are penetrating and therefore the damage done in the body is relatively uniform – typically within a factor of two or three. The alpha rays emitted by plutonium carry a great deal of energy and do great damage to cellular DNA – indeed an estimated 20 times more per unit energy deposited than gamma rays – but they deposit that energy in a very short distance, shorter than the thickness of a paper bag or of the dead layer of cells that covers our skin. The damage done by plutonium is therefore done to the lung tissue where it is first deposited and where some remains, and then to other organs to which dissolved plutonium is transported via the bloodstream. Doses must therefore be estimated for each organ where a significant amount of plutonium ends up.

A third difference is that the estimation of the doses received by the Palomares veterans is based on a very indirect measure: measurements of plutonium excreted in their urine – in most cases, only a single measurement of questionable validity.

In order to deduce doses from measurements of plutonium in urine, it is necessary to have a model of redistribution of the plutonium in the body to the various organs and then of the rate at which the plutonium in each organ is excreted into the urine. Until recently, there has been very little data on the transport and therefore the dosimetry of plutonium in the body. What existed was based primarily on controversial experiments done in the mid-1940s based on injections of plutonium by Langham's collaborators into uninformed hospital patients and on post mortems of these patients and a few Los Alamos plutonium workers.[16] Uncertain mathematical models were constructed to fill the gap.

Since the end of the Cold War, another source of dosimetry and epidemiological data has become available from workers exposed to plutonium at the Mayak plutonium production and processing facility in the Urals where corners were cut during the late 1940s and early 1950s as the Soviet Union rushed to catch up to the U.S. in the production of nuclear weapons.[17] The extent to which this new data and analysis can be used to reduce the uncertainties discussed below remains to be seen.

The Air Force's attempts at dose estimation

Perhaps in response to claims for benefits from Palomares veterans, the Air Force contracted with the consulting firm Labat-Anderson (LA), a firm that specialized in "litigation support and information services,"[18] to estimate the doses received by the Palomares veterans. In April 2001, the Air Force published the resulting analysis. It is labeled "revised."[19] The report is very unusual for a scientific analysis in that its authors are not listed. Also, it does not contain a description of the review process, the revisions that were made in response or who made them. Unfortunately, Labat-Anderson no longer exists. It was bought in 2009 by USIS, which went bankrupt in 2015 after a massive data breach and the settlement with the U.S. government of a claim of fraud.[20]

The Labat-Anderson report included two very different estimates of the doses that the veterans had received:

1. A detailed attempt to estimate doses from the measurements of plutonium excretion in urine; and

2. A cursory alternative "environmental" exposure estimate based on measured airborne plutonium in the Palomares area *after* the cleanup.

[16] See William Moss and Roger Eckhardt, "The Plutonium Injection Experiments," *Los Alamos Science* 1995, http://la-science.lanl.gov/lascience23.shtml

[17] *Reconstruction of Radiation Dose from Past Inhalation of Plutonium: The Mayak Worker Dosimetry System – 2013*, special double issue of *Radiation Protection Dosimetry,* Vol. 176, Nos 1 and 2, October 2017, https://academic.oup.com/rpd/issue/176/1-2.

[18] David Hubler, "USIS buys professional services firm Labat-Anderson," https://washingtontechnology.com/articles/2009/05/20/usis-buys-professional-services-firm-labat-anderson.aspx

[19] Labat-Anderson, lnc. *Palomares Nuclear Weapons Accident*: *Revised Dose Evaluation Report*, April 2001, https://assets.documentcloud.org/documents/2797013/xxplutonium-2001-USAF-Revised-Dose-Evaluation.pdf. The appendices are not included in the version posted by the Air Force. Those appendices were provided to me by Nona Watson, the wife of one of the veterans.

[20] Associated Press, "USIS to lose federal contracts after cyberattack compromises security of 25,000 government workers,"10 July 2015, http://wjla.com/news/local/usis-to-lose-government-work-after-cyberattack-compromises-security-of-25-000-government-workers-106; "Security check firm USIS accepts $30 million fraud settlement," Homeland Security Newswire, 20 August 2015, http://www.homelandsecuritynewswire.com/dr20150820-security-check-firm-usis-accepts-30-million-fraud-settlement .

The Air Force Surgeon General preferred the "environmental" estimates, which were generally much lower than the estimates based on the urine excretion data, and put out a press release in May 2002 stating[21]

> "the re-evaluations, using modern modeling methods, confirmed original conclusions that the exposures were not significant.
>
> "The Palomares report found that the ability to reconstruct doses from urinalysis was confounded by poor data quality, mostly as a result of sample contamination and limited analytical sensitivity. However, environmental (air) sampling data suggests that exposures were less than 500 mrem [0.5 rem or 0.005Sv],[22] 1/10 the current limit for radiation workers…"

As will be explained below, the "environmental" dose estimates most likely grossly underestimated the doses received by the Palomares veterans.

The maximum dose of 0.5 rem attributed in 2002 by the Air Force Surgeon General is comparable to the average annual dose of 0.24 rems from natural background radiation, including from indoor radon[23] and – as the Air Force release stated – one tenth the 5-rem limit that the Nuclear Regulatory Commission has set for the radiation dose that a nuclear worker can receive in one year.[24]

Based on this dose estimate, the veterans were not entitled to the benefits that some would have been accorded had the estimated doses been much higher. Faced with this situation, fewer than one percent of the veterans appear to have applied for benefits. A 6 December 2013 memo from the Air Force to the VA states[25]

> We have records for 19 USAF veterans who submitted claims since 2001 in association with the Palomares response, with three individual appeals for re-assessment for a total of 22 claims. For several of these claims, dose estimates and subsequent responses involved assistance from the Air Force Safety Center."

Because of the huge disparities between its dose estimates from the urine samples and from the environmental data after the cleanup, the authors of the 2001 reanalysis recommended that[26]

> "Additional effort is needed to reconcile the estimated intakes and doses derived from the urinary bioassay data with the estimates from environmental measurements. A targeted effort that includes participant activities, participant interviews, urine and other appropriate

---

[21] "AF Surgeon General releases reports on two nuclear weapons accidents," Air Force Medical Services SG Newswire for May 2002, supplied by Nona Watson.

[22] The units Gray (Gy) and rad are measures of the intensity of the ionizing energy absorbed. A Gray equals 1 joule/kg and a rad = 0.01Gy. The units Sievert (Sv) and rem are measures of radiation damage. For gamma radiation 1 Gray energy deposition density corresponds to a dose of 1 Sievert. For the alpha radiation emitted by plutonium, it is generally assumed that 1 Gray energy deposition density results in a dose of 20 Sieverts. A rem = 0.01 Sv.

[23] *Sources and Effects of Ionizing Radiation* (UN, 2000) Vol. 1, Annex B, Table 31.

[24] http://www.nrc.gov/reading-rm/doc-collections/cfr/part020/part020-1201.html

[25] "Radiation Exposure Estimates for USAF Nuclear Weapon Accident Responders – Palomares, Spain" FROM: Air Force Medical Support Agency/SG3PB, TO: Department of Veterans Affairs, Jackson, MS, Attn: Ms. Gail Berry, 6 December 2013.

[26] Labat-Anderson*, op. cit.* Executive Summary, p. 3.

plutonium analyses using current techniques, medical records review, and modeling should be considered…"

The Air Force did not, however, commission the recommended further studies. Twelve years later, in 2013, in response to a Congressional request for an explanation,[27] the Air Force Surgeon General responded that[28]

> "The follow-up biomonitoring results obtained in 1967 provide a reasonable, yet conservative (worst case) exposure estimate for response personnel. Modeling methods currently available to perform dose reconstruction would not change the fundamental conclusions reached in 1968 that adverse acute health effects were neither expected or observed, and long-term risks for increased incidence of cancer to the bone, liver and lung were low. Biomonitoring today, though technically feasible, is not expected to confirm a correlation between health outcome and exposure due to the low exposure level. The Air Force is able to establish an upper bound on possible exposures for response personnel, based on the "High 26" cohort (considered the highest exposed 26 individuals) using actual bio-monitoring results from a time close to the actual exposures and will apply this conservative approach in addressing requests from Veterans Affairs for exposure assessments. This revised conservative approach will afford the veteran with the benefit of the doubt as to level of exposure. Hence, we do not recommend additional, broad-scale, follow-up biomonitoring."

There was no mention here of the "environmental" estimates the Air Force had favored for the previous eleven years. The Air Force had shifted to dose estimates based on the urinary excretion data.

In a simultaneous 6 December 2013 memo to the VA, the Air Force established the following procedure for assigning doses:

a. "Establish the veteran 's presence at the incident site.

b. "Perform a review of duties based on historical records and statements provided by the veteran.

c. "Review available bioassay data for the veteran and assign an intake value.

   "(1) If the veteran is a member of the cohort with the highest exposure potential (designated as the 'High 26'), use their established intake estimates. The established intakes range from 34,000 to 570,000 picocuries (pCi) [1260-21,000 Bq].[29]

   "(2) For the remaining responders, define intake as 'does not exceed the intake calculated for the least exposed member of the High 26 group.' The intake range for this group will

[27] Section 1059 of the Defense Authorization Act for FY 2014, "Not later than one year after the date of the enactment of this Act, the Secretary of the Air Force shall submit to the Committees on Armed Services of the Senate and the House of Representatives a report on the implementation of the recommendations of the Palomares Nuclear Weapons Accident Revised Dose Evaluation Report released by the Air Force in April 2001."

[28] *Report on implementation of the Recommendations of the Palomares Nuclear Weapons Accident Dose Evaluation Report,* 6 December 2013, https://assets.documentcloud.org/documents/2797042/xxplutonium-USAF-Response-to-Amendment-to-HR-1960.pdf.

[29] The LA report used two models to estimate plutonium intake from the amount in the urine sample. This estimated range is from one of the models. The other gave an estimated range of 19,000 to 2,600,000 pCi, LA report, p. 24.

be conservatively set at 1,100 to 34,000 pCi [41-1260 Bq].[30]

d. "Estimate committed doses for the organ(s) of concern. The primary organs of concern from plutonium exposure are the lung, liver, and bone surface, based on International Commission on Radiological Protection (ICRP) Publication 30 (used by the Nuclear Regulatory Commission and Environmental Protection Agency) and ICRP Publication 68 (used by the Department of Energy and the Defense Threat Reduction Agency). We will provide both ICRP model results in responses to the VA.

e. "lf the member does not have a valid urine sample, reconstruct the dose based on similar exposures using their specific duties, if possible. If that is not possible, consider having the member provide a urine sample for analysis using the latest analytical procedures that claim to eliminate or greatly reduce confounding factors such as radioactivity from natural or background sources."

Thus, unless measurements on new urine samples are carried out, the revised dose estimates are to be based on the 2001 revised estimates of the doses received by the "High 26" group of veterans and any veteran not among the less than 2 percent in the "High 26" will be assigned a dose range with its top equal to the estimated dose of the least exposed of the 26.

A follow-on memo on 27 January 2014, provided a table of "Equivalent organ doses from single Intake of [34 nCi (34,000 pCi)] $^{139+240}$Pu based on [International Council on Radiation Protection reports] ICRP 26/30/48 and ICRP 71.[31]

This table of organ estimates is reproduced below. It would be desirable to compare with values obtained from the study of the Mayak workers.

[30] There is nothing conservative about this range. The LA report estimated 75,000 to 20,000,000 pCi for the "remaining cases" group (1063 individuals). See below.

[31] "Memorandum for Department of Veterans Affairs Jackson, MS from: AFMSA/SG3PB SUBJECT: Revised Response for Radiation Dose Information on Veteran [REDACTED] 27 January 2014."

Attachment
HQ AFSEC/SEWN Ltr to AFMSA/SG3PB,
9 January 2014

Equivalent Organ Doses from Single Intake of $^{239+240}Pu$,
Based on ICRP 26/30/48 and ICRP 71.

				Intake (nCi) =	34
Class Y	ICRP 26/30/48 Inhalation Exposure Pathway		Type S	ICRP 71 Inhalation Exposure Pathway	
	Organ	Dose (rem)		Organ	Dose (rem)
	Gonads	1.51		Adrenals	0.040
	Breast	0.00005		Bladder Wall	0.040
	Lung	40.6		Bone Surface	21.4
	Red Marrow	8.3		Brain	0.040
	Bone Surface	103		Breast	0.040
	Thyroid	0.00005	GI-Tract	Oesophagus	0.040
	Liver	3.80		St Wall	0.040
	Effective	10.5		SI Wall	0.040
				ULI Wall	0.040
				LLI Wall	0.042
				Colon	0.042
				Kidneys	0.10
				Liver	4.9
				Muscle	0.040
				Ovaries	0.30
				Pancreas	0.040
				Red Marrow	1.14
			Respiratory Tract	ET Airways	4.8
				Lungs	10.9
				Skin	0.040
				Spleen	0.040
				Testes	0.31
				Thymus	0.040
				Thyroid	0.040
				Uterus	0.040
				Remainder	0.043
				Effective Dose	2.0

Table 1. Guidance given by the Air Force to the VA in January 2014 for maximum estimated doses for all but the "High 26".

As discussed below, the 2001 re-analyses of the doses to the "High 26" excluded the earlier field measurements of plutonium excretion, whose inclusion would have resulted in considerably higher doses. Also, the field measurements of plutonium excretion of many of the veterans not among the 26 were higher than those of the 26.

Labat-Anderson (LA) estimates of doses

As mentioned above, LA made two sets of dose estimates for the veterans, one "environmental" set based on air contamination measurements *after* the cleanup was completed and one based on the amount of plutonium in selected urine samples. As noted above, the dose estimates based on the after-cleanup air concentrations were recommended by the Air Force until late 2013.

Doses based on air measurements. After the cleanup, air-sampling stations were set up at four locations around and in Palomares to assure that the resident population was not being exposed to dangerous levels of wind-blown plutonium. The nearest station was about 0.5 kilometers from the impact site of one of the bombs. The three others were about a kilometer away. Measurements were taken starting in June 1966, two months after the cleanup had ended.[32] LA estimated maximum doses from this data in two ways:

1. From the maximum annual average and maximum 10-day measured plutonium concentrations in the air – both in 1967, a year after the cleanup – perhaps due to dry weather or unusually high winds.[33] The measured air concentrations after the cleanup were obviously irrelevant, however, to the plutonium that would have been inhaled shoveling plutonium-contaminated dirt into barrels without effective respiratory protection in the most contaminated area during the cleanup.
2. Assuming the *minimum* measured surface plutonium contamination level in the cleanup areas[34] and the highest 10-day value of the plutonium resuspension factor (the ratio between the plutonium level in the air measured in Bq per cubic meter and the ground contamination ratio measured in Bq per square meter). The maximum equivalent full-body dose calculated in this way was 0.31 rem.

Approach #2 is slightly more defensible than the first since the maximum dose was referenced to the minimum original contamination level in the cleanup area but even the highest resuspension coefficient assumed was measured more than a year after the cleanup after the ground in the air-sampling site had been deep plowed to reduce the surface activity.[35] In any case, shoveling contaminated soil into barrels could have caused much more resuspension of fine particles than the wind.

As noted above, in 2013, the Air Forces abandoned the environmental dose estimates.

---

[32] E. Iranzo, S. Salvador and C.E. Iranzo, "Concentrations of ^{239}Pu and ^{240}Pu and Potential Radiation Doses to People Living Near Pu-Contaminated Areas in Palomares, Spain," *Health Physics* Vol. 52 (1987) pp. 453-461; and Emma Iranzo, "Resuspension in the Palomares Area of Spain: A Summary of Experimental Studies," *Journal of Aerosol Science,* Vol. 25 (1994) pp. 833-841.
[33] Labat-Anderson, Table 5.
[34] Labat-Anderson, Table 6. The maximum surface contamination of 1.18 MBq/m^2 assumed by LA corresponded to the boundary level and hence minimum level for the area that the servicemen cleaned up, Iranzo *et al*, "Concentrations of ^{239}Pu and ^{240}Pu…", *op. cit.*
[35] Iranzo *et al*, "Concentrations of ^{239}Pu and ^{240}Pu…", *op. cit.*

Dose estimates based on urine samples

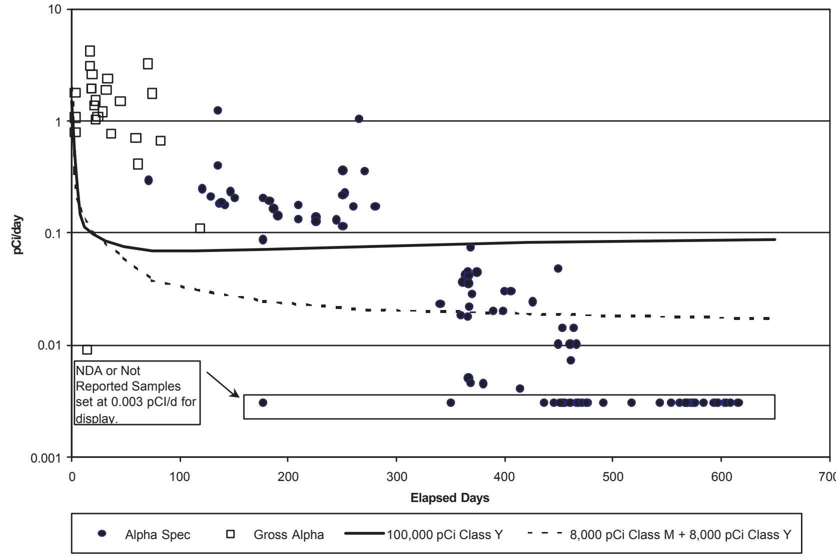


Figure 1. Measured plutonium excretion rates in urine of the 26 "high-dose" veterans with uncontaminated samples taken during the cleanup.[36] Most of the samples before 100 days were taken in the field and the measurements were of gross alpha activity in the urine. The later samples were taken in laboratories and measurements were made of the energy of the alpha particles (alpha spectrometry) to check that the alpha particles were coming from plutonium decays. The curves (model not specified, probably CINDY, see below) show the fits to the predicted rate of excretion assuming either the inhalation of 100,000 pCi of low solubility plutonium or of 16,000 pCi with half low solubility and half higher solubility plutonium. The dispersed plutonium in the environment was measured as 87% low-solubility PuO_2 (Class Y or Type S)[37] for which the excretion would be relatively constant after first ten days or so as for the solid line. The figure shows, however, that the early gross alpha measurements,[38] mostly made before 100 days, are about ten times higher than the measurements made between 100 and 300 days after exposure and that those in turn are ten times higher than the measurements made after 300 days. LA decided to ignore the early urine measurements and base its inhalation estimates on the later measurements despite the fact that the drop with time in the excretion rates that its biological model could not explain continued in the later measurements as well. NDA stands for samples with no detectable activity that were assigned plutonium concentrations equal to the limit of detectability.

In the LA dose evaluation based on the measured plutonium levels in the urine of 1456 individuals, the samples of 1063 were only evaluated cursorily "because their data indicated contamination from collection on site" and because they gave high doses.[39] The evidence for contamination appears to have been the presence of alpha-emitting particles

[36] Labat-Anderson, Figure E-4.
[37] Labat-Anderson, p. E-10, full cite not given there.
[38] The gross alpha measurements were measurements of the rate of alpha decays in the urine sample. This could have included uranium as well as plutonium. The alpha spectrometer measurements also measured the energy of the alpha rays to determine which were from plutonium. It would be interesting to determine how much of a difference was found in these two measurements for the same sample. I have not checked yet whether this is reported in the articles on the measurements.
[39] Labat-Anderson, p. ES-2.

on the outsides of the sample bottles.[40] Samples from 313 individuals were also contamination suspects but the dose estimates that they produced were not seen to be outrageously high. Only the analyses of urine samples from 80 individuals, about 5 percent of the total veterans, who had laboratory tests were considered worthy of careful analysis. Of these, 26 or less than 2 percent had been subject to resampling over a follow-up period of 18 to 24 months.[41] These 26 were labeled the "High 26" although their dose estimates were not, in fact, high compared to dose estimates based on the available data for the other 1560 veterans.

As, in the 1968 analysis, LA found that the urinary excretion rate for the 26 dropped much more rapidly with time than the model predicted (figure 1). This was true not just for the comparison of the gross alpha measurement with the alpha spectrometer measurements but also within the alpha spectrometer measurements.

Section 4.2 of the LA report discusses how internal doses were estimated from the urine excretion measurements. Two models were used: the Code for Internal Dosimetry (CINDY, Pacific Northwest Laboratory, 1992), and the Lung Dose Evaluation Program (LUDEP version 2.06, UK National Radiological Protection Board, 1991). The discussion of dosimetry is expanded in LA, Appendix D. The models describe the transport of plutonium from the lung to other organs and then its excretion into the urine from those organs. LA Figure D-6 shows the different models' estimates of intake for a given excretion rate. The excretion rates are shown as relatively constant for the first year and show a ratio of 2,700 to 14,000 between intake and daily excretion rates in urine, depending upon the model.

For the "High 26," with their high early measurements excluded, the range of intakes estimated was from 34,000 to 570,000 pCi for CINDY and 19,000-2,600,000 pCi for LUDEP. The corresponding range of lung doses is given as 0.38-6.33 Sv (38-633 rem).[42] Table 1 above, from the Air Force memo to the VA dated 27 January 2014, updated this estimate for the veteran with the lowest estimate intake, providing "Equivalent organ doses from Single Intake of [34 nCi (34,000 pCi)] $^{139+240}$Pu. It compares the previous ICRP model predictions with the mostly lower predictions from the more recent (ICRP 71, 1995) model. For lung dose, it reduced the dose estimate for an intake of 34,000 pCi to 0.11 Sv (11 rem).[43] The predictions of these models should be compared with those from a model recently developed based on data from the workers at Russia's Mayak plutonium production site. This data includes autopsy measurements of plutonium in

[40] L.T. Odland *et al*, "Industrial Medical Experience Associated with the Palomares Nuclear Incident," *op. cit.*

[41] L.T. Odland *et al*, "Industrial Medical Experience Associated with the Palomares Nuclear Incident," *op. cit.*and Labat-Anderson, p. ES-2.

[42] Labat-Anderson, Table E-5.

[43] Memorandum for Department of Veterans Affairs Jackson, MS
From: AFMSA/SG3PB
SUBJECT: Revised Response for Radiation Dose Information on Veteran [REDACTED] 27 January 2014.

different organs. For a lung dose of 1 Sv, the Mayak study finds an excess lung-cancer risk of about 40% for smokers and about 150% for non-smokers.[44]

Based on Figure 1, if the early measurements of plutonium excretion had not been excluded, the estimated doses to the “High 26” would have increased several-fold. Combining this uncertainty with the model uncertainties, it cannot be excluded that the maximum organ doses received by some of the 26 would be in the range where, if they developed some radiogenic cancers or other radiogenic disabilities, it would be more likely than not that their conditions were caused by the plutonium that they inhaled.

After estimating the doses of the “High 26,” the LA report divided the remaining cases into three groups:[45]

i) A “Repeat Analysis” group of 54 individuals whose urine sample had been either reanalyzed or from whom an additional urine sample had been taken. The LA estimates of the range of plutonium intakes for this group was 2,900 to 1,300,000 pCi from CINDY and 11,900 to 5,240,000 pCi from LUDEP.[46] For CINDY, this corresponds to 0.08 to 38 times the lowest estimated intake in “High 26.” For LUDEP, the factor is 0.35 to 154. The Air Force’s instruction in its 6 December 2013 memo to the VA that this entire group should be assumed to have a lower dose than the lowest of the “High 26” therefore could do the high-dose individuals in this group a considerable injustice. Indeed, the highest-dose individual in the “Repeat Analysis Group” was estimated by LA to have ingested more plutonium than the highest exposed individual in the “High 26” group.

ii) A “Contamination Cutoff” group (313 individuals) where the urine excretion rate was estimated as below 0.1 pCi/day. Here, for 30 individuals for which more than one sample was taken, “[t]he lowest results for any individual were used regardless of whether the analysis was performed using gross alpha counting or alpha spectrometry.”[47] No reason was given for this bias toward lower doses. The resulting intake range was estimated with CINDY as 1,500-110,000 pCi or 0.04 to 3 times the lowest value among the “High 26”.

iii) A “Remaining Cases” group (1063 individuals) for which only one sample had been obtained or a follow-up sample did not produce results because of low recovery of plutonium or laboratory error. This is the group whose samples were both considered to be environmentally contaminated and which gave high doses. Here the LA estimates for plutonium intakes using CINDY ranged from 75,000 to 20,000,000 pCi or from 2 to 600 times the lowest intake in the “High 26” with the estimated highest intake 36 times higher than the highest intake among the “High 26”. Here, once again, the Air Force’s instruction that the intakes of all these

---

[44] E.V. Labutina, I.S. Kuznetsova, N. Hunter, J. Harrison, and N.A. Koshurnikova, “Radiation Risk of Malignant Neoplasms in Organs of Main Deposition for Plutonium in the Cohort of Mayak Workers with Regard to Histological Types,” *Health Physics*, Vol. 105 (2013), pp. 1-12. Assuming the standard 1 Gy = 20 Sv for alpha radiation and linearity of effect with dose, which appears to be a reasonable approximation for the Mayak lung-cancer data.

[45] Labat-Anderson, pp. 25-27.

[46] Labat-Anderson, section E.4.2.2.1.

[47] Labat-Anderson, section E.4.3.2.2.

veterans should be taken to be less than the lowest of the "High 26" does not appear be justified.

The Air Force could counter that the measurements for this group is unreliable because of possible environmental contamination. But that introduces an uncertainty into the analysis. It does not necessarily mean that the measurements were wrong.

Conclusions

1. The Palomares veterans were knowingly exposed to airborne plutonium, an extremely potent carcinogen, without proper protection.
2. Until 2013, 47 years after their exposure, the maximum radiation dose estimates recommended by the Air Force to the VA for the determination of the eligibility of the Palomares veterans for benefits were based on measurements of airborne plutonium resuspension *after* the cleanup. The veterans were almost certainly exposed to much higher levels of airborne plutonium during the cleanup.
3. Beginning in 2013, the Air Force recommended organ radiation dose estimates for the "High 26" based on plutonium levels in their urine using a biological model that failed its only available test. The model predicted almost constant plutonium levels in the veterans' urine after the first ten days of exposure while, in fact, the level fell by an order of magnitude[48] between the measurements taken before 100 days and those taken between 100 and 300 days and by another order of magnitude for the measurements taken between 300 and 500 days (Figure 1). Because of concerns about the quality of those early measurements, they were not used in making the dose estimates. The data should, however, have been used to at least increase the uncertainty of the estimates and thereby the maximum estimated doses. In any case, it cannot be excluded that the maximum organ doses received by some of the 26 are in the range where, if they are have developed some radiogenic cancers or other radiogenic disabilities, it would be more likely than not that their conditions were caused by the plutonium that they inhaled
4. Beginning in 2013, the Air Force also instructed that the 98+ percent of the Palomares veterans not included in the "High 26" be assumed to have doses equal to or lower than the lowest dose incurred by one of the "High 26". The 2001 analysis done for the Air Force found, however, that the urine sample measurements for those not in the "High 26" indicated that they had inhaled up to 600 times more plutonium than the lowest of the "High 26." The quality of the urine measurements may not have been as good as those for the "High 26" but, once again, they should have been used to at least establish the maximum doses that those Palomares veterans might have received. Based on the fact that the highest estimated intake among the "Remaining Cases" group of 1063 veterans was 36 times higher than that of the highest among the "High-26", it cannot be excluded that the maximum organ doses received by many in the "Remaining Cases" group are in the range where, if they developed some radiogenic cancers or other radiogenic disabilities, it would be more

[48] "Order of magnitude denotes very roughly a factor 10, e.g. a factor between 3 and 30.

likely than not that their conditions were caused by the plutonium that they inhaled

5. Thus, the Air Force's dose estimates have huge uncertainties and the maximum doses incurred by those not in the "High 26," could be hundreds of times higher than those that the Air Force has recommended to the VA for determination of benefits.

Exhibit 2

OPEN

Paper

HISTORY OF DOSE, RISK, AND COMPENSATION ASSESSMENTS FOR US VETERANS OF THE 1966 PLUTONIUM CLEANUP IN PALOMARES, SPAIN

Jan Beyea[1] and Frank N. von Hippel[2]

Abstract—**In 1966, about 1,600 US military men—mostly Air Force—participated in a cleanup of plutonium dispersed from two nuclear bombs in Palomares, Spain. As a base for future analyses, we provide a history of the Palomares incident, including the dosimetry and risk analyses carried out to date and the compensation assessments made for veterans. By law, compensation for illnesses attributed to ionizing radiation is based on maximum estimated doses and standard risk coefficients, with considerable benefit of the doubt given to claimants when there is uncertainty. In the Palomares case, alpha activity in urine fell far faster than predicted by plutonium biokinetic excretion models used at the time. Most of the measurements were taken on-site but were disqualified on the grounds that they were "unreasonably high" and because there was a possibility of environmental contamination. Until the end of 2013, the Air Force used low dose estimates derived from environmental measurements carried out well after the cleanup. After these estimates were questioned by Congress, the Air Force adopted higher dose estimates based on plutonium concentration measurements in urine samples collected from 26 veterans after they left Palomares. The Air Force assumed that all other cleanup veterans received lower doses and therefore assigned to them maximum organ doses based on the individual among the 26 with the lowest urine measurements. These resulting maximum organ doses appear to be sufficient to justify compensation to all Palomares veterans with lung and bone cancer and early-onset liver cancer and leukemia but not other radiogenic cancers.**

Health Phys. 117(6):625–636; 2019

Key words: accidents, transport; dose assessment; excretion, urinary; plutonium

INTRODUCTION

On 17 January 1966, a US bomber on airborne alert collided with its refueling tanker and three US thermonuclear bombs fell in the Mediterranean village of Palomares, Spain. In two of the bombs, the chemical explosives detonated and dispersed plutonium in a fine dust containing plutonium oxides.

About 1,600 US military personnel—mostly Air Force but including 107 Army, 37 Navy, and 38 other individuals—participated in the Palomares cleanup over a period of almost 3 mo (17 January to 11 April 1966). Most were assigned to work for a period of 2 wk, but some stayed for up to the entire 85 d duration of the cleanup.

These servicemen (we believe they were all men) were exposed via inhalation of airborne plutonium. In this paper, a history is provided of the Palomares incident, including the bioassays, dosimetry, and risk assessments carried out to date. Also covered are the compensation assessments made for veterans. Our intent is to provide a base on which future policy and scientific analyses can build. A natural next step would be to see if modifications to any conclusions would arise after a full uncertainty analysis and the use of the most recent International Commission on Radiological Protection (ICRP) biokinetic models, now being finalized for plutonium to appear in part 4 of the ICRP publication series on occupational intakes of radionuclides (OIR).[3]

Plutonium was inhaled as a result of "activities such as vehicle movement, handling debris during recovery, plowing fields to mix the contaminant into the soil, and vehicle movement. Persistent winds also contributed to the resuspension of contaminated soils from the ground or contaminated dusts

[1]Consulting in the Public Interest, Lambertville, NJ; [2]Princeton University, Princeton, NJ.

Conflicts of interest: von Hippel's research was supported by the Carnegie Corporation and MacArthur Foundation. An early version of this paper (von Hippel 2017) was used by the Yale Law Clinic for an appeal to the US Veterans Administration (YLC 2018). Between 10 and 20 y ago, Beyea provided alternate dose assessments for four military personnel, none of them assigned to Palomares. No one but the authors and Journal reviewers have seen or commented on this paper.

For correspondence contact Frank N. von Hippel, Program on Science and Global Security, Princeton University, 221 Nassau Street, Princeton, NJ 08542, or email at **fvhippel@princeton. edu**.

(*Manuscript accepted* 13 *March* 2019)

Supplemental digital content is available in the HTML and PDF versions of this article on the Journal's website www.health-physics.com.

0017-9078/19/0

DOI: 10.1097/HP.0000000000001103

[3]Personal communication, Keith F. Eckerman (eckermankf@ornl. gov), retired-consultant, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN, 7 March 2019.

from the surfaces of accident debris, local buildings, or agricultural crops" (Labat-Anderson 2001d).

Reportedly, 4,810 barrels were filled with contaminated soil and crops and shipped to the United States (Labat-Anderson 2001d).

The young men worked without protection against inhalation or ingestion of plutonium-contaminated particles. Wright Langham, the Los Alamos National Laboratory expert who advised on the protection of the men during the operation, later told his colleagues, "the manual says you will dress up in coveralls, booties, cover your hair, wear a respirator, wear gloves." He explained that none of that was done, however, because of concerns about alarming the local population (US DOE 1967). Further comments by Langham on this decision are reproduced in the supplemental digital content (SDC), Text S-1, http://links.lww.com/HP/A162.

A similar event occurred 2 y later in 1968 when another B-52 loaded with thermonuclear bombs crashed on the ice off of Thule, Greenland. This time, however, in the absence of a local population, a serious effort was made to protect personnel involved in the cleanup from plutonium inhalation and contamination (US SAC 1969). After this second accident, the US abandoned its policy of keeping nuclear-armed bombers in the air at all times (US DOD undated).

Upon departure from the Palomares cleanup, each of the men provided a urine sample that was shipped for analysis to the Air Force's Radiological Health Laboratory at the Wright-Patterson Air Force Base in Ohio (Odland et al. 1968). Virtually all of the assays of these samples collected on-site were done on the basis of gross alpha counts. Questions were raised about possible contamination, however, and these assays were later dismissed (Labat-Anderson 2001d).

After the cleanup personnel had left the site, additional urine samples were obtained from some of them, and measurements of their ^{239}Pu urine excretion rates were obtained using alpha spectrometry for 422 of them. Of these, 26 were selected as the highest exposed in this group and were requested to provide at least three additional urine samples over a period of almost 2 y after the accident (Odland et al. 1968). "Alpha spectrometry methods for detecting ^{239}Pu were very much at the developmental stage for most of 1966," however, and a later review questioned the quality of the measurements obtained for most of the 422 (Labat-Anderson 2001d).

A question considered was what to do with the results. The Air Force established a Plutonium Deposition Registry Board (PDRB) with representatives from all military branches to advise it on follow-up. That group met once, in October 1966, and opinion was split by service branch as to whether or not estimates of plutonium body burdens should be entered into the medical records of the veterans. It was decided to send the data "to the appropriate [service] Surgeon General for deposition and recording, as he saw fit" (PDRB 1966).

A key part of assessing risk from radiation exposure is to make a best estimate of the doses, but doing so is an uncertain business. Compensation of veterans, therefore, has evolved to include giving them the benefit of the doubt. Uncertainty analysis becomes critical. As will be seen, however, no uncertainty analysis has been provided for the estimated exposures of the Palomares veterans.

Some of the veterans of the cleanup have developed cancers and other conditions they attribute to their plutonium exposure and some have applied for benefits. A June 2016 *New York Times* article 50 y after the event described the frustrations of a group of Palomares Air Force veterans in their efforts to obtain Department of Veterans Affairs (VA) assistance for health problems they attributed to their participation in the cleanup 50 y earlier (Philipps 2016).

Basis for determining veterans' compensation

From the start of the effort to assess the doses the servicemen had received, there was recognition of the possibility of future requests for compensation: "Considerable discussion centered around the possibility of inciting undue concern in these individuals, perhaps to the point of legal action for compensation. However, this was realized, and a certain probability of risk had to be accepted if any follow-up program was to be pursued" (PDRB 1966, p. 24).

Today, a US veteran can go directly to the Department of Veterans Affairs to seek compensation.

Establishing whether or not veterans or their survivors are entitled to benefits is a two-step process laid out in Title 38 of the Code of Federal Regulations (CFR), §3.311, Claims based on exposure to ionizing radiation (US Dept of VA 2018):

1. The veteran's disease must be "radiogenic," i.e., have been shown by epidemiologic data to be caused by ionizing radiation; and
2. Since the probability of ionizing radiation causing a radiogenic disease increases with dose, the veteran must have received a large enough dose so that "it is at least as likely as not the veteran's disease resulted from exposure to radiation in service. "

The dependence of risk on dose (D) is usually measured by relative risk $RR(D)$, the factor by which the risk of a radiogenic disease is increased over the baseline in the absence of radiation exposure beyond that received by a comparable unexposed population. An alternative measure is excess relative risk, $RR - 1$. For compensation purposes, the likelihood criterion in 38 CFR 3.311 is interpreted as

$$\frac{[RR(D)-1]}{RR(D)} \geq 0.5. \tag{1}$$

Because the left-hand side of the equation is a valid probability only for a simple cancer model (Beyea and Greenland 1999), it is today formally called an assigned share (AS) with the historical designation, probability of causation (PC), kept for continuity with earlier literature (US DHHS 2003).

Calculations of the assigned share/probability of causation. The National Institute for Occupational Safety and Health (NIOSH) has established a website where the AS/PC can be calculated using the interactive radioepidemiological program (IREP) (Kocher et al. 2008; ORCRA 2018). Excess risk for 19 cancers known to be radiogenic can be calculated as a function of estimated organ dose and converted into the AS/PC using the IREP program's online calculator. Specific inputs include claimant's ages at exposure and diagnosis, and smoking status. Risk coefficients have been determined as a function of these covariates from multivariate regression analyses of epidemiological data, primarily data from the atomic bomb survivors in Japan.

It is the VA that uses the NIOSH IREP when a veteran makes a claim. In principle, however, on appeal, a veteran can submit an expert report with calculations made with different assumptions.

Handling uncertainty in the relationship between a dose and disease is a key element of IREP. Under VA rules, the 50% criterion need be met only in the upper 99% credibility interval of the overall uncertainty (ORCRA 2005). The range of uncertainty of the AS/PCs calculated by IREP can be performed for a single (e.g., maximum) dose or for a range of doses if the uncertainty in dose can be expressed in terms of a standard statistical distribution.

Establishing the organ doses a veteran received and their uncertainty ranges is therefore critical to the determination of eligibility for benefits. When the dose is uncertain, 38 CFR 3.311 again gives the veteran the benefit of the doubt: "When dose estimates provided pursuant to paragraph (a)(2) of this section are reported as a range of doses to which a veteran may have been exposed, exposure at the highest level of the dose range reported will be presumed" (US Dept of VA 2018).

The VA sets the dose range. On appeal, however, claimants can introduce their own expert opinion for both dose and uncertainty. As will be seen below, the dose estimates that have been provided by the Air Force to the VA for the Palomares veterans are extremely uncertain and, in many cases, the maximum end of the uncertain range appears to have been seriously underestimated.

MATERIALS AND METHODS

Documentation

Air Force and VA documents relating to the Palomares dosimetry and compensation decisions include PDRB 1966; USDOE 1967; AFLC 1968; Odland et al. 1968; Place et al. 1975; Maydew and Bush 1997; Labat-Anderson 2001b and d; Ashworth 2013; USAF 2014; and BVA 2017.

Software calculations

Estimates of assigned share (probability of causation) for a sample of veterans were made using the NIOSH online IREP (Kocher et al. 2008; ORCRA 2018).

Units

To facilitate comparison with the historical literature, curie units are included in parenthesis in the text and on certain figure axes. All doses are organ doses, unless otherwise indicated.

RESULTS AND DISCUSSION

Initial estimates of systemic body burdens

Langham formula. The original estimates for intake of plutonium for each of the 1,600 participants in the Palomares cleanup were based on the on-site, urine excretion data and a formula devised by Wright Langham to relate excretion rates of plutonium in urine samples with systemic body burden, not including lung burden (Langham 1956; Odland et al. 1968).[4]

$$A_L = 435 \times M(t) \times t^{0.78}. \tag{2}$$

Here A_L is the initial body burden (i.e., activity [A] using the Langham [L] equation). A_L was often listed for veterans as a fraction of a "maximum permissible body burden" (MPBB), which at the time was an intake of 1.6 kBq (44 nCi) (Labat-Anderson 2001d). $M(t)$ is the amount excreted daily in urine at time t, with t measured in days. A_L and $M(t)$ have consistent units, so that if $M(t)$ is given in terms of Bq d^{-1}, A_L has units of Bq (Langham 1963).

The formula applies if the exposure happens during a short period around $t = 0$. The data was obtained from human injection experiments coordinated by Langham (McCally et al. 1994; Moss and Eckhardt 1995). Intramuscular and intravenous injections were used to establish resulting tissue distribution patterns (Langham 1963). The Langham formula does not account for the addition to the circulatory system of inhaled plutonium from the lungs, so that a cleanup worker's body burden estimated by eqn (2) could be much less than the total intake that would be estimated by modern biokinetic models, especially for inhalation of insoluble particles. Some inhalation data on plutonium workers existed at the time, but this data was considered inconsistent by Langham (Langham 1963). Only eqn (2) was used to assess burden at Palomares, although at times Langham multiplied his results by a factor of 10 to estimate lung burdens, based on animal experiments (Eakins and Morgan 1964).

Use of the Langham formula

In the dosimetry estimates for the Palomares cleanup veterans, inhalation was assumed to be the dominant route of intake, based on the fact that the absorption fraction from the gut is very low (Langham 1963; Harrison 1991). Using

[4]The t exponent is sometimes given as 0.76 or 0.77.

the Langham formula, the Air Force's Radiological Health Laboratory concluded that of 1,586 urine samples taken on-site, 20 indicated body burdens larger than the then-specified MPBB, and 422 indicated between 9% and 99% of the MPBB (Odland et al. 1968). Later, off-site urine samples were sought from those whose on-site samples indicated 10% of the MPBB or more. The off-site measurements resulted in much lower estimates, however. Of the 422 cleanup veterans whose off-site samples were remeasured, only 6 were classified as having inhaled more than 10% of the MPBB (Odland et al. 1968).

Of the 422 individuals, 26 of them (the "High 26") were asked to provide three additional urine samples over a period of about 18 mo. Of these, the highest plutonium excretion rate in the first follow-on measurements corresponded to 34% of the MPBB, implying a maximum intake of 550 Bq (15 nCi) using the Langham formula. The highest of the second follow-on measurements corresponded to 10% of the MPBB, and by the time the third follow-on measurements were taken, the plutonium excretion levels had fallen, with a few exceptions, below the Air Force's assigned but not published limit of detectability for alpha spectrometry (Odland et al. 1968).

Thus, the urinary excretion rates of the High 26 dropped much more rapidly than predicted by Langham's formula, raising questions about the validity of the formula and/or the urine data. The same inconsistency arises with biokinetic excretion models in use in 2001, the last year that anyone has published fits to Palomares data (Fig. 1).

Fig. 1, which is reprinted from the Labat-Anderson report (Labat-Anderson 2001d), shows the excretion measurements for the High 26 along with four model excretion rate curves for the inhalation of various quantities of soluble and insoluble forms of ^{239}Pu, as calculated by Labat-Anderson using the CINDY biokinetic model, which would be considered outdated today. The lowest excretion curve corresponds to inhalation of 560 Bq (15 nCi) of insoluble plutonium (type S). The two highest curves correspond to inhaling 560 Bq (15 nCi) of soluble ^{239}Pu (type M) with and without the addition of 185 Bq (5 nCi) of the insoluble form. The middle curve is for 185 Bq (5 nCi) of insoluble plutonium plus 185 Bq (5 nCi) of soluble plutonium. None of the curves are consistent with the time course of the grouped excretion measurements.

The question of contamination of the on-site urine samples. Most of the urine samples obtained from the cleanup workers were collected on-site just before the men left the cleanup project (Odland et al. 1968). Most of the samples obtained thereafter were collected at the men's subsequent locations.

In the first recorded discussion of the samples, it was asserted that the on-site samples were contaminated and that plutonium body burdens calculated from them were therefore suspect. This provided the initial justification for collection of follow-on off-site samples (PDRB 1966). In the first published analysis (Odland et al. 1968), it was reported that "opportunities for sample contamination were numerous. Strong winds spread dust over a wide area, including the base camp, troops did not always follow decontamination procedures, initial samples were collected in makeshift containers, and when more acceptable ones became

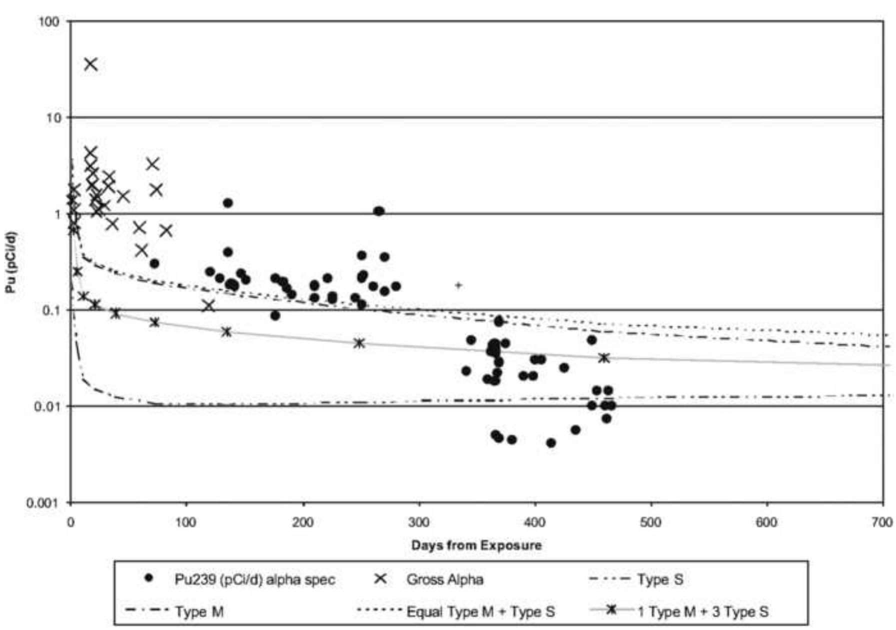


Fig. 1. Measured excretion rates for the High 26, reproduced from Fig. E-2 of Labat-Anderson (2001d). The X symbols indicate gross alpha measurements for urine samples collected on-site. The solid circles correspond to alpha spectrometry measurements for samples mostly collected off-site. They are grouped roughly according to the first and second samples taken. Nondetects are included in SDC Fig. S-1, http://links.lww.com/HP/A162.

available, their storage in a dust-free environment was not always possible."

There are no reports, however, of attempts to estimate the magnitude of the contamination, its variance, or the contribution it might have made to the body burdens.

Contamination by naturally occurring alpha emitters in the decay chains of uranium and thorium also is possible. Typical values of background alpha activity in urine have been reported by Perkin Elmer as 1.3–23 mBq L^{-1} (0.053 to 0.93 pCi d^{-1}), assuming 1.5 L of urine per day (Eikenberg et al. 2011). The analysts apparently considered this possibility at the time (Labat-Anderson 2001d). A few tens of the on-site samples were remeasured for ^{239}Pu using alpha spectrometry (Labat-Anderson 2001d). Although apparently looked for, no alpha emitters other than plutonium were reported (Labat-Anderson 2001d). The ^{239}Pu alpha measurements of the samples taken on-site were generally lower than the gross alpha results, however (Labat-Anderson 2001d).

Dose estimates by Labat-Anderson

Perhaps in response to claims for benefits, the Air Force contracted with the firm Labat-Anderson, Inc., to estimate the doses received by the Palomares veterans. Labat-Anderson was described in media reports as specialized in risk assessment (Bloomberg 2019) and in "litigation support and information services" (Hubler 2009).

The Labat-Anderson analysis published by the Air Force in April 2001 is labeled "revised" (Labat-Anderson 2001d). Neither its authors nor its reviewers are listed. It is indicated in an appendix (Labat-Anderson 2001d) that one of the unnamed authors had been director of radioanalysis at the US Air Force Radiological Health Laboratory from 1969 to 1976.

It has not been possible to seek additional information from Labat-Anderson because the company no longer exists. It was bought in 2009 by US Investigation Services (USIS), which went bankrupt in 2015 after a massive data breach and settlement of a claim of fraud by the US government (Associated Press 2014; HSN 2015).

As discussed below, Labat-Anderson carried out detailed analyses of the urine excretion data. Its report concluded, however, that the results were "unrealistically high when compared with estimates prepared for other plutonium exposure cases—persons residing in the Palomares vicinity and Manhattan Project workers" (Labat-Anderson 2001d).

No explanation was given for why the exposures of Manhattan Project workers should have been comparable to those of the veterans of the Palomares cleanup, but Labat-Anderson did develop alternative dose estimates based on environmental measurements of airborne plutonium around Palomares *after* the cleanup. The environmental estimate takes up less than two pages in the massive Labat-Anderson report. Until late 2013, however, the Air Force based its benefit recommendations for Palomares cleanup veterans on Labat-Anderson's environmental dose estimate.

Environmental dose estimate. Labat-Anderson's environmental dose estimate was based on data taken by air-sampling stations set up after the cleanup at four locations around and in Palomares to make certain that the resident population was not being exposed to dangerous levels of wind-blown plutonium. The nearest station was about 0.5 km from the impact site of one of the bombs. The three other stations were about 1 km away from the nearest impact site. Measurements were taken starting in June 1966, 2 mo after the cleanup ended (Iranzo et al. 1987).

Labat-Anderson estimated maximum plutonium inhalation of a hypothetical cleanup veteran who had worked 12 h d^{-1}, 6 d wk^{-1} for 11 wk in postcleanup Palomares. It assumed that during that period, the veteran would have been exposed to the highest 10 d value of the *postcleanup* plutonium resuspension factor (10^{-7} m^{-1}) for an area contaminated with ^{239}Pu at a concentration of 1.18 MBq m^{-2} (Labat-Anderson 2001d). The resuspension factor is the ratio of the concentration of plutonium in the air above the ground, measured in Bq m^{-3}, to the contamination level of the ground, measured in Bq m^{-2}.

The maximum organ-weighted committed effective dose equivalent (CEDE) calculated in this way was 0.0031 Sv.

There are a number of reasons to question this estimate, however.

1. Dust generated by shoveling contaminated soil and vegetation into barrels, by deep-plowing fields, and by movement of trucks and other machinery across fields during the cleanup could have caused much more resuspension of particles than the wind.
2. It is well known that resuspension factors decline rapidly with time (Maxwell and Anspaugh 2011). The maximum resuspension coefficient of 10^{-7} quoted by Labat-Anderson for Palomares was measured 6 mo after the accident (Iranzo et al. 1994). This is consistent with measurements made 6 mo after the Chernobyl release, but measurements of resuspension coefficients immediately after the Chernobyl accident were 2 orders of magnitude higher (Garger et al. 1997).
3. The cleanup effort deliberately attempted to reduce the wind resuspension factor by deep-plowing fields that had been contaminated. The purpose was to redistribute surface plutonium through the top 30 cm of the soil and thereby make most of it inaccessible to the wind.
4. The land contamination level of 1.18 MBq m^{-2} assumed by Labat-Anderson was the level below which cleanup was deemed unnecessary—much less than the contamination levels in the areas where the cleanup took place (Iranzo et al. 1987).

Labat-Anderson recommendations for further analysis. The authors of the Labat-Anderson report were aware of the weaknesses of both the "unrealistically high" dose estimates based on plutonium levels in the servicemen's urine and the very uncertain estimate based on a hypothetical exposure to wind-blown plutonium. They acknowledged their inability to explain the great difference between these estimates. They therefore recommended that "additional effort is needed to reconcile the estimated intakes and doses derived from the urinary bioassay data with the estimates from environmental measurements. A targeted effort that includes participant activities, participant interviews, urine and other appropriate plutonium analyses using current techniques, medical records review, and modeling should be considered…" (Labat-Anderson 2001d).

Another factor Labat-Anderson could have mentioned for consideration was day-to-day variability in urine excretion, the so-called (urine bioassay) scattering factor (Castellani et al. 2013).

Initial Air Force guidance on doses, 2002

The Air Force did not, however, commission additional studies and opted to use the lower environmental dose estimate. The Air Force surgeon general issued a press release stating that "re-evaluations, using modern modeling methods, confirmed original conclusions that the exposures were not significant. …The Palomares report found that the ability to reconstruct doses from urinalysis was confounded by poor data quality, mostly as a result of sample contamination and limited analytical sensitivity. However, environmental (air) sampling data suggests that exposures were less than 500 mrem [0.005 Sv], 1/10 the current [annual] limit for radiation workers…" (AFMS 2002).

A maximum CEDE of 0. 0031 Sv is also comparable to the estimated average annual global dose of 0.0024 Sv from natural background radiation, including from indoor radon (UNSCEAR 2000). Such a dose estimate, even accounting for somewhat higher individual organ doses, is too low to support a conclusion that a radiogenic illness was more likely than not due to plutonium inhaled during the Palomares cleanup.

Revised Air Force guidance, 2013

A decade later, Congress asked why the Air Force had not implemented the Labat-Anderson recommendations for additional studies (US Congress 2013). In response, the then Air Force surgeon general decided to change the recommended maximum dose estimates from the environmental estimate to doses obtained for the High 26 from the Labat-Anderson analyses of the urine data. He argued that "the follow-up biomonitoring [urine excretion] results obtained in 1967 provide a reasonable, yet conservative (worst case) exposure estimate for response personnel. Modeling methods currently available to perform dose reconstruction would not change the fundamental conclusions reached in 1968 that adverse acute health effects were neither expected or observed, and long-term risks for increased incidence of cancer to the bone, liver and lung were low. Biomonitoring today, though technically feasible, is not expected to confirm a correlation between health outcome and exposure due to the low exposure level. The Air Force is able to establish an upper bound on possible exposures for response personnel, based on the 'High 26' cohort (considered the highest exposed 26 individuals) using actual bio-monitoring results from a time close to the actual exposures and will apply this conservative approach in addressing requests from Veterans Affairs for exposure assessments. This revised conservative approach will afford the veteran with the benefit of the doubt as to level of exposure. Hence, we do not recommend additional, broad-scale, follow-up biomonitoring" (USAF 2013).

A simultaneous (6 December 2013) memo from the Air Force to the VA (Ashworth 2013) recommended the following procedure for assigning doses:

a. "Establish the veteran's presence at the incident site.
b. "Perform a review of duties based on historical records and statements provided by the veteran.
c. "Review available bioassay data for the veteran and assign an intake value.
   "(1) If the veteran is a member of the cohort with the highest exposure potential (designated as the 'High 26'), use their established intake estimates. The established intakes range from 34,000 to 570,000 picocuries (pCi) [1,260–21,000 Bq].
   "(2) For the remaining responders, define intake as 'does not exceed the intake calculated for the least exposed member of the High-26 group.' The intake range for this group will be conservatively set at 1,100 to 34,000 pCi [41–1,260 Bq].
d. "Estimate committed doses for the organ(s) of concern. The primary organs of concern from plutonium exposure are the lung, liver, and bone surface, based on International Commission on Radiological Protection (ICRP) Publication 30 (used by the Nuclear Regulatory Commission and Environmental Protection Agency) and ICRP Publication 68 (used by the Department of Energy and the Defense Threat Reduction Agency). We will provide both ICRP model results in responses to the VA.
e. "If the member does not have a valid urine sample, reconstruct the dose based on similar exposures using their specific duties, if possible. If that is not possible, consider having the member provide a urine sample for analysis using the latest analytical procedures that claim to eliminate or greatly reduce confounding factors such as radioactivity from natural or background sources."

Thus, unless measurements on new urine samples are carried out—an option raised as a possibility by Labat-Anderson

Table 1. Maximum organ dose estimates (Sv) recommended by the Air Force (USAF 2014) for compensation decisions for non-High 26 Palomares cleanup veterans, when based on a urine-excretion estimate of 1,300 Bq (34 nCi) of plutonium inhaled by the lowest exposed of the High 26 (Labat-Anderson 2001d).[a]

	Dose estimates (Sv)			
Organ	Labat-Anderson (2001d)	Air Force (2014) (using ICRP 30)[b]	Air Force (2014) (using ICRP 71)[c]	Recommendation in Air Force memo (2014)[d]
Lung	0.380	0.406	0.109	0.406
Bone surface	1.060	1.030	0.214	1.030
Liver	0.192	0.038	0.049	0.049
Red marrow[e]	0.081	0.083	0.011	NA[e]
Gonads/testes[e]	0.015	0.015	0.003	NA[e]
Committed effective dose equivalent	0.100	0.105	0.020	0.105[f]

[a]Labat-Anderson 2001d; USAF 2014. Intake of 1,300 Bq (34 nCi) using CINDY program was the lowest intake for the High 26, which serves as the maximum intake, and hence the intake for compensation purposes, for all Palomares veterans other than the High 26 (Ashworth 2013; USAF 2014).

[b]Based on ICRP Reports 26, 30, and 48, as indicated in the Air Force memo (USAF 2014). CINDY estimate was based on ICRP 30.

[c]Warning: uses dose coefficients from a biokinetic model that was developed later than the model (CINDY) used to generate the 1,300 Bq (34 nCi) plutonium intake, leading to an inconsistent dose estimate.

[d]The higher of the two Air Force columns.

[e]Not explicitly discussed in the memo text.

[f]Upper limit of range of Labat-Anderson's 0.0031 CEDE environmental estimate and the 0.105 CEDE from the second dose column.

and mentioned as a possibility in point (e) of the Air Force's advice above—the revised dose estimates are to be based on Labat-Anderson's 2001 estimates of the doses received by the High 26 group of veterans. The 98% of the Palomares cleanup veterans not in the High 26 are to be assigned a maximum dose equal to the lowest of the doses estimated for the High 26. Table 1 shows the Air Force's recommended estimates of the organ doses received by this individual.

Implications of the Air Force's 2013 guidance

As indicated in Table 2, basing plutonium inhalation estimates on maximum postcleanup environmental air measurements—as the Air Force recommended from 2002 through most of 2013—produces AS/PCs that are all well below 50% even at the 99% credibility level. On the other hand, lung and bone cancers among the Palomares survivors would be declared service related (AS/PC > 50%, at the 99th percentile) if the Labat-Anderson inhalation biokinetic dose estimates for the lowest of the High 26 are used, as recommended by the Air Force after 2013. Liver cancer reaches 50% for early diagnoses (before 1990) and comes close even for a late diagnosis at the 99+% credibility level. Although leukemia is not explicitly covered in the 2014 memo, based on the dose estimate given there for red marrow, the AS/PC for leukemias diagnosed in 1980 and earlier would also exceed 50% at the 99+% credibility level (ORCRA 2005). Additional details about the calculations

Table 2. Assigned share/probability of causation (AS/PC) obtained using the NIOSH IREP (ORCRA 2005) at the 99th percentile credibility level for maximum doses allowed for non-High 26 Palomares veterans, assumed to be male, born in 1946 and former smokers.[a]

Cancer type	Cancer onset by	Dose estimate before 2014, based on Labat-Anderson's maximum "environmental" exposure (Sv)[b]	AS/PC at 99+% credibility (%)	Dose estimate after 2013, based on Labat-Anderson's lowest Pu intake for High 26 (Sv)[c]	AS/PC at 99+% credibility (%)
Lung	2017	0.012	1.9	0.406	61
Bone	2017	0.030	11	1.03	80
Liver	1989[d]	0.0015	3.1	0.049	51
Liver	2017	0.0015	2.4	0.049	45
Leukemia	1980[d]	0.0024	2.3	0.081[e]	59
Leukemia	2017	0.0024	0.07	0.081[e]	2.4

[a]Exposure in 1966.

[b]Basis for guidance prior to 2014, based on estimates of resuspension intake. Values in Table 1 scaled by 0.31/10.5, the ratio of committed effective dose equivalents (USAF 2014).

[c]From Table 1.

[d]Only early onset cases will rise above 50% at 99th percentile credibility with an assigned dose of 0.049 Sv for liver and 0.081 Sv for leukemia.

[e]Not explicitly mentioned as an accepted maximum dose in Air Force memo (USAF 2014).

of assigned shares can be found in SDC Text S-2, http://links.lww.com/HP/A162.

Dose estimate uncertainties

The Air Force's maximum recommended dose estimates for all but 26 of the approximately 1,600 veterans are based on central values for three data urine measurements obtained off-site from a single veteran, including one nondetect that was assigned an ad hoc value of 0.11 mBq d^{-1} (0.003 pCi d^{-1}) (SDC Table S-1, http://links.lww.com/HP/A162). There is no recorded measurement of an on-site sample for this serviceman. A least-squares procedure was used to obtain the central value. No uncertainty range for intake or corresponding dose was assigned. Thus, no uncertainty in maximum dose can be included in compensation assessments using the NIOSH IREP. The uncertainty distribution for assigned share/probability of causation is therefore entirely due to uncertainties in the dose-cancer coefficient.

In addition to the data for the High 26, there are more than 1,000 other measurements, including at least one each for most of the 1,600 veterans. Most of these measurements were made on samples taken on-site, and the possibility of contamination has been raised. But, aside from noting that plutonium was detected on the outsides of some of the sample bottles, none of the analyses have attempted to establish how much the estimated doses could have been affected by contamination. In other cases, Labat-Anderson raised the possibility that laboratory errors could have affected the results. These observations support a conclusion that the measured doses are uncertain. Labat-Anderson's assessment of these doses is therefore reviewed below.

Labat-Anderson's assessment of dose using excretion measurements. Labat-Anderson reviewed and organized the available records of the 1,600 cleanup personnel. This information was then preserved in a massive Appendix C to its report (Labat-Anderson 2001a, b, c) that was only released in May 2018 with personal identifying information redacted as a result of a Freedom of Information Act request from a Yale Law School clinic working on an appeal on behalf of one of the cleanup veterans (YLC 2018). As discussed above, most of the urine samples collected within 100 d of the accident were taken in the field, and all but a few tens of those were measured only for gross alpha emissions. As noted above, concern was expressed about the accuracy of the on-site measurements due to detected contamination of the outsides of some of the sample bottles by wind-blown plutonium-contaminated dust.

Also, as already noted, 422 of the cleanup personnel had a repeat analysis recorded, a urine sample taken offsite and measured using alpha spectrometry (Odland et al. 1968). Labat-Anderson concluded, however, that, beyond the High 26 who were asked to provide additional samples, the measurement of off-site urine samples for only 31 additional veterans among the 422 (7%) produced "usable results" (Labat-Anderson 2001d)

"Other samples submitted did not produce usable results for several reasons. These reasons included laboratory errors during processing and chemical recoveries that were unreported, too low to be measured or below 40%.[5] This project established a minimum requirement for chemical recovery at 40% for alpha-spectrometry samples as a reasonable lower limit for credible results" (Labat-Anderson 2001d).

Chemical recovery percentages were determined by spiking the urine samples with 66 mBq of ^{236}Pu in an unreported chemical form (Odland et al. 1968b).

The problems that Labat-Anderson identified with the plutonium measurements were consistent with a contemporaneous evaluation: "It seems clear that in the field of low-level plutonium analysis the techniques are so exacting and the evaluation so difficult that it is common for the chemist to be unable to duplicate the work of others" (Nielsen and Beasley 1964).

On the other hand, the Air Force's Radiation Health Laboratory, which did the measurements, stated that "by use of split-sample techniques with other laboratories, we learned that our results compared favorably with theirs" (AFLC 1968).

No indication was given, however, as to the plutonium concentrations or the ^{236}Pu/^{239}Pu ratios in the split samples.

Reliability problems with plutonium were found at sites other than Palomares. Retrospective analysis of worker plutonium measurements from Britain's Sellafield plutonium separation center, carried out for epidemiology studies, found reliability problems for plutonium bioassays prior to the 1970s (Riddell 2011; Riddell et al. 2000). Assessments of dose made using early excretion measurements were thought to be high compared to assessments made with later excretion measurements. This expectation was based on the idea that plutonium exposures should follow contamination levels, which were building up over time. Apparently, the possibility that protection management was weaker in the early years was not considered an important contributing factor.

For the most recent Sellafield studies, in order to get robust estimates, dose assessments were produced only for individuals with five or more usable samples (Riddell 2011). This sample-size threshold matches the 2013 recommendation of a European consensus group (Castellani et al. 2013). Based on our extraction of data from Appendix C of the Labat-Anderson report, when nondetects were included in the totals, 19 of the High 26 had as many as five data points (SDC Table S-1, http://links.lww.com/HP/A162). When nondetects were excluded from the totals, only one of the 26 had five or more data points.

[5]For the record, we note that contemporaneous documents indicated that all recoveries for the 422 were greater than 40%, with a range of 43–113% (Odland et al. 1968). On the other hand, Labat-Anderson did have access to the original lab cards and file notes for each veteran.

Contamination problems considered at Sellafield were of a different sort than those considered at Palomares: for instance, plating out of plutonium on the walls of the sample bottles and funnels occurred, "which was not removed by washing in water but which did re-dissolve in urine when these items were re-used."(Riddell 2011). Of course, the identification of potential problems does not mean the Palomares data are unusable; only that the uncertainties are larger than occur from alpha counting variations alone.

Assessment by groups of veterans. Given the different numbers of urine samples per serviceman and the different qualities of the measurements made on them, Labat-Anderson placed the veterans in four groups: High 26, repeat analysis, contamination cutoff, and remaining cases.

High 26 group. These were the primary focus of analysis because all had at least three off-site urine samples measured (Labat-Anderson 2001d). The on-site measurements were discarded and individual intake estimates were obtained by obtaining a best fit to theoretical excretion curves of the off-site urine excretion data points.

The on-site measurements were discarded both because they were "unreasonably high" and because there was a possibility of contamination (Labat-Anderson 2001d). Also, the fit to the predictions of the biokinetic models "tended to produce better fits for samples with lower values and taken at longer time following the exposure" (Labat-Anderson 2001d). This last rationale simply reflects that the theoretical excretion curve used by Labat-Anderson for inhaled plutonium oxide was almost flat starting 10 d after exposure (Fig. 1) while the excretion measurements fell by about an order of magnitude between the on-site urine samples and those taken off-site about 200 d after exposure, by another order of magnitude by about 400 d, and by another order of magnitude to below the limit of Labat-Anderson's assumed detectability by about 600 d (SDC Fig. S-1, http://links.lww.com/HP/A162). It is not surprising that a fit to a nearly flat theoretical curve gets better if early high data points are discarded. The fit would also have improved if the nondetects or other lower groups of late readings were removed.

After the on-site measurements were discarded, the estimated High 26 intakes ranged from 1,260 to 21,000 Bq (34 to 560 nCi) (Labat-Anderson 2001d). In its revised 2013 guidance, the Air Force chose the low end of this range as the upper bound of the dose range for all the other cleanup veterans.

A historical note: Labat-Anderson's estimate of the highest intake for the High 26, assuming inhalation of insoluble particles, is some 37 times the 560 Bq (15 nCi) value estimated using the Langham formula for systemic body burden, which was largely based on lung-bypassing injections of plutonium. Those unfamiliar with these experiments carried out on hospital patients thought to have less than a 10 y life expectancy, in the days before informed consent was a requirement, can consult the references (McCally et al. 1994; Moss and Eckhardt 1995).

Repeat analysis group. This second group comprised 54 individuals not among the High 26 who had urine assays that passed the Labat-Anderson quality tests. Measurements of on-site samples were excluded unless they reported as no detectable activity (NDA), in which case they were assumed to be at the detection threshold. Also, "some alpha-spectrometry results that did not fit the expected urinary excretion pattern were excluded" (Labat-Anderson 2001d). The remaining measurements translated into estimated intakes ranging from 107 to 48,000 Bq (2.9–1,300 nCi). More than three-quarters of the estimated intakes (42) were higher than the lowest estimated intake for the High 26 (Labat-Anderson 2001d).

Contamination cutoff group. This group contained 313 individuals whose on-site measurements corresponded to plutonium excretion rates of less than 0. 0037 Bq d^{-1} (0.1 pCi d^{-1}). According to Labat-Anderson, this was approximately the lowest level that could be detected by the gross alpha counting techniques of the time (Labat-Anderson 2001d). Thirty individuals had more than one measurement. In these cases, Labat-Anderson discarded the higher measurement without explanation (Labat-Anderson 2001d). The resulting estimated intakes ranged from 56 to 5,600 Bq (1.5 to 150 nCi). A tally of the entries in the relevant table shows that almost half (143) were greater than the lowest estimated intake for the High 26 (Labat-Anderson 2001d).

Remaining cases group. This group contained 1,063 individuals, i.e., 73% of the 1,456 veterans who were assigned doses. All or virtually all their samples were taken on-site and Labat-Anderson concluded that "the possibility of contamination prevents useful evaluation of these data." It did report, however, that measured excretion data corresponded to intakes

Table 3. Labat-Anderson estimates of exposure range for different groups of veterans.

Group	Number of Palomares cleanup vets in group	Labat-Anderson plutonium inhalation estimate based on urinary excretion (Bq)	Ratio of inhalation estimate to lowest of the High 26
High 26	26	1,260 to 21,000	1 to 16
Repeat analysis	54	107 to 48,000	0.003 to 1.4
Contamination cutoff	313	56 to 5,600	0.0016 to 4.4
Remaining cases	1,063	2,800 to 740,000	2.2 to 590

ranging from 2,800 to 740,000 Bq (75 to 20,000 nCi) of ^{239}Pu (Labat-Anderson 2001d).

It will be seen from Table 3 that the lowest intake calculated for the remaining cases group is higher than the lowest intake calculated for the High 26, which, after 2013, the Air Force decided to use as the upper bound for the doses that would be assumed to have been received by the remainder of the 1,600 cleanup veterans. There are two potential explanations for this result. First, the estimated intake for a High 26 veteran is reduced by the existence of multiple data points used in the fits to urine excretion curves that are fairly flat over time. The later data points tend to be lower than the first alpha spectrometry measurements, thus bringing down the estimated intake. Second, there appears to be a contributing artifact due to the fact that the threshold measurement limit used for the gross alpha measurements of the on-site excretion rates were about 3 times higher than the threshold measurement limit assumed for the alpha spectrometry used for virtually all the samples taken off-site—0.009 pCi d^{-1} vs. 0.003 pCi d^{-1} (Labat-Anderson 2001d). These levels are much lower than plutonium detection thresholds reported elsewhere, however. The Air Force reported a detection limit of 19 mBq d^{-1} (0.5 pCi d^{-1}) for alpha spectrometry in connection with the similar accident that occurred near Greenland (Labat-Anderson 2001e). Other statements of detection limits associated with the Palomares accident include 0.37 mBq d^{-1} (0.01 pCi d^{-1}) (Iranzo and Richmond 1987) and 0.74 mBq d^{-1} (0.02 pCi d^{-1}) (Espinosa et al. 1998). Unstated was the extent to which any of these limits included process uncertainty as opposed to count rate uncertainty alone.

The High 26 group was thought to have had the highest plutonium excretion rates of 422 participants in the resampling program. As discussed above, this is debatable. The High 26 certainly did not have the highest measured excretion rates among the urine measurements collected on site. Based on our review of a spreadsheet printout of the on-site results (SDC Fig. S-2, http://links.lww.com/HP/A162), many readings of other veterans showed higher on-site plutonium excretion rates than many of the High 26 and some were higher than the highest of the High 26. Of the High 26, 18 had on-site readings above 1 pCi d^{-1} and 4 above 3 pCi d^{-1} (37 and 110 mBq d^{-1}, respectively). For the entire cohort, the spreadsheet printout shows 288 readings above 1 pCi d^{-1} (37 mBq d^{-1}) and 91 above 3 pCi d^{-1} (110 mBq d^{-1}), with a highest value of 124 pCi d^{-1} (4. 6 Bq d^{-1}). This is 3.5 times greater than the highest value of 35 shown for the High 26 on Fig. 1. The geometric mean for the 288 readings is 2.6 pCi d^{-1} (96 mBq d^{-1}), with an arithmetic mean of 5.4 pCi d^{-1} (200 mBq d^{-1}), while the geometric mean of the High 26 gross alpha readings is 3 pCi d^{-1} (110 mBq d^{-1}).

The fact that the High 26 did not have the highest among the on-site measurements is significant because as already noted, the Air Force has assigned to all veterans not among the High 26 the organ doses estimated for the lowest of the High 26. If, instead, estimates of inhaled plutonium based on the on-site measurements were used with the biokinetic models of the day to calculate the high ends of the uncertainty ranges for the veteran's doses, the high-end doses received by many would be much higher than their Air Force-assigned maximum doses.

CONCLUSION

About 1,600 US military men—mostly Air Force—participated in a cleanup of plutonium contamination in the Spanish village of Palomares in 1966. They worked without protection against inhalation of plutonium-contaminated particles because their supervisors did not wish to alarm Spanish citizens and officials observing the cleanup. In this paper, a history is provided of the Palomares incident, the bioassay and dosimetry that has been carried out to date, and its use in compensation decisions.

One reason that dosimetry was carried out in a 2001 report was that under 38 CFR 3.311, US veterans are entitled to compensation if they develop a radiogenic disease after their service and if they received a radiation dose to the diseased organ large enough so that the "evidence supports the conclusion it is at least as likely as not the veteran's disease resulted from exposure to radiation in service" (US Dept of VA 2018). Since such dose estimates have an uncertainty range, the veteran is given, under the law, the benefit of assuming the highest credible dose. With regard to uncertainty in cancer risk coefficients, the threshold for compensation is assessed at the 99+% credibility as determined, for example, by the NIOSH IREP calculator.

Between 2001 and 2013 (35 to 47 y after the accident), the Air Force based its estimates of the veterans' doses on measurements of airborne plutonium 6 mo *after* the cleanup. These theoretical exposures had no relationship to the actual amount of plutonium taken in by the veterans during the cleanup, when the concentration of airborne plutonium is likely to have been orders of magnitude higher.

In 2013 (47 y after the cleanup), the Air Force changed to the assumption that 26 veterans in a "high-dose" group, for which multiple off-site measurements of urine activity were available, had inhaled the amount of plutonium estimated in a 2001 reanalysis of that data and that the remainder of the group of about 1,600 had received lower doses. It was decided that the remainder, i.e., non-High 26 veterans, would be assigned the lowest inhalation estimate among the High 26 as a basis for estimating organ doses for determining compensation for a radiogenic illness. Based on the NIOSH IREP calculator, these post-2013 allowed doses are sufficiently high to justify a Palomares service connection for lung and bone cancer, as well as liver cancer diagnosed before 1990 and leukemia diagnosed before 1982.

The dose estimation process for the High 26 was limited, however, by the fact that high early urine measurements were excluded, on the grounds of potential sample contamination evidenced by the order-of-magnitude lower plutonium excretion results obtained in the first set of off-site measurements. This drop was inconsistent with the biokinetic model for excretion after exposure to plutonium oxide that was being used at the time. Discarding the early data is questionable, however, because the excretion rates calculated from off-site samples continued to drop by an order of magnitude each 200 d in contradiction to the relatively flat prediction of the biokinetic model for either soluble or insoluble plutonium. Several hundred veterans might have had higher readings than the lowest of the High 26 had their measurements not been dismissed because of laboratory failures such as low plutonium-recovery rates from the samples as evidenced by low recovery rates of a ^{236}Pu tracer. Even for the measurements that were accepted, many of the readings recorded for the veterans not among the non-High 26 were higher than some of those for the High 26, putting into question the designation of the High 26.

Virtually all the non-High 26 had either an on-site or a single off-site urine sample collected, with its plutonium content measured and fitted to a standard biokinetic model of the period to estimate the quantities of plutonium inhaled. These estimates indicate that a significant fraction could have inhaled much larger quantities of plutonium than the lowest of the High 26 currently proposed by the Air Force as a surrogate basis for calculating their doses.

It therefore appears, based on the present record, that as a result of inattention to uncertainty in urine measurements, uncertainty in biokinetic modeling, and the Air Force's exclusion of the on-site urine samples, the uncertainty ranges in the dose estimates currently being used to determine the veterans' benefits have been seriously underestimated.

Whether or not this and other conclusions would change using the most recent ICRP biokinetic models and a full uncertainty analysis is not known. The history presented here, however, can provide a base on which future policy and dosimetric analyses can build.

REFERENCES

Air Force Logistics Command. Palomares Broken Arrow—report on medical follow-up program. Wright Patterson Air Force Base, OH: AFLC; 1968.

Air Force Medical Service. AF surgeon general releases reports on two nuclear weapons accidents [online]. 2002. Available at ***https://www.princeton.edu/sgs/faculty-staff/frank-von-hippel/Palomares-AFMS2002.pdf***. Accessed 20 August 2018.

Ashworth RA. Radiation exposure estimates for USAF nuclear weapon accident responders—Palomares, Spain. Washington, DC: US Air Force Medical Support Agency; 2013. Available at ***http://www.airforcemedicine.af.mil/Portals/1/Images/About/Palomares/SG3PB-memo-to-VA***. Accessed 25 April 2018.

Associated Press. USIS to lose federal contracts after cyberattack compromises security of 25,000 government workers [online]. 2014. Available at ***http://wjla.com/news/local/usis-to-lose-government-work-after-cyberattack-compromises-security-of-25-000-government-workers-106***. Accessed 22 April 2018.

Beyea J, Greenland S. The importance of specifying the underlying biologic model in estimating the probability of causation. Health Phys 76:269–274; 1999.

Bloomberg. Company overview of Labat-Anderson, Inc. [online]. Available at ***https://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=2535401***. Accessed 29 April 2018.

Board of Veterans Appeals. Decision on appeal from the Department of Veterans Affairs Regional Office in St. Louis [online]. 2017. Available at ***https://va-claim.com/2017/12/16/service-connection-for-colon-cancer-to-include-as-a-result-of-in-service-radiation-exposure-denied-citation-nr-1749076***. Accessed 27 April 2018.

Castellani C, Marsh J, Hurtgen C, Blanchardon E, Berard P, Giussani A, Lopez M. EURADOS-IDEAS guidelines (version 2) for the estimation of committed doses from incorporation monitoring data. Braunschweig, Germany: EURADOS; 2013. Available at ***www.eurados-online.de/~/media/Files/Eurados/documents/EURADOS%20Report%202013-01%20online%20version.pdf***. Accessed 20 December 2018.

Eakins J, Morgan A. The role of faecal analysis in a bioassay programme. In: Proceedings of the symposium on the assessment of radioactive body burdens in man [online]. 1964. Available at ***https://inis. iaea. org/search/search. aspx?orig_q=RN:44089064***. Accessed 8 July 2018.

Eikenberg J, Zumsteg I, Rüthi M, Bajo S, Scherrer P. A rapid procedure for screening transuranium nuclides in urine using actinide resin and low evel α/β-LSC. Waltham, MA: Perkin Elmer; 2011. Available at ***https://www.perkinelmer.com/PDFs/downloads/009599_01APP_RapidProcedureScreeningTransuraniumNuclidesLSC.pdf***. Accessed 7 July 2018.

Espinosa A, Aragon A, Stradling N, Hodgson A, Birchall A. Assessment of doses to adult members of the public in Palomares from inhalation of plutonium and americium. Radiat Protect Dosim 79:161–164; 1998.

Garger EK, Hoffman FO, Thiessen KM. Uncertainty of the long-term resuspension factor. Atmos Environ 31:1647–1656; 1997.

Harrison JD. The gastrointestinal absorption of the actinide elements. Sci Total Environ 100:43–60; 1991.

Homeland Security Newswire. Security check firm USIS accepts $30 million fraud settlement. HSN [online]. 2015. Available at ***www.homelandsecuritynewswire.com/dr20150820-security-check-firm-usis-accepts-30-million-fraud-settlement***. Accessed 22 April 2018.

Hubler D. USIS buys professional services firm Labat-Anderson. Washington Technology [online]. 2009. Available at ***https://washingtontechnology.com/articles/2009/05/20/usis-buys-professional-services-firm-labat-anderson.aspx***. Accessed 22 April 2018.

Iranzo E, Espinosa A, Martinez J. Resuspension in the Palomares area of Spain: a summary of experimental studies. J Aerosol Sci 25:833–841; 1994.

Iranzo E, Richmond CR. Plutonium contamination twenty years after the nuclear weapons accident in Spain. Oak Ridge, TN: Oak Ridge National Laboratory; Madrid: Junta de Energia Nuclear, Madrid; 1987. Available at ***https://inis.iaea.org/search/search.aspx?orig_q=RN:19017225***. Accessed 4 July 2018.

Iranzo E, Salvador S, Iranzo CE. Air concentrations of ^{239}Pu and ^{240}Pu and potential radiation doses to persons living near Pu-contaminated areas in Palomares, Spain. Health Phys 52:453–461; 1987.

Kocher DC, Apostoaei AI, Henshaw RW, Hoffman FO, Schubauer-Berigan MK, Stancescu DO, Thomas BA, Trabalka JR, Gilbert ES, Land CE. Interactive radioepidemiological program (IREP): a web-based tool for estimating probability of causation/assigned share of radiogenic cancers. Health Phys 95:119–147; 2008.

Labat-Anderson, Inc. Palomares dose evaluation report, volume 1 (with Appendix C spreadsheet). Yale Law Clinic [online]. 2001a. Available at ***https://law.yale.edu/studying-law-yale/clinical-and-experiential-learning/our-clinics/veterans-legal-services-clinic/palomares-foia-litigation***. Accessed 24 July 2018.

Labat-Anderson, Inc. Palomares dose evaluation report, volume 2, (Appendix C.1, High 26). Yale Law Clinic [online]. 2001b. Available at ***https://law.yale.edu/studying-law-yale/clinical-and-experiential-learning/our-clinics/veterans-legal-services-clinic/palomares-foia-litigation***. Accessed 24 July 2018.

Labat-Anderson, Inc. Palomares dose evaluation report, volume 3 (with Appendix C. 2, 3 4). Yale Law Clinic [online]. 2001c. Available at ***https://law.yale.edu/studying-law-yale/clinical-and-experiential-learning/our-clinics/veterans-legal-services-clinic/palomares-foia-litigation***. Accessed 24 July 2018.

Labat-Anderson, Inc. Palomares nuclear weapons accident: revised dose evaluation report (without Appendix C). McLean, VA: Labat-Anderson, Inc.; 2001d. Available at ***www.airforcemedicine.af.mil/Portals/1/Images/About/Palomares/2001-Palomares-Dose-Evaluation-Report.pdf***. Accessed April 6 2018.

Labat-Anderson, Inc. THULE nuclear weapons accident [online]. 2001e. Available at ***http://www.airforcemedicine.af.mil/Portals/1/Images/About/Palomares/2001-Thule-Dose-Report.pdf***. Accessed 22 April 2018.

Langham WH. Determination of internally deposited radioactive isotopes from excretion analyses. Am Industrial Hygiene Assoc Q 17:305–318; 1956.

Langham WH. Physiological properties of plutonium and assessment of body burden in man. Los Alamos, NM: Los Alamos Scientific Laboratory; LADC-6104; CONF-448-3; 1963. Available at ***https://www.osti.gov/servlets/purl/4074400***. Accessed 20 July 2018.

Maxwell RM, Anspaugh LR. An improved model for prediction of resuspension. Health Phys 101:722–730; 2011.

Maydew RC, Bush J. America's lost H-bomb! Palomares, Spain, 1966. Manhattan, KS: Sunflower University Press; 1997.

McCally M, Cassel C, Kimball DG. US government-sponsored radiation research on humans, 1945–1975. Med Glob Surviv 1:4–16; 1994.

Moss W, Eckhardt R. The human plutonium injection experiments. Los Alamos Sci 23:177–233; 1995.

Nielsen J, Beasley T. Radiochemical determination of plutonium for radiological purposes. In: Proceedings of the symposium on the assessment of radioactive body burdens in man, 11–16 May 1964, Heidelberg, Germany. Vienna: IAEA; 1964. 1: 245–260. Available at ***https://inis.iaea.org/search/search.aspx?orig_q=RN:44089064***. Accessed 8 July 2018.

Oak Ridge Center for Risk Analysis. User's guide for the Interactive RadioEpidemiological Program (NIOSH-IREP) [online]. 2005. Available at ***https://www.niosh-irep.com/irep_niosh/Help/irepug.pdf***. Accessed 20 April 2018.

Oak Ridge Center for Risk Analysis. Interactive RadioEpidemiological Program NIOSH-IREP v.5.8.1 [online]. 2018. Available at ***https://www.niosh-irep.com/irep_niosh***. Accessed 6 June 2018.

Odland LT, Farr RL, Blackburn KE, Clay AJ. Industrial medical experience associated with the Palomares nuclear incident. J Occup Environ Med 10:356–362; 1968.

Philipps D. Decades later, sickness among airmen after a hydrogen bomb accident. New York Times. 19 June 2016.

Place WM, Cobb FC, Defferding CG. Palomares summary report. Albuquerque, NM: Field Command, Defense Nuclear Agency, Kirtland AFB; 1975. Available at ***www.dtic.mil/dtic/tr/fulltext/u2/a955702.pdf***. Accessed 7 July 2018.

Plutonium Deposition Registry Board. Proceedings of the first annual meeting of the Plutonium Deposition Registry Board [online]. 1966. Available at ***https://www.documentcloud.org/documents/2797034-xxplutonium-1966-Plutonium-Deposition-Registry.html***. Accessed 29 April 2018.

Riddell AE. Development of an improved internal dose assessment methodology for plutonium [online]. 2011. Available at ***http://etheses.bham.ac.uk/3226***. Accessed 18 December 2018.

Riddell AE, Battersby WP, Peace MS, Strong R. The assessment of organ doses from plutonium for an epidemiological study of the Sellafield workforce. J Radiol Protect 20:275–286; 2000.

United Nations Scientific Committee on the Effects of Atomic Radiation. Sources and effects of ionizing radiation, Vol. 1, Annex B. New York: United Nations; 2000.

US Air Force. HQ USAF/SG memorandum for the House Armed Services Committee: report on implementation of the recommendations of the Palomares nuclear weapons accident; revised dose evaluation report (in response to draft FY14 NDAA SEC 1080A). Transmitted for the Air Force by Thomas W. Travis [online]. 2013. Available at ***www.airforcemedicine.af.mil/Portals/1/Images/About/Palomares/SG-Memo-Report-to-HASC-NDAA-FY14-20131206.pdf***. Accessed 25 April 2018.

US Air Force. Memorandum for Department of Veterans Affairs, Jackson, MS. Transmitted for the Air Force by Anthony J. Cagle [online]. 2014. Available at ***www.airforcemedicine.af.mil/Portals/1/Images/About/Palomares/Redacted-non-High-26-Veteran-Dose-Memo.pdf***. Accessed 24 April 2018.

US Congress. National Defense Authorization Act for fiscal year 2014. Pub. Law 113-66, Stat. 127; 2013.

US Department of Defense. Narrative summaries of accidents involving US nuclear weapons 1950–1980 [online]. Undated. Available at ***https://nsarchive.files.wordpress.com/2010/04/635.pdf***. Accessed 23 June 2018.

US Department of Energy. US DOE secret briefing [online]. 1967. Provided to ***documentcloud.org*** by News Documents; New York Times; 8 April 2016. Available at ***https://www.documentcloud.org/documents/2797062-xxplutonium-1967-DOE-secret-briefing.html***. Accessed 22 April 2018.

US Department of Health and Human Services. Report of the NCI-CDC working group to revise the 1985 NIH radioepidemiological Tables. Washington, DC: US Department of Health and Human Services, US National Cancer Institute; 2003. Available at ***https://www.cdc.gov/niosh/docket/archive/pdfs/NIOSH-209/0209-010103-land.pdf***. Accessed 7 July 2018.

US Department of Veterans Affairs. Claims based on exposure to ionizing radiation. 38 CFR 3.311 [online]. 2018. Available at ***https://www.ecfr.gov***. Accessed 20 April 2018.

US Strategic Air Command. Project Crested Ice, the Thule nuclear accident (Strategic Air Command Historical Study 113) [online]. 1969. Available at ***http://nsarchive.gwu.edu/nukevault/ebb267/03.pdf***. Accessed 23 June 2018.

von Hippel FN. Assessment of the US Air Force's estimates of the radiation doses received by the veterans of the cleanup of plutonium from two nuclear bombs that fell on Palomares, Spain in 1966; working paper. Princeton, NJ: Program on Science and Global Security; 2017. Available at ***https://www.princeton.edu/sgs/faculty-staff/frank-von-hippel/SGS-working-paper.pdf***. Accessed 25 June 2018.

Yale Law Clinic. Palomares FOIA litigation. New Haven, CT: Yale Law Clinic; 2018. Available at ***https://law.yale.edu/studying-law-yale/clinical-and-experiential-learning/our-clinics/veterans-legal-services-clinic/palomares-foia-litigation***; ***https://law.yale.edu/yls-today/news/veteran-sickened-plutonium-brings-nationwide-class-action***. Accessed 7 June 2018.

■■

Exhibit 3

Frank von Hippel

Professor of Public and International Affairs, Woodrow Wilson School
Director, Center for Science and Global Security
Ph.D., Oxford University, 1962

Research Interests

Von Hippel, a theoretical physicist, is a Professor of Public and International Affairs and co-principal investigator with Harold Feiveson of Princeton's research program on Science and Global Security. From September 1993 through 1994, he was on leave as Assistant Director for National Security in the White House Office of Science and Technology Policy, and played a major role in developing U.S.-Russian cooperative programs to increase the security of Russian nuclear-weapon materials. He is the chairman-elect of the American Physical Society's Panel on Physics and Public Affairs. He also chairs the editorial board of *Science & Global Security* and is a member of the editorial board of the *Bulletin of the Atomic Scientists*.

Von Hippel received his B.S. degree in physics from MIT in 1959 and D.Phil. in theoretical physics in 1962 from Oxford, where he was a Rhodes Scholar. During the following ten years, while his research focus was in theoretical elementary-particle physics, he held research positions at the University of Chicago, Cornell University, and Argonne National Laboratory and served on the physics faculty of Stanford University.

In 1974, von Hippel's interests shifted to "public-policy physics." After spending a year as a Resident Fellow at the National Academy of Science, during which time he organized the American Physical Society's Study on Light-Water Reactor Safety, he was invited to join the research and in 1984 the teaching faculty of Princeton University.

During the late 1970s, von Hippel's research focused on technical questions relating to the containment and mitigation of nuclear-reactor accidents, alternatives to recycling plutonium in nuclear-reactor fuel, and the potential for major improvements in automobile fuel economy. Since the early 1980s his research has focused on developing the analytical basis for deep cuts in the U.S. and Soviet/Russian nuclear stockpiles and removal of their nuclear missiles off launch-on-warning alert; verifying nuclear-warhead elimination, a universal cutoff of the production of weapon-usable fissile materials and the phasing out of their use in nuclear-reactor fuel; and a comprehensive nuclear-warhead test ban.

Von Hippel has served on advisory panels to the Congressional Office of Technology Assessment, U.S. Department of Energy, National Science Foundation, and U.S. Nuclear Regulatory Commission, and on the boards of directors of the American Association for the Advancement of Science and the *Bulletin of the Atomic Scientists*. For many years he was the elected chairman of the Federation of American Scientists.

In 1977, von Hippel shared with Joel Primack the American Physical Society's 1977 Forum Award for Promoting the Understanding of the Relationship of Physics and Society for their book, *Advice and Dissent: Scientists in the Political Arena*. In 1989, he was awarded the Federation of American Scientists' Public Service Award for serving as a "role model for the public interest scientist." In 1991, the American Institute of Physics published a volume of von Hippel's selected works under the title *Citizen Scientist*, as one of the first three books in its "Masters of Physics" series. In 1993 he was awarded a five-year MacArthur Prize fellowship. In 1994, he received the American Association for the Advancement of Sciences' Hilliard Roderick Prize for Excellence in Science, Arms Control and International Security.

Courses

WWS 304: Science, Technology and Public Policy
WWS 556d: Protection against Weapons of Mass Destruction

Selected Publications

Zhang, H., and F. von Hippel. 2001. Eyes in the sky: Watching for weapons work. *Bulletin of the Atomic Scientists*, July-August, 61-66.

MacFarlane, A., F. von Hippel, J. Kang, and R. Nelson. 2001. Plutonium disposal: The third way. *Bulletin of the Atomic Scientists* 57:53-57.

Chunyan, M., and F. von Hippel. 2001. Ending the production of highly-enriched uranium for naval reactors. *Nonproliferation Review* 8:86-101.

von Hippel, F., and M. Bunn. 2000. Saga of the Siberian plutonium-production reactors. *Federation of American Scientists Public Interest Report* 53 (November–December).

Blair, B., H. Feiveson, and F. von Hippel. 1997. Taking nuclear weapons off hair-trigger alert. *Scientific American* 277:74-81.

Contact Information

221 Nassau St.
Tel 609-258-4695
Fax 609-258-3661
fvhippel@princeton.edu

Exhibit 4

1 January 2019

FRANK NIELS VON HIPPEL
Phone: (609) 258-4695: fvhippel@princeton.edu

EDUCATION: D.Phil. (Theoretical Physics, Oxford, 1962); B.S. (Physics, M.I.T., 1959)

Professional Experience:

July 2013-: Senior Research Physicist, Program on Science and Global Security and Professor of Public and International Affairs emeritus, Princeton University

1984-1993, 1995-2013: Professor, Woodrow Wilson School of Public and International Affairs, Princeton University

Sept. 1993-Dec. 1994: Assistant Director for National Security, Office of Science and Technology Policy, Executive Office of the President (while on leave from Princeton University)

1974-1983: Senior Research Physicist, Center for Energy and Environmental Studies, Princeton University

1973-74: Resident Fellow, National Academy of Sciences

1970-73: Associate Physicist, High Energy Physics Division, Argonne National Laboratory

1969-70: A. P. Sloan Foundation Fellow, Lawrence Berkeley Laboratory

1966-69: Assistant Professor, Physics Department, Stanford University

1964-66: Research Associate, Newman Laboratory for Nuclear Studies, Cornell University

1962-64: Research Associate, Enrico Fermi Institute for Nuclear Studies, University of Chicago

AWARDS AND HONORS

Leo Szilard Lectureship Award, American Physical Society, 2010, for "outstanding work and leadership in using physics to illuminate public policy in the areas of nuclear arms control and nonproliferation, nuclear energy, and energy efficiency."

First George F. Kennan Distinguished Peace Leadership Award (Coalition for Peace Action, 2004)

American Association for the Advancement of Science, Hilliard Roderick Prize in Science, Arms Control and International Security, 1994

MacArthur Prize Fellow, 1993-1998

Dorothy Eldridge Award, New Jersey Sane/Freeze, 1993

Advisory Professor, Fudan University, Shanghai, 1992

Einstein lecture, New York Academy of Sciences, 1989

Federation of American Scientists, Public Service Award, 1989

Fellow, American Association for the Advancement of Science, 1988-

Fellow, American Physical Society, 1984-

American Physical Society Forum Award for Promoting the Understanding of the Relationship of Physics and Society, 1977 (with Joel Primack)

National Academy of Science Resident Fellowship, 1973 - '74

A.P. Sloan Foundation Fellowship, 1969 - '70

Rhodes Scholarship, 1959 - '62

SELECTED OFFICES, COMMITTEES, ETC.

Current

Science and Global Security, Editorial Board, (1989-)

Past

Forum on Physics and Society, Executive Committee, Member at Large, 2016-18

Co-chair, International Panel on Fissile Materials (2006-2013)

Princeton University, Scholars in the Nation's Service Initiative Selection Committee (2009); MPA Admissions Committee (2007-08), Selection Committee, Scholars in the Nation's Service (2007-08); Chair, Science, Technology and Environmental Policy Program PhD Seminar (2005-2008), Woodrow Wilson School: Undergraduate Program Committee (1984-93, 95-96, 98-, 2005-7); Advisory Committee of Dean of the Faculty's Rules and Procedures Group (2005-6), Council on Science and Technology (1992-93, 2001-04); PhD Committee (1988-93, 95-98, 2005-7), Director, Science, Technology and Environmental Policy Program (1984-93, 97-98), Interdepartmental Committee for the Program in Engineering and Management Systems (1990-93, 95-97); Coordinating Committee, Center for Energy and Environmental Studies (CEES, 1974-93, 95-01); Acting Director CEES (1997-8); University Research Board (1988-92); Council on Energy and Environmental Studies (1990-91); MPA Program Committee (1990-93, 97-98)

Ploughshares Fund (Advisory Committee, 1990-93, 95-)

Bulletin of the Atomic Scientists, Chairman, Editorial Board, (1991-93); Board of Directors (1983 - `86), Editorial Board (1975 - `83, 96-2005)

University of Chicago/Argonne National Laboratory, Advisory Committee on Nuclear Non-proliferation (2004-6)

Co-Director, Program on Science & Global Security (formerly Program on Nuclear Policy Alternatives, 1974-2006); Acting Director (fall 2009)

Panel on Public Affairs, American Physical Society (2003-6), chair (2005)

Russian Academy of Sciences/U.S. National Academies Joint Committee on U.S.-Russian Cooperation on Nuclear Nonproliferation (2003-5)

National Academy of Sciences: member, National Academy of Sciences, Committee on Lessons Learned from the Fukushima Nuclear Accident for Improving Safety & Security of U.S. Nuclear Plants (2012-2016.). Report reviewer: *Strengthening Nuclear Security: Protecting Nuclear Weapon-useable Material in Russia* (2004); *Safety and security of commercial nuclear spent fuel storage* (2004); *Methods and Technical Capabilities for Monitoring Transparency and Verification of Controls on Nuclear Weapons and Nuclear-Explosive Materials* (2004).

Federation of American Scientists: Chairman (1979-`84; 2000-2003), Chairman, FAS Fund (the tax-exempt research arm of the F.A.S., 1986-93, 95-2000), Vice Chairman (1984-`86); Council Member (l975-`79); Director, Cooperative Research Project on Nuclear Disarmament and Nonproliferation (1987-93, 95-99)

Student Pugwash, USA, Board of Directors (1998-2001).

Los Alamos National Laboratory External Review Board Member, Nonproliferation and International Security Division, (1995-2001)

Arms Control Association, Board of Directors, (1996-2001)

Frankfurt Peace Research Institute, Research Advisory Committee (1998-2002)

Moscow Institute of Physics and Technology, Center for Arms Control, Energy and Environmental Studies, Board of Directors (1990-93)

Advisor to the Director, Office of Nonproliferation and Arms Control, U.S. Department of Energy (1995-7)

Secretary of Energy Advisory Board, Member, Weapons Usable Fissile Materials Disposition Task Force (1996)

Department of Energy Study on "The National Ignition Facility and the Issue of Nonproliferation," External Reviewer, August 1995.

Social Science Research Council, Peace and Security Fellowship and Workshop Program, Member, Advisory Committee (1995-97)

American Association for the Advancement of Science: Nominating Committee (1992-93); Board of Directors (1987); Council (1974 - `76); Chairman, Selection Committee, Award for Scientific Freedom and Responsibility (1981); Chairman, Subcommittee on Protection of Professional Responsibility of the Committee on Scientific Freedom and Responsibility (1976 - `81); Congressional Science Fellowship Selection Committee (1973, 1974); Selection Committee for the first Hilliard Roderick Prize for Science, Arms Control and International Security (1990)

Congressional Office of Technology Assessment: Advisory Panel on Managing Nuclear Materials from Warheads (1992-93); Advisory Panel, Study on Solar Power Satellite Issues (1979 - `81)

Natural Resources Defense Council: Chairman's Council (1986-93), Nuclear Weapons Data Book Project Advisory Committee (1984-93)

Sane/Freeze Campaign for Global Security (Advisory Council, 1989-93)

Parliamentarians for Global Action: Technical Advisor (1984-88), Nuclear Test Ban and Non-Proliferation Program Advisory Committee (1989-93)

American Physical Society: Study Group on Light Water Reactor Safety (organizer and member, 1974-75); Congressional Science Fellowship Selection Committee (1973)

CTB Coalition (Advisory Committee, 1990-1991)

International Pugwash Scientists' Movement (Council, 1987-89)

International Foundation for the Survival and Development of Humanity; Member of the Board and Chairman of the International Security Program (1988-92)

Nuclear Weapons Freeze Campaign, National Advisory Board (1982-86)

Institute of Medicine: Steering Committee, Symposium on Nuclear War (1985-86)

Greater London Council, War Risk Study, Commission Member (1984-86)

World Resources Institute, Board of Directors (1982-84)

Public Health Advisory Committee on Radiation, (New York City Health Department, 1978 - 1984)

Three Mile Island Public Health Fund Advisory Board (1982 - `83)

International Nuclear Fuel Cycle Evaluation: US Delegate (1977-78)

Nuclear Regulatory Commission: Risk Assessment Review Group (1977-78)

Energy Research and Development Administration: Steering Committee, Breeder Reactor Program Review (1977)

National Academy of Sciences-National Academy of Engineering-National Research Council: Panel on Breeder Reactor Safety (1976-77)

National Science Foundation: Subcommittee on Science for Citizens (1977-79)

PUBLICATIONS

Books

Lessons Learned from the Fukushima Nuclear Accident for Improving Safety and Security of U.S. Nuclear Power Plants: Phase 2 (National Academies Press, May 2016, with 16 others).

Lessons Learned from the Fukushima Nuclear Accident for Improving Safety and Security of U.S. Nuclear Power Plants: Phase 1 (National Academy Press, May 2014, with 23 others).

Unmaking the Bomb: A Fissile Material Approach to Nuclear Disarmament and Nonproliferation (MIT Press, 2014, 277 pp.) (with Harold A. Feiveson, Alexander Glaser and Zia Mian)

The Nuclear Turning Point: A Blueprint for Deep Cuts and De-alerting of Nuclear Weapons (with Harold A. Feiveson, Bruce G. Blair, Jonathan Dean, Steve Fetter, James Goodby, George N. Lewis, Janne E. Nolan, and Theodore Postol) Brookings Institution Press, 1999, 402 pp.

Citizen Scientist. New York: American Institute of Physics, Masters of Modern Physics series, 1991; New York; Simon and Schuster [paperback], 1991, 285 pp.

Reversing the Arms Race: How to Achieve and Verify Deep Reductions in Nuclear Weapons, co-edited with Roald Z. Sagdeev. New York: Gordon and Breach Science Publishers, 1990, 432 pp.

London Under Attack: The Report of the Greater London Area War Risk Study Commission (with A. Ehrlich, S.W. Gunn, J.S. Horner, J.M. Lee, and P. Sharfman. Oxford: Basil Blackwell, 1986, 397 pp.

Life in Times of Turbulent Transitions, and other writings of Arthur R. von Hippel (edited by Frank N. von Hippel, Materials Research Society, 1982, 2004, http://vonhippel.mrs.org/

Advice and Dissent: Scientists in the Political Arena (with J. Primack). New York: Basic Books, 1974; Meridian-New American Library, 1976, 299 pp. Received American Physical Society Forum Award for Promoting the Understanding of the Relationship of Physics and Society (1977).

Chapters in books

Mitigating the Threat of Nuclear Proliferation from Nuclear-Submarine Programs in *Reducing Risks from Naval Nuclear Fuel*, George Washington University, Institute for International Science & Technology Policy, Occasional Papers Series, October 2018, https://cpb-us-e1.wpmucdn.com/blogs.gwu.edu/dist/c/1963/files/2018/10/Occasional-Papers_Reducing-Risks-from-Naval-Nuclear-Fuel-2anfj76.pdf

"Ban Production of Highly Enriched Uranium," in *10 Big Nuclear Ideas for the Next President*, Tom Z. Collina and Geoff Wilson, eds. (Ploughshares Fund, 2016)

Citizen Activism Against the Nuclear Threat [Contribution to Lois Nicolai's *Ordinary People, Extraordinary Times,* 13 Sept. 2015 (to be published)

Policy and technical issues facing a Fissile Material (Cutoff) Treaty, *Handbook of Nuclear Proliferation and Policy,* Nathan E. Busch and Joseph F. Pilat, eds. (Routledge, 2015, with Zia Mian)

Issues Raised by the Report of the Independent Investigation Commission on the Fukushima Nuclear Accident, Commentary in the English edition of the *"The Fukushima Daiichi Nuclear Power Station Disaster: Investigating the Myth and Reality"* (*Bulletin of the Atomic Scientists* in collaboration with Routledge/Earthscan, 2014)

History and Current Status of Reprocessing and Plutonium Breeder-reactor Programmes Worldwide, Chapter 7 in *India's Nuclear Energy Programme*, R. Rajaraman, ed, Indian National Science Academy, 2013.

Nuclear Energy, Chapter 14 in *Global Energy Assessment,* Cambridge University Press, 2013 (lead convening author)

The Feasibility of a Diplomatic Solution to the Confrontation over Iran's Nuclear Program, chapter in *Assessment of the Nuclear Programs of Iran and North Korea,* Jungmin Kang, ed. (Springer, 2013)

Plutonium, proliferation and radioactive-waste politics in East Asia, chapter 4 in *The Next Arms Race,* Henry Sokolski, ed (Strategic Studies Institute, US Army War College, 2012)

Spent-Fuel Management: The Cases of Japan, South Korea, and Russia in *Multinational Approaches to the Nuclear Fuel Cycle*, American Academy of Arts and Sciences, 2010

The Costs and Benefits of Reprocessing in *Expanding Nuclear Power: Weighing the Costs and Risks,* Henry Sokolski, ed. (Strategic Studies Institute, U.S. Army War College, 2010) pp. 525-553.

Managing spent fuel in the United States: The illogic of reprocessing, *Falling Behind: International Scrutiny of the Peaceful Atom,* Henry Sokolski, ed. (Strategic Studies Institute, 2008)

Fissile materials: global stocks, production and elimination, *SIPRI Yearbook 2007: Armaments Disarmament and International Security* (Oxford University Press, 2007, p. 558 (with Harold Feiveson, Alexander Glaser and Zia Mian).

In memoriam in ***Hans Bethe and his physics*****,** Gerald E. Brown and Chang-Hwan Lee, eds,, World Scientific Publishing Company, 2006 (reprint of article from *Arms Control Today* April 2005*,* with Richard Garwin)

Alternatives to war on Iraq, North Korea and Iran in *The Iraq War and its Consequences: Thoughts of Nobel Peace Laureates and Eminent Scholars,* Irwin Abrams and Wang Gungwu, eds. (World Scientific, 2003), pp. 287-294.

Security of nuclear materials and Pakistan's Nuclear Weapons in *Tactical Nuclear Weapons: Time for Control*, Taina Susiluoto, ed. (United Nations Institute for Disarmament Research, 2002), pp. 25-33.

Getting Back to Basics: Controlling Fissile Materials, in *Twenty-first Century Weapons Proliferation,* Henry Sokolski and James M. Ludes, eds. (London: Frank Cass, 2001), pp. 84-96.

U.S.-Russian Cooperation on Fissile Material Security and Disposition (with Oleg Bukharin), in *The Weapons Legacy of the Cold War: Problems and Opportunities*, Dietrich Schroeer and Alessandro Pascolini, eds. (Brookfield, VT: Ashgate, 1997), pp. 51-66.

Eliminating Nuclear Warheads by Anatoli Diakov and Frank von Hippel in *1993 Science and International Security Anthology,* Elizabeth J. Kirk, W. Thomas Wander and Brian D. Smith, eds. (Washington, D.C.: American Association for the Advancement of Science, 1993), pp. 425-439.

Convergence of the Nuclear Arms Reduction and Non-proliferation Agendas in *Nuclear Deterrence and Global Security in Transition,* David Goldfischer & Thomas Graham, eds. (Boulder, CO: Westview Press, 1992), pp. 87-102.

Danger: warheads being dismantled, and **No more excuses**, *The World in 1993* (The Economist, 1992), pp. 83-84.

Recollections of Sakharov in *Andrei Sakharov: Facets of a Life*, edited by B.L. Altshuler, B.M. Bolotovsky, I.M. Dremin, V.Ya. Fainberg and L.V. Keldysh. Paris: Editions Frontires: 1991, pp. 325-333. Also published in the Soviet journal, *Nature* (*Priroda*), May 1991, pp. 98-101, and excerpted in *Pravda*, 21 May 1991, p. 2.

The Technical Basis for Bans on Space Nuclear Reactors and Ground-based Anti-satellite Lasers in *Space and Nuclear Weaponry in the 1990's,* Carlo Schaerf, Giuseppe Longo and David Carleton, eds (London: MacMillan, 1992), pp. 71-82.

Nuclear Weapon Elimination: Fissile Material and Warheads in *Security Without Nuclear Weapons?,* Regina Cowan Karp, ed. (Oxford University Press, 1992), pp. 153-163.

Stability of the Nuclear Balance after Deep Reductions (with Harold A. Feiveson) in *Reversing the Nuclear Arms Race, How to Achieve and Verify Deep Reductions in Nuclear Weapons,* edited by Frank von Hippel and Roald Sagdeev. (Gordon and Breach Science Publishers, 1990), pp. 23-55. Reprinted in *The Arms Race in an Era of Negotiations*, David Carlton and Carlo Schaerf, eds. (London: MacMillan, 1991), pp. 141-178.

Warhead and Fissile-Material Declarations in *Reversing the Nuclear Arms Race, How to Achieve and Verify Deep Reductions in Nuclear Weapons,* edited by Frank von Hippel and Roald Sagdeev. New York: Gordon and Breach Science Publishers, 1990, pp. 61-81.

Limited Attacks on the United States and the Soviet Union, Annex 4B in Effects of Nuclear War on Health and Health Services, Second Edition (Geneva: World Health Organization, 1987), pp. 101-120 (with Barbara G. Levi).

Controlling Nuclear Weapons at the Source: Verification of a Cutoff in the Production of Plutonium and High-Enriched Uranium for Nuclear Weapons (with B.G. Levi), in *Verification of Arms Control: The Technologies That Make It Possible,* edited by K. Tsipis, D.A. Hafmeister and P. Janeway. Washington/New York/Oxford/Toronto/Sydney/ Frankfurt: Pergamon-Brasseys, 1986, pp. 338-388.

Perspectives on Limited Nuclear War in *Security and Survival: the Nuclear Arms Race*, edited by T.C. Smith and I.B. Singh. Boulder Colo: Lynne Rienner Publishers Inc. 1985, pp. 23-52.

The Short-Term Consequences of Nuclear War for Civilians (with J.S. Duffield) in *The Environmental Effects of Nuclear War,* edited by J. London and G. White (Boulder, CO: Westview Press, 1984) pp. 19-64.

The Effects of Nuclear War, in *Physics, Technology and the Nuclear Arms Race*, edited by D.W. Hafemeister and D. Schroer (New York: American Institute of Physics) 1983, pp. 1-46.

Global Risks from Energy Consumption, in *Health Risks of Energy Technologies: Symposium Volume* of the American Association for the Advancement of Science, edited by E. Etnier and C. Travis. Boulder, CO: Westview Press, 1982, pp. 209-227, reprinted in *Citizen Scientist*.

Forty Miles a Gallon by 1995 at the Least! - Why the U.S. Needs a New Automotive Fuel Economy Standard, in *The Dependence Dilemma: Gasoline Consumption and America's Security*, edited by D. Yergin. Cambridge MA: Harvard University, Center for International Affairs, 1980, pp. 89-108. Draft version reprinted in U.S. Senate Committee on Energy and Natural Resources Hearing, *Potential for Improved Automobile Fuel Economy Between 1985 and 1995*, April 30, 1980, pp. 480-516.

Energy Supply Options and Climatology: How Fast Must We Move Into the Post-Fossil Fuel Era? in *Multidisciplinary Research Related to the Atmosphere Sciences* (Boulder Co: National Center for Atmospheric Research, 1978) pp. 126-136.

An Evolutionary Strategy for Nuclear Power (with H.A. Feiveson and R.H. Williams) in *Nuclear Energy and Nuclear Weapons Proliferation* (Stockholm: Stockholm Peace Research Institute, 1979) pp. 11-47; also in *The Hazards of the International Energy Crisis*, edited by D. Carlton and C. Schaerf – (London: McMillan Press, 1982) pp. 127-168; and also in *Energy: For Ourselves and Our Posterity*, edited by R.L. Perrine and W.G. Ernst (Englewood Cliffs, NJ: 1985) pp. 229-263.

Articles in refereed journals

An Alternative to the Continued Accumulation of Separated Plutonium in Japan: Dry Cask Storage of Spent Fuel, *Journal on Peace and Nuclear Disarmament,* October 2018, https://doi.org/10.1080/25751654.2018.1527886 (with Masafumi Takubo)

Nuclear safety regulation in the post-Fukushima era, *Science*, 26 May 2017, Vol. 356, pp. 808-809 (with Edwin Lyman and Michael Schoeppner)

Economic Losses from a Fire in a Dense-Packed U.S. Spent Fuel Pool, *Science & Global Security* (2017) Vol. 25, pp. 80-92 (with Michael Schoeppner)

Reducing the Danger from Fires in Spent Fuel Pools, *Science and Global Security* Vol. 24 (2016) pp. 141-173 (with Michael Schoeppner)

"After the Iran deal: Multinational enrichment. World powers should buy a stake in Iran's enrichment capacity and accept the same rules," *Science, Vol* 348, No. 6241, 19 June 2015 (with Alexander Glaser and Zia Mian).

Accounting for long-term doses in "Worldwide health effects of the Fukushima Daiichi nuclear accident", *Energy & Environmental Science*, Vol. 6 (2013) p. 1042, (with Jan Beyea and Edwin Lyman)

Consistency Tests for the Declarations of U.S. Fissile-Material Production, *Science & Global Security*, Vol. 19, pp. 1–14, 2011

Fast Reactor Development in the United States, *Science & Global Security*, Vol. 17 (2009), pp. 109-131.

Nuclear Waste Management in the United States – Starting Over, *Science,* 10 July 2009, pp. 151-2 (with Rodney Ewing); letters, 11Dec. 2009, p. 1480.

How the radiological and nuclear medical communities can improve nuclear security, *The Journal of the American College of Radiology Vol 4, No. 4*, April 2007, pp. 248-251 (with Laura Kahn).

The U.S. HEU Declaration: Transparency Deferred but not Denied, *Nonproliferation Review14, #1,* March 2007, pp. 149-161 (with Steven Aftergood).

Feasibility of eliminating the use of highly enriched uranium in the production of medical radioisotopes, *Science & Global Security 14*, 2006, p. 151-162. (with Laura Kahn)

Feasibility of converting pp. **Russian icebreaker reactors from HEU to LEU fuel,** *Science & Global Security 14,* (2006) pp. 33-48 (with Alexander M. Dimitriev, Anatoli C. Diakov, Jungmin Kang, and Alexey M. Shuvayev),

Limited proliferation-resistance benefits from recycling unseparated transuranics and lanthanides from light-water reactor spent fuel, *Science & Global Security 13* (2005), pp. 169-181 (with Jungmin Kang).

A comprehensive approach to elimination of high-enriched-uranium from all nuclear-reactor fuel cycles, *Science & Global Security 12* (2004), pp. 137-164.

Damages from a Major Release of ^{137}Cs into the Atmosphere of the United States (with Jan Beyea and Ed Lyman) *Science & Global Security 12* (2004), pp. 125-136

Nuclear Power Plant Emergencies and Thyroid Cancer Risk: What New Jersey Physicians Need to Know (with Laura Kahn) *NJ Medicine*, April 2004, pp. 22-27.

Reducing the hazards from stored spent power-reactor fuel in the United States, (with Robert Alvarez, Jan Beyea, Klaus Janberg, Jungmin Kang, Ed Lyman, Allison Macfarlane and Gordon Thompson) Science *and Global Security 11* (2003), pp. 1-51; **The Authors respond to Allan Benjamin's comments,** pp. 59,60; **Response by the authors to the Nuclear Regulatory Commission review**, pp. 213-223; **Responses by Beyea, Lyman and von Hippel to Herschel Spector letter to the editor** *12, pp.252-3*.

Nuclear and radiological terrorism (Keynote address, American Statistical Association Conference on Radiation and Health, Deerfield Beach, June 23-23, 2002) *Radiation Research 158,* #6, Dec. 2002, pp. 802-3.

Storage Mox: A Third Way For Plutonium Disposal? (with J. Kang, A. Macfarlane, and R. Nelson), *Science & Global Security 10. #2* (2002), pp. 85-101.

Plutonium and Reprocessing of Spent Nuclear Fuel, *Science*, Vol. 293, # 5539, 28 September 2001, pp. 2397-2398.

U^{232} and the Proliferation-resistance of U^{233} in Spent Fuel (with Jungmin Kang) *Science & Global Security* 9, #1 (2001), pp. 1-32.

Ending the production of highly-enriched uranium for naval reactors (with Ma Chunyan) *Nonproliferation Review 8* (2001), pp. 86-101.

Using Commercial Imaging Satellites to Detect the Operation of Plutonium-Production Reactors and Gaseous-Diffusion Plants (with Hui Zhang) *Science & Global Security 8* (2000), pp. 261-313.

The Hazard Posed by Depleted Uranium Munitions (with Steve Fetter), *Science & Global Security 8* (2000), pp. 125-161.

The Question of Pure Fusion Explosions Under the CTBT (with Suzanne Jones), *Science & Global Security 7* (1998), pp. 1-22.

How to simplify the plutonium problem, *Nature 394,* July 30, 1998, pp. 415-16

Might Underground Waste Repositories Blow Up? by Frank von Hippel, *Science and Global Security 5 (3)*, Winter 1995-96, pp. 273-277.

Probabilities of Different Yields [from different grades of plutonium] (with Edwin S. Lyman). *Science and Global Security 4* (fall 1993).

Disposition of Separated Plutonium (with Frans Berkhout, Anatoli Diakov, Harold Feiveson, Helen Hunt, Ed Lyman and Marvin Miller) *Science & Global Security 3* (Winter 1992/93), pp 161-213

An Atmospheric Limit on Nuclear-powered Microwave Weapons (with Dan L. Fenstermacher). *Science & Global Security 2*, fall 1991, pp. 301-324.

Nuclear Warhead Safety and the CTB, *Science & Global Security 2*, Spring 1991, pp. 253-257.

The Hazard from Plutonium Dispersal by Nuclear Warhead Accidents (with Steve Fetter). *Science & Global Security 2, #1* (1990), pp. 21-42.

The 1969 ACDA Study on Warhead Dismantlement, *Science & Global Security 2, #1* (1990) pp. 103-108.

Beyond START: How to Make Much Deeper Cuts (with Harold A. Feiveson), *International Security,* summer 1990, pp. 154-180; reprinted in *Citizen Scientist.*

Revisiting Sakharov's Assumptions (in his calculations of the health effects of atmospheric nuclear testing) *Science & Global Security 1, # 3/4* (1990), pp. 185-186.

Every Profession Needs Its Own Journal, *Science and Global Security 1* (Fall 1989), pp. iii-iv.

Sary Shagan and Kyshtym: A Visit to Soviet Nuclear Facilities, *Science and Global Security 1* (Fall 1989), pp. 165-174 (with Tom Cochran and Christopher Paine).

Civilian Casualties from `Limited' Nuclear Attacks on the USSR, *International Security 11*, #3, Winter 1987/88, pp. 168-189 (with Barbara G. Levi and William H. Daugherty). Excerpted in *The Nuclear Reader, 2nd edition*, Charles W. Kegley Jr. and Eugene R. Wittkopf, eds. (New York: St. Martin's Press, 1989, pp. 281-283.

A Low-Threshold Test Ban is Feasible, *Science,* 23 October 1987, pp. 455-459 and 463-464 -- with Harold .A. Feiveson and Christopher E. Paine, reprinted in *Citizen Scientist.*

A Low-Threshold Nuclear Test Ban, *International Security,* Fall 1987, pp. 135-151 -- with Harold A. Feiveson and Christopher E. Paine.

The Consequences of "Limited" Nuclear Attacks on the US (with W.H. Daugherty and B.G. Levi), *International Security 10,* #4 Spring 1986, pp. 3- 45.

The Consequences of a 'Limited' Nuclear War in East and West Germany (with W.M. Arkin and B.G. Levi), *Ambio,* Vol, XI, #2-3, 1982, pp. 163-173. See also **Addendum,** Vol. XII, #1, 1983, p. 57. Adapted as **Kollectiver Selbstmord? Atomkrieg in Deutschland**, *Spektrum de Wissenschaft* (the German-language version of Scientific American), March 1983. Also reprinted in *Nuclear War: The Aftermath*, edited by J. Peterson. New York: Pergamon, 1983, pp. 165-187; and *The Aftermath*, edited by J. Peterson. New York: Pantheon, 1983, pp. 165-187.

Automobile Fuel Efficiency: The Opportunity and the Weakness of Existing Market Incentives (with B.G. Levi), *Resources and Conservation, Vol. 10,* 1983, pp. 103-124.

The Solar Radiation Resource (with A. Rabl), *Energy 8*, No. 4, 1983, pp. 295-316.

Radioactive Waste: the Problem of Plutonium (with H. Krugman), *Science,* October 17, 1980, pp. 319-321.

Fission Power: An Evolutionary Strategy (with H.A. Feiveson and R.H. Williams), *Science* 203, January 26, 1979, pp. 330-337.

Radioactive Wastes: A Comparison of U.S. Military and Civilian Inventories (with H. Krugman), *Science,* August 26, 1977, pp. 883-885.

Report to the American Physical Society by the Study Group on Light Water Reactor Safety (with H.W. Lewis, R.J. Budnitz, A.W. Castleman, D.E. Dorfan, F.C. Finlayson, R.L. Garwin, L.C. Hebel, S.M. Keeny Jr., R.A. Muller, G.F. Smoot and T.B. Taylor), *Reviews of Modern Physics 47*, Supplement 1, Summer 1975. 124 pp.

Public Interest Science, *Science 177*, (1972), pp. 1166-1171 (with J. Primack). Reprinted in *Technology as a Social and Political Phenomenon* edited by P.L. Bereano (New York: John Wiley & Sons, 1976), pp. 507-518; *Science, Technology and Society: Emerging Relationships*, Rosemary Chalk, ed. (Washington, D.C.: American Association for the Advancement of Science, 1988), pp. 82-87; and *Citizen Scientist* by Frank von Hippel [American Institute of Physics, Masters of Modern Physics series, and Simon & Schuster (paperback), both in 1991], pp. 1-15.

Inclusive contributions to the rising inelastic proton-proton cross-section (with Dennis Sivers). *Physical Review D, Vol. 9 #3* (1 February 1974), pp. 830-833.

Neutrino + proton --> μ^- + N^{*++} (1236): Comparison with Theory (with Philip Schreiner). *Physical Review Letters 30* (19 February 1973), pp. 339-342. (See also a longer article in *Nuclear Physics,* summer 1973).

Incoherent Multiple Scattering Effects in the Production of Particles on Nuclear Targets (with J.S. Trefil), *Physical Review D, Vol. 7,* (1973), p. 2000.

Final-State-Interaction Contributions to the Exotic Forward Peak in $\pi^- p$ --> $K^+ Y^{*-}$(1385) (with Dennis Sivers), *Physical Review D, Vol. 6, #3,* 1 August 1972, pp. 874-884.

Centrifugal-Barrier Effects in Resonance Partial Decay Widths, Shapes and Production Amplitudes (with Chris Quigg). *Physical Review D, Vol. 5, #3,* 1 February 1972, pp. 624-638.

S-wave Bound States Implied by the SU(3)xSU(3) Charge Algebra (with J. Finkelstein). *Physics Letters 31B,* 16 February 1970, pp. 226-229.

Nature of SU(3)xSU(3) Symmetry Breaking -- Results from a Systematic Test of the Soft-Meson Theorems (with Jae Kwan Kim) *Physical Review D, Vol. 1, #1,* 1 January 1970, pp. 151-164. See also erratum in *Physical Review D, Vol. 3, #11,* 1 June 1971, p. 2933.

Coupling Constants and SU(3) Classification of the Y_0^*(1405) (with Jae Kwan Kim) *Physical Review 184, #5,* 25 August 1969, pp. 1961-1963.

Systematic Test of the Soft-meson Theorems and of a Theory of SU(3)xSU(3) Symmetry Breaking (with Jae Kwan Kim) *Physical Review Letters 22, #14*, 7 April 1969, pp. 740-744.

Zero-parameter Model of the N-N Potential (with Hirotaka Sugawara) *Physical Review 172, # 5,* 25 August 1968, pp. 1764-1788. See also erratum in *Physical Review 185 #5,* p. 2046.

(π-Sigma)$_{I=0,1}$ and -N Scattering Lengths: Experimental and Theoretical Values (with Jae Kwan Kim) *Physical Review Letters 20, #23,* 3 June 1968, pp. 1303-1306.

K^- Mesonic X Rays and the -N Scattering Lengths (with John H. Douglas) *Physical Review 146, #4,* 24 June 1966, pp. 1042-1048.

Vector-Meson Couplings to the Baryons (with H. Sugawara) *Physical Review 145, #4,* 27 May 1966, pp. 1331-1334.

SU(6) and the Electromagnetic Form Factors (with K.J. Barnes and P. Carruthers) *Physical Review Letters 14, #3,* 18 January 1965, pp. 82-84.

Consequences of Analyticity and Unitarity for Partial-wave Amplitudes (with A.P. Balachandran). *Annals of Physics 30,* 1964, pp. 446-475.

Electromagnetic Lambda-Sigma(zero) Mixing and Charge Symmetry of the Lambda Hyperon (with R.H. Dalitz) *Physics Letters 10, #1,* 15 May 1964, pp. 153-157.

Parity and Sign of the Sigma(+) --> n + π^+ Decay Amplitude and a Model for π^+ Emission in Hypernuclear Decays, *Physical Review 136, #2B,* 26 October 1964, pp. B455-B471.

The Charge-exchange Contributions to π^+ Emission in Hypernuclear Decay (with R.H. Dalitz). *Il Nuovo Cimento 34,* 1 November 1964, pp. 799-806.

Analysis of the Experimental Evidence for the Existence of a ^{4}H State with T = 2 (with P.P. Divakaran), *Physical Review Letters 12, #3,* 3 February 1964, pp. 128-131.

Papers in conference proceedings

A Ban on the Production of Highly Enriched Uranium, Beijing Seminar on International Security, Suzhou, China, 1-5 November 2016 (with Sébastien Philippe)

A Ban on the Production of Highly Enriched Uranium, Annual Meeting of the Institute for Nuclear Materials Management, Atlanta, GA, 26 July 2016 (with Sébastien Philippe)

Iran and Multinational Enrichment, *Proceedings of the* *Beijing Seminar on International Security: Strategic Stability and Cooperation,* Hangzhou, China, 19 – 22 October 2014

Gorbachev's unofficial arms-control advisers in *Nuclear Weapon Issues in the 21st Century,* AIP Conference Proceedings 1596, 2014, Pierce S. Corden, David Hafemeister and Peter Zimmerman eds, p. 39.

Scope and verification of a Fissile Material (Cutoff) Treaty in *Nuclear Weapon Issues in the 21st Century,* AIP Conference Proceedings 1596, 2014, Pierce S. Corden, David Hafemeister and Peter Zimmerman eds, p. 200.

The Uncertain Future Of Reprocessing In Japan, *Proceedings of the 2013 Annual Conference of the Institute of Nuclear Materials Management,* Palm Desert, July 2013 (with Masafumi Takubo)

Decreasing HEU Stocks and Use at the Institute of Physics and Power Engineering, *Proceedings of the 2013 Annual Conference of the Institute of Nuclear Materials Management,* Palm Desert, July 2013 (with I. Matveenko, V. Poplavko, and G. Pshakin)

A Global Cleanout of Nuclear-weapon-usable Materials, *Proceedings of the Beijing Seminar on International Security,* 31 October - 3 November, 2012

Preventing Nuclear-explosive Terrorism by Eliminating Fissile Material: A Progress Report, *Proceeding of the 45th International Seminar on Planetary Emergencies, Erice, 18-26 August 2012*

Global Nuclear-weapon Material Stocks and Risks, *Proceedings of the 2012 Seoul Nuclear Security Symposium, 23 March 2012; Seoul, South Korea*

New IPFM Estimates of Weapon-State Stockpiles of HEU and Separated Plutonium, ***Proceedings of the*** *Annual Conference of the Institute of Nuclear Materials Management,* Palm Desert, CA, 20 July 2011

Spent Fuel Management in South Korea: The Illogic of Pyroprocessing, *Proceedings of the Annual Conference of the Institute of Nuclear Materials Management, Baltimore, 11-15 July 2010*

Treatment of Pre-Existing Fissile Material Stocks in a Fissile Material (Cutoff) Treaty, *Proceedings of the Annual Conference of the Institute of Nuclear Materials Management*, Baltimore, 11-15 July 2010 (with Harold A. Feiveson, Alexander Glaser, Arend Meerburg and Zia Mian)

Opportunities for nuclear disarmament: Physicists need to get involved again, *Proceedings of a joint Conference of the Congress of the Federation of German Scientists and German Physical Society, Berlin, 24 Oct. 2009.*

Managing Spent Fuel in the United States: The Illogic of Reprocessing, *Proceedings of the Annual Meeting of the Institute on Nuclear Materials Management,* Nashville, TN, July 13-17, 2008.

Verification of a Fissile Material (Cutoff) Treaty, *Proceedings of the Annual Meeting of the Institute on Nuclear Materials Management,* Nashville, TN, July 13-17, 2008.

The International Panel on Fissile Materials, *Proceedings of the Annual Meeting of the Institute of Nuclear Materials Management,* July 16-20, 2006.

Future Needs For HEU-Fueled Critical Assemblies, *Proceedings of the International Meeting on Reduced Enrichment for Research and Test Reactors, Boston, Massachusetts, 6-10 November 2005.*

Science, Technology and Global Security, *Vision 2033: Linking science and policy for tomorrow's world: Proceedings celebrating the 30th anniversary of the AAAS Science and Technology Policy Fellowship Programs,* May 13-14, 2004, Carnegie Institution, Washington, DC.

Security hazards from urban research reactors *Proceedings of the international workshop on "Solutions To Security Concerns about the Radioactive Legacy of the Cold War that Remain in Urban Environments," Vanderbilt University, Nashville, Tennessee, November 15, 2004,* in press.

The need to address the larger universe of HEU-fueled reactors, including: critical assemblies, pulsed reactors and propulsion reactors, *Proceedings of the International Meeting on Reduced Enrichment for Research and Test Reactors, IAEA, Vienna, 7-12 November 2004*

On the importance of ending the use of HEU in the nuclear fuel cycle: an updated assessment (with Alexander Glaser), *Proceedings of the 24th International Meeting on Reduced Enrichment for Research and Test Reactors, November 3-8, 2002, San Carlos de Bariloche, Argentina*

Reducing stockpiles and use of highly-enriched uranium, *Proceedings of the 8th ISODARCO Beijing Seminar on Arms Control, October 14-18, 2002, Beijing China*

Storage Mox: A Third Way For Plutonium Disposal? (with A. Macfarlane, J. Kang, and R. Nelson), *Proceedings of the Global 2001 International Conference on the Back End of the Fuel Cycle,* Paris, Sept. 12, 2001.

Feasibility of Converting Russian Ice-Breaker Reactors From High-enriched To Low-enriched Uranium Fuel *(with Jungmin Kang), poster, Global 2001 International Conference on Back End of the Fuel Cycle: From Research to Solutions, Palais des Congres, Paris, September 9-13, 2001.*

To reprocess or not? Security Implications in *Proceedings of the Workshop on Management and Disposal of Nuclear Waste, Beijing, September 1999*, Yih-yun Hsu and Wang Rui-Ping, eds, (Institute for Global Chinese Affairs, University of Maryland, 2000), E23-35.

The Convergence of Nuclear Arms Control and Nuclear Materials Management, Keynote address, *Proceedings of the Annual Meeting of the Institute of Nuclear Materials Management,* Phoenix, Arizona, July 21, 1997.

Global Nuclear-Materials Control, *Proceedings of the Annual Meeting of the Institute of Nuclear Materials Management,* Phoenix, Arizona, July 21, 1997 (Abstract)

Addressing the International Overhang of Fissile Material by Frank von Hippel, *Proceedings of the Carnegie Endowment Conference on "Nuclear Non-Proliferation and the Millennium: Prospects and Initiatives,"* Washington, D.C., February 12-13, 1996.

An Evolutionary Strategy for Fission Power by Frank von Hippel *Proceedings of Global 1995: International Conference on Evaluation of Emerging Nuclear Fuel Cycle Systems,* Versailles, France, September 11-14, 1995, pp. 380-387.

Contributions of Independent Analysts and Activists to Disarmament and the Conversion of Military Resources in *Proceedings of the International Congress of Scientists on Science and Peace in a Rapidly Changing Environment, 29 November - 1 December 1991,* Rainer Rillling, Hartwig Spitzer, Owen Greene, Ferdinand Hucho and Gyula Pati, eds; Vol. 1, pp. 26-32.

Verification of Nuclear Warheads and Their Dismantlement: A Joint American-Soviet Study, *Nuclear Materials Management 19: Proceedings of the Annual Meeting of the Institute of Nuclear Materials Management, Los Angeles, CA, 15-18 July, 1990,* pp. 589-591.

Controlling and Reducing the Arsenals of the Nuclear Weapon States in *Non-Proliferation in a Disarming World*, Proceedings of the VIth International Colloquium organized by the Groupe de Bellerive, Geneva 20-21 June 1990, Sadruddin Aga Khan, ed., pp. 49-58.

Independent Scientists Contribution to Disarmament in *Ways Out of the Arms Race*, *Proceedings of the Second International Scientists' Congress*, Imperial College, London, 2-4 December 1988, John Hassard, Tom Kibble and Patricia Lewis, eds. (Singapore: World Scientific, 1989), pp. 277-287.

Advances in Weapons Technology and Their Impact on National Security and Arms Control in "Nuclear and Conventional Forces in Europe: Implications for Arms Control and Security," Proceedings of the Second AAAS Colloquium on Science, Arms Control and National Security, 28-29 September 1987, Arlington, VA. W. Thomas Wander and Kenneth N. Luongo, eds, (American Association for the Advancement of Science, 1988), pp. 33-41, 51, 52-53.

Verification of a Cutoff in the Production of Plutonium and Highly-Enriched Uranium for Nuclear Weapons in *Proceedings of the Workshop on Scientific Aspects of the Verification of Arms Control Treaties, Hamburg, 13-14 November 1986* (Univeristy of Hamburg, Hamburger Beitra"ge zur Friedensforschung und Sicherheitspolitik, Vol. 19, June 1987), pp. 55-83.

Verification of Nuclear Disarmament Agreements (with Jack Weiss), in the *Proceedings of the International Scientists' Congress on Ways Out of the Arms Race, Hamburg*, West Germany, 14-16 Nov. 1986.

Seismological Monitoring of Nuclear Explosions in *Proceedings of the 36th Pugwash Conference on Science and World Affairs; Budapest, Hungary; 1-6 September 1986*, pp. 101-103.

Cutting Off Nuclear Weapons at the Source, in *Nuclear War, Nuclear Proliferation and Their Consequences, Proceedings of the Vth International Colloquium Organized by the Groupe de Bellerive, Geneva, 27-29 June 1985*, edited by Sadruddin Aga Khan. Oxford: Clarendon Press, 1985, pp. 65-79.

Why the Nuclear Arms Race? in *Nuclear War -- By Mistake, Inevitable or Preventable?,* Report from an International Conference in Stockholm, Sweden, 15-16 February 1985. Stockholm: Swedish Physicians Against Nuclear Arms, 1985, pp. 24-30.

Comments on Nuclear Power in *The Nuclear Chain Reaction - Forty Years Later," Proceedings, a University of Chicago Commemorative Symposium*, Robert G. Sachs, ed. (Chicago, Ill. University of Chicago, 1984), pp. 231, 234, 236.

The Possibility of a Nuclear Weapons Freeze, *Proceedings of the Princeton Conference on the Nuclear Weapons Debate,* 1983, pp.??

The Environmental Consequences of Nuclear War, *Proceedings of the first Conference on the Fate of the Earth,* Oct. 19-21, 1982 (San Francisco: Earth Island Institute, 1983) pp. 276 - 285

Soviet Diversion of Plutonium Under IAEA Safeguards, Proceedings of the Conference on the Nuclear Weapons Freeze and Arms Control, American Academy of Arts and Sciences, January 13-15, 1983, pp. 37, 38.

Automotive Fuel Economy: the Technological Potential in *Low Consumption/Low Emission Automobiles, Proceedings of an Expert Panel, Rome, 14-15 February 1991.* Paris: OECD, International Energy Agency, 1991, pp. 31-32.

Automobile Fuel Economy in *Proceedings of the Soviet-US Symposium on Energy Conservation, Moscow, 6-11 June 1985*, published in *Energy: The International Journal 12* (1987), pp. 1063-1071.

Book Reviews

Strange Bedfellows. review of *Doomed to Cooperate: How American and Russian Scientists Joined Forces to Avert Some of the Greatest Post–Cold War Nuclear Dangers,* Siegfried S. Hecker, Ed. Bathtub Row Press, 2016, *Science,* 23Sept. 2016, p. 1372.

The First Proliferation: Waiting for the Soviet Bomb, *American Scientist*, Vol. 98, No. 4, July/Aug. 2010, Review of Red Cloud At Dawn: Truman, Stalin, and the End of the Atomic Monopoly. Michael D. Gordin (Farrar, Straus and Giroux, 2009).

Public Defenders, review of *Defusing Armageddon: Inside NEST, America's Secret Nuclear Bomb Squad* by Jeffrey T. Richelson, Norton, 2009**,** *American Scientist 97,* May-June 2009, p. 256.

Promising the Sun, review of *Sun in a Bottle: The Strange History of Fusion and the Science of Wishful Thinking* by Charles Seife, *Science,* Vol. 322, 28 November 2008, p. 1328.

The Stuff of Bombs, a review of *Plutonium: A History of the World's Most Dangerous Element by Jeremy Bernstein*, *American Scientist 95* (May-June 2007), pp. 266-68.

Better active today than radioactive tomorrow: A review of *Toward Nuclear Abolition: A history of the world nuclear disarmament movement, 1971 to the present* by Lawrence Wittner (Stanford University Press, 2003) *International Network of Engineers and Scientists Against Proliferation Newsletter* #22, Dec. 2003, pp. 46-47;*Federation of American Scientists Public Interest Report 57* (Winter 2004), pp. 1, 11-13.

A Brief For Power and Against Weapons, book review of *Megawatts and Megatons A Turning Point in the Nuclear Age?* by Richard L. Garwin and Georges Charpak, *Science 295*, January 25, 2002, p. 632.

Review of U.S. Military Research and Development, 1984, edited by Kosta Tsipis and Penny Janeway, *Physics Today,* April 1985, p. 85.

How Should We Rethink Nuclear Weapons Policy? review of Freeman Dyson's Weapons and Hope, *Physics Today*, November 1984, pp. 105,106.

Articles in *Scientific American*

Are we any closer to preventing nuclear holocaust? *Scientific American,* August 2016

Chernobyl Didn't Kill Nuclear Power, *Scientific American,* April 2016

"Time to Ban Production of Materials for Nuclear Weapons," *Scientific American website,* 13 January 2010 (with Alex Glaser and Zia Mian)

Rethinking Nuclear Fuel Recycling, *Scientific American,* May 2008, pp. 88-93.

Thwarting nuclear terrorism by Alex Glaser and Frank von Hippel, *Scientific American,* February 2006, pp. 56-63.

Taking Nuclear Weapons off Hair-Trigger Alert by Bruce Blair, Harold Feiveson and Frank von Hippel, *Scientific American 277, #5,* November 1997, pp. 74-81.

Eliminating Nuclear Warheads (with Marvin Miller, Harold Feiveson, Anatoli Diakov and Frans Berkhout) *Scientific American 269,* August 1993, pp. 44-49.

Civilian Casualties from Counterforce Attacks, *Scientific American,* September 1988, pp. 36-42 (with Barbara G. Levi, Theodore B. Postol and William H. Daugherty), reprinted in *Citizen Scientist*.

Stopping the Production of Fissile Material for Weapons (with D.A. Albright and B.G. Levi) *Scientific American*, September 1985, pp. 40-47 (delayed in the Russian edition of Scientific American until September 1987), reprinted in *Citizen Scientist*.

The Fuel Economy of Light Vehicles (with C. Gray) *Scientific American*, May 1981, pp. 48-59, reprinted in *Citizen Scientist*.

Limited Nuclear Warfare (with S.D. Drell) *Scientific American*, November 1976, pp. 27-37. Reprinted in *Progress in Arms Control*, edited by B.M. Russett and B.G. Blair. San Francisco: W.H. Freeman and Co., 1979, pp. 144-154; and in *Arms Control and the Arms Race*, edited by B.M. Russett and F. Chernoff. San Francisco: W.H. Freeman and Co., 1985, pp.??.

Articles in *Physics Today*

Nuclear Weapons dangers and policy options, *Physics Today,* April 2018, pp. 32-39, https://physicstoday.scitation.org/doi/10.1063/PT.3.3896 (with Steve Fetter and Richard Garwin)

Sakharov, Gorbachev, and nuclear reductions, *Physics Today*, April 2017, pp. 49-54.

A disarmament agenda, interview with *Physics Today*, June 2015, pp. 26-29 (with Alex Glaser and Zia Mian)

Gorbachev's Unofficial Arms-control Advisors, *Physics Today,* Sept. 2013, pp. 41-47; letters to the editor and responses, **Russia and the US in the Cold War arms race,** *Physics Today,* April 2014, pp. 8-11.

"James Franck: Science and Conscience," *Physics Today,* May 2010, pp. 41-46.

The Question of Pure Fusion Explosions Under the CTBT (with Suzanne Jones and Ray Kidder) *Physics Today*, September 1998, pp. 57-59.

Fissile Material Security in the Post-Cold War World by Frank von Hippel, *Physics Today 48, #6,* June 1995, pp. 26-31.

Big Government and Little Analysts by Frank von Hippel, *Physics Today 48, #6,* June 1995, pp. 51-52 (reprinted in *Philosophy and Social Action 21, #4,* Oct.-Dec. 1995, pp. 57-59.

Arms Control Physics: The New Soviet Connection, *Physics Today*, November 1989, pp. 39-42, 44, 46 (reprinted in *Citizen Scientist* and in *Physics and Nuclear Arms Today*, David Hafemeister, ed. (New York: American Institute of Physics, 1991).

Measurements of Radiation from a Soviet Warhead, *Physics Today,* November 1989, p. 45 (with Steve Fetter), reprinted in *Physics and Nuclear Arms Today*.

Visit to a Laser Facility at the Soviet ABM Test Site, *Physics Today,* November 1989, pp. 34-35, reprinted in *Physics and Nuclear Arms Today*.

The Freeze and The Counterforce Race (with H.A. Feiveson) *Physics Today*, January 1983, pp. 36, 38, 40, 42, 44, 46-49. See also letters to the editor, *Physics Today*, May 1983, pp. 12-13, reprinted in *Citizen Scientist* and *Physics and Nuclear Arms Today*.

The Emperor's New Clothes – 1981, *Physics Today,* July 1981, pp. 34-41.

The importance of defending Andrei Sakharov, Guest Comment, *Physics Today,* April 1980, p. 9.

More on Plutonium Recycling, *Physics Today*, Feb. 1976, pp. 13, 15.

More on Waste Disposal, *Physics Today,* August 1976, pp. 68, 69.

Public Interest Science -- An Overview (with J. Primack and M. Perl), *Physics Today*, June 1974, pp. 23-31.

Articles in *Physics and Society*
(Journal of the Forum on Physics and Society)

Comments on "The New Era of Nuclear Arsenal Vulnerability" by Lieber and Press, *Physics & Society*, January 2018, https://www.aps.org/units/fps/newsletters/201804/comments.cfm

Usability of Reactor-grade Plutonium in Nuclear Weapons: A Reply to Alex DeVolpi, by Marvin Miller and Frank von Hippel, *Physics & Society 26, #3* (July 1997), pp. 10-11.

Contributions of Arms-Control Physicists to the Ending of the Cold War, *Physics & Society,* April 1996, pp. 1, 9-10.

Articles in *Arms Control Today*

Improving U.S. Ballistic Missile Defense Policy, *Arms Control Today,* May 2018, pp. 16-22, https://www.armscontrol.org/act/2018-05/features/improving-us-ballistic-missile-defense-policy (with George Lewis)

The Feasibility of Ending HEU Fuel Use in the U.S. Navy, *Arms Control Today*, November 2016, pp. 15-22 (with Sébastien Philippe)

Building on the Iran Deal: Steps Toward a Middle Eastern Nuclear-weapon-free Zone, *Arms Control Today,* December 2015, pp. 14-20 (with Alexander Glaser, Zia Mian and Hossein Mousavian)

Agreeing on Limits for Iran's Centrifuge Program: A Two-Stage Strategy, *Arms Control Today,* July/August 2014, pp. 8-14 (with Alexander Glaser, Zia Mian and Hossein Mousavian)

A Win-Win Solution for Iran's Arak Reactor, *Arms Control Today,* April 2014, pp. 8-13 (with Ali Ahmad, Alexander Glaser, and Zia Mian)

The Future of Plutonium Disposition, *Arms Control Today,* July/August 2013, pp. 8-15 (with Tom Clements and Edwin Lyman)

South Korean Reprocessing: An Unnecessary Threat to the Nonproliferation Regime, *Arms Control Today,* March 2010, pp. 22-29; letters to the editor, June 2010, pp. 49-51.

Complete Cutoff: Designing a Comprehensive Fissile Material Treaty, *Arms Control Today,* March 2009, pp 16-23 (with Arend Meerburg).

National Fuel Stockpiles: An Alternative to a Proliferation of National Enrichment Plants? *Arms Control Today,* September 2008, pp. 20-24.

Reprocessing revisited: The international dimensions of the Global Nuclear Energy Partnership, *Arms Control Today,* April 2008, pp. 6-14 (with Edwin Lyman)

The North Korean Test and the Limits of Nuclear Forensics, *Arms Control Today,* January/February 2007, pp. 42-43 (with Jungmin Kang and Hui Zhang) and correction, April 2007, p. 48.

Deconstructing North Korea's October 9 Nuclear Test, *Arms Control Today,* November 2006, pp. 15-17 (with Richard Garwin); reprinted in the Japanese journal, *Sekai,* December 2006, pp. 68-71

Global cleanout: Reducing the threat of HEU-fueled nuclear terrorism, *Arms Control Today,* January-February 2006, pp. 18-23 (with Alexander Glaser)

Is U.S. reprocessing worth the risk? By Steve Fetter and Frank von Hippel, *Arms Control Today,* September 2005, pp. 6-12.

Hans Bethe (1906-2005), *Arms Control Today 35,* April 2005, pp. 44-46 (with Richard Garwin)

Does the United States need a new plutonium-pit facility? (with Steve Fetter), *Arms Control Today,* May 2004, pp. 10-14.

A Step-by-Step Approach to a Global Fissile Materials Cutoff by Steven Fetter and Frank von Hippel, *Arms Control Today 25, #8* (October 1995), pp. 3-8.

The Administration, Congress and Nuclear Testing (transcript of a press conference), *Arms Control Today,* July/August 1993, p. 4.

Worse than Chernobyl? [plutonium dispersal from a nuclear-warhead accident] (with Steve Fetter). *Arms Control Today 22*, September 1992, p. 13.

Articles in *Disarmament Forum*
(Journal of the U.N. Institute for Disarmament Research)

Building confidence in a fissile materials production moratorium using commercial satellites (with Hui Zhang) *Disarmament Forum*, 2000, #3, pp. 71-77

The FMCT and Cuts in Fissile Material Stockpiles, by Frank von Hippel, *UNIDIR Disarmament Forum 2,* spring 1999, pp. 35-44.

De-Alerting Russian and American Nuclear Missiles (with Bruce Blair and Harold Feiveson) *UNIDIR Newsletter*, *No 38* (1998) Special issue: "Nuclear De-alerting: Taking a Step Back," pp. 19-22.

Articles in *The Bulletin of the Atomic Scientists*

Limitations on ballistic missile defense—Past and possibly future, *Bulletin of the Atomic Scientists,* Vol. 74 (4) pp. 199–209, August 2018, https://doi.org/10.1080/00963402.2018.1486575.

Tillerson was right about Trump (re taking the US out of the Iran Deal), *Bulletin of the Atomic Scientists,* 9 May 2018, https://thebulletin.org/commentary/tillerson-was-right-about-trump/

"Forty years of impasse: The United States, Japan and the plutonium problem," *Bulletin of the Atomic Scientists*, August 2017 (with Masafumi Takubo)

Reprocessing policy and South Korea's new government, *Bulletin of the Atomic Scientists,* 15 May 2017, http://thebulletin.org/reprocessing-policy-and-south-korea's-new-government10768 (with Jungmin Kang)

"A renewed mobilization to reduce the danger from nuclear weapons," *Bulletin of the Atomic Scientists*, 14 November 2016

"How many nuclear warheads does the United States need?" *Bulletin of the Atomic Scientists*, September 2016.

Why the United States did not demonstrate the Bomb's power ahead of Hiroshima, *Bulletin of the Atomic Scientists,* August 2016 (with Fumihiko Yoshida)

Banning the production of highly enriched uranium, *Bulletin of the Atomic Scientists,* 15 March 2016 (with Zia Mian and Michael Schoeppner)

Explain This: Subcritical experiments, *Bulletin of the Atomic Scientists,* 14 December 2012, *www.thebulletin.org/web-edition/features/explain-subcritical-experiments*

Murphy's Law and the doomsday machine (remembering the Cuban Missile Crisis) *Bulletin of the Atomic Scientists,* 17 October 2012, http://thebulletin.org/web-edition/features/remembering-the-cuban-missile-crisis

"The radiological and psychological consequences of the Fukushima Daiichi accident," *Bulletin of the Atomic Scientists,* Vol. 67, Sept. 2011, pp. 27-36.

"Managing nuclear spent fuel: Policy lessons from a 10-country study, *Bulletin of the Atomic Scientists,* 27 June 2011 (with Harold Feiveson, Zia Mian and M. V. Ramana)

It's Time to Give Up on Breeder Reactors, *Bulletin of the Atomic Scientists*, May/June 2010, pp. 50-56 (with Thomas B. Cochran, Harold A. Feiveson, Zia Mian, M. V. Ramana, and Mycle Schneider)

Dry-cask storage: How Germany led the way, *Bulletin of the Atomic Scientists,* Sept.-Oct. 2009, p. 24 (with Klaus Janberg)

Remembering Jo [Rotblat], *Bulletin of the Atomic Scientists,* November/December 2005.

Where Fermi Stood, *Bulletin of the Atomic Scientists 57,* September/October, 2001, pp. 26-29.

Eyes in the sky: Watching for weapons work (with Hui Zhang), *Bulletin of the Atomic Scientists 57,* July/August 2001, pp. 61-66.

Plutonium Disposal: The Third Way, (with Allison MacFarlane, Jungmin Kang and Robert Nelson) *Bulletin of the Atomic Scientists 57,* May/June, 2001, pp. 53-57.

Help the nuclear cities, help ourselves, *Bulletin of the Atomic Scientists 56,* November/December 2000, pp. 21-23.

"When the dust settles: Depleted uranium is not the radioactive nightmare some say but it is still a dangerously toxic heavy metal" by Steve Fetter and Frank N. von Hippel, *Bulletin of the Atomic Scientists 55*, Nov.-Dec. 1999, pp. 42-45, (bullatomsci.org/issues/1999/nd99/nd99toc); see also, letter to the editor and the authors' response, "The DU dispute continues," Jan/Feb. 1999 issue, pp. 4-5.

Retooling Russia's Nuclear Cities by Oleg Bukharin, Matthew Bunn, Jill Cetina, Ken Luongo and Frank von Hippel, *Bulletin of the Atomic Scientists 54*, September/October 1998, pp. 44-50.

The slow death of the fast [plutonium] breeder [reactor] by Frank von Hippel and Suzanne Jones, *Bulletin of the Atomic Scientists 53, #5,* September/October 1997, pp. 46-51

Let's reprocess the MOX plan by Marvin Miller and Frank von Hippel, *Bulletin of the Atomic Scientists,* July/August 1997, pp. 15-17 (on plutonium disposition).

Paring Down the Arsenal by Frank von Hippel, *Bulletin of the Atomic Scientists 53,* May/June 1997, pp. 33-40.

Take a Hard Look at Subcritical Tests by Suzanne Jones and Frank von Hippel, *Bulletin of the Atomic Scientists 52,* November-December 1996, pp. 44-47.

Testing, testing, 1,2,3 -- forever (not our title), *Bulletin of the Atomic Scientists 49,* July/August 1993, pp. 28-32.

Russian whistleblower faces jail in *Bulletin of the Atomic Scientists 49* (March 1993), pp. 7-8.

Plutonium: True Separation Anxiety (with Frans Berkhout, Anatoli Diakov, Harold Feiveson and Marvin Miller) *Bulletin of the Atomic Scientists 48*, November 1992, pp. 28-34.

Test Ban Debate, Round Three: Warhead Safety, *Bulletin of the Atomic Scientists 47*, April 1991, pp. 29-31 and letters to the editor in the June issue, pp. 44, 45.

How to Prevent Accidental Nuclear War, *Bulletin of the Atomic Scientists,* June 1990, pp. 35-37.

Soviets Debate Minimum Deterrence, *Bulletin of the Atomic Scientists,* Jan/Feb. 1990, pp. 5-6.

Taking Apart the Doomsday Machine, *Bulletin of the Atomic Scientists,* May 1989, pp. 10-12.

A U.S. Scientist Addresses Gorbachev, *Bulletin of the Atomic Scientists*, May 1987, pp. 12-13, reprinted in *Citizen Scientist*.

The Danger of Military Reactors, *Bulletin of the Atomic Scientists,* October 1986, pp. 44-48 (with D.A. Albright and C. Paine).

Breaking the Fuel/Weapons Connection (with H.A. Feiveson and D.A. Albright) *Bulletin of the Atomic Scientists*, March 1986, pp. 26-31.

Reducing U.S. and Soviet Nuclear Arsenals (with H.A. Feiveson and R.H. Ullman) *Bulletin of the Atomic Scientists,* August 1985, pp. 144-150. Reprinted in Assessing the Nuclear Age, edited by L. Ackland and S. McGuire (Chicago: University of Chicago Press, 1986) pp. 311-324.

Attacks on Star Wars Critics a Diversion, *Bulletin of the Atomic Scientists,* April 1985, pp. 8-10. Reprinted in *Assessing the Nuclear Age*, edited by L. Ackland and S. McGuire (Chicago: University of Chicago Press, 1986) pp. 163-170 and in *Citizen Scientist*.

The Myths of Edward Teller, *Bulletin of the Atomic Scientists* (BAS), March 1983, pp. 6-12. See also subsequent exchange with Teller in BAS, April 1983, pp. 42-44, and the letter to the editor by Frank von Hippel in the November 1983 issue of the *BAS*, pp. 60,61. Reprinted in *The Consequences of Nuclear War on the Global Environment*, report by the House Committee on Science and Technology, 1983, pp. 41-50 and in *Citizen Scientist*.

Towards a Solar Civilization (with R.H. Williams), *Bulletin of the Atomic Scientists*, October, 1977, pp. 12-15, 56-60. Reprinted in *Towards a Solar Civilization,* edited by R.H. Williams (Cambridge, MA: M.I.T. Press, 1978) pp. 221-238.

Solar Technologies (with R.H. Williams) *Bulletin of the Atomic Scientists*, November, 1975, pp. 25-31. Reprinted in *Towards a Solar Civilization* (see above), pp. 1-14.

Energy Waste and Nuclear Power Growth (with R.H. Williams), *Bulletin of the Atomic Scientists,* December 1976, pp. 20-32.

The Plutonium Economy: Why We Should Wait and Why We Can Wait (with H.A. Feiveson, T.B. Taylor and R.H. Williams) *Bulletin of the Atomic Scientists*, December 1976, pp. 10-14. Reprinted in the *Reader on Nuclear Nonproliferation* (US Senate Committee on Government Affairs, 1978) pp. 145 - 150.

Chernobyl, The Emerging Story: Estimating Long-Term Health Effects (with Thomas B. Cochran) *Bulletin of the Atomic Scientists*, August/September 1986, pp. 18-24. See also, letter to the editor, November 1986, pp. 55-56, reprinted in *Citizen Scientist*. See also, William J. Broad, "Experts Voice Concern on East Europe Cancers, *New York Times,* 16 May 1986.

Containment of a Reactor Melt-Down (with J. Beyea), *Bulletin of the Atomic Scientists*, September 1982, pp. 52-59, reprinted in *Citizen Scientist*.

The NRC and Thyroid Protection - One Excuse After Another, *Bulletin of the Atomic Scientists 36* (October 1980), pp. 44-46, reprinted in *Citizen Scientist*.

Looking Back on the Rasmussen Report, *Bulletin of the Atomic Scientists,* February 1977, pp. 42-47.

Will Our Problems be Solved if We Abolish Nuclear Power Plants? *Bulletin of the Atomic Scientists,* September 1979, p. 5. Excerpted on the *Washington Post* editorial page, September 21, 1979, p. A18.

A Perspective on the Debate, *Bulletin of the Atomic Scientists*, July 1975, p. 37; **Further Points of Clarification,** *Bulletin of the Atomic Scientists,* January 1976, p. 44 (reprinted in Hans Bethe, *The Road from Los Alamos* (American Institute of Physics/Simon and Schuster, 1991), pp. 206-213.

Scientists, Politics and the SST: A Critical Review, *Bulletin of the Atomic Scientists 28* (April 1972, pp. 24-30 (with Joel Primack).

Articles in *Technology Review*

Plutonium Perils (commentary), *Technology Review 96,* August/September 1993, p. 70.

Dismantling the Doomsday Machine [post-START nuclear cuts] (with H.A. Feiveson) *Technology Review* 95, May-June 1992, pp. 61-69.

Due Process for Dissenting `Whistle-Blowers' (with R. Chalk), *Technology Review*, June/July 1979; pp. 45-55, (excerpted in the *Boston Globe*, August 12, 1979, p. D1 and in two parts in *Mechanical Engineering,* April 1980, p. 82, May 1980, p. 76, reprinted in *Citizen Scientist*.

Articles in *Issues of Science & Technology*
(Policy journal of the National Academy of Sciences)

Nuclear Stockpile Stewardship, Invited comment, *Issues in Science and Technology,* Summer 1999, p. 9.

Looking Beyond INF, *Issues of Science and Technology,* Summer 1988, pp. 31-32 (based on testimony before the Joint Commission on Foreign Relations of the Supreme Soviet of the USSR, 24 March 1988).

SDI Research: Differences in Thrust (invited comment), *Issues of Science and Technology*, Spring 1988, pp. 12-13.

Long-Term Health Consequences of Chernobyl, *Issues of Science and Technology*, Winter Issue 1986-'87, p 8.

Articles in the Federation of American Scientists' *Public Interest Report*

The Federation of American Scientists' Contribution to Ending the Cold War Nuclear Arms Race, *Federation of American Scientists Public Interest Report,* Special 70th Anniversary Issue*,* May 2016.

Presentation of the Federation of American Scientists' Hans A. Bethe Award to Phillip Morrison, *Federation of American Scientists Public Interest Report, Vol. 56, #1,* Spring 2003.

Recommendations for Preventing Nuclear Terrorism, *Federation of American Scientists Public Interest Report* (November/December 2001), p. 1, 4-8, 10.

Saga of the Siberian Plutonium-Production Reactors *(with Matthew Bunn)* Federation of American Scientists *Public Interest Report* 53, November/December 2000.

"Did India Test an H-bomb?" by M.V. Ramana and Frank von Hippel, *FAS Public Interest Report,* January-February 1999, p. 8.

The Department of Energy's Stockpile Stewardship Program, *F.A.S. [Federation of American Scientists] Public Interest Report 50,* January/February 1997, pp. 7-9.

Industrial Conversion in Russia: A Tale of Two "Plutonium Cities" by Frank von Hippel, *F.A.S. [Federation of American Scientists] Public Interest Report,* July/August 1996, pp. 3-4.

Working in the White House on Nuclear Nonproliferation and Arms Control: A Personal Report by Frank von Hippel, *F.A.S. Public Interest Report 48, #2,* March/April 1995, pp. 1, 3-8.

On to START II -- Now! (with Harold A. Feiveson). *Federation of American Scientists, Public Interest Report*, June 1990, pp. 1,2, 5-8.

The Technical Basis for Deep Reductions, *Federation of American Scientists Public Interest Report,* November 1989, p. 7.

Analysts Address Gorbachev (with a response from Gorbachev) in *Federation of American Scientists' Public Interest Report,* February 1988, pp. 14-15 (with Anders Boserup, Robert Nield and Albrecht von Mu"ller).

A Cutoff in the Production of Fissile Material for Nuclear Weapons (with B.G. Levi) in *Federation of American Scientists' Public Interest Report,* February 1985, pp. 3-7 (reprinted in Verifying a Nuclear Freeze, edited by Roger Harrison. London: Berg Publishers, 1986, pp. 167-177.

The Committee of Soviet Scientists Against the Nuclear Threat, *Federation of American Scientists Public Interest Report,* January 1984, pp. 1-4.

Cutting Off the Production of Fissile Material for Nuclear Weapons (with H.A. Feiveson), *Federation of American Scientists Public Interest Report*, June 1982, pp. 10, 11.

FAS Opposes the Clinch River Breeder, *Federation of American Scientists' Public Interest Report*, May 1982, p. 7.

Applying Cost-Benefit Analysis to Environmental Regulations: No Panacea, *F.A.S. Public Interest Report,* March 1982, pp. 1, 3, 4.

The Net Energy from Nuclear Reactors, *Federation of American Scientists Professional Bulletin*, April 1975, p. 5 (with Margaret Fels and Hartmut Krugmann).

Articles in other journals

"Nuclear power and nuclear safety," *Materials Research Society Bulletin* Vol. 41, December 2016, p. 665 (editorial).

Life after the Trail Crew, *Chips and Clippings,* Fall 2016, p. 11.

Memoriam: Stanislav Nikolaevich Rodionov, *Science & Global Security*, Vol. 24 (August, 2016) pp. 63-64 (with Oleg Prilutsky).

Weapons plutonium riskier above ground, Letter to the editor, *Nature,* 18 February 2016 (with Ed Lyman)

Overcoming the challenge of disposing of separated plutonium, *Sekai* (*The World*) January 2016, pp, 219-229 (with Masafumi Takubo)

Overcoming the challenge of disposing of separated plutonium, *Disarmament Review,* Electronic Journal of Japan Association of Disarmament Studies, Vol. 6, No. 6, November 2015, pp. 13-18.

China must avoid costly trap of reprocessing nuclear fuel, *China Dialogue,* 2013 (with M.V. Ramana).

Minimizing global stocks of nuclear-weapon-usable materials, *Courier of Analytics* quarterly, Moscow (2013)

Missing in Action: The Obama Administration and Japan's Plutonium Program, Perspective, *Nuclear Intelligence Weekly,* 28 September 2012, p. 10

Time to bury plutonium, Comment, *Nature,* 10 May 2012, p. 167 (with Rodney Ewing, Richard Garwin and Allison MacFarlane)

Making nuclear power safer and less proliferative after Fukushima (perspective) in *Elements,* Vol. 8 (2012) p. 171.

From reprocessing and breeder reactor development to dry cask storage of spent fuel (*Sekai,* August 2012, in Japanese), p. 118

The 'Plutonium Economy,' 40 Years Later, In Perspective, *Nuclear Intelligence Weekly,* 24 January 2011 p. 9

Physicists' Efforts to Control Nuclear Weapons, *INESAP Information Bulletin 26,* April 2008, pp. 75-81.

Amulya Reddy and the Social Responsibility of Engineers and Scientists, *Energy and Sustainable Development,* June 2006

No hurry to recycle [plutonium], *Mechanical Engineering,* May 2006, p. 32.

Arthur von Hippel: The scientist and the man, *Materials Research Society Bulletin 30,* November 2005, pp. 838-844.

Blocking of an MIT fraud investigation by the DOD's Missile Defense Agency by John Ahearne, Richard Garwin and Frank von Hippel, *MIT Faculty Newsletter XVIII, No. 1,* September/October 2005.

Commentary on "Bush, Missile Defense, and the Critics" by Frank Gaffney, *Commentary,* May 2001, pp. 16, 18.

Depleted uranium not a high priority for the anti-nuclear movement (with Steven Fetter) *Medicine and Survival 7,* March 2001, pp. 46-47

Are We Missing a Window of Opportunity? by Frank von Hippel, *Newsletter of Economists Allied for Arms Reduction 7, #3*, Fall/Winter 1995, pp. 1, 8 (based on an invited statement prepared for the observance of the 50th Anniversary of the *Bulletin of the Atomic Scientists,* University of Chicago, December 7, 1995.

Nuclear Weapons by Frank von Hippel, *The Amicus Journal, Winter 1996* (special issue commemorating the 25th anniversary of the Natural Resources Defense Council), pp. 49-52.

Ban on the Production of Fissile Material for Weapons: Global and Regional Considerations by Frank von Hippel, *Philosophy and Social Action 21 (2),* 1995, pp. 15-24 (prepared talk for the Workshop on Global and Regional Linkages of Arms Control, Fort Aguada Beach Resort, Goa, India, January 15-18, 1995).

Bombs away [on nuclear-warhead dismantlement], *Discover 13*, April 1992, pp. 32-35.

Activists and Analysts*, Melampus Journal for Environmental Education I*, Spring 1992, pp. 3-4.

START, *Nuclear Times 9*, Autumn 1991, pp. 4-5.

Activists and Analysts, Editorial, *Nuclear Times,* March-April 1986, pp. 19-20.

Automobiles and the West's Umbilical Cord (with W.U. Chandler), *Energy Conservation Bulletin,* April/May 1982, pp. 1, 3, reprinted in *Citizen Scientist*.

Should Breeder Reactors Be Built in the United States? No! *Public Power*, May/June 1981, pp. 19, 21, 24.

The Automobile Fuel Economy Standards - Are They Cost Effective? *Technology and Society,* June 1980, pp. 1-7.

Mitigating the Effects of Nuclear Accidents, *IEEE Spectrum*, Nov. 1979, p. 79.

Scientists and the Politics of Technology, *Applied Spectroscopy 25* (25th anniversary issue, July/August 1971), pp. 403-413 (with Joel Primack).

Opeds

A dangerous nuclear dinosaur, Kyodo News Service, 8 March 2017, https://english.kyodonews.jp/news/2017/03/462427.html (with Masafumi Takubo)

Direct disposal is better solution for South Carolina's plutonium problem, *Augusta Chronicle,* 24 October 2015 (with Edwin Lyman)

A Really Good Idea: Multinationalize Iran's Enrichment Program, *The National Interest,* 1 July 2015, http://www.nationalinterest.org/feature/really-good-idea-multinationalize-irans-enirchment-program-13223

Highly Enriched Danger, *New York Times,* 22 March 2014 (with Alan Kuperman)

Japan's Nuclear Mistake, *New York Times,* Oped, 28 November 2012 (with Masafumi Takubo)

Japan's reprocessing program and proliferation in East Asia, opinion (Kyodo News Network, 27 June 2012) (with Masafumi Takubo)

Reconsidering the Rokkasho Reprocessing Plant, Opinion, Kyodo News Service, 13 March 2012

"It could happen here [Fukushima Daiichi Accident]**,"** *New York Times,* 24 March 2011

When the waste is Nuclear, ***Los Angeles Times,*** 15 September 2009

Feeding potential for South Asia's nuclear fire, *Asahi Shimbun,* April 20, 2007, p. 77 (with Zia Mian and M.V. Ramana)

Nuclear Role Models, *Washington Post* Oped, August 6, 2002, p. A15 (with Zia Mian and R. Rajaraman)

A Longer Nuclear Fuse, *Washington Post* Oped June 6, 2000 ; A27 (with Bruce Blair)

Missile defense -- A dangerous move, *Washington Post,* "Outlook" Section, Sunday, December 12, 1999, page B09 (reprinted in the *International Herald Tribune,* Dec. 23, 1999, p. 8 as "A Missile Defense System Isn't What America Needs) (with Phillip Bleek).

False Fears About a Test Ban by Ray Kidder, Lynn Sykes and Frank von Hippel, *Washington Post,* Outlook Section, Sunday, October 10, 1999; Page B07

Does India need the H-bomb? by M. V. Ramana and Frank von Hippel, *The Hindu,* Wednesday, December 23, 1998, *Opinion,* p. 12

U.S. Tritium Production Plan Lacks Strategic Rationale by Charles Ferguson and Frank von Hippel, *Defense News*, December 7-13, 1998, p. 29.

The Alternative to Nuclear Tests by Zia Mian and Frank von Hippel, *Washington Post*, Sunday, May 31, 1998, p. C-7.

Redoubling Nuclear Weapons Reduction Without Weakening Deterrence by Bruce Blair, Harold Feiveson and Frank von Hippel, *Washington Post* (Oped), November 12, 1997, A23.

Russian-U.S. Cooperation in Reducing the Nuclear Danger: Successes and Problems, "*Nezavisimaya Gazeta [Independent Newspaper],*" Moscow, April 19, 1996, p. 4.

Negotiating the Future of Disarmament by Frank von Hippel, *The Washington Post* (Op-ed), March 6, 1996.

Don't Leave Nuclear Disarmament to the Professionals! by Frank von Hippel *The [Trenton] Times* [Commentary], Sunday, July 30, 1995, pp. CC1,CC6.

A Pentagon Shell Game with Everything to Lose by Ray E. Kidder and Frank von Hippel, *Los Angeles Times* (OpEd), July 26, 1995, B9. Reprinted in many U.S. newspapers and under the title, **A Pentagon Arms Plan Goes France One Better**, in the *International Herald-Tribune*

The Myth of the Soviet `Killer' Laser, *New York Times* Oped, 19 August 1989.

Nuclear-Arms Treaties Could Save Us a Bundle, *Los Angeles Times* Oped, 11 April 1989, Part II, p. 7 (with Michael I. Sobel)

Let's Work to Halt Plutonium Output, *Seattle Times* Oped, 4 March 1987 (with David Albright).

The Test Ban Is Up to the U.S., Op-ed, *The Philadelphia Inquirer*, 6 August 1986, p. 11-A.

Laboratories vs. a Nuclear Ban (with J. Stein), *New York Times* Oped, 28 March 1986, reprinted in *Citizen Scientist*.

Star Wars "Research" to Waste Billions, *The Times* (Trenton), 27 April, 1985, p. A15.

The Election Offers Clear Alternatives on Arms Control, *Princetonian,* 3 October 1984, p. 4.

Nuclear "Turkey" [plutonium breeder reactor] **on Congress' Menu,** Op-ed, *Los Angeles Times*, Sunday, August 22, 1982, Part IV, p. 5.

Uranium Security Without the Breeder Reactor (with H.A. Feiveson and R.H. Williams) Op-ed, *Washington Post,* March l6, l979

Alternatives to the Plutonium Breeder (with H.A. Feiveson and R.H. Williams), Op-ed, *Washington Post*, September 16, 1977.

Breedermania (with H.A. Feiveson, T.B. Taylor and R.H. Williams), Op-ed, *New York Times,* June 20, 1977, p. 27.

Blogs

Declaring more U.S. weapon-grade uranium excess could delay the need to build a new national enrichment plant, IPFM blog, 4 April 2018, http://fissilematerials.org/blog/2018/04/declaring_more_us_weapon-.html; http://fissilematerials.org/library/fvh18.pdf

Fissile material issues in the U.S. National Defense Authorization Act for Fiscal Year 2018, IPFM Blog, 15 December 2017, www.fissilematerials.org/blog/2017/12/fissile_material_issues_i.html

Future of Japan's Monju plutonium breeder reactor under review, IPFM blog, 1 September 2016, http://fissilematerials.org/blog/2016/09/future_of_japans_monju_pl.html (with Masafumi Takubo)

U.S. Office of Naval Reactors Outlines $1 Billion R&D Plan for Development of LEU Fuel 14 August 2016, http://fissilematerials.org/blog/2016/08/report_on_development_of_leu_fuel.html(with Sébastien Philippe)

A Little-Known Nuclear Race Taking Place in East Asia is Dangerous and Pointless, *The WorldPost* (Huffington Post and *Asahi Shimbun*), 5 April 2016 (with Fumihiko Yoshida)

Could the U.S. Waste Isolation Pilot Plant go critical if more plutonium were disposed in it? 6 January 2016, (with Edwin Lyman) http://fissilematerials.org/blog/2016/01/could_the_us_waste_isolat.html

Forwords, etc.

Stanislav Nikolaevich Rodionov (1929-2014) *Science & Global Security* (with Oleg Prilutsky) (to be published)

Foreword: A transition (on the retirement of *S&GS* founding editor, Harold A. Feiveson**,** *Science & Global Security*, Vol. 19 (2011) pp. iii–iv

Allan S. Krass (1935-2013), *Science & Global Security*, Vol. 22, no. 1 (2014) pp. 76-79 (with Dan Fenstemacher, Chuck Messick and Parrish Staples,)

A Transition, *Science & Global Security,* Vol. 19, pp. iii–iv, 2011

Japan's Spent Fuel and Plutonium Management Challenges by Tadahiro Katsuta and Tatsujiro Suzuki (International Panel on Fissile Materials, Sept. 2006, with Jose Goldemberg)

Fissile Materials in South Asia: The implication of the U.S.-India nuclear deal by Zia Mian, A.H. Nayyar, R. Rajaraman and M.V. Ramana (International Panel on Fissile Materials, Sept. 2006, with Jose Goldemberg)

Help needed to eliminate a dangerous legacy of the Cold War, Foreword, *Russian Weapons Plutonium and the Western Option* (Nuclear Disarmament Forum, Zug, Switzerland, 2002), 5 pp.

Preface, *Russian Strategic Nuclear Weapons*, Pavel Podvig, ed, (MIT Press, 2001), pp. xv-xviii.

Generation Upon Generation, foreword to *Nuclear Weapons Databook, Vol. I: US Forces and Capabilities*, by T.B. Cochran, W.M. Arkin, and M.M. Hoenig, (Cambridge, MA: Ballinger, 1983), 2 pp.

Foreword to *World Military and Social Priorities*, 1983 (Leesburg, Va.: World Priorities, 1983) p. 3.

Interviews

A moment with ... Frank von Hippel, on nuclear power by Eric Hand, *Princeton Alumni Weekly,* 27 April 2011

Congressional Testimony, Etc.

The UK Government's Consultation on the Management of the UK's Plutonium Stock, Submission to the UK Department of Energy and Climate Change, 7 August 2012 (with Gordon MacKerron)

The NRC's advisory to evacuate to 50 miles from the Fukushima-Daiichi NPP: Implications for reactor-accident evacuation and thyroid protection strategies, submitted to the Nuclear Regulatory Commission, 4 August 2012

Comment on the Future of the United Kingdom's Nuclear Deterrent, invited testimony, presented to the UK Parliament's Defense Committee, January 10, 2007 (with Richard Garwin, Philip Coyle and Theodore Postol).

Steps to Strengthen Compliance with the Nuclear Nonproliferation Treaty, Testimony before the House Government Reform Committee's Subcommittee on National Security, Emerging Threats, and International Relations, Washington, DC, September 26, 2006

A Technology Whose Time Has Not Come, *Hearing on the Potential Use of Advanced Liquid Metal Reactors for Disposal of High-Level Radioactive Waste* before the Subcommittee on Energy and Power of the House Committee on Energy and Commerce, 9 June 1993.

Controls on Nuclear warheads and Materials in *Disposition of U.S. and Commonwealth of Independent States (CIS) Strategic Nuclear Warheads Under the START I Treaty and the June 17, 1992 U.S.-Russian Joint Understanding on Further Reductions in Strategic Offensive Arms,* hearing before the Senate Armed Services Committee, 4 August 1992.

Nuclear-weapons Testing: Why We Can and Should Stop in *The Nuclear Testing Moratorium Act, S. 2064 and Other Nuclear Testing Issues*, hearing before the Senate Foreign Relations Committee, 23 July 1992, pp. 28-36, 48-59.

The Future of Nuclear-weapons Testing in *Hearing before the Department of Energy Defense Nuclear Facilities Panel of the House Committee on Armed Services*, 31 March 1992

Urgent Next Steps: Warhead Elimination and Deeper Cuts in *Strategic Nuclear Reduction in a Post-Cold War World: Arms Control Viewpoint,* hearing before the Senate Committee on Foreign Relations, 5 March 1992.

A Perspective on START in *START: Present Status and Prospects*, hearing before the Senate Committee on Foreign Relations, 17 April 1991, pp. 52-60.

A Cutoff of the Production of Fissile Material for Weapons in *International Plutonium Control Act. -- H.R. 2403*, hearing before the Subcommittee on Arms Control, International Security and Science of the House Committee on Foreign Affairs, 20 June 1989, pp. 50-71.

A Cutoff of the Production of Fissile Material for Weapons in *Department of Energy Modernization Study and Department of Energy Defense Programs*, hearings before the Procurement and Military Nuclear Systems Subcommittee and Nuclear Systems Subcommittee and Department of Energy Defense Nuclear Facilities Panel of the House Armed Services Committee, 6 June 1989, pp. 1186-1899.

Stability and Verifiability of Deep Post-START Reductions, briefing at the U.S. Arms Control and Disarmament Agency, 9 June 1989.

After the 150-kt Threshold Test Ban, *Hearing before the Senate Armed Services Committee*, Feb. 26, 1987

Preparing for Nuclear War While Trying Not to Think About It, in U.S. House of Representatives, Committee on Science and Technology, Subcommittee on Investigations and Oversight, *Hearing on The Consequences of Nuclear War on the Global Environment* September 15, 1982, pp. 161-178.

The Consequences of "Limited" Nuclear War in the Germanies, *ad hoc* Congressional *Hearings on the Full Implications of the Military Budget,* March 17, 1982.

The Thyroid Protection Problem: to Predistribute or Not to Predistribute Potassium Iodide? - testimony before the Subcommittee on Oversight and Investigations of the House Committee on Interior and Insular Affairs, March 5, 1982

Uranium, Electricity, and Economics, in U.S. House of Representatives, Committee on Energy and Commerce, Subcommittee on Energy Conservation and Power *Hearing on Uranium Efficiency Improvements,* October 5, 1981, pp. 3-32, 53-64.

Why the U.S. Needs an Automotive Fuel Economy Policy, in U.S. House of Representatives, Committee on Energy and Commerce, Subcommittee on Energy Conservation and Power, *Hearing on Energy Conservation in Transportation,* June 24, 1981, pp. 29-54, 66-79.

The NRC Decision-Making Process Concerning Thyroid Protection, Invited Briefing to the Nuclear Regulatory Commission, November 18, 1980.

The Harbridge House Study and the Federal Automotive Fuel Economy Standards: Attacking Good Policy With Bad Analysis, U.S. House of Representatives, Committee on Interstate and Foreign Commerce, Subcommittee on Oversight and Investigations *Hearing on Cost-Benefit Analysis: The Potential for Conflict of Interest,* June 17, 1980, pp. 40-61.

Why the U.S. Needs Ambitious Post-1985 Automotive and Light Truck Fuel Economy Standards, in U.S. Senate, Committee on Commerce, Science, and Transportation, Subcommittee on Science, Technology, and Space *Hearing on Automotive Technology and Fuel Economy Standards*, May 14, 1980, pp. 304-330.

Consequences of Reactor Core Melt-Down Accidents and Strategies for their Mitigation, Testimony before the Energy Subcommittee of the California State Assembly, April 12, 1979.

An Evolutionary Strategy for Nuclear Energy - A Safer Economic Alternative to the Breeder, in U.S. Senate, Committee on Energy and Natural Resources, Subcommittee on Energy Research and Development *Hearings on the Department of Energy Fiscal Years 1980-81 Authorization (Civilian Applications)*, Hearings, April 5, 1979, pp. 1302-1329 (with H.A. Feiveson and R.H. Williams).

The Uranium Requirements, Economics and Proliferation Resistance of Isotopically Denatured Fuel Cycles in Already Developed Reactors Compared with those of the Plutonium Fuel Cycle in the Fast Breeder Reactor, Testimony before the Subcommittee on Fossil and Nuclear Energy Research, Development and Demonstration of the U.S. House Committee on Science and Technology, April 4, 1978, (with H.A. Feiveson and R.H. Williams).

Alternatives to the Plutonium Breeder, Testimony before the Subcommittee on Fossil and Nuclear Energy Research, Development, and Demonstration of the House Committee on Science and Technology, June 10, 1977.

Alternative Futures for Nuclear Power, Presentation of the Meeting of Experts on the Fast Breeder Reactor Organized by the German Minister of Science and Technology, Bonn, May 19,1977

Nuclear Power Growth Projections -- written testimony presented to the Nuclear Regulatory Commission's Hearing Board on the Generic Environmental Statement on Mixed Oxide Fuel (Plutonium Recycle) on behalf of the State of Wisconsin, March 4, 1977 (with R.H. Williams).

The Need for Federal Support of Independent Policy Analysis, in House of Representatives Committee on Science and Technology, Subcommittee on Science Research and Technology *Hearing on the 1978 National Science Foundation Authorization,* February 18, 1977, pp. 881-900.

Some Issues with Regard to Nuclear Research and Development -- Briefing of the Subcommittee on Fossil and Nuclear Research, Development and Demonstration, House Committee on Science and Technology, February 11, 1977.

The Plutonium Economy: Why We Should Wait and Why We Can Wait, Testimony before the California Energy Resources, Conservation, and Development Commission, February 2, 1977.

Nuclear Reactor Safety, Briefing given to Norwegian Committee on Nuclear Power, Norway, August 30, 1977.

Critique of the Nuclear Regulatory Commission's Reactor Safety Study, Testimony before the N.R.C.'s Advisory Committee on Reactor Safeguards, January 4, 1977.

Emergency Planning for Nuclear Reactor Accidents, Testimony before the New York City Board of Health, August 12, 1976.

The Nuclear Regulatory Commission's Reactor Safety Study: What is it Good For? in Subcommittee on Energy and Environment of the House Committee on Interior and Insular Affairs, *Hearings on the Reactor Safety Study* (Rasmussen Report), 1976.

Issues Relating to the Use of Nuclear Energy in New York State, Talk to the New York State Legislature, May 5, 1976.

A Roadmap to the Major Issues Relating to Nuclear Energy, Briefing to the Subcommittee on Energy and Environment of the House Committee on Interior and Insular Affairs, U.S. Congress, April 24, 1975 (reprinted in *Oversight Hearings on Nuclear Energy -- Overview of the Major Issues* by the same subcommittee, April-May 1975, p. 5ff).

Federal Support for Public Interest Science, in Special Subcommittee on the National Science Foundation, Senate Committee on Labor on Public Welfare, *Hearings on National Science Foundation Legislation,* 1975, April 21, 1975, pp. 872-901.

Reports

Banning the Production of Highly Enriched Uranium (International Panel on Fissile Materials, 2016)

Plutonium Separation in Nuclear Power Programs: Status, Problems, and Prospects of Civilian Reprocessing Around the World (International Panel on Fissile Materials, July 2015, co-editor with M.V. Ramana, author of chapter on transmutation, co-author of overview and chapters on South Korea and Japan)

Alternatives to MOX: Direct-disposal options for stockpiles of separated plutonium (International Panel on Fissile Materials, April 2015, with Gordon MacKerron)

Lessons Learned from the Fukushima Nuclear Accident for Improving Safety of U.S. Nuclear Plants (National Academy of Sciences, 2014, 367 pp) (with 23 others)

Ending reprocessing in Japan: An alternative approach to managing Japan's spent nuclear fuel and separated plutonium, International Panel on Fissile Materials, 2013 (with Masafumi Takubo)

Fissile Material Controls in the Middle East: Steps toward a Middle East Zone Free of Nuclear Weapons and all other Weapons of Mass Destruction, International Panel on Fissile Materials, 2013 (with Seyed Hossein Mousavian, Emad Kiyaei, Harold A. Feiveson and Zia Mian)

Background and History of Ethan Pond Shelter and Campsite, Appalachian Mountain Club, 2013

Increasing Transparency of Nuclear Warheads and Fissile Material Stocks and Production Histories in *Global Fissile Material Report 2013: Increasing Transparency of Nuclear Warhead and Fissile Material Stocks as a Step toward Disarmament* (with Harold Feiveson, Alexander Glaser and Zia Mian)

Fissile Material Controls in the Middle East: Steps toward a Middle East Zone Free of Nuclear Weapons and all other Weapons of Mass Destruction, International Panel on Fissile Materials Research Report #11, 2013 (with Harold Feiveson, Emay Kiyaei, Zia Mian and Sayed Hossein Mousavian)

The Uncertain Future of Nuclear Energy (International Panel on Fissile Materials, Sept. 2010) lead author and editor (also appeared after additional editing as a chapter in the Global Energy Assessment, Cambridge University Press, 2013).

Fast Breeder Reactor Programs: History and Status (International Panel on Fissile Materials, Feb. 2010) co-edited with Harold Feiveson, Alexander Glaser and Zia Mian, chapter 1, "Overview: The Rise and Fall of Plutonium Breeder Reactors," chapter 7, "Fast Reactor Development in the United States," (with Thomas Cochran and Harold Feiveson).

Challenges and Opportunities for Russia-U.S. Nuclear Arms Control, Century Fund, Nov. 2009 (with Anatoli Diakov)

Global Fissile Material Report 2009: A Path to Nuclear Disarmament (International Panel on Fissile Materials) co-edited with Harold Feiveson, Alexander Glaser and Zia Mian, chapter 5, "Verified Warhead Dismantlement;" chapter 6, "Disposition of Plutonium and Highly Enriched Uranium," chapter 7, "Verified Cutoff of Fissile Material Production for Weapons," and chapter 8 (co-author), "Nuclear Power and Nuclear Disarmament"

Global Fissile Material Report 2008 (International Panel on Fissile Materials) co-edited with Harold Feiveson, Alexander Glaser and Zia Mian, chapter 5, "Reprocessing plants" (with Shirley Johnson and Harold Feiveson); chapter 7, "HEU in the naval-reactor fuel cycle" (with Ferenc Dalnoki-Veress and Alexander Glaser); and chapter 8, "Challenge Inspections at Military Sites"

Toward True Security: Ten Steps the Next President Should Take to Transform U.S. Nuclear Weapons Policy, Federation of American Scientists, Natural Resources Defense Council, Union of Concerned Scientists (with Bruce Blair, Thomas Cochran, Jonathan Dean, Steve Fetter, Richard Garwin, Kurt

Gottfried, Lisbeth Gronlund, Henry Kelly, Hans Kristensen, Robert Nelson, Robert Norris, Ivan Oelrich, Christopher Paine, David Wright and Stephen Young, 2008)

Consultancy on the Status of Pulsed Reactors and Critical Assemblies, IAEA headquarters, Vienna, Austria, 16-18 January 2008 (with N. Arkangelsky, H. McFarlane, J. Matos, V. Pavshook et al)

Global Fissile Material Report 2007 (International Panel on Fissile Materials) co-edited with Harold Feiveson, Alexander Glaser and Zia Mian, co-author of chapter 4, "Fissile Material Consolidation in the U.S. Nuclear Complex" (with Peter Stockton); and chapter 8, "Russia's Nuclear-Energy Complex and its Roles as an International Fuel-Cycle-Services Provider" (with Anatoli Diakov).

Managing Spent Fuel in the United States: The Illogic of Reprocessing, International Panel on Fissile Materials, January 2007, 48 pp.

Global Fissile Material Report 2006, International Panel on Fissile Materials, (with Harold Feiveson, Alexander Glaser and Zia Mian).

Consultancy on "Assessing HEU Facilities for Future Conversion Efforts" IAEA Headquarters, Vienna, Austria, 8 – 10 February 2006 (with N. Arkhangelsky, J. Matos, and C. Chuen).

International Assessment of the Interim Report of the New Nuclear Policy-Planning Council of Japan's Atomic Energy Commission, Takagi Fund, 2005 by Fred Barker, You Fujimua, Tetsunari Iida, Yuichi Kaito, Takeo Kikkawa, Christian Küppers, Mycle Schneider, Frank von Hippel, and Hitoshi Yoshionka)

Nuclear Power and Proliferation Resistance: Securing the Benefits, Limiting Risk, American Physical Society, Panel on Public Affairs, May 2005 (with John Ahearne, Robert Budnitz, Steve Fetter, Roger Hagengruber, Ernest Moniz, Burton Richter, Thomas E. Shea and James Tape)

The *Search for Common Ground* Iran Group Options Paper, April 2005

The Future Use of Critical and Subcritical Assemblies, Report of a Consultation held at International Atomic Energy Agency, Vienna, 7 – 10 February 2005 (with Sergei Chiginov, SOSNY Scientific and Technical Center, Academy of Sciencies of Belarus; Robert Jacqmin, Commissariat à l' Energie Atomique, Centre de Cadarache, France; Takamasa Mori, Head, Research Group for Reactor Physics, Department of Nuclear Energy Systems, Japan Atomic Energy Research Institute; Nikolay Arkhengelskij, Ministry of Russian Fed.on Nuclear Energy, 25 pp.

The Modern Pit Facility: No urgency a MPR. Resolve key technical issues before proceeding. (with Steve Fetter and Francis Slakey) American Physical Society Panel on Public Affairs White Paper, April 2004**,** http://www.aps.org/public_affairs/index.cfm).

Toward True Security: A US Nuclear Posture for the Next Decade (with 15 others, Federation of American Scientists, Natural Resources Defense Council, Union of Concerned Scientists, June 2001), 33 pp.

The Last 15 Minutes: Putting Ballistic-Missile Defense Into Perspective (co-edited by Joseph Cirincione and Frank von Hippel, Coaliton to Reduce Nuclear Dangers, May 1996, 85 pp.

Ending the Production of Fissile Material for Weapons, Verifying the Dismantlement of Nuclear Warheads: The Technical Basis for Action, (Washington, D.C.: Federation of American Scientists, 1991) 58 pp.

Toward a Comprehensive Nuclear Warhead Test Ban (with Dan Fenstermacher and Nikolai Kapranov). Washington, D.C.: International Foundation, January 1991, 58 pp.

Reducing the Dangers of Accidental and Unauthorized Nuclear Launch and Terrorist Attack: Alternatives to a Ballistic Missile Defense System (with Robert S.McNamara, William G. Miller and Roald Z. Sagdeev). Washington, D.C.: International Foundation, January 1990), 24 pp.

Casualties Due to the Blast, Heat and Radioactive Fallout From Various Hypothetical Nuclear Attacks on the United States (with W.H. Daugherty and B.G. Levi) in *The Medical Implications of Nuclear War,* edited by F. Solomon and R.Q. Marston. Washington, DC.: National Academy Press, 1986), pp. 207-232. See also backup report with the same title and by the same authors. Princeton University, Center for Energy and Environmental Studies Report # PU/CEES 198, March 1986.

A Bilateral Cutoff of the Production of Fissile Material for Nuclear Weapons, *Hearings on a Nuclear Weapons Freeze organized by the Federation of American Scientists, Washington, D.C., March 7, 1983*

Nuclear Fuel Reprocessing and Radioactive Waste Disposal (Columbia, SC: Energy Research Foundation, 1983) 10 pp.

Some Long-Term Consequences of Hypothetical Major Releases of Radioactivity to the Atmosphere from Three Mile Island: Report to the President's Council on Environmental Quality (with J. Beyea). Princeton University, Center for Energy and Environmental Studies Report # PU/CEES 109, 1980, 94 pp.

Proliferation Resistant Nuclear Power Technologies: Preferred Alternatives to the Plutonium Breeder (with T.B. Cochran, R.E. Train and R.H. Williams), minority report of the Steering Committee of the LMFBR Program Review of the U.S. Energy Research and Development Administration, April 6, 1977, ?? pp.

Risk Assessment Review Group Report to the U.S. Nuclear Regulatory Commission (with H.W. Lewis, R.J. Budnitz, H.J.C. Kouts, W.B. Loewenstein, W.D. Rowe and F. Zachariasen). Washington, D.C.: NRC, Report # NUREG/CR-0400, 1978, 65 pp.

Issues Bearing on the Need for and the Timing of the U.S. Liquid Metal Fast Breeder Reactor, Report prepared for the Subcommittee on Energy and Environment, U.S. House Interior Committee (Committee Print No. 16, May, 1976.

Some Introductory Lectures on Strong Interaction Theory for Experimentalists (Argonne National Laboratory, High Energy Physics Report # 7226, 1972).

The Politics of Technology: Activities and Responsibilities of Scientists in the Direction of Technology, (Stanford Workshop on Social and Political Issues), September 1970, 167 pp. (with Joel Primack).

Congress and Technology, (SWOPSI, 590A Old Union, Stanford, CA 94305), April 1970, 21 pp. (with Joel Primack).

Princeton Reports

Assessment of the U.S. Air Force's estimates of the radiation doses received by the veterans of the cleanup of plutonium from two nuclear bombs that fell on Palomares, Spain in 1966, Program on Science and Global Security Working Paper, 7 December 2017, https://www.princeton.edu/sgs/faculty-staff/frank-von.../SGS-working-paper.pdf

Conversion and Job Creation in Russia's Closed Nuclear Cities (with Oleg Bukharin and Sharon K. Weiner) Center for International Studies/Center for Energy and Environmental Studies report, November 2000, 81 pp.

Using Commercial Observation Satellites to Verify that Uranium Enrichment Gaseous Diffusion Plants are Not Operating (with Hui Zhang) May 2000, PU/CEES Report # 325.

Helping Russia Downsize its Nuclear Complex: A Focus on the Closed Nuclear Cities (with Oleg Bukharin, Harold Feiveson and Sharon Weiner; Matthew Bunn, William Hoehn and Kenneth Luongo) Center for International Studies/Center for Energy and Environmental Studies Report, June 2000, 53 pp.

Defense Conversion and Small Business Development: A Proposal for Two IFC Projects in Three of Russia's Closed Nuclear Cities by Jill Cetina, Oleg Bukharin and Frank von Hippel, PU/CEES Report # 306, March 1998.

Consequences of 'Limited' Nuclear Attacks on the U.S.S.R., (Princeton University, Center for Energy and Environmental Studies Report # 211, June 1987), 69 pp. (with Barbara G. Levi, William H. Daugherty and David Thickens).

Quantities of Fissile Materials in US and Soviet Nuclear Weapons Arsenals (with D.H. Albright and B.G. Levi), Princeton University, Center for Energy and Environmental Studies Report # PU/CEES 168, July 1986, 120 pp.

The Prospect for a Freeze on Nuclear Weapons, in *The Nuclear Arms Debate: Ethical and Political Implications* (Princeton: Center of International Studies, World Order Studies Program, Occasional Paper No. 12) May 1983, pp. 95-100.

The Energy Demand of U.S. Buildings, Princeton University, Center for Energy and Environmental Studies, Report # PU/CEES 119, 1981, 77 pp.

U.S. Transportation Energy Demand, Princeton University, Center for Energy and Environmental Studies Report # PU/CEES 111, 1981, 49 pp.

Nuclear Reactor Accidents: The Value of Improved Containment (with J. Beyea) (Princeton University, Center for Energy and Environmental Studies, Report # PU/CEES 94, 1980) 58 pp.

Letters to the editor

The North Korean Test and The Limits of Nuclear Forensics, *Arms Control Today,* January 2007 (with Jungmin Kang and Hui Zhang, in press)

Nuclear Pit Facility's Merits, Snags, and Timelines, by Steve Fetter and Frank von Hippel, response to letter to the editor from Everet Bechner, Deputy Administrator for Defense Programs, National Nuclear Security Administration, *Physics Today,* January 2005, pp. 12-13.

Revisiting nuclear power safety, *Science 299,* January 10, 2003, letter to the editor, pp. 201-2.

Does the U.S. need new nuclear weapons? *Physics and Society,* July 2002.

Availability of potassium iodide for thyroid protection, letter to the editor, *Princeton Packet,* June 25, 2002; *Town Topics,* June 26, 2002 (with Grace Sinden, Laura Kahn, Vrunda Patel, Johathan Spergel, Kurt Stenn)

"Radiation Risk and Ethics:' Health Hazards, Prevention Costs, and Radiophobia, letter to the editor, *Physics Today 53*, April 2000, p. 11.

"Proposed Anti-missile System Could be Neutralized by Air Bags" by Frank von Hippel, letter to the editor, *Princeton Packet,* March 29, 1999.

U.S. Can Begin Cutting its Tritium Needs and Nuclear Arsenal without STARTing," by Charles Ferguson and Frank von Hippel, letter to the editor, *Physics Today* , May 1999, pp. 11, 13.

Task force should look at other nuclear-deterrent options by Charles Ferguson and Frank von Hippel, letter to the editor, *Washington Times,* Dec. 16, 1998, p. 18.

Underground Nuclear Testing, *Physics Today,* March 1992, pp. 95-96 (letter to the editor).

DoE [Department of Energy] and the National Labs, *Science 254,* 13 December 1991, p. 1566 (letter to the editor).

Lethal Radiation Dose, letter to the editor, *Science, Vol. 230*, 29 November 1985, p. 992.

Automobile Fuel Efficiency, (letter), *Science 228* (19 April 1985), pp. 263, 265.

Bombs from Fuel, letter to the editor, *Wall Street Journal,* 16 August 1982 (see also T.E. Phillips and L. Bernath, 12 July and 26 August 1982).

Putting the Chernobyl Cancer Risk in Perspective, Letter to the Editor, New York Times, early June 1986.

Thyroid Protection, letter to the editor, *Science 221*, 2 September 1983, p. 906.

Potassium Iodide for Thyroid Protection, letter to the editor, *Science* 218, December 17, 1982, p. 1174.

Potassium Iodide Policy, letter to the editor, *Science* 218, October 1, 1982, p. 6.

Available Thyroid Protection, letter to the editor, *Science 204*, June 8, 1979, p. 1032.

Other publications

29 U.S. Scientists Praise Iran Nuclear Deal in Letter to Obama, by William Broad, *New York Times,* 8 August 2015.

In Memoriam: Allan S. Krass (1935–2013) *Science & Global Security*, Vol. 22 (2014) pp. 76–79 (with Dan Fenstermacher, Charles Messick, and Parrish Staples)

Hot Archives: Transcript of fragments of a conversation with Academician Andrei Sakharov (with Jeremy Stone and Frank von Hippel) *Novaya Zhizn (New Life) 2,* March 28, 2002, pp. 8-9 (secretly transcribed by the KGB, from the files of Mikhail Gorbachev).

Military Research Cooperation by a Japanese Corporation, (with Masa Takubo), *Kagaku (Science)* 71 No.8, Aug. 2001, pp1019-1022.

Civil plutonium stockpiles: challenging the rationale for reprocessing by Frank von Hippel in *Managing Plutonium in Britain: Current Options* (Oxford Research Group, September 1998), pp. 17-20; reprinted with minor updates in *Nuclear Reprocessing: Has it a Future?* (Oxford Research Group, Current Decisions Report #22, Oct. 1999), pp. 1-9.

Coupling a Moratorium to Reductions as a First Step toward the Fissile-Material Cutoff Treaty by Frank von Hippel in *The Road to Nuclear Zero: Three Approaches,* Francine Frankel, ed. (Center for the Advanced Study of India, University of Pennsylvania, 1998), pp. 13-28.

Weapons-Useable Nuclear Materials Security After The Cold War by Frank von Hippel in *Weapons-useable Nuclear Material -- Open Questions About the Possibilities of Secure Disposal,* Norbert Arnold, ed. Konrad-Adenenaur Institute, Bonn, 1995, pp. 17-28.

Are a Comprehensive Test Ban, and the Cessation of Production of Fissionable Materials for Weapons Now Possible? in *New Realities: Disarmament, Peace-building and Global Security* (exerpts from the panel discussions organized by the NGO Committee on Disarmament, Inc., at a conference held at the United Nations, 20-23 April 1993; United Nations, 1993), pp. 188-190 and discussion following.

The Laboratories and the Former Soviet Union in *The Future of the Nuclear Weapons Laboratories,* Transcript of a Congressional Research Service Seminar, 14 April 1993, Part 1, pp. 31-35.

Why We Can and Should Stop [Nuclear] Testing in *Nuclear Testing Issues*, transcript of a CRS Seminar (Washington, D.C.: Congressional Research Service, Library of Congress, 15 July 1992), pp. 2-5, 22-29.

A Ban on the Production of New Fissile Material for Weapons, *Disarmament Possibilities*, Excerpts from the Panel Discussion Organized by the NGO Committee on Disarmament, United Nations, 10-12 May 1989, pp. 82-85, 87,88.

Focus on Nuclear Warheads (Interview), *Moscow News*, 25 October 1987, p. 7.

M.S. Gorbachev's Meeting With Representatives of an International Forum of Scientists Favoring a Ban on Nuclear Testing (with A.P. Alexandrov, A.T. Balevski, S. Bergstrom, T.B. Cochran, D. Paul, K. Fushimi, M.S. Gorbachev, G.F. Lenci, G.B. Marini-Bertolo, O.`Nathan and J. Rotblat), translation of a transcript published in *Pravda*, 15 July 1986, pp. 1-2.

The Campaign to Ban the Testing of Nuclear Weapons -- Where Do We Stand?, keynote address at the International Scientists' Forum on the Comprehensive Test Ban, Moscow, 11 July 1986, excerpted in *Novoye Vremya,* 25 July 1986, pp. 3-5.

"On experts," and **"Reactor safety"** in *Naturens Verden*, 1978, No. 4, pp. 138 -140 (proceedings of a debate about nuclear power broadcast by Radio Denmark, January 29, 1978)

Unpublished but important

The potential value of stricter limits on Iran's stockpile of low-enriched UF6 (Memo to the Iranian and U.S. negotiators, 25 Sept. 2014) (with Alex Glaser)

Exhibit 5

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

BACKGROUNDER
Office of Public Affairs
301.415.8200
www.nrc.gov ■ opa.resource@nrc.gov

Plutonium

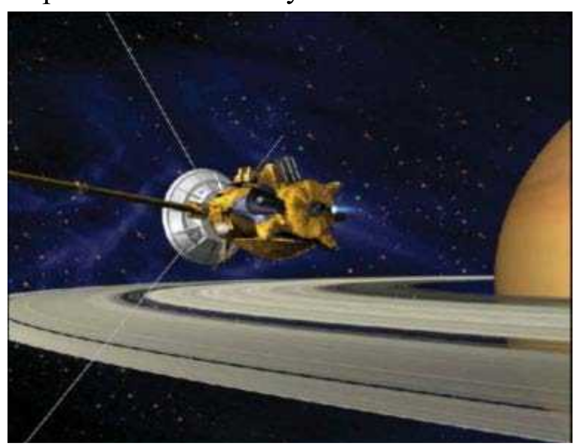
Plutonium is a radioactive metallic element with the atomic number 94. It was discovered in 1940 by scientists studying how to split atoms to make atomic bombs. Plutonium is created in a reactor when uranium atoms absorb neutrons. Nearly all plutonium is man-made.

Plutonium predominantly emits alpha particles – a type of radiation that is easily stopped and has a short range. It also emits neutrons, beta particles and gamma rays. It is considered toxic, in part, because if it were to be inhaled it could deposit in the lungs and eventually cause damage.

There are five "common" isotopes of plutonium, Pu-238, Pu-239, Pu-240, Pu-241, and Pu-242. These are all "fissionable" – the atom's nucleus can easily split apart if it is struck by a neutron.

The different isotopes have different "half-lives" – the time it takes to lose half of its radioactivity. Pu-239 has a half-life of 24,100 years and Pu-241's half-life is 14.4 years. Substances with shorter half-lives decay more quickly than those with longer half-lives, so they emit more energetic radioactivity.

Like any radioactive isotopes, plutonium isotopes transform when they decay. They might become different plutonium isotopes or different elements, such as uranium or neptunium. Many of these "daughter products" are themselves radioactive.



Plutonium-238 powers the Cassini spacecraft orbiting Saturn (NASA)

Different uses have been found for plutonium. Plutonium-238 has been used to power batteries for some heart pacemakers, as well as provide a long-lived heat source to power NASA space missions. Like uranium, plutonium can also be used to fuel nuclear power plants. This is done in a few countries but not currently in the United States.

Today's light water reactors – used to make commercial power in the United States – create plutonium when the uranium in their fuel fissions. Some of the neutrons released by uranium interact with other uranium atoms to form plutonium. Some of the plutonium itself fissions – part of the chain reaction of splitting atoms that is the basis of nuclear power. Any plutonium that does not fission stays in the spent fuel. Spent nuclear fuel from U.S. reactors contains about 1 percent plutonium by weight.

There are many metric tons of plutonium in spent nuclear fuel stored around the world. To be usable, plutonium would need to be separated from the other products in spent fuel. This process, known as reprocessing, uses chemicals to separate plutonium from uranium and other fission products. Once separated, plutonium oxide can be mixed with uranium oxide to produce mixed oxide or MOX fuel. MOX fuel can be used in power reactors. The U.S. policy on MOX fuel has a complicated history.

The NRC is currently overseeing construction of a facility in South Carolina to make MOX fuel using plutonium removed from U.S. nuclear weapons declared excess to military needs. This facility is part of a Department of Energy program to convert it into a form that would be difficult to convert again for use in nuclear weapons.

March 2017

Exhibit 6

UNITED STATES COURT OF APPEALS FOR VETERANS CLAIMS

NO. 17-2574

VICTOR B. SKAAR, APPELLANT,

V.

ROBERT L. WILKIE,
SECRETARY OF VETERANS AFFAIRS, APPELLEE.

Before BARTLEY, *Chief Judge*, and PIETSCH, GREENBERG, ALLEN, MEREDITH, TOTH, FALVEY, *Judges*; and DAVIS and SCHOELEN, *Senior Judges*.*

ALLEN, *Judge*, with BARTLEY, *Chief Judge*, and GREENBERG, TOTH, *Judges*; and DAVIS, *Senior Judge*.

SCHOELEN, *Senior Judge*, concurring in part and dissenting in part.

FALVEY, *Judge*, with PIETSCH and MEREDITH, *Judges*, dissenting.

O R D E R

United States Air Force veteran Victor B. Skaar was exposed to ionizing radiation while participating in the cleanup of plutonium dust in Palomares, Spain, following a midair aircraft collision. He later developed a blood disorder, leukopenia, which he believes was caused by in-service radiation exposure, even though an Air Force radiation dose estimate found the levels of exposure he suffered far below those required to cause his disability. In an April 14, 2017, decision the Board of Veterans' Appeals (Board) denied him service connection. This appeal followed.

We do not today address the merits of Mr. Skaar's claim. Rather, we consider his motion to certify a class of similarly situated veterans to proceed in an aggregate action. The issue we confront here—class certification in the context of an appeal of an individual Board decision—is one of first impression. For many years, we held this Court categorically lacked the power to certify classes. *See Monk v. McDonald*, No. 15-1280, 2015 WL 3407451, at *3 (May 27, 2015) (*Monk I*); *Harrison v. Derwinski*, 1 Vet.App. 438, 439 (1991) (en banc) (per curiam); *Lefkowitz v. Derwinski*, 1 Vet.App. 439, 440 (1991) (en banc) (per curiam). This changed when the United States Court of Appeals for the Federal Circuit (Federal Circuit) held we possess, at least in certain contexts, the authority to certify class actions. *Monk v. Shulkin*, 855 F.3d 1312, 1321-22 (Fed. Cir. 2017) (*Monk II*). We then held we would, in appropriate cases, certify classes seeking writs of mandamus under the All Writs Act. *Monk v. Wilkie* (*Monk III*), 30 Vet.App. 167, 174 (2018); *see, e.g.*, *Godsey v. Wilkie*, 31 Vet.App. 207, 220-25 (2019); *see also Wolfe v. Wilkie*, __ Vet.App. __, No. 18-6091, 2019 WL 4254039, at *14-19 (Sept. 9, 2019).

---

* Judges Davis and Schoelen are Senior Judges acting in recall status. *In re: Recall of Reitred Judge*, U.S. VET. APP. MISC. ORDERS 16-19, 17-19 (Dec. 4, 2019).

This brings us to Mr. Skaar's motion for class certification. We hold (1) the Court may, in appropriate situations, certify classes in the context of an individual appeal of a Board decision; (2) our jurisdiction allows us to include in such classes both persons who have obtained a final Board decision as well as those who have not; and (3) as in the petition context, we will use Federal Rule of Civil Procedure 23 as a guide when deciding whether to grant class certification. Finally, class certification will be reserved for those cases where appellants demonstrate the class device is a superior vehicle for litigating the class claim than a precedential decision. Applying these principles, we grant in part and deny in part the motion for class certification.

TABLE OF CONTENTS

I. BACKGROUND

In the early morning hours of January 17, 1966, a U.S. Air Force B-52 Superfortress bomber, armed with four thermonuclear weapons, collided with a KC-135 refueling tanker over the small fishing village of Palomares, Spain. *See* Record (R.) at 28-29, 560, 796-98, 1878-80, 3509, 3557-802. Part of Operation Chrome Dome, a U.S. military plan calling for continuous patrol by nuclear bombers around the airspace of the former Soviet Union, the bomber was supposed to refuel with the tanker for the trip home. R. at 3574-76. The midair collision destroyed both aircraft, and the bomber's atomic payload was scattered across the Spanish countryside. R. at 3605-07. Eventually, one weapon was recovered intact and another fished from the depths of the Mediterranean. R. at 3613-32. Emergency parachutes attached to the other two bombs, however, failed to deploy. R. at 3603-04. Both bombs impacted at high speeds, causing internal, nonnuclear explosives in the devices to detonate. R. at 3606-07. The resulting explosions released a cloud of radioactive plutonium dust over the area, contaminating soil and crops, and spreading radioactive debris for miles. R. at 1878.

Mr. Skaar, along with nearly 1,400 other U.S. military personnel, was sent to the accident site to assist in cleanup and monitoring efforts. While there, to assess possible radioactive exposure, the military personnel gave urine and nasal swab samples. Mr. Skaar was a member of a group of the 26 service members (the High 26) who were determined to be among the most exposed and who were monitored for a period of 18 to 24 months after the accident for signs of radiogenic conditions. R. at 2124-28. The monitoring efforts were discontinued, however, in December 1967 when the Air Force informed Mr. Skaar his "health is in no jeopardy from retention of radioactive materials as a result of participation in the [Palomares cleanup] operation." R. at 2430.

But in 1998, 32 years after the Palomares cleanup, Mr. Skaar was diagnosed with leukopenia, a decrease in white blood cell count. R. 2157. The diagnosing physician opined that exposure to ionizing radiation "[h]istorically does appear to be the positive agent" causing leukopenia, but concluded "we have been unable to prove this." *Id.* Mr. Skaar then filed a claim with VA, seeking service connection for that condition. R. at 2155. In February 2000, VA denied his claim. *See* R. at 2090-99. This was so, VA explained, because leukopenia is not a radiogenic disease VA recognizes as resulting from a "radiation-risk activity," and because Mr. Skaar had not presented sound scientific or medical evidence linking the disease to radiation exposure. R. at 2097.

Two separate regulatory paths lead to to service connection for veterans who suffer a disability they believe was caused by exposure to ionizing radiation. Both are at issue here as part of Mr. Skaar's motion for class certification. Under 38 C.F.R. § 3.309(d)(3)(ii), VA recognizes certain nuclear incidents as "radiation-risk activities." Those who participated in a radiation-risk activity listed in § 3.309 and who later developed one or more of the radiogenic diseases enumerated in § 3.309(d)(1) benefit from a presumption of service connection. § 3.309(a). For those who did not participate in a listed radiation-risk activity, § 3.311(a) is available. *See Hilkert v. West*, 12 Vet.App. 145, 148-49 (1999) (en banc). Under that provision, VA requests exposure data from a veteran's service branch. 38 C.F.R. § 3.311(a)(1)-(2). For those claims that meet certain threshold requirements, the Under Secretary for Benefits then reviews the gathered information and determines whether "sound scientific and medical evidence supports the conclusion [that] it is at least as likely as not" the condition is the result of ionizing radiation exposure. § 3.311(a), (c). The regulation defines "sound scientific evidence" as "observations, findings, or conclusions which are statistically and epidemiologically valid, are statistically significant, are capable of replication, and withstand peer review," and "sound scientific medical evidence" as "observations, findings, or conclusions which are consistent with current medical knowledge and are so reasonable and logical as to serve as the basis of management of a medical condition." § 3.311(c)(3). In making that determination, the Under Secretary for Benefits may request an advisory opinion from the Under Secretary for Health. § 3.311(c)(1). The Under Secretary's final determination is then sent to the agency of original jurisdiction, which considers the opinion as evidence. § 3.311(f). For Palomares veterans, § 3.309's presumption of service connection is unavailable because VA does not recognize the Palomares plutonium dust cleanup as a radiation-risk activity. So instead, veterans such as Mr. Skaar must seek service connection under § 3.311's less favorable provisions. *See Ramey v. Gober*, 120 F.3d 1239, 1242-43 (Fed. Cir. 1997).

The Air Force provides VA with dose estimates for Palomares veterans. In April 2001, a consulting firm, Labat-Anderson, evaluated the Air Force's dose methodology. *See* R. at 2682-2818. This evaluation culminated in a report (the LA Report or the Report) establishing preliminary dose estimates for various subcategories of veterans. R. at 2691. The LA Report stated that the recorded urine dose intakes for Palomares veterans "seemed unreasonably high" compared to "environmental measurements" derived from air sampling some 15 years after the cleanup and "estimates prepared for other plutonium exposure cases – persons residing in the Palomares vicinity and Manhattan Project workers." R. at 2701. These air samples and comparisons "provided a basis for preparing independent estimates of intake and dose using representative scenarios" rather than actual recorded dose intakes. R. at 2691. After comparing those "independent estimates" with the actual recorded dose intakes, the Report "excluded data from the on-site samples and attributed more significance to samples collected at later dates for the High 26 Group." R. at 2795. This exclusion of "unreasonably high" dose estimates forms the basis for Mr. Skaar's allegation that the Air Force's dose estimates do not constitute "sound scientific evidence" as required by law. *See* Appellant's Apr. 23, 2019, Response (Resp.) at 4. The Report noted its findings "represent preliminary estimates that cannot be considered as definitive" and recommended further study "to develop credible estimates of dose that are compatible with those calculated from environmental data." *Id.* Despite these reservations, the Air Force adopted the LA Report's dose estimate methodology in full. *See* R. at 1580-81, 3508-511.

After VA's initial denial in 2000, Mr. Skaar requested that VA reopen his claim in March 2011. R. at 2077. Based on that claim and per § 3.311, the regional office (RO) requested a radiation exposure opinion. R. at 1886. In response, the Air Force estimated in April 2012 that Mr. Skaar's maximum total effective dose during the Palomares cleanup was 4.2 rem with a bone marrow committed dose of 1.18 rem, compared to annual dose limits of 5 and 50 rem, respectively, for occupations typically involving radiation exposure.[1] R. at 1888-89. Based on these estimates, the director of the Post 9/11 Environmental Health Program, writing for the Under Secretary for Benefits, advised in May 2012 that "it is unlikely that [Mr. Skaar's] leukopenia . . . can be attributed

[1] A rem (roentgen equivalent man) is the unit of measurement for radiation. One unit represents "the dosage of a ionizing radiation that will cause the same biological effect as one roentgen of X-ray or gamma-ray exposure." MERRIAM-WEBSTER DICTIONARY, https://www.merriam-webster.com/dictionary/rem (last visited Oct. 31, 2019).

to radiation exposure while in military service." R. at 1877. And, based on this opinion, the RO in June 2012 denied Mr. Skaar's claim. R. at 1869. Mr. Skaar timely disagreed with the RO's denial, but the RO continued to deny the claim in September 2013. R. at 1690-91. He then perfected an appeal to the Board. R. at 1588-89.

In October 2013, a private physician opined that Mr. Skaar's leukopenia "is likely related to exposure to heavy radioactive material in [1966]." R. at 39-40. And 2 months later, the Air Force concluded an evaluation of its radiation dose methodology that revealed "inconsistencies in dose assignment over the past 12 years" since the LA Report. R. at 1580. The Air Force's methodology, derived from the LA Report, "appear[ed] to underestimate doses to some individuals" and, thus, the Air Force intended to "formally standardize [its] response methodology for radiation dose inquiries involving Palomares participants" by establishing dose estimates based on each veteran's specific duties. *Id.* Finally, the Air Force stated it would reevaluate the individual dose estimates it had already provided for Palomares veterans. R. at 1581. And in June 2014, the Air Force provided VA with Mr. Skaar's revised dose estimate, assigning him a new maximum total effective dose of 17.9 rem and a bone marrow committed dose of 14.2 rem. *See* R. at 1301, 1274-75.

Meanwhile, the Board in May 2015 found the Air Force's revised dose estimates were new and material evidence warranting reopening of Mr. Skaar's claim. R. at 695-99. The Board then remanded the claim to the RO because the Air Force's "revised assessment [was] significantly higher than the April 2012 assessment" and, thus, "another [dose estimate] opinion [was] warranted." R. at 698. That opinion was provided in August 2016. The RO found that, based on the revised bone marrow committed dose estimate of 14.2 rem, "it is not likely that the Veteran's leukopenia was caused by exposure to ionizing radiation during military service." R. at 131-35. The RO then again denied Mr. Skaar's claim, citing the results of the August 2016 revised dose estimate. R. at 113-14. Nonetheless, in September 2016, a private physician opined that Mr. Skaar's leukopenia was "a result of exposure to ionizing radiation/plutonium." R. at 38.

Mr. Skaar then returned to the Board, which, on April 14, 2017, again denied his claim. *See* R. at 2-12. The Board concluded VA's May 2012 dose estimate opinion lacked probative value "as it was based on an inaccurate dose estimate." R. at 10. But the Board found the August 2016 dose estimate "highly probative" because it "was based on a review of the entire record," while Mr. Skaar's private medical opinions were not as probative because "none offered any rationale for their statements." R. at 10-11. Mr. Skaar then appealed to this Court, and filed the pending motion for class certification. The Secretary moved to stay proceedings in this matter pending our resolution of *Monk III*, a request we denied. This matter was assigned to a panel of the Court for decision on the merits but, given the novelty of the issue, the motion for class certification was submitted to the full Court for decision.

Mr. Skaar asks us to certify a class of "all U.S. veterans who were present at the 1966 cleanup of plutonium dust at Palomares, Spain[,] and whose application for service-connected disability compensation based on exposure to ionizing radiation the VA has denied or will deny." Motion (Mot.) for Class Certification at 1. He later clarified the proposed class encompasses (i) "veterans whose claims for service-connected disability benefits related to exposure to ionizing radiation at Palomares the VA has denied at any level, from the RO through the [Board], except for those who have appealed to this Court and received a decision for which the mandate has issued;" (ii) "veterans whose claims the RO or [Board] has denied and for which the deadline for appeal has expired, as well as veterans whose claims are currently pending before a [decision review officer] or the [Board] after an initial RO denial;" and (iii) "Palomares veterans with an appeal currently pending before this Court[.]" Appellant's Apr. 16, 2018, Resp. at 2. The proposed class also includes "veterans with claims that have not yet been filed at the RO," including "those who have not filed a claim for an existing condition, including because they are aware of the VA's history of denial of Palomares veterans' claims or the methodology used to calculate dose exposure" and "those who have only recently developed a radiogenic condition, and those whose claims have been delayed at the RO." *Id.*

The proposed class raises two claims. The first challenges VA's omission of the Palomares cleanup from the list of radiation-risk activities in 38 C.F.R. § 3.309(d)(3)(ii) (the § 3.309 claim), while the second centers around VA's compliance with § 3.311(c)'s command that when adjudicating Palomares veterans' claims VA rely on dose estimates based on "sound scientific and medical evidence" (the § 3.311 claim). Mr. Skaar's proposed class alleges VA's actions regarding both claims are invalid under the Administrative Procedure Act and violate class members' due process and equal protection rights. The putative class asks us to order VA to (i) recognize the Palomares cleanup as a "radiation-risk activity;" (ii) apply dose estimate methodology that is supported by "sound scientific and medical evidence;" and (iii) re-adjudicate the benefits claims of those class members whose claims have already been denied.

During the Court's review of this matter, it became clear the Board had failed to address several of Mr. Skaar's arguments regarding the § 3.311 claim. *See* R. at 106-07, 778-83. Thus, we ordered a limited remand to the Agency for it to "provide a supplemental statement of reasons or bases addressing the appellant's expressly raised argument in the first instance." *Skaar v. Wilkie*, 31 Vet.App. 16, 18 (2019). The Board faithfully complied with our order. In its supplemental statement, the Board stated Mr. Skaar's arguments based on the first, lower 2012 dose estimate "appear moot" as "the Board's April 2017 decision specifically did not rely on [the] May 2012 findings . . . since those findings were based on the April 2012" Air Force dose estimate that had since been found to have inconsistencies. Secretary's Mar. 29, 2019, Resp. at 4.

Regarding the June 2014 revised dose estimate, the Board found that "on its face it is based on sound scientific evidence" because it "was based on then recently re-evaluated internal processes which were initiated to ensure a comprehensive and consistent approach to dose estimates," and because it "considered the Veteran's previously reported intake values based on the application of contemporary models to his bioassay data collected in the 1960's." *Id.* at 5. As to whether the previous inconsistencies in the Air Force's dose methodology that plagued its earlier April 2012 estimate still plagued the June 2014 revised dose estimate, the Board stated that "just as it is prohibited from exercising its own independent judgment to resolve medical questions, the Board is not in a position to exercise such independent judgment on matters involving scientific expertise." *Id.* (citing *Colvin v. Derwinski*, 1 Vet.App. 171, 175 (1991)).

Finally, the Board explained it "is bound by regulations of the Department," and those regulations "provide specific instructions for obtaining dose estimates." *Id.* at 6 (citing 38 U.S.C. § 7104(c); 38 C.F.R. §§ 19.5, 20.101(a) (2018)). Thus, "[w]ithout an independent dose estimate, and without a rational basis to reject the competent findings of the Air Force," the Board had no evidentiary basis on which to grant service connection. *Id.* at 5. Armed with a record sufficient for the Court to consider the class certification motion, we turn to that endeavor now.

II. ANALYSIS

First, we confront a threshold issue. We must decide whether Mr. Skaar has the requisite standing to assert the claims on which he seeks to represent a class. We conclude he lacks standing to bring the § 3.309 claim, but has standing to pursue the § 3.311 claim.

We then assess whether we have the power to use the class action device as a matter of law. We conclude we do. We then consider whether, as a normative matter and given our status as an appellate court with the power to issue precedential opinions, we will exercise our discretion to certify class actions in appropriate appeals. We conclude, as we did in the petition context, class actions have a role to play in appeals in appropriate situations.

Returning to the proposed class, we examine the proposed class definition and modify it to exclude those claimants with adverse decisions who chose not to appeal (i.e., their claims have expired). We then address whether we should certify the modified class as to the § 3.311 claim. In this regard, we first make clear, as we did with petitions, *see Monk III*, 30 Vet.App. at 174, we will use Federal Rule of Civil Procedure 23 as a guide for determining whether class certification is appropriate. We then conclude the modified class satisfies Rule 23(a)'s requirements and is consistent with the functional requirements of Rule 23(b)(2). But we also recognize Rule 23 is only a guide. We are not similarly situated to the Federal district courts, for which Rule 23 was written. Thus, we consider whether our status as an appellant court (both in terms of the use of precedential opinions and the challenges we may face in managing a class action) counsels against certification. We conclude, in the context of this case, our appellate role does not counsel against certification. But we also hold we will presume class actions should not be certified because of our ability to render binding precedential decisions. Claimants seeking class certification can rebut this presumption by showing by a preponderance of the evidence that a class action is "superior to other available methods for fairly and efficiently adjudicating the controversy" before we will exercise our discretion in certifying a class.

Having determined class certification is appropriate, we next consider appointment of class counsel. Following the guidance of Federal Rule of Civil Procedure 23(g), we appoint Michael Wishnie, Esq., of the Jerome N. Frank Legal Service Organization at Yale Law School as class counsel.

Our final consideration concerns whether class members may elect to opt out of this action and what notice, if any, the class should receive of our certification decision. In line with the overwhelming weight of Federal jurisprudence, we hold the nature of this class is such that opt out rights are not required. And, because class members may not opt out, there is no need to provide individualized notice of certification. However, we conclude generalized notice of class certification designed to reach as many class members as possible is appropriate and order the parties to develop a joint plan for effecting such notice.

Having summarized our holdings, we now address each point in detail in the balance of this order.

A. Standing

"[S]tanding is a threshold inquiry in all actions," including class actions.[2] *Allen v. Wright*, 468 U.S. 737, 750 (1984). "In an era of frequent litigation, class actions, sweeping injunctions with prospective effect, and continuing jurisdiction to enforce judicial remedies, courts must be more careful to insist on the formal rules of standing, not less so." *Ariz. Christian Sch. Tuition Org. v. Winn*, 563 U.S. 125, 146 (2011). "Standing is one of the keys necessary to open the door to the federal courthouse." *Matte v. Sunshine Mobile Homes, Inc.*, 280 F. Supp. 805, 826 (W.D. La. 2003). The appellant has the burden of showing standing. *See Lujan v. Defs. of Wildlife*, 504 U.S. 555, 561 (1992). "That a suit may be a class action . . . adds nothing to the question of standing, for even named plaintiffs who represent a class 'must allege and show that they personally have been injured, not that injury has been suffered by other, unidentified members of the class to which they belong and which they purport to represent.'" *Simon v. E. Ky. Welfare Rights Org.*, 426 U.S. 26, 40 n.20 (1976) (quoting *Warth v. Seldin*, 422 U.S. 490, 502 (1975)). "[S]tanding cannot be acquired through the back door of a class action." *Allee v. Medrano*, 416 U.S. 802, 829 (1974) (Burger, C.J., concurring in part and dissenting in part). "If the individual plaintiffs lack standing, the court need never reach the class action issue." *Hawecker v. Sorensen*, No. 1:10-cv-00085 OWW JLT, 2011 WL 98757, at *2 (E.D. Cal. Jan. 12, 2011).

Standing requires the appellant show (1) an injury-in-fact; (2) traceability; and (3) redressability. *See Defs. of Wildlife*, 504 U.S. at 560-61; *see also Friends of the Earth, Inc. v. Laidlow Envtl. Servs. (TOC), Inc.*, 528 U.S. 167, 180-81 (2000). An injury-in-fact is one that is "concrete," "particularized," "not abstract," and "actual or imminent." *Defs. of Wildlife*, 504 U.S. at 560-61. Claimants cannot simply "allege a bare procedural violation, divorced from any concrete harm" to satisfy the injury requirement. *Spokeo, Inc. v. Robins*, 136 S. Ct. 1540, 1549 (2016). Standing is determined on a claim-by-claim basis. *See, e.g.*, *McGuire v. BMW of N. Am., LLC*, No. 13-7356 (JLL), 2014 WL 2566132, at *6 (D.N.J. June 6, 2014). In class actions with multiple claims, at least one named representative must have standing with respect to each claim. *See Keepseagle v. Veneman*, No. Civ.A.9903119EGS1712, 2001 WL 34676944 (D.D.C. Dec. 12, 2001); *Prado-Steiman ex rel. Prado v. Bush*, 221 F.3d 1266, 1279 (11th Cir. 2000). Without it, the claims must be dismissed. *See, e.g.*, *King Cty. v. IKB Deutsche Industriebank AG*, Nos. 09 Civ. 8387(SAS), 09 Civ. 8822(SAS) 2010 WL 2010943 (S.D.N.Y. May 18, 2010). Accordingly, we separately analyze Mr. Skaar's standing to challenge both §§ 3.309 and 3.311.

1. Mr. Skaar lacks standing to pursue the § 3.309 claim on behalf of the class.

The § 3.309 claim alleges VA's omission of the Palomares incident from its list of recognized radiation-risk activities under § 3.309 is arbitrary and capricious, violates the Administrative Procedure Act, and is unconstitutional. Section 3.309 establishes a presumption of service connection for veterans who have (i) a listed radiogenic disease (ii) resulting from a

[2] This Court has adopted Article III of the Constitution's case-or-controversy requirement. *See Mokal v. Derwinski*, 1 Vet.App. 12, 13 (1990).

recognized radiation-risk activity. So, for Mr. Skaar to show an injury-in-fact he must demonstrate VA's exclusion of Palomares from the regulation's list of radiation-risk activities harmed him in a concrete and particularized way. *See Defs. of Wildlife*, 504 U.S. at 560-61. But the Board decision before us denied service connection for leukopenia, which is not one of § 3.309's enumerated radiogenic conditions. Thus, if we were to grant the requested relief as to this claim, Mr. Skaar would not benefit from the regulation's presumption. Mr. Skaar attempts to sidestep this by arguing Palomares' recognition as a radiation-risk activity would entitle him to enroll in VA's Ionizing Radiation Registry (IRR). This program provides certain health screening benefits for veterans exposed to ionizing radiation. *See* VHA Directive 1301 (Apr. 6, 2017).

We hold Mr. Skaar lacks standing to challenge § 3.309 because he would not benefit from the relief requested as his condition, leukopenia, is not a listed radiogenic condition under that regulation. Thus, the inclusion of Palomares as a radiation-risk activity, while it may assist many unnamed class members, would not entitle him to § 3.309's presumption of service connection. Further, any harm Mr. Skaar has suffered from not having access to the IRR is distinct from the alleged harm suffered by veterans with qualifying radiogenic diseases. The unavailability of IRR enrollment also fails to meet the proposed class definition. Mr. Skaar seeks to represent "all U.S. veterans who were present at the 1966 cleanup of plutonium dust at Palomares, Spain[,] and whose application for service-connected disability compensation based on exposure to ionizing radiation the VA has denied or will deny." Mot. for Class Certification at 1. But IRR enrollment, to the extent Mr. Skaar has been denied it and to the extent it represents a "benefit," is not an "application for service-connected disability compensation" and, thus, cannot serve as the basis for Mr. Skaar's standing to represent the proposed class as to the § 3.309 claim.

"It is not enough that the conduct of which the plaintiff complains will injure *someone*. The complaining party must also show that he is within the class of persons who will be concretely affected. Nor does a plaintiff who has been subject to injurious conduct of one kind possess by virtue of that injury the necessary stake in litigating conduct of another kind, although similar, to which he has not been subject." *Blum v. Yaretsky*, 457 U.S. 991, 999 (1982) (emphasis in original). *But see Gratz v. Bollinger*, 539 U.S. 244, 262-63 (2003) (declining to answer whether respondent, who was an undergraduate transfer student, had standing to represent a class that included both undergraduate transfer students and freshmen or whether the issue was more properly analyzed under Rule 23's typicality analysis). Mr. Skaar may very well be correct he has suffered some type of harm from not having access to the IRR, but his proper remedy for that particular injury is to pursue relief from VA, not this Court. Thus, we dismiss Mr. Skaar's challenge to VA's omission of Palomares from § 3.309's list of radiation-risk activities as he lacks standing to bring the claim. *See Rosinski v. Shulkin*, 29 Vet.App. 183, 190-92 (2018); *Prado-Steiman ex rel. Prado*, 221 F.3d at 1279.

2. Mr. Skaar has standing to pursue the § 3.311 claim on behalf of the class.

However, we hold Mr. Skaar does have standing to challenge VA's reliance on the Air Force's dose estimate methodology in deciding claims under § 3.311. First, he has suffered an injury-in-fact. Certain qualifying radiogenic conditions not listed in § 3.309 are analyzed under § 3.311, which requires evidence of radiation exposure and dosages for the award of service connection. *See* 38 C.F.R. § 3.311(a)(1); *see also Hilkert*, 12 Vet.App. at 145-49. Leukopenia is not listed as a qualifying radiogenic condition. *See* § 3.311(b)(2). But § 3.311, unlike § 3.309, provides that, for conditions other than those specifically listed by VA as qualifying radiogenic diseases, "VA shall nevertheless consider the claim under the provisions of this section provided the claimant has cited or submitted competent scientific or medical evidence that the claimed condition is a radiogenic condition." § 3.311(b)(4). And the Board favorably found Mr. Skaar's private medical opinions linked his leukopenia to radioactive exposure. *See* R. at 6. Thus, Mr. Skaar's leukopenia qualifies for the dose estimate procedures of § 3.311.

VA regulations require dose estimates be supported by "sound scientific and medical evidence." 38 C.F.R. § 3.311(c)(1)(i). Mr. Skaar, both individually and on behalf of the class, argues the Air Force's dose methodology, which VA relies on in adjudicating service connection claims by Palomares veterans, fails to meet that standard. Unlike the class claim under § 3.309, in his class claim under § 3.311 Mr. Skaar was subject to the challenged conduct.

For claims under § 3.311, "an assessment will be made as to the size and nature of the radiation dose or doses." § 3.311(a). For claims based on exposure other than from atmospheric nuclear weapons testing or the military occupations of Hiroshima or Nagasaki, VA must request "any available records concerning the veteran's exposure to radiation," such as service medical records and "other records which may contain information pertaining to the veteran's radiation dose in service." § 3.311(a)(2)(iii).

Mr. Skaar filed a service connection claim for leukopenia in March 2011. VA then requested a dose estimate from the Air Force. That estimate stated Mr. Skaar's maximum total effective dose was 4.2 rem. In May 2012, the VA Environmental Health Program found that, because Mr. Skaar's effective dose was less than 5 rem, "it is unlikely that his leukopenia . . . can be attributed to radiation exposure." R. at 1877. VA then denied his claim in June 2012. However, in December 2013, the Air Force increased its assigned dose values for Palomares veterans after determining its previous methods led to inconsistent dose estimates. VA then again denied Mr. Skaar's leukopenia claim in March 2014, choosing not to apply the revised dose methodology to his claim. The Air Force then *again* revised its assigned dose value for Mr. Skaar to 17.9 rem, a more than quadruple increase from its previous assigned dose value. The Board then reopened Mr. Skaar's leukopenia claim in May 2015 because of the new dose estimate and remanded the claim to the RO, which again denied the claim. Mr. Skaar perfected an appeal to the Board, which then yet again denied service connection. R. at 2-12. The proposed class here challenges VA's reliance on both the Air Force's pre- and post-2013 dose estimate methodologies. *See* Appellant's Apr. 8, 2019, Resp. at 3.

The parties spill a great deal of ink discussing Mr. Skaar's standing to represent the class challenge. The Secretary argues there is a crucial distinction between the pre-2013 and post-2013 methodologies.[3] *See* Secretary's Apr. 18, 2019, Resp. at 1-3. He contends Mr. Skaar lacks standing to challenge the pre-2013 methodology because that method was derived from air sampling, while his dose estimates came from urine sampling. *Id.* at 2. Mr. Skaar counters that "[t]he pre-2013 and

[3] As stated above, the Air Force adopted the LA Report in 2001. *See* R. at 1580-81; 3508-511. Thus, and because Mr. Skaar challenges only VA's reliance on dose estimates prepared using the Report's methodology, he does not have standing to challenge denials of claims due to ionizing radiation exposure from the Palomares cleanup that were based on dose estimates pre-dating 2001.

post-2013 distinction is meaningless because [he] challenges the VA's reliance on the LA Report as a whole." Appellant's Apr. 23, 2019, Resp. at 4. In his view, "the LA Report's original sin is that it excluded the urine samples with the highest plutonium measurements." *Id.* Mr. Skaar alleges this exclusion of the highest dose estimates applies equally to both the pre-2013 and post-2013 methodologies.

Whether one considers the question of differences in the pre- and post-2013 methodologies as one of constitutional standing or under Rule 23's typicality analysis is largely one of semantics here, involving significant overlap. Thus, we analyze the pre- and post-2013 distinction in the context of both standing and typicality.

First, Mr. Skaar has standing to challenge the post-2013 methodology because the Air Force's post-2013 methodology excluded the highest measurements recorded. In a December 2013 document, the Air Force stated it was revising Palomares dose estimates by setting the estimated dose intake for the High 26 group as "their established intake estimates," and by using, for all other Palomares veterans, the lowest dose intake from the High 26. R. at 1580-81. But Mr. Skaar contends the established plutonium intakes for the High 26 are artificially deflated by the earlier decision to exclude "unrealistically high" measurements taken on-site. Thus, the Air Force's revised methodology does nothing to correct the exclusion of the urine samples with the highest plutonium measurements as to Mr. Skaar, and he has sufficiently shown an injury-in-fact as to the post-2013 methodology. Appellant's Apr. 23, 2019, Resp. at 4.

Second, debating whether Mr. Skaar has standing to represent those class members solely challenging VA's reliance on pre-2013 Air Force dose estimates is almost certainly an academic exercise. As discussed in the balance of this order, we will certify a modified class of claimants that excludes those whose claims related to ionizing radiation exposure from the Palomares cleanup have been denied by VA or this Court and those whose appeals windows for those denials have expired. Put differently, our decision affects only claimants who will file claims after the date of this order or those whose claims are currently before the Court or pending before VA. That means it's exceedingly unlikely there are any remaining class members who will *only* have a dose estimate based solely on the pre-2013 methodology.

But, even if there are class members whose claims were denied solely on the basis of the Air Force's pre-2013 methodology, Mr. Skaar has sufficient standing to represent them. He has shown injury-in-fact from the pre-2013 methodology, which was derived from the LA Report. *See* R. at 1580-81. This methodology was applied to Mr. Skaar in the form of the May 2012 advisory opinion implementing the LA Report's dose estimate methodology, which specifically "excluded data from the on-site [urine] samples and attributed more significance to samples collected at later dates for the High 26 Group," of which Mr. Skaar was a member. R. at 2795. The Secretary argues, however, the exclusion of the urine samples from the pre-2013 methodology is irrelevant here because, in the decision on appeal, the Board expressly discounted the findings of the May 2012 advisory opinion as they were "based on an inaccurate dose estimate." R. at 10. But it is unclear how this makes any difference. It is undisputed that the dose estimate methodology under § 3.311, whether it be from pre- or post-2013, excluded certain urine dose samples. If Mr. Skaar is successful in showing this exclusion is not based on "sound scientific evidence" as required by VA's own regulations, then he will have suffered an injury-in-fact.

Mr. Skaar's injury is also "fairly traceable to the challenged conduct of the defendant." *Spokeo*, 136 S. Ct. at 1547. VA's own regulations require it to use "sound scientific evidence" in adjudicating radiation exposure claims, s*ee* 38 C.F.R. § 3.311, and VA is free to request dose estimates from private entities or to establish its own dose estimates procedures. Finally, Mr. Skaar's injury is "likely to be redressed by a favorable judicial decision." *Spokeo*, 136 S. Ct. at 1547. An order from us holding the Secretary is in noncompliance with § 3.311 and directing him to comply with the law would immediately give Mr. Skaar relief because he could not again be subject to the same allegedly unlawful process. Thus, Mr. Skaar has standing to bring the § 3.311 claim.

Having concluded Mr. Skaar has standing to challenge § 3.311 but not § 3.309, we have occasion to modify Mr. Skaar's proposed class definition to reflect our legal conclusions. *See Suchanek v. Sturm Foods, Inc.*, 764 F.3d 750, 757 (7th Cir. 2014) (courts should modify proposed class definitions that are slightly overbroad rather than deny certification outright); *Schorsch v. Hewlett-Packard Co.*, 417 F.3d 748, 750 (7th Cir. 2005) ("Litigants and judges regularly modify class definitions . . . ."); *In re Monumental Life Ins. Co.*, 365 F.3d 408 (5th Cir. 2004); *Robidoux v. Celani*, 987 F.2d 931, 937 (2d Cir. 1993) ("A court is not bound by the class definition proposed in the complaint and should not dismiss the action simply because the complaint seeks to define the class too broadly."). But first, we must consider whether, as a matter of law, we have the power to certify class actions in the appeal context at all. We conclude we do.

B. The Power To Certify Class Actions in the Appeal Context

Before the passage of the Veterans' Judicial Review Act (VJRA), Pub. L. 100-687, 102 Stat. 4105 (1988), veterans were free to aggregate challenges to VA regulations in the limited context in which judicial review was available. *See, e.g.*, *Johnson v. Robison*, 415 U.S. 361 (1974); *Wayne State Univ. v. Cleland*, 590 F.2d 627 (6th Cir. 1978); *Giusti-Bravo v. U.S. Veterans Admin.*, 853 F. Supp. 34 (D.P.R. 1993); *Nehmer v. U.S. Veterans' Admin.*, 118 F.R.D. 113 (N.D. Cal. 1987); *In re "Agent Orange" Prod. Liab. Litig.*, 506 F. Supp. 762 (E.D.N.Y. 1980). Yet, until recently this Court did not recognize its authority to entertain class actions. *See Monk II*, 855 F.3d at 1320-21; *Harrison*, 1 Vet.App. at 439. In *Monk II*, the Federal Circuit disagreed, reasoning there was "no persuasive indication that Congress intended to *remove* class action protection for veterans when it enacted the VJRA." 855 F.3d at 1320 (emphasis in original). "Rather, Congress gave the Veterans Court express authority to prescribe rules of practice and procedure for its proceedings." *Id.* Thus, "[o]n the basis of th[is] express statutory authority . . . , the Veterans Court may prescribe procedures for class actions or other methods of aggregation." *Id.*

Although *Monk II* concerned a petition and this is an appeal, nothing in that decision indicates our authority to certify classes is limited to the petition context. Indeed, when describing the bases on which we had the power to certify classes, the Federal Circuit stated: "We hold that the Veterans Court has such authority [to certify and adjudicate class action cases] under the All Writs Act, other statutory authority, and the Veterans Court's inherent powers." *Monk II,* 855 F.3d at 1318. Although the reference to the All Writs Act arguably could be confined to the context of a petition (although that is not necessarily the case), the other two sources of authority to certify classes are not so limited. Moreover, the Federal Circuit specifically discussed our authority in the context of an appeal. *See id.* at 1320. To be sure, that court had no occasion to rule on the question of class actions in the appeal context because *Monk II* concerned a petition. Nevertheless, its analysis is instructive. At a minimum, our inherent authority supports the use of the class action device as does our ability to craft rules of practice and procedure. *See* 38 U.S.C. § 7264(a). There is no principled distinction between the authority the Federal Circuit recognized for petitions from appeals. Thus, faithfully applying the Federal Circuit's logic in *Monk II*, we hold we possess the authority to certify class actions in the appeal context.

Having concluded we possess the power to aggregate claims and certify class actions in the appeal context, we now address whether we will exercise that power. We hold that, in appropriate circumstances, we will.

C. The Utility of Class Actions in the Appeal Context

Class actions are "an exception to the usual rule that litigation is conducted by and on behalf of the individual named parties only." *Califano v. Yamasaki*, 442 U.S. 682, 700-01 (1979). They are "a procedural device intended to advance judicial economy by trying claims together that lend themselves to collective treatment." *Blaz v. Belfer*, 368 F.3d 501, 504 (5th Cir. 2004). And they have a long history, originating with English "bills of peace," which allowed courts to consolidate numerous persons with the same claim against the same defendant. *See* Benjamin Kaplan, *Continuing Work of the Civil Committee: 1966 Amendments of the Federal Rules of Civil Procedure*, 81 HARV. L. REV. 356, 376 (1967). They have been an established part of Federal practice since the original version of Rule 23 was promulgated in 1937 and established three types of class actions plaintiffs could bring. *See* FED. R. CIV. P. 23(b) advisory committee's note to 1937 adoption. The Rule was revised to its current form in a landmark 1966 amendment laying out the procedural "measures which can be taken to assure the fair conduct of [class] actions." FED. R. CIV. P. 23(b) advisory committee's note to 1966 amendment; *see also In re Gen. Motors Corp. Pick-Up Truck Fuel Tank Prods. Liab. Litig.*, 55 F.3d 768, 785 (3d Cir. 1995).

"Class relief is 'peculiarly appropriate' when the 'issues involved are common to the class as a whole' and when they 'turn on questions of law applicable in the same manner to each member of the class." *Gen. Tel. Co. of Sw. v. Falcon*, 457 U.S. 147, 155 (1982) (quoting *Yamasaki*, 442 U.S. at 700-01). "[T]he class action device saves the resources of both the courts and the parties by permitting an issue potentially affecting every" class member "to be litigated in an economical fashion under Rule 23." *Yamasaki*, 442 U.S. at 701.

Class actions can also be an effective force for institutional change. As one court has observed, "[u]nless we can use the class action and devices built on the class action, our judicial system is not going to be able to cope with the challenges of [] mass repetitive wrongdoing." *Cimino v. Raymark Indus., Inc.*, 751 F. Supp. 649, 652 (E.D. Tex. 1990), *aff'd in part, vacated in part on other grounds by* 151 F.3d 297 (5th Cir. 1998). The Federal Circuit has observed that "[c]lass actions can help [this Court] . . . by promoting efficiency, consistency, and fairness, and improving access to legal and expert assistance by parties with limited resources." *Monk II*, 855 F.3d at 1320. Further, "[c]lass actions may help [this Court] consistently adjudicate cases by increasing its prospects for precedential opinions," help "prevent the VA from mooting claims scheduled for precedential review," and "could be used to compel correction of systemic error and to ensure that like veterans are treated alike." *Id.* at 1320-21.

We agree with the Federal Circuit's views on the utility of the class action device. Although that court made its comments in the petition context, the concepts of "efficiency, consistency, and fairness" apply equally to appeals. It is true this Court has the power to issue precedential decisions that, in some measure, mimic the effect of a class action. However, that power does not mean there is no use for the class action device. We conclude although our ability to issue binding precedent is a factor we should consider when deciding whether to certify a class (a matter we return to below), that ability does not counsel in favor of categorically rejecting the use of this procedural device.

Thus, as we have the power to certify class actions and will exercise our discretion to do so in appropriate cases, we now consider whether this matter is appropriate for certification. To do so requires precisely defining the proposed class. *See* FED. R. CIV. P. 23(c)(1)(B) (class action orders "must define the class and the class claims, issues, or defenses"). To do so we must have "a readily discernible, clear, and precise statement of the parameters defining the class or classes to be certified" that "provid[es] the parties with clarity and assist[s] class members in understanding their rights and making informed opt-out decisions." *Marcus v. BMW of N.A., LLC*, 687 F.3d 583, 591 (3d Cir. 2012).

D. The Proposed Class Composition

Mr. Skaar asks us to certify a class of "all U.S. veterans who were present at the 1966 cleanup of plutonium dust at Palomares, Spain[,] and whose application for service-connected disability compensation based on exposure to ionizing radiation the VA has denied or will deny." Mot. for Class Certification at 1. Combined with his later clarification of the class definition, the proposed class contains five subgroups.[4] They are the following:

- Past Claimants: those Palomares veterans whose claims based on ionizing radiation exposure were denied before reaching the Board but who did not perfect an appeal of that denial;
- Expired Claimants: those Palomares veterans whose claims based on ionizing radiation exposure the Board has denied but whose appeal windows to this Court have expired without the filing of a Notice of Appeal;
- Present Claimants: those Palomares veterans whose claims based on ionizing radiation exposure the Board has denied and whose appeal windows to this Court have not yet expired or who have already appealed an adverse decision to this Court;
- Present-Future Claimants: those Palomares veterans who have filed claims based on ionizing radiation exposure that remain pending before VA at any level and that VA will deny; and

[4] We separate the class into subgroups merely for purposes of analyzing our jurisdiction as to each subgroup and do not divide the class into formal subclasses. *See* FED. R. CIV. P. 23(c)(5) (permitting district courts to divide a class into subclasses).

- Future-Future Claimants: those Palomares veterans who have developed a radiogenic condition but have not yet filed claims based on ionizing radiation exposure.

The proposed class composition depends on whether we have jurisdiction over each subgroup. First, we clearly have jurisdiction over the Present Claimants because they possess final Board decisions and either their 120-day windows to appeal those decisions to this Court have not yet expired or these claimants have already appealed within the 120-day time period. *See* 38 U.S.C. §§ 7252(a), 7266(a). We consider the remaining subgroups in turn.

1. The Present-Future and Future-Future Claimants

The Present-Future and Future-Future Claimants pose a unique jurisdictional issue. Neither subgroup has had final Board decisions dispose of its claims. Indeed, the Future-Future Claimants have not yet even filed disability compensation claims. We must decide whether our jurisdictional statute prohibits the inclusion of class members without a final Board decision as we have "an independent obligation to ensure that [we] do not exceed the scope of [our] jurisdiction." *Henderson ex rel. Henderson v. Shinseki*, 562 U.S. 428, 434 (2011). Relying on the Supreme Court's holding in *Bowen v. City of New York*, 476 U.S. 467 (1986), we conclude our jurisdictional statute does not prohibit their inclusion.

i. There is no indication Congress intended veterans to receive fewer procedural protections under the VJRA than they enjoyed before its enactment.

"Courts created by statute," like ours, "can have no jurisdiction but such as the statute confers." *Christianson v. Indus. Operating Corp.*, 486 U.S. 800, 818 (1988). Subject-matter jurisdiction "can never be waived or forfeited." *Gonzalez v. Thaler*, 565 U.S. 134, 141 (2012). "A statute affecting federal jurisdiction must be construed both with precision and with fidelity to the terms by which Congress has expressed its wishes." *Kucana v. Holder*, 558 U.S. 233, 252 (2010). Guided by the Federal Circuit, we hold that, pursuant to our statutory authority under 38 U.S.C. §§ 7252 and 7261, we have the authority to certify class actions that include veterans who have not yet received a final Board decision and those who have not yet filed a claim. *See Monk II*, 855 F.3d at 1318.

We have only one source of jurisdiction: 38 U.S.C. § 7252. *See Henderson*, 562 U.S. at 434. It gives us "exclusive jurisdiction to review [Board] decisions," allowing us to "affirm, modify, or reverse" Board decisions and "remand the matter, as appropriate." 38 U.S.C. § 7252(a). Essentially, a final Board decision operates as the jurisdictional "trigger" that gives us the authority to hear a particular appeal. *See Ledford v. West*, 136 F.3d 776, 779 (Fed. Cir. 1998) (our Court's "jurisdiction is premised on and defined by the Board's decision concerning the matter being appealed"); *Wick v. Brown (In re Wick)*, 40 F.3d 367, 373 (Fed. Cir. 1994) (a Board decision is a "statutory prerequisite for [this Court's] jurisdiction"). 38 U.S.C. § 7261 then lays out our scope of review in cases in which we already possess jurisdiction under section 7252 and "does not provide an independent basis for jurisdiction." *Wick*, 40 F.3d at 371; *see also Dixon v. McDonald*, 815 F.3d 799, 803 (Fed. Cir. 2016). Instead, this provision delineates what types of relief we may provide. *See* 38 U.S.C. §§ 7252(b) ("The extent of [this Court's judicial] review shall be limited to the scope provided in section 7261 . . . ."), 7261(a)(1)-(4) (laying out the various actions this Court can take when deciding appeals). Both statutes play important, but differing roles. First, for jurisdiction to be proper in a given matter, it must lie under section 7252. Then, once jurisdiction is proper, section 7261 informs us what, if any, actions we may take.

In *Harrison*, we decided we lacked the authority to hear class actions because, among other reasons, section 7252 limited our jurisdiction to review of Board decisions. 1 Vet.App. at 439. But in *Monk II*, the Federal Circuit addressed that, stating *Harrison* "reflect[ed] a concern that the Veterans Court would exceed its jurisdiction if, for example, it certified a class that included veterans that had not yet received a Board decision or had not yet filed a notice appealing a Board decision." 855 F.3d at 1320. The Federal Circuit "disagree[d] that [our] authority is so limited," explaining that 38 U.S.C. § 7264(a), which authorizes us to create the procedures necessary to exercise our jurisdiction, allows us to "prescribe procedures for class actions or other methods of aggregation." *Monk II*, 855 F.3d at 1320. The Federal Circuit also noted that "[b]efore the VJRA, veterans seeking to enforce veterans benefit statutes were able to file class actions in some circumstances." *Id.* at 1319. In essence, the Federal Circuit's holding was supported by the notion that veterans should be afforded more procedural protections after the VJRA's enactment, not less.

Thus, absent any express indication from either Congress or the Federal Circuit that veterans in the context of an appeal should be afforded *less* procedural protections than were available to them before the VJRA's enactment, rather than more, we will not place such a restriction on this most favored class of citizens and their ability to pursue their disability benefits claims in the manner and fashion of their choosing. *See Henderson*, 562 U.S. at 441 ("We have long applied 'the canon that provisions for benefits to members of the Armed Services are to be construed in the beneficiaries' favor.'" (quoting *King v. St. Vincent's Hosp.*, 502 U.S. 215, 220-21 n.9 (1991))).

The dissent asserts that section 7252(a) "contains the nonwaivable, jurisdictional elements that a veteran must have both filed a claim and received a Board decision." *Post* at 49, 50. The dissent goes on to reason that "[t]he majority's focus on determining whether to waive the requirement of a Board decision is at best premature because it did not explain why it determined that our jurisdictional statute has waivable components." *Id.* But, the dissent misreads our decision. We do not today hold that the requirement of a final Board decision is waivable. Rather, we hold that because Mr. Skaar, as class representative, has obtained a final Board decision pursuant to section 7252, the jurisdictional door has been opened, and we may use our other authorities, as explained in *Monk II*, to aggregate Mr. Skaar's claims with those of the remaining class members.

Our reasoning can be analogized to a magistrate judge's exercise of jurisdiction over a class action. 28 U.S.C. § 636 is jurisdictional in nature, and, in sum, provides that a magistrate judge can exercise jurisdiction over proceedings in civil matters with the consent of the parties. *Roell v. Withrow*, 538 U.S. 580, 585-86 (2003). Yet, even though section 636 is jurisdictional in nature, a magistrate can enter judgment in a class action without each class member giving consent. *Koby v. ARS Nat'l Servs., Inc.*, 846 F.3d 1071, 1078-79 (9th Cir. 2017); *Day v. Persels & Assocs., LLC*, 729 F.3d 1309, 1324-25 (11th Cir. 2013); *Dewey v. Volkswagen Aktiengesellschaft*, 681 F.3d 170, 180-81 (3d Cir. 2012); *Williams v. Gen. Elec. Capital Auto Lease, Inc.*, 159 F.3d 266, 268-69 (7th Cir. 1998). Thus, the jurisdictional mandates of section 636(c) are satisfied when only the named plaintiff in a class action has consented to proceed before a magistrate.

The courts to have considered the issue of consent in a class action have not "waived" the jurisdictional requirement of consent. Rather, they have held that the jurisdictional requirement is satisfied for all class members through the named plaintiff providing consent. *Williams*, 159 F.3d at 269 ("[T]he named representative . . . is the 'party' to the lawsuit who acts on behalf of the entire class, including with regard to the decision to proceed before a magistrate judge. This is an inherent part of representational litigation."). We find that Mr. Skaar's satisfaction of our jurisdictional requirement of a final Board decision, *see* 38 U.S.C. § 7252(a), is sufficient to vest this Court with subject matter jurisdiction, much in the same way a named plaintiff's consent to proceed before a magistrate is sufficient to grant the magistrate jurisdiction to enter final judgment as to all class members.

ii. We may certify classes that include claimants without final Board decisions.

The Secretary argues we lack jurisdiction to certify a class of veterans that includes those without a final Board decision "[b]ecause a Board decision is a jurisdictional prerequisite to review in this Court[.]" Secretary's Resp. to Mot. for Class Certification at 5. Thus, in his view, we could never certify a class of veterans without first ensuring there is a final Board decision as to each veteran in the class. In support, he relies on three Social Security cases: *Weinberger v. Salfi*, 422 U.S. 749 (1975); *Yamasaki*, 442 U.S. at 682; and *City of New York*, 476 U.S. at 467. We examine each in turn.

In *Salfi*, the District Court certified a class of claimants challenging a Social Security regulation that required a marriage to have existed at least 9 months before the death of a wage earner for a surviving spouse to receive benefits. The District Court held jurisdiction was proper under 28 U.S.C. § 1331 (the general Federal question jurisdictional statute), certified the class, and held the regulation unconstitutional. On direct appeal, the Supreme Court reversed, finding jurisdiction lay under 42 U.S.C. § 405 instead. That statute requires a final decision after a hearing by the Secretary of Health and Human Services before claimants can appeal adverse Social Security decisions to a district court. The Court concluded the District Court erred by certifying a class that included claimants who had *not yet filed an application for benefits* because "the [class] complaint was deficient in that it contain[ed] no allegations that [claimants] ha[d] even filed an application with the Secretary, much less that he has rendered any decision, final or otherwise." But, the Court went on to also hold that the District Court did not err in certifying a class of claimants who *had filed a benefits application but had not yet been afforded a hearing*—a nonjurisdictional requirement of § 405(g). The Court reasoned that the exhaustion requirement was not necessary when the issue was one that would be futile to bring before an agency. When read in isolation, *Salfi* is clearly disadvantageous to the proposed class members who do not have final Board decisions. However, as we will see, the lack of a final agency decision for each of a proposed class's members was not a concern for the Court 11 years later in *City of New York*.

Although the Secretary argues *Yamasaki* weighs against our having jurisdiction over the proposed class, we find it inapposite. There, the Supreme Court was confronted with a nationwide class of Social Security claimants whom the Government had overpaid. The Government sought to recoup those overpayments by withholding the respondents' future benefits. The respondents requested reconsideration or waiver of the recoupment. Two district courts then certified a nationwide class of claimants and granted injunctive relief requiring the Agency to provide every class member with a pre-recoupment oral hearing. On appeal, the Court of Appeals for the Ninth Circuit affirmed. The Supreme Court needed to determine, among other things, whether section 405(g) "permits a federal district court to certify a nationwide class and grant injunctive relief." The Court concluded it did, reasoning Congress would have explicitly proscribed class actions in the Social Security context if it had intended to do so. *Yamasaki* is relevant here only to the extent the Court discusses the *relief* granted, not the lower courts' jurisdiction. The Court held "[w]ith respect to that relief, the classes certified were plainly too broad" as both classes "included persons who had not filed requests for reconsideration or waiver in the past and would not do so in the future." But that discussion was not key to the Court's holding, as it explained: "The Secretary's objection to the class definition is well taken, but it provides no basis for altering the relief actually granted in this case." 442 U.S. at 682. Thus, *Yamasaki* sheds no light on the question before us.

City of New York, however, bears a striking similarity to the matter before us. There, the Supreme Court considered a class of claimants challenging an internal policy of the Social Security Administration that operated to deny otherwise deserving claimants benefits to which they were entitled. "The gravamen of respondents' complaint was that petitioners had adopted an unlawful, unpublished policy under which countless deserving claimants were denied benefits." The District Court found the Government's internal policy invalid and certified a class that included both (i) claimants who had not appealed Social Security's decision within the required 60-day timeframe, thus requiring equitable tolling, and (ii) claimants who had not received a final agency decision. The Court of Appeals for the Second Circuit affirmed. 476 U.S. at 467.

The Supreme Court grappled with two issues in *City of New York*. The first, which we discuss elsewhere in this order, concerned whether the District Court erred by equitably tolling the statute of limitations for class members who had not timely appealed the Government's decision. The second issue, however, concerned whether the District Court lacked jurisdiction to certify a class that included claimants who had not received a final agency decision, as required by section 405(g). In *Salfi*, the Court called this requirement "central to the requisite grant of subject-matter jurisdiction" and, thus, claimants without a final decision could not be certified as part of a class. 422 U.S. at 764. But this time, in *City of New York*, the Court concluded section 405(g) was *not* a bar to class certification, even for claimants who had not received a final decision. This was so because (i) the class claims were "collateral to the claims for benefits that class members had presented administratively;" (ii) "the claimants . . . would be irreparably injured were the exhaustion requirement now enforced against them;" and (iii) "[t]he purposes of exhaustion would not be served by requiring these class members to exhaust administrative remedies." The Court further explained the class

> stand[s] on a different footing from one arguing merely that an agency incorrectly applied its regulation. Rather, the District Court found a systemwide, unrevealed policy that was inconsistent in critically important ways with established regulations. Nor did this policy depend on the particular facts of the case before it; rather, the policy was illegal precisely because it ignored those facts. . . . Under these unique circumstances, there was nothing to be gained from permitting the compilation of a detailed factual record, or from agency expertise.

> In addition, the relief afforded by the District Court is fully consistent with the policies underlying exhaustion. The court did not order that class members be paid benefits. Nor does its decision in any way interfere with the agency's role as the ultimate determiner of eligibility under the relevant statutes and regulations. Indeed, by ordering simply that the claims be reopened at the administrative level, the District Court showed proper respect for the administrative process. It did no more than the agency would have been called upon to do had it, instead of the District Court, been alerted to the charge that an undisclosed procedure was illegal and had improperly resolved innumerable claims.

476 U.S. at 485.

The Court also found its decision in *Mathews v. Eldridge* dispositive. There, the Court held "cases may arise where a claimant's interest in having a particular issue resolved promptly is so great that deference to the agency's judgment is inappropriate." 424 U.S. 319, 330 (1976). The Court in *City of New York* explained that "[t]wo factors influenced the Court's judgment that *Eldridge* was a case in which deference to the [A]gency's determination of finality was not necessary. First, the constitutional challenge brought there was 'entirely collateral to [a] substantive claim of entitlement.' Second, the claim rested 'on the proposition that full relief cannot be obtained' [as a result of the district court's decision]." 476 U.S. at 483 (citation omitted) (quoting *Eldridge*, 424 U.S. at 330-31). The *City of New York* Court was "especially sensitive to this kind of harm where the Government seeks to require claimants to exhaust administrative remedies merely to enable them to receive the procedure they should have been afforded in the first place." *Id.* at 484. The purposes of exhaustion include (i) permitting evidentiary development; (ii) allowing the agency to bring its expertise to bear on an issue before judicial review; and (iii) giving due respect to the agency's established procedures. *City of New York*, 476 U.S. at 486.

City of New York tells us an administrative exhaustion-of-remedies requirement can be waived where (i) the challenged conduct is collateral to a claim for benefits; (ii) enforcing the exhaustion requirement would irreparably harm the claimant; and (iii) the purposes of exhaustion would not be served by its enforcement. Turning to the instant appeal, we hold we have jurisdiction to certify a class action that includes members who do not have a final Board decision provided (i) the challenged conduct is collateral to the class representative's administratively exhausted claim for benefits—i.e., the class representative has obtained a final Board decision; (ii) enforcing the exhaustion requirement would irreparably harm the class; and (iii) the purposes of exhaustion would not be served by its enforcement.

Applying this test here, we have jurisdiction over the proposed class and will not require exhaustion of administrative remedies by each and every class member. First, jurisdiction over Mr. Skaar's appeal is proper under section 7252(a), for he has exhausted his administrative remedies, and the challenged conduct is collateral to both his and the unnamed class members' benefits claims because granting the requested relief would not be an "order that class members be paid benefits." *City of New York*, 476 U.S. at 486. "[A] claim is collateral when the 'plaintiffs' claims are essentially to the policy itself, not its application to them, nor to the ultimate substantive determination of their benefits.'" *Stengel v. Callahan*, 983 F. Supp. 1154, 1159 (N.D. Ill. 1997) (quoting *Johnson v. Sullivan*, 922 F.2d 346, 353 (7th Cir. 1990)). Second, the alleged harm here, if shown to be true, is precisely the type of "harm where the Government seeks to require claimants to exhaust administrative remedies merely to enable them to receive the procedure they should have been afforded in the first place" the Supreme Court was concerned with in *City of New York*. 476 U.S. at 484. And, finally, the purposes of exhaustion would not be served by enforcement of section 7252(a)'s exhaustion requirement on the unnamed class members. The parties have compiled and agreed on a detailed factual record containing the Board's findings and conclusions. VA, through the Board, has brought its agency expertise to bear by providing a supplemental statement of reasons or bases addressing Mr. Skaar's challenge to § 3.311. *See generally* Secretary's Mar. 29, 2019, Resp. And, if the requested relief is granted, our order would not "in any way interfere with the [A]gency's role as the ultimate determiner of eligibility under the relevant statutes and regulations." *See City of New York*, 476 U.S. at 486. Thus, we waive the exhaustion requirement for the Present-Future and Future-Future Claimants, permitting them to be included in the proposed class.

Our reading of this caselaw is consistent with class action adjudication in the veterans' benefits context before the VJRA's enactment. For example, the lack of final Board decisions was not an impediment to pre-VJRA class certification in *Nehmer*. There, a district court certified a class of veterans challenging VA's implementation of 38 U.S.C. § 354, the Dioxin and Radiation Exposure Compensation Act, even though "[n]one of the named plaintiffs presented the claims raised in this lawsuit to the VA, either during their individual claim adjudications or in a petition for rulemaking[.]" The court reasoned the class members did not need to exhaust administrative remedies because (i) although VA may have had expertise in creating its procedures, "it does not possess particular expertise in determining what procedures adhere to the statutory mandate of the Dioxin Act and the Administrative Procedure Act;" (ii) a full record would be available through discovery; (iii) "the Court's hearing of the plaintiff's claims will not engender disrespect for the [A]gency's procedures;" (iv) the likelihood of the plaintiff's success by exhausting their administrative remedies was "low" because "the VA itself has adopted a system-wide policy; any errors committed in adopting the policy were made by the VA itself, not an individual fact-finder;" (v) "the class attack on the VA's procedural irregularities is distinct from any individual's attack on their denial of benefits;" and (vi) requiring exhaustion of remedies would place a "substantial burden" on the class members. *Nehmer*, 118 F.R.D. at 113. *Nehmer*, which predated the VJRA, thus fits with our holding today and, again, there is "no persuasive indication that Congress intended to *remove* class action protection for veterans when it enacted the VJRA." *Monk II*, 855 F.3d at 1320 (emphasis in original).

iii. This Court is the appropriate forum to hear challenges that are collateral to a benefits claim.

The remaining class claim here is collateral to Mr. Skaar's claim for benefits. Veterans cannot preemptively bring such collateral claims to VA seeking only to invalidate a specific procedure or practice. Instead, their only avenue would be to proceed to exhaust their administrative remedies by asking the Board to provide relief it is powerless to give. *See* 38 U.S.C. § 7104(c) (Board decisions are "bound by the regulations of the Department"). Congress cannot have intended such a result. Requiring every class member to have a final Board decision when the Board is powerless to provide the relief sought does not comport with the principle that, when interpreting statutory finality requirements, "[t]he prevailing rule of construction is that crucial collateral claims should not be lost and that irreparable harm should be avoided." *Mental Health Ass'n of Minn. v. Heckler*, 720 F.2d 965, 969 (8th Cir. 1983). If veterans cannot aggregate actions to collaterally challenge alleged systemic wrongdoing before us, where should they seek such review? It is not enough to say Palomares veterans instead should have petitioned for rulemaking when the regulations at issue were drafted. *See* 38 U.S.C. § 553(e). If the class claim is proven, veterans could not have known and should not be required to have known their benefits claims would be subject to a legally invalid process. Thus, this Court is the appropriate forum to hear their collateral challenges to benefits claims.

Having concluded the Present, Present-Future, and Future-Future Claimants are members of the proposed class, we next consider the Expired Claimants.

2. The Expired Claimants

The Expired Claimants require a different analysis because they received final Board decisions but did not appeal them to this Court. Mr. Skaar asks us to exercise our discretion and waive section 7266(a)'s 120-day Notice of Appeal filing requirement, allowing their expired benefits claims to be revived before us, aggregated as part of the proposed class, and then, if the class prevails on the merits, returned to the Agency for readjudication. *See* Appellant's Mar. 21, 2018, Resp. at 3-4; s*ee also Bove v. Shinseki*, 25 Vet.App. 136, 140 (2011) (per curiam order), *overruled on other grounds by Dixon v. McDonald*, 815 F.3d 799 (Fed. Cir. 2016). We decline to do so.

As the Supreme Court explained in *Henderson*, section 7266(a)'s 120-day appeal window for obtaining review before this Court "does not have jurisdictional attributes" but nonetheless was "an important procedural rule," leaving it to us to determine whether and when waiver applied. 562 U.S. at 441. In *Bove*, we explained waiver is warranted "when circumstances precluded a timely filing despite the exercise of due diligence." 25 Vet.App. at 140. Those circumstances include (1) mental illness that renders one incapable of handling one's own affairs or other extraordinary circumstances beyond one's control; (2) reliance on incorrect statements by VA officials; or (3) misfilings at the regional offices or the Board. *See, e.g.*, *Brandenburg v. Principi*, 371 F.3d 1362, 1364 (Fed. Cir. 2004) (misfiling); *Barrett v. Principi*, 363 F.3d 1316, 1321 (Fed. Cir. 2004) (mental illness); *Bailey v. West*, 160 F.3d 1360, 1365-68 (Fed. Cir. 1998) (en banc) (incorrect statement by VA official); *McCreary v. Nicholson*, 19 Vet.App. 324 (2005) (extraordinary circumstances). But this is not an exhaustive list because there are no bright line rules in the equitable tolling context. As the Federal Circuit recently reminded us, "the extraordinary circumstances element [of equitable tolling] necessarily requires a case-by-case analysis and not a categorical determination." *James v. White*, 917 F.3d 1368, 1373 (Fed. Cir. 2019).[5]

The Supreme Court dealt with a similar issue in *City of New York*. Recall there the Court upheld certification of a class of Social Security claimants that included those who had not

[5] Given the case-by-case analysis equitable tolling requires and the prohibiting of the use of categorical rules under *James*, it is difficult to see how equitable tolling matters could be resolved through aggregate action. We leave for another day whether such a class would be appropriate, but the uncertainty on that question is an additional reason to exclude the Expired Claimants from the class here.

appealed adverse benefits determinations within the relevant appeal window. 476 U.S. at 486. The Court concluded equitable tolling was warranted. *Id.* at 482. This was so, the Court reasoned, because equitable tolling "served the purpose of the [Social Security] Act where . . . 'the Government's secretive conduct prevents plaintiffs from knowing of a violation of rights.'" *Id.* at 481 (quoting *City of New York v. Heckler*, 742 F.2d 729, 738 (1984)). *But see Pittson Coal Grp. v. Sebben*, 488 U.S. 104, 123 (1988) (finding equitable tolling was not warranted where "[t]he agency action was not taken pursuant to a secret, internal policy, but under a regulation that was published for all to see"). To the Court, the Government's conduct in *City of New York* represented one of the "cases [that] may arise where the equities in favor of tolling . . . are 'so great that deference to the agency's judgment [of finality] is inappropriate.'" 476 U.S. at 480 (quoting *Eldridge*, 424 U.S. at 330). Mr. Skaar essentially asks us to equate VA's adjudication of Palomares veterans' claims with the secretive conduct the Supreme Court found so reprehensible in *City of New York*, to extend *Bove* to such situations, and to allow equitable tolling here. We will not.

Including the Expired Claimants in the class offends the very notion of finality. Each of them received Board decisions and could have challenged VA's treatment of Palomares veterans just like Mr. Skaar, yet each chose not to. Mr. Skaar has presented no reason for us to depart from *Bove*'s principle that the 120-day Notice of Appeal window to this Court will only be waived "when circumstances precluded a timely filing despite the exercise of due diligence." 25 Vet.App. at 140. Indeed, he has never alleged the Expired Claimants were precluded from timely filing appeals to this Court for any reason other than VA's historical practice in adjudicating claims from Palomares veterans. But before a claimant succeeds in changing the law, VA will always (presumably) adjudicate claims in accord with its own interpretation of that law and our legal pronouncements. Thus, there is no principled way to distinguish the Expired Claimants here and *any* other claimants who have been denied benefits, failed to appeal to this Court, and later discovered their benefits denial was based on an incorrect reading of the law. The proper course for such claimants is to file supplemental claims based on new and relevant evidence with VA, *see* 38 C.F.R. § 3.2501, not to attempt to skirt finality and existing precedent merely because of the novel procedural nature of this case.

The unfair substantive legal advantage the Expired Claimants would enjoy if we permitted them to join the class is illustrated by a recent Court decision, *Ray v. Wilkie*, 31 Vet.App. 58 (2019). There, a panel of the Court held VA's historical practice of refusing to define a key regulatory phrase in 38 C.F.R. § 4.16(b) frustrated judicial review, warranting remand in cases where the phrase is undefined. *Id.* at 73-74. The *Ray* decision surely benefited the named appellant. And it also benefited any claims involving that regulation currently pending before the Court or VA. But it certainly provided no retrospective relief for claimants who had been denied benefits previously but whose appeal windows had expired.

Or consider this matter. Had Mr. Skaar filed the instant appeal, *not* sought class certification, and succeeded on the merits, his appeal would be decided through precedential decision. That decision would bind Mr. Skaar and any and all claimants with claims currently pending before VA and the Court (the Present, Present-Future Claimaints) as well as any claimants with claims filed in the future (Future-Future Claimants). But there would be no authority to support that precedential decision reviving expired claims, as Mr. Skaar asks us to do here.

At first glance, our exclusion of the Expired Claimants may seem unduly harsh. But claimants in the veterans benefits system do not face the same consequences of finality as litigants in traditional civil litigation. Instead, under 38 U.S.C. § 5108(a) and 38 C.F.R. § 20.1105(a), if the class succeeds on the merits, then the Expired Claimants can file supplemental claims based on new and relevant evidence. The Expired Claimants may not enjoy the same effective date protections as the other subgroups within the class, but they would still have an avenue to service connection available to them.

In sum, that this is a class action does not and should not change this analysis as the class action device is a *procedural* rule that, if we are to employ it, should not yield *substantive* legal benefits. We will not now excuse the Expired Claimants' lack of diligence in pursuing their claims, depart from precedent, and grant retrospective relief merely because this is a class action. Thus, we decline to equitably toll the Expired Claimants' claims and modify the proposed class to exclude them. *See* FED. R. CIV. P. 23(c)(5); *Suchanek*, 764 F.3d at 757; *Schorsch*, 417 F.3d at 750; *Robidoux*, 987 F.2d at 937.

3. The Past Claimants

The Past Claimants were denied by VA but never reached the Board because they did not perfect an administrative appeal. For our purposes, they are akin to the Expired Claimants in that they have no final Board decisions. But unlike the Expired Claimants, that is not because they failed to appeal their denials to this Court. Instead, these claimants were denied by some part of VA other than the Board. Thus, if they are to be included in the class, they require equitable tolling of their appellate review windows before VA. *See Jaquay v. Principi*, 304 F.3d 1276, 1286 (Fed. Cir. 2002), *overruled on other grounds by Henderson v. Shinseki*, 589 F.3d 1201 (Fed. Cir. 2009); *Hunt v. Nicholson*, 20 Vet.App. 519, 522 (2006) ("[T]he same principles that guided the Federal Circuit in allowing equitable tolling of the deadline for filing appeals to this Court apply with equal force to tolling the deadline for filing Substantive Appeals."). For the same reasons we decline to equitably toll the appeal windows for the Expired Claimants, we decline to do so for the Past Claimants as well and modify the proposed class to exclude them. There is simply no principled distinction between the proposed class here and any other individual challenge to VA action that warrants excusing the Past Claimants' lack of diligence in preserving their claims.

Considering Mr. Skaar lacks standing to bring the § 3.309 claim but possesses standing to pursue the § 3.311 claim and considering our exclusion of the Expired and Past Claimants from class certification, we must modify the proposed class definition. *See* FED. R. CIV. P. 23(c)(5); *see also Suchanek*, 764 F.3d at 757. Thus, we modify the proposed class definition as follows: *All U.S. veterans who were present at the 1966 cleanup of plutonium dust at Palomares, Spain, and whose application for service-connected disability compensation based on exposure to ionizing radiation VA has denied or will deny by relying, at least in part, on the findings of dose estimates requested under 38 C.F.R. § 3.311, except those whose claims have been denied and relevant appeal windows of those denials have expired, or those whose claims have been denied solely based on dose estimates obtained before 2001.* With this modified definition in mind, we now turn to the class certification analysis.

E. Class Certification Analysis

At this time, our Court has no rule of procedure governing class actions. Indeed, as far as we are aware, we are the only appellate court in the Nation with the authority to aggregate actions in the first instance. But while we are unique in that regard, we are not starting with a blank slate. As alluded to before, the Federal Rules of Civil Procedure provide for class actions in Rule 23. As we did in the petition context, *see Monk III*, 30 Vet.App. at 174, we adopt Rule 23 as a guide for class certification in the appeal context. Also, as with petitions, *see id.*, we have at least some limited factfinding ability in the context of determining whether a class should be certified.

"Rule 23 does not set forth a mere pleading standard. A party seeking class certification must affirmatively demonstrate his [or her] compliance with the Rule[.]" *Wal-Mart Stores, Inc. v. Dukes*, 564 U.S. 338, 350 (2011). A party seeking class certification must demonstrate by a preponderance of the evidence the four requirements of Rule 23(a), and at least one of the requirements of Rule 23(b).[6] *See N.J. Carpenters Health Fund v. Rali Series 2006-Q01 Tr.*, 477 F. App'x 809, 812 (2d Cir. 2012); *see also Wal-Mart Stores, Inc.*, 564 U.S. 338 at 351 ("A party seeking class certification . . . must be prepared to prove that there are *in fact* sufficiently numerous parties, common questions of law or fact, etc.") (emphasis in original).

Rule 23(a) requires (1) the class be "so numerous that joinder of all members is impracticable;" (2) there be common questions of law or fact; (3) the claims or defenses of the named representative be typical of the class; and (4) the class representatives "fairly and adequately protect the interests of the class." FED. R. CIV. P. 23(a). These requirements "effectively 'limit[] the class claims to those fairly encompassed by the named plaintiff's claims.'" *Falcon*, 457 U.S. at 156 (quoting *Gen. Tel. Co. of Sw. v. EEOC*, 446 U.S. 318, 330 (1980)). Rule 23(b)(2), the relevant subsection here, states class actions are appropriate when "the party opposing the class has acted or refused to act on grounds that apply generally to the class, so that final injunctive or corresponding declaratory relief is appropriate respecting the class as a whole." Taken together, the Rule 23 analysis tells us "whether the named plaintiff's claim and the class are so interrelated that the interests of the class members will be fairly and adequately protected in their absence," while protecting defendants' rights. *Falcon*, 457 U.S. at 157.

We must conduct "a rigorous analysis" of the proposed class, *Falcon*, 457 U.S. at 160-61, that may "entail some overlap with the merits of the plaintiff's underlying claim" as the "class determination generally involves considerations that are enmeshed in the factual and legal issues comprising the plaintiff's cause of action," *Comcast Corp. v. Behrend*, 569 U.S. 27, 33 (2013).

---

[6] Although not explicitly listed under Rule 23, many courts have required that class membership be "ascertainable." *See, e.g.*, *Ward v. EZCorp, Inc.*, 679 F. App'x. 987 (11th Cir. 2017); *Leyse v. Lifetime Entm't Servs., LLC*, 679 F. App'x 44, 47 (2d Cir. 2017); *Sandusky Wellness Ctr., LLC v. Medtox Sci., Inc.*, 821 F.3d 992, 996 (8th Cir. 2016); *Mullins v. Direct Dig., LLC*, 795 F.3d 654, 659 (7th Cir. 2015); *see also McKeage v. TMBC, LLC*, 847 F.3d 992, 998 (8th Cir. 2017) ("A class may be ascertainable when its members may be identified by reference to objective criteria."); *Rikos v. Procter & Gamble Co.*, 799 F.3d 497, 525 (6th Cir. 2015). We need not weigh in on this debate here because it is clear ascertainability is not required for Rule 23(b)(2) classes such as the one at issue here. *See Shook v. El Paso City*, 386 F.3d 963, 972 (10th Cir. 2004) ("while the lack of identifiability is a factor that may defeat Rule 23(b)(3) class certification, such is not the case with respect to class certification under Rule 23(b)(2)"); *Yaffe v. Powers*, 454 F.2d 1362, 1366 (1st Cir. 1972); *Shelton v. Bledsoe*, 775 F.3d 554, 561 (3d Cir. 2015); *Cole v. City of Memphis*, 839 F.3d 530, 541-42 (6th Cir. 2016).

But, crucially, "[i]n determining the propriety of a class action, the question is not whether the plaintiff or plaintiffs have stated a cause of action or will prevail on the merits, but rather whether the requirements of Rule 23 are met." *Eisen v. Carlisle & Jacquelin*, 417 U.S. 156, 177-78 (1974). "Rule 23 grants courts no license to engage in free-ranging merits inquiries at the certification stage." *Amgen, Inc. v. Conn. Ret. Plans & Tr. Funds*, 568 U.S. 455, 466 (2013). Instead, "[m]erits questions may be considered to the extent—and only to the extent—that they are relevant to determining whether the Rule 23 prerequisites for class certification are satisfied." *Id.* As we explain below, the proposed class meets the requirements for class certification for the remaining class claim.

1. The proposed class is so numerous that joinder would be impracticable.

To warrant certification under the Federal Rules of Civil Procedure, the proposed class must be "so numerous that joinder of all members is impracticable." FED. R. CIV. P. 23(a)(1). This requirement is a bit of a square peg in a round hole at this Court. In Federal district court, parties have numerous devices they may use to "join" additional parties. *See, e.g.*, FED. R. CIV. P. 19 (mandating joinder of certain parties), 20 (allowing joinder of certain other parties), 22 (interpleader), 24 (intervention). The rules thus make the class action a more exceptional device with stringent requirements because there are alternative means for parties to join others in a proceeding that do not require the binding of absent parties. We have no comparable joinder devices.[7] Thus, asking if joinder in an appeal is "impracticable" does not make the same sense here as doing so in a district court. If anything, given the difficulty in terms of "joinder" before our Court, the numerosity standard would likely be met on a lesser showing than in a district court. In any event, it is met here under any standard.

Numerosity need not be proven exactly. *See, e.g.*, *Hinman v. M&M Rental Ctr., Inc.*, 545 F. Supp. 2d 802, 806 (N.D. Ill. 2008). "[C]ourts generally find that the numerosity factor is satisfied if the class comprises 40 or more members and will find that it has not been satisfied when the class comprises 21 or fewer." *Celano v. Marriott Int'l, Inc.*, 242 F.R.D. 544, 549 (N.D. Cal. 2007); *see Lightfoot v. District of Columbia*, 246 F.R.D. 326, 335 (D.D.C. 2007) ("Courts in this District have generally found that the numerosity requirement is satisfied and that joinder is impracticable where a proposed class has at least forty members."). But "[t]here is no minimum number of members needed for a suit to proceed as a class action." *Marcus v. BMW of N. Amer., LLC*, 687 F.3d 583, 595 (3d Cir. 2012). "[I]t is permissible for a plaintiff to make reasonable inferences drawn from available facts" and "an 'information monopoly [by the party opposing the class] will not stand in the way of persons seeking relief.'" *Violette v. P.A. Days, Inc.*, 214 F.R.D. 207, 213 (S.D. Ohio 2003) (quoting *Jackson v. Foley*, 156 F.R.D. 538, 542 (E.D.N.Y. 1994)). Additionally, the numerosity requirement is relaxed for classes seeking injunctive relief. *Sueoka v. United States*, 101 F. App'x. 649, 653 (9th Cir. 2004) ("Because plaintiffs seek injunctive and declaratory relief, the numerosity requirement is relaxed and plaintiffs may rely on the reasonable inference arising from plaintiffs' other evidence that the number of unknown and future members . . . is sufficient to make joinder impracticable."). And although "[n]umerosity is more than a numbers game," *Howard's Rexall Stores, Inc. v. Aetna U.S. Healthcare, Inc.*, No. CIV. oo-CV-

---

[7] Indeed, our rules do not even expressly *allow* for joinder, much less describe how parties are to seek it. Thus, in so far as the numerosity requirement asks whether "joinder of all members is impracticable," it would appear to always be answered in the affirmative in proposed class actions before us until we craft such a rule.

31B, 2001 WL 501055, at *6 (D. Me. May 8, 2001), "[w]hen class size reaches substantial portions, . . . the impracticability requirement is usually satisfied by numbers alone." *In re Am. Med. Sys., Inc.*, 75 F.3d 1069, 1079 (6th Cir. 1996).

In response to a Court order requesting more information, the Secretary stated that, per the Department of Defense, 1,388 U.S. military personnel participated in the Palomares nuclear cleanup. *See* Secretary's Dec. 13, 2018, Resp. The order also asked him to provide information relating to certain categories of veterans in the proposed class. But instead, the Secretary explained VA's "internal databases are not equipped to furnish the Court with the number of veterans falling within the" class's various subcategories. *Id.* In reply, Mr. Skaar questioned the Secretary's compliance with our order and noted the record reflects there are "at least nineteen veterans who had filed claims for Palomares-related disabilities with the VA, 'including three appeals for reassessment for a total of 22 claims.'" Appellant's Jan. 4, 2019, Resp. at 3 (quoting R. at 1580). Given the overall number of veterans present at Palomares, the relaxed numerosity standard for classes seeking injunctive relief, *see Sueoka*, 101 F. App'x. at 653, and Mr. Skaar's additional information concerning the claims made, we may reasonably infer the proposed class contains potentially up to 1,388 veterans and at least 22, a number sufficient to satisfy the numerosity requirement. *See, e.g.*, *Lightfoot*, 246 F.R.D. at 335. Thus, we hold the class satisfies the numerosity requirement.

2. The proposed class presents a common issue capable of classwide resolution.

The second Rule 23 requirement for class certification, commonality, "requires the plaintiff to demonstrate that the class members have suffered the same injury. This does not mean merely that they have all suffered a violation of the same provision of law." *Wal-Mart*, 564 U.S. at 350. Rather, "[t]heir claims must depend upon a common contention." *Id.* "That common contention, moreover, must be of such a nature that it is capable of classwide resolution – which means that determination of its truth or falsity will resolve an issue that is central to the validity of each one of the claims in one stroke." *Id.* "[F]or purposes of Rule 23(a)(2) [e]ven a single [common] question will do." *Id.* "What matters to class certification . . . [is] the capacity of a classwide proceeding to generate common answers apt to drive the resolution of the litigation." *Id.* "The critical point is 'the need for *conduct* common to members of the class.'" *Suchanek*, 764 F.3d at 756 (quoting *In re IKO Roofing Shingle Prods. Liab. Litig.*, 757 F.3d 599, 602 (7th Cir. 2014)) (emphasis in original). "Where the same conduct or practice by the same defendant gives rise to the same kind of claims from all class members, there is a common question." *Suchanek*, 764 F.3d 750, 756 (7th Cir. 2014); *see In re Nat'l Football League Players Concussion Injury Litig.*, 821 F.3d 410 (3d Cir. 2016).

The Secretary concedes the proposed class would satisfy the commonality requirement if the class is limited "to include only those veterans whose applications [for service-connected disabilities] were denied based on § 3.311[.]" *See* Secretary's Feb, 20, 2018, Resp. at 17. Considering our dismissal of the class challenge to § 3.309 and corresponding modification of the class definition, this is an effective concession of commonality as to the class challenge under § 3.311 as only "those veterans whose applications were denied based on § 3.311" would qualify as class members. Further, we agree commonality is met for this claim. The class members' claims "depend upon a common contention"—that VA's dose estimate procedures do not rely on "sound scientific and medical evidence" in contravention to § 3.311(c)(1)(i)—that "is capable of classwide resolution"—in the form of an order enjoining the Secretary from denying claims under § 3.311 until VA's procedures comply with the regulation. *Wal-Mart*, 564 U.S. at 350.

3. Mr. Skaar's claim is typical of that of the proposed class.

Class certification also requires that "the claims or defenses of the representative parties are typical of the claims or defenses of the class." FED. R. CIV. P. 23(a)(3). This inquiry focuses on whether "in pursuing his own claims, the named plaintiff will also advance the interests of the class members." *In re Am. Med. Sys.*, 75 F.3d 1069, 1082 (6th Cir. 1996). Or, put differently, "as goes the claim of the named plaintiff, so go the claims of the class." *Sprague v. Gen. Motors Corp.*, 133 F.3d 388, 399 (6th Cir. 1998). Although distinct, the typicality requirement overlaps with certain other requirements of Rule 23(a). In particular, "[t]he commonality and typicality requirements . . . tend to merge." *Falcon*, 457 U.S. at 157 n.13.

Courts will deny class certification "when the variation in claims" between a class representative and absent class members "strikes at the heart of the respective causes of actions." *Deiter v. Microsoft Corp.*, 436 F.3d 461, 466-67 (4th Cir. 2006). The class representative's claims need not be identical, but must "share the same essential characteristics as the claims of the class at large." *Haggart v. United States*, 89 Fed. Cl. 523, 534 (2009); *Arreola v. Godinez*, 546 F.3d 788, 798 (7th Cir. 2008). "The test of typicality 'is whether other members have the same or similar injury, whether the action is based on conduct which is not unique to the named plaintiffs, and whether other class members have been injured by the same conduct.'" *Wolin v. Jaguar Land Rover N.A., LLC*, 617 F.3d 1168, 1175 (9th Cir. 2010) (quoting *Hanon v. Dataproducts Corp.*, 976 F.2d 497, 508 (9th Cir. 1992)). "[T] he typicality prong of Rule 23(a) sets a relatively low threshold." *Karvaly v. eBay, Inc.*, 245 F.R.D. 71, 82 (E.D.N.Y. 2007); *see, e.g.*, *Stirman v. Exxon Corp.*, 280 F.3d 554, 562 (5th Cir. 2002); *Lightbourn v. Cnty. of El Paso, Tex.*, 118 F.3d 421, 426 (5th Cir. 1997). Typicality is also easier to satisfy where classes seek injunctive relief. *See Baby Neal ex. Rel. Kanter v. Casey*, 43 F.3d 48 (3d Cir. 1994).

The Secretary argues Mr. Skaar's claim is not typical enough to permit him to serve as class representative because the reason for any denials of Palomares veterans' claims related to ionizing radiation exposure may not turn on the results of dose estimates requested under § 3.311. *See* Secretary's Feb. 20, 2018, Resp. at 17-19; Secretary's July 27, 2018, Resp. at 8-11. Much like any concerns regarding commonality and standing, this concern is alleviated by our restructuring of the class. As explained above, because we are dismissing the class challenge to § 3.309 for lack of standing, the only issue before us concerns those claims that have either been denied or will be denied under § 3.311.

And as discussed above regarding Mr. Skaar's standing to represent the class, the Secretary's argument that Mr. Skaar lacks standing to represent class members whose claims had been denied under the Air Force's pre-2013 methodology also presents potential typicality concerns. But, as we explained, the pre- and post-2013 distinction is largely theoretical. Put simply, Mr. Skaar shares the same injury from VA's reliance on Air Force's dose estimates as any conceivable claimant falling within the modified class. Thus, his claim "share[s] the same essential characteristics as the claims of the class at large," and his claim is typical enough to permit him to serve as class representative. *Haggart*, 89 Fed. Cl. at 534.

4. Mr. Skaar will fairly and adequately protect the interests of the class.

The final Rule 23(a) inquiry asks whether "the representative parties will fairly and adequately protect the interests of the class." FED. R. CIV. P. 23(a)(4). "A decision with respect to the class is conclusive only if the absent members were adequately represented by the named litigants and class counsel." *In re Bridgestone/Firestone, Inc., Tires Prods. Liab. Litig.*, 333 F.3d 763, 768 (7th Cir. 2003), *abrogated on other grounds by Smith v. Bayer Corp.*, 564 U.S. 299 (2011).[8] "Adequacy is twofold: the proposed class representative must have an interest in vigorously pursuing the claims of the class, and must have no interests antagonistic to the interests of other class members." *In re Literary Works in Elec. Databases Copyright Litig.*, 654 F.3d 242, 249 (2d Cir. 2011). Thus, "[t]he adequacy inquiry under Rule 23(a)(4) serves to uncover conflicts of interest between named parties and the class they seek to represent." *Amchem Prods., Inc. v. Windsor*, 521 U.S. 591, 626 (1997). Class representatives serve as fiduciaries for certified classes. *See London v. Wal-Mart Stores, Inc.*, 340 F.3d 1246, 1254 (11th Cir. 2003).

To be adequate, class representatives must possess the claim asserted on behalf of the class, have interests otherwise aligned with and not antagonistic to those of the class, and be able to advocate vigorously and competently for the interests of the class. *See Kirkpatrick v. J.C. Bardford & Co.*, 827 F.2d 718, 727 (11th Cir. 1987). For much of the same reasons typicality and commonality are present here, we hold Mr. Skaar is adequate to serve as class representative. He possesses the same claim as the unnamed class members, his interest in VA complying with § 3.311(c)(1)(i) is aligned with the class, and there is no indication he is unable to vigorously and competently advocate for the interests of the class. *Id.* Moreover, we see no conflict of interest that would prevent Mr. Skaar from advancing the interests of the class.

5. The requested injunctive relief is appropriate respecting the class as a whole.

Federal Rule of Civil Procedure 23(b)(2) permits aggregation when all Rule 23(a)'s perquisites have been met, and "the party opposing the class has acted or refused to act on grounds that apply generally to the class, so that injunctive relief or corresponding declaratory relief is appropriate respecting the class as a whole." The Supreme Court has instructed that "[t]he key to the (b)(2) class is 'the indivisible nature of the injunctive or declaratory remedy warranted – the notion that the conduct is such that it can be enjoined or declared unlawful only as to all of the class members or as to none of them." *Wal-Mart*, 564 U.S. at 360 (quoting Richard A. Nagareda, *Class Certification in the Age of Aggregate Proof*, 84 N.Y.U. L. REV. 97, 132 (2009)). Rule 23(b)(2) requires that "a single injunction or declaratory judgment . . . provide relief to each member of the class." *Id.* Thus, if there are class members who would not benefit from a class-wide injunction (or declaration), certification under Rule 23(b)(2) would not be appropriate. *See Jennings v. Rodriguez*, 138 S. Ct. 830, 852 (2018) (commenting in action concerning claims by detained aliens that, because some members of the class may not be entitled to the requested relief, certification under Rule 23(b)(2) might be inappropriate).

[8] We consider the adequacy of class counsel below.

We hold the proposed class meets Rule 23(b)(2)'s requirements for certification. The class seeks a single class-wide injunction ordering VA to comply with the provisions of § 3.311. And with the dismissal of the class challenge to § 3.309 and the restriction of the class to those claimants who have been or will be subject to § 3.311, there is no question that, if the class succeeds on the merits, "injunctive relief or corresponding declaratory relief"—in the form of an order from this Court to the Secretary that he comply with the provisions of § 3.311—"is appropriate respecting the class as a whole." FED. R. CIV. P. 23(b)(2).

6. The class action device is a superior method of litigating the class claim.

Having concluded Rule 23(a) and Rule 23(b)(2) are satisfied, we could stop our certification analysis were we sitting as a district court. However, we are not. We have used Rule 23 as a "guide" for class certification. But we are not bound by it. *See Int'l Union, UAW, Local 283 v. Scofield*, 382 U.S. 205, 217 n.10 (1965) (the "Federal Rules of Civil Procedure . . . apply only in the federal district courts"); FED. R. CIV. P. 1 ("These rules govern the procedure in the United States district courts."). As we mentioned earlier in our discussion, to our knowledge, we are the only appellate body in the Nation with the authority to aggregate actions in the first instance. Our appellate nature and national jurisdiction make us stand apart from the ordinary course of aggregate litigation in Federal district courts, which are empowered to find facts and conduct discovery while we are not, absent some limited circumstances. *See* 38 U.S.C. § 7261(c) ("In no event shall findings of fact made by the Secretary or the Board of Veterans' Appeals be subject to trial de novo by the Court."); § 7252(b) ("Review in the Court shall be on the record of proceedings before the Secretary and the Board."); *but see Monk III*, 30 Vet.App. at 171 (holding this Court "has authority to conduct limited factfinding to determine whether class certification is warranted"); *Bove*, 25 Vet.App. at 143 ("[T]his Court . . . may seek facts outside the record before the Board and independently weigh the facts to determine if equitable tolling is appropriate."); *Erspamer v. Derwinski*, 1 Vet.App. 3, 10 (1990) (Court may consider facts not before the Board when considering the merits of a petition for extraordinary relief). Moreover, we are different than district courts because we can issue precedential decisions that bind those not before the Court. In other words, unlike district courts, our decisions can have something like the effect of a class action judgment without receiving class treatment.

As we explain below, class actions before us will serve as a special procedural device for certain types of claims that lend themselves to aggregate adjudication. This is because class actions "conserve judicial resources by allowing courts to treat common claims together, obviating the need for repeated adjudications of the same issues." *Cochran v. Volvo Grp. N.A., LLC*, No. 1:11-CV-927, 2013 WL 1729103, at *1 (M.D.N.C. Apr. 22, 2013). They also relieve absent class members from having to bring and litigate complex claims individually. "[A]n absent class-action plaintiff is not required to do anything. He [or she] may sit back and allow the litigation to run its course, content in knowing that there are safeguards provided for his [or her] protection." *Phillips Petroleum Co. v. Shutts*, 472 U.S. 797, 810 (1985). Especially in an adjudicatory system involving large numbers of unrepresented claimants, class actions may allow claimants, such as Mr. Skaar, who have the resources, knowledge, and desire to challenge VA conduct and regulations to step forward and represent similarly situated claimants and, through notice of certification, educate other class members about the existence of a legal claim against the VA. *See Watkins v. Simmons & Clark, Inc.*, 618 F.2d 398, 404 (6th Cir. 1980).

But our unique nature requires considerations beyond those applicable to district courts under Rule 23. Just as there are reasons in favor of exercising our discretion to certify a class in a particular matter, so, too, are there reasons counseling against certification. In *Harrison*, we declined to adopt class action procedures because (i) we believed we lacked the power to adopt such procedures; (ii) the potential difficulties in managing class actions in the first instance at the appellate level; and (iii) the availability of precedential decision-making as a superior form of litigation. 1 Vet.App. at 439. As we stated in *Monk III*, the Federal Circuit has expressly overruled *Harrison*'s first factor, lack of authority. 30 Vet.App. at 171 n.5. In *Monk III*, we declined to decide whether the remaining two *Harrison* factors were appropriate considerations for class certification. *Id.* We now explain that the remaining two *Harrison* factors—manageability and the availability of precedential decisions—stem from the unique nature of this Court and are relevant considerations in the class certification analysis before this Court, even if they are not *categorical* reasons to decline to certify class actions.

While we recognize for traditional Rule 23(b)(2) class actions, "superiority [is] self-evident," *Wal-Mart*, 564 U.S. at 363, our national jurisdiction makes the inquiry different here. Requiring claimants to justify the use of the class action device considering the available alternatives, such as single-party precedential decisions, consolidation, petitions for rulemaking, and the ability to issue writs of mandamus, is necessary to justify the expenditure of judicial time and energy required to adjudicate class actions as an appellate court in the first instance and assume the risk of prejudicing the rights of absent veterans. *See Pipefitters Local 636 Ins. Fund v. Blue Cross Blue Shield*, 654 F.3d 618, 630-31 (6th Cir. 2011). Thus, considering our appellate nature and limited factfinding abilities and guided by Rule 23, class actions before this Court are the exception, not the rule. In other words, we will presume classes should not be certified because our ability to render binding precedential decisions ordinarily will be adequate. Claimants seeking class certification can rebut this presumption by showing by a preponderance of the evidence that a class action is "superior to other available methods for fairly and efficiently adjudicating the controversy" before we will exercise our discretion in certifying a class. FED. R. CIV. P. 23(b)(3). This is a "fact-specific analysis" that "will vary depending on the circumstances of any given case." *Madison v. Chalmette Ref., L.L.C.*, 637 F.3d 551, 555 (5th Cir. 2011).

Rule 23(b)(3) lists several factors for determining the superiority of a class action. This is at least a useful starting point. Of these, only 23(b)(3)(D) is relevant here.[9] That factor addresses "the likely difficulties in managing a class action," a highly relevant concern given our previously

[9] Subsection (A) looks at "the class members' interests in individually controlling the prosecution or defense of separate actions. FED. R. CIV. P. 23(b)(3)(A). But absent claimants are already bound by our precedential decisions, *see* 38 U.S.C. § 7269, and thus we need not require this factor. Subsection (B) considers "the extent and nature of any litigation concerning the controversy already begun by or against class members." FED. R. CIV. P. 23(b)(3)(B). Our national jurisdiction addresses this factor. *See* 38 U.S.C. § 7269. Duplicative legal issues can already be brought in this Court and we have adequate means to address them. *See* U.S. VET. APP. R. 5(a)(3) (allowing us to stay matters pending before the Court "in the interest of judicial efficiency"). Finally, subsection (C) is not relevant here as we are the appropriate forum for claimants to challenge VA's denial of benefits. *See* FED. R. CIV. P. 23(b)(3)(C) (listing "the desirability or undesirability of concentrating the litigation of claims in the particular forum" as a 23(b)(3) factor); *see also* 38 U.S.C. §§ 7252, 7261.

discussed limitations. FED. R. CIV. P. 23(b)(3)(D). Manageability "encompasses the whole range of practical problems that may render the class action format inappropriate for a particular suit." *Eisen*, 417 U.S. at 164. Courts have declined to certify classes because of manageability concerns where individual class members brought claims in different states under different state laws, *see Riordan v. Smith Barney*, 113 F.R.D. 60, 66 (N.D. Ill. 1986); communication with some class members would be unduly difficult, *see Mateo v. The M/S Kiso*, 805 F. Supp. 761, 774 (N.D. Cal. 1991); individual damages calculations would be too complex, *see Abrams v. Interco, Inc.*, 719 F.2d 23, 31 (2d Cir. 1983); the class required too many individualized determinations, *see Danvers Motor Co., Inc. v. Ford Motor Co.*, 543 F.3d 141, 149 (3d Cir. 2008); and the sheer size of the class made effecting notice and providing opt out rights unmanageable, *see Gaffney v. United States*, 834 F. Supp. 1, 6 (D.D.C. 1993). Importantly, the "focus is not on the convenience or burden of a class action suit *per se*, but the relative advantages of a class action suit over whatever other forms of litigation might be realistically available" to claimants. *Klay v. v. Humana, Inc.*, 382 F.3d 1241, 1269 (11th Cir. 2004); *see also Johnston v. HBO Film Mgmt.*, 265 F.3d 178, 194 (3d Cir. 2001) (class action must represent the best available method for fair and efficient adjudication to warrant certification). But again, we only use Rule 23 as a guide. It is imperfectly crafted for our appellate setting and Rule 23(b)(3)(D)'s baseline is only the starting point of our analysis. In the balance of this section, we provide a non-exhaustive set of factors we will consider when deciding if a claimant has rebutted the presumption against aggregate action.

After canvassing federal class action jurisprudence and considering our unique appellate nature, we hold that, when considering whether the presumption against aggregate action has been rebutted, the Court will consider, as appropriate, whether (i) the challenge is collateral to a claim for benefits; (ii) litigation of the challenge involves compiling a complex factual record; (iii) the appellate record is sufficiently developed to permit judicial review of the challenged conduct; and (iv) the putative class has alleged sufficient facts suggesting a need for remedial enforcement. No one of these factors is more or less important than the others, rather the Court must engage in a case-by-case balancing to determine whether class certification is appropriate.

The first factor, whether the challenge is collateral to a claim for benefits, focuses on whether "the 'plaintiffs' claims are essentially to the policy itself, not its application to them, nor to the ultimate substantive determination of their benefits.'" *Stengel*, 983 F. Supp. at 1159 (quoting *Johnson*, 922 F.2d at 346). Such claims are "not essentially a claim for benefits" because they do "not merely challeng[e] the merits of the" agency's ultimate benefits determination. *Id.* In appeals involving clear regulatory or constitutional attacks on VA's application of a regulation such as this one, determining whether a matter is collateral will likely involve a simpler analysis than those instances where the regulatory or constitutional challenge is necessarily intertwined with VA's merits determination. Thus, the proper focus is whether the class challenge "is bound up with the merits so closely that our decision would constitute 'interference with agency process.'" *Johnson*, 922 F.2d at 353 (quoting *Salfi*, 422 U.S. at 765).

The second factor, whether litigation of the challenge involves compiling a complex factual record, is meant to reserve the class device for challenges that will likely require extensive record development at the Agency beyond the class representative's individual benefits claim. Without such factual development, many claimants could find it extraordinarily difficult to litigate such challenges as they would lack the ability to obtain the information necessary to substantiate the class claims. Additionally, class certification centralizes litigation in a single appellate record, obviating the need for unnamed class members to collect evidence or request information from VA and for VA to adjudicate duplicative information requests.

The third factor requires considering whether the record is sufficiently complete for adjudication. This reflects the fact that "the focal point for judicial review [of agency conduct] should be the administrative record already in existence, not some new record made initially in the reviewing court." *Camp v. Pitts*, 411 U.S. 138, 142 (1973). Further, the putative class representatives have control over this factor as ordinarily the completeness of the record is strongly influenced by claimants expressly raising arguments before the Board and entering relevant evidence into the record. As stated above, we do, just as in the petition context, have some limited factfinding ability when deciding motions for class certifications in the appeal context. *See Monk III*, 30 Vet.App. at 174. But factfinding is "typically unnecessary to judicial review of agency decisionmaking." *Fla. Power & Light Co. v. Lorion*, 470 U.S. 729, 744 (1985). This is doubly so for our court, which, as discussed, has unique limitations on its factfinding ability above and beyond those of a federal district court. *See* 38 U.S.C. §§ 7261(c), 7252(b). *But see Monk III*, 30 Vet.App. at 171; *Bove*, 25 Vet.App. at 143; *Erspamer*, 1 Vet.App. at 10. Thus, the extent to which a proposed class will require additional factfinding is an important consideration in determining whether the presumption against aggregate action is rebutted.

The final factor deals with enforcement. When this Court issues a favorable precedential decision, it certainly binds VA in all pending and future claims. *See* 38 U.S.C. § 502. But claimants not party to that decision who may be subject to errors affecting their rights, whether due to VA's non-compliance with our decision at a later date or otherwise, do not have any right to prompt remedial enforcement. Their only recourse is bringing the allegedly invalid agency action before us by fully exhausting agency review before filing a notice of appeal. And in some cases, this will be an ordinary feature of litigation. But where the facts suggest a need for prompt remedial enforcement, claimants may instead seek class certification. This is a fact-specific analysis that will vary based on the unique facts of each individual appeal. So, for example, one need not find that the Agency is likely to disobey—we find such willful noncompliance unlikely in all but the most extreme case. Instead, a special need for remedial enforcement might be the result of the class members' age or some similar factor suggesting the need for especially timely relief.

Applying these factors here, class certification is the superior method for litigating the remaining class claim. The class claim is collateral to Mr. Skaar's claim for benefits because it challenges VA's adherence to a generally applicable regulation and is not "bound up with the merits [of Mr. Skaar's claim for disability benefits] so closely that our decision would constitute 'interference with agency process,'" *Johnson*, 922 F.2d at 353 (quoting *Salfi*, 422 U.S. at 765), as a favorable decision on the merits would not be an "order that class members be paid benefits" nor would it "in any way interfere with the agency's role as the ultimate determiner of eligibility" for benefits. *City of New York*, 476 U.S. at 485. In fact, a merits decision in the class's favor would do "no more than the agency would have been called upon to do had it, instead of [us], been alerted to the" alleged deficiencies in the Air Force's dose estimate methodologies. *Id.* Thus, this factor weighs in favor of certification.

So, too, does the second. The record in this case is complex and voluminous, containing numerous documents related to technical and scientific matters, *e.g.*, R. at 2635-50, 2682-3501, and decades old records, *e.g.*, R. at 3558-4148. Centralizing the class challenge in one litigation strikes us as a far better use of our limited judicial resources and avoids the specter of both unnamed class members and VA engaging in duplicative record development.[10]

The third factor also weighs in favor of certification. Mr. Skaar and the proposed class have submitted scientific evidence challenging the validity of the Air Force's dose estimates. *See* R. at 2635-50. We are also equipped with the Board's supplemental statement addressing Mr. Skaar's challenge to VA's adherence to § 3.311. *See generally* Secretary's Mar. 29, 2019, Resp. We require no additional information to decide the class challenge on the merits. Importantly, if the class sought not only to challenge VA's compliance with § 3.311 but *also* proffered an alternative dose methodology, we would likely require significant amounts of additional information such that class certification could prove impractical. However, here, the record is complete.

Finally, the class has alleged sufficient facts suggesting a need for timely remedial enforcement, and thus the final factor also weighs in favor of certification. The Palomares nuclear cleanup occurred on January 17, 1966, nearly 54 years ago. The advanced age of the class members, especially considering they all must suffer from a radiogenic disability to qualify, suggests a need for the availability of prompt remedial enforcement. VA already considers claimants' ages when determining whether to expedite appeals. *See* 38 U.S.C. § 7107. Thus, we think it an apt consideration in the class certification context as well. Additionally, the requested relief is identical across the class—a Court order to VA that it comply with § 3.311. It is more efficient and prudent to administer the requested class relief here collectively through an orderly and consistent process amenable to judicial supervision, rather than through piecemeal litigation.

All four factors weigh in favor of certification. Thus, we hold class certification is a superior method of litigating the remaining class claim.

7. Proposed counsel is adequate.

Having now concluded a class action is appropriate in this appeal as to the § 3.311 claim, we turn to the appointment of class counsel who is adequate to protect the interests of absent class members. Although Rule 23(a)(4) historically included an analysis of the adequacy of class counsel, that inquiry is now codified in 23(g). *See Sheinberg v. Sorensen*, 606 F.3d 130, 132-35 (3d Cir. 2010). Despite the rule change, the analysis is largely the same. *See Kalish v. Karp & Kalamotousakis, LLP*, 246 F.R.D. 461, 463 (S.D.N.Y. 2007). The Rule provides a set of factors courts must consider when judging class counsel's adequacy: (i) the work already done investigating and developing the claims; (ii) counsel's class action and substantive legal experience; (iii) counsel's relevant legal knowledge; and (iv) counsel's willingness to litigate the claim. FED. R. CIV. P. 23(g)(1)(A)(i)-(iv). Courts are not limited to these factors and "may consider any other matter pertinent to counsel's ability to fairly and adequately represent the interests of the

---

[10] As an example of the type of duplicative recordmaking we hope to discourage, Mr. Skaar indicated that several other putative class members with claims at the Board would "shortly submit in their own cases the same records" he has already submitted to the Court. Appellant's June 20, 2018, Resp. at 14, n.4. Such duplicative recordmaking cannot be in the interest of systemic efficiency.

class." FED. R. CIV. P. 23(g)(1)(B). We adopt these Rule 23(g) factors as guides for our assessment of the adequacy of class counsel.

Proposed class counsel in this action is Michael Wishnie, Esq., of the Veterans Legal Services Clinic of Yale Law School's Jerome N. Franks Legal Services Organization. He is adequate. Counsel has done extensive work developing the claims at issue in this matter, demonstrated both "relevant legal knowledge" of and experience in both class action litigation and veterans law through prior aggregate actions before us, *see, e.g.*, *Monk III*, 30 Vet.App. at 174, and shown a willingness to commit the necessary resources to lead this action through counsel's extensive work on this matter. Thus, and because there are no "other matter[s] pertinent to counsel's ability to fairly and adequately represent the interests of the class," counsel is adequate and will be appointed to represent the class. *See* FED. R. CIV. P. 23(g)(1)(B).

8. Generalized notice of class certification is required but opt out rights are not.

We have two final matters to consider, although they are related. We must first determine whether to afford class members the opportunity to opt out of the class we have certified. Next, we must determine what type of notice, if any, to provide to the class about this certification. The issues are related because if opt out rights are available, ensuring actual notice of the pendency of the class action takes on greater importance.

Classes certified under Rule 23(b)(2) generally do not require opt-out rights for absent class members. *See Stoetzner v. U.S. Steel Corp.*, 897 F.2d 115, 119 (3d Cir. 1990). This is so because the indivisible nature of injunctive relief means it applies to every member of the class no matter what. *See In re Allstate Ins. Co.*, 400 F.3d 505, 506 (7th Cir. 2005) (commenting that "[t]he thinking behind this distinction [concerning opt out rights] is that declaratory and injunctive relief will usually have the same effect on all members of the class as individual suits would"). This same indivisible nature of the injunctive relief requested here combined with this Court's national jurisdiction counsel against allowing opt-out opportunities for members of the class we have certified. *See* 38 U.S.C. § 7269.

Federal Rule 23(c) states "[f]or any class certified under Rule 23(b)(1) or (2), the court *may* direct appropriate notice to the class" while for those certified under (b)(3) "the court *must* direct to class members the best notice practicable under the circumstances." (emphasis added). Because we have determined the class members do not have the right to opt out of the class we have certified, notice at this stage of the proceedings is less critical than if class members could remove themselves from the class. Nonetheless, we believe it is the best practice to take reasonable steps to inform class members of the pendency of this action. Such notice need not be individualized for each member of the class but, rather, may be a generalized notice. As directed at the conclusion of this order, the parties are to jointly submit a proposed class notice and plan for effecting notice, both of which we must approve. If the parties are unable to agree, they should submit separate sections and include them in the joint submission.

III. CONCLUSION

We are, as we have observed before, "in uncharted waters." *Monk v. Shulkin*, No. 15-1280, 2018 WL 507445, at *2 (Jan. 23, 2018). We recently recognized our authority to aggregate actions in the petition context, *see Monk II*, 30 Vet.App. at 170-71, and we will now do so in the appeal context as well. Our decision today heralds the beginning of an era in which we will entertain, but by no means always certify, class actions in the first instance, making us the only Federal appellate court in the Nation to do so. Grappling with the complexities of the law of aggregate action while also maintaining fidelity to the VJRA and congressional intent to benefit those who have served the Nation has been—and no doubt will continue to be—a challenge we must face. But if class action procedures can lead to more consistent, efficient, and effective adjudication, then our Nation's veterans deserve no less.

Upon consideration of the foregoing, it is

ORDERED that the motion for class certification is GRANTED IN PART and DENIED IN PART. It is further

ORDERED that the proposed class definition is modified as explained herein and the following class is certified in this matter: *All U.S. veterans who were present at the 1966 cleanup of plutonium dust at Palomares, Spain, and whose application for service-connected disability compensation based on exposure to ionizing radiation VA has denied or will deny by relying, at least in part, on the findings of dose estimates requested under 38 C.F.R. § 3.311, except those whose claims have been denied and relevant appeal windows of those denials have expired, or those whose claims have been denied solely based on dose estimates obtained before 2001.* It is further

ORDERED that Michael J. Wishnie, Esq., is appointed as class counsel. It is further

ORDERED that, within 30 days, the parties jointly submit a proposed class notice and plan for effecting notice. If the parties are unable to agree, they are to submit separate sections and include them in the joint submission. It is further

ORDERED that this matter is returned to the original panel appointed to this appeal for management of the class action and a decision on the merits.

DATED: December 6, 2019

SCHOELEN, *Senior Judge*, concurring in part and dissenting in part:

I agree with my colleagues in the majority generally as to the usefulness of the class action mechanism in the context of appeals before this Court. I particularly agree that class certification could be a useful device for dealing with broad, ancillary issues such as the potentially flawed dose estimate methodology challenged in the case before us. That issue exists outside the boundaries of traditional veterans law litigation, and having a system in place to address a discrete legal issue divorced from class members' underlying benefits claims will increase judicial efficiency and agency adjudication rates. Nonetheless, I respectfully disagree with the majority's ill-explained finding that our jurisdictional statute permits us to include Future-Future Claimants as class members. I also disagree with their unwillingness to include Past Claimants and Expired Claimants in the class. In my view, the majority's interpretation and application of *Bowen v. City of New York*, 476 U.S. 467 (1986), is flawed, and their flawed view systematically precludes vulnerable veterans from receiving full and fair hearings. Additionally, I am very concerned about reconciling our role as an appellate court that can issue precedential decisions with the necessity and superiority of class actions. To that end, I propose additional factors for the balancing test analyzing whether class actions are superior to precedential decisions.

I. THE FUTURE-FUTURE CLAIMANTS SHOULD BE EXCLUDED FROM THE CLASS

The majority states that *City of New York* "bears a striking similarity to the matter before us." Majority at 19. I strongly agree, and find our jurisdictional statute, 38 U.S.C. § 7252, to be properly analogous to the Social Security jurisdictional statute, 42 U.S.C. § 405(g), at issue in *City of New York*, which is why I find the majority's inclusion of the Future-Future Claimants in the class troubling.

At the outset, I agree with my dissenting colleagues insofar as they find that section 7252 includes the nonwaivable, jurisdictional requirement that a veteran's claim be presented preliminarily to VA, just as the Supreme Court in *Mathews v. Eldridge* held that presentment was a nonwaivable, jurisdictional requirement for Social Security claimants to obtain judicial review under section 405(g). Dissent at 46-48; 424 U.S. 319, 328 (1976) ("The waivable element is the requirement that the administrative remedies prescribed by the Secretary be exhausted. The nonwaivable element is the requirement that a claim for benefits shall have been presented to the Secretary."). This is so because, intuitively, there can be no decision under either statute absent a claim.

The majority glosses over this requirement and instead summarily concludes that we have jurisdiction over the Future-Future Claimants. It is unclear to me whether the majority finds that we have jurisdiction over nonpresenting Palomares veterans because we have jurisdiction over Mr. Skaar or because they should be treated in like manner to the Present-Future Claimants under the administrative exhaustion analysis. If it is the former, the Social Security cases we rely upon throughout this opinion counsel that the jurisdictional requirement that someone file a claim is an individual requirement that cannot be waived; if it is the latter, the majority improperly conflates the concepts of presentment and exhaustion. Nothing in our caselaw or the analogous Social Security cases leads me to believe that either of these theories is a faithful interpretation of our jurisdictional statute. To the contrary, section 7252 is, on its face, sufficiently comparable to section 405(g) and this Court should find that presentment is a jurisdictional requirement. Simply put, it cannot possibly be true that our jurisdictional statute is waivable in its entirety for potential class members who have never filed a claim.

Further, I find no Social Security caselaw that allows a District Court to assert jurisdiction over nonpresenting individuals pursuant to section 405(g). In fact, when nonpresenting individuals have been consolidated with other Social Security class members, courts have invoked creative mechanisms such as mandamus jurisdiction under 28 U.S.C. § 1361. *See Clark v. Astrue*, 274 F.R.D. 462, 467 (S.D.N.Y. 2011) ("[I]ndividuals failing to present their claims can still be part of the class because the Court may exercise mandamus jurisdiction over their claims pursuant to 28 U.S.C. § 1361."); *see also City of New York v. Heckler*, 742 F.2d 729, 739 & n.7 (2d Cir. 1984); *Ellis v. Blum*, 643 F.2d 68, 77-82 & n.10 (2d Cir. 1981). Our closest analogue is the All Writs Act, which does not provide an independent source of jurisdiction, but rather allows us to protect our future jurisdiction. *See Syngenta Crop Prot., Inc. v. Henson*, 537 U.S. 28, 33 (2002) (affirming that the All Writs Act does not confer jurisdiction on the federal courts); *see also Clinton v. Goldsmith*, 526 U.S. 529, 534-35 (1999) (noting that the express terms of the All Writs Act confine a court "to issuing process 'in aid of' its existing statutory jurisdiction; the Act does not enlarge that jurisdiction"). Because other federal courts have found the need to invoke an independent source of jurisdiction for nonpresenting class members, and because we have no other statutory grant of jurisdiction outside section 7252, it follows that our Future-Future Claimants cannot be consolidated as part of the class.

Despite the fact that I believe the Future-Future Claimants should not be part of the class, it is worth noting that this group of veterans is unlikely to be harmed by exclusion. In some ways, the exclusion of the Future-Future Claimants presents a legal fiction unique to this Article I appellate court – the precedential effect of our decision will bind them regardless of their nonpresenting status, and as soon as they file, they will be subject to whatever rule VA has been judicially mandated to follow. Although the Future-Future Claimants are necessarily implicated in this litigation, our authority to issue precedential decisions means they will not suffer any injustice during these proceedings, and our jurisdictional statute should not be skirted to establish a false equivalent with the Present-Future Claimants.

II. THE PAST AND EXPIRED CLAIMANTS SHOULD BE INCLUDED IN THE CERTIFIED CLASS

I also take exception with the majority's exclusion of the Past and Expired Claimants from the class. *City of New York* addressed the same legal issues we now face in deciding class composition – exhaustion of administrative remedies and equitable tolling – but, here, the majority has only adopted the Supreme Court's holding insofar as it pertains to the exhaustion of remedies issue. I do not believe the majority's application of that case is uniform or consistent.

In *City of New York*, the Supreme Court, in affirming the rulings of both the District Court and the Court of Appeals, notes that the District Court included claimants in the class who had not exhausted their administrative remedies. *City of New York*, 476 U.S. at 475-76 (citing *Eldridge*, 424 U.S. at 319). The Supreme Court then recounts the District Court's analysis as to why the class properly included those who had not complied with the 60-day statute of limitations:

> The [District] [C]ourt noted that the 60-day requirement is not jurisdictional . . . [and] found that "the same reasons which justify implying waiver of the exhaustion requirement *are stronger for the sixty*[-]*day requirement* because the statute of limitations is not, as is the exhaustion requirement, 'central to the requisite grant of subject-matter jurisdiction.'"

Id. at 476 (emphasis added) (citations omitted).

Effectively, the majority properly applies *City of New York*'s analysis as to the jurisdictional question (at least insofar as it pertains to the Present-Future Claimants), but chooses to impose a higher burden on the claimants in the nonjurisdictional portion of the case. This should not be so. Here, as in *City of New York*, the same rationales for waiver of the administrative exhaustion requirement are applicable to, and indeed stronger for, the equitable tolling issue. Succinctly stated, this Court should not waive the jurisdictional requirements for one class of veterans and then exclude other classes of veterans who present no jurisdictional impediments.[11]

Moreover, it is unclear to me whether the majority purports to adopt *City of New York*'s equitable tolling framework and chooses to find that the nonsecretive nature of VA's dose estimate methodology distinguishes the matter, or whether they do not believe that framework applies at all to the Past and Expired Claimants simply because the specter of equitable tolling "offends the very notion of finality." Majority at 23. Regardless, I respectfully find their interpretation far too narrow.

A. Proper Application of Equitable Tolling Framework

This Court should endorse a wholesale import of *City of New York*'s framework. That means that, when analyzing whether equitable tolling is warranted for Past and Expired Claimants in a class context, two questions are presented: (1) "[W]hether equitable tolling is consistent with Congress' intent," and (2) "whether tolling is appropriate on these facts." *City of New York*, 476 U.S. at 480.

The first question should be answered now and applied to all future class certification analyses: Yes, equitable tolling in the context of the Expired Claimants and Past Claimants is consistent with congressional intent. Just like 42 U.S.C. § 405(g) at issue in *City of New York*, Congress designed the applicable veterans benefits statutes to be "unusually protective" of claimants. *Id.*; *see Henderson ex rel. Henderson v. Shinseki*, 562 U.S. 428, 437 (2011) ("The Social Security disability benefits program, like the veterans benefits program, is 'unusually protective' of claimants.") (quoting *Heckler v. Day*, 467 U.S. 104, 106-07 (1984)). As the U.S. Court of Appeals for the Federal Circuit has stated, "Congress' intent in crafting the veterans benefits system is to award 'entitlements to a special class of citizens, those who risked harm to serve and defend their country. This entire scheme is imbued with special beneficence from a grateful sovereign.'" *Barrett v. Nicholson*, 466 F.3d 1038, 1044 (Fed. Cir. 2006) (quoting *Bailey v. West*, 160 F.3d 1360, 1370 (Fed. Cir. 1998) (en banc) (Michel, J., concurring)); *see also Jaquay v. Principi*, 304 F.3d 1276, 1286 (Fed. Cir. 2002) (en banc); *Hensley v. West*, 212 F.3d 1255, 1262 (Fed. Cir. 2000). That "special beneficence" is noted time and again in caselaw, and "in the context of veterans' benefits where the system of awarding compensation is so uniquely pro-claimant, the importance of systemic fairness and the appearance of fairness carries great weight." *Hodge v. West*, 155 F.3d 1356, 1363 (Fed. Cir. 1998).

[11] I note that, although I agree with the dissent's point regarding the nonwaivability of section 7252's presentment requirement, I diverge from their thinking as to exhaustion. I agree with the majority's finding that our jurisdictional statute is sufficiently analogous to section 405(g) to warrant the same exhaustion analysis conducted in *City of New York*.

Keeping in mind this rationale as to why equitable tolling is appropriate in veterans law cases generally, we must assess whether tolling is appropriate on the facts of this case. That must be done by comparing this case to *City of New York* and determining whether the conduct at issue here warrants our tolling of the filing deadline.

The majority tersely states that they will not equate VA's adjudication of Palomares veterans' claims with the secretive conduct at issue in *City of New York*, then asserts that "there is no principled way to distinguish the Expired Claimants here and any other claimants who have been denied benefits, failed to appeal to this Court, and later discovered that their benefits denial was based on an incorrect reading of the law." Majority at 23. In context, this means that the majority has (1) implicitly held that "secretive conduct" *must* be at issue to trigger equitable tolling, and (2) placed this case on equal footing with conventional challenges to denials of veterans' disability compensation claims.

Other courts have not applied *City of New York* so strictly. For instance, the U.S. Court of Appeals for the Eighth Circuit analyzed whether secretive conduct is "an absolute prerequisite" for equitable tolling to be appropriate and held that "although a secret, internal policy is probably not a prerequisite to equitable tolling, some type of misconduct on the part of the agency or gross, but good-faith, error on the part of the claimant should justify this extraordinary remedy." *Medellin v. Shalala*, 23 F.3d 199, 204 (8th Cir. 1994), *rehearing denied* (June 2, 1994). Similarly, the Southern District of Ohio has previously held that equitable tolling was appropriate for a class of plaintiffs challenging the former practice of the Secretary of Health and Human Services in calculating the amount of supplemental security income (SSI) benefits. Though the policy at issue was not secret or clandestine, the District Court found equitable tolling was warranted because the calculation of SSI benefits was not made pursuant to an established regulation and claimants "might well be unaware of the specific factors taken into account by the Secretary." *Gould v. Sullivan*, 131 F.R.D. 108, 112 (S.D. Ohio 1989). Additionally, when certifying a class of claimants, the Southern District of New York in *Hill v. Sullivan* stated that it did "not believe it necessary to determine whether . . . behavior amounts to a 'clandestine policy' to 'prevent[ ] plaintiffs from knowing of a violation of [their] rights.'" 125 F.R.D. 86, 95 (S.D.N.Y. 1989) (citations omitted). Rather, the court agreed with the plaintiffs that the Secretary's failure to publish challenged rulings "had the same practical effect on claimants as the defendant's secretive conduct in [*City of New York*]." *Id.* (citations omitted).[12]

I do not attempt here to explicitly import another court's test or draw a bright line that can be applied in future cases. Rather, when taken together, these cases demonstrate that equitable tolling can be appropriate in instances where the conduct complained of falls short of "secretive," and I believe that, on the facts of this specific case, tolling is warranted. *See Toomer v. McDonald*, 783 F.3d 1229, 1239 (Fed. Cir. 2015) (citing *Holland v. Florida*, 560 U.S. 631, 649 (2010)) (stating that equitable tolling is a matter assessed by the Court on a case-by-case basis with an

[12] Additionally, although not arising in the equitable tolling context, the District Court in *Nehmer v. U.S. Veterans' Admin.* did not require secretive conduct by VA to include the "Expired Claimants" – i.e., the pre-1985 claimants – in the class. 118 F.R.D. 113 (N.D. Cal. 1987). Nevertheless, they were allowed to participate in the class because they shared a threat of "future harm" with other class members. *Id.* at 117. This harkens to the analysis by the majority that surely Congress did not expect veterans to have fewer rights after the Veterans' Judicial Review Act than they did before its enactment.

acknowledgment of the "need for flexibility" and "for avoiding mechanical rules"). The U.S. Air Force originally worked with consultants who developed a methodology for deriving dose estimates for Palomares veterans, which was detailed in the LA Report; the inputs for this methodology included vast amounts of scientific data not easily understood by laypersons, including dosimetry readings, bioassay data, environmental testing, and multiple complex computer models; over 12 years after the LA Report was published, the Air Force – *not VA* – determined that inconsistencies existed in dose estimates; thereafter, the Air Force began using a revised methodology when providing VA with dose estimates for Palomares veterans; and the revised methodology also contained highly complex measurements and datasets (which may or may not be flawed). There is no doubt in my mind that this development-and-assignment exercise, conducted outside VA's purview and essentially devoid of oversight, prevented veterans from continuing administrative appeals and pursuing benefits they may have been entitled to, and thus is sufficient under *City of New York*'s framework that the equities in this case favor tolling.

B. The Majority's Other Contentions

Further, the majority should not equate a flawed dose estimate methodology with a misapplication of law. *City of New York* itself states that claimants who were subject to the systemwide, unrevealed policy "stand on a different footing from one arguing merely that an agency incorrectly applied its regulation."[13] 476 U.S. at 485. The dose estimates produced by that methodology function as scientific facts ancillary to administrative proceedings, not as a legal interpretation subject to future revision. And the development of this methodology behind a veil at the Department of Defense (DoD) "prevented [the claimants] from realizing that they had valid grounds for seeking administrative review." *McDonald v. Sec'y of Health & Human Servs.*, 834 F.2d 1085, 1090 (1st Cir. 1987). The flawed dose estimates did not function like a new legal interpretation that was disadvantageous to veterans, but rather provided a flawed factual basis that prevented claimants from even *accessing* the veterans benefits system.

Additionally, the majority says there is no principled way to distinguish the Past and Expired Claimants from any other claimants who have been denied benefits, failed to appeal to this Court, and later discover their benefits denial was based on an incorrect reading of the law. Majority at 23. But I would assert that the same rationales for inclusion of the Present-Future Claimants apply with equal – if not greater – force to the Past and Expired Claimants. The majority views it a "substantive advantage" that veterans' claims will be relitigated maintaining their effective dates, but to frame this advantage as more substantive than the inclusion of those claimants over whom we do not typically have jurisdiction is incorrect. Equitable tolling is a procedural tool the Court can use just like waiver of administrative exhaustion. The fact that veterans can file supplemental claims under 38 U.S.C. § 5108(a) and 38 C.F.R. § 20.1105(a) is of no consequence. Moreover, they may very well lose their original effective date, and thus it is not a similar remedy. Veterans who are effectively barred from an entire administrative system via a

[13] The Supreme Court made this statement when discussing claimants who had not exhausted their administrative remedies as opposed to those who argued equitable tolling was warranted. Nevertheless, the phrase is easily extended to the claimants seeking equitable tolling, as its purpose is merely to distinguish the policy challenge from an illegal application of a regulation. In other words, regardless of which group within the proposed class we are discussing, a claimant's challenge to the underlying obscured policy differs from a claimant's challenge to a regulation.

factual error developed by an agency we have no direct authority over would not be "substantively advantaged" in any way by including them in the class; instead, they would only be given what they were improperly denied initially under the law.

Further, for the sake of argument, even if I agreed with the majority's premise that utilizing the class device here renders substantive benefits for the Past and Expired Claimants, it is unclear to me why that precludes this Court from including them in the class. *City of New York* clearly endorsed certification of just such a group of Social Security claimants. Those claimants arguably were privy to the same types of "substantive benefits" that our Past and Expired Claimants would be, but were still included in the class. I believe it error to first invoke a categorical rule that class certification should never be used for a substantive advantage, then label inclusion in the class a substantive advantage, all while overlooking that *City of New York* did the very thing the majority prohibits.

At the end of the day, Article III caselaw is not controlling, but this Court has chosen of its own volition to import the narrowest interpretation possible of *City of New York* to justify certifying an unjustly narrow class.[14] Our failure to equitably toll in this case does not show reverence for existing interpretations of law or respect for the administrative process, but rather provides tacit endorsement of DoD-developed policies and facts to be used later by VA, no matter the consequences within VA's regulatory scheme.[15] It is a statement that a group of vulnerable veterans should not have full and fair hearings because they were not legally savvy enough to challenge a complicated and convoluted dose reconstruction methodology developed by consultants at an agency wholly separate from VA. As the U.S. Court of Appeals for the Second Circuit stated in *City of New York v. Heckler*, "[a]ll of the class members who permitted their administrative or judicial remedies to expire were entitled to believe that their Government's determination of ineligibility was the considered judgment of an agency faithfully executing the laws of the United States." 742 F.2d at 738. The Past and Expired Claimants should be allowed their (legitimate) day in court, just like the Present-Future Claimants over whom we would not traditionally have jurisdiction.

III. SUPERIORITY TEST

Another significant issue involves the determination of when we will grant class certification versus when we will issue a precedential decision – a question unique to this appellate court engaging in an activity typically committed to District Courts. Because we possess the authority to issue precedential decisions that bind all future VA decisions, class actions would likely be more appropriate in rare and unique circumstances. When assessing whether the class action device is superior to a precedential decision, I agree with the majority that a balancing test is appropriate; however, it must be a sufficiently robust test. To that effort, I would add two factors

---

[14] *See Henderson*, 562 U.S. at 437-38 ("[N]one of the precedents cited by the parties controls our decision here. All of those cases involved review by Article III courts. This case, by contrast, involves review by an Article I tribunal as part of a unique administrative scheme.").

[15] That is not to say that I necessarily agree with Mr. Skaar as to the merits underlying this case. But I believe the majority to be saying that no matter how far removed from the veterans benefits process or the agency which oversees it, and no matter how scientifically dense or ill-conceived the policy, we lack the power as an institution to equitably toll veterans' cases if the alleged misconduct is not clandestine.

to their analysis. The first additional factor addresses whether litigation of the challenge involves complex technical or scientific matters. The second addresses whether the alleged conduct is "systemic" – that is, whether a significant number of VA claims involve this issue.

A. Technical or Scientific Complexity

This first additional factor is meant to reserve the class device for challenges that will likely require sophisticated knowledge beyond the normal level of savvy needed by claimants or their attorneys to litigate veterans' individual benefits claims. Many claimants could find it extraordinarily difficult to litigate challenges involving technical data or complex scientific concepts, as they would lack the ability to obtain or understand the information necessary to substantiate their claims. Class certification centralizes litigation, obviating the need for unnamed class members to independently construct theories based on data not readily available or understandable.

This factor is related to, but separate from, the majority's second prong, which contemplates whether "litigation of the challenge involves compiling a complex factual record." One of these considers whether the underlying concepts that will be contemplated in merits litigation are complicated to a litigant and one considers whether development before the agency is extensive and onerous (essentially making it complicated for the Court). Future cases can and should contemplate both factors when asking whether class certification is superior.

Here, the additional factor is clearly met. Understanding how DoD constructed dose estimates for Palomares veterans, and understanding whether or how those dose estimates were miscalculated, is a highly complex exercise that requires skills far beyond those of individual litigants. This lends extra weight to the majority's findings as to superiority.

B. Systemic Complaint

The second factor I propose adding – whether the issue in the appeal is a systemic complaint – is a distinct inquiry from the numerosity prong of the class certification test set out under Rule 23(b), where the concerns are more related to whether the class is so numerous as to make individual adjudication of claims at the Court impractical. The systemic-complaint factor looks at the question from VA's perspective – are there so many claims at VA involving this issue that this decision will have a significant effect on the agency and will the agency likely benefit from a single-stroke class action decision rather than one-by-one appeals?

I would find that this factor weighs against a class action and favors a precedential decision. Although 1,600 veterans is a significant number of parties affected (and sufficient to satisfy Rule 23's numerosity requirement), it is not sufficient to be deemed a systemic complaint when VA handles over a million claims per year.[16] Nevertheless, as the superiority test is a balancing test, failing one factor does not foreclose class certification. When taken as a whole, I concur with the majority that class certification is superior in this case to a precedential decision.

---

[16] *See* VA, CONGRESSIONAL SUBMISSION, FY 2020, VOL. III: BENEFITS AND BURIAL PROGRAMS AND DEPARTMENTAL ADMINISTRATION 146 (2019), https://www.va.gov/budget/docs/summary/fy2020VAbudgetvolumeIIIBenefitsBurialProgramsAndDeptmentalAdministration.pdf.

FALVEY, *Judge*, with whom PIETSCH and MEREDITH, *Judges*, join, dissenting:

The majority boasts that "we are the only appellate court in the Nation with the authority to aggregate actions in the first instance." *Ante* at 25. There are sound reasons why no other appellate court has undertaken this innovation. Given the limited nature of our jurisdiction and scope of review, we question the efficacy of the majority's action, and, considering our ability to issue precedential decisions that direct VA practices nationwide, we also question its necessity. We believe that the majority has created a class that exceeds our jurisdiction and offers a comparable outcome to members of that class that a precedential decision could provide without the manageability and preclusion problems inherent in class litigation. Because we disagree with the substance of the majority's order, the rationale underlying it, and the way the majority has developed this case, we respectfully dissent.

I. ANALYSIS

Although there is much in the majority's order with which we disagree, we will focus here on those matters related to our jurisdiction to conduct class actions in the appellate context and the utility of doing so even if we have such jurisdiction, and how that applies to Mr. Skaar's proposed class.

A. The Power to Certify Class Actions in the Appeal Context

1. Our authority to certify a class is derived from our procedural statutes.

Under our jurisdictional statute—38 U.S.C. § 7252—the Court's review is limited to Board decisions and the record of proceedings before the Secretary and the Board. We agree that, if a proposed class satisfies the jurisdictional requirements of section 7252, then the Court has the authority to certify that class. Under such circumstances, if the Court chooses to exercise that authority, it may certainly utilize procedural statutes, such as 38 U.S.C. § 7264(a), to aggregate a class. In our view, our jurisdictional statute restricts classes that we may certify in the appeal context under our procedural statutes to those containing only class members who have obtained a final Board decision. And, our review of those members' cases is limited to the record of proceedings.

The majority goes much further. It finds the authority to conduct class actions in an esoteric "inherent authority." Citing the United States Court of Appeals for the Federal Circuit (Federal Circuit) in *Monk v. Shulkin* (*Monk II*), 855 F.3d 1312 (Fed. Cir. 2017), the majority contends that our "inherent authority" supports our use of class actions. *Ante* at 13-14. The majority fails to explain the source and scope of the term "inherent authority." More importantly, it does not explain how "inherent authority" expands our jurisdiction beyond that provided by our jurisdictional statute, aside from a conclusory statement that it does. It is equally unclear why vague references to "inherent authority" are necessary to justify class actions where section 7264(a)—which provides that proceedings of the Court "shall be conducted in accordance with such rules of practice and procedure as the Court prescribes"—allows for such aggregation, so long as the jurisdictional requirements under section 7252 are first met.

The Federal Circuit in *Monk II* cited the All Writs Act (AWA) as the basis for this Court's authority to certify class actions in the petition context. The majority itself questions whether the AWA grants us authority to certify classes in the appeal context. It does not. Neither the AWA nor *Monk II* can stand as the legal basis for aggregating appeals because, unlike the wide authority the AWA gives us to protect our prospective jurisdiction, our authority to review appeals has been tightly circumscribed by Congress.

Thus, we would find that, although the Court has authority to certify a class in the appeal context when jurisdictional requirements are satisfied, such authority is derived from the procedural discretion granted to us by Congress, not the AWA or any purported "inherent authority."

2. But our procedural statutes do not create jurisdiction.

The majority, relying on *Monk II*, conflates the procedural statutes, which provide us with the methods to manage cases over which we have jurisdiction, with the statute authorizing our jurisdiction. The Federal Circuit in *Monk II* noted that *Harrison v. Derwinski*, 1 Vet.App. 438 (1991) (en banc) (per curiam order), in which the Court found that it lacked power to adopt a class action rule because, inter alia, section 7252 limited our review to Board decisions, reflected a concern that we would "exceed [our] jurisdiction" if we certified a class that included veterans without a Board decision. *Monk II*, 855 F.3d at 1320. The Federal Circuit then stated that it disagreed that our "authority is so limited," indicating that Congress expressly gave us "the authority to 'compel action of the Secretary unlawfully withheld or unreasonably delayed.'" *Id.* (quoting 38 U.S.C. § 7261(a)(2)).

The authority to compel action of the Secretary, coupled with our power under the AWA, allows us to aggregate cases in the petition context. It does not help us determine how to handle direct appeals. Anything the Federal Circuit said about direct appeals is dicta. That tribunal has yet to discuss our authority to conduct class actions on direct appeal when that issue was directly presented, properly briefed, and accompanied by an appropriate record. We, therefore, have no precedential guidance concerning that matter and do not rely on any unnecessary statements the Federal Circuit may have made.

After noting that the Federal Circuit disagreed with the Court's finding in *Harrison*, the majority references section 7264(a). A procedural statute, which authorizes us to create mechanisms necessary to exercise our jurisdiction (i.e., we may utilize such tools once we have jurisdiction), cannot be used to overcome the jurisdictional barrier that the Court identified in *Harrison*. *See Henderson v. Shinseki*, 562 U.S. 428, 434 (2013); *In re Wick*, 40 F.3d 367, 373 (Fed. Cir. 1994) ("If Congress had intended the court's jurisdiction to be broader than that conferred by § 7252, Congress would have expressed that intention legislatively.").

3. Based on section 7252(a) and Supreme Court precedent, we are prohibited from waiving any administrative exhaustion requirements and assuming jurisdiction over class members who have not filed a claim and do not have a Board decision.

The majority acknowledges the Secretary's argument that the Court lacks jurisdiction to include veterans without a Board decision in the certified class because such a decision is a jurisdictional prerequisite for Court review. *Ante* at 18; *see* 38 U.S.C. § 7252(a). Of those without a Board decision, the majority indicates that such veterans fall into one of two subgroups within the proposed class: (1) Present-Future claimants—those who have filed claims that remain pending before VA; and (2) Future-Future claimants—those who have not yet filed claims. *Ante* at 15-16. The majority then states that it waives the exhaustion requirement—which, presumably, is that each class member have a Board decision—for these claimants and finds that the Court has jurisdiction over them. *Id.* at 20-21.

The Supreme Court's Social Security Administration (SSA) cases the Secretary and the majority reference to support their positions regarding jurisdiction are not directly on point as to our judicial review statutes. Although these cases provide helpful guidance as to how jurisdictional requirements should be analyzed, this precedent does not undermine the jurisdictional requirements of section 7252(a) or show that those requirements are waivable by the Court.

a. A statute may contain nonwaivable jurisdictional requirements and waivable administrative exhaustion requirements.

In *Mathews v. Eldridge*, the Supreme Court explained that its decision in *Weinberger v. Salfi*, 422 U.S. 749 (1975), identified three conditions[17] that must be satisfied to obtain judicial review under 42 U.S.C. § 405(g). 424 U.S. at 328. Of these, the requirement that there be "a final decision of the Secretary made after a hearing" was central to the requisite grant of subject-matter jurisdiction. *Id.* (citing *Salfi*, 422 U.S. at 764). The Supreme Court stated that, implicit in *Salfi*, was the principle that

> this condition consists of two elements, only one of which is purely "jurisdictional" in the sense that it cannot be "waived" by the Secretary in a particular case. The waivable element is the requirement that the administrative remedies prescribed by the Secretary be exhausted. The nonwaivable element is the requirement that a claim for benefits shall have been presented to the Secretary. Absent such a claim there can be no "decision" of any type. And some decision by the Secretary is clearly required by the statute.

Id. Recently, the Supreme Court in *Smith v. Berryhill* reiterated the *Eldridge* holding that section 405(g) contains both a nonwaivable jurisdictional requirement and a waivable requirement regarding the exhaustion of administrative requirements. 139 S. Ct. 1765, 1773 (2019).

[17] The Supreme Court noted that two of these conditions—that civil action be commenced within 60 days after the mailing of notice of such decision and that the action be filed in an appropriate district court—specified a statute of limitations and appropriate venue, and are waivable by the parties. *Mathews v. Eldridge*, 424 U.S. 319, 328 n.9 (1976).

b. There is a difference between a requirement being waivable and determining whether to waive that requirement.

Although the majority notes the axiom that "[s]ubject-matter jurisdiction 'can never be waived or forfeited,'" *ante* at 16 (quoting *Gonzalez v. Thaler*, 565 U.S. 134, 141 (2012)), it then proceeds to do just that. It does so by applying a test for determining whether to waive a statutory requirement without first ascertaining whether the statutory requirements in question are in fact waivable.

Lest there be any residual doubt after 30 years of caselaw, section 7252(a) is jurisdictional. Indeed, it's hard to imagine that the English language could produce a more clearly jurisdictional provision. *See Fort Bend Cty. v. Davis*, 139 S. Ct. 1843, 1849 (2019) (courts should deem a requirement jurisdictional when Congress clearly states that it is). The statute is labeled "[j]urisdiction" and the phrase in question says that this Court "shall have exclusive jurisdiction to review decisions of the Board." The majority here investigates whether it may expand the Court's traditional view of its authority by reaching back into the agency's adjudicatory process and laying hold of claims that have not yet been subject to a Board decision. As we will explain, its actions contravene the intentions of Congress.

In *Bowen v. City of New York*, 476 U.S. 467 (1986), and *Eldridge*, the Supreme Court found that the waivable element of section 405(g) was the requirement that the administrative remedies prescribed by the Secretary be exhausted. The Supreme Court then utilized the test referenced by the majority (whether the challenged conduct is collateral to a claim for benefits; exhaustion would cause irreparable harm; and the purpose of exhaustion is not served by its enforcement) when assessing whether deference to the agency's determination of finality was necessary. *City of New York*, 476 U.S. at 483 (noting that, "[o]rdinarily, the Secretary has discretion to decide when to waive the exhaustion requirement," but that in certain cases deference to the agency's judgment is inappropriate), 484 ("The ultimate decision of whether to waive exhaustion . . . should also be guided by the policies underlying the exhaustion requirement."); *Eldridge*, 424 U.S. at 328, 330.

In other words, the Supreme Court first determined whether the statutory element was waivable and only then assessed whether those steps created by the Secretary to reach a final decision warranted any deference, a process that the majority did not follow. As discussed below, no portion of section 7252(a) is waivable.

c. Section 7252(a) contains the nonwaivable requirement that a class member must have filed a claim with VA.

Once again, under section 7252(a), our Court "shall have exclusive jurisdiction to review decisions of the Board of Veterans' Appeals," and, by way of comparison, under section 405(g), an individual may obtain review by a court of "any final decision of the Commissioner of Social Security made after a hearing."[18] Section 7252(a) includes the nonwaivable, jurisdictional

[18] At the time of *Eldridge*, the title of the agency head was Secretary of Health, Education, and Welfare and thus this portion of section 405(g) read "any final decision of the Secretary made after a hearing." 424 U.S. at 327. Currently, the title is Commissioner. Aside from this title change, the language of section 405(g) has remained the same.

requirement identified in *Eldridge*—that a claim for benefits shall have been presented to the agency—given that, under both statutes, there could be no decision absent a claim. 424 U.S. at 328 (noting that a decision was "clearly required by the statute"); *see Berryhill*, 139 S. Ct. at 1773. Therefore, if a veteran has not filed a claim with VA, our Court would not have jurisdiction over that individual. Since this requirement is jurisdictional, we cannot waive it. Thus, as discussed further below, the notion that the majority's so-called "Future-Future" claimants can be part of a class over which we have jurisdiction does not make it past the starting line.

d. Section 7252(a) does not contain the waivable requirement that administrative remedies prescribed by the Secretary be exhausted.

Our jurisdictional statute contains nothing like the waivable element identified in *Eldridge*—that the administrative remedies prescribed by the Secretary be exhausted. Section 405(g) allows for judicial review of "any final decision" of the Secretary/Commissioner, whereas section 7252(a) requires a decision of the Board. Congress specifically identified the type of VA decision that a claimant must obtain before jurisdiction in this Court is established, while section 405(g) does not specify which component of SSA must have provided the decision.

The Supreme Court relied on the fact that section 405(g) did not identify a particular component of SSA from which a decision need be issued when determining that the exhaustion of administrative remedies could be waived. For context, the SSA administrative review process generally requires that, if an SSA claimant disagrees with the state agency's initial denial of benefits, the claimant may seek (1) reconsideration by the original state agency; (2) if reconsideration is adverse, a hearing by an administrative law judge (ALJ); and (3) if the ALJ's decision is adverse, review by the Appeals Council. *See City of New York*, 476 U.S. at 471-72. In *Salfi*, the Supreme Court found that, because the Secretary in that case did not raise an exhaustion of administrative remedies argument, the reconsideration determination was "final." 422 U.S. at 767; *see id*. at 766 (stating that the term "final decision" was left undefined by the Act and its meaning left to the Secretary to flesh out by regulation).

In *Eldridge*, the claimant, rather than request reconsideration of the state agency's determination, commenced judicial action challenging the constitutional validity of SSA's administrative procedures and the Supreme Court held that the denial of the claimant's request for continued benefits was a final decision for the purpose of section 405(g) jurisdiction over his constitutional claim. 424 U.S. at 324-25, 332 (noting that *Salfi* required only that there be a "final decision" with respect to the claim for entitlement to benefits and that denying Mr. Eldridge's substantive claim would not answer his constitutional challenge).

In contrast, section 7252(a) requires a Board decision, rather than any VA decision. The statute, therefore, precludes the Court from using the waivable element identified in *Eldridge* to find that an agency decision other than a Board decision meets the requirements for section 7252(a) jurisdiction.

Moreover, the Supreme Court in *Salfi* and *Eldridge* focused on the fact that the Secretary/Commissioner was responsible for establishing the steps in SSA's administrative process, given that the waivable element was the requirement that the administrative remedies *prescribed by the Secretary* be exhausted. *See City of New York*, 476 U.S. at 471-72 (noting that reconsideration of the state agency determination and review by the Appeals Council were prescribed by regulations, not statutes). Those factors are fully inapposite here.

Although the Secretary may establish administrative procedures through regulations, our jurisdictional statute inherently includes the administrative step of appealing an adverse regional office (RO) decision to the Board because the statute itself requires a Board decision. *See Am. Legion v. Nicholson*, 21 Vet.App. 1, 4-5 (2007) (citing Senate Bill 11); *see also* 134 Cong. Rec. S9184 (daily ed. July 11, 1988) (Senator Cranston, in outlining the procedure for judicial review under the Veterans Judicial Review Act (VJRA), stated that such review "would be available only after a veteran's claim has been turned down by a VA regional office and, on appeal, by the Board"). Because the administrative steps the majority here is seeking to waive are prescribed by Congress in a statement of jurisdiction, rather than the Secretary (who must also comply with the statute), *Eldridge* cannot be used as a tool to make a requirement that is plainly jurisdictional and unwaivable into something that is not.

We note also that section 405(g) contains the language "after a hearing." But, in waiving the administrative remedies requirement, the Supreme Court in its SSA cases focused on the fact that this statute did not specify the type of decision required before judicial review, rather than whether the hearing component in the statute could be waived. In *Salfi*, however, the Supreme Court briefly addressed this requirement and it found that a hearing would be futile once the Secretary determined that the only issue to be resolved was a matter of constitutional law beyond his competence to decide and that the Secretary may award benefits without a hearing. *Salfi*, 422 U.S. at 767. Our jurisdictional statute does not require a hearing before judicial review. Moreover, although the SSA Secretary may make a benefits determination without a hearing, VA cannot make a benefits determination without issuing a decision. Further, according to the Supreme Court's guidance in *Eldridge*, 424 U.S. at 328, "some decision . . . is clearly required" by our statute and, as noted, specifies it must be a *Board* decision.

e. We conclude that section 7252(a) includes no waivable elements.

As the Court and Federal Circuit have assumed for 30 years, section 7252(a) contains the nonwaivable, jurisdictional elements that a veteran must have both filed a claim and received a Board decision. Under the Supreme Court's framework, the Court and the Secretary are unable to waive any requirement of our jurisdictional statute. The majority's focus on determining whether to waive the requirement of a Board decision is at best premature because it did not explain why it determined that our jurisdictional statute has waivable components.

Further, the test that the majority utilizes to determine waivability was used by the Supreme Court to assess whether deference should be given to the administrative steps prescribed by the Secretary to reach a final decision. Because administrative remedies inherent in section 7252(a) are prescribed by Congress rather than the Secretary, the test that the majority cites does not apply.[19] Because the requirement of a Board decision under section 7252(a) cannot be waived, we

[19] The majority's analogy of Mr. Skaar's case to magistrate judges exercising jurisdiction over proceedings in civil matters with the consent of parties, *ante* at 17-18, is unpersuasive. First, our analysis for finding that our

do not have jurisdiction over individuals who have yet to obtain one. We will now address the two subgroups contained within this category.

f. We do not have jurisdiction over the Future-Future claimants.

As we explained above, the Court cannot take jurisdiction over the majority's so-called Future-Future claimants—i.e., those veterans who have not yet filed a claim. In *Salfi*, *Eldridge*, *City of New York*, and *Berryhill*, the Supreme Court noted that the requirement that a claim for benefits shall have been presented to the agency was a nonwaivable, jurisdictional statutory element. Accordingly, in *Salfi*, the Supreme Court found that, as to the unnamed plaintiffs, "the complaint is deficient in that it contains no allegations that [those class members] have even filed an application with the Secretary, much less that he has rendered any decision . . . . The class thus cannot satisfy the requirements for jurisdiction under 42 U.S.C. § 405(g)." *Salfi*, 422 U.S. at 764; *see Califano v. Yamasaki*, 442 U.S. 682, 704 (1979) (stating that the certified classes were too broad, but indicating that, at least in this instance, the relief offered by the injunction would not be afforded to individuals until they filed a written waiver request to the Secretary—i.e., met the statutory jurisdictional prerequisites).

Our statute contains the nonwaivable, jurisdictional requirement that a claimant have filed a claim with VA. The majority's conclusion that we have jurisdiction over individuals who have not filed a claim cannot be correct.

g. We also do not have jurisdiction over the Present-Future claimants.

As to the Present-Future claimants—those veterans who have filed claims that remain pending before VA at any level—we would also find that the Court does not have jurisdiction over these individuals. As stated, no element of section 7252(a) is waivable, given that Congress prescribed the administrative remedy necessary to obtain judicial review in our Court and specified that a veteran must have a Board decision before we assume jurisdiction. Therefore, we disagree that the majority has the authority to waive this requirement.

The Present-Future claimant subgroup can be further subdivided: (1) veterans who have filed a claim that remains pending before the RO (i.e., veterans who do not have a VA decision at all); and (2) veterans who have a claim pending before the Board (i.e., veterans who have appealed an RO decision, but have not obtained a Board decision).

The first group is in the same boat as the Future-Future claimants. *See Eldridge*, 424 U.S. at 328 ("[S]ome decision by the Secretary is clearly required by the statute."). Regarding the

---

jurisdictional statute contains no waivable requirements is based on Supreme Court precedent regarding SSA benefits, where at least two of those cases pertained to class actions. *See generally City of New York*, 476 U.S. at 467; *Salfi*, 422 U.S. at 749. Those Supreme Court cases discussing disability benefits are more analogous to our VA disability benefits cases and provide more guidance than do circuit court cases pertaining to magistrate judges. Second, as we will discuss, there are significant distinctions between trial courts—i.e., where magistrate judges practice—and our Court—i.e., an appellate body, where class certifications generally are not initiated. Third, even though all members of a class need not consent to proceed before a magistrate if the named plaintiff has done so, other jurisdictional requirements must still be met. *See* 28 U.S.C. § 636(c)(1) (a "magistrate judge . . . may conduct any or all proceedings . . . when specially designated to exercise such jurisdiction by the district court or courts he serves").

second group, once more, Congress, not the Secretary, prescribed the administrative steps necessary to obtain review in our Court and insisted that claimants obtain a Board decision before appealing here. The cases discussed by the majority are inapposite, and we have neither jurisdiction over that group nor authority to accrue more power than Congress explicitly intended.

4. Under section 7252(b), we are prevented from reviewing class members' records that were not first reviewed by VA as well as the evidence Mr. Skaar submitted following the Court's limited remand.

Under section 7252(a), we would find that we do not have jurisdiction over a large portion of Mr. Skaar's proposed class because they do not have a Board decision.[20] But our jurisdictional statute contains another section, which provides that our review is limited to the record before the Board or the Secretary. 38 U.S.C. § 7252(b). This statutory requirement raises issues not only for the other class members, but for Mr. Skaar as well.

a. We do not have jurisdiction to review other class members' records.

In the appellant's June 20, 2018, response to the Court's May 21, 2018, order, Mr. Skaar explained that three other veterans intended to submit the exhibits he had attached to his merits brief to a decision review officer (DRO) and the Board. The Secretary had moved to strike those documents because they were not in Mr. Skaar's record before the Board. Mr. Skaar asserted that, "[a]s a result, should this Court certify the proposed class, so much of the Secretary's motion to strike as addresses Mr. Skaar's exhibits would likely become moot, because the contested exhibits would indisputably be before the Secretary in the individual records of other class members." Appellant's June 2018 Response (Resp.) at 14, n.4. Yet, the Court could not review these documents, or any other such evidence, and make determinations based on them where the Secretary or the Board had not first reviewed those veterans' records and made findings, in a decision, as to that evidence. *See* 38 U.S.C. §§ 7252, 7261(c); *see also Owens v. Brown*, 7 Vet.App. 429, 433 (1995) (holding that the Board is responsible for assessing the credibility and weight of evidence).

b. We do not have jurisdiction to review Mr. Skaar's supplemental record.

Mr. Skaar and the majority faced a significant impediment in reaching class certification. Mr. Skaar's arguments could not result in class certification unless he and the majority found a way to force many hundreds of pages of documents that he did not present to the Board before us. They were not part of his record of proceedings, cannot plausibly be said to have been constructively before the Board, and are not of the kind subject to judicial notice. Mr. Skaar is the only named veteran. We are not aware of any potential class member that has obtained a final decision after submitting the documents in question to the Board.

The Secretary asked us to strike those documents. In a typical case, we certainly would have granted the motion. In this instance, however, members of the majority issued an order on February 1, 2019, which we will refer to as the limited remand order. For reasons we need not

---

[20] And some do not even have a claim filed with VA that would lead to such a decision.

repeat here, that order was not in accordance with law. *See Skaar v. Wilkie*, 31 Vet.App. 16, 22 (2019) (Pietsch, J., dissenting). We cannot condone the Court's decision to use a record created by judicial artifice to certify a class. *See Camp v. Pitts*, 411 U.S. 138, 142 (1973) (per curiam) ("[T]he focal point for judicial review [of agency conduct] should be the administrative record already in existence, not some new record made initially in the reviewing court.").

c. Mr. Skaar should not have been permitted to submit additional evidence to the Board and we do not have jurisdiction to review those documents.

The Court should not have permitted Mr. Skaar to submit additional evidence after the limited remand. The Court, in *Kutscherousky v. West*, explained that providing an appellant with 90 days to submit additional evidence and argument to the Board after a Court remand was "consistent with the shift of the claim upon remand by the Court from the Court's adversarial process back to the nonadversarial, ex parte adjudication process carried out on behalf of the Secretary." 12 Vet.App. 369, 372 (1999) (per curiam order); *see Williams v. Wilkie*, ___Vet.App. ___, No. 16-3988, 2019 WL 4365058, *6 (Sept. 13, 2019). This case never left the adversarial process. The Court explicitly stated in its limited remand order that it retained jurisdiction over the matter. Unlike in *Kutscherousky*, where the Court stated, as justification for allowing the submission of additional evidence and argument, that the "nonadversarial process should begin anew with a full de novo adjudication," 12 Vet.App. at 372, the majority in Mr. Skaar's case indicated that "what we require from the Board is not a new decision," *Skaar*, 31 Vet.App. at 19. Rather, the Court required only a supplemental statement of reasons or bases from the Board addressing in the first instance a challenge to the dose methodology that Mr. Skaar made prior to the April 2017 Board decision.

As the word "supplemental" reveals, the April 2017 Board decision remains the jurisdiction-conferring decision on appeal. Mr. Skaar's submissions plainly run afoul of our caselaw stating that we may not review documents postdating the Board decision on appeal. *See Obert v. Brown*, 5 Vet.App. 30, 32 (1993) ("This Court is a Court of review that may consider only evidence that was in the record and before the Board in its adjudication."); *Rogozinski v. Derwinski*, 1 Vet.App. 19, 20 (1990). The majority ignored the matter in its decision. It should have explained why what it has done here is not artificial record-building that assisted Mr. Skaar in overcoming the obvious deficiencies in his class certification motion.

Second, in the limited remand order, the majority, by stating that Mr. Skaar could submit additional materials "including the evidence submitted to this Court," 31 Vet.App. at 19, highlighted a method for circumventing procedures that the Court itself and Congress had put in place—i.e., it offered Mr. Skaar and other veterans a way to defeat motions to strike and possibly obtain review of documents that would not otherwise be afforded. *See id.* at 31 (Pietsch, J., dissenting). It is difficult to read that passage and not conclude that the Court has put a thumb on the scales in this case.

Third and most importantly, we do not have jurisdiction to review the documents Mr. Skaar submitted to the Board following the limited remand order. As we noted in our dissent, *id.* at 31, the Federal Circuit, in *Kyhn v. Shinseki*, held that the Court's review of affidavits requested by the Court and generated after the Board decision on appeal "was in contravention of the jurisdictional requirement that '[r]eview . . . shall be on the record of proceedings before the Secretary and the Board,'" 716 F.3d 572, 576-77 (Fed. Cir. 2013) (quoting 38 U.S.C. § 7252(b)). The documents Mr. Skaar submitted following the limited remand, which discuss dose methodology, are evidentiary in nature and were not in the record prior to the Board decision on appeal. *See id*. (the affidavits were evidentiary in nature and could not be considered by the Court in the first instance).

Further, the Board did not make factual findings in the first instance about much of the later-submitted evidence. *See* Board Mar. 26, 2019, Supplemental Statement at 2-5 (discussing evidence it had previously considered in the April 2017 Board decision, such as the April 2012 and December 2013 Air Force Memorandums and the June 2014 Air Force revised radiation dose estimate). To the extent that it made such findings, the Board addressed only one of the later-submitted documents—a December 2017 publication—and noted that it was published after the April 2017 Board decision and that the author's disagreement with the methodology used by the Air Force "does not necessarily render the June 2014 opinion 'unsound.'" *Id*. at 4-5. Rather than faithfully undertake the factfinding the limited remand intended, the Board correctly noted that it is limited to reviewing the evidence available at the time it renders its decision. *Id*. at 5. Ultimately, the Board determined that in April 2017 it had no evidentiary basis to reject the dose estimate offered by the Air Force. *Id*.

These correct findings mean that the limited remand order did not solve the record problems that the Court faces in this case. The Court is not permitted to review evidence submitted to the Board following the February 1, 2019, limited remand or, even if it were, to make findings of fact as to most of that evidence because the Board has not done so in the first instance. *See Kyhn*, 716 F.3d at 576-77. The answer remains the same as the one we proffered in our dissent to the limited remand order. The class motion should be denied and this case remanded. Then, the Board, with full jurisdiction, may consider any evidence that Mr. Skaar wishes to submit, and Mr. Skaar, should the Board deny his claim again, will be better positioned to support a class motion.

As we have noted before, "[b]ecause the [Notice of Appeal (NOA)] triggering our jurisdiction relates only to the April 2017 Board decision, the date of the Board's decision governs what materials are considered part of the record of proceedings under section 7252(b)," *Skaar*, 31 Vet.App. at 30 (Pietsch, J., dissenting) (citing U.S. VET. APP. R. 10(a)(1) (providing that the record before the agency consists of all evidence before the Board "on the date the Board issued *the decision from which the appeal was taken*" (emphasis added))). The majority, in neither the limited remand nor this order certifying the class, cites any authority indicating that a "supplement" to the Board decision on appeal is legally sufficient for it to deem the date of the supplement to be the decision date and to then augment the record accordingly. *See* Secretary's Apr. 23, 2019, Resp. at 1 n.1 (arguing that the Board's supplemental statement is not a decision because it does not grant or deny relief as required by 38 U.S.C. § 7104(d)(2)).

Therefore, Mr. Skaar has not met the jurisdictional requirement under section 7252(b) such that he may adequately represent other class members in challenging the dose methodology, where (1) that challenge is based on documents not previously reviewed by the Board, and (2) we are not permitted to review or make findings as to most, if any, of the evidence submitted following the limited remand.

5. In addition to our jurisdictional restrictions, our procedural statutes limit our scope of review.

Section 7261(c) provides that "[i]n no event shall findings of fact made by the Secretary or the Board . . . be subject to trial de novo by the Court." 38 U.S.C. § 7261(c). The majority acknowledges this, stating that "[o]ur appellate nature and national jurisdiction make us stand apart from the ordinary course of aggregate litigation in federal district courts, which are empowered to find facts and conduct discovery while we are not." *Ante* at 30 (citing 38 U.S.C. §§ 7252(b), 7261(c)). Our procedural limitations make it near impossible to develop a motion for class certification as well as adjudicate the merits of the appeal without dubious mechanisms like the limited remand order.

The majority cites to three cases apparently to demonstrate that we are perhaps not so unlike district courts. *Ante* at 30, 33. The majority first cites *Erspamer v. Derwinski*, 1 Vet.App. 3, 10 (1990), noting that the Court may consider facts not before the Board when addressing the merits of a petition. But, in considering whether to grant a petition, the Court necessarily requires information not included in the record before the Board, such as evidence of actions taken by VA to process a veteran's claim where delay is alleged. *See Cheney v. U.S. Dist. Court*, 542 U.S. 367, 380-81 (2004) (an appellate court must determine whether mandamus is appropriate under the circumstances); *Cox v. West*, 149 F.3d 1360, 1363 (Fed. Cir. 1998) (this Court's jurisdiction is "irrelevant to the question of the [C]ourt's power under the AWA," which provides authority for the Court to grant petitions). That evidence is not used, as the evidence collected here is intended to be used, to address the merits of the underlying claim. It is used only for the purpose of determining whether our prospective jurisdiction has been blocked.

We are restricted by law (*but see Wolfe v. Wilkie*, __ Vet.App. __, No. 18-6091, 2019 WL 4254039, at *23-24 (Sept. 9, 2019) (granting the petition and invalidating a regulation despite the availability of agency remedies because obtaining a final agency determination would be "'a useless act'")) from using the facts we gather in the petition context for any purposes other than ensuring that our potential jurisdiction is protected. *See Lamb v. Principi*, 284 F.3d 1378, 1384 (Fed. Cir. 2002) ("'[E]xtraordinary writs cannot be used as substitutes for appeals, even though hardship may result from delay and perhaps unnecessary trial.'" (quoting *Bankers Life & Cas. Co. v. Holland*, 346 U.S. 379, 382 (1953))). Thus, the Court's ability to review evidence not before the Board in addressing a petition does not provide support for that same type of review of appeals, where section 7252(b) firmly restricts us from conducting discovery. For these same reasons, the majority's citation to *Monk v. Wilkie* (*Monk III*), 30 Vet.App. 167, 171 (2018) (en banc order), for the proposition that the Court has authority to conduct limited factfinding to determine whether class certification in the petition context is warranted, *ante* at 30, is unpersuasive in the context of adjudicating class action appeals on the merits.

Finally, the majority cites *Bove v. Shinseki*, stating that the Court "'may seek facts outside the record before the Board and independently weigh the facts to determine if equitable tolling is appropriate,'" *ante* at 30 (quoting 25 Vet.App. 136, 143 (2011) (per curiam order)). As with a petition, however, determining whether to equitably toll a late filing necessarily requires information not in the record before the Board, because the Court must assess whether events that happened after the Board issued the decision on appeal were extraordinary and prevented the claimant from timely filing the document in question despite due diligence. *See Toomer v.*

McDonald, 783 F.3d 1229, 1238 (Fed. Cir. 2015). The merits of the underlying claim are not considered at that stage and section 7252(b) does not apply. If equitable tolling is granted, the merits decision that the Court ultimately issues will be based on the record before the Board at the time of the decision on appeal, as required by law, and not on evidence gathered to determine whether equitable tolling is warranted. If it postdates the Board decision, that evidence will not appear in the record of proceedings.

Thus, the process for determining whether to equitably toll a filing deadline is not analogous to reviewing class action appeals on the merits. The distinction between our Court and district courts remains, as does the issue of how our jurisdictional and procedural statutes impact our ability to adjudicate aggregated appeals.

6. There are distinctions between an appellate court and trial courts.

The Federal Circuit in *Monk II* and the majority here determined that veterans should be afforded more, not less, procedural protections after the VJRA's enactment and thus, because veterans were previously allowed to aggregate appeals, they should be able to do so now. *See Monk II*, 855 F.3d at 1319-20; *ante* at 13, 16-17. The Federal Circuit found "no persuasive indication that Congress intended to *remove* class action protection for veterans when it enacted the VJRA." *Monk II*, 855 F.3d at 1320, n.4 (referencing a Congressional Budget Office cost estimate from 1988 that discussed potential litigation challenges, stating that, according to SSA, most challenges to regulations are class actions). Congress, however, created an appellate tribunal with distinct features that separate it from district courts and even other appellate courts. We must account for those differences. *See Henderson*, 562 U.S. at 441 ("[T]he review opportunities available to veterans before the VJRA was enacted are of little help in interpreting [a statute within the VJRA].").

The VJRA provided a new framework for veterans to pursue their disability benefits and with it a new procedure to ensure that this Court's findings applied to many veterans—i.e., a precedential decision. *See* 38 U.S.C. §§ 7254, 7267; *see also Frankel v. Derwinski*, 1 Vet.App. 23, 25-26 (1990). A precedential decision ensures that judicial determinations are broadly and consistently applied across VA and afford similar, if not greater, protections for veterans than did the rare instances of class actions in district courts prior to the VJRA. To the extent that our jurisdictional requirements inhibit our ability to certify a class in the appeal context, we assume that Congress was aware of any such limitations when it enacted the VJRA. If Congress wishes to expand our class action authority in the appeal context, then it should legislate the change to our jurisdictional statute. It is not for us to enhance our own authority by rewriting statutes to suit our preferences.

Three of the five cases cited by the majority (and the Federal Circuit in *Monk II*) to demonstrate that veterans were previously able to aggregate cases are district court cases. *Ante* at 13 (citing *Nehmer v. U.S. Veterans' Admin.*, 118 F.R.D. 113 (N.D. Cal. 1987); *Giusti-Bravo v. U.S. Veterans Admin.*, 853 F. Supp. 34 (D.P.R. 1993); *In re Agent Orange Prod. Liab. Litig.*, 506 F. Supp. 762 (E.D.N.Y. 1980)). *Nehmer* demonstrates a key distinction between an appellate court and a trial court. There, the U.S. District Court for the Northern District of California reasoned that class members did not need to exhaust administrative remedies because, inter alia, a full record would be available through discovery. *Nehmer*, 118 F.R.D. at 122. All agree that our Court is precluded by statute from relying on discovery to complete the record.

The other two cases the majority and the Federal Circuit reference are from appellate courts. In both, the trial courts determined whether the classes should be certified prior to the cases being appealed. *See Johnson v. Robison*, 415 U.S. 361, 364 n.3 (1974) (noting that class action was commenced in the U.S. District Court for the District of Massachusetts and that the district court defined the class); *Wayne State Univ. v. Cleland*, 590 F.2d 627, 628, n.1 (6th Cir. 1978) (indicating that the district court certified the class and remanding in part for the district court to decide a matter in the first instance). The appellate courts reviewed the propriety of decisions regarding class actions but did not, as the majority is trying to do, make certification decisions in the first instance.

The primary tension in this case is that we are an appellate court doing what appellate courts normally should not do. Trial courts are equipped to certify classes and adjudicate aggregated cases because they are not statutorily prohibited from supplementing the record through discovery and making factual findings in the first instance. Our inability to conduct those basic functions vital to certifying a class means that, unless Congress restructures our authority, adjudicating class certification cases that come to us through an appeal will likely present the jurisdictional hurdles that we have seen in this case.

B. The Utility of Class Actions in the Appeal Context

In *Harrison*, our Court declined to establish class action procedures, in part, because they would be "highly unmanageable" and because class actions are "unnecessary," given the binding effect of the Court's precedential decisions in pending and future cases. 1 Vet.App. at 438-39. Although the Federal Circuit disagreed with our finding in *Harrison* that we lack authority to certify a class, it did not disturb our determination that class actions are unnecessary and highly unmanageable. *See Monk II*, 855 F.3d at 1320. That conclusion was correct when *Harrison* issued and remains so today.

1. Class actions are unnecessary because we can issue precedential decisions, which may be used to attain institutional change and efficiency.

The majority, referencing *Monk II*, states that class actions will stop VA from preventing judicial review of meritorious arguments by mooting the cases in which they arise. *Ante* at 14-15. The Federal Circuit authority on which the majority relies applies to petitions, not appeals. The Federal Circuit noted that in *Young v. Shinseki*, 25 Vet.App. 201, 215 (2012) (en banc per curiam order) (Lance, J., dissenting), the dissent explained that VA's delay in adjudicating appeals evades review at times because VA usually acts promptly to resolve petitions. *Monk II*, 855 F.3d at 1320-21. The Federal Circuit noted that, after we order VA to respond to a petition, "the 'great majority of the time' the VA 'responds by correcting the problem within the short time allotted for a response, and the petition is dismissed as moot.'" *Id*. (quoting *Young*, 25 Vet.App. at 215 (Lance, J., dissenting)).

The Secretary cannot "moot" an appeal in the same manner that he can "moot" a petition. The Secretary may offer to settle an appeal, but that offer must be accepted by an appellant. A motivated appellant who has decided to place his or her own outcome second to the greater cause of veterans rights—in other words, an appellant like Mr. Skaar—can always decline even the most generous settlement offer if a greater victory remains to be won. The Secretary also may concede error before a judge, but the Court is free to ignore or accept his concession and find additional errors. Unlike with petitions, the Secretary cannot unilaterally stop an appeal from proceeding to judicial review or control the outcome once it reaches a judge or panel.

Second, the majority states that class actions "can . . . be an effective force for institutional change" and may be used to correct systemic error and ensure that veterans are treated alike. *Ante* at 14-15. Leaving aside for a moment the problem of judicial overreach inherent in that declaration, a precedential decision may be used to achieve the same objective. *See Harrison*, 1 Vet.App. at 438 (finding that class actions were unnecessary due to the binding effect of precedential decisions). If we had an adequate record, a panel might have, months ago, found that the dose methodology VA used in Mr. Skaar's case was flawed and counter to 38 C.F.R. § 3.311. Its decision, a nationwide precedent, would have fixed any such systemic dose estimate problem and VA would have been required to apply the Court's holding consistently to all veterans' cases.

The majority responds that claimants not party to a panel decision and potentially subject to errors affecting their rights, whether due to VA's non-compliance with our decision or otherwise, "do not have any right to prompt remedial enforcement." *Ante* at 33. The assumption that VA will not comply with our precedential decisions, like the assumption that it will moot every potential embarrassment, is needlessly cynical and suggests that we are acting at least in part with punitive intent. Moreover, all so-called Future-Future claimants' claims will be governed by the precedent, Present-Future claimants can point out the new precedent to VA and ask for it to be considered, claimants on appeal at the Court can ask for a remand based on the new precedent, and claimants who have already received a final decision may seek to reopen or file a supplemental claim.

Furthermore, if we found against an appellant in a precedential decision, other claimants impacted by that decision will have a full and fair opportunity to attempt to distinguish their cases. Bound class members will presumably have no such leverage. Given the difficulty in conveying the meaning of a class litigation, they may be surprised by the fact that their individual cases are subsumed and decided through arguments made by another.

Third, the majority and the Federal Circuit in *Monk II* tout class actions as an efficient method for correcting VA error. This case is not good support for that position, as we are now, more than 800 days after Mr. Skaar filed his NOA, issuing our third substantive en banc order and have not begun to address the merits.

We see no indication that class certification appeals are going to move as quickly as the average panel decision, particularly where the class appeals would require the additional step of certifying the class. We also are not moved by the novelty of this case. Had the Court waited to develop rules for aggregate litigation rather than issue a string of contested ad hoc decisions, it might have significantly reduced the time and resources it has expended on this case.

Finally, the procedural history of Mr. Skaar's case demonstrates that aggregated appeals at our Court may not be as efficient as expected. As we noted above, given our inability to conduct discovery, limited remand decisions or other suspect mechanisms may routinely be necessary to grant future class motions. That can only lead to delay.

2. Class actions are more unmanageable for our appellate Court than they are for trial courts.

The majority states that the *Harrison* manageability factor stems from the unique nature of the Court and, although it is not a categorical reason to decline class certification, it is a relevant consideration. *Ante* at 31. The majority indicates that class actions will only be allowed if the appellant demonstrates the superiority of the class action to a precedential decision. It then sets forth a several factor balancing test, cut from whole cloth, for making this determination. *Id*. at 32. One factor is whether the record is sufficiently complete for adjudication, including whether additional factfinding is needed. *Id.* at 33 (acknowledging Supreme Court precedent that the record may not be created by a reviewing court and that we have unique limitations on factfinding). That factor is no factor at all if limited remands are to become the norm in class cases. We also believe that there are additional related considerations.

First, when assessing whether the named appellant meets the section 7252(b) requirement—such that we have jurisdiction not only over his or her record but also over class members who themselves do not meet our jurisdictional prerequisites—the Court should not rely on circuitous methods (e.g., limited remands) to find this requirement satisfied, which presumably would become unmanageable over time. Rather, the record of the named appellant should be itself complete before appeal to this Court. By using the limited remand here, the Court has provided a poor and probably misleading example of how these cases should be handled in the future. Its actions do not square with its *Harrison* analysis.

Relatedly, class actions are more unmanageable for our Court because, for class members who do not meet section 7252 jurisdictional requirements and there is no record of proceedings, we cannot make necessary factual findings in the first instance. Therefore, although some potential class members here purportedly submitted the same scientific evidence to VA that was the subject of the Secretary's motion to strike, we are not persuaded by Mr. Skaar's argument that any problem in reviewing this evidence was resolved. In other words, records not reviewed by VA cannot be used to supplement the named appellant's incomplete record. We do not have jurisdictional authority to review those records even if they contained more favorable evidence than that found in the named appellant's record. The evidence must come before us in the form of a record of proceedings from a properly appealed Board decision.

Second, we once more reiterate that this Court does not have the same discovery and factfinding abilities as trial courts. *See Nehmer*, 118 F.R.D. at 122 (highlighting a key distinction between those courts and our appellate body when the Northern District of California determined that class members did not need to exhaust administrative remedies because, inter alia, a full record would be available through discovery). Further, the Court also does not have the same ability as a trial court to hear from an expert about complex scientific matters.

As indicated throughout our dissent, we would find that the third factor of the majority's balancing test, the completeness of the record, heavily weighs against certifying the class in Mr. Skaar's case, particularly where the Court is not permitted to review the evidence submitted to the Board following the February 1, 2019, limited remand or, even if it were, to make findings of fact as to most of that evidence. *See Kyhn*, 716 F.3d at 576-77.

C. Class Certification in Mr. Skaar's Case

For the most part, we will not address the majority's class certification analysis. As to numerosity, however, based on our view that we do not have jurisdiction over those veterans without a final Board decision, we would find that Mr. Skaar's proposed class does not satisfy this factor.

The Secretary stated that he knew of only six Palomares veterans who had received a Board decision (adverse or not) from 2001 to the present addressing any claim dealing with claimed ionizing radiation exposure concerning the Palomares cleanup. *See* Secretary's Dec. 13, 2018, Resp. at 3. Mr. Skaar responded that the record reflects that there are "at least [19] veterans who had filed claims for Palomares-related disabilities with the VA, 'including [3] appeals for reassessment for a total of 22 claims,'" Appellant's Jan. 4, 2019, Resp. at 3 (quoting R. at 1580), but he does not indicate how many of those claims resulted in a Board decision. Even if the six Board decisions referenced by the Secretary pertain to 38 C.F.R. § 3.311 and applied the post-2013 methodology (given that Mr. Skaar does not have standing to challenge 38 C.F.R. § 3.309 or the pre-2013 methodology)[21] and that those decisions were adverse,[22] six or seven potential class members is not sufficient to fulfill the numerosity requirement.

Although such an adverse finding on numerosity would be dispositive when assessing whether to certify a class, we will also briefly address the adequacy of the class representative. Mr. Skaar cannot adequately protect the interests of the class because we do not have jurisdiction to review the evidence he submitted to the Board following its April 2017 decision (i.e., the documents that form the basis of his challenge to the VA methodology) or to make any determinations regarding that evidence.

---

[21] Although we recognize that it is unlikely that there are individuals who have a dose estimate based solely on the pre-2013 methodology, we would find that Mr. Skaar lacks standing to challenge the pre-2013 methodology and only has standing to challenge the post-December 2013 methodology. He suffered no injury-in-fact in his current appeal based on the pre-2013 methodology. The Board expressly discounted the findings of the May 2012 advisory opinion, which were based on the pre-2013 methodology. R. at 10. Although there is some overlap between standing and typicality, the majority appears to have conflated these issues when explaining how Mr. Skaar has established standing. The majority states that, if he is successful in showing that the exclusion of urine samples was not based on sound scientific evidence, he will have suffered an injury-in-fact. *Ante* at 12-13. But that only indicates that he may satisfy the typicality requirement—his issue regarding the urine sample exclusion is typical of class members with dose estimates based on both pre- and post-2013 methodologies. However, this does not show that Mr. Skaar in his current appeal was harmed by the pre-2013 methodology.

[22] Although this is unlikely because the Secretary also stated that he knew of three Palomares veterans who had received an adverse Board decision from 2001 to the present addressing any claim dealing with claimed ionizing radiation exposure concerning the Palomares cleanup. *See* Secretary's Dec. 13, 2018, Resp. at 3.

Finally, related to our concern that class actions, if unfavorable to the class, may preclude members from raising different arguments as to the dose methodology, we question whether Mr. Skaar has presented the best argument to challenge this methodology. *See McDowell v. Brown*, 5 Vet.App. 401, 408 (1993) (noting that "courts will more carefully scrutinize the adequacy of representation afforded to absent [class] members [who are not afforded notice and opt-out protections] . . . before determining that they are bound, by res judicata, by the final judgment or settlement in the prior class action."). Mr. Skaar's argument focuses on the 2001 Labat-Anderson (LA) Report. Although the April 2012 Air Force dose estimate relied, in part, on the LA Report, R. at 1888 (citing seven other references), it is unclear whether the Air Force's post-December 2013 methodology relied on that report. We note that, at least on its face, the June 2014 Air Force memorandum regarding revised radiation dose information does not appear to rely on the LA Report because it does not mention it and instead states that the new dose estimates were based on International Committee on Radiological Protection (ICRP) reports. R. at 1301-02. It may be that Mr. Skaar has presented the best challenge to the VA methodology, but we believe that the majority should "more carefully scrutinize" this matter where preclusion is an issue. *See McDowell*, 5 Vet.App. at 408.

II. CONCLUSION

This case highlights some of the jurisdictional and practical challenges inherent in entertaining class actions in an appeal context, given the statutory framework that governs our review of Board decisions and the record before the Board or Secretary. *See Ledford v. West*, 136 F.3d 776, 779 (Fed. Cir. 1998) ("[T]he court's jurisdiction is premised on and defined by the Board's decision concerning the matter being appealed."). The majority has created a mechanism that exceeds our jurisdiction and offers no more benefits than a precedential decision, but with significant manageability and preclusion problems. Although we are sympathetic to the veterans who served in Palomares and who may have suffered injuries as a result, and we applaud Mr. Skaar's efforts to remedy this matter for all veterans, a class action in the appeal context is no answer. A simple precedential decision on this issue, when properly before the Court, would more efficiently provide them and Mr. Skaar with the answers they deserve.

Finally, we are concerned with the manner that this case has been handled. The Court has seized more power than Congress allotted to it with unsound legal innovations.

For these reasons, we respectfully dissent.

Exhibit 7

PALOMARES NUCLEAR WEAPONS ACCIDENT

REVISED DOSE EVALUATION REPORT

Volume I
Report, Appendix A, B, D, & E

Date: April 2001

Contract: GS-35F-4813G

Task Order: WFZ578410
T0799BG0031

Prepared For: Radiation Protection Division
Air Force Medical Operations Agency
Bolling AFB, DC 20332-7050

Prepared By: LABAT-ANDERSON INCORPORATED
8000 West Park Drive, Suite 400
McLean, VA 22102

TABLE OF CONTENTS

VOLUME I

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

A nuclear weapons accident occurred on January 17, 1966 over Palomares, Spain when a United States Air Force (USAF) B-52 bomber and an USAF KC-135 tanker aircraft collided. That accident lead to the release of four thermonuclear weapons. The accident damaged two of the weapons with release of radioactive contamination, leading to a three-month response effort to identify, characterize, remove, and remediate the accident site. During the response effort, some personnel were exposed to airborne dust and debris contaminated with plutonium.

Radiation monitoring efforts during the response were limited to the evaluation of exposures and their possible effects on health using principles and methods accepted at that time. However, recent interest in radiation exposure to veterans and government employees, as well as the availability of improved technology for assessing doses led the Air Force to review the data for possible use in estimating radiation exposures.

Initial Exposure Evaluation

The response effort began on the evening of January 17. A base of operations (Camp Wilson) was established, and measurements for released plutonium began on January 18. The response force peaked at about 680 U.S. personnel on January 31, and then gradually fell until the effort ceased on April 11. Approximately 1,600 personnel participated during the operation.

Response personnel provided urine and nasal swab samples while on site to assess possible intakes of plutonium and the potential effects on health. The sample results were evaluated in terms of guidelines available at the time.

The assessment program concluded that of the nearly 1,600 participants, less than 20% showed levels of plutonium in their bodies that could be detected in urine samples. Only 26 personnel showed values of 7% to 67% of the upper limit for plutonium in the body (Odland 1968a). Those 26 were followed up for a period of 18 to 24 months following the accident. A 1968 Air Force review of the follow-up program concluded that no additional information could be gained from continued sampling and recommended that further sampling effort be suspended.

Exposure and Dose Updates

The evaluations conducted during 1966 through 1968 depended on the limited understanding of plutonium’s behavior under field conditions. Since then, advances in that understanding and in methods for assessing dose provided an opportunity to reexamine the monitoring data. The approach uses the concept of Committed Effective Dose Equivalent (CEDE) - a cumulative dose, weighted for the contributions of individual organs, and summed over a 50-year period – as an indicator of possible risk from the exposure. Comparisons can also be made to the annual limit on intake (ALI) of 20,000 picocuries (NRC 2000), to the 21 rem from cumulative exposure to average background radiation over 70 years, or to the 50 rem guideline for cumulative dose to workers (1 rem per year over 50 years of work).

During the project, computer programs that perform the necessary intake and dose calculations were tested. Two programs (CINDY and LUDEP) were selected because intakes they estimated agreed to within a factor of two for the majority of the test cases. That agreement was judged reasonable and acceptable for this assessment.

Available Records

The initial urine sampling that began within three days of the accident experienced some problems such as sampling for less than the desired 24-hour period, possible sample contamination from dust spread by strong winds, and use of non-clinical sample containers. Follow-up sampling was conducted on personnel with initial urine results indicating retained plutonium at 10% of the maximum permissible body burden (MPBB) or more. This second phase was implemented to assess whether sample contamination may have produced spurious urine levels, indicating a false-positive exposure.

Most of the cases involved samples collected on site that were assayed once for gross alpha radioactivity. The remaining cases involving samples collected on site were either resampled, or reanalyzed using alpha spectrometry. Finally, 26 cases were resampled for 18 to 24 months.

Analysis of all the data produced the following four groups.

- A High 26 Cases Group that included the 26 individuals who were resampled for 18 to 24 months after the initial phase of sampling in 1966.
- A Repeat Analysis Cases Group that contained 54 individuals who either had submitted initial samples that were reanalyzed using more sensitive methods (alpha spectrometry), or who were resampled.
- A Contamination Cutoff Cases Group that included 313 individuals with results that were below an assumed cutoff level of 0.1 pCi per day.
- A Remaining Cases Group that contained 1,063 individuals with records that were not otherwise evaluated because their data indicated contamination from collection on site.

Environmental measurements obtained in the Palomares vicinity for over 15 years following the accident provided a basis for preparing independent estimates of intake and dose using representative scenarios for response force activities.

Results

The CEDEs estimated from urinary bioassay were judged unrealistically high when compared with estimates prepared for other plutonium exposure cases – persons residing in the Palomares vicinity and Manhattan Project workers. The estimates of plutonium intake and CEDE from inhalation using environmental data measured in Palomares ranged up to no more than about 0.2 rem. Consequently, the estimates from urine analyses are not useful as representative intakes and doses. The detailed evaluations performed for the High 26, Repeat Analysis and Contamination Cutoff Cases represent preliminary estimates that cannot be considered as definitive. Follow-up studies are required to develop credible estimates of dose that are compatible with those calculated from environmental data.

Conclusions

Preliminary results calculated for all 26 individuals in the High 26 Cases Group, the 54 individuals in the Repeat Analysis Cases Group, and the 313 individuals in the Contamination Cutoff Cases Group proved unrealistically high. They are inconsistent with those calculated from environmental data and when compared with the experience from exposed workers. Furthermore, the urine results are inconsistent with plutonium's known behavior and are inadequate by themselves to support meaningful intake and dose evaluations without confirmatory studies, such as analysis of urine samples now using very sensitive instrumentation, detailed review of participant medical records, participant interviews, and comprehensive assessments based on sound environmental measurements.

Recommendations

Several future actions should be considered to further refine these initial estimates.

1. Additional effort is needed to reconcile the estimated intakes and doses derived from the urinary bioassay data with the estimates from environmental measurements. A targeted effort that includes participant activities, participant interviews, urine and other appropriate plutonium analyses using current techniques, medical records review, and modeling should be considered.
2. The results of this effort should be communicated to responders, veterans organizations, and other interested parties using appropriate information that clearly confirms the conclusions of the original medical evaluation program, recognizes the difficulties in preparing updated intake and dose estimates, and outlines the options for strengthening the estimates.
3. Further contacts with the Department of Energy for comparison with evaluations of their personnel who responded to this accident could provide useful data. The effort should be summarized in a companion document that conveys the details of the project and its potential effects on health in an easily understood manner. That document should be made available to any of the responders who desire a copy.

1 INTRODUCTION

LABAT-ANDERSON INCORPORATED was awarded TASK ORDER Number TO 799BG0031 under General Services Administration Contract GS–35F-4813G to provide services to the Air Force Medical Operations Agency for evaluating the radiation exposure records of personnel who responded to past nuclear weapons accidents and incidents for the purpose of updating dose estimates. The Task Order specified the following objectives:

- To identify, locate and review the records of the incident, radiation exposure assessments, and other information pertinent to the study.
- To evaluate current methods and models for estimating radiation doses and risks from the intake of radioactive materials contained in nuclear weapons.
- To recommend a methodology for conducting the re-evaluation of the available radiation exposure information.
- To evaluate any and all radiation exposure information, such as urine bioassays, nasal swabs, air sampling information, etc. for scientific soundness and possible use in updating the radiation records of the response personnel.
- To perform the update and prepare records for input to the Air Force Master Radiation Exposure Registry.

The Task Order did not specify extensive searches of personnel records, or efforts to locate and contact the personnel involved except on a limited basis where specific information might be useful or when individuals expressed interest in the project.

The Task Order also required that the effort should begin with the nuclear weapons accident of January 17, 1966 over Palomares, Spain involving a United States Air Force (USAF) B-52 bomber and a USAF KC-135 tanker aircraft. That accident involved a mid-air collision between the two aircraft, the release of four thermonuclear weapons, damage to two of the weapons with release of radioactive components, and a three-month response effort to identify, characterize, remove, and remediate the accident site. During the response effort, personnel were exposed to airborne dust and debris contaminated with plutonium.

Substantial response efforts provided a foundation for evaluating the potential radiation effects from the exposure using accepted principles and methods of the time. However, heightened interest in radiation exposure within the Department of Energy and veterans of the 1991 Gulf War led to this effort to review the data and update radiation exposures, wherever possible, using current methods and procedures.

This report provides the results of the efforts conducted under this Task Order and includes a review of the accident details and radiation assessment efforts and results in Section 2; and a summary of the environmental measurements and review of the radiation assessment data from 1966 through 1968, an evaluation of its accuracy and usefulness, and efforts to prepare the data for re-assessment of radiation doses in Section 3. Section 4 provides a summary of radiation effects and dosimetry methods. Section 5 discusses the methods and results of preparing estimates from environmental data. Section 6 summarizes the methods and results for preparing estimates from the urinary bioassay results. Section 7 discusses the results, assesses the implications of the results on health, and Section 8 concludes with a summary and recommendations for further evaluations of the responders to this accident.

2 BACKGROUND

At 10:30 a.m. (local time), on January 17, 1966, a U.S. Air Force B-52 bomber and a USAF KC-135 tanker collided during a refueling operation at 9.44 km (31,000 ft.) over the southeastern coast of Spain (DNA 1975). The incident released four thermonuclear weapons that fell to earth near the small coastal hamlet of Palomares, Spain. Serious damage to two of the weapons caused dispersion of their contents over a limited area. Strong winds contributed to further spread of the material and contaminated aircraft debris to the village, surrounding lands, and agricultural crops (Odland 1968a). The response to the incident to find, safeguard, recover, and return weapons contents to the United States, and to assess and mitigate effects on the local populace required significant effort involving hundreds of personnel for almost three months.

Responding personnel encountered the contaminated debris, lands, village, and crops. Although emergency protection measures were followed, responders and local citizens were exposed to the plutonium dispersed from the two weapons. Extensive efforts assessed the effects of those exposures on US military and civilian responders during a program that went on for two years after the incident. Soon after the accident, the Government of Spain represented by the Spanish Junta de Energia Nuclear (JEN) and the Government of the United States, represented at the time by the Atomic Energy Commission (now the Department of Energy), agreed to cooperative programs for extensive follow-up studies of the site and surrounding areas (DOE 2001). Those studies have produced significant understanding about the characteristics of the residual plutonium, its environmental distribution, resuspension into the air, and migration through the soil and other pathways; as well as estimates of the radiation doses to the local populace and evaluations of their health condition.

This section provides additional details about the accident itself, discusses the nature of the response, reviews the methods, procedures and operation of the health and safety assessment program, and reviews the results and limitations of the assessment.

2.1 ACCIDENT SUMMARY

Both aircraft were destroyed in the air. Four thermonuclear weapons, 11 men (four survived), and hundreds of tons of debris fell to earth in and around the barriada (Hamlet) of Palomares. Parts of the aircraft were scattered over a wide area generally between Cuevas de Almanzora and Vera along the Mediterranean Sea between Puerto Rey and Villaricos. At that time Palomares had no telephones and did not appear on maps of the area. The population of the time was estimated to be about 1200.

The first of the four nuclear weapons was found intact with its primary chute deployed on the evening of January 17, 1966 just east of Palomares. A radiation survey showed that no radioactivity escaped the weapon. The area was designated impact point 1.

The primary chutes did not open for two other weapons whose chemical high explosives detonated. One weapon was found on the morning of January 18, 1966 about one mile west of the village (impact point 2). The third weapon was found about two hours later on the eastern edge of Palomares (impact point 3) with high explosive and radioactive material scattered by impact and explosions. The fourth weapon was finally recovered intact from the Mediterranean Sea on April 7, 1966 (Odland 1968a).

The explosions and fires around impact points 2 and 3 produced airborne clouds of plutonium-containing dust that were carried over some distance by 30 knot winds. Eventually, a total of 558 acres of soil contaminated above 5.4 micrograms per square meter ($\mu g/m^2$) were remediated by removal or plowing. These levels provided many opportunities for responders to inhale or ingest the radioactive plutonium.

2.2 Response Summary

The Guardia Civil, the first representatives of the Spanish government, arrived on site about one hour after the accident. They immediately took charge, secured the accident site and informed both Spanish and American authorities. The commander of the 16th Air Force headquartered at Torrejon Air Base near Madrid and the Strategic Air Command Headquarters at the Offutt Air Force Base in Omaha, Nebraska were notified and the "Broken Arrow " response system was initiated. The commander and three staff members surveyed the accident site from the air and arrived at San Javier (195 km from Palomares) at 1:30 p.m.

OPERATION RECOVERY was initiated by deciding to bring personnel in from two Spanish bases, Moron, and Torrejon. Movement of personnel started at 0100Z on January 18 from Moron with a second convoy at 0310Z. 126 personnel were transported in six buses. The first of two convoys from Torrejon departed at 0137Z, the second at 0202Z, with 175 persons in six buses. Following a 12 to 14 hour drive to the southern coast, the first of buses arrived at 1300Z and the last arrived about 1700Z.

Another Disaster Control Team from Offutt Air Force Base in Omaha Nebraska arrived at the accident scene at 7:30 am on January 18. Members of the Joint Nuclear Accident Coordinating Center (JNACC), Sandia Corporation, and the Los Alamos Scientific Laboratory (LASL) left Albuquerque at 1800 GMT on January 17.

By the evening of January 17, 49 U.S. personnel were on site. Camp Wilson was established as a general headquarters, and measurements for released plutonium began on January 18. About 300 more airmen from the Moron and Torrejon air bases were on site by the evening of January 18. A maximum of about 680 U.S. personnel were at Camp Wilson on January 31.

By January 21, the camp moved to leveled, higher ground some 5.6 km east of the Garrucha where it remained until April 3. A helicopter pad, motor pool, and 75 tents were on firmer ground in less danger of flooding. The camp was moved again where it remained until closure on April 11.

Manning reached a peak by January 31, with 598 Air Force, 64 Army, and 19 Navy. All except some officers were housed at the camp. Those were quartered in two hotels close to the accident scene. Personnel involved with search, recovery, and decontamination generally rotated through the camp at two-week intervals. Population at the camp varied, but from the high on January 31, there was a gradual reduction until the camp closed on April 11. The first major reduction occurred on February 9 and 10 when about 50 of the clean-up personnel and the 40-man ordnance disposal team left. A slight upswing occurred from March 11 to 17 during the period of filling of 4,810 barrels with contaminated soil and crops. Other personnel at camp included 126

Guardia Civil and 39 Spanish personnel who worked in the cleanup and other activities. Overall, almost 1,600 personnel participated in the response effort at one time or another.

Response activities included performing radiation surveys, protection, and recovery of nuclear weapons, development of remediation plans, and decontamination of affected areas. These will not be discussed in this report. However, details of the efforts to assess and control radiation exposure are of vital importance to this effort and are described next.

2.3 SUMMARY OF HEALTH ASSESSMENT ACTIVITIES

This accident represented one of the first times that plutonium had been dispersed on and around civilian property outside the United States. Furthermore, the response placed a significant number of military and civilian personnel resources at risk. Procedures for assessing and controlling contamination from the materials in these weapons were available and used. However, there were many questions about the behavior of inhaled and ingested plutonium under field conditions.

2.3.1 On-Site Sampling

Urine sampling, recognized as a reasonable method for assessing exposure to plutonium, was begun within three days of the accident. Urine sample collection on site was subject to collection of less than the desired 24-hour specimen and possible sample contamination. Samples were shipped by the most expedient means to the USAF Radiological Health Laboratory (USAF RHL) at Wright-Patterson AFB, Ohio for analysis. Two sampling phases were used – an initial phase and a resample phase.

2.3.2 Interpretation of Urine Results

The results were evaluated in terms of the maximum permissible body burden (MPBB, see Appendix A) of ^{239}Pu as recommended by the National Bureau of Standards (NBS) in Handbook 69 (NBS 1959). The NBS recommendations were based in part on Publication 2 of the International Commission on Radiation Protection, *Recommendations of the International Commission on Radiological Protection, Report of Committee II on Permissible Dose for Internal Radiation*, published in 1959 (ICRP 1960). The MPBB for ^{239}Pu considers the bone as the "critical organ" or the organ that is most susceptible to radiation from plutonium and is the basis for developing protection limits. The body burden is defined as that portion of ^{239}Pu distributed by systemic circulation. It does not include that amount fixed in the lungs. The MPBB was 0.044 microcurie (μCi) of ^{239}Pu.

The MPBB was developed as an operational tool for limiting dose to a critical organ over a working lifetime. The dosimetry model used assumed uniform deposition of the radionuclide in the organ, energy emitted equals energy absorbed, and the characteristics of the model could be represented by "Standard Man" data. The concept was designed to provide adequate protection over a 50-year working lifetime and as such applied to continuous intake of radionuclides over the entire period. Thus for a material like plutonium, the limit would allow for continuous intake for 50 years while keeping the dose to the bone (the critical organ) below the limit.

An individual's body burden was estimated from the measured urinary gross alpha radioactivity for initial samples. The following equation was used, taken from Langham (Langham 1956):

$$D_r = 435\ U\ t^{0.76}$$

where:

D_r	=	retained systemic body burden (pCi or Bq); meaning the amount retained in the body "t" days after exposure
U	=	^{239}Pu activity (pCi or Bq) in a 24-hour sample
t	=	time in days from exposure to sampling

The analysis required assumptions about the type of exposure (acute or continuous), and about whether samples represented true 24-hour urine outputs. This calculation applies to a single acute exposure. The individuals responding to the incident were generally on site for two weeks, some more and some less. Others remained for almost the entire period of operations. The beginning date for the exposure was assumed as the midpoint of time an individual arrived on site until ceasing activities (departing). Odland (Odland 1968b) reported that "When the 12-hour volume was less than 1.2 L, calculations were so adjusted as to express the total activity had the output been 1.2 L. When the volume exceeded 1.2 L, the actual value for calculating systemic body burden was used."

2.3.3 Resampling Program

The Air Force conducted a resampling program at 90 to 150 days after collection of the initial sample. This resampling applied to individuals whose gross alpha results for initial samples suggested a systemic body burden of 10% or more of the MPBB.

The program established procedures to identify and quantify the isotope of interest in the urine – ^{239}Pu.

2.4 SUMMARY OF RESULTS

Odland reported that the USAF RHL processed almost 1600 urine samples during the initial phase (Odland 1968a). Table 1 gives the distribution of the samples in relation to the systemic body burdens they represent. Those results indicate that 20 individuals potentially exceeded the MPBB and 442 samples exceeded 10% of the MPBB and required resampling. However, the possibility for contamination of the initial samples collected on site introduced uncertainty about that conclusion. This potential for sample contamination in and around Palomares was also recognized by the Spanish Junta de Energia Nuclear (JEN), which transferred urine sample collection and medical examination of local residents from Palomares to Madrid in 1967 (Iranzo 1987).

Table 1. Initial Urine Samples (Percentage of one MPBB).

Number Analyzed	1586
BB greater than 100%	20
BB 9% to 99%	422
BB 0.9% to 9%	537
BB less than 0.9%	607

A resampling program began shortly after on-site operations ended. Originally, samples were desired at two-month intervals; however, this became impractical and samples were collected primarily at the discretion of the individuals. Table 2 contains the results of the resampling program (Odland 1968a). The laboratory processed 422 samples during the resampling phase. Of those, only six exceeded 10% of the MPBB with slightly less than half of those resampled (203) showing results below 1% of the MPBB.

Table 2. Urine Resampling Program Results.

BB greater than 10%	6
BB 1 to 10%	213
BB less than 1%	39
BB zero	164
Total	422

A small specimen of lung tissue, obtained at time of necropsy from an early responder who died from heart disease, contained 2.8 pCi of ^{239}Pu; or about 0.00034 microcuries (about 2% of estimated maximum permissible lung burden) when extrapolated to the total mass of the lung. Early urine analyses for the individual indicated a rapid decrease in gross alpha radioactivity that was attributed to contamination. However, early behavior of inhaled plutonium was not excluded as a possibility (Odland 1968a). Nevertheless, if correct, the quantity in the lung of this individual represents a small fraction of the MPBB after 9 months following exposure.

In summary, the assessment program indicated that of the nearly 1,600 participants, less than 20% indicated systemic body burdens of plutonium that could be detected by urine bioassay, and only 25 showed values in the range 7% to 67% of the MPBB guideline (Odland 1968a). Those 25 and one additional individual were followed up for a period of 18 to 24 months following the accident.

2.5 Plutonium Deposition Registry Board

The Air Force recognized that the consequences of possible exposure to plutonium from the Palomares Broken Arrow required in-depth and credible assessment, provisions for long-term maintenance of the records, and possible follow-up of those exposed. To satisfy that need, representatives of the U.S. Air Force Medical Service met in Omaha, Nebraska in March 1966 and identified the need for a detailed and long-range program to provide follow-up and treatment, when required. The concept of a special board to satisfy those needs was developed into a Plutonium Deposition Registry and Board with the following purposes as stated in the proceedings of the first meeting (Odland 1966):

(1) It would provide adequate follow-up of personnel with internal deposition of plutonium, in order that any possible biological injury would be detected at the earliest date, and it would provide, when required, the best possible treatment to reduce body burdens of Plutonium-239.

(2) It would provide the government with complete factual data upon which to evaluate claims for compensation that might subsequently arise.

(3) It would provide the medical profession with additional urgently needed data with which to manage medical problems at future Broken Arrows or laboratory accidents of a similar nature.

The Plutonium Deposition Registry Board met first on October 26-28, 1966 (Odland 1966) to establish the Board; to review progress to date, and to set policy for further follow-up. The Board reflected a tri-service nature as well as an interagency flavor with participation by the Atomic Energy Commission, the Veterans Administration, and the Defense Atomic Support Agency. Additionally, several recognized experts in plutonium medical effects participated as Board Members or as Consultants (Odland 1966). Board deliberations produced recommendations in the following areas:

- Samples should be collected from all that departed the accident scene without submitting a sample, or whose initial samples suggested a systemic body burden greater than 9%.
- No further sampling of individuals whose **initial** urine results suggested a systemic body burden of less than 9%.
- Sampling should be continued on members whose results on resampling were in the top 10% of the resampling group and showed systemic body burdens of 1-10%.

The Board also discussed the use of whole-body counting as an additional assessment tool and the use of ^{239}Pu to ^{241}Am ratios in the weapon components, soil and urine as possible method for determining ^{239}Pu in the lungs; however, no specific recommendations were developed.

On January 16, 1968, the Air Force Logistics Command Surgeon issued a letter report that reviewed progress of the follow-up effort (Wallace 1968). The report summarized the results of resampling of the 26 individuals whose initial urine samples showed the highest ^{239}Pu content suggesting systemic body burdens of 7% to 67%. The report concluded that little additional information could be gained from continuing the effort. Finally, the report announced that the Surgeon General of the Air Force had concurred with canceling the Board meeting scheduled for 1967 and that further activities would be limited to analyzing tissue specimens, as they became available. As a practical matter, this letter report suspended activities of the Board in the matter of the Palomares accident. Research during this project identified no evidence of additional testing efforts or results.

Our review of the urinary levels reported during the assessments conducted in 1966 and 1967 indicated that the initial intakes could exceed the current annual limit on intake (ALI) recommended by the ICRP (ICRP 1979). Consequently, a repeat evaluation of the urinary data seemed warranted to provide assessments using currently accepted methods for analysis and management of radiation risks. The remainder of this report discusses the detailed approach for performing those assessments.

3 ASSESSMENT OF AVAILABLE DATA

The response effort discussed in Section 2 above included a health evaluation program that generated records of the possible doses to those who responded to the accident. Locating those records involved contacts with the Air Force Medical Operations Agency (AFMOA) at Bolling AFB, DC and the Air Force Institute for Environmental, Safety and Occupational Health Risk Analysis (AFIERA) at Brooks AFB, TX. Those records required detailed review to understand the data they contained and the processes that produced the data; an analysis of the consistency and reliability of the contents; and possible adjustments to estimate intake and dose equivalent.

In addition, the Government of Spain, in collaboration with the U.S. Department of Energy, has conducted extensive studies of the environmental characteristics of the residual contamination in the Palomares area. In particular, air sampling, particle size characteristics, and resuspension factors have been determined from data collected for more than 15 years. These data provide a valuable source for independent intake and dose estimates.

3.1 ENVIRONMENTAL DATA

Studies of the environment around Palomares have included air sampling at four locations, and estimates of the resuspension of plutonium particles from the surface into the air for subsequent inhalation by the local populace. Those studies used air samplers placed in four locations representing possible sources of plutonium. Samplers were located near the impact points of the two destroyed weapons, at another contaminated area, and in the town of Palomares. From 1966 to 1980, the highest annual average air concentration was measured at 11.9 fCi/m^3 (442 µBq/m^3) in 1967. The highest average for a weekly measurement period occurred in March 1967 with a concentration of 292 fCi/m^3 (10.8 mBq/m^3) (Iranzo 1987). Measurements during other periods were lower than these, but demonstrated some variation over time.

Studies at Palomares have also estimated the resuspension of plutonium at and around Palomares from the same air sampling data combined with knowledge of the plutonium surface contamination levels. Resuspension is a process that represents the air concentration of a material above a surface contaminated with the same material. The resuspension factor (in units of m^{-1}) is the ratio of the air concentration (expressed in units of pCi/ m^{-3} or Bq/m^{-3}) to the surface contamination (in units of pCi/ m^2 or Bq/m^{-2}). The studies at Palomares indicate that the resuspension factors initially were 10^{-7} m^{-1} initially, dropped to values on order of 10^{-9} m^{-1} months later, and to 10^{-9} m^{-1} to 10^{-10} m^{-1} after several years (Iranzo 1994). The air concentrations were determined in areas where the surface contamination ranged from 3.2 µCi/m^3 (0.118 MBq/m^2) to 32 µCi/m^3 (1.18 MBq/m^3).

Both the air sampling and the resuspension results represent credible efforts that can be used as the basis for estimates of intake and dose.

3.2 AIR FORCE BIOASSAY DATA

During the initial contact, AFIERA and AFMOA provided records in the form of:

- Air Force Forms with laboratory analytical and exposure details of the nasal swipe and urine samples submitted and processed.
- Complete case files for the 26 individuals identified for follow-up in 1966 and commonly referred to as the "High 26".
- A Microsoft Excel spreadsheet prepared by AFIERA staff that contained the data from those Air Force Forms, and some data related specifically to the 26 individuals (referred to as the "High 26" who were considered as having the highest exposures).
- Copies of the accident response reports, USAF RHL documents on the evaluation of exposures by urinalysis, and selected publications from journals and conference proceedings.

Appendix B contains a detailed discussion of the information collected, an evaluation of the information's suitability for a dose evaluation, and adjustments made to the data for performing intake and dose calculations. The record prepared and maintained by the Air Force consisted of forms, computer spreadsheets, and written correspondence and reports of activities.

The data were evaluated to assess the availability of the elements required by the internal dosimetry models. Review indicated that the exposure date or dates, sample date, and results were not completely recorded for all cases. Substantial numbers of samples lacked one or more important pieces of data. Data forms for 115 individuals apparently represented a repeat analysis of a sample or a follow-up sample for an individual. Sample collection proceeded for only 12 hours for many samples collected at Camp Wilson, indicating a correction to 24 hours would be needed. Our review indicated that 12-hour samples were clearly designated in only 42 of the samples. Lacking any other recorded information, sample volumes were assumed to represent 24-hour output unless specifically designated as 12-hour samples.

Urine sampling, begun within three days of the accident, was subject to several compromises, including: collection limited to 12 hours or less for operational requirements; sample contamination from strong winds; non-uniform decontamination procedures; make-shift sample containers, and frequently contaminated storage areas.

Records for 122 nasal swab reviewed indicated that only 13 contained a result (8 were 0 pCi, 4 had values all below 1.5 pCi, and 1 was reported as NDA). Therefore, the nasal swab records were not used in this analysis.

The majority of available records contained results from the gross alpha method on samples collected on site. Most of the records for samples collected on site raised serious questions about estimates derived from them. Records for the 26 individuals in follow-up contained multiple samples collected up to two years after the incident. Unfortunately, the pattern of results for samples collected during the resampling phase often did not follow the pattern expected for Class Y (Type S) plutonium. However, treatment of the records for the 26 served as the model for the other cases. A second group of records contained repeated analyses using the more sensitive alpha spectrometry and provided a reasonably well-defined set of cases for analysis. These two groups were designated the High 26 Group and the Repeat Analysis Group, respectively. Appendix E provides additional details of the bioassay data evaluation and grouping of cases.

The remaining results generally fell into two categories: those with the results of some resampling; and those with one sample and often very high results. Careful review of the group of data indicated that processing all of the cases would produce unrealistic estimates that would be based on potentially contaminated samples. Gross alpha results from samples collected on site produced intake estimates and doses that seemed unreasonably high. Contamination of samples collected at the accident site continued to impact the evaluation as it did at the time of the accident. However, review of those data also indicated a substantial number of cases with urinary results that were essentially below the detection limit or were quite low. Their data were reviewed again to determine whether a reasonable lower cutoff could be determined. Analysis of the processes (Appendix E) supported a cutoff limit at 0.1 pCi/day for gross alpha activity. This was similar to the detection limit of 0.74 mBq/d (0.02 pCi/d) used in studies by the Government of Spain from 1966 to 1985 (Iranzo 1987). Consequently, 0.1 pCi/day was selected as a cutoff limit, and cases in that category were designated the Contamination Cutoff Group.

Applying a cutoff to urinary excretion to individual cases does not precisely impact all samples equally. A fixed value for the cutoff concentrations produces higher estimated intakes and correspondingly higher dose equivalent values for samples taken at longer times after the exposure, especially for Class Y (Type S) plutonium.

After applying the cutoff, 1,219 samples for 1,063 individuals had urine concentrations above 0.1 pCi/d that were classified in the Remaining Cases Group. These were not evaluated further.

4 RADIATION EFFECTS AND DOSIMETRY METHODS

Responders to the Palomares accident encountered sources of possible exposure from plutonium-contaminated aircraft debris, contaminated lands, and agricultural crops, and dust produced by winds. Evaluation of the potential radiation effects requires estimates of the exposure and associated radiation dose, and comparison with knowledge about the effects of radiation on human health. Furthermore, these evaluations must take into account current knowledge and apply accepted methods for estimating the radiation exposure and dose. The approach to accomplishing these estimates is guided by recommendations of both international and national scientific bodies concerned with radiological protection. These bodies, primarily the International Commission on Radiological Protection (ICRP) have published recommendations on the relevant guidelines for limiting radiation effects and exposure, and estimating doses from radioactive materials that may enter the body, as plutonium does.

This section summarizes the current understanding of radiation effects, in general, and plutonium, specifically, on health, and the guidelines to protect workers and the public from those effects. It also summarizes updated internal dosimetry methods relevant to evaluating plutonium exposures.

4.1 SUMMARY OF RADIATION EFFECTS

This study of exposure to plutonium at Palomares and calculation of possible doses to internal organs raises questions about the possible health effects that may be associated with them. This section provides a brief summary of our understanding of the possible health effects from ionizing radiation and plutonium in particular, some of the guidelines for limiting exposure to it, and some basic information about the possibility that a certain dose could cause some kind of effect on health.

4.1.1 General Radiation Effects

In discussing health effects relating to ionizing radiation, the term “dose” is used. “Dose” comes from the early medical use of x-rays, much as a dose of medicine is measured in grains or ounces. It refers to the amount of radiation energy absorbed by an organ, tissue, or cells, measured in rem (or Sv). Today, the average American receives a dose of 0.3 rem (0.003 Sv) every year from natural sources—radioactive materials in rocks and soil, cosmic radiation, radon, and radioactivity in our bodies. Over a 70-year lifetime, the cumulative background dose averages 21 rem (0.21 Sv). In some areas of the world, people receive much higher doses from background radiation. For example, in areas of India and Brazil the ground is covered with monazite sand, a radioactive ore. Radiation exposure rates there are many times the average background levels elsewhere. People who live in these areas receive doses of up to about 0.7 rem

(0.007 Sv) each year from the gamma radiation alone (NAS 1990). These levels combined with the other sources of background radiation (cosmic rays, radon, etc.), cause average doses that are about three times more than the U.S. average. Yet these people show no unusual rates of cancer or other diseases linked to radiation.

The effects of ionizing radiation can be categorized as either prompt or delayed, based on the time frame in which the effects are observed. Prompt effects, like rapid death, occur when high doses are received in a short period of hours to weeks. Delayed effects, such as cancer, can occur when the combination of dose and dose rate is too small to cause prompt effects. Both animal experiments and human exposures to high levels of radiation show that ionizing radiation can cause some cancers (NAS 1990). All of the observed effects of ionizing radiation in humans occur at relatively high doses. At the low doses that are of interest to radiation workers and the general public (that is, below a few rem), studies to date are inconclusive (NAS 1990). Although adverse health effects have not been observed at low doses, the carcinogenic nature of ionizing radiation makes it wise to limit the dose.

For low-doses, there are no conclusive data that relate dose to health effects or showing a threshold, or minimum, level for cancer. Because of this, experts who study radiation effects have decided that the results from high-dose, high-dose-rate studies must be used to control the low-dose, low-dose-rates experienced by workers and the public. A convenient way to do this is to assume that no effects occur at zero dose. In addition, since the rate at which effects occur is extrapolated from higher doses, it is also assumed that the effect increases linearly with dose. These two assumptions are known as the “linear-dose-response, non-threshold” (LNT) hypothesis. This implies that the same number of additional cancers would occur from exposing 100 persons to 100 rem (1 Sv), or 10 thousand persons to 1 rem (0.01 Sv), or 10 million persons to 0.001 rem (0.00001 Sv). No prompt effects have ever been reliably observed in humans below about 10 rem (0.1 Sv). Reports from the Japanese atomic bomb survivor studies conclude that the location and reality of such a threshold, if one does exist, are difficult to assess. Nevertheless, the Health Physics Society (HPS 1996) has stated that “Below 10 rem (which includes occupational and environmental exposures), risk of health effects are either too small to be observed or are non-existent.”

Within the first 30 years after the discovery of x-rays, standards were developed for the measurement of radiation. At about the same time, acceptable levels of dose were set. The first level, known as the ‘tolerance dose’, or that amount of radiation that could be tolerated, was set at one-tenth of a unit (about 0.1 rem (0.001 Sv) in today’s units) per day for 300 days a year, which amounts to 30 rem (0.3 Sv) in a year.

From World War II to the early 1980s, radiation dose limits were adjusted downward in response to increased concern about radiation effects, the increased uses of radiation, and because improved radiation protection technologies appeared. The National Council on Radiation Protection and Measurements (NCRP, established in the 1930s) developed the recommended changes for the United States. During that time, the dose limit was reduced from three-tenths of a rem in a six-day period in 1946 to 5 rem (0.05 Sv) per year in the mid-1950s. In addition, a limit for the public was set at one-tenth of the worker limit to provide an additional margin of safety.

Research does not show a clear threshold dose for cancers from radiation, so the small risk per person at low doses had to be considered in relation to the large number of workers who were receiving those doses (NCRP 1993b).

The NCRP adopted three radiation protection principles: (a) no practice shall be carried out unless it produces a positive net benefit (sometimes called justification); (b) all exposures shall be kept as low as reasonably achievable (ALARA), economic and social factors being taken into account (called optimization); and (c) the dose equivalent to individuals shall not exceed the recommended limits (called limitation). These principles work together to protect against both prompt and delayed effects in large groups of workers and the public.

In 1993, the NCRP released a new set of national recommendations based on International Commission on Radiation Protection's 1990 recommendations. Those limits for non-threshold effects differ slightly from the earlier recommendations: 50 rem (0.5 Sv) per year to any tissue or organ and 15 rem (0.15 Sv) to the lens of the eye to avoid cataract formation. The recommended occupational limits on whole-body doses (total effective dose equivalent), first set at 5 rem (0.05 Sv) per year in 1958, are now set at no more than 5 rem (0.05 Sv) in any one year and a lifetime average of no more than 1 rem (0.01 Sv) per year (NCRP 1993).

Occupational radiation exposure limits for federal agencies are currently established in "Radiation Protection Guidance to Federal Agencies for Occupational Exposure," 52FR 1717, signed by President Reagan on January 20, 1987. The Nuclear Regulatory Commission implemented that guidance in its regulations on radiation protection (Title 10, Code of Federal Regulations, Part 20). These limits apply to all licensed uses of radioactive material under NRC's jurisdiction. Similarly, other Federal agencies as a matter of policy and directive, including the DoD in DODI 6055.8, Occupational Radiation Protection Program, also observe this guidance.

The current established protection standards are (NRC 1999):

- 5 rem in a year for workers (to protect against cancer).
- 50 rem in a year for workers to any organ (to protect against threshold effects, such as radiation burns, etc.).
- 50 rem in a year to the skin or to any extremity.
- 15 rem in a year to the lens of the eye (to protect against cataracts).
- 0.1 rem in a year (70-year lifetime) for members of the public.

These limits are in addition to the radiation doses a person normally receives from natural background, medical testing and treatment, and other sources.

The protection standards mentioned above provide regulatory guidelines to be used primarily for designing radiation protection programs and facilities. Their intent is to limit dose to a worker so that risk is limited to levels that are similar to so-called "safe industries." Limits for the public perform the same purpose but generally include additional margins of safety to account for a wider range of ages (childhood to aged), more diverse health condition, and individual sensitivities. Their primary purpose is to prevent exposures that are associated with risks exceeding the established guides.

These guidelines also offer usable comparisons for evaluating the possible effects of exposures. For example, the occupational limit of 5 rem (0.05 Sv) in a year provides one such value. Since 5 rem (0.05 Sv) represents an acceptable risk, any exposure below 5 rem (0.05 Sv) should be considered acceptable. NCRP recommends that the average dose equivalent per year for workers should not be more than 1 rem (0.01 Sv) a year over 50 years or work. That is the same as 50 rem (0.5 Sv) in 50 years. Therefore, 50 rem (0.5 Sv) provides a reasonable guide for an exposure from radioactive materials in the body, such as plutonium. Since these guides are set with margins of safety, receiving a higher dose does not mean that one will be harmed. However, it would mean that further evaluation might be needed to determine whether the exposure was a one-time incident or one that could recur.

An alternate approach to evaluating the possible effects of an exposure considers the possibility that an exposure will lead to health effects, such as cancer or hereditary effects. The NCRP has provided risk factors for the probability that a certain dose equivalent from radiation will cause an effect. Those factors for workers are 0.0004 per rem (0.04 per Sv) for fatal cancer, 0.00008 per rem (0.008 per Sv) for non-fatal cancer, and 0.00008 per rem (0.008 per Sv) for hereditary disorders for a total of 0.00056 per rem (0.056 per Sv) (NCRP 1993a). For members of the entire population, these factors are 0.0005 per rem (0.05 per Sv) for fatal cancer, 0.0001 per rem (0.01 per Sv) for non-fatal cancer and 0.00013 per rem (0.013 per Sv) for hereditary disorders, for a total of 0.00073 per rem (0.073 per Sv).

4.1.2 Health Effects of Plutonium

Plutonium, discovered in 1941, is radioactive and can be dangerous when it gets into the human body. Some have even referred to plutonium as "the most toxic substance known to man". Early concerns about the health risks of plutonium arose from knowledge of the effects of radium, discovered by Marie Curie in 1899. With its half-life of 1620 years, radium-226 presents an intense and constant radiation source for hundreds of years. Early uses of radium exposed workers to significant doses with acute cases ending in rapid death, and lower exposures leading to infections of the jawbones, pathological bone fractures, or cancers of the bone.

The National Bureau of Standards addressed radium's dangers by developing an occupational standard for radium, adopted in May 1941, about two months before the discovery of plutonium. Scientists on the Manhattan Project then recognized the potential hazards of plutonium, which is similar to radium. They estimated that plutonium would be roughly as dangerous as radium when comparing equal masses.

Plutonium gives off alpha particles that produce heavy ionization and give up their energy more quickly than the lighter beta particles, or x-rays and gamma rays. In air, alphas travel only 3 to 5 centimeters and in living tissue only about 30 micrometers. That distance is less than the thinnest part of the dead layer of external skin cells (called the epidermis), or the thickness of a piece of paper (about 100 micrometers). Because of this low penetrating power, materials that give off alpha particles present no hazard when kept outside the body.

Unfortunately, when they get inside the body, alpha emitters come into very close contact with the body tissues and irradiate cells. Plutonium can be inhaled, ingested, or passed into the blood stream through a wound. When that happens, about 90 percent eventually goes to the lung, liver, or bones.

The half-life of plutonium-239 is 24,065 years. This half-life is short enough that 1 microgram of material will undergo more than 2000 decay events per second, but it is long enough to allow that microgram to decay at an approximately constant rate for thousands of years.

No one has ever died from an acute plutonium uptake. But, researchers have estimated lethal doses from studies on dogs, rats, and mice, which indicate that a few milligrams of plutonium per kilogram of tissue is a lethal dose. Extrapolated to humans, an intravenous injection of about

22 milligrams into an average human (70 kilograms; about 154 pounds) would be lethal within about 30 days to half the people exposed. Inhalation would require about four times more or 88 milligrams.

Recognizing the similarity of plutonium to radium, scientists worked to develop exposure standards that would limit the risks to workers, especially on the important war-time effort of developing a plutonium-implosion bomb. Beginning in 1945, those efforts have evolved into a set of radiation protection recommendations that have received international acceptance. In 1977, the ICRP published major revisions in those recommendations that based radiation protection for plutonium on dose rather than deposition in the body. Those recommendations, known as ICRP 30, have been largely adopted in the United States. In 1991, the ICRP published new recommendations (ICRP 60), which reduced the recommended annual occupational limit to 2 rem (20 millisieverts) per year. Thus far, these recommendations have not been adopted in the United States, however, they are considered in most radiation protection assessments.

Plutonium absorption in the body depends mainly on the plutonium compound and how it enters the body. The body generally absorbs the soluble forms (nitrates, citrates, and certain oxides) more readily than insoluble forms. Plutonium absorption through intact skin is usually quite low, but deposits in tissues through puncture wounds, cuts, and somewhat less through skin burns. Soluble plutonium begins movement throughout the body within minutes or hours of the uptake and may move to the lymph nodes near the wound; remaining for years. Some insoluble plutonium gets into the blood circulation quickly, but most remain at the site and are slowly redistributed over weeks and months. About 90 percent of the systemic burden deposits in the liver and bones. The kidneys excrete plutonium in urine that represents the concentration of the plutonium in the blood making plutonium measurements in urine a convenient indicator of plutonium in the body.

Ingesting plutonium is perhaps the least likely means for plutonium to enter the body. But even if plutonium is ingested, the gastrointestinal tract provides a natural barrier, and in adults only about 0.05 percent of the soluble plutonium compounds and a mere 0.001 percent of the insoluble ones enter the blood stream. The rest of the plutonium simply moves out of the body in feces.

Inhalation of plutonium dust provides the most likely entry route for plutonium. Particle size affects plutonium absorption. Smaller particles are more likely to be retained. Particles over 10 micrometers in diameter (considered large) are filtered out in the nose and upper respiratory region, swallowed, and eventually passed out through the gastrointestinal tract. Particles less than 10 micrometers in diameter (called respirable particles), deposit on the mucus layer of the bronchial tubes. Through a process, known as lung clearance, hair-like structures of the lining (called celia) transport the mucus layer and dust particles up to the throat, removing much of the foreign material deposited in the bronchial tubes.

Smaller particles, especially those under 1 micrometer in diameter, are carried down into the tiniest airways of the lung and into alveoli (also known as air sacs). These structures have no effective lung-clearance mechanisms, but scavenger cells called phagocytes, engulf the inhaled plutonium particles, and transport them into lymph nodes or into lung tissues.

Autopsy studies reveal that, initially, plutonium is mostly deposited on the bone surfaces. Less than 5 percent of the plutonium is typically found within the bone marrow. Based on this this pattern of deposition, the primary carcinogenic risk from plutonium in the skeleton is bone cancer. There is no conclusive evidence that plutonium increases the risk for leukemia, which is the unchecked proliferation of certain blood cells produced in the bone marrow.

Plutonium in the bone remains there for a very long time, gradually being redistributed throughout the bone. Current models (based on observation of exposed persons and autopsy data) estimate a half time of about 50 years for plutonium retention.

The plutonium deposited in the liver is eventually transformed from relatively soluble forms in hepatic cells into insoluble forms (hemosiderin deposits), which are sequestered in the cells that form the linings of liver ducts (reticuloendothelial cells). The retention half time for the plutonium deposited in the liver is approximately 20 years.

To date, there have been only few epidemiological studies of workers exposed to plutonium. Studies of workers at Los Alamos National Laboratory (Wiggs 1994) and Rocky Flats (Wilkinson 1987) are the only ones in the United States to have used quantitative measurements of plutonium exposures, but they involved few workers: 303 at Los Alamos and 1450 at Rocky Flats. These two studies showed no evidence of statistically increased rates of lung, liver, and bone cancers, which are shown in animal experiments to be the highest-risk cancers due to plutonium exposure. Another study (Reyes 1984) indicates that an increased brain-cancer rate in Rocky Flats workers was not caused by plutonium exposure or external radiation.

A study (Voelz 1983) involving 224 males exposed to plutonium between 1944 and 1974 who had plutonium deposition greater than 0.16 microgram (0.01 microcurie) found no cases of bone or liver cancer. By 1980, the final year of the study, only one person had died of lung cancer indicating risks were much lower than predicted by some nuclear-industry critics. Another study looked at 26 chemists, metallurgists, and technicians at Los Alamos, who were accidentally exposed to plutonium between 1944 and 1946.Their plutonium body burdens ranged from 50 Bq to 3,180 Bq when estimated by analysis of their urine (Voelz 1997). Interestingly, the mortality rate of these men has been lower than that of the population in general, and in 1996, 19 of them were still living.

Of those who are no longer alive, one died of lung cancer in 1989, at the age of 66, and two died of prostate cancer and congestive heart failure, respectively, but both had lung cancer at the time of death. All three men were very heavy smokers. Significantly, three cases of lung cancer are consistent with the national cancer incidence rate, over the same period, in U.S. white males of the same age. Another subject, who had an estimated plutonium deposition of 0.245 microgram, developed a rare bone cancer 43 years after exposure and died in 1990. This finding is statistically significant for the small group of 26, but in the Los Alamos study (Wiggs 1994) of 303 workers, this same individual remained the only one to have developed bone cancer. That one death from bone cancer in this larger group could well be due to chance and is not statistically significant. Finally, three more died of causes unrelated to cancer.

Overall, data from the several studies of persons exposed to low levels of plutonium radiation in the United States do not show a relation- ship between dose and effect. They merely indicate that such a relationship does not exist or cannot be confirmed. If plutonium is harmful at these low levels, its health risks are so small that, given the small number of workers involved, epidemiological methods cannot differentiate between effects triggered by plutonium radiation and variations in a group of people unexposed to such radiation.

Although studies on plutonium workers in the United States did not demonstrate the risk from plutonium radiation, there are data from much higher doses to which Russian plutonium workers have been exposed. Russian scientists have recently published two studies (Tokarskaya et al.1997, Koshurnikova et al.1998) of workers who had been exposed to plutonium at the Mayak Plant. The authors demonstrate that an increased risk for lung cancer is associated with higher exposures. Although both studies investigate this risk on many of the same workers, their conclusions about the relationship between dose and risk are different.

In one study, (Koshurnikova 1998) analyzed data from a cohort of 1479 workers who had been exposed to high doses of various types of radiation, including plutonium radiation, between 1948 and 1993. The control group was composed of 3333 other workers at Mayak who had also been exposed to radiation but within occupational limits. The study found a linear relationship between lung doses from 0.5 to 30 sieverts (or 50 to 3000 rem) and standardized mortality ratios. While this result found no threshold for effects, the trend of increasing rates with increasing dose is impressive.

The second study (Tokarskaya 1997) found a nonlinear threshold relationship between dose and lung cancer risk in a case-control study devoted to 162 plutonium workers who developed lung cancer between 1966 and 1991 and a control group of 338 Mayak workers who, during the same period, did not. The authors found no lung cancer risk up to a threshold dose of 16 sieverts, corresponding to about 1.6 micrograms of plutonium deposited. Above this threshold value, however, the risk rises rapidly. The two Russian studies are very different in the dose response relationships reported. However, the data demonstrate that lung cancer risk does indeed increase with higher doses.

A recently reported study to estimate the mortality risk per unit dose from exposure to plutonium produced results that compare well with estimates derived by other workers. This study developed the estimates using four independent approaches – epidemiologic studies of workers exposed to plutonium; epidemiologic studies of persons exposed to low-LET radiation combined with a relative biological effectiveness factor (RBE) for alpha particles appropriate to the cancer site; epidemiologic studies of persons exposed to alpha-emitting radionuclides other than plutonium; and controlled studies of animals exposed to plutonium and other alpha-emitting radionuclides extrapolated to humans (Grogan 2001). That work reported mortality risk per unit dose of 0.13 per Gy for lung, 0.057 per Gy for liver, 0.0013 per Gy for bone, and 0.013 per Gy for bone marrow (leukemia). Calculations of the risk for a unit intake compared well with estimates prepared by other workers.

It has been almost six decades since plutonium was first made. No doubt, the dangers of plutonium are real. However, plutonium has been handled in different chemical forms, fabricated as a metal, machined, and used successfully primarily because standards and procedures were established early. Because of this, there has been no instance of acute death from taking plutonium into the body.

4.2 REVIEW OF INTERNAL DOSIMETRY METHODS

Exposure to radiation can occur from sources of penetrating radiation outside the body, such as x-ray machines or industrial radiography sources, or from sources of radioactive materials, such as plutonium or uranium, that enter the body, locate in an internal organ or organs, and irradiate the tissues of those internal organs. The problem of calculating the dose depends on many factors such as the shape of the organ, the type of radiation, the amount of the deposit, and the distribution of the deposit. Each of these individual factors is subject to considerable variability and difficulty in determining accurately. Once a dose is calculated, effectively communicating the possible effect of the dose on health requires additional skill and effort.

The current approach to limiting radiation exposure in the United States is derived from recommendations in ICRP Publications 26 and 30. The ICRP approach uses the concept of Committed Effective Dose Equivalent (CEDE) - a cumulative dose, weighted for the contributions of individual organs, and summed over a 50-year period for workers. Quantities derived from the CEDE such as the Annual Limit on Intake (ALI) and the Derived Air Concentration (DAC) provide operational limits for workers so that the overall guidelines will not be exceeded. The ALI is the activity of a radionuclide that would irradiate a person to the limit set by the ICRP for each year of occupational exposure. The DAC is found by dividing the ALI by the volume of air inhaled (2,400 m^3) in a working year (2,000 hours) (ICRP 1979).

For internal exposures, determining the dose requires knowledge of the following questions:

- How does the material get into the body?
- Once in the body, how quickly does the material move to other organs?
- Does the material in the initial organ leave the organ or does some remain?
- Once in an organ, how does the material irradiate the organ and other organs?
- Once in an organ, how does the material move to other organs?
- Finally, how does is the material eliminated from the body if at all?

Answers to these provide the basis for developing an approach to calculate the dose to organs, the effective dose equivalent to the body, and interpreting the effects of the dose.

4.2.1 Internal Dosimetry Methods

The methods for estimating organ dose from internal radionuclides have evolved since radioactive materials were discovered and used. Until 1979, ICRP Publication 2 provided the guidelines and methodology. In 1979, ICRP Publications 26 and 30 changed the basic approach to limiting radiation, and for internal radionuclides in particular. ICRP Publications 54, 60 and 66 provided revised recommendations and updated models on the behavior of radionuclides in the body.

ICRP-2 assumed that a single organ could be considered the critical organ; that the organ retention could be represented by a single exponential term; that the physical characteristics, such as intake parameters, transfer functions, and tissue size and weight, could be represented by "Standard Man" data; that organs could be assumed to be spherical; and that scattered radiation could be ignored. Intakes of radionuclides were controlled by limiting "Maximum Permissible Concentration" (MPC) values in air and water for workers so that the annual dose limit to the critical organ would not be exceeded.

ICRP Publication 26 revised the system of dose limitation to one based on risk. This approach acknowledged the availability of sufficient information about the effects of radiation to estimate risk for fatal cancer from a unit dose equivalent in exposed people and in the risk of serious disease to offspring of exposed people. The basic recommendations addressed both stochastic effects and non-stochastic effects. For stochastic effects, such as cancer and hereditary effects, risks are assumed to be directly related to dose equivalent with no threshold, meaning that the probability of the effect occurring, rather than the severity, is related to the dose equivalent. The severity of non-stochastic effects, such as cataracts and erythema, varies with dose, usually above a threshold or minimum dose.

ICRP Publication 30 provided revised dosimetry models that assume organ retention is represented by one or more exponential expressions, the critical organ concept no longer applies, the dose in an organ must consider radiation emitted by other organs in the body, and the physical characteristics are represented by "Reference Man" data in ICRP Publication 23 (ICRP 1975).

Under the revised system, dose equivalent limits are intended to prevent non-stochastic effects and to limit stochastic effects to acceptable levels. To meet this end, an annual occupational limit of 50 rem (0.5 Sv) to any organ was established (ICRP 1979). For stochastic effects, the limit on risk is the same whether the whole body is irradiated or organs are non-uniformly irradiated. This is accomplished by assigning organ weighting factors, w_t, that represent the ratio of the risk for the effect in an organ to the risk for whole body irradiation. The limit on risk to the whole body – called committed effective dose equivalent (CEDE) is then determined by summing the contributions for each irradiated organ and is limited to 5 rem (0.05 Sv). The committed dose equivalent (CDE) is the total dose equivalent averaged over a tissue (T) in the 50 years following intake and is limited to 50 rem (0.5 Sv). Table 3 contains the organ weighting factors from ICRP-30.

The dosimetry model calculates the absorbed dose averaged over the organ mass during 50 years following intake. It considers each radiation type and applies a radiation weighting factor, sometimes called the quality factor, which has the following value:

Q=1 for beta particles, electrons and all electromagnetic radiation.

Q=10 for fission neutrons emitted in spontaneous fission and protons.

Q=20 for alpha particles from nuclear transformations, for heavy recoil particles, and for fission fragments.

Table 3. ICRP-30 Tissue weighting factors, w_T (ICRP 1979).

Tissue	Weighting Factor, w_T
Gonads	0.25
Red Marrow	0.12
Lung	0.12
Breast	0.15
Thyroid	0.03
Bone Surface	0.03
Remainder 0.06 for the organs with the five highest dose.	0.30

The ICRP further refined its basic recommendations and updated certain models for the respiratory tract and the biokinetics of deposited materials. The ICRP's 1990 recommendations

(ICRP 1991) provide weighting factors for tissues that were part of the remainder in the 1979 recommendations of ICRP-26 (ICRP 1979). Table 4 compares the tissue weighting factors of ICRP-26 and ICRP-60 and include a reduction in the bone surface and breast factors by three times, a 67 percent increase in the thyroid factor, and assignment of factors for additional organs, including the skin of the whole body.

Table 4. Tissue Weighting Factors (ICRP 1991).

	ICRP Recommendations	
Tissue or organ	1979	1990
Gonads	0.25	0.20
Red Marrow	0.12	0.12
Colon		0.12
Lung	0.12	0.12
Stomach		0.12
Bladder		0.05
Breast	0.15	0.05
Liver		0.05
Esophagus		0.05
Thyroid	0.03	0.05
Skin		0.01
Bone Surface	0.03	0.01
Remainder	30[1]	.05[2]

[1] A value of 0.06 is applicable to each of the five remaining organs or tissues receiving the highest equivalent doses.
[2] The remainder is composed of the following tissues or organs: adrenals, brain, small intestine, kidney, muscle, pancreas, spleen, thymus and uterus.

The differences between the two ICRP models for the respiratory tract could be expected to produce differences in estimated doses. During development of the updated respiratory tract model, its performance was tested in detail to determine the affects of various parameters taken alone and in combination. Some examples of the performance of both systems provide useful information about likely differences in estimating both equivalent dose and effective dose equivalent.

One such evaluation, reported by James (James 1994) compared the lung dose equivalent and effective dose for several categories of radionuclides, including insoluble alpha emitters, such as plutonium at Palomares. In those illustrations, James compared doses for intakes of 1 µm activity median aerodynamic diameter (AMAD) particles although ICRP recommends 5 µm AMAD for workers. For 1 µm AMAD, Type S (Class Y) ^{239}Pu, the ICRP-30 and ICRP-66 equivalent dose per unit intakes were 320 µSv/Bq and 84 µSv/Bq, respectively. The ICRP-66 equivalent dose was lower by about a factor of 3.8. For 5 µm AMAD particles, ICRP-66 estimated 50 µSv/Bq, or about 6 times lower. Calculating effective dose for the same conditions, ICRP-30 produced 60 µSv/Bq and ICRP-66 produced 16 µSv/Bq for 1 µm AMAD particles and 9.1 µSv/Bq for 5 µm AMAD particles, representing reductions of about 3.7 and 6.5, respectively. Thus, other factors being equal, the ICRP-66 respiratory tract model can produce equivalent doses that are roughly 3 to 6 times lower for the same intake than the ICRP-30 model. This difference, attributed to the modified model for lung deposition and clearance and revised tissue weighting factors must be recognized in evaluating methods for this project.

Determining the amount of material taken into the body during an exposure forms the basis for estimating the amount of material that is transferred to the blood stream and internal organs as well as the amount that clears from the body. Estimates of the organ dose from internal emitters generally follows from an intake assessment, which is usually based on measures of the material in the body or excreted from the body. Common methods include in-vitro bioassay of the amount of the material excreted, measurements of body or organ content, or estimates from air or water concentrations. For this case, estimates of the intakes from environmental plutonium concentrations provide the best available method for assessing the intake. The large collection of urinary analyses were evaluated and used to estimate intakes and doses; however, those were judged unrealistically high. The methods and models used for accomplishing the estimates from urine analyses are discussed in Appendix D.

4.2.2 Computer Models Investigated

Many computer programs have been developed and are available for performing the calculations of the models discussed above. Currently more programs implement the ICRP-30 system than the ICRP-66 model. This comes as no surprise since the ICRP-30 system remains the current system for regulation of the doses from radioactive materials in the United States. However, one objective for this project included the evaluation and recommendation or the best calculation method. Since ICRP provisions are usually adopted in the U.S., investigating at least one software program that implemented the most recent approach seemed reasonable. After some review of the available software, three programs were selected for further study – the Radiological Bioassay and Dosimetry Program (RBD) as modified for the Air Force, Code for Internal Dosimetry (CINDY), and Lung Dose Evaluation Program (LUDEP ver 2.06). Testing of program performance and selection for use are described in Appendix D.

4.3 MODEL ADOPTION

RBD/AF, CINDY, and LUDEP all provide acceptable performance on estimating intake, calculating dose, and providing compatibility with the available data. LUDEP is somewhat less convenient for manipulating large numbers of cases and for generating outputs that can be used in other manipulations; however it implements the current ICRP respiratory tract model.

CINDY and RBD/AF implement the current regulatory system of the NRC and DOE for radiation protection, while LUDEP offers the alternative for applying the respiratory tract model and other features of recent ICRP recommendations. CINDY provides somewhat more flexibility in setup, estimating intakes, and reporting. Consequently, CINDY was chosen as the primary method for assessing the Palomares cases. LUDEP was retained as a reasonable alternate that provides complementary assessments for interesting cases and offers a much-needed point for comparison of results.

5 ESTIMATES FROM ENVIRONMENTAL MEASUREMENTS

5.1 METHODS

The environmental studies summarized in Section 3.1 reported values for the annual average air concentration and the highest weekly measurement obtained with air samplers located near the impact point for weapon number 2. These were selected as reasonable values for air concentrations that response force personnel could have experienced. Those values were combined with dose conversion factors for Type S plutonium calculated using LUDEP. Since breathing rates affect the intake – the more air one breathes in, the more plutonium that enters the lungs – the calculations were performed for standard workers (breathing rate of 1.2 m^3 per hour) and for heavy workers (1.688 m^3 per hour). Also, the calculations were performed for particle sizes of 1 micrometer and 5 micrometers AMAD. Smaller particle sizes tend to produce higher deposition in the lung and consequently higher doses. Previous recommendations of the ICRP (ICRP-30) recommended 1 micrometer AMAD; however, recent recommendations (ICRP-66) favor 5 micrometers AMAD as more representative of worker exposures.

5.2 RESULTS

Calculations of intake and dose were performed for three exposure scenarios. The first assumed that response force workers were on site for two weeks, and worked 6 days per week for 12 hours a day. This would represent many of the responders who rotated at two-week intervals. The second scenario used 4 weeks on site under the same work conditions to represent those who stayed somewhat longer. Finally, the last scenario assumed that responders could have been exposed for 11 weeks, which essentially represents the entire response effort; i.e. from just after the accident until March 31, 1966. Those estimates are shown in Table 5 and indicate that even the highest scenario produces much less than 1 rem whole body committed effective dose equivalent.

The resuspension factors described in Section 3.1 were used to calculate air concentrations, intakes, and doses (CEDE) for the same scenarios described above. The results listed in Table 6 indicate that even the highest dose (0.312 rem) is well below a significant amount. Furthermore, these estimates differ significantly from the intakes and dose estimates derived from urine analysis, and demonstrate the need to refine the analysis with follow-up studies.

6 RESULTS FROM URINALYSIS DATA

The response to the Palomares nuclear accident involved hundreds of personnel working toward the common purpose of recovering vital materials, protecting themselves and the local populace, and restoration of the accident scene to useable and safe conditions. The accident itself released plutonium during explosions and fires that followed the impact of two of the nuclear weapons with the ground. The plutonium was released primarily as airborne dust and as residues from fire that contaminated the ground. Since the fires essentially were out long before serious response efforts started, the main source of exposure arose from activities such as vehicle movement, handling debris during recovery, plowing fields to mix the contaminant into the soil, and vehicle movement. Persistent winds also contributed to the resuspension of contaminated soils from the

Table 5. Intake and dose estimates from air concentrations.

Average Air Concentration 0.000442 Bq/m^3
Maximum Air Concentration 0.0108 Bq/m^3

					Dose Conversion Factor (Sv/Bq)		Average Air Concentration			Maximum Air Concentration		
								CEDE (Sv)/ CEDE (rem)			CEDE (Sv)/ CEDE (rem)	
Scenario	Worker Type	Breathing Rate (m^3/hr)	Particle Size (um)	Exposure Time (hours)	ICRP-26	ICRP-60	Intake (Bq)	ICRP-26	ICRP-60	Intake (Bq)	ICRP-26	ICRP-60
2 weeks	Standard	1.2	1	144	1.946E-05	1.531E-05	0.076	1.486E-06	1.169E-06	1.87	3.632E-05	2.857E-05
6 days per week								0.00015	0.00012		0.0036	0.0029
12 hours per day	Standard	1.2	5	144	1.084E-05	8.647E-06	0.076	8.279E-07	6.604E-07	1.87	2.023E-05	1.614E-05
								0.00008	0.00007		0.0020	0.0016
	Heavy	1.688	1	144	1.975E-05	1.571E-05	0.107	2.122E-06	1.688E-06	2.63	5.185E-05	4.124E-05
								0.00021	0.00017		0.0052	0.0041
	Heavy	1.688	5	144	1.227E-05	1.010E-05	0.107	1.318E-06	1.085E-06	2.63	3.221E-05	2.651E-05
								0.00013	0.00011		0.0032	0.0027
4 weeks	Standard	1.2	1	288	1.946E-05	1.531E-05	0.153	2.973E-06	2.339E-06	3.73	7.263E-05	5.714E-05
6 days per week								0.00030	0.00023		0.0073	0.0057
12 hours per day	Standard	1.2	5	288	1.084E-05	8.647E-06	0.153	1.656E-06	1.321E-06	3.73	4.046E-05	3.227E-05
								0.00017	0.00013		0.0040	0.0032
	Heavy	1.688	1	288	1.975E-05	1.571E-05	0.215	4.244E-06	3.376E-06	5.25	1.037E-04	8.248E-05
								0.00042	0.00034		0.0104	0.0082
	Heavy	1.688	5	288	1.227E-05	1.010E-05	0.215	2.637E-06	2.170E-06	5.25	6.442E-05	5.303E-05
								0.00026	0.00022		0.0064	0.0053
Full Response	Standard	1.2	1	792	1.946E-05	1.531E-05	0.420	8.175E-06	6.431E-06	10.3	1.997E-04	1.571E-04
11 weeks								0.00082	0.00064		0.0200	0.0157
6 days per week	Standard	1.2	5	792	1.084E-05	8.647E-06	0.420	4.554E-06	3.632E-06	10.3	1.113E-04	8.876E-05
12 hours per day								0.00046	0.00036		0.0111	0.0089
	Heavy	1.688	1	792	1.975E-05	1.571E-05	0.591	1.167E-05	9.283E-06	14.4	2.852E-04	2.268E-04
								0.00117	0.00093		0.0285	0.0227
	Heavy	1.688	5	792	1.227E-05	1.010E-05	0.591	7.250E-06	5.968E-06	14.4	1.772E-04	1.458E-04
								0.00073	0.00060		0.0177	0.0146

Table 6. Intake and dose estimates from resuspension.

Minimum Resuspension Factor	1.29E-09	m^{-1}	Maximum Resuspension Factor	1.00E-07	m^{-1}
Minimum Surface Contamination	1.18E+05	Bq/m^2	Maximum Surface Contamination	1.18E+06	Bq/m^2
Minimum Air Concentration	1.522E-04	Bq/m^3	Maximum Air Concentration	0.118	Bq/m^3

							Minimum Air Concentration			Maximum Air Concentration		
					Dose Conversion Factor (Sv/Bq)			CEDE (Sv)/ CEDE (rem)			CEDE (Sv)/ CEDE (rem)	
Scenario	Worker Type	Breathing Rate (m^3/hr)	Particle Size (um)	Exposure Time (hours)	ICRP-26	ICRP-60	Intake (Bq)	ICRP-26	ICRP-60	Intake (Bq)	ICRP-26	ICRP-60
2 weeks	Standard	1.2	1	144	1.946E-05	1.531E-05	0.026	5.119E-07	4.027E-07	20.4	3.968E-04	3.122E-04
6 days per week								5.119E-05	4.027E-05		0.0397	0.0312
12 hours per day	Standard	1.2	5	144	1.084E-05	8.647E-06	0.026	2.851E-07	2.274E-07	20.4	2.210E-04	1.763E-04
								2.851E-05	2.274E-05		0.0221	0.0176
	Heavy	1.688	1	144	1.975E-05	1.571E-05	0.037	7.308E-07	5.813E-07	28.7	5.665E-04	4.506E-04
								7.308E-05	5.813E-05		0.0566	0.0451
	Heavy	1.688	5	144	1.227E-05	1.010E-05	0.037	4.540E-07	3.737E-07	28.7	3.519E-04	2.897E-04
								4.540E-05	3.737E-05		0.0352	0.0290
4 weeks	Standard	1.2	1	288	1.946E-05	1.531E-05	0.053	1.024E-06	8.054E-07	40.8	7.936E-04	6.244E-04
6 days per week								1.024E-04	8.054E-05		0.0794	0.0624
12 hours per day	Standard	1.2	5	288	1.084E-05	8.647E-06	0.053	5.703E-07	4.549E-07	40.8	4.421E-04	3.526E-04
								5.703E-05	4.549E-05		0.0442	0.0353
	Heavy	1.688	1	288	1.975E-05	1.571E-05	0.074	1.462E-06	1.163E-06	57.4	1.133E-03	9.012E-04
								1.462E-04	1.163E-04		0.1133	0.0901
	Heavy	1.688	5	288	1.227E-05	1.010E-05	0.074	9.080E-07	7.474E-07	57.4	7.039E-04	5.794E-04
								9.080E-05	7.474E-05		0.0704	0.0579
Full Response	Standard	1.2	1	792	1.946E-05	1.531E-05	0.145	2.815E-06	2.215E-06	112.1	2.182E-03	1.717E-03
11 weeks								2.815E-04	2.215E-04		0.2182	0.1717
6 days per week	Standard	1.2	5	792	1.084E-05	8.647E-06	0.145	1.568E-06	1.251E-06	112.1	1.216E-03	9.697E-04
12 hours per day								1.568E-04	1.251E-04		0.1216	0.0970
	Heavy	1.688	1	792	1.975E-05	1.571E-05	0.204	4.019E-06	3.197E-06	157.8	3.116E-03	2.478E-03
								4.019E-04	3.197E-04		0.3116	0.2478
	Heavy	1.688	5	792	1.227E-05	1.010E-05	0.204	2.497E-06	2.055E-06	157.8	1.936E-03	1.593E-03
								2.497E-04	2.055E-04		0.1936	0.1593

ground or contaminated dusts from the surfaces of accident debris, local buildings, or agricultural crops.

Ingestion by hand to mouth transfer is a second possible route of entry. However, that route is very inefficient. Furthermore, the fraction of plutonium that enters the bloodstream from the intestines is very small (0.00001 for Type S). For reasons discussed in Appendices D and E, the ingestion route is not considered further.

The type of exposure was assumed a single acute exposure. This assumption accommodates the long time for removal of plutonium oxides from the human body. The response activity occurred from January 18, 1966 until April 3, 1966 when activities were moved from Camp Wilson to another location. Personnel on site reached a maximum in late January; tapered off during February, and then increased slightly in mid-March during the packaging of contaminated debris, soil and other wastes for disposal. Most departed the site by late March 1967. The nominal length of assignment was about two weeks. However, records indicate that some personnel stayed much longer.

6.1 HIGH 26 CASES

The responders were assigned to four groups of cases, as discussed above – the High 26 Cases Group, the Repeat Analysis Cases Group, the Contamination Cutoff Cases Group and the Remaining Cases Group. The High 26 Cases Group offered the best collection of urinary measurement data to develop an overall understanding of the relationship between the measurement results and possible intake of plutonium. Therefore, substantial effort was applied to evaluating these cases. Then, that understanding was applied to the remaining three groups of cases. As discussed above, however, the quality of the data set limited the preparation of reasonable estimates. This section describes the approach to evaluating each group, the results obtained, the relationship between the estimated dose equivalents and effects.

6.1.1 Methods and Results

The High 26 Cases Group represents the collected measurement data from 26 responders who were identified for follow-up after the initial phase of sampling in 1966. This group provided 127 urine samples during their on-site and resampling activities. Most of those samples (102 of 127) produced ^{239}Pu measurements from alpha spectrometry. Appendix E provides detailed discussions of the data evaluation, results of model fitting, and estimated intakes and doses.

6.1.1.1 Methods

Careful evaluation of the results revealed several difficulties with the reported results. These included differences in the reporting of confidence levels for the results. The reported errors for gross alpha measurements represented the 95% confidence level while the reported errors for alpha spectrometry measurements represented the 68% confidence level. Since the criterion for reporting a result as no detectable activity was based on the 95% confidence limit, some alpha spectrometry results may have been reported as positive when the estimated errors did not support that conclusion. In addition, some alpha spectrometry reports contained calculated values although the reported results indicated NDA. Those results were used in these estimates when recorded on the individual data cards.

Laboratory measurements experienced some difficulties with reproducibility also. In several samples with multiple analyses, differences in reported concentrations of two to three times were observed.

The urine analysis results for the High 26 Cases Group indicated that those cases with several measurements for samples collected over the entire initial and resampling efforts could provide the best data for testing. The data and CINDY and LUDEP program setup were varied in several ways. Assumptions were developed for the date of exposure, the use of gross alpha results and the use of NDA results. For the programs, the main adjustment involved the method for weighting results during intake assessment using CINDY and LUDEP. Generally, the date of exposure was assumed as the first day on site, gross alpha measurements were rejected, and values were developed for NDA reports. These variations are discussed in detail in Appendix E.

6.1.1.2 Results

For the 26 cases, the preliminary intake estimates varied from 34,000 pCi to 570,00 pCi from CINDY and 19,000 pCi to 2,600,000 pCi from LUDEP with the gross alpha results excluded in all the cases. Estimates of committed effective dose equivalent ranged from 10 rem to 170 rem (0.1 to 1.7 Sv) from CINDY and 1.3 to 180 rem (0.013 to 1.8 Sv) from LUDEP. LUDEP ranged from –83% to +150% of CINDY results. The range of differences between LUDEP results and CINDY results seems reasonable considering the variation in the data and the complexities of the assessment. In addition to the intakes and CEDE estimates, 50-year committed dose equivalents were calculated for organs using CINDY. Those results are discussed in Appendix E, however, when compared with independent estimates from environmental data and with the results of other exposure cases, these estimates seem unreasonably high.

6.2 REPEAT ANALYSIS CASES GROUP

Palomares responders were placed in the Repeat Analysis Cases Group if they met one or both of the following conditions:

- They submitted an initial urine sample while on site that was analyzed for gross alpha radioactivity and then reanalyzed by alpha spectrometry for ^{239}Pu; or
- They submitted an initial sample while on site that was analyzed by gross alpha counting and then submitted one or more follow-up samples after returning to their base of assignment for analysis by alpha spectrometry.

6.2.1 Methods and Results

From January 17, 1966 to June 22, 1966, this group provided 82 urine samples from 54 individuals that produced usable results. The gross alpha and alpha spectrometry measurements are primarily greater than 0.1 pCi/d and the two types of measurements are interspersed among one another. Most of the samples were characterized by a gross alpha measurement followed by reanalysis by alpha spectrometry in an attempt to identify the radionuclide responsible for the gross alpha result. In most cases, the alpha spectrometry result was lower than the gross alpha measurement. Unfortunately, resampling was not accomplished for those in this group.

6.2.1.1 Methods

The Repeat Analysis Cases Group had exposure dates that extended over a broader range of dates than the High 26 Cases Group. However, many were among the initial responders who arrived in January 1966. Because the time on site seemed shorter and better recorded for this group, the exposure date was assumed as the midpoint of the time at Camp Wilson. In general, gross alpha results for samples collected on site were excluded from the analysis, gross alpha results reported as NDA were assigned a value of 0.009 pCi/d, numerical results recorded on alpha spectrometry records reported as NDA were used, and some alpha spectrometry results were excluded when they did not fit the expected urinary excretion pattern. Method details are provided in Appendix D.

6.2.1.2 Results

For the 54 cases, the estimated intakes varied from 2,900 pCi to 1,300,000 pCi from CINDY and 11,900 pCi to 5,240,000 pCi from LUDEP with the gross alpha results excluded in all the cases. Estimates of committed effective dose equivalent ranged from 0.9 rem to 400 rem (0.009 to 4.0 Sv) from CINDY and 0.8 to 367 rem (0.008 to 3.67 Sv) from LUDEP. LUDEP results ranged from –238% to +94% of CINDY results. In addition to the intakes and CEDE estimates, annual dose equivalents and committed dose equivalents were calculated for organs using both CINDY and LUDEP. Details of these results are discussed in Appendix E. As for the High 26 Group, these estimates are unrealistic when compared with the estimates from environmental measurements.

6.3 CONTAMINATION CUTOFF CASES GROUP

The Contamination Cutoff Cases Group of analyses was created to calculate estimated intake and dose equivalent for those whose urine measurement results indicated potentially contaminated samples collected at the accident site but were below a reasonable minimum level that did not represent unusually high exposures. While the data for this group were not especially robust, this approach offered an opportunity to evaluate additional cases. As discussed in Appendix E, a level of 0.1 pCi/d was adopted as reasonable maximum level for cases included in the Contamination Cutoff Cases Group.

6.3.1 Methods and Results

6.3.1.1 Methods

The procedures for analysis of the High 26 Cases Group were applied to the Contamination Cutoff Cases Group, except that the intakes and dose equivalents were calculated using only the CINDY program. The group had exposure dates that began over a similar range of dates to the Repeat Analysis Cases Group. Many of this group stayed on site for one to two weeks, with some up to a month. The exposure date was assumed as the midpoint of the time at Camp Wilson. See Appendix E for additional details of this group's analyses.

6.3.1.2 Results

For the 313 individuals in the Contamination Cutoff Cases Group, the estimated intakes varied from 1,500 pCi to 110,000 pCi. Estimates of committed effective dose equivalent ranged from 0.46 rem to 34 rem (0.0046 to 0.34 Sv). The higher estimated intake and dose were produced by a urine sample, taken at 25 days after the assumed exposure date, with a result of 0.099 pCi/d of gross alpha activity. According to the excretion function derived, the urinary content on day 25 represents approximately 9×10^{-7} of the inhalation intake. This case illustrates how urine concentrations that are even slightly above delectability can lead to sizeable estimated intakes and dose equivalents. This further illustrates the difficulty in obtaining realistic estimates from sparse data at or near the analytical methods detection limit.

6.4 REMAINING CASES GROUP

The cases that were not included in one of the previous three groups were placed in the Remaining Cases Group. These samples included those from individuals who submitted only one sample, or from cases where some follow-up was attempted but results were inadequate because of low or no chemical recovery or laboratory error. This group contains sample measurements on 1,063 individuals for 1,219 samples. For discussion purposed, the lowest and the highest urine results of 0 and 237.9 pCi/d of gross alpha radioactivity were input to CINDY, and produced estimated intakes of 75,000 pCi to 20,000,000 pCi corresponding to CEDEs of about 23 rem to 6,000 rem (0.23 to 60 Sv). These results are clearly unrealistic, not supported by the air concentrations observed at Palomares and require careful evaluation.

7 DISCUSSION

The preliminary intake and dose equivalent estimates for the Palomares response personnel used the available data to the best extent possible. The approach involved reasonable assumptions about the type of activities that the responders performed and about the length of time, they may have been exposed. Detailed assignment records on the personnel were not available, nor was any significant effort expended to determine the details. Written accounts of the accident and response, correspondence in the records of some High 26 Cases Group personnel, and personal conversations with some of these individuals provided a reasonable description of the situation during the response.

Results obtained in environmental characterization programs around Palomares for over 15 years following the accident provided an alternative route to assessing intakes and doses. Those estimates are much more realistic when compared with the estimated intakes and doses for other plutonium exposures to workers or members of the public.

7.1 RESULTS FROM ENVIRONMENTAL MEASUREMENTS

The estimated intakes and doses for three scenarios of worker activity indicate that the exposures are well below recommended limits for workers and a small fraction of the dose (10 rem) for which health effects have been reliably demonstrated in humans. The estimates are limited, however, because they represent evaluations using representative scenarios. They do not represent the exposures to any specific individual responder. Additional information on responder activities, time exposed, conditions of exposure, use of personal protective equipment, and factors that influence intake are needed to develop case-specific assessments. Nevertheless, these estimates form serious concerns about the reliability of estimates from the urinary bioassay data. As a matter of fact, the difficulty in extrapolating urinary concentrations determined at the limits of detection of the analytical methods are well known and are most likely a major contributor to the disparity in the two approaches.

The estimates from the environmental data are very consistent with the results obtained for residents of the Palomares area and with results for Manhattan Project workers. These comparisons lend credibility to the bounds of estimates from the environmental data and support conclusions about the significance of the exposures reached in 1966 through 1968.

7.2 Results from Urinary Bioassay

The estimated intakes and doses for all groups were unrealistically high as discussed above. Nevertheless the implications of these estimates for effects on health are included to provide some interpretation for what are likely to be upper bound estimates. Furthermore, comments on the analytical methods, case specific information, and other inconsistencies in the data are presented as background for possible reevaluations in the future.

7.2.1 Assessment of Possible Effects

Characterizing the preliminary estimates of intakes and dose are useful only to indicate that many individual cases represent significant to very serious situations when compared to accepted guidelines for management of radiation exposures. About half the estimates exceeded the cumulative dose that would be experienced by anyone in the United States from lifetime exposure to the average background dose (roughly 21 rem (0.21 Sv) over 70 years). Fortunately, the estimates derived from environmental data (Section 6.1.3.2 above), using very conservative scenarios and assumptions, provide upper bound estimates that are well below accepted guidelines and are more consistent with the exposure experience of the local populace on site at Palomares and of industrial plutonium workers. All, but the extreme cases of the estimates, are below the recommended average radiation exposure for members of the public in one year.

7.2.2 Comments on the Estimates

Substantial experience and useful observations arose from the attempts at preparing estimates of plutonium intake and dose from the urinary bioassay data. Those observations and comments are discussed below for each of the groups.

7.2.2.1 High 26 Cases

The intakes and doses discussed in the previous section represent conservative estimates of the intakes and dose equivalents for the High 26 Cases Group. Additional comments are required to put the estimates into perspective. Those comments address the quality of the urine bioassay measurements, assumptions about the type and duration of exposure, the class (type) of material involved and specific details of the duties performed by each individual. Without further details and possible confirmation, permanent assignment of these intakes and doses to the individuals may be premature.

The laboratory analyses performed in 1966 and 1967 represent a comprehensive effort to assess the possible exposure to plutonium. At the time, the urine results used the best available models for estimating body burden. However, methods for estimating intake and deposition of plutonium in the lungs were not well understood. Progress since then allows better estimates to be made now. In fact, deposition in the lungs and the associated dose is the major contributor to the annual dose in the first few years after the exposure. Unfortunately, a very small amount of plutonium in urine can be associated with an intake that produces sizeable doses.

For the cases evaluated, the amount of plutonium in the urine after about one month is more than one million times less than the amount of the intake. That fraction decreases slowly, but steadily, thereafter. The sensitivity of the analytical methods limit the ability to confirm the amount deposited. Samples were collected out to about 15 months following the accident yet the expected excretion curve implies that plutonium excretion would continue beyond that time for actual intakes. More sensitive techniques are now available that could provide new analyses of urine samples.

At 34 years after the accident, the amount excreted per day would be about two million times less than the initial intake. The feasibility of obtaining useful assessments of plutonium uptake by sampling urine now depends mainly on the sensitivity of the analytical techniques and on the ability of the available models to represent human excretion of the plutonium in urine.

Analytical techniques currently available that provide potentially adequate sensitivity include alpha spectrometry, neutron induced fission track analysis (FTA), and mass spectrometry (Wrenn 1994). Alpha spectrometry, which cannot distinguish between ^{239}Pu and ^{240}Pu has nominal sensitivity for both of about 0.02 pCi per sample. That is about the same level available during the resampling conducted in 1966 and 1967. Most mass spectrometry techniques provide about the same sensitivity as alpha spectrometry. Thermal Ionization Mass Spectrometry (TIMS) offers sensitivities of about 0.005 pCi per sample but is tedious and costly. Neutron induced FTA provides sensitivities of about 0.00003 pCi per sample, or about 1,000 times better than alpha spectrometry and routine mass spectrometry. However, FTA is performed at only one or two laboratories.

The biokinetics and urinary excretion models available in ICRP-30 and from Jones (Jones 1985) vary in their ability to model the available data on human excretion at long times after exposure. The Jones model corresponds quite well as recently discussed (Luciani 2000). At 34 years after exposure, the model predicts that the daily urinary excretion would be 10^{-5} of the amount transferred to the blood. As an example, a urine sample with a measured ^{239,240}Pu content of 0.00003 pCi/L would translate into an uptake of 4.2 pCi to the blood from the original inhalation intake. For Class Y plutonium, about 5 percent of the inhaled plutonium transfers to blood. Therefore, the intake would be 84 pCi, which is well below one ALI of 13,500 pCi. Follow-up sampling and analysis using the most sensitive techniques available today, offers a reasonable potential for obtaining useful information. A decision to use the approach should also consider other factors, such as cost, ability to locate and obtain cooperation of response personnel, and limited laboratory availability.

Assumptions were made concerning the type of exposure (single, acute inhalation) and dates of the exposure. For some individuals, this assumption may represent up to several weeks of difference in determining the elapsed time between exposure and collection of samples. The elapsed time is one of the primary parameters for estimating the intake.

The assessment also assumed that the plutonium was PuO_2 and represented by lung Class Y (Type S). All (100%) of the intake was assumed to be from this material. Limited tests were also performed using CINDY assuming a mixed material (50% Class W and 50% Class Y). Those attempts produced lower estimated intakes and doses, however, difficulties with reconciling the approach with experimental confirmation of typical plutonium at Palomares are problematic. In addition, as discussed in Section 3, the cases of mixed plutonium forms also demonstrate a long-term excretion component that is not observed for the data. Never the less, the estimates obtained with the 100% Class Y assumption are higher and therefore conservative.

Finally, these estimates were performed with limited information about the specific activities and times that the individuals were on the site. Efforts to perform a comprehensive search of all records and information, including interviews, were beyond the scope of this effort. Some additional refinement might be possible from an expanded search for more specific information. However, the cost of such an effort should be balanced with the possible benefits from confirmatory measurements of urinary content. Ultimately, credible estimates of intake and dose will depend on an expensive, multi-phased approach involving:

- Urinalysis of selected individuals using highly sensitive techniques to assess the presence of plutonium in their urine.
- Detailed interviews with individuals to develop the details of their exposure circumstances as well as they can recall them.
- Research and evaluation of all available information, especially that collected during the recovery and response phases of the incident, including records available at DOD's Defense Threat Reduction Agency, the Air Force Safety Agency, the Department of Energy, and possibly the appropriate representatives of the Government of Spain.

7.2.2.2 Contamination Cutoff Cases

The intakes and doses discussed in the previous section represent conservative estimates of the intakes and dose equivalents for the Contamination Cutoff Group. The estimates are considered conservative because the methods and data selected tend to overestimate the actual intakes and doses. The additional comments made regarding the High 26 Cases Group apply to these cases as well. Furthermore, confirmation of the possible exposures for this group are very important because this group did not have any measurements taken in late 1966 or 1967, when alpha spectrometry measurements were more commonly used.

7.2.2.3 Repeat Analysis Cases

The intakes and doses discussed in the previous section represent conservative estimates of the intakes and dose equivalents for the Repeat Analysis Cases Group. The estimates are considered conservative because the methods and data selected tend to overestimate the actual intakes and doses. The additional comments made regarding the High 26 Cases Group apply to these cases as well. Furthermore, confirmation of the possible exposures for this group are very important because this group did not have any measurements taken in late 1966 or 1967, when alpha spectrometry measurements were more commonly used.

7.3 Comparison of Intakes and Doses to Other Plutonium Exposure Cases

The results can be evaluated for reasonableness by comparing them to other plutonium exposure situations. Two such reported cases are the evaluation of the citizens of Palomares by a Joint Spanish-United States effort since the accident, and the follow-up of Manhattan Project workers who received exposures to plutonium at Los Alamos. In addition, measurements of environmental plutonium at Palomares provide data for performing independent estimates of the intakes and doses for the accident response force.

7.3.1 Dose Estimates for Residents of Palomares

Since the accident, the Government of Spain has conducted a program to monitor the residual radioactivity at the accident site. That effort has included measurements of air concentrations of plutonium, soil contamination levels, and assessment of intakes and doses to the population.

During 1966, 59 people provided urine samples on three occasions. Those samples indicated the possibility of contamination (Iranzo 1997). In 1967 samples were collected in Madrid under controlled conditions. Of those, 23 exceeded the minimum detectable level of 0.02 pCi/ day. During the ensuing years, additional samples have been collected from a larger group of Palomares citizens and analyzed. The results indicate that 45 individuals who may have received intakes during the initial clean-up showed intakes that represented committed effective dose equivalents of 2 rem to 20 rem (0.02 to 0.2 Sv) (Iranzo 1987). That range includes the lower portion of the results obtained for responders. In addition, the early concerns for sample contamination and efforts to mitigate the possibility support similar concerns for the Air Force urine sampling. Although, the Air Force resample effort was conducted away from the accident site, the possibility exists that samples provided in mid to late 1966 and early 1967 may have been influenced by continued sample contamination.

7.3.2 Manhattan Project Worker Evaluations

During the Manhattan Project, 26 white, male adult workers received intakes of plutonium primarily by inhalation. Reports of follow-up studies of that group have indicated continuing refinement of the estimates of their plutonium deposition. A recent report provided the results of 50 years of follow-up. The report indicated that the depositions for the 26 individuals ranged from 1.35 nanocuries (50 Bq) to 85.86 nanocuries (3,180 Bq) (Voelz 1997). The corresponding effective doses ranged from 10 rem to 720 rem (0.1 to 7.2 Sv). If those exposures occurred by inhalation, the intake would have been approximately 20 times higher than the deposition or 27 nanocuries to 2.3 microcuries. Although the range of exposures is similar to the preliminary estimates for Palomares response personnel, the responders' exposures were unlikely to approach those of the Manhattan Project workers. Responders would have handled the much different (lower) quantities and forms of plutonium for much shorter times than the Manhattan Project workers. Those workers performed continuous, industrial operations on a daily basis over several years under what have been called "primitive conditions".

The results of follow-up of citizens of Palomares and Manhattan Project workers indicate the range of doses from exposures received under field conditions and those received in laboratory or industrial conditions. It seems reasonable to consider the results for the Palomares citizens as more representative of the kind of exposure conditions experienced by the response personnel because both were exposed to the same or similar sources, while the Palomares residents were exposed for many years. Consequently, the results for responders that exceed even a fraction of the upper range of CEDE (20 rem/0.2 Sv), may well represent sample contamination or other artifacts. If that is the case, additional sampling and analysis of a carefully selected subset of the response force today offers an attractive approach to confirming the deposition and associated doses.

8 CONCLUSIONS AND RECOMMENDATIONS

Records of urinary ^{239}Pu and gross alpha radioactivity of samples collected from responders to the Palomares nuclear weapons accident were evaluated for possible use in calculating estimate radioactivity intakes and committed effective dose equivalent using accepted models. Data were reviewed and individuals assigned to four groups according to the amount and reliability of the data. The groups included:

- The High 26 Cases Group that included 26 individuals identified for resampling for 18 to 24 months after the initial phase of sampling in 1966.
- A Repeat Analysis Cases Group that included 54 individuals who either had submitted samples that were reanalyzed using more specific methods (alpha spectrometry), or who were resampled.
- A Contamination Cutoff Cases Group that included 313 individuals with results that were below a reasonable, assumed cutoff level of 0.1 pCi per day.
- A Remaining Cases Group that contained 1,063 records that were not otherwise evaluated and that were strongly suspected of contamination from collection on site.

Two current computer methods were tested and used to estimate intakes of plutonium by acute inhalation exposure. One method (CINDY) employed the ICRP-30 system for limiting internal dose. The other method (LUDEP) implemented the new respiratory tract model described in ICRP-66 and the organ/tissue weighting factors of ICRP-60.

Plutonium intake and dose values were estimated for all of the High 26 Cases Group, the 54 individuals in the Repeat Analysis Cases Group, and 313 individuals in the Contamination Cutoff Cases Group. The intakes and doses ranged from below annual occupational limits to more than the 50 rem (0.5 Sv) guideline for cumulative dose for workers. Some doses ranged as high as several hundred rem. However, when compared with estimates derived from environmental measurements, dose estimates for Palomares citizens, and dose estimates for Manhatten Project workers, these preliminary estimates seen unreasonably high in many cases. Additional efforts are needed to reconcile the results from the urine data with the levels that can be reasonably supported by the environmental data and experience with other exposed people.

Several future actions should be considered to further refine these initial estimates.

1. Additional effort is needed to reconcile the estimated intakes and doses derived from the urinary bioassay data with the estimates from environmental measurements. A targeted effort that includes participant activities, participant interviews, urine and other appropriate plutonium analyses using current techniques, medical records review, and modeling should be considered.

2. The results of this effort should be communicated to responders, veterans organizations, and other interested parties using appropriate information that clearly confirms the conclusions of the original medical evaluation program, recognizes the difficulties in preparing updated intake and dose estimates, and outlines the options for strengthening the estimates.

3. Further contacts with the Department of Energy for comparison with evaluations of their personnel who responded to this accident could provide useful data. The effort should be summarized in a companion document that conveys the details of the project and its potential effects on health in an easily understood manner. That document should be made available to any of the responders who desire a copy.

9 REFERENCES

Bevington, P. R. Data Reduction and Error Analysis for the Physical Sciences. McGraw-Hill Book Company, New York.. 1969.

Case, David R., Chief, Radiochemistry, USAF Radiological Health Laboratory (1969-1975).

Eckerman, K.F., R. C. Ward, and L. B. Maddox. "U.S.Army Radiological Bioassay and Dosimetry: The RBD Software Package." Report ORNL/TM-11858. Oak Ridge National Laboratory. Oak Ridge, TN. 1993.

Grogan, H.A., W. K. Sinclair, and P. G. Voilleque, "Risks of Fatal Cancer From Inhalation of ^{239,240}Plutonium by Humans: A Combined Four-Method Approach with Uncertainty Evaluation," Health Physics, 80(5), pp 447-461, May 2001.

Health Physics Society. "Radiation Risk in Perspective, Position Statement of the Health Physics Society." McLean, Virginia. 1996.

Iranzo, E., Salvador, S. and Iranzo, C.E., "Air Concentrations of 239Pu and 240Pu and Potential Radiation Doses to Persons Living Near Pu-Contaminated Areas in Palomares, Spain, Health Physics Volume 52, Number 4, 453-461, April 1987.

Iranzo, Emma, Espinosa, Asuncion , and Javier Martinez, "Resuspension in the Palomames area of Spain: A summary of experimental studies.", J. Aerosol Sci., Vol. 25, No. 5, pp. 833-841. 1994. Elsevier Science Ltd.

International Commission on Radiological Protection. Report of the Task Group on Reference Man. Pergamon Press, Oxford. ICRP Publication 23. 1975.

International Commission on Radiological Protection. Limits for Intakes of Radionuclides by Workers. Pergamon Press, Oxford. ICRP Publication 30. 1979.

International Commission on Radiological Protection. Individual Monitoring for Intakes of Radionuclides by Workers: Design and Interpretation. Pergamon Press, Oxford. ICRP Publication 54. 1988.

International Commission on Radiological Protection. 1990 Recommendations of the International Commission on Radiological Protection. Pergamon Press, Oxford. ICRP Publication 60. 1991.

International Commission on Radiological Protection. Human Respiratory Tract Model for Radiological Protection. Pergamon Press, Oxford. ICRP Publication 66. 1994.

International Commission on Radiological Protection. Recommendations of the International Commission on Radiological Protection, Report of Committee II on Permissible Dose for Internal Radiation. ICRP Publication 2. Pergamon Press, Oxford. 1960.

James, Anthony C. "Dosimetric Applications of the New ICRP Lung Model," in *Internal Radiation Dosimetry*. Otto Raabe, Editor. Medical Physics Publishing, Madison, Wisconsin. 1994.

Jones, S. R. "Derivation and Validation of a Urinary Excretion Function for Plutonium Applicable Over Tens of Years Post Intake." Radiation Protection Dosimetry 11(1):19-27. 1985.

Koshurnikova, N.A., M.G. Bolotnikova, L.A. Ilyin, I.B. Keirim-Markus, Z.S. Menshikh, P.V. Okatenko, et al. "Lung Cancer Risk due to Exposure to Incorporated Plutonium". Radiation Research.149 :366. 1998.

Langham, W.H. "Determination of internally deposited radioactive isotopes from excretion analyses." Industrial Hygiene Quarterly 17:305-318. 1956.

Leggett, R.W., and K.F. Eckerman. "A method for estimating the system burden of Pu from urinalysis." Health Physics 52(13):337-346. 1987.

Luciani, A., and E. Polig. "Verification and Modification of the ICRP-67 Model for Plutonium Dose Calculation." Health Physics 78(3) 303-310. March 2000

National Academy of Sciences. Health Effects of Exposure to Low Levels of Ionizing Radiation. National Academy Press, Washington, D.C. 1990.

National Bureau of Standards. 1959. Maximum Permissible Body Burderns and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure. Superintendent of Documents, U.S. Government Printing Office. Washington, DC.

National Council of Radiation Protection and Measurements. Limitation of Exposure to Ionizing Radiation. NCRP Report No. 116. Bethesda, MD. 1993

National Council of Radiation Protection and Measurements. Risk Estimates for Radiation Protection. NCRP Report No. 115. Bethesda, MD. 1993

Nuclear Regulatory Commission. Title 10, Code of Federal Regulations, Part 20, Standards for Protection Against Radiation. Government Printing Office. Washington, DC. 1999

Jarvis, N. S. and A. Birchall. LUDEP 2.0, Personal Computer Program for Calculating Internal Doses Using the ICRP Publication 66 Respiratory Tract Model. Report NRPB-SR-287. National Radiological Protection Board. Oxford. Undated.

Odland, L. T., "Plutonium Deposition Registry Board, Proceedings: First Annual Meeting, 26 – 28 October 1966," Air Force Logistics Command, Wright-Patterson AFB, Ohio, 1966.

Odland, L.T., R. G, Thomas, J. C. Taschner, H. R. Kaufman, and R. E. Benson. "Bioassay Experiences in Support of Field Operations Associated with Widespread Dispersion of Plutonium, in Proceedings of Symposium on Diagnosis and Treatment of Deposited Radionuclides. EXCERPTA MEDICA FOUNDATION, Richland, Washington. 1968a.

Odland, L.T., R. L. Farr, K. E. Blackburn, and A. J. Clay. "Industrial medical experience associated with the Palomares nuclear incident." Journal of Occupational Medicine 10(7):356-361. 1968b.

Place, W.M., F.C. Cobb, and C.G. Defferding. Palomares Summary Report. Field Command Defense Nuclear Agency, Kirtland AFB, New Mexico. 1975.

Reyes, M., G.S. Wilkinson, G. Tietjen, G.L. Voelz, J.F. Acquavella, and R. Bistline. "Brain Tumors at a Nuclear Facility." Journal of Occupational Medicine. 26:721-724. 1984.

Strenge, D. L., R. A. Kennedy, M. J. Sula, and J. R. Johnson. Code for Internal Dosimetry (Cindy Version 1.2); Part 1: Conceptual Representation. Report PNL-7493. Pacific Northwest Laboratory. Richland, Washington. 1992.

Strong, R., and S. R. Jones. “A Review of the Development and Application of a Plutonium Urinary Excretion Model at the Nuclear Fuel Processing Site of British Nuclear Fuels plc.” Radiation Protection Dosimetry 26(1/4):141-144. 1989.

Taschner, John, Director of Radiochemistry, USAF Radiological Heatlth Laboratory (1966-1968), Personnal Communication, September 1999.

R. Traub. Personal communication. Pacific Northwest National Laboratory, Richland, WA. February 1, 2000.

Tokarskaya, Z.B., N.D. Okladnikova, Z.D. Belyaeva, and E.G. Drozhko. “Multifactorial Analysis of Lung Cancer Dose- Response Relationships for Workers at the Mayak Nuclear Enterprise.” Health Physics. 73 (6):899. 1997.

United States Department of Energy, Environment, Safety, and Health Information Portal, Project Indalo, Hall-Otero Agreement of February 25, 1966, located at http://tis.eh.doe.gov/ihp/Indalo/Spain.html ,DOE, 2000.

Voelz, G.L., G.S. Wilkinson, J.W. Healy, J.F. McInroy, and G.L. Tietjen. “Mortality Study of Los Alamos Workers with Higher Exposures to Plutonium”. In Proceedings of the 16th Midyear Topical Meeting of the Health Physics Society . Washington, DC: Technical Information Service. 1983.

Voelz, G., J.N.P. Lawrence, and E. R. Johnson. “Fifty Years of Plutonium Exposure to the Manhattan Project Plutonium Workers: An Update.” Health Physics 73(4) 611-619. October 1997.

Wallace, H.G. “Palomares Broken Arrow – Report on Medical Follow-up Program.” Letter, Headquarters, Air Force Logistics Command, Wright-Patterson AFB, Ohio. January 16, 1968.

Wiggs, L.D., E.R.Johnson, C.A. Cox-DeVore, and G.L.Voelz. "Mortality Through 1990 Among White Male Workers at the Los Alamos National Laboratory: Considering Exposures to Plutonium and External Ionizing Radiation." Health Physics 67:577-588. 1994.

Wilkinson, G.S., G.L. Tietjen, L.D. Wiggs, W.A. Galke,J.F. Acquavella, M. Reyes, G. Voelz, and R. Waxweiler. American Journal of Epidemiology. 125 :231-250. 1987.

Wrenn, M. E., and L. Bertelli. “Dose Reconstruction From Bioassay Measurements of Long-Lived Residual Activity” in *Internal Radiation Dosimetry*. Otto Raabe, Editor. Medical Physics Publishing, Madison, Wisconsin. 1994.

APPENDIX A

GLOSSARY

APPENDIX A GLOSSARY

Absorbed Fraction (AF) – The fraction of energy emitted as a specified radiation, R, in a specified source tissue, S, which is absorbed in a specified target tissue, T. [AF (T←S)R]

Accuracy – The comparison of a measurement to the true value of a parameter. It is a function of both bias and precision.

Activity Median Aerodynamic Diameter (AMAD) - The diameter in an aerodynamic particle size distribution for which the total activity above and below this size are equal. A log-normal distribution of particle sizes is assumed.

Activity Median Thermodynamic Diameter (AMTD)– The particle Diameter, D_{tn} (thermodynamically classified) for which 50 percent of the total airborne activity, is associated with particles of thermodynamic diameter is greater than the AMTD.

Aerodynamic Diameter (d_{ae}) – The diameter (µm) of a unit density (1 g cm^{-3}) sphere that has the same terminal settling velocity in air as the particle of interest. Same as AED.

Aerodynamic Equivalent Diameter (AED) - The diameter of a sphere, in µm, of unit density (1 g cm^{-3}) that has the same terminal settling velocity in air as the particle of interest (a 1 µm AED particle has 1000 times the volume of a 0.1 µm AED particle).

Aerosol – A suspension of fine solid or liquid particles in a gaseous medium.

Airborne Concentration – The activity of particulate matter or material in a unit volume of aerosol, usually expressed in µCi cm^{-3}, µCi mL^{-1} or µCi m^{-3}.

Annual Limit on Intake (ALI) – The activity in µCi of a radionuclide which taken alone would irradiate a person represented by reference man, to a limit established by a regulatory agency for each year of occupational exposure.

Becquerel (Bq) – the International System of Units adopted unit for radioactivity. One Bq is equal to a radioactivity of 1 nuclear transformation per second (ntps).

Biokinetic Model – A set of mathematical relationships formulated to relate the intake of a material to the uptake, distribution, and retention of the material or radionuclide in various organs and tissues of the body. Some models include subsequent excretion from the body by various pathways.

Breathing Zone – The region adjacent to a worker's nose and mouth from which air is drawn into the lungs while he/she performs the assigned work.

CINDY – Code for Internal Dosimetry is a computer program that addresses the radiation protection aspects of Department of Energy orders and Nuclear Regulatory Commission regulations by implementing the approach described in ICRP Publication 30.

Class – The lung or inhalation classification scheme, developed in ICRP Publication 30, for inhaled material according to its rate of clearance from the pulmonary region of the lung. Materials are classified as D, W, or Y, which applies to a range of clearance half-times: for Class D (days) of less than 10 days; for Class W (weeks) from 10 days to 100 days; and Class Y (years) of greater than 100 days.

Clearance Pathway – The route by which material that is deposited in the lungs can move into the blood, lymph nodes or bronchi.

Committed Dose Equivalent (CDE) ($H_{T,50}$) – The dose equivalent to organs or tissues (targets) of reference (T) that will be received from an intake of radioactive material by an individual during the 50 year period following the intake.

Committed Effective Dose Equivalent (CEDE) ($H_{E,50}$) – The sum of the products of the tissue weighting factor and the radiation weighting factor or quality factor applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues. [$H_{E,50} = \sum w_t\ (H_{t,50})$].

Curie (Ci) – A unit of radioactivity. One Ci is equal to that quantity of radioactive material in which there are 3.7 x 10^{10} nuclear transformations per second (ntps) or 3.7 x 10^{10} Becquerels (Bq). One microcurie (1μCi) is equal to 3.7 x 10^{4} ntps or one-millionth part of a Ci.

Derived Air Concentration (DAC) – The concentration of a radionuclide in air, which breathed or inhaled alone for 1 work yr (2000 hrs) would irradiate reference man to the radiation safety limit for occupational exposure. The DAC equals the ALI of the radionuclide divided by the volume of air inhaled by reference man in a working year (i.e., 2.4 x 10^{3} m^{3}).

Detriment – The identification and where possible the quantification of all the deleterious effects of exposure to ionizing radiation. Total detriment is the sum of the contributions due to fatal cancers, non-fatal cancers, and severe hereditary disorders weighted for life lost.

Disintegrations per Minute (dpm) – A rate of spontaneous emission of particles and energy from the unstable nucleus of an atom. The curie is a unit of activity quantifying this process of radioactive decay.

Dose Assessment – The process of assessing/estimating the radiological dose and associated uncertainty based on best available information. Included in this dose estimate, through use of exposure scenarios, source term data, bioassay results, monitoring or radiological survey data, and pathway analysis.

Effective Half-Life – The time required for the amount of a contaminant deposited in a living organism to be diminished to 50 percent as a result of the combined action of radioactive decay and biological elimination.

Elimination – The removal of material from the body via urine, feces, sweat or exhalation. Excretion usually refers to elimination via urine or feces.

Equilibrium, Radioactive – The state that prevails in radioactive series when the ratios between the activities of two or more successive members of the series remains constant.

Equivalent Diameter – The diameter of the sphere that would have the same value of a particular physical property as that of the irregular particle.

Exposure – The act of being exposed to a contaminant.

Exposure Assessment – The process of assessing/estimating the exposure to a contaminant and associated uncertainty, based on best available information. Included in this exposure estimate, through use of exposure scenarios, source term data, bioassay results, monitoring data, and pathway analysis.

Extrathoracic Fraction – The mass fraction of the inhaled particles which do not or fail to penetrate beyond the larynx.

Geometric Standard Deviation – For a log-normal distribution, the exponential of the standard deviation of the associated normal distribution (always ≥ 1).

Inhalabilty – The ratio of the number concentration of particles with a particular diameter inspired through the nose or mouth to the number concentration of particles with the same aerodynamic diameter present in the inspired volume of ambient air.

Inhalable Fraction – The mass fraction of the total airborne particles which are inhaled through the nose and mouth.

Intake – The total amount of material that enters the body through the principal exposure routes of inhalation, ingestion, or skin wounds.

Log-Normal Distribution – A distribution in which the logarithms of a variable (such as particle size) is normally distributed.

Lower Limit of Detection (LLD) – The smallest amount of mass or radioactivity that yields a statistically significant net result above the laboratory method background.

LUDEP – Lung Dose Evaluation Program is a computer program developed by the National Radiological Protection Board of the United Kingdom that implements the Respiratory Tract Model recommended by the ICRP's Task Group on Lung Dynamics as adopted in 1993 and published in ICRP Publication 66.

Mass Concentration – The mass of particulate matter or material in a unit volume of aerosol, usually expressed in $\mu g\ m^{-3}$, $mg\ m^{-3}$, or $g\ m^{-3}$.

Mass Median Aerodynamic Diameter (MMAD) – The aerodynamic diameter of a particle having a median mass i.e., the masses of particles above and below this vehicle are equal.

Maximum Permissible Concentration (MPC) – A concentration for a radionuclide (established in ICRP-2) in air or water set to keep dose to the critical organ from exceeding the annual limit. The annual limit applied over an intake period of 50 years.

Maximum Permissible Body Burden (MPBB) – A limit associated with Maximum Permissible Concentration that was the amount of material in the body that would not cause an organ dose to exceed the annual limit to the critical organ.

Metabolic Model – A mathematical description of the behavior of inhaled or ingested radionuclides in the metabolic process of cells, tissues, organs and organisms (humans). It is most frequently used to describe its distribution among tissues/organs and elimination/excretion.

Micrometer (µm) – A unit of measure. One micrometer (1 µm) is one millionth of a meter (1×10^{-6} m).

Non-Stochastic Effects –Those effects for which the severity of the effect varies with the dose received and for which a threshold may exist. The following are examples of non-stochastic somatic effects that are specific to particular tissues; cell depletion in the bone marrow causing hematological deficiencies, and gonadal cell damage leading to impairment of fertility. For these changes to occur, the severity of the effect depends on the magnitude of the dose received, and there is a threshold of dose below which no detrimental effects are observed.

Parent – A radionuclide that, on nuclear transformation (disintegration), forms a specified nuclide either directly or as a later member of a radioactive series.

Particle Density – The mass of the particle itself per unit volume, usually expressed in g cm^{-3}, mg m^{-3}.

Particle Dissolution Rate – The rate at which the change of a particle from a solid to a liquid form takes place.

Particle Transport – The process that clear material from the respiratory tract to the gastrointestinal tract and to the lymph nodes, and move material from one part of the respiratory tract to another.

Precision – The repeatability or reproducibility of a measurement. Precise results have small random errors.

Progeny – The decay product or products resulting after a radioactive decay or a series of radioactive decays of the parent radionuclide. The progeny can also be radioactive, and the decay chain will continue until a stable nuclide is formed.

Rad - The special unit of absorbed dose. One rad is equivalent to an absorbed dose of 0.01 J kg^{-1} or 0.01 Gray (Gy).

Reference Man – A male individual between 20 to 30 years of age weighting 154 pounds (70 kg) is 5.6 feet (1.7 m) in height, and lives in a climate with an average temperature of 50°F to 68°F (10°C to 20°C). He is a Caucasian and is a Western European or North American in habitat and custom (ICRP Publication No. 23; updated by ICRP Publication No. 66 and ICRP Publication No. 70).

Rem - The special unit of any of the radiation quantities expressed as dose equivalent. The dose equivalent in rem is equal to the absorbed dose in rad multiplied by the quality factor or radiation weighting factor. One rem equals 0.01 sievert (Sv). (1 millirem (mrem) is 1/1000 of a rem.)

Respirable Fraction (RF) – The mass fraction of the inhaled particles which penetrate to the unciliated airways of the respiratory tract.

Respiratory Tract Clearance – The removal of material from the respiratory tract by particle transport and by absorption into blood.

Respiratory Tract Deposition – The initial process determining how much of the material in the inspired air that remains in the lungs after exhalation. Deposition of material may occur during both inspiration and inhalation.

Respiratory Tract (Lung) Model – The model that describes the behavior of particles in the respiratory tract of man. This model was developed by the ICRP's task group on lung dynamics and published in ICRP Publication 30. This model is used in the CINDY program; however, LUDEP (an alternate computer program also used) uses the ICRP's new lung model published in ICRP Publication 66.

Resuspension - The transport of particles from surfaces (inside and environmental) back into the atmosphere.

Risk – The characterization of a situation or action wherein two or more outcomes are possible, the particular outcome that will occur is unknown, and at least one of the possibilities is undesired. Risk is also the sum of the possible alternative numbers of injuries or fatalities weighted by their probabilities.

Sensitivity Analysis – The sensitivity of the model prediction to selected perturbation of model parameters.

Solubility - The ability of a substance to form a solution with another substance. Normally lung or tissue fluid is considered the fluid of choice.

Source Tissue – Tissue (may be a body organ) that contains a significant amount of a radionuclide following an intake of that radionuclide into the body.

Specific Absorbed Fraction – The fraction of energy that is emitted as a specified radiation type (alpha, beta, electron or photons) in a source organ/tissue that is absorbed in 1 g of a target organ/tissue.

Stochastic Effect –Those effects for which the probability of an effect occurring, rather than its severity, is regarded as a function of dose. Both hereditary effects and carcinogenesis are stochastic effects.

Target Tissue – Tissue (which may be a body organ) in which radiation is absorbed.

Thoracic Fraction – The mass fraction of the inhaled particles which penetrate beyond the larynx.

Tracheobronchial Fraction – The mass fraction of the inhaled particles which penetrate beyond the larynx, but which do not or fail to penetrate to the unciliated airways of the respiratory tract.

Transfer Compartment – The compartment introduced (for mathematical convenience) into the biokinetic model to account for the translocation of radioactive material through the body fluids from where they are deposited in tissues or excreted.

Translocation – The movement of material, that has been deposited respiratory tract, by dissolution and absorption into the blood.

Transportable Half-Time – The amount of time for half of the contaminant to be transferred to a transfer compartment.

Transuranic (TRU) – An element with an atomic number greater than that of uranium. Neptunium has an atomic number of 93 and plutonium has an atomic number of 94.

Uncertainty Analysis – The analysis of the uncertainty in model prediction. The production of a Probability Density Function (PDF) that describes the confidence with which it can be claimed that some characteristic of risk (probability, severity, episodic frequency, or total number of effects) lies between two values.

Uptake – That quantity of material that is taken up or enters the body from the location of intake. The routes of entry into the body are from the respiratory tact, gastrointestinal tract, absorption through the intact skin, injection, or via a wound.

Weighting Factors –

- Organ or tissue weighting factor (w_t) – The multiplication factor by which the committed dose equivalent (CDE) in an organ/tissue is multiplied to yield the Committed Effective Dose Equivalent (CEDE). This factor represents the relative contribution of that organ or tissue to the total detriment due to these effects resulting from uniformed irradiation of the whole body. (The w_t values are those given in ICRP Publication No. 26 for CINDY assessments and in ICRP Publication 60 for LUDEP assessments.)

- Radiation Weighting Factor (w_R) – A factor [quality factor (Q)] which is dependent on the type and energy of the radiation and is independent of the exposed organ/tissue. As used in the calculation the average quality factor is used for both external and internal radiation. (The Q values are those given in ICRP No. 26.)
- Least Squares Regression Weighting Factor (w_i) – A factor that determines the relative significance of the i^{th} data point in a least squares regression analysis. The factor is generally user selected to represent a measure of the confidence or estimated error of the data point.

APPENDIX B

AVAILABLE AIR FORCE DATA

APPENDIX B AVAILABLE AIR FORCE DATA

B.1. INTRODUCTION

This effort to re-evaluate possible doses to those who responded to the Palomares nuclear accident required a complete and careful review and assessment of available data. Since the accident occurred over 33 years ago, this review depended on the ability to identify relevant records, reports and other data to form as complete a picture of the situation as possible. Initial efforts focused on accumulating and reviewing records provided by the Air Force Medical Operations Agency (AFMOA) at Bolling AFB, DC and the Institute for Environmental, Safety, And Occupational Health Risk Analysis (IERA) at Brooks AFB, TX. IERA succeeded the USAF Radiological Health Laboratory (RHL) as the Air Force's primary radiological consultant laboratory and custodian of personnel radiation exposure records in the USAF Master Radiation Exposure Registry. Initial contact with both AFMOA and IERA identified and provided information on the availability of Palomares records. IERA and AFMOA provided their records in the form of:

- Air Force Forms with laboratory analytical and exposure details of the nasal swipe and urine samples submitted and processed.
- Complete case files for the 26 individuals identified for follow-up in 1966 and commonly referred to as the "High 26".
- A Microsoft Excel spreadsheet prepared by IERA staff that contained the data from those Air Force Forms, and some data related specifically to the 26 individuals (referred to as the "High 26" who were considered as having the highest exposures.
- Copies of reports of the accident response, RHL documents on the evaluation of exposures by urinalysis, and selected publications from journals and conference proceedings.

Those records formed the basis for significant effort: to understand what information the various records contained; to determine how the data were used in the initial evaluations; to identify data gaps, inconsistencies, and concerns with the use or interpretation of the data; and to prepare the records for input to this intake and dose assessment effort. This appendix discusses the results of this review and the modifications and assumptions made to the data for use in the dose assessment. The appendix provides specific details of the three types of records and the concerns they generated, as well as efforts to correct, improve, or interpret those records for this project.

B.2. TYPES OF RECORDS KEPT

The records prepared and maintained by the Air Force consisted of forms, computer spreadsheets, and written correspondence and reports of activities. This section provides details of the forms and the data they contained.

B.2.1. Forms

RHL, as the central laboratory for providing radiological services to Air Force units, applied their laboratory processes with some modifications to this accident. RHL, a sub-unit of the Air Force Logistics Command (AFLC) at the time, used AFLC sanctioned forms for recording the data and results of samples processed. Three series of forms were identified in the records provided: AFLC Form 1165, Internal Dosimetry Data (May 66), AFLC Form 1165, Radiological Sample Data (May 66), and AFLC Form 1165, Radiological Sample Data (Jul 67). Although similar in design and content, these three forms apparently evolved over the course of the laboratory effort on Palomares and other services at the time.

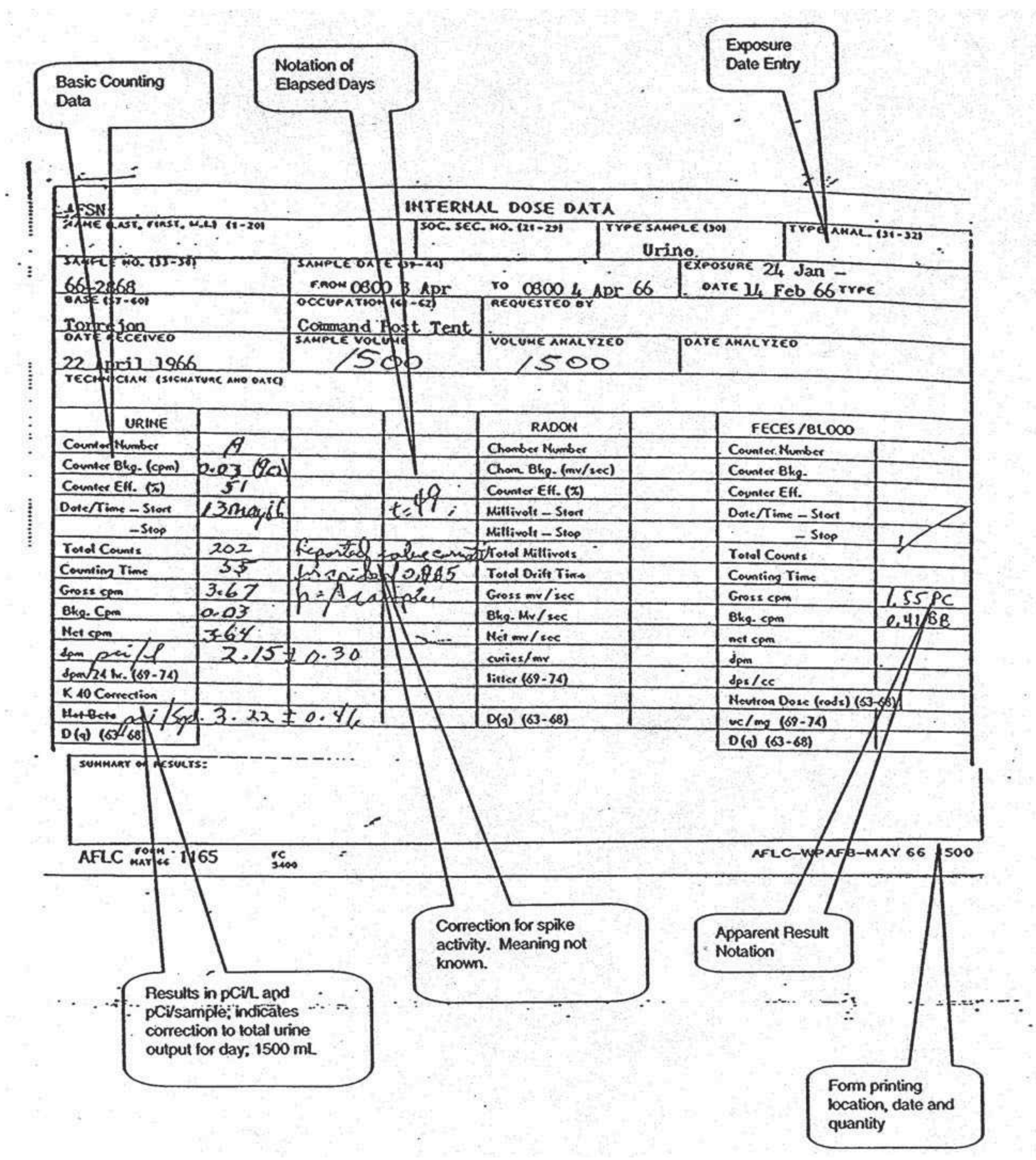
B.2.1.1 AFLC Form 1165, Internal Dose Data (May 66)

The AFLC Form 1165, Internal Dose Data contained data about the individual who submitted the sample, radiation measurement data for urine, radon (breath) (sic), and feces/blood samples. The form provides areas for recording counting data, instrument data, and other factors. For Palomares, the form primarily recorded urine sample data and results. Figure B-1 illustrates an example AFLC Form 1165.

Annotated comments (callout boxes) on Figure B-1 draw attention to several features of the form and its use for the Palomares Accident. In addition to basic identifying information (name, and Social Security Number (SSN)), the form typically contained an entry for the Air Force Serial Number (AFSN) as an additional entry. At the time, the SSN had not become an official identifier for Air Force military personnel.

Comments about certain uses of the form pertain to the review and analysis of data contained on these forms for possible use in the reassessment project. These include (identified by text in callout box on Figure B-1):

- **Basic Counting Data**: this area provides spaces for the entry of Counter Identification (N), Counter Background (cpm), Counter Efficiency (%), and other pertinent counting information. Additional data were often recorded in this area. For example, the entry for Counter background - 0.03 (900) – refers to the counts per minute (0.03) and the time the background was counted (900 minutes).
- **Notation of Elapsed Days**: this entry – t = 49 – refers to the elapsed time (in days) between the assumed exposure and the date the sample was collected. According to other records, the exposure date was generally assumed to occur on the day that was the midpoint of an individual's time on station.
- **Exposure Date Entry**: an entry with the known or estimated dates of exposure. Often this represented the actual calendar time at the site performing duties. In this case, the entry contains a range of dates.



AFSN:
INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20) | SOC. SEC. NO. (21-29) | TYPE SAMPLE (30): Urine | TYPE ANAL. (31-32)

SAMPLE NO. (33-36): 66-2868 | SAMPLE DATE (37-44): FROM 0800 3 Apr TO 0800 4 Apr 66 | EXPOSURE DATE: 24 Jan – 14 Feb 66 TYPE

BASE (57-60): Torrejon | OCCUPATION (61-62): Command Post Tent | REQUESTED BY

DATE RECEIVED: 22 April 1966 | SAMPLE VOLUME: 1500 | VOLUME ANALYZED: 1500 | DATE ANALYZED

TECHNICIAN (SIGNATURE AND DATE)

URINE				RADON		FECES/BLOOD	
Counter Number	A			Chamber Number		Counter Number	
Counter Bkg. (cpm)	0.03 (9a)			Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)	51			Counter Eff. (%)		Counter Eff.	
Date/Time – Start	13 May 66		t=49	Millivolt – Start		Date/Time – Start	
– Stop				Millivolt – Stop		– Stop	
Total Counts	202	Reported value corrected		Total Millivots		Total Counts	
Counting Time	55	for spike [illegible] 0.015		Total Drift Time		Counting Time	
Gross cpm	3.67	p = [illegible]		Gross mv/sec		Gross cpm	1.55 pc
Bkg. Cpm	0.03			Bkg. Mv/sec		Bkg. cpm	0.41 BB
Net cpm	3.64			Net mv/sec		net cpm	
dpm pci/l	2.15 ± 0.30			curies/mv		dpm	
dpm/24 hr. (69-74)				litter (69-74)		dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
Net Beta pci/Sp.	3.22 ± 0.46					uc/mg (69-74)	
D(q) (63-68)				D(q) (63-68)		D(q) (63-68)	

SUMMARY OF RESULTS:

AFLC FORM MAY 66 1165 FC 3400 AFLC-WPAFB-MAY 66 1500

Figure B- 1. AFLC Form 1165, Internal Dose Data (May 66)

- **Results, etc.**: this section demonstrates flexibility in use of the form by hand written notations of the meaningful result. In this example, the result (2.15 ± 0.30 pCi/L) is expressed in activity per unit volume as picocuries per liter (pCi/L) and as activity per sample (pCi/spl). In this case, the pCi/spl means the total gross alpha activity excreted in one day as required by equations relating content in urine to systemic body content. In addition to the actual value, the estimated error (based on 95% confidence level of the counting data only) is also shown.
- **Correction for spike activity**: This notation apparently refers to a factor applied to correct for added ^{236}Pu radioactivity. The exact meaning of this notation has not been determined for gross alpha measurements.
- **Apparent Result Notation**: an entry in the feces/blood section that apparently represents an independent evaluation of the radioactivity content and an estimate of the fractional systemic body burden (0.44 BB).
- **Form printing location, etc.**: represents the place (WPAFB – Wright-Patterson Air Force Base), date (May 66), and quantity of forms printed (4500). This is an administrative requirement.

Figure B-2 provides a second example of an AFLC Form 1165, Internal Dose Data. For this case, three features are discussed.

- **Background counts, etc.**: this form clearly shows the entry of the counter background rate and counting time.
- **Exposure Date Entry**: this form contains one date rather than a range. Based on personal conversations with the individual, he arrived at the accident site early on 18 Jan 66 so the date of 19 Jan 66 is reasonable. Also, the individual said that he stayed at the site until close to the end of the operation. Therefore, a sample date of 18 Mar 66 could represent his last sample while on site. In fact that is the case.
- **Apparent Result Notation**: this entry refers to written notation ($D_R = 6.59 \times 10^{-3}$ μc). The notation D_R is identical to the notation for retained body burden in Langham's excretion equation for plutonium. That entry apparently denotes a retained body burden of 0.00659 microcuries or about 15%.

The previous examples provide the basis for further investigating the relevance of the data on these forms. The relevance may be particularly crucial because these forms represent data for some of the earliest samples collected; especially those collected on site at Camp Wilson that had a very high potential for sample container contamination as referred to by Odland (Odland 1968a and Odland 1968).

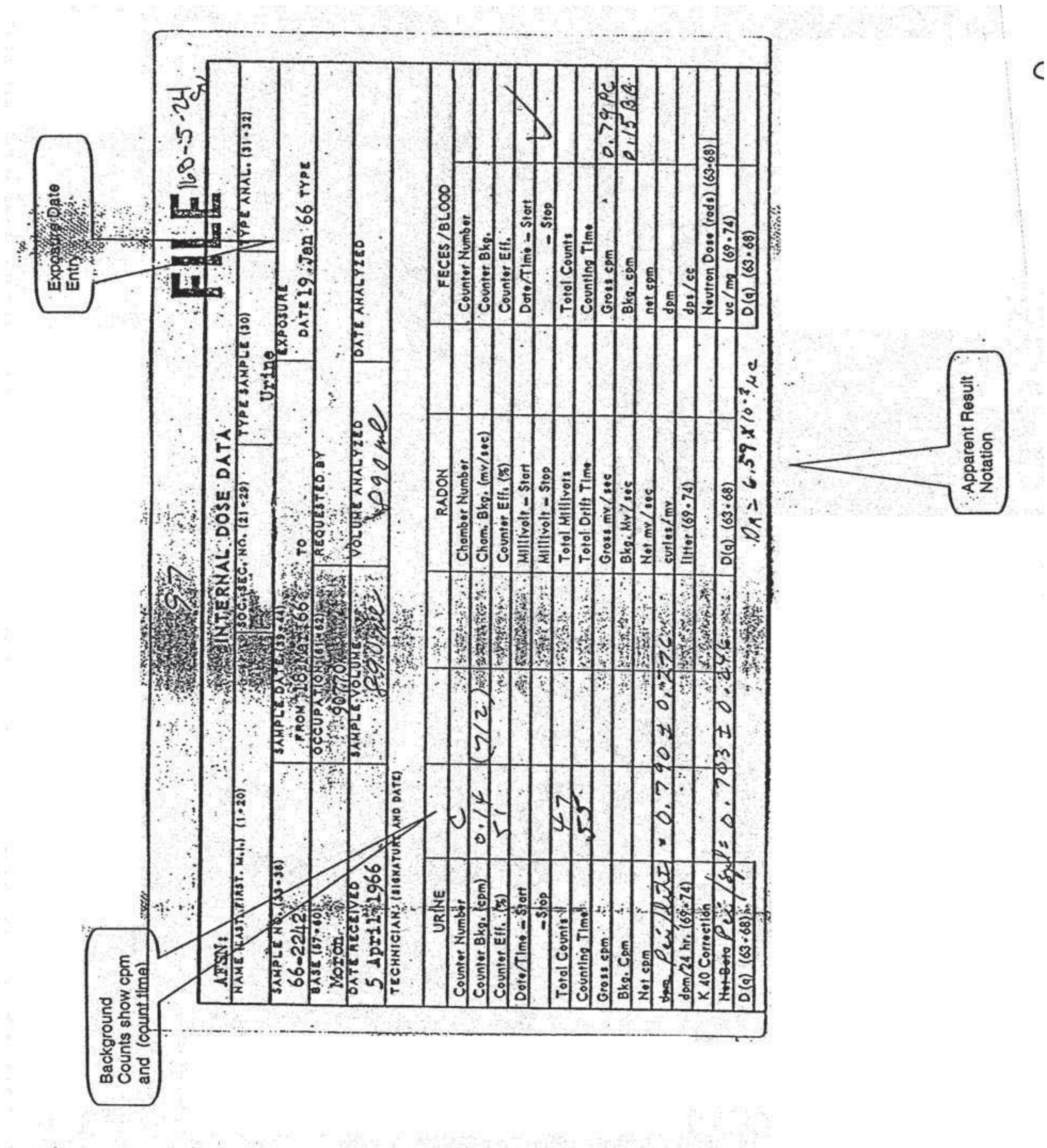


Figure B- 2. Another Example AFLC Form 1165, Internal Dose Data (May 66)

B.2.1.2 AFLC Form 1165, Radiological Sample Data (May 66)

The AFLC Form 1165, Radiological Sample Data (May 66) was apparently also used during the same time period as the previous form. However, our review indicates that this form applied primarily to samples analyzed by alpha spectrometry. Figure B-3 provides an example of this form and contains notations on several interesting features. These features include:

- **Alpha Spectrometry Counting Information:** This section of the form provides room for recording specific information about the radioactivity counting process. Entries include: identification of the radionuclide (^{236}Pu and ^{239}Pu) in separate columns; counter and efficiency (SPEC 2, 24.3); total counts and minutes for each (400, 571, 1 are the time, and the counts in the ^{236}Pu and the counts in the ^{239}Pu); background counts and time (800, 1, 1 as time, counts in the ^{236}Pu area and counts in the ^{239}Pu area). These entries are self-explanatory for the most part.
- **Elapsed Time in Days:** the time from exposure (assumed as midpoint of time at the accident site) to sample collection.
- **Exposure Time Entry:** An entry of the presumed exposure period. This example contains only the entry "66", presumably indicating the year 1966. No day or month information is entered.
- **Calculated Result:** the results of calculating the radioactivity. In this case entered as (Fci/Spl 4.5 ± 10.0) indicating 4.5 femtocuries per sample with an estimated counting error of 10.0 femtocuries per sample. Other evaluations indicate that for alpha spectrometry RHL calculated and reported the estimated error at the 68% confidence level. In this example, the error is greater than the calculated result.
- **Reported Results:** the result formally reported for this analysis. In this case the result was reported as No Detectable Activity (NDA) meaning that the sample result was less than the estimated error.

Observations about other data on this example reveal details of the processes used in analyzing samples. For instance, the Sample Volume (2000 mL) and the Volume Analyzed (1000 mL) indicate the standard practice that used one-half a submitted sample's volume thereby retaining a portion for further confirmation or reanalysis if laboratory difficulties were encountered.

B.2.1.3 AFLC Form 1165, Radiological Sample Data (Jul 67)

This data form represents an evolution of the previous two versions of the AFLC Form 1165. However, the form retains the same essential data presented on a piece of letter sized (8-1/2" × 11") card stock. This revised form retains the identifying information, but expands on and reformats the basic radioactivity counting and results information. Figure B-4 provides and example of this version of the form. Interesting features on the form are noted as before and include:

- **Gross Alpha Information:** this section contains the same information about the alpha counter data. In this case, total counts and time appear to be reversed; i.e. for TOTAL CTS AND TIME, the entries are 55 and 155. The first (55) was the RHL standard time for

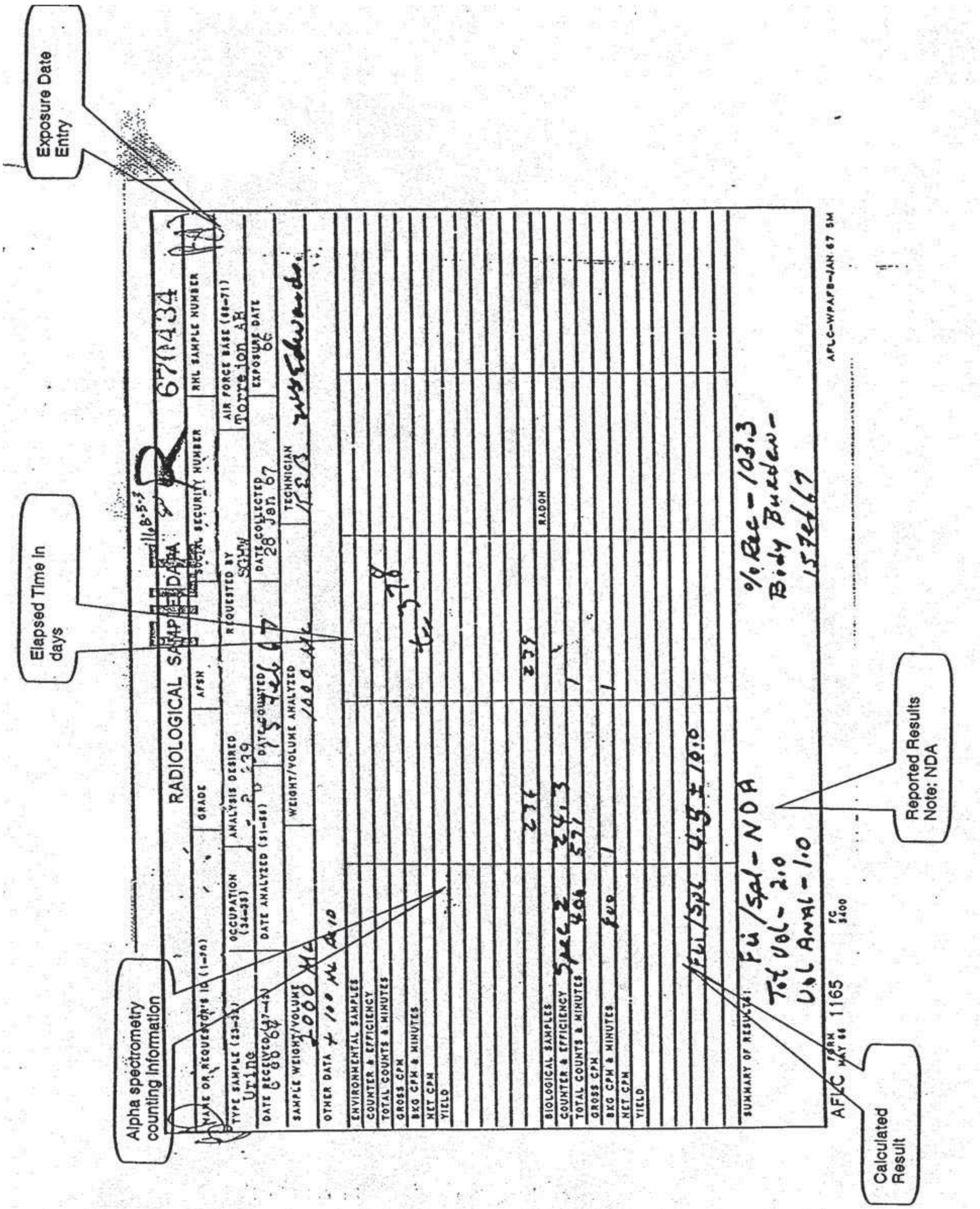
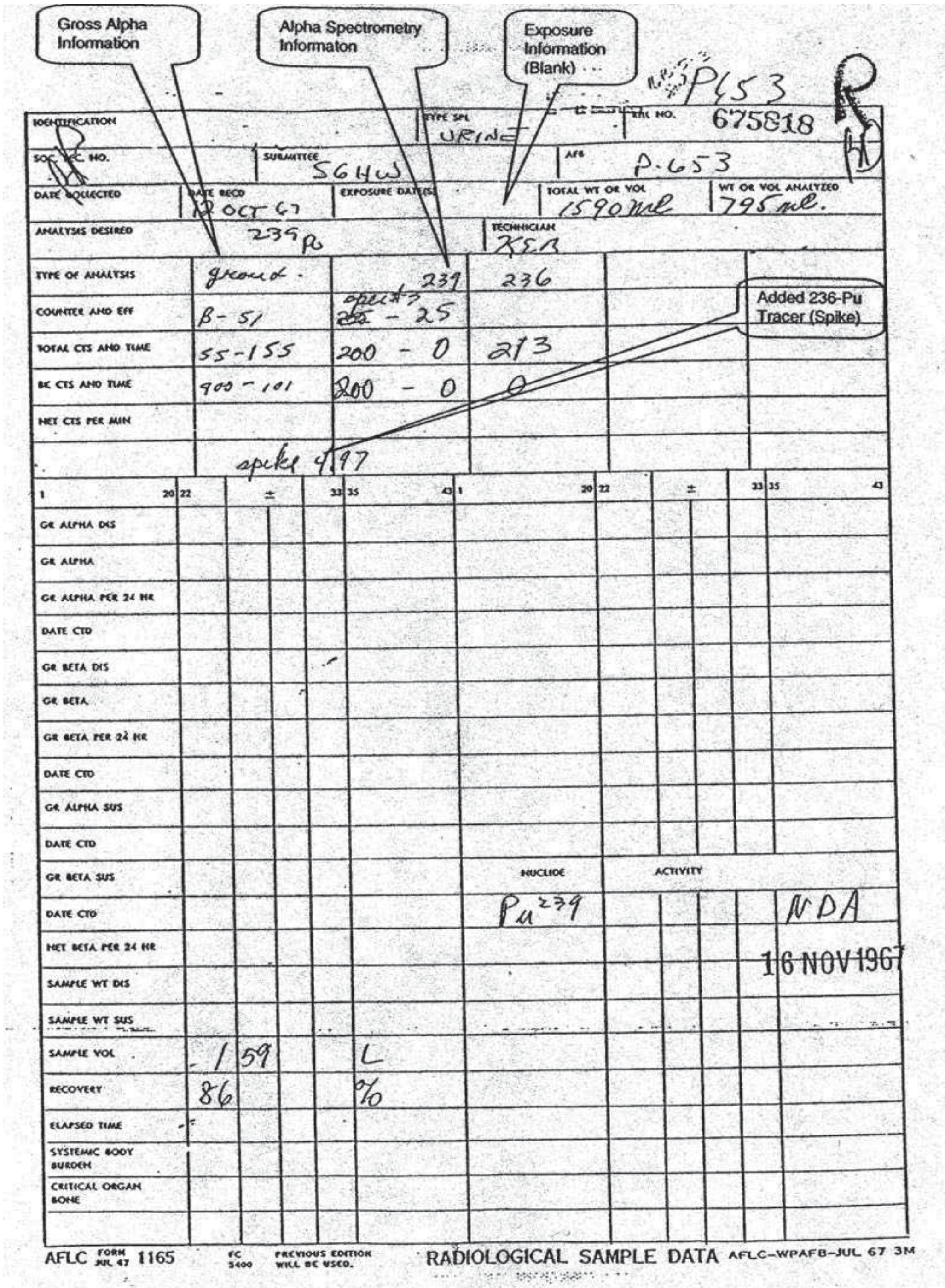


Figure B- 3. AFLC Form 1165, Radiological Sample Data (May 66)



Gross Alpha Information

Alpha Spectrometry Informaton

Exposure Information (Blank)

P453

IDENTIFICATION	TYPE SPL: URINE		SERIAL NO. 675818
SOC. SEC. NO.	SUBMITTEE: 56HW		AFB: P-653
DATE COLLECTED	DATE RECD: 12 OCT 67	EXPOSURE DATE(S)	TOTAL WT OR VOL: 1590 ml / WT OR VOL ANALYZED: 795 ml.
ANALYSIS DESIRED	239Pu		TECHNICIAN: KER

Added 236-Pu Tracer (Spike)

TYPE OF ANALYSIS	gross α	239	236
COUNTER AND EFF	β-51	spect#3 25	
TOTAL CTS AND TIME	55-155	200 - 0	213
BK CTS AND TIME	900 - 101	200 - 0	0
NET CTS PER MIN			
		spike 4.97	

GR ALPHA DIS	
GR ALPHA	
GR ALPHA PER 24 HR	
DATE CTD	
GR BETA DIS	
GR BETA	
GR BETA PER 24 HR	
DATE CTD	
GR ALPHA SUS	
DATE CTD	
GR BETA SUS	NUCLIDE / ACTIVITY
DATE CTD	Pu^{239} NDA
NET BETA PER 24 HR	16 NOV 1967
SAMPLE WT DIS	
SAMPLE WT SUS	
SAMPLE VOL	1.59 L
RECOVERY	86 %
ELAPSED TIME	
SYSTEMIC BODY BURDEN	
CRITICAL ORGAN BONE	

AFLC FORM JUL 67 1165 FC 5400 PREVIOUS EDITION WILL BE USED. RADIOLOGICAL SAMPLE DATA AFLC-WPAFB-JUL 67 3M

Figure B- 4. AFLC Form 1165, Radiological Sample Data (Jul 67)

counting gross alpha samples. So, the second entry (155) represents the sample counts. Similar comments apply to the background entries.

- **Alpha Spectrometry Information:** Similar information for calculating the results from the alpha spectrometry counting are included here. The counts and the counting time are interchanged as above.
- **Add ^{236}Pu Tracer (Spike):** the entry indicates the amount (in disintegrations per minute – dpm) of tracer added to the portion of the sample taken for analysis. This value is used in calculating the chemical recovery.

The preceding discussion about the forms provides the foundation for understanding the evaluation process applied to analyzing entries in the spreadsheet discussed in the next section. Clearly, consistency among the entries on the data forms and the entries in any final data set would be required. The data cards formed the only permanent record available of the actual data generated at the time of the incident. Consequently, they provided the primary means for verifying information from other sources; at least when the data on the cards were unambiguous.

B.2.1.4 Informal Data Records

An informal, handwritten record appeared in the case files of the High 26 group. That record was prepared on available paper scrap and was apparently used as source data for transfer to punched data cards. RHL used punched data cards as the primary medium for maintaining data and results for later use in organizing, sorting, reporting, and transfer to computer tape.

Figure B-5 illustrates one example of that form. The form contained an entry at the top (3826) that represents the sequential portion of the RHL assigned sample number (66-3286). The form also contains six numbered entries. The meaning of those data contained in those entries is explained in Table B-1.

Table B-1. Data contained on informal RHL form.

No.	Meaning
1.	Urinary excretion pCi/24 hr and error
2.	Chemical Recovery (%)
3.	Total Sample Volume in Liters (L)
4.	Days elapsed from exposure to sample
5.	Day of Year Sample Completed (6256 means 256th day of 1966 or September 13, 1966
6.	Fraction of a systemic body burden

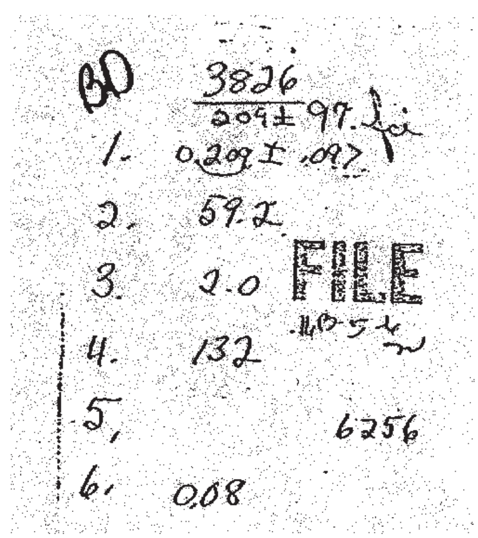


Figure B-5. Informal RHL data form.

B.2.2. Spreadsheet

During an initial visit, IERA representatives provided a copy of a Microsoft EXCEL spreadsheet that they had prepared. The spreadsheet contained the basic data transcribed from the hardcopy data forms into the spreadsheet. Table B-2 explains the data items in the spread sheet. Figure B-6 contains an example of one page of the spreadsheet to illustrate the items of information transferred to the sheet. The individual names, Social Security Numbers, and AFSNs have been masked on this example for privacy reasons.

The spreadsheet contains information for 1,758 entries on 1,555 individuals.

Table B- 2. Data Items in IERA spreadsheet

Data Item	Meaning
Name:(Last, First, M.I)	Individual Name
SSN:	Social Security Number
AF ID # :	Air Force Service Number
Type Sample	Type of Sample – urine, nasal swipe, fecal, etc.
Type Anal.	Type of analysis performed – gross alpha, ^{239}Pu
Sample No.	Sample Number assigned by RHL
Sample Date:	Date the sample was collected.
Base:	Base of assignment of the person sampled.
Date Recived (*sic*)	Date the sample was received at RHL
Sample Volume	The total volume of the sample in Liters or milliliters
Sample Analyzed	Volume of sample used in a specific analysis procedure
Date Analyzed	The date the analysis was completed
Final Sample Result	Result in picocuries per day
Uncertainty	The counting error or uncertainty of the result (apparently 95% confidence level for gross alpha results; 68% confidence level for alpha spectrometry results.)

Although this spreadsheet does not contain any new data, it represented a substantial Air Force effort that could serve as the basis for preparing data for further evaluation and use in the dose assessment. The data added and revisions made are discussed in a later section of this appendix.

B.2.3. Reports

Additional information in the form of correspondence and written reports can provide details of the accident and the response effort, as well as insight into the approach to evaluating possible health and safety issues associated with the response effort. Several documents provided key information about those factors and formed the foundation for the pertinent analysis required of this effort. Documents that provided those kinds of key information included:

The *Palomares Summary Report* prepared by the Field Command, Defense Nuclear Agency that provides a comprehensive summary of the details of the accident, contamination levels, response efforts and limited discussions of health and safety actions (DNA 1975).

"Plutonium Deposition Registry Board, Proceedings: First Annual Meeting, 26 – 28 October 1966" prepared by the Air Force Logistics Command that described the proceedings of the first meeting of this board and reviewed key issues and discussions on the progress and future plans for the follow-up effort (Odland 1966).

Name:(Last, First, M.I)	SSN:	AF ID # :	Type Sample	Type Anal.	Sample No.	Sample Date:	Base:	Date Recived	Sample Volume	Sample Analyzed	Date Analyzed	Final Sample Result	Uncert.
Data Masked	Data Masked	Data Masked	Urine	N/A	66-2475	n/a	Torrejon	7-Apr-66	1000	1000	N/A	0.131	n/a
Data Masked	Data Masked	Data Masked	Urine	N/A	66-2867	Fr:845 10 Apr66 To: 650 11 Apr 66	Torrejon	22-Apr-66	1800	1800	N/A	1.10+/-0.27	n/a
Data Masked	Data Masked	Data Masked	Urine	PU	66-1193	19-Feb-66	Torrejon	3-Mar-66	1500	1000	N/A	n/a	n/a
Data Masked	Data Masked	Data Masked	Urine	Gross Alpha	66-1428	26-2-66	Moron	9-Mar-66	600	624	N/A	n/a	n/a
Data Masked	Data Masked	Data Masked	Nasal Swipe	N/A	66-2525	12-Mar-66	Torrejon	6-Apr-66	n/a	n/a	N/A	n/a	n/a
Data Masked	Data Masked	Data Masked	Urine	N/A	66-2049	n/a	Torrejon	31-Mar-66	430	430	N/A	0.0639+/- 0.0793	n/a
Data Masked	Data Masked	Data Masked	Urine	N/A	66-2146	19-Mar-66	Torrejon	1-Apr-66	850	850	N/A	0.179+/-0.118	n/a
Data Masked	Data Masked	Data Masked	Urine	N/A	66-1811	3-Feb-66	Torrejon	28-Mar-66	720	720	N/A	0.0405	n/a
Data Masked	Data Masked	Data Masked	Urine	N/A	66-2332	19-Mar-66	Torrejon	1-Apr-66	890	890	N/A	n/a	n/a
Data Masked	Data Masked	Data Masked	Urine	N/A	66-2866	Fr:0700 6 Apr 66	Torrejon	22-Apr-66	1100	1100	N/A	1.04+/-0.26	n/a
Data Masked	Data Masked	Data Masked	Urine	Gross Alpha	66-1403	26-Feb-66	Torrejon	9-Mar-66	660	685	N/A	n/a	n/a
Data Masked	Data Masked	Data Masked	Urine	N/A	66-2885	Fr: 1 Apr 66 To: 2 Apr 66	Torrejon	26-Apr-66	1500	1500	N/A	0.137+/-0.107	n/a
Data Masked	Data Masked	Data Masked	Urine	N/A	66-1097	25-Jan-66	Wiesbaden	1-Mar-66	850	850	17-Mar-66	n/a	n/a
Data Masked	Data Masked	Data Masked	Urine	N/A	66-2912	19-Mar-66	Torrejon	1-Apr-66	550	550	N/A	0.189+/-0.124	n/a
Data Masked	Data Masked	Data Masked	Urine	Gross Alpha	5(66-213)		Torrejon	25-Jan-66	430	200	N/A	n/a	n/a
Data Masked	Data Masked	Data Masked	Urine	Gross Alpha	23(66-231)	n/a	Torrejon	25-Jan-66	475	200	N/A	0.473+/-0.233	n/a
Data Masked	Data Masked	Data Masked	Urine	Gross Alpha	25(66-233)	n/a	Torrejon	25-Jan-66	475	200	N/A	0.473+/-0.233	n/a
Data Masked	Data Masked	Data Masked	Urine	N/A	66-2581	23-Mar-66	Moron	11-Apr-66	1000	1000	N/A	0.0336+/- 0.0623	n/a
Data Masked	Data Masked	Data Masked	Urine	Gross Alpha	66-888	5-Feb-66	Moron	18-Feb-66	970	200	N/A	3.77+/-1.36	n/a
Data Masked	Data Masked	Data Masked	Urine	Gross Alpha	66-1402	26-Feb-66	Torrejon	9-Mar-66	1000	1000	N/A	1.04+/-1.68	n/a
Data Masked	Data Masked	Data Masked	Nasal Swipe	N/A	66-1308	n/a	Moron	9-Mar-66	n/a	n/a	N/A	n/a	n/a
Data Masked	Data Masked	Data Masked	Urine	Gross Alpha	66-496	7-Feb-66	Moron	10-Feb-66	600	200	N/A	3.89+/-1.05	n/a
Data Masked	Data Masked	Data Masked	Urine	N/A	66-2073	19-Mar-66	Torrejon	1-Apr-66	490	490	N/A	0.141+/-0.083	n/a
Data Masked	Data Masked	Data Masked	Urine	N/A	66-2057	9-Mar-66	Torrejon	1-Apr-66	650	650	N/A	0.0787+/- 0.0622	n/a
Data Masked	Data Masked	Data Masked	Urine	N/A	66-2684	Fr: 27 Mar 66 To:28 Mar 66	Torrejon	12-Apr-66	1100	1100	N/A	0.+/-0.	n/a
Data Masked	Data Masked	Data Masked	Urine	N/A	66-2498	n/a	Moron	7-Apr-66	950	950	N/A	0	n/a
Data Masked	Data Masked	Data Masked	Urine	Gross Alpha	66-1379	28-Feb-66	Torrejon	9-Mar-66	500	520	N/A	n/a	n/a
Data Masked	Data Masked	Data Masked	Urine	N/A	66-2294	20-Mar-66	Moron	1-Apr-66	950	950	N/A	0.162+/-0.136	n/a
Data Masked	Data Masked	Data Masked	Urine	Gross Alpha	66-732	9-Feb-66	Hanaw Germany	17-Feb-66	860	200	N/A	2.62+/-1.07	n/a

Figure B- 6. Example page of IERA results spreadsheet.

An article entitled "Bioassay Experiences in Support of Field Operations Associated with Widespread Dispersion of Plutonium," in *Proceedings of Symposium on Diagnosis and Treatment of Deposited Radionuclides*, sponsored by the Hanford Environmental Research Foundation (Odland 1968a).

An article entitled "Industrial Medical Experience Associated with the Palomares Nuclear Incident" published in the Journal of Occupational Medicine that was a peer-reviewed version of the previous proceedings.

A letter by Colonel Wallace, Air Force Logistics Command Surgeon, with the subject: "Palomares Broken Arrow – Report on Medical Follow-up Program" that summarized the results of the follow-up program through January 1968 and concluded that neither additional follow-up nor meetings of the Plutonium Deposition Registry Board were required (Wallace 1968).

These documents provided a narrative overview of the approach to conducting the assessment of possible exposure to plutonium at Palomares. The discussions highlighted the issues faced, the problems encountered, and the rationale that formed the basis for the effort and decisions made throughout the period of on-site activity and subsequent follow-up. These issues are discussed in Section 2 of the main report. However, key points from that review are repeated here and serve as reference for the analyses to follow. The key points include the following.

- *Sample Contamination*. During the initial phase on site, samples were collected under less than ideal conditions that could have contaminated the sample containers and samples themselves from the blowing dust containing plutonium. In fact, RHL reported frequent episodes of gross alpha contamination on the outer surfaces of the sample containers received.
- *Sample Collection Period*. Ideally, samples should be collected for a full, 24-hour period to obtain the best representation of the daily excretion required by methods for estimating body content. In fact, most of the on-site samples were limited to 12 hours because of mission needs and difficulties keeping subjects confined for an entire 24 hours. To compensate for this, RHL corrected the result for every sample with a total volume of less than 1000 milliliters to 1200 milliliters; the volume assumed to represent the daily urine output of a normal, adult male.
- *Exposure Type and Date*. Most of the response personnel spent several weeks at the site. Their activities varied from daily presence in contaminated areas to primary work in administrative areas. As a simplifying assumption, exposures were considered as single, acute intakes that occurred on the mid-point of the period of time spent on the site.

B.3. DATA EVALUATION AND PREPARATION FOR DOSE ASSESSMENT

B.3.1. Data Evaluation

One final product from this project is a dataset, containing the estimates of the possible intake of plutonium and of the associated committed effective dose equivalent that can be loaded into the Air Force Master Radiation Exposure Registry. This process requires that the data provided undergo detailed scrutiny to determine its suitability and to identify possible consistency problems. Upon receiving the collection of data forms, spreadsheet, and reports discussed above the data review occurred in several stages. Objectives of the review included availability of data elements required for input to chosen internal dosimetry models. The primary parameters include: the type of intake (inhalation, ingestion, skin contact), the date or dates the exposure occurred, the date of collection of nasal swab or urine samples, the duration of the urine sample collection, and the results of the sample analysis. Review of the data indicated that the hardcopy forms recorded exposure date or dates, sample date, and results for many samples. In other cases, forms did not contain all the required data. Consequently, our investigators sought alternate approaches.

First, the spreadsheet and data forms were compared to determine whether all forms were present in the spreadsheet and whether the entries were correct. The initial evaluation identified a number of problems with the spreadsheet and supporting forms as shown in Table B-3.

This initial review indicated that substantial numbers of samples lacked one or more important pieces of data such as a Sample Date or Exposure Date. The review also identified 115 data forms attached to a primary card that apparently represented a repeat analysis of the same sample or a follow-up sample for an individual. Those additional samples were not in the spreadsheet.

Following the initial review additional efforts corrected many of the missing entries through more careful analysis of the information and reasonable assumptions about the missing information.

Table B- 3. Issues with Palomares Data.

Issue	Number of Entries	Percentage
Exposure Date Not Available	402	22.7
Sample Date Not Available	445	25.1
No SSN Available	385	21.8
No Air Force ID Available	2	0.11
Sample Vol. < 600 mL	323	18.3
Sample Vol. > 1000 mL	434	24.5
Number with Additional Sampling Data (2nd page)	115	6.50
Number of Cards Marked Out	2	0.11
Number of Cards Not Found	5	0.28
		Total Number of Samples = 1768

The duration of sample collection is a critical piece of data that determines the daily excretion rate of plutonium in urine. Daily excretion, as mentioned above, is the accepted parameter for estimating body content at a time following exposure. Air Force reports indicated that sample collection lasted 12 hours for many samples collected at Camp Wilson. To correct, the Air Force established a procedure that corrected the result for any urine sample of less than 1200 milliliters to 1200 milliliters. Although this may have been somewhat arbitrary, it provided a reasonable and conservative correction. The procedure was deemed conservative because it would tend to overestimate urinary excretion. For example, if an individual actually collected 900 milliliters in a 24-hour period, the correction would still be applied and the estimated daily excretion would be increased by 25%. When other factors are equal, increasing the urinary excretion also raises the estimated body content.

Our review of the data indicated that 12-hour samples were clearly designated in 42 of the samples entered in the initial spreadsheet. Attempts to duplicate the Air Force estimate of systemic body burden revealed that the sample volume correction might have been applied inconsistently. However, this did not adversely affect any conclusions about the individuals tested. This finding does not materially affect preparation of the data for this assessment except for the samples clearly identified as 12-hour samples. This review concluded that adjustments to samples that were not designated as 12-hour samples presented were unnecessary. Therefore, recorded sample volumes were assumed to represent 24-hour output unless specifically designated as 12-hour samples.

Missing or incorrect entries for Exposure and Sample Date present additional challenges to performing a reasonable estimate of radiation dose. Careful review of the data indicated that additional analysis would be required to establish these parameters.

Other observed issues included missing SSNs, AFSNs, and other entries. Upon further analysis, it became evident that the records included information on the entire spectrum of responders – from Air Force to other Services (Army, Navy, Marines); other US agencies (State Department, Bureau of Mines), possible Spanish civilian employees of Torrejon Air Base or local citizens, and at least one media representative. Only US Air Force personnel would have AFSNs, however, entries for members of the other services had similar entries. Missing SSNs introduce some problems for integrating the results into current data systems, however the issue can be resolved.

B.3.2. Preparation of Data for Analysis

The issues identified in the previous section provided the basis for an approach to refine the data by correcting errors and inconsistencies and by developing reasonable estimates of missing data. As mentioned, this process had the primary objective of developing input data for the following parameters: exposure date, sample date, sample duration, and urinary excretion rate and its estimated error. Other inconsistencies observed in the data were also corrected to the extent possible. Each of these procedures is summarized in the following sections.

B.3.2.1 Exposure Date

Exposures were assumed to be acute inhalation as discussed in the main report. The exposure date was then calculated by determining the midpoint of the time an individual spent on station. Exposure date entries on the forms included all of the following: a single date (25 Jan 66), a date range (18 Jan 66 to 30 Jan 66), an arrival date (Arr: 20 Jan 66), a month and year (Jan 66), a year (66) and a few others.

Generally, an arrival date or single date entry could be assumed to represent the beginning of exposure and that was done. The end of the exposure presented additional difficulties. For data forms that did not clearly indicate the end of the exposure period, Sample Dates for all samples for an individual were reviewed. The day before the last Sample Date was assigned as the end of exposure period. This approach seemed reasonable since the established procedure was to collect a sample from everyone before his or her departure. In some cases, individuals may have returned to their base of assignment before providing a sample. These cases would generally represent a few days. That delay was not viewed as serious when the other difficulties and uncertainties are considered. If the last sample was collected after Camp Wilson ceased all operations on April 11, 1966, that date was used as the end of exposure.

B.3.2.2 Sample Date

Data forms did not contain Sample Date entries for 445 samples. An alternative approach was developed to provide a reasonable estimate of the Sample Date. Data on the date a sample was received at RHL and the assigned laboratory sample numbers were used to develop the estimate.

The approach compared the range of valid Sample Date entries with the Date Received at RHL and with the sequence of assigned sample numbers. Figure B-7 illustrates the distribution of the receipt of samples at the laboratory. The results of the comparison and some additional judgement allowed the Sample Date to be estimated. Although not necessarily precise, the approach allowed reasonable estimates of the Sample Date. The derived Sample Date information was then entered into a master dataset along with the other data for each urine sample. Notations documenting the source of the Sample Date were made for each entry.

B.3.2.3 Sample Duration

Actual sample duration was documented in a very small fraction (42 samples) of the samples received. Fortunately, basic sample volume data provide the basis for making any corrections needed. As discussed above, this project elected to treat recorded sample volumes as representing 24-hour outputs unless the data forms specifically designated the samples as 12-hour samples. For those, the results were adjusted to the currently accepted nominal daily urine output (1400 mL) for Reference Man. Those adjustments were performed in the intake assessment process.

B.3.2.4 Other Parameters

Analytical results for daily urinary excretion and the estimated error were transcribed as entered on the hardcopy forms. However, in the case of samples reported as No Detectable Activity, the data forms were reviewed for the presence of other calculations of a numerical result and its estimated error. When found, these actual results were used in the analysis, even when the error value exceeded the result. This procedure applied primarily when the results of multiple samples were available, as was the case for many of the “High 26” group. In these cases, although the errors were large, they nevertheless provided order of magnitude information about the levels present and were useful comparisons to other values. Specific notes are contained in the individual case files in Volumes II and III.

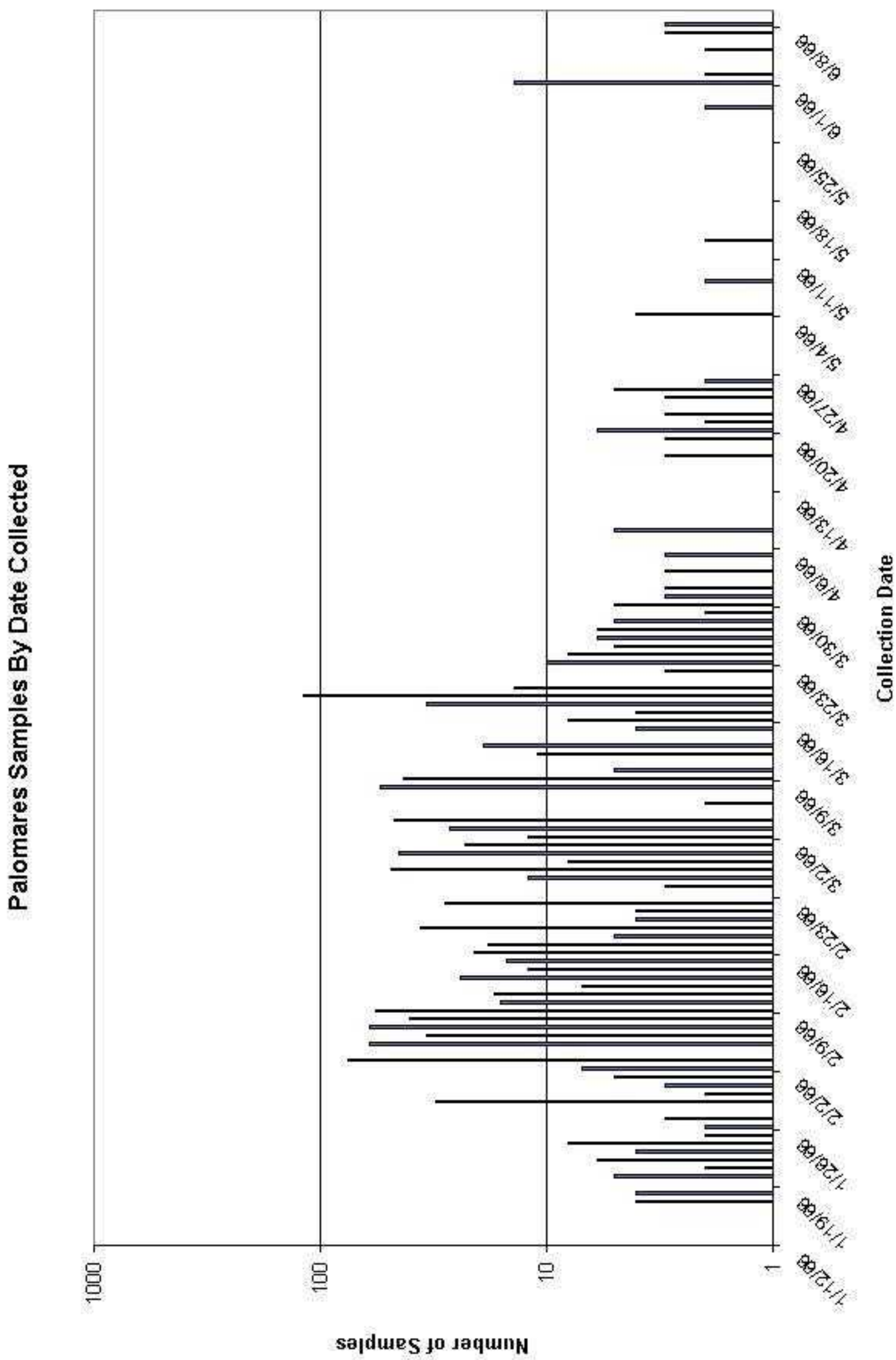


Figure B- 7. Distribution of Samples Received at RHL

B.3.2.5 Other Inconsistencies

Other inconsistencies in the dataset were also identified and corrected where possible. Although these did not affect the actual intake and dose assessments, they do affect identifying information. This review discovered inconsistencies in:

- Individual names caused by interchange of a letter or two.
- SSNs caused by typographical errors or easily identified keyboarding errors.
- Errors in designation of the analysis type, such as GrossAlpha for Gross Alpha.
- Base names caused by typing errors.

Other inconsistencies affecting only a few entries were revised as they were discovered.

B.4. SUMMARY OF THE DATA EVALUATION AND PREPARATION

After making the changes and updates discussed above the data set served as the basis for additional evaluations before processing of the intake and dose assessments. Those additional evaluations considered the amount of data available for each individual, the quality of the data, and possible issues with the data that would limit its reliability in assessing individual cases. In particular, the High 26 group had substantially more data than any other group of individuals. That group of 26 was followed-up for more than a year. Follow-up began in the summer of 1966 and continued until August and September 1967 for some of the group. Because of this, that group served as the primary group for study.

Evaluation of the data also revealed that about 115 appeared to have had their initial gross alpha analyses repeated using the alpha spectrometry technique. Or, they submitted follow-up samples upon request for analysis by alpha spectrometry. Those individuals comprised a second group that received additional evaluation of their conditions. Review of their data for reliability as indicated by adequate chemical recovery and other factors resulted in a total of 54 individuals with adequate sample data. The remaining 62 were removed because their sample results were not reported through laboratory error or other problems, or the chemical recoveries of their alpha spectrometry samples were below 40% and not considered reliable. This group was called the "Repeat Analysis" Group. Their individual cases were evaluated and the results are reported in Appendix C.2.

Of the remaining majority of samples, most represented only one sample for an individual collected while at Camp Wilson. As discussed in Appendix C.3, many of those results were quite high indicating possible contamination. Review of the data also revealed that a substantial number showed relatively low urine measurements. Their results were in the same range of urinary excretion as the individuals with the lower intakes and associated CEDEs of the High 26 and Repeat Analysis Cases. Further review of the data and assessment of a reasonable lower level of detection led to the conclusion that samples with results of less that 0.1 picocuries per day represented that reasonable lower level. Individuals with daily excretions at that level were evaluated and reported in Appendix C.3. This group, called Contamination Cutoff Cases, was not evaluated to the depth of detail as the previous cases, primarily because they had only one result for urine content. Nevertheless, the assessment provides an approximate estimate of their intake and dose.

Finally, all remaining samples were reviewed. Since their samples were collected on site and were at risk of sample contamination, the urine measurements are entered at Appendix C.4. However, no further assessment of their results was attempted.

APPENDIX D

SELECTION OF DOSE METHODOLOGY

D. SELECTION OF DOSE METHODOLOGY

D.1. REVIEW OF INTERNAL DOSIMETRY METHODS

Exposure to radiation can occur from sources of penetrating radiation outside the body, such as x-ray machines or industrial radiography sources, or from sources of radioactive materials, such as plutonium or uranium, that enter the body, locate in an internal organ or organs, and irradiate the tissues of those internal organs. The problem of calculating the dose depends on many factors such as the shape of the organ, the type of radiation, the amount of the deposit, and the distribution of the deposit. Each of these individual factors is subject to considerable variability and difficulty in determining accurately. Once a dose is calculated, effectively communicating the possible effect of the dose on health requires additional skill and effort.

The current approach to limiting radiation exposure in the United States is derived from recommendations in ICRP Publications 26 and 30. The ICRP approach uses the concept of Committed Effective Dose Equivalent (CEDE) - a cumulative dose, weighted for the contributions of individual organs, and summed over a 50-year period for workers. Quantities derived from the CEDE such as the Annual Limit on Intake (ALI) and the Derived Air Concentration (DAC) provide operational limits for workers so that the overall guidelines will not be exceeded. The ALI is the activity of a radionuclide that would irradiate a person to the limit set by the ICRP for each year of occupational exposure. The DAC is found by dividing the ALI by the volume of air inhaled (2,400 m^3) in a working year (2,000 hours) (ICRP 1979).

For internal exposures, determining the dose requires knowledge of the following questions:

- How does the material get into the body?
- Once in the body, how quickly does the material move to other organs?
- Does the material in the initial organ leave the organ or does some remain?
- Once in an organ, how does the material irradiate the organ and other organs?
- Once in an organ, how does the material move to other organs?
- Finally, how does is the material eliminated from the body if at all?

Answers to these provide the basis for developing an approach to calculate the dose to organs, the effective dose equivalent to the body, and interpreting the effects of the dose.

D.1.1. Internal Dosimetry Methods

The methods for estimating organ dose from internal radionuclides have evolved since radioactive materials were discovered and used. Until 1979, ICRP Publication 2 provided the guidelines and methodology. In 1979, ICRP Publications 26 and 30 changed the basic approach to limiting radiation, and for internal radionuclides in particular. That approach currently remains the accepted approach in the United States for purposes of regulation. However, progress in all areas of radiation effects and the behavior of radionuclides in the body have produced more recent recommendations on a number of key elements in the process as presented in ICRP Publications 54, 60 and 66. As for any dynamic area of study, continued improvements in the understanding of plutonium's behavior in the body, improved methods for estimating body content, and more accurate mathematical models for estimating intake and dose from body content will evolve.

D.1.1.1. ICRP Publication 2 Methods

The models of ICRP-2 assumed that a single organ could be considered the critical organ; that the organ retention could be represented by a single exponential term; that the physical characteristics, such as intake parameters, transfer functions, and tissue size and weight, could be represented by "Standard Man" data; that organs could be assumed to be spherical; and that scattered radiation could be ignored. In performing the dosimetry, it was assumed that the material was distributed uniformly throughout the organ and that the energy absorbed equaled the energy emitted. Doses were limited to a specified annual dose to the critical organ.

Intakes of radionuclides were controlled by limiting "Maximum Permissible Concentration" (MPC) values in air and water for workers so that the annual dose limit to the critical organ would not be exceeded. The annual limit on dose to the critical organ applied over a 50-year intake period so that the limit would not be exceeded even if a radionuclide were taken in continuously over 50 years. An associated limit, called the "Maximum Permissible Body Burden," was that amount of a material in the body that would not exceed the annual dose limit to the critical organ. The ICRP-2 method was in effect and adopted for the Palomares accident.

D.1.1.2. ICRP-30 Models and Methods

The ICRP changed its basic recommendations and revised the system of dose limitation in ICRP Publication 26 based on risk. This approach acknowledged the availability of sufficient information about the effects of radiation to estimate risk for fatal cancer from a unit dose equivalent in exposed people and in the risk of serious disease to offspring of exposed people. The basic recommendations addressed both stochastic effects and non-stochastic effects. For stochastic effects, such as cancer and hereditary effects, risks are assumed to be directly related to dose equivalent with no threshold, meaning that the probability of the effect occurring, rather than the severity, is related to the dose equivalent. The severity of non-stochastic effects, such as cataracts and erythema, varies with dose, usually above a threshold or minimum dose.

ICRP Publication 30 provided revised dosimetry models that assume organ retention is represented by one or more exponential expressions, the critical organ concept no longer applies, the dose in an organ must consider radiation emitted by other organs in the body, and the physical characteristics are represented by "Reference Man" data in ICRP Publication 23 (ICRP 1975). The model assumes that deposition in an organ is uniform, and that the total dose is averaged over the organ.

Under the revised system, dose equivalent limits are intended to prevent non-stochastic effects and to limit stochastic effects to acceptable levels. To meet this end, an annual occupational limit of 50 rem (0.5 Sv) to any organ was established (ICRP 1979). For stochastic effects, the limit on risk is the same whether the whole body is irradiated or organs are non-uniformly irradiated. This is accomplished by assigning organ weighting factors, w_t, that represent the ratio of the risk for the effect in an organ to the risk for whole body irradiation. The limit on risk to the whole body is then determined by summing the contributions for each irradiated organ and is given by:

$$\sum_T w_T H_{50,T} \leq 5 \text{ rem } (0.05 \text{ Sv})$$

where $w_t H_{50,T}$ is called the weighted committed dose equivalent or the committed effective dose equivalent (CEDE), and $H_{50,T}$, called the committed dose equivalent (CDE), is the total dose equivalent averaged over tissue (T) in the 50 years following intake and is limited to 50 rem (0.5 Sv). Table D-1 contains the organ weighting factors from ICRP-30.

The dosimetry model calculates the absorbed dose averaged over the organ mass during 50 years following intake. It considers each radiation type and applies a radiation weighting factor, sometimes called the quality factor, which has the following value:

Q=1 for beta particles, electrons and all electromagnetic radiation.

Q=10 for fission neutrons emitted in spontaneous fission and protons.

Q=20 for alpha particles from nuclear transformations, for heavy recoil particles, and for fission fragments.

Table D- 1. ICRP-30 Tissue weighting factors, w_T (ICRP 1979).

Tissue	Weighting Factor, w_T
Gonads	0.25
Red Marrow	0.12
Lung	0.12
Breast	0.15
Thyroid	0.03
Bone Surface	0.03
Remainder 0.06 for the organs with the five highest dose.	0.30

Additional modifying factors, not discussed here, that consider irradiation from other organs and radionuclides are used to calculate the final organ dose equivalent.

For inhaled radionuclides, the Task Group on Lung Dynamics developed a respiratory tract model, which uses the approach shown in Figure D-1. That approach considers three classes (D, W, and Y) of material based on retention in the deep or pulmonary section of the lung. The classification depends on a range of retention half-times: D < 10 days; 10 days < W < 100 days; and Y > 100 days. ICRP-30 contains metabolic data for certain chemical forms of the materials.

The model defines three regions of deposition: nasal-pharyngeal (N-P), tracheo-bronchial (T-B) and pulmonary (P). Fractions initially deposited in these regions are D_{N-P}, D_{T-B}, and D_P and are based on an aerosol particle size of 1 µm. As Figure D-1 indicates, each section is divided into compartments that are associated with clearance pathways and have an established clearance half-time T and fraction F for removal of material. Compartments a, c, and e represent direct transfer to body fluids, known as the transfer compartment, for further transfer to other organs or excretion. Compartment g represents indirect transfer to body fluids through lymph nodes. For Class Y material, only some material is transferred (in compartment i) to other bodily fluids. The remainder stays indefinitely in compartment j. Compartments b, d, f and h transfer material to the

		Class					
		D		W		Y	
Region	Compartment	T Day	F	T day	F	T day	F
N-P	a	0.01	0.5	0.01	0.1	0.01	0.01
(D_{N-P} = 0.25)	b	0.01	0.5	0.4	0.9	0.4	0.00
T-B	c	0.01	0.95	0.01	0.5	0.01	0.01
(D_{T-B} = 0.08)	d	0.2	0.05	0.2	0.5	0.2	0.99
	e	0.5	0.8	50	0.15	500	0.05
P	f	n.a.	n.a	1.0	0.4	1.0	0.4
(D_P = 0.25)	g	n.a.	n.a	50	0.4	500	0.4
	h	0.5	0.2	50	0.05	500	0.15
L	i	0.5	1.0	50	1.0	1000	0.9
	j	n.a.	n.a.	n.a.	n.a.		0.1

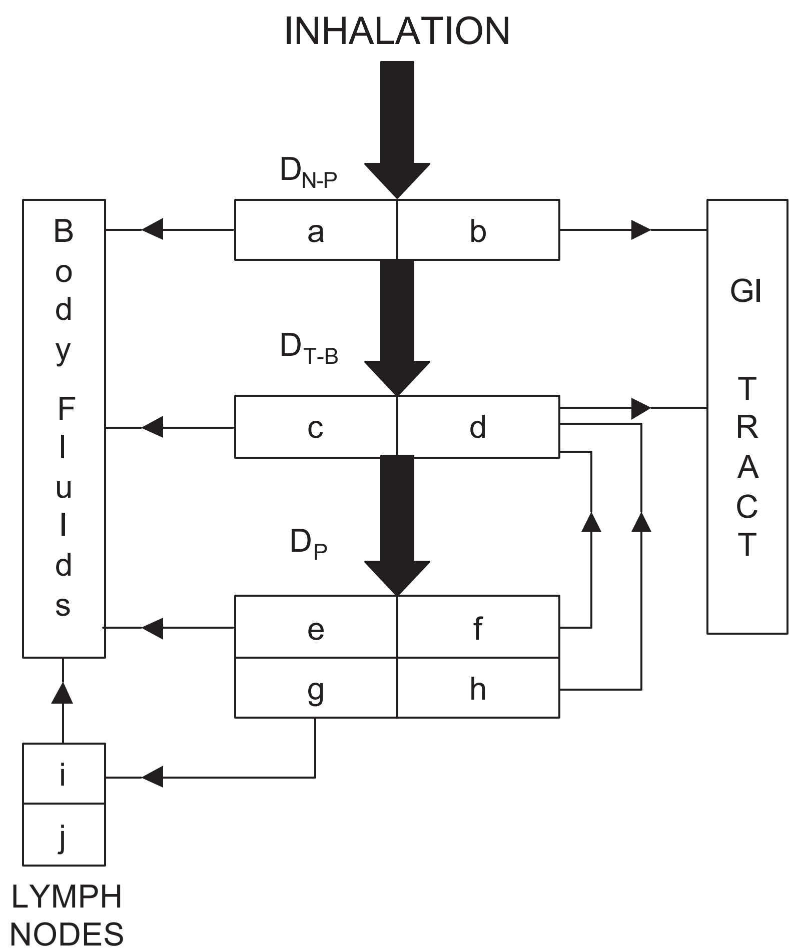


Figure D- 1. ICRP-30 Model of the respiratory tract (ICRP 1979).

gastro-intestinal tract (GI tract). Once a radionuclide reaches other organs, its behavior is then governed by the metabolic model.

The gastro-intestinal tract model is based on the fraction transferred from the GI tract to the systemic system (f_1). Since f_1 for Class Y plutonium is 0.00001, ingestion is not considered significant for evaluation of the Palomares responders and the GI tract will not be considered further.

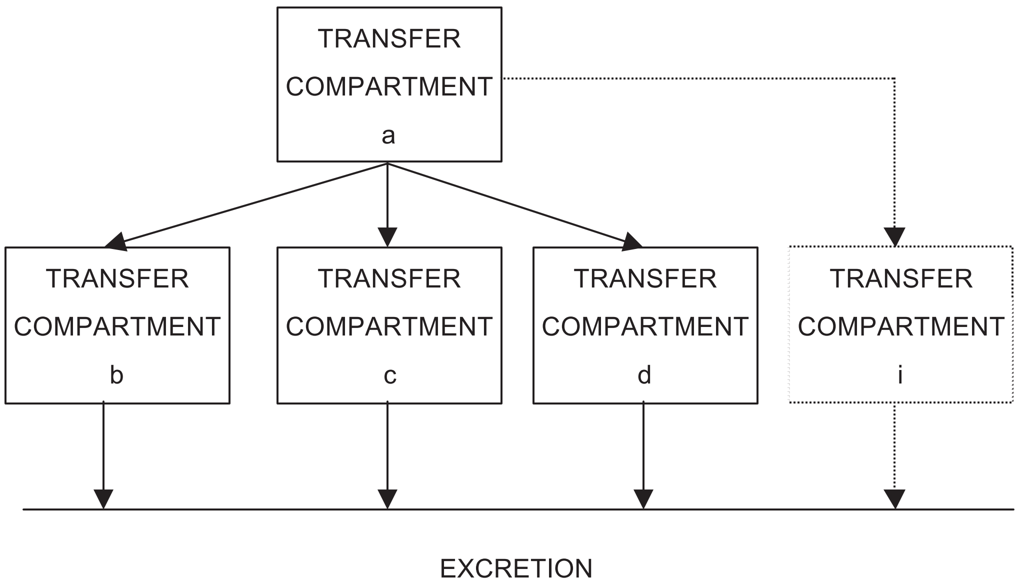


Figure D- 2. ICRP-30 Transfer Compartment Model (ICRP 1979).

Material that has been transferred to bodily fluids and other compartments of various tissues are indicated in Figure D-2, taken from ICRP-30. The time a material takes to transfer from the deposition site is represented by transfer compartment a. The clearance half-time for this compartment is 0.25 day unless stated otherwise. Each tissue that receives the radionuclide will have one or more compartments with an associated elimination rate. The model assumes that there is no feedback, or recycling, of a material to an original compartment. That means the model is a one-pass, or pass-through, model. Figure D-3 shows the ICRP-30 model for a Class Y plutonium aerosol.

Calculation of the committed dose equivalent (CDE) for a given organ is the sum of the product of two factors: U_s, the total number of transformations of the radionuclide in the source organ (S) over 50-years following intake, and SEE (T←S), the energy absorbed in the target tissue (T), modified by the quality factor, for each type of radiation emitted in S. ICRP tables of SEE values are available for estimating the committed dose equivalent for an organ.

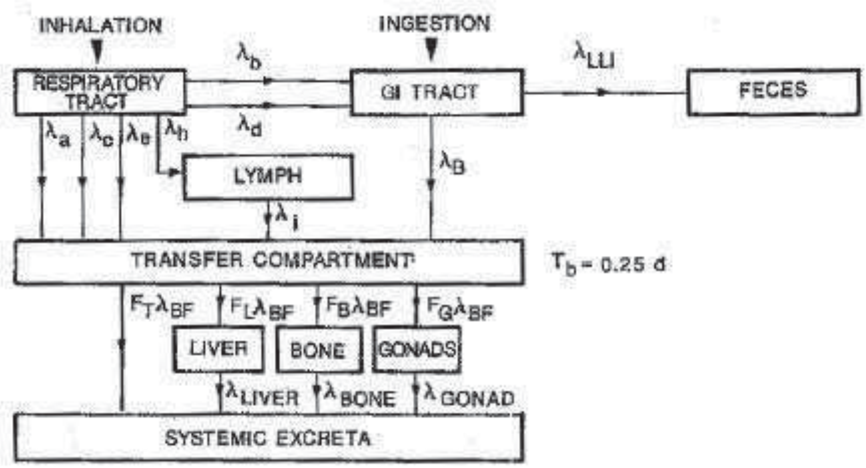


Figure D- 3. ICRP-30 Pu Metabolic Model (ICRP 1979).

Reprint permission requested.

D.1.1.3. ICRP-60 and 66 Methods

Further refinement in the basic recommendations of the ICRP and in certain models have been achieved since the revisions of ICRP-26 and 30. Most notable is a revision of the Respiratory Tract Model by the Task Group on Lung Dynamics, approved by the ICRP and published in Publication 66 (ICRP 1994). That model represents an update to ICRP-30 that provides a broader scope, having been designed not only to evaluate secondary limits on intake of radionuclides by inhalation for a worker, but also to:

- Provide a realistic framework for modeling lung retention and excretion characteristics in an individual case, and the resulting lung and systemic organ doses, based on bioassay data;
- Take into account factors such as cigarette smoking and lung disease which influence lung particle retention;
- Enable knowledge of the dissolution and absorption behavior of specific materials to be used in the calculation of the lung dose, systemic absorption and excretion of the materials;
- Apply explicitly to age-dependent members of a population; and
- Calculate biologically meaningful doses in a manner that is consistent with the morphological, physiological, and radiobiological characteristics of the various tissues of the respiratory tract.

The ICRP-66 lung model consists of three parts:

- A particle deposition model,
- A particle transport model, and
- A particle absorption model.

The new lung model is fundamentally different from the lung model published in ICRP-30, which calculates only the average dose to the lungs. It accounts for the differences in radiosensitivity of the respiratory tract tissues, and the wide range of doses they may receive, and calculates doses to the specific tissues in the respiratory tract.

The respiratory tract is represented by five regions (Figure D-4): the nasal and oral passageways termed the "extrathoracic" (ET) airways; three thoracic regions termed the Bronchial region (BB); the Bronchiolar region (bb), and the Alveolar-Interstitial region (AI, the gas exchange region); and the lymphatics associated with the extrathoracic (LN_{ET}) and thoracic airways (LN_{TH}). The model evaluates the risks of lung and other cancers by calculating the doses received by tissues in each of the regions, then summing and weighting those doses to obtain equivalent doses, and finally applying the tissue weighting factors in ICRP Publication 60 (ICRP 1991).

The new model accommodates calculating the intake of different individuals (adults and children), although that feature is not pertinent to this project. Intake depends on two factors: inhalability and breathing rate. Inhalability is the ratio of the concentration of particles or gases in air entering the respiratory tract to the concentration in ambient or surrounding air. Larger particles (20 µm and larger) have higher inertia and therefore are not inhaled as easily as smaller particles under most conditions. The breathing rate depends on age and physical activity. The model provides tables of reference values of breathing rates for men and women as well as children aged 15, 10, 5, and 1 year, and 3 months for different levels of activity. The reference values for adults were developed to simulate common activity levels in the workplace that combine periods of sitting and exercise. The "reference male worker" is assumed to spend 3% of an 8-hour work period sitting and 69% at "light exercise."

Deposition is provided for each of the five regions of the lung for the various categories of activity and breathing type – nose or mouth.

The model contains three clearance pathways: material in ET_1 clears by direct means such as nose blowing; in other regions clearance may be to GI tract and lymphs or absorption into blood. Once cleared, particle transport is represented by the model in Figure D-5 that shows 14 compartments with individual values of the particle transport rate constant. Absorption into blood is treated as a two-stage process involving dissociation into material that can be absorbed (called dissolution) and absorption into blood of soluble material and material dissociated from particles (called uptake). In addressing absorption, the model uses three material "Types": F (fast), M (moderate), and S (slow). These Types correspond to Classes D, W, and Y of ICRP-30.

The Types are characterized by the amount of deposit that enters the blood and an approximate half-life according to the following:

- Type F: 100% at 10 minutes.
- Type M: 10% at 10 minutes and 90% at 140 days.
- Type S: 0.1% at 10 minutes and 99.9% at 7000 days.

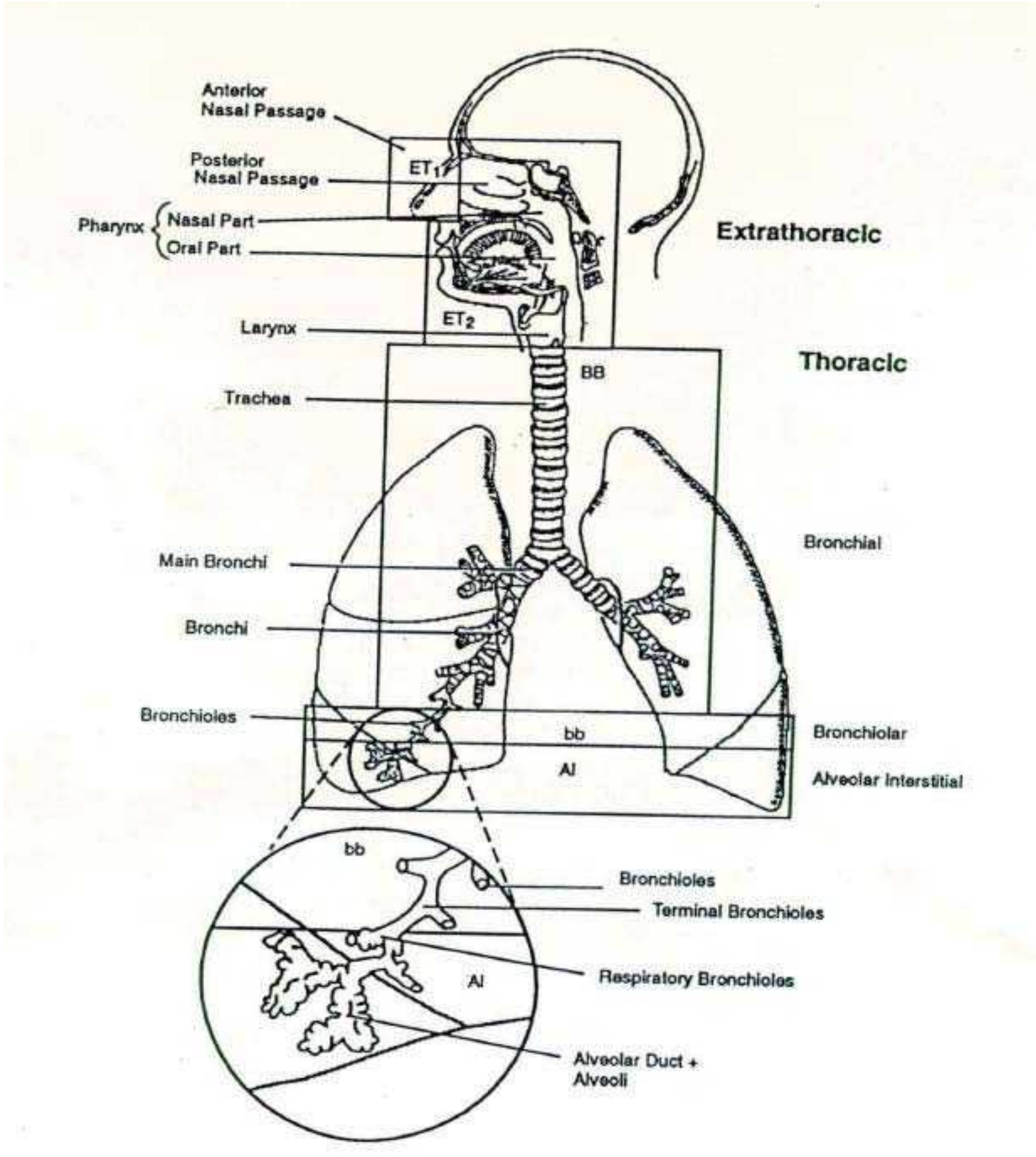


Figure D- 4. Anatomical Regions of the Respiratory Tract (ICRP 1994).

The dose to each region is determined according to ICRP's general approach of averaging the dose to target tissue in each region. Target cells in ET_1, ET_2, BB, and bb are calculated, and then modified by a risk apportionment factor that represents the relative sensitivity of the region to the whole organ. Finally, the ICRP tissue weighting factors are applied.

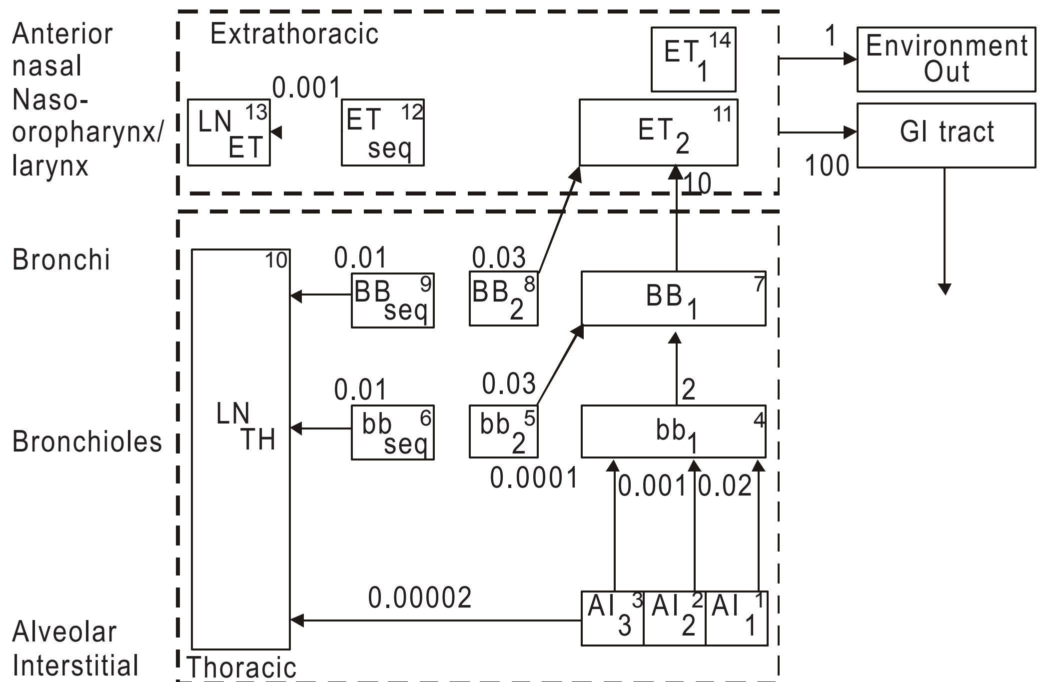


Figure D- 5. Compartment Model of ICRP-66 (ICRP 1994).

Assessment of intake presents one of the more difficult problems for estimating organ dose and the CEDE. Commonly applied methods include in-vitro bioassay of the amount of the material excreted, measurements of body content or organ content by external whole body counting, or for inhalation or ingestion, estimating the amount of material in the air or water using air or water samplers. Each method has its advantages and disadvantages. For this case, the in-vitro bioassay measurements of urine samples from 1966 and 1967 provided the best available method for assessing the intake based on a substantial amount of recorded urinary excretion results.

Organ or tissue weighting factors affect the calculation of committed effective dose equivalent from the effective dose equivalent for each organ or tissue. The ICRP's 1990 recommendations (ICRP 1991) provide weighting factors for a number of tissues that were part of the remainder in the 1979 recommendations of ICRP-26 (ICRP 1979). Table D-2 lists the tissue weighting factors of ICRP-60 as well as those of ICRP-26 for comparison. Substantial differences between the two sets of weighting factors include a reduction in the bone surface and breast factors by three times, a 67 percent increase in the thyroid factor, and assignment of factors for additional organs, including the skin of the whole body.

D.1.1.4. Effect of Respiratory Tract Model on Dose

The differences between the two ICRP models for the respiratory tract could be expected to produce differences in estimated doses. During development of the updated respiratory tract model, its performance was tested in detail to determine the affects of various parameters taken alone and in combination. Some examples of the performance of both systems provide useful information about likely differences in estimating both equivalent dose and effective dose equivalent.

Table D- 2. Tissue Weighting Factors (ICRP 1991).

	ICRP Recommendations	
Tissue or organ	1979	1990
Gonads	0.25	0.20
Red Marrow	0.12	0.12
Colon		0.12
Lung	0.12	0.12
Stomach		0.12
Bladder		0.05
Breast	0.15	0.05
Liver		0.05
Esophagus		0.05
Thyroid	0.03	0.05
Skin		0.01
Bone Surface	0.03	0.01
Remainder	30[1]	.05[2]

[1] A value of 0.06 is applicable to each of the five remaining organs or tissues receiving the highest equivalent doses.
[2] The remainder is composed of the following tissues or organs: adrenals, brain, small intestine, kidney, muscle, pancreas, spleen, thymus and uterus.

One such evaluation, reported by James (James 1994) compared the lung dose equivalent and effective dose for several categories of radionuclides, including insoluble alpha emitters, such as plutonium at Palomares. In those illustrations, James compared doses for intakes of 1 μm activity median aerodynamic diameter (AMAD) particles although ICRP recommends 5 μm AMAD for workers. For 1 μm AMAD, Type S (Class Y) ^{239}Pu, the ICRP-30 and ICRP-66 equivalent dose per unit intakes were 320 μSv/Bq and 84 μSv/Bq, respectively. The ICRP-66 equivalent dose was lower by about a factor of 3.8. For 5 μm AMAD particles, ICRP-66 estimated 50 μSv/Bq, or about 6 times lower. Calculating effective dose for the same conditions, ICRP-30 produced 60 μSv/Bq and ICRP-66 produced 16 μSv/Bq for 1 μm AMAD particles and 9.1 μSv/Bq for 5 μm AMAD particles, representing reductions of about 3.7 and 6.5, respectively. Thus, other factors being equal, the ICRP-66 respiratory tract model can produce equivalent doses that are roughly 3 to 6 times lower for the same intake than the ICRP-30 model. This difference, attributed to the modified model for lung deposition and clearance and revised tissue weighting factors – must be recognized in evaluating methods for this project.

D.1.1.5. Intake Assessment

Intake assessment presents one of the more difficult problems for estimating the dose in affected organs and the CEDE. Commonly applied methods include in-vitro bioassay of the amount of the material excreted, measurements of body content or organ content by external whole body counting, or for inhalation or ingestion, estimating the amount of material in the air or water using air or water samplers. Each method has it advantages and disadvantages. For the case at hand, in-vitro bioassay of urine samples provides the best available method for assessing the intake.

This problem is common to the models discussed above. At the present time, either or both models can assist in calculating an estimate of the intake from knowledge of in-vitro bioassay, whole body counting, or measurement of air concentrations. Assessment of intake using in-vitro bioassay is the primary method of interest in this case because urine sample results are available for those who responded.

The models discussed above provide mathematical expressions, supported by a body of reference data to determine the amount of a radionuclide that can be excreted. Special excretion functions have been derived and are recommended for specific materials (ICRP 1988). In general, the amount of a radionuclide excreted in urine per day is related to the amount of radioactivity in one or more systemic retention compartments and fractional transfer parameters from those compartments to urine or feces. For plutonium, two special models have been developed and are commonly used. These are the "Jones" model and the "Durbin" model.

The Jones model (Jones 1985; Strong and Jones 1989) describes how plutonium excretion in urine varies with time. The model is used with the standard intake models (respiratory tract, gastro-intestinal tract, and direct), and models the material leaving those models as going directly into the four Jones model compartments. The Jones model was originally developed to describe the excretion rate of plutonium following intravenous injection. However, it has been modified for use in estimating chronic and acute inhalation and ingestion exposures. The Jones model is described by the following expression:

$$E_u = \sum_{j=1}^{4} F_{jj} \exp(-k_{jj} t)$$

where E_u = urinary excretion rate of plutonium at time t, in pCi/d

F_{jj} = fraction of injected activity that excretes according to exponential term j, in pCi/d per pCi injected.

k_{jj} = rate constant for decrease of excretion for exponential term j, in d^{-1}.

t = time, d.

The Jones Model transfer parameters are provided in Table D-3.

A second model, known as the Durbin Plutonium Excretion Model (ICRP 1988) performs in a similar fashion to the Jones model. As with the Jones model, material leaving the intake models (respiratory tract, gastro-intestinal tract, and direct) is modeled as going directly to the Durbin model excretion compartments. The Durbin model is characterized by five compartments and has the following form:

$$E_{u,t} = \sum_{j=1}^{5} F_{pj} \exp(-k_{pj} t)$$

where $E_{u,t}$ = urinary excretion rate of plutonium at time t, in pCi/d
F_{Pj} = fraction of injected activity that excretes according to exponential term j, in pCi/d per pCi injected.
k_{Pj} = rate constant for decrease of excretion for exponential term j, in d^{-1}.
t = time, d.

Table D- 3. Jones Model Transfer Parameters (Strong and Jones 1989).

Compartment	Rate Constant, d^{-1}	Fractional Excretion Rate by Compartment, d^{-1}
1	5.58×10^{-1}	4.75×10^{-3}
2	4.42×10^{-2}	2.39×10^{-4}
3	3.80×10^{-3}	8.55×10^{-5}
4	2.84×10^{-5}	1.42×10^{-5}

The Durbin Model parameters are given in Table D-4.

Table D- 4. Durbin Model Transfer Parameters (ICRP 1988).

	Urine Excretion		Fecal Excretion	
Excretion Compartment	Fractional Rate, d^{-1}	Rate Constant, d^{-1}	Fractional Rate, d^{-1}	Rate Constant, d^{-1}
1	4.1×10^{-3}	5.78×10^{-1}	6.0×10^{-3}	3.47×10^{-1}
2	1.2×10^{-3}	1.26×10^{-1}	1.6×10^{-3}	1.05×10^{-1}
3	1.3×10^{-4}	1.65×10^{-2}	1.2×10^{-4}	1.24×10^{-2}
4	3.0×10^{-5}	2.31×10^{-3}	2.0×10^{-5}	1.82×10^{-3}
5	1.2×10^{-5}	1.73×10^{-4}	1.2×10^{-5}	1.73×10^{-4}

D.1.2. Description of Computer Models

Many computer programs have been developed and are available for performing the calculations of the models discussed above. Currently more programs implement the ICRP-30 system than the ICRP-66 model. This comes as no surprise since the ICRP-30 system remains the current system for regulation of the doses from radioactive materials in the United States. However, one objective for this project included the evaluation and recommendation or the best calculation method. Since ICRP provisions are usually adopted in the U.S., investigating at least one software program that implemented the most recent approach seemed reasonable. After some review of the available software, three programs were selected for further study – the Radiological Bioassay and Dosimetry Program (RBD) as modified for the Air Force, Code for Internal Dosimetry (CINDY), and Lung Dose Evaluation Program (LUDEP ver 2.06). This section provides a general description of each program and some salient features. Later sections discuss the approach and results of testing the methods for this report.

D.1.2.1. Radiological Bioassay and Dosimetry Program (RBD)

The RBD software package (ORNL 1993) was developed for the U.S. Army and modified for the U.S. Air Force (Version RBD/AF) by Oak Ridge National Laboratory to demonstrate compliance with Federal radiation protection guidance.

The algorithms within the RBD and RBD/AF programs are the same. The RBD/AF program contains the following changes and enhancements to RBD:

- Increased number of organs for which committed dose can be calculated.
- Replacement of the "department identifier" input with "base code."
- Addition of an identifier field for gender of individual assayed.
- The display of the allowable lifetime intake (ALI) for a radionuclide was changed to the calculation of the fraction of the ALI received by the individual.
- The format of the committed effective dose report was revised to reflect Air Force reporting requirements.

The RBD model implements the ICRP-30 lung model and a urinary excretion model adapted from Leggett and Eckerman (Eckerman 1987). The software package was designed to run interactively on an IBM-compatible personal computer. RBD consists of a data base module to manage bioassay data and a computational module that incorporates algorithms for estimating radionuclide intakes from either acute or chronic exposures. These calculated results are based on the measurement of the worker's rate of excretion of the radionuclide or the retained activity in the body using the approach contained in ICRP-30. RBD estimates an intake using a separate file for each radionuclide containing parametric representations of the retention and excretion functions. These files also contain dose-per-unit intake coefficients used to compute the committed dose equivalent. Computed results derived from bioassay data (estimates of intake and committed dose equivalent) are stored in separate databases, and the bioassay measurements used to compute a given result can be identified.

D.1.2.2. Code for Internal Dosimetry (CINDY)

The Code for Internal Dosimetry (CINDY) (v.1.4) is a menu-driven interactive computer program that was developed to address the Department of Energy Order 5480.11 and the Nuclear Regulatory Commission's Standards for Protection Against Radiation (10 CFR Part 20). The CINDY software package (PNL 1992) was developed by Pacific Northwest National Laboratory to provide the capabilities to calculate organ dose equivalents and effective dose equivalents using the approach contained in ICRP-30.

CINDY supports calculation of organ dose equivalents, effective dose equivalents and committed effective dose equivalents; interpretation of bioassay data; and evaluation of committed and calendar-year doses from intake or bioassay measurement data.

For inhalation exposures, CINDY uses the ICRP-30 lung model and approach for calculation of organ dose equivalents and effective dose equivalents, which is described in the previous discussion of the RBD/AF model. Biokinetic models are used to estimate intakes based on bioassay data. For intake and urinary excretion of plutonium, the Jones and Durbin models are both available, as in the LUDEP program.

The metabolic and excretion models available in CINDY are:

- ICRP-30 Lung model
- ICRP-30 Gastrointestinal (GI) model
- ICRP-30 General systemic model
- Jones and Durbin Plutonium Excretion Models

CINDY uses the quality factors and tissue or organ weighting factors published in ICRP-26.

D.1.2.3. Lung Dose Evaluation Program (LUDEP ver 2.06)

The Lung Dose Evaluation Program (LUDEP) (v. 2.0) is a personal computer program for calculating internal doses using the ICRP-66 respiratory tract model. The LUDEP program runs on an IBM-compatible personal computer in a DOS or Windows environment.

LUDEP was designed initially for two applications: (1) to help the ICRP Task Group examine the ICRP-66 lung model (during its proposal stage) in detail, by testing the predictions of deposition, clearance, and retention against experimental data, and by determining the model's implications for doses to the respiratory tract; and (2) to test the practicality of implementing the model.

LUDEP calculates doses to all body organs. It includes a bioassay module that allows calculations of excreted activity and retention in the lungs, other organs, and whole body.

The model contains several built-in databases, including radionuclide decay data from Oak Ridge National Laboratory and from ICRP-38; biokinetic models from ICRP-30; and bioassay functions from ICRP-54. ICRP data are generally used as the default values within the model, although the user is given the option to input case-specific parameters.

The ICRP-66 model that is implemented in LUDEP 2.06 was designed to realistically represent the deposition of inhaled particles in the respiratory tract, the subsequent biokinetic behavior of inhaled radionuclides, and the doses delivered to the respiratory tract.

The LUDEP code allows the user to input the particle size of an airborne concentration or intake. LUDEP allows the user to input the characteristic aerosol AMAD (or activity median thermodynamic diameter - AMTD) for a given airborne concentration or intake. The code contains a biokinetic model and organ dosimetry.

The metabolic and excretion models available in LUDEP are:

- ICRP-66 Lung model
- ICRP-30 Gastrointestinal (GI) model
- ICRP-30 General systemic model
- ICRP-30 Plutonium biokinetic model
- ICRP-54 Durbin Plutonium excretion model
- Jones Plutonium Excretion Model

LUDEP allows users to choose either the quality factors or organ/tissue weighting factors published in ICRP-26, or the radiation weighting factors and organ/tissue weighting factors published in ICRP-60. The bone dosimetry is a recycling model with initial uptake onto bone surfaces, transfer from surface to bone volume, and recycling from bone and other tissues to plasma.

D.2. MODEL TESTING AND COMPARISON

Selection of a computer program to support intake and dose assessment required a set of criteria to guide the testing and evaluation process. Criteria based on the ability to perform credible assessments from the data available were a prime objective. That is, the computer tool should demonstrate an ability to produce credible results with the data from 1966 and 1967. Considering all of this, our approach recognized a need to be able to estimate plutonium intakes from urine bioassay data, to calculate committed effective dose equivalents from those intakes, and to readily accommodate the available data without major conversion efforts.

D.2.1. Performance Criteria

The major task for this project involved an attempt to calculate intake from the urine bioassay information available. Other data from the response and cleanup operation simply do not exist to support intake estimates from air sampling or other means. Studies performed by JEN for decades following that effort offer some data for developing independent intake and dose estimates using environmental data. Nevertheless, the methods for estimating intake of plutonium by inhalation from the urinary data must be evaluated for performance and ease of use. Performing the intake assessment using this approach acknowledges that sizeable uncertainties can be expected because the assessments assume the characteristics of reference man rather than the specific characteristics of the individual involved.

Calculation of the organ dose equivalents and committed effective dose equivalent for each responder based on the intake must also meet accepted performance.

Finally, the selected method must have data requirements that can be met using the available data with as few conversions as possible.

These three criteria formed the primary basis for evaluating the performance of the three computer programs.

Ease of use provided a secondary factor for evaluating each of the three programs. This factor concentrated primarily on requirements for setting up input data sets and producing output data and reports that could be manipulated easily for a number of purposes – comparing the results of testing the three methods, evaluating trends in intakes and doses for selected groups of subjects, data plotting and report preparation.

D.2.1.1. Performance on Intake Estimates

Review of the documentation for each of the three methods indicated that all employed generally accepted excretion models, i.e., either the ICRP-54 Durbin model, or the Jones model, or both. Implementation of calculation procedures for those excretion models seemed similar in that the approaches involved solutions to differential equations to determine the excretion patterns from estimated intakes.

The common approach among the models involved:

- calculating an initial estimate of intake from urine results,
- calculation of the expected urinary output rate (pCi/d or Bq/d),
- comparison of calculated urinary excretion to measured excretion using a form of statistical goodness of fit, and
- iteration until a selected calculation error was achieved.

The three methods were initially tested with an assumed excretion of 0.1 Bq/day (27 pCi/day) excretion rate at a series of sampling times after acute inhalation intake over one year. That is, for selected days, the urinary output of Class Y (Type S) ^{239}Pu was set at 0.1 Bq/day. The results of that test are shown in Figure D-6. In those tests, LUDEP provided estimates that were typically about 2 times higher than RBD estimates and about 3.5 times higher than CINDY estimates. The committed effective dose equivalents associated with those intakes are shown in Figure D-7.

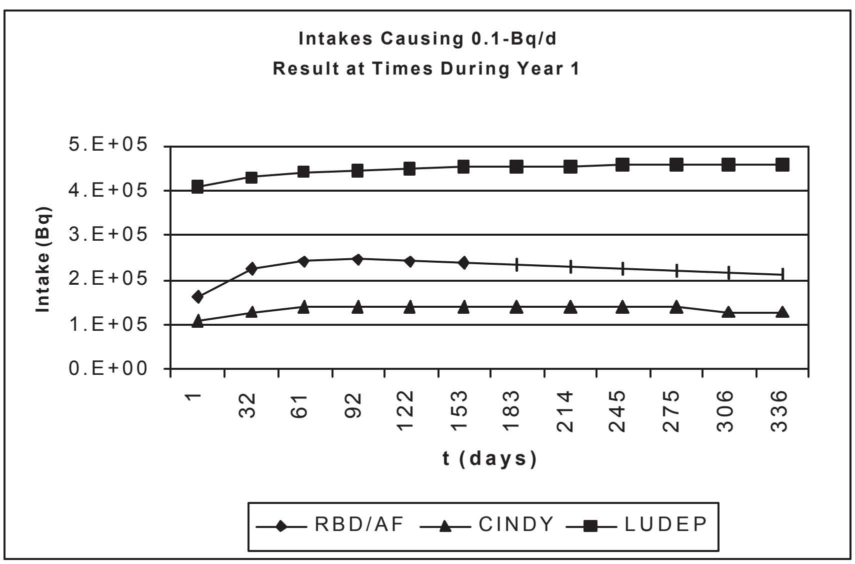


Figure D- 6. Intake estimates of the three methods.

Two of the three models (CINDY and LUDEP) offered options for weighting the measured results in performing the estimate. RBD/AF applied weighting based only on the relative contribution of multiple bioassay methods, e.g., results from urine bioassay and whole body counting.

CINDY's options include:

- Unweighted least squares: The weighting factors are assumed constant and equal, implying that the variance is independent of the magnitude of the measurement.
- Ratio of the means: The weighting factors are assumed inversely proportional to the expected value (as defined by the unit intake function). This assumption implies that the variance is proportional to the magnitude of the expected value.
- Average of the slopes: The weighting factors are assumed inversely proportional to the square of the expected value, implying that the variance is proportional to the square of the expected value.
- User-defined weights: The user supplies the estimate of the variance for each measurement value. The weighting factors are taken to be the inverse of the supplied variance.

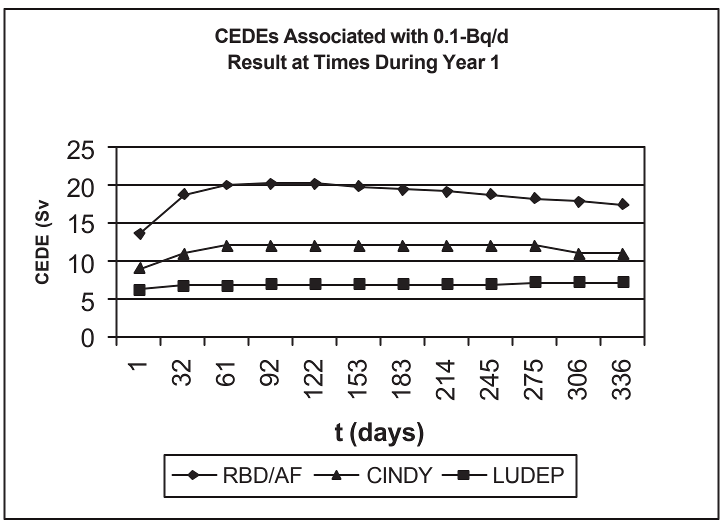


Figure D- 7. Estimated CEDE for three methods.

LUDEP offers the following options:

- Uniform absolute errors: The uncertainty values are a constant value, K.
- Uniform relative errors: Each uncertainty value is a constant proportion of the data point.
- Square root errors: Each uncertainty value is a constant multiple of the square root of the corresponding data point.
- Errors included in data set: The values of the uncertainties in the data, if known, are used.
- Logarithmic errors: Assumes the measured values fall about the true value with a log-normal distribution.

In comparing the approaches available in the two models, CINDY's "unweighted least squares", "ratio-of-the-means", "average-of-the-slopes", and "user-defined weights" methods seem to be roughly similar to LUDEP's methods using "uniform-absolute errors", "uniform-relative errors", "square-root errors", and "errors included in the data set." This conclusion results from evaluation of the discussion on weighting in the CINDY user guide (PNL 1992), summarized below.

Methods for comparing the estimated values with the measured values are based on the basic formula for weighted least-squares regression of a linear relationship with zero intercept as follows:

$$I = \frac{\sum_{i=1}^{n} w_i R_i X_i}{\sum_{i=1}^{n} w_i R_i^2} \qquad (1)$$

where I = estimated intake (pCi for acute intakes and pCi/d for chronic intakes)

w_i = least-squares regression weighting factor.

X_i = bioassay measurement for the ith data point (pCi/d for excretion and pCi for retention).

R_i = fractional retention or excretion estimate.

n = number of bioassay measurement points.

In CINDY, the four methods for intake estimation relate to four methods for defining the weighting factor, w_i. Ideally, the weighting should involve the variance of the measurement value (Bevington 1969). Each of the four methods, therefore, involves a particular assumption about the estimation of the variance.

In general, the intake estimate from the "user-defined weights" method is preferred when the input weighing factors represent good estimates of the variance of the measurement. Alternatively, the "ratio-of-the-means" intake estimate is probably the best estimate because the weighting is based on an estimate of the variance as proportional to estimated bioassay result. This method generally gives better "eyeball" fit to the bioassay data (PNL 1992).

The unweighted least-squares regression analysis is expressed by the following equation:

$$I = \frac{\sum_{i=1}^{n} X_i R_i}{\sum_{i=1}^{n} R_i^2} \qquad (2)$$

where terms are as previously defined. This method may be used when all measurement values are expected to have similar accuracy and all are significantly above the detection limits of the measurement method. This method could also be referred to as "uniform weighting" because all weights, w_i, are assumed equal in derivation of Equation 2 from Equation 1.

The "ratio-of-the-means" method is based on the assumption that the variance of the expected value is proportional to the magnitude of the expected value. The weights are expressed as follows:

$$w_i = \frac{1}{kIR_i} \qquad (3)$$

where k is a constant of proportionality. Substitution of Equation 3 into Equation 1 results in the following expression for the intake estimate:

$$I = \frac{\sum_{i=1}^{n} X_i}{\sum_{i=1}^{n} R_i} \qquad (4)$$

As can be seen from this expression, the intake estimate is just the ratio of the sum of the measured values to the sum of the unit intake function values. This is equivalent to the ratio of the means of the measured values and the unit intake function values (proportional to the expected values), hence, the name "ratio-of-the-means" method. Note also that from Equation 4, the sum of the measured values is equal to the sum of the expected values:

$$\sum_{i=1}^{n} X_i = \sum_{i=1}^{n} IR_i \qquad (5)$$

This method is appropriate when the variance of the measurement is expected to be proportional to the measured value.

The average-of-the-slopes method is derived from Equation 1 by defining the weights as inversely proportional to the square of the unit intake function values:

$$w_i = \frac{1}{kI^2 R_i^2} \qquad (6)$$

The resulting expression for the intake estimate is as follows:

$$I = \frac{\sum_{i=1}^{n} \frac{X_i}{R_i}}{n} \qquad (7)$$

This expression gives the average of the ratios of measurement value to unit intake function value, which is equivalent to the average of the slopes of the equation

$$X_i = IR_i \qquad (8)$$

This method is appropriate when the variance of the measurement is expected to be proportional to the square of the expected value.

The user has the option of identifying the variance for each measurement data point. The fourth method (user-defined weights) uses this statistical parameter as an inverse weight in Equation 1:

$$w_i = \frac{1}{V_i} \tag{9}$$

where V_i is the user-supplied statistical parameter value for bioassay measurement i. This method allows the user to implement almost any weighting method desired based on predetermined weights. In evaluating the intake estimate using this method, only the data points having a defined value for V_i are used in the calculation.

As an example of the use of the "user-defined weights" method, consider a set of bioassay data values that includes an estimate of the standard deviation of the measurement value. The user-defined weights method can be used to provide an intake estimate based on the variance of the measurement values. To perform the analysis, the reported standard deviations are squared to provide the values for the weights to be entered into the CINDY program. This results from the assumption that the variance of the measurement is represented by the square of the standard deviation of the measurement. The code will use the inverses of the squared values as weights in Equation 1 to give an estimate of the intake with variance weighting.

As noted above, selection of the weighting method and any factors are important for reasonable results.

A number of cases were developed for testing the performance on estimating intakes. The primary data used were derived from the group of High 26 individuals from the Palomares follow-up. These were the only cases of data available with multiple bioassay measurements taken over an extended period – 12 to 18 months from the time of the accident. Unfortunately even those data raised questions about the actual dates of sampling and exposure, the reliability of results and other matters. Significant concerns arose from the use of gross alpha counting of initial samples and the possibility of contamination of samples collected on site (See Section 2 and Appendix B).

Using the bioassay data for two individuals who each had multiple samples taken, intakes and associated CEDEs were estimated by LUDEP, CINDY, and RBD/AF. The results indicated the estimated intakes were highest using LUDEP, lowest using CINDY, and intermediate using RBD/AF. The 50-year CEDEs were highest using RBD/AF, while the other two models provided lower results—in one case, LUDEP's CEDE was slightly lower than that predicted by CINDY, with the order reversed in the other case. The greatest difference in predicted CEDE was a factor of 2.2.

Using a subset of the bioassay results (all individuals with sample results greater than 10 pCi/sample from the initial spreadsheet provided by the Air Force), CEDEs were estimated by RBD/AF, CINDY, and LUDEP. As in the previously described case, RBD/AF generally predicted higher results, while those of CINDY and LUDEP were more similar.

The bioassay results for the "High 26" were modeled using CINDY and LUDEP to determine intakes and CEDEs. When CINDY doses were estimated using the "ratio-of-the-means" method, the CINDY CEDEs were higher than those predicted by LUDEP by an average factor of 13.5. When the "user-defined weights" method was used in CINDY, the CEDEs exceeded those predicted by LUDEP by an average factor of 1.5.

For CINDY and LUDEP, the estimated errors from counting, as reported on the data forms, or recalculated from the raw data on the forms, were used to calculate the statistical variance, which was used as the input value in the "user-defined weights" option for CINDY; the counting error itself was used in the "errors included in data set" option for LUDEP. The estimated counting errors involved some inconsistency – they were reported at 95% confidence level for gross alpha results and at the 68% confidence level for alpha spectrometry; this difference was taken into account in calculating the variance used in the CINDY "user-defined weights" option. Often, the later results were reported as No Detectable Activity. In that case, a value of 0.009 pCi/day was assumed for gross alpha results, and a value of 0.003 pCi/day was assumed for alpha spectrometry results. The errors in those were set at 25% of the value; which may be somewhat low for the level of activity.

Using both the CINDY and LUDEP models, the sample data sets for the "High 26" were input to estimate CEDEs for each individual, using first all the samples, then excluding those that were analyzed by gross alpha, which would correspond with the early samples taken onsite. The results show that the CEDEs are generally lower when gross alpha results are excluded, averaging a 24% or 62% decrease in CINDY results (depending on weighting factor used—see next paragraph) and a 6% decrease in LUDEP results. This difference between models may be due to a noted tendency of LUDEP to weight sample results for longer times after exposure more strongly in calculations using multiple bioassay data points.

When gross alpha data were included in the CINDY model runs, the CEDE using the "ratio-of-the-means" method exceeded the CEDE using the "user-defined weights" method by an average factor of 13. The CEDE from the "user-defined weights" method exceeded the CEDE from the "ratio-of-the-means" method in only 2 of the 26 cases. When gross alpha data were excluded, the CEDE from the "ratio-of-the-means" method exceeded the CEDE from the "user-defined weights" method by an average factor of 3.4; in 3 cases the CEDE from the "user-defined weights" method exceeded the CEDE from the ratio-of-the-means" method.

In general, from other tests, the "user-defined weights" estimates tended to apply more significance to measurements taken at longer elapsed times from exposure. Coincidentally, those values were generally much lower than the early measurements and had much lower absolute values for the variance, which was estimated from the counting error.

For LUDEP, similar comparisons of the performance of the assumed errors options revealed reasonable agreement among results from the "uniform-absolute errors", the "uniform-relative errors", the "square-root errors" and the "errors included in the data set" options when applied to the actual urine results of three of the High 26 Cases Group. Those agreements were achieved for reasonable values of K (0.25 to 1), and showed agreement within about 50%, which seems acceptable considering the nature of the data. The logarithmic errors option produced estimates of intake that were 3 to 4 times higher than the other methods.

For CINDY, the "user-defined weights" method also seemed to attribute greater significance to lower values of results, yielding lower values of intake. In effect, the approach seemed to ignore other measured values. After multiple attempts to better characterize CINDY performance and consultation with its developers (Traub 2000), we concluded that the uncertainty in the estimated errors themselves contributed to this performance, and the "user-defined weights" method was no longer used. The "ratio-of-the-means" method, recommended by the CINDY user manual (PNL 1992), showed reasonable performance and was selected as the method to be used.

When other factors were held equal, intakes estimated by CINDY (using the "ratio-of-the-means" weighting method) and LUDEP (using the "errors included in the data set" option) agreed to within a factor of two for the majority of the High 26 Cases Group. Given the variability of the data, the agreement was deemed reasonable and the performance acceptable for the type of assessment performed.

D.2.1.2. Performance on Dose Calculations

The performance evaluation tested conversion of intakes into committed dose equivalent in organs or tissues and calculation of committed effective dose equivalents with RBD/AF, CINDY and LUDEP. Testing the dose performance involved two separate efforts: basic assessments using assumed intakes, and assessments of selected cases from the High 26 Cases Group.

The basic assessment test consisted of assessments of the same set of Palomares data derived from the first 29 entries in the data listing (see Appendix B) provided by the Air Force. These data consisted of single urine measurements (generally of 10 pCi/day or more), collected at the accident site during the accident response effort. RBD, CINDY, and LUDEP calculated intakes and doses for each of the 29 cases. Committed effective dose estimates from the three programs varied by no more than a factor of about two from the highest dose to the lowest dose estimate for each case, with RBD/AF generally giving the highest estimated CEDE; LUDEP yielding the lowest; and CINDY providing intermediate dose estimates. That LUDEP produced the lowest doses seems consistent with the findings about its performance discussed above.

The second part of the testing involved actual test cases from two members of the High 26 Cases Group. Those cases had several urine measurements taken on site and during the follow-up period. RBD/AF, CINDY, and LUDEP provided estimates of the intake and dose for these two cases. These cases were calculated with several variations involving exclusion of selected urinary measurements for reasons, such as suspected contamination, possible chemical recovery issues, results below the detection limit, or simply to evaluate the behavior of the programs. The results of these tests confirmed the tendency of the methods to favor urine results with lower values, taken at long times after exposure. Generally, the CEDEs were highest for RBD/AF, lowest for LUDEP, and intermediate for CINDY. Again, results differed by no more than a factor of two. That performance seems acceptable.

Finally, CINDY and LUDEP were tested further with the entire High 26 Cases Group. In tests paralleling the intake assessments, CEDEs were also estimated with and without gross alpha results. LUDEP provided estimates that were about 30% lower than CINDY when gross alpha results were excluded, and from about 30% to 90% lower than CINDY when all urine measurements were included. Considering the nature of the data, the results are acceptable.

D.2.1.3. Ability to Satisfy Data Requirements

Parameters required for calculating estimates of intake from urine bioassay and the associated dose equivalents satisfy the model selected to perform the task. Computer software that implements the models establishes unique processes for satisfying the data input needs. The three computer methods were evaluated for the compatibility with available urine bioassay data. Primary parameters included the date of exposure, date of sample, radionuclide, type of exposure, pathway, particle characteristics, lung type or class, results and units, and sample volume, among others. The requirements of each program are discussed and compatibility with the available data assessed.

RBD

Data items and that may require assumptions to achieve compatibility include:

- **Date** – Since the Palomares data reflect exposure due to an incident, rather than a series of routine monitoring measurements, the date of the exposure incident is required. In some cases, this will have to be estimated based on the data on each dose data card, such as when a range is presented. In some cases, the date of exposure and date of sampling recorded on the dose data cards are the same. Unless adjusted based on additional information or other reasonable assumptions, this will result in an error during model execution.
- **Time** – The time of exposure does not affect the execution of the model if it is left blank.
- **Nuclide** – Data for ^{239}Pu are included in the files of the model.
- **Pathway** – As in the previous studies, inhalation exposure only can be assumed.
- **AMAD** – The default value of 1 μm can be used; range is 0.2 to 10 μm.
- **Class** – For inhalation, ^{239}Pu can be either Class W or Class Y. If it is assumed that all ^{239}Pu is in the form of PuO_2, then Class Y should be assumed, per ICRP-30.
- **Measurement date** – In some cases, this must be assumed due to incomplete data on the dose data cards.
- **Measurement time** – The time of measurement does not affect the execution of the model if it is left blank.
- **Result and Units** – The results on the dose data cards must be converted to units that are accepted by the model. For urinalysis, the options are dpm/mL, dpm/day, dpm/sample, dpm/L, μg/mL, Bq/L, Bq/day.
- **MDA** – The minimum detectable amount does not appear to be generally available on the dose data cards. A value could be estimated. The model will accept a zero value in this field.
- **Volume** – Sample volume is required if results are input in units of dpm/sample; otherwise, it can be left blank.
- **Volume/day** – The urinary volume per day is required for execution. The default is 1400 mL; the existing Palomares reports state that a value of 1200 mL was used as a default.

Overall, data are sufficiently available or can be reasonably estimated to run the RBD/AF model using the Palomares internal dose data. However, the nature of the available data could result in potentially large relative errors in time from exposure to sampling, which could have a significant impact on the validity of any resulting conclusions as to the intake and committed effective dose of a particular individual. It is however, reasonable to assume that these errors will average out over the large data set available, leading to conclusions that are more supportable for the exposure cohort as a whole.

Other model specific parameters are available as defaults appropriate for the model within the program and supporting data files. These seem reasonable or can be readily modified.

CINDY

Most data items required to perform the calculations are available and compatible. Those data items that may require assumptions to achieve compatibility include:

- **Excretion period** – Set to 24 hours if not specified otherwise.
- **Intake mode -** Acute inhalation is assumed; can be changed.
- **Date and time of intake** – Based on data reported on bioassay cards. Time set to 12:00 PM since no times were reported, however the impact is unimportant for the radionuclide involved.
- **Particle size** – 1 ìm assumed.

Overall, data are sufficiently available or can be reasonably estimated to run the CINDY model using the Palomares internal dose data. However, the nature of the available data could result in potentially large relative errors in time from exposure to sampling, which could have a significant impact on the validity of any resulting conclusions as to the intake and committed effective dose of a particular individual. It is however, reasonable to assume that these errors will average out over the large data set available, leading to conclusions that are more supportable for the exposure cohort as a whole.

LUDEP

Most data items required to perform the calculations are available and compatible. Those data items that may require assumptions to achieve compatibility include:

- **Intake -** Acute intake by the inhalation pathway can be assumed.
- **AMAD** – A value of 1 ìm can be assumed.
- **Absorption Type** – This factor introduced in ICRP-66 as F, M, or S for default absorption values corresponding to fast, medium, or slow absorption. Type S, which corresponds to the Class Y designation of PuO_2, can be assumed.
- **Time after intake (days)** - In some cases, this must be assumed due to incomplete data on the dose data cards.

Overall, data are sufficiently available or can be reasonably estimated to run the LUDEP model using the Palomares internal dose data. However, as with the programs, the nature of the available data could result in potentially large relative errors in time from exposure to sampling, which could have a significant impact on the validity of any resulting conclusions as to the intake and committed effective dose of a particular individual. It is however, reasonable to assume that these errors will average out over the large data set available, leading to conclusions that are more supportable for the exposure cohort as a whole.

The three programs provide adequate data compatibility. LUDEP uses SI units of becquerels (Bq) for radioactivity, and sieverts (Sv) for dose equivalent. However, conversion of units from picocuries per day (pCi/d) to becquerels per day (Bq/d) can be easily accommodated.

D.2.1.4. Ease of Use

With over 1,500 individual cases potentially requiring assessment, data input, result output and other manipulations can impact efficiency. Each program was assessed for features of convenience or difficulty that could impact effectiveness.

RBD/AF

Input features of RBD/AF include:

A data input screen for bioassay data with the choices for selectable entries for: gender, base code, assay, reason, nuclide, pathway, AMAD, class, in-vitro assay (measurement date, measurement time), result (unit – for urine, units can be dpm/mL, dpm/day, dpm/sample, dpm/L, ìg/mL, Bq/L, Bq/day), MDA, volume, and volume/day.

The program stores the data in files describing sets of cases, facilities or other convenient means. This allows data preparation, calculation, and reporting to be conducted as separate activities.

Output features of RBD/AF include:

Estimated intake (in Bq and ìCi), estimated intake as a percent of the ALI, ALI (in Bq), committed dose equivalent (in ìSv and mrem, by organ/tissue), and effective dose (in ìSv and mrem). An optional graph of excretion rate vs. time can also be generated.

The summary output report presents, by individual committed dose equivalent (in mrem, by organ/tissue), effective dose (in mrem).

The summary output report is presented in a space-delimited file, that is easily imported into a spreadsheet (with only minor editing required) for manipulation and sorting.

CINDY

Input features of CINDY include:

Subject identification: name, identification number, SSN, dates of birth, sex, file name prefix.

Subject/Bioassay Measurement-Specific: exclusion flag, bioassay type, bioassay radionuclide, sample end date and time, excretion period, measured value, measurement inverse weighting factor, measurement unit numerator (pCi/nCi/dpm/Bq), unit denominator type, sample size and units.

Subject/Intake Specific: exposure duration, intake mode, begin date and time of intake, end date and time of intake, particle size, facility, employer at time of intake, radionuclides of concern, intake estimate.

Run-Specific: dose report times, dose reporting limits, bioassay projection endpoint, bioassay projection report times, bioassay projection graph selections, text report selections, radiological working units options, error tolerances, radionuclide daughter handling, model selection, and model parameter values.

Output features of CINDY include:

- Several different output reports: For the current effort, useful data points are found on the subject report, which reflects data inputs and normalization, as well as the intake assessment summary and dose assessment reports.
- Intake Assessment Report: includes intake estimate, lung model details, mean residence time in each compartment of GI tract, and urinary excretion model details.
- Dose Assessment Report: includes dose equivalent, weighting factors, and organ dose equivalents, by organ; effective dose equivalent; lung model details; and systemic model details.

- Optional display of a urinary excretion curve on the monitor or printed using text characters.

CINDY output formats can be saved in formats that are easily imported into most personal computer application software.

LUDEP

- LUDEP includes data input screens for the sequence of calculations necessary to estimate an acute intake from urine bioassay data that include:
- Intake (acute or chronic, inhalation or ingestion or injection, value entered in Bq (acute) or Bq/day (chronic)), or exposure (concentration in Bq/m^3 and duration in hours);
- Deposition (AMAD (ìm));
- Absorption (F, M, or S),
- Radionuclides;
- Biokinetic model,
- Quantity to calculate (whole body retention, lung retention, urinary excretion rate, fecal excretion rate, or specified organ retention);
- Function (ICRP-54 function or enter own function);
- Number of points: days (in this case) that encompass all sampling intervals;
- Time: enter a start and stop time, in days;
- Urine Sample Activity Data: time after intake (days), measured activity (Bq), and estimated uncertainty (if known)

LUDEP does not generate a printable output report. Results are displayed on-screen. The output for the calculation of intake based on urinary bioassay sample data provides a best estimate of intake (Bq), standard error of intake (Bq), 95% confidence limit on intake, chi square test statistic, and probability.

LUDEP operates solely as an interactive, desktop program that requires substantial effort to set up and operate. Input parameters can be established for exposure scenarios, saved in files, and used for multiple cases. Organ dose results can be saved to files, as can urine excretion data. Overall, LUDEP does not provide the reporting convenience of RBD or CINDY.

D.2.2. Sensitivity of parameters

Estimated intakes and associated doses depend on the selection of the various input parameters and data. These parameters determine how the intake, biokinetic, and excretion models treat the characteristics of each case. Some of those parameters depend on the characteristics of the exposure scenario, while others depend primarily on the models themselves. In the latter case, ICRP provides recommended values for many of these parameters based on calculating estimates for reference man.

D.2.2.1. Time from Exposure to Sampling

Exposure dates and sampling dates in Palomares records have substantial uncertainty. When recorded, the data are quite specific. When not recorded, or when several samples were collected on different dates, determining a representative acute exposure date can involve an element of subjectivity. This issue also relates to determining the type of exposure – acute or continuous – as discussed in the next section. The effect of the time between exposure and sampling on estimated intake was assessed with a simple test that varied the time only for a fixed urine excretion value. The time values were varied in increments of one month for a period of two years. Estimated intakes from CINDY varied from 15% for the first month to 7% for the second and third months with a total decrease of 18% over the two-year period. LUDEP results decreased by 5% at one month to 2% at the second month with a total decrease over the first year of 12%. At worst, the differences during the first 30 days should be less than 15 % for CINDY and about 5% for LUDEP.

D.2.2.2. Use of Multiple Bioassay Measurements.

Multiple bioassay measurements affect the estimated intake primarily through the process of obtaining the best fit of the calculated expected values of excretion to the measurements. Testing the methods showed that the selection of weighting factors in CINDY (errors in data sets in LUDEP) could have substantial effect on the intakes. The variations in those were discussed in Section D.2.1.1. The methods performed acceptably within the boundaries of the expectations for the available data.

D.2.2.3. Particle Size

Using LUDEP, the estimated intakes of inhaled ^{239}Pu particles of different AMADs were compared. In one test, the series of bioassay results for one individual were input using AMADs of 0.5, 0.6, 0.7, 0.8, and 1.0 µm. Decreasing the AMAD between 1.0 and 0.5 led to a decrease in the estimated intake; the difference over the entire range tested was less than 8% of the intake associated with an AMAD of 1.0 µm. In another evaluation, the organ dose equivalents to organs were modeled using AMADs of 1, 2.5, 5, 7.5, and 10 µm as shown in Figure D-8. In this case, the organ dose equivalents decreased more than 70% over the range from 1 to 10 µm in all organs except the ovaries and the organs of the gastrointestinal (GI) system. There was no change in the doses to the ovaries, and doses to the GI organs increased from 7 to 23%. Overall, there was a decrease of 75% in committed effective dose equivalent (Figure D-9) when AMAD was varied from 1 ìm to 10 ìm, and a decrease of 40% when the AMAD was increased from 1 µm to 5 µm.

These two comparisons indicate that using an AMAD of 1.0 :m in LUDEP leads to the highest estimated doses, and would therefore be the most conservative estimate of particle diameter. ICRP-30 recommended a default AMAD of 1.0 ìm, but ICRP-66 recommended 5 ìm as generally more representative in occupational settings in the absence of specific information. The variation of organ dose equivalents and committed effective dose equivalent with particle size is acknowledged. A value of 1 ìm AMAD was selected for modeling calculations as a conservative measure.

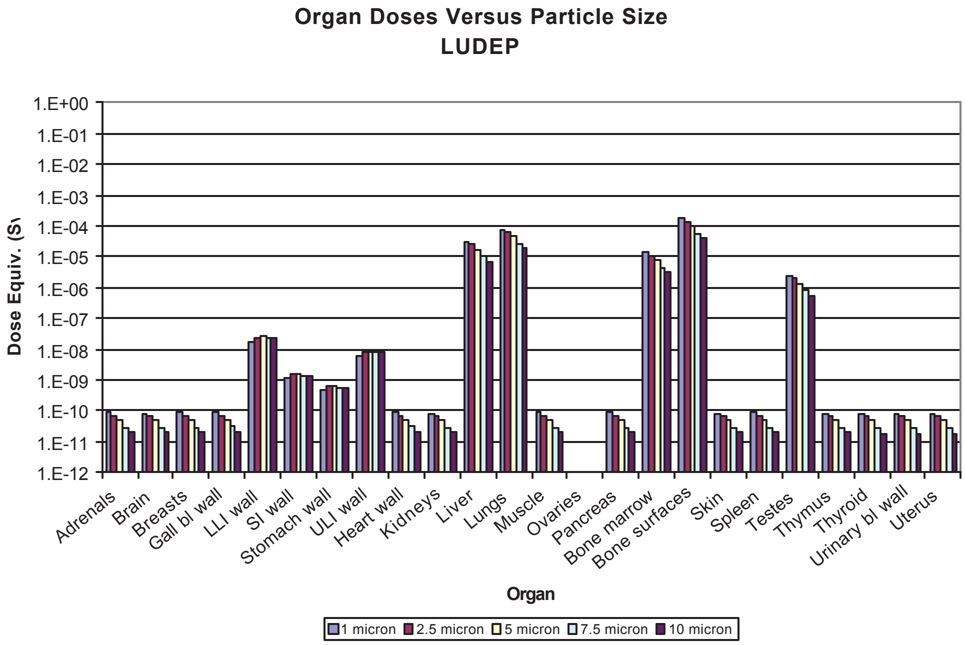


Figure D- 8. Variation of organ dose equivalent with particle size in LUDEP.

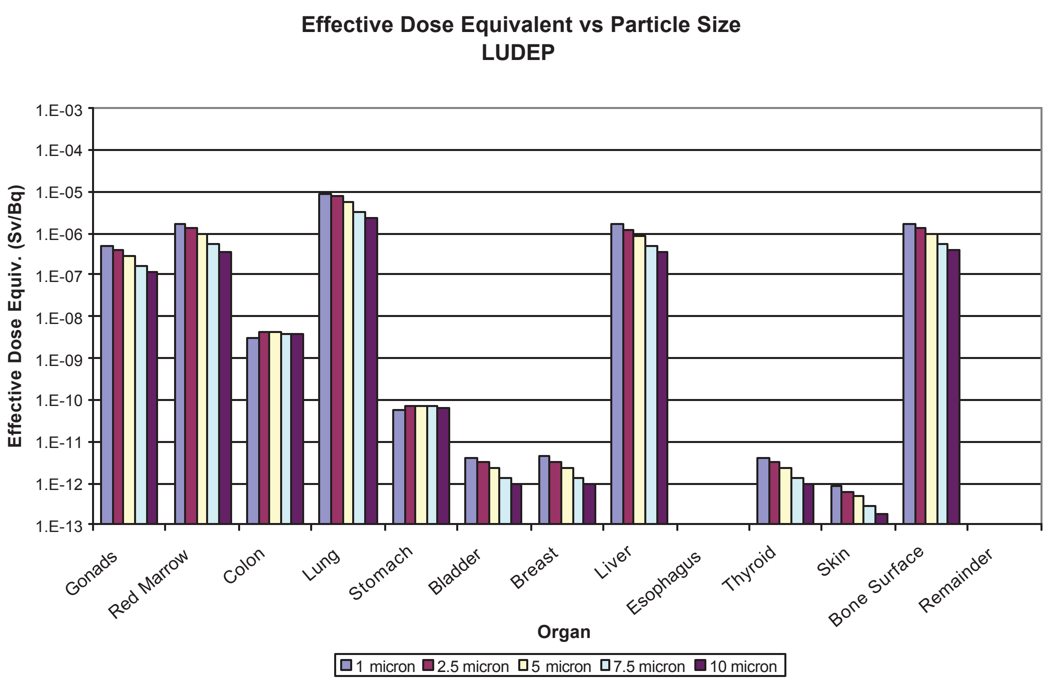


Figure D- 9. Variation of committed effective dose equivalent with particle size from LUDEP.

D.2.2.4. Type of Exposure

The data for some cases indicated possible exposures at several times during the two to three months on site. Evaluation of these cases could assume either a single acute exposure or a series of exposures similar to a continuous intake over the time. CINDY provides for either type of exposure scenario. A quantitative comparison of the two possible exposure scenarios was conducted. In all cases attempted, the estimated intake for an acute exposure was higher than the estimated intake for a continuous exposure, with an average increase of 50% and ranging up to 110%. When the range of exposure dates is reasonably well known, CINDY yields little difference in the results obtained by assuming either an acute (median exposure date) or continuous exposure. The differences in the two methods (acute vs. continuous) become greater as more assumptions are required to establish the dates of exposure. The results were very close when a range of dates was provided, varied significantly when only one date was provided, and showed the largest variation when assumptions were required for both the beginning and end of the exposure period. When only one date was entered on the bioassay data card, significant (>50%) differences resulted for the acute and continuous estimated intakes for 22 of 30 individuals. The highest difference was an 80-percent increase in estimated intake using the acute mode. When a range of dates was entered on the bioassay data card, there were no significant differences in the estimated intakes when either the acute or continuous approach was used. When no exposure date was entered on bioassay data card, significant differences occurred in intakes estimated for seven out of eight individuals, ranging from 70 to 110 percent.

The LUDEP model as currently configured requires significant additional effort to calculate continuous exposures when there is a time lapse between the end of exposure and the collection date for a bioassay sample. The number of manipulations required to perform this assessment were manageable for a few cases; however, the method was very unwieldy, and judged error-prone when applied to hundreds or thousands of cases.

In all comparisons, the estimated intake assuming acute exposure was higher than the estimated intake assuming continuous exposure, with an average increase of 50% and ranging up to 110%. These results emphasize the sensitivity of the estimated intake to the exposure date range.

D.3. MODEL ADOPTION

Taking the four factors considered above, RBD/AF, CINDY, and LUDEP all provide acceptable performance on estimating intake, calculating dose, and providing compatibility with the available data. LUDEP is somewhat less convenient for manipulating large numbers of cases and for generating outputs that can be used in other manipulations; however it implements the current ICRP respiratory tract model.

CINDY and RBD/AF implement the current regulatory system of the NRC and DOE for radiation protection, while LUDEP offers the alternative for applying the respiratory tract model and other features of recent ICRP recommendations. CINDY provides somewhat more flexibility in setup, estimating intakes, and reporting. Consequently, CINDY was chosen as the primary method for assessing the Palomares cases. LUDEP was retained as a reasonable alternate that provides complementary assessments for interesting cases and offers a much-needed point for comparison of results.

APPENDIX E

ESTIMATES FROM URINALYSIS

ESTIMATES FROM URINALYSIS

Urinalysis results existed for 1,758 samples collected from 1,555 individuals taken over a period extending from a few days to about 2 years following the accident. Earlier samples, collected on site, indicated the strong possibility of contamination. Follow-up samples, collected after personnel returned to their permanent base of assignment, showed dramatically lower concentrations. In 1968, those results demonstrated that no responder received a systemic body burden above a small fraction of the maximum permissible body burden (MPBB) – the standard for comparison at the time. This conclusion support expectations that estimates of intake and dose using currently accepted methods could support similar conclusions. This appendix discusses the urine data, provides preliminary estimates of intake and dose, and draws conclusions about the reliability of the estimates.

Estimates of intake and dose based on urinalysis for plutonium proved to be affected by numerous technical difficulties that made the results unrealistic compared to other plutonium exposure cases from industrial and environmental settings. Nevertheless, review of the extensive urinalyses confirmed the conclusions about the minimal impacts on the health of the responders made during the post-accident evaluations in 1966 through 1968. Furthermore, this effort completed a much-needed organization of the data, consistency checks and revisions, and preparation of the data for use in future evaluations.

E.1 DATA

The Air Force Institute of Environment, Safety, and Occupational Health Risk Analysis (AFIERA) and the Air Force Medical Operations Agency (AFMOA) provided records in the form of:

- Air Force Forms with laboratory analytical and exposure details of the nasal swipe and urine samples submitted and processed.
- Complete case files for the 26 individuals identified for follow-up in 1966 and commonly referred to as the "High 26".
- A Microsoft Excel spreadsheet prepared by AFIERA staff that contained the data from those Air Force Forms, and some data related specifically to the 26 individuals (referred to as the "High 26" who were considered as having the highest exposures).
- Copies of the accident response reports, USAF RHL documents on the evaluation of exposures by urinalysis, and selected publications from journals and conference proceedings.

Appendix B contains a detailed discussion of the information collected, an evaluation of the information's suitability for a dose evaluation, and adjustments made to the data for performing intake and dose calculations. The record prepared and maintained by the Air Force consisted of forms, computer spreadsheets, and written correspondence and reports of activities.

E.1.1. Forms

The USAF Radiological Health Laboratory (USAF RHL), the central laboratory for providing radiological services to Air Force units in 1966, recorded the data and results of samples processed on three series of forms: AFLC Form 1165, Internal Dosimetry Data (May 66), AFLC

Form 1165, Radiological Sample Data (May 66), and AFLC Form 1165, Radiological Sample Data (Jul 67). Although similar in design and content, these three forms evolved over the course of the laboratory effort on Palomares. The three forms recorded the data about the individual who submitted the sample, radiation measurement data for urine, radon (breath) (sic), and feces/blood samples, counting data, instrument data, and other factors; and finally the results. The Internal Dosimetry Data (May 66) form apparently served primarily for the samples processed during the initial, or on-site, phase of the response. Figure B-1, Appendix B illustrates that the May 66 version of the form contained information from samples collected in April 1966. The Radiological Sample Data (May 66) form was used to record alpha spectrometry data for most of the follow-up phase. The Radiological Sample Data (Jul 67) form was used during the end of the follow-up phase.

Consistency among the entries on the data forms and the entries in any ultimate data set would be required. The data cards formed the only permanent record available of the actual data generated at the time of the incident. Consequently, they provided the primary means for verifying information from other sources, at least when the data on the cards were unambiguous.

E.1.2. Spreadsheet

AFIERA representatives also provided a copy of a Microsoft EXCEL® spreadsheet that contained the basic data transcribed from the hardcopy data forms into the spreadsheet. Figure B-6, Appendix B contains an example of one page of the spreadsheet to illustrate its contents. The spreadsheet contains information on some 1,758 individual entries for 1,555 individuals. The spreadsheet served as a good starting point for evaluating the data contained on the hardcopy records.

E.1.3. Reports

Several other documents provided essential information about the details of the accident, the response effort, and the approach to evaluating health and safety issues during the response. These documents provided a narrative overview of the approach to assessing possible exposure to plutonium at Palomares. The discussions highlighted the issues faced, the problems encountered, and the rationale that formed the basis for the effort and decisions made throughout the period of on-site activity and subsequent follow-up. These issues are discussed in some detail in Section 2 above. The issues related to possible sample contamination, the sample collection period, and the exposure type and date formed the basis for evaluating the suitability of the data for the evaluation effort.

E.2 EVALUATION OF THE DATA

E.2.1. Condition of the Data

The data were evaluated to assess the availability of the elements required by the internal dosimetry models, including: the type of intake (inhalation, ingestion, skin contact), the date or dates the exposure occurred, the date of collection of nasal swab or urine samples, the duration of the urine sample collection, and the results of the sample analysis. Review indicated that the exposure date or dates, sample date, and results were not completely recorded for all cases. The collection of information was reviewed by comparing the spreadsheet and data forms to determine whether all forms were present in the spreadsheet and whether the entries were correct. The initial evaluation identified a number of problems with the spreadsheet and supporting forms as shown in Table E-1.

This initial review indicated that substantial numbers of samples lacked one or more important pieces of data and identified 115 data forms that apparently represented a repeat analysis of a sample or a follow-up sample for an individual. Following the initial review, many of the missing entries were corrected through careful analysis of the information and reasonable assumptions about the missing information.

The duration of sample collection is critical to estimating the daily excretion rate of plutonium in urine. Air Force reports indicated that sample collection lasted 12 hours for many samples collected at Camp Wilson. The Air Force corrected the result for any urine sample of less than 1200 milliliters to 1200 milliliters. This conservative procedure would tend to overestimate urinary excretion. Our review indicated that 12-hour samples were clearly designated in 42 of the samples; however, attempts to duplicate the Air Force estimate of systemic body burden revealed that the sample volume correction might have been applied inconsistently. However, this did not adversely affect any conclusions about the individuals tested. Our review concluded that adjustments to samples that were not designated as 12-hour samples presented were unnecessary. Therefore, recorded sample volumes were assumed to represent 24-hour output unless specifically designated as 12-hour samples.

Table E- 1. Issues with dose records.

Issue	Number of Entries	Percentage
Exposure Date Not Available	402	22.7
Sample Date Not Available	445	25.1
No SSN Available	385	21.8
No Air Force ID Available	2	0.11
Sample Vol. < 600 mL	323	18.3
Sample Vol. > 1000 mL	434	24.5
Number with Additional Sampling Data (2nd page)	115	6.50
Number of Cards Marked Out	2	0.11
Number of Cards Not Found	5	0.28
Total Number of Samples = 1768		

Missing or incorrect entries for Exposure and Sample Date also hinder a reasonable estimate of intake and radiation dose. Additional analysis would be required to establish these parameters.

Other observed issues included missing Social Security Numbers (SSNs), Air Force Service Numbers (AFSNs), and other entries. Many of those records pertained to a broad spectrum of responders – from Air Force to other Services (Army, Navy, Marines); other US agencies (State

Department, Bureau of Mines), possible Spanish civilian employees of Torrejon Air Base or local citizens, and at least one media representative.

E.2.2. Sample Collection and Handling

Urine sampling was begun within three days of the accident. Urine sample collection on site was subject to several compromises. First, isolation of responders for 24 hours was desired and attempted but operational requirements limited the period to 12 hours or less. Opportunities for sample contamination from strong winds frequently spread dust over the base camp; decontamination procedures were not always followed; make-shift sample containers were used, and even when preferred containers were obtained, storage areas were frequently contaminated by blowing winds.

Nasal swabs were also collected and submitted to the laboratory, however, records indicated that of the 122 nasal swab records reviewed, 109 did not contain a result, 13 contained a result (8 were 0 pCi, 4 had values all below 1.5 pCi, and 1 was reported as NDA). Therefore, the nasal swab records were not used in this analysis.

Laboratory personnel observed alpha particle contamination on the outside of sample containers from the operational site very early in the program. This immediately raised issues about whether any alpha activity detected in urine represented material excreted by responders. Follow-up sampling was recognized as one means for resolving issues of possible contamination for persons with urine levels indicating significant exposure.

Upon receipt at the laboratory, a unique sample number was assigned, the samples were recorded into a sample logbook, and the AFLC Forms, discussed above, were completed. Attempts to locate the logbook(s) were unsuccessful. Samples were then submitted for the selected radioactivity analysis procedure.

During the follow-up sampling effort, sample containers obtained specifically for the purpose and tested for contamination were used to collect urine specimens from individuals. Whenever possible, sample collection was conducted at an Air Force medical facility under controlled conditions to reduce the likelihood of mishandling and to fulfill the need for a legitimate 24-hour collection period.

E.2.3. Sample Analysis Procedures

The USAF Radiological Health Laboratory processed the urine samples in a two-phased program – an initial phase and a resample phase. During the initial phase, samples collected on site were processed by a gross alpha counting procedure with preliminary chemical processing to extract any alpha emitting radionuclides from the bulk urine sample (Odland 1968a).

E.2.3.1. Initial Phase Procedures

During the initial phase, samples were processed for counting by: digesting a portion of the urine sample with nitric acid and hydrogen peroxide to a white residue; dissolving the residue and coprecipitation of plutonium with bismuth salts; dissolving the salts with hydrochloric acid, addition of lanthanum carrier, and coprecipitation of plutonium on lanthanum fluoride; and direct mounting of the precipitate onto 2" stainless steel planchets for gross alpha counting (Odland 1966).

A small amount of ^{239}Pu tracer was added to pooled urine and processed in the same batch as Palomares samples. The added tracer served as an indicator of the effectiveness of plutonium recovery, which was reported to average 75.6 ± 19.6% (68% confidence) (Odland 1966).

The samples were counted in internal proportional counters optimized for detecting alpha particles. Daily checks monitored instrument response, and daily background counts were done. According to reports (Odland 1966), samples were counted for 120 minutes, and background was counted for 960 minutes. Review of the initial data indicated that samples were often counted for 55 minutes. Background was reported to range from 0.02 to 0.06 count per minute and counting chambers were decontaminated whenever the background count exceeded 0.1 count per minute.

Gross alpha results were reported in pCi/sample, where:

$$\text{pCi/sample} = \frac{\text{(gross counts/gross ctg time)- (background counts/bkgrd ctg time)}}{\text{(counting efficiency)(2.22)(procedural yield)}}$$

Analysis of selected samples from the initial phase indicated that the results and estimated errors were calculated, recorded, and reported. The estimated errors were determined from counting data only and were reported at the 95% confidence level.

Procedural yield was determined from the results of the traced urine sample for each batch of urine processed.

E.2.3.2. Resample Phase Procedures

During the resample phase, the laboratory derived its procedures from those used for monitoring workers at other facilities handling significant quantities of plutonium. The process involved nitric acid digestion, coprecipitation of alkaline earth and plutonium phosphates, precipitation with cerium, ion exchange to remove interfering ions, and electrodeposition onto stainless steel planchets for radioactivity counting. A small quantity of ^{236}Pu was added to each sample before chemical processing to evaluate radiochemical recovery.

Radioactivity counting was conducted using alpha particle spectrometry with solid-state surface-barrier detectors in a vacuum. Count data were collected with a multichannel pulse-height analyzer. Detector efficiency and background were monitored daily. Background was counted for 800 minutes duration and samples for 100 minutes. Review of results indicated that samples were counted for 100, 200, or 400 minutes, perhaps in attempts to achieve lower detectability.

Data were accumulated in 255 storage positions. Total events in a 236-Pu band and in a 239-Pu band were determined. The activity in the counting sample was determined from the following equation:

$$\text{pCi/sample} = \frac{\text{(net cpm in 239 - Pu band)} \times \text{(dpm 236 - Pu added)}}{\text{(net cpm in 236 - Pu band)} \times 2.22}$$

$$\text{where net cpm in 239 - Pu band} = \left[\frac{\text{gross cts in 239 - Pu band}}{\text{gross ctg time}} - \frac{\text{bkg cts in 239 - Pu band}}{\text{bkg ctg time}} \right]$$

$$\text{and net cpm in 236 - Pu band} = \left[\frac{\text{gross cts in 236 - Pu band}}{\text{gross ctg time}} - \frac{\text{bkg cts in 236 - Pu band}}{\text{bkg ctg time}} \right]$$

dpm 236-Pu = activity of 236-Pu spike added to sample corrected for decay to date of count.

Corrections for sample volume to convert the result into the amount excreted in a day (24 hours) were also applied before calculating the body burden. Errors were estimated based on counting statistics and minimum detectable activity levels established and applied. Odland reported that the minimum detectable activity (MDA) as used in the program was defined as the sample activity associated with a counting error at the 95% confidence level equal to 0.95 times the sample activity (Odland 1968a). That means that any sample whose estimated error exceeded 95% of the sample activity was reported as no detectable activity (NDA).

During review of the records, assessments of the procedures indicated that the estimated errors on alpha spectrometry samples were calculated and reported at the 68% confidence level.

E.2.4. Data Preparation

E.2.4.1. Description of Changes

Adjustments to the data provided were made to fill data gaps and to overcome inconsistencies for exposure date, sample date, sample duration, and urinary excretion rate and its estimated error. Other inconsistencies observed in the data were also corrected to the extent possible.

E.2.4.1.1 Exposure Date

The exposure date was determined from the midpoint of the time an individual spent on station. Exposure date entries on the forms included all of the following: a single date, a date range, an arrival date, a month and year, a year only and a few others. Missing start dates were developed from reasonable estimates based on other recorded information, such as arrival date. Exposure end dates were derived similarly, or from recorded sample collection dates. Both of these modifications are discussed further in Appendix B.

E.2.4.1.2 Sample Date

Missing Sample Date entries for the 445 samples identified (Table E-1) were estimated with an approach that used data on sample receipt at USAF RHL and assigned laboratory sample numbers (See Appendix B). The approach recognized that receipt of samples at USAF RHL, the sample number sequence assigned, and collection date were related. Derived Sample Date information was then entered into a master data set along with the other data for each urine sample.

E.2.4.1.3 Sample Duration

Actual sample duration was documented in a very small fraction (42 samples) of the samples received. Fortunately, basic sample volume data provide the basis for making any corrections needed. As discussed above, this project elected to treat recorded sample volumes as representing 24-hour outputs unless the data forms specifically designated the samples as 12-hour samples. For those, the results were adjusted to the currently accepted nominal daily urine output (1400 mL) for Reference Man. Those adjustments were performed in the intake assessment process.

E.2.4.1.4 Other Parameters

Analytical results for daily urinary excretion and the estimated error were transcribed as entered on the hardcopy forms. However, in the case of samples reported as No Detectable Activity, the data forms were reviewed for the presence of other calculations of a numerical result and error. When found, these calculated results were used in the analysis, even when the error value exceeded the result. This procedure applied primarily when the results of multiple samples were available, as was the case for many of the High 26 Cases Group. In these cases, although the errors were large, they nevertheless provided order of magnitude information about the levels present and were useful comparisons to other values.

E.2.4.1.5 Other Inconsistencies

Other inconsistencies in the data set were also identified and corrected where possible. Although these did not affect the actual intake and dose assessments, they do affect identifying information. These reviews discovered inconsistencies in names, SSNs caused by typographical errors or keyboarding errors, errors in analysis type, inconsistent base names, and others.

E.2.5. Grouping of Cases

The majority of available records contained results from the gross alpha method on samples collected on site. Typically, one record was available for each individual and initial results indicated that intakes and doses estimated using the records would be unusually high. On the other hand, the individual records for the High 26 Cases Group generally contained several results with most from the preferred alpha spectrometry method. In between, the 115 individuals with results from alpha spectrometry follow-up analyses had more limited data. An overall approach to evaluating the cases was clearly needed.

E.2.5.1. Review of Data Available

Estimating intake from urine bioassay depends on reasonably accurate urinary excretion values that follow the expected pattern for the assumed type of exposure and Class (Type) of the contaminant. The data should be as free of artifacts as possible. The varied quality of the records cast doubt about whether reasonable estimates could be developed for all individuals. Records for the High 26 Cases Group offered the best opportunity. On the other hand, most of the records for samples collected on site raised serious questions about estimates derived from them. Some of those issues arose from initial attempts to use the High 26 records as the model for the other cases. As mentioned earlier, those studies indicated that including the results from gross alpha analyses obtained from samples collected on site produced intake estimates and doses that seemed unreasonably high. Furthermore, the pattern of results for samples collected during the resampling phase often did not follow the pattern expected for Class Y (Type S) plutonium.

Figure E-1 contains results and expected urinary excretion for one case that illustrates the difficulty. The figure shows the actual samples as data points and calculated curves for the actual CINDY fit (intake = 58,000 pCi) and reasonable "eye-ball" fits of 23,200 and 870,000 pCi. The first two samples were taken at 3 days and 59 days after the incident. This subject was one of the first responders to arrive. In addition, the last two samples, taken at 472 and 547 days after the incident were reported as NDA. They are plotted as 0.003 pCi/day for graphing purposes. The "final" fitted result was obtained by excluding the first two samples from consideration. Even for this case, the upper and lower rough estimates differ from the fitted curve by a factor of two, with associated CEDEs of approximately 10 to 270 rem (0.1 to 2.7 Sv).

The apparent difficulties with fitting urinary excretion models to the actual data required further investigation. Peer reviewers of a draft version of this report suggested that all of the data should be considered to assess whether some other form of plutonium behavior was being observed rather than the assumption of inhalation exposure to very insoluble Class Y (Type S) material. These suggestions were evaluated for this revision by considering the validity of the Class Y (Type S) assumption, by considering other routes of entry (e.g. ingestion), and by assessing the effect of the alternate approaches on all data for the High 26 group.

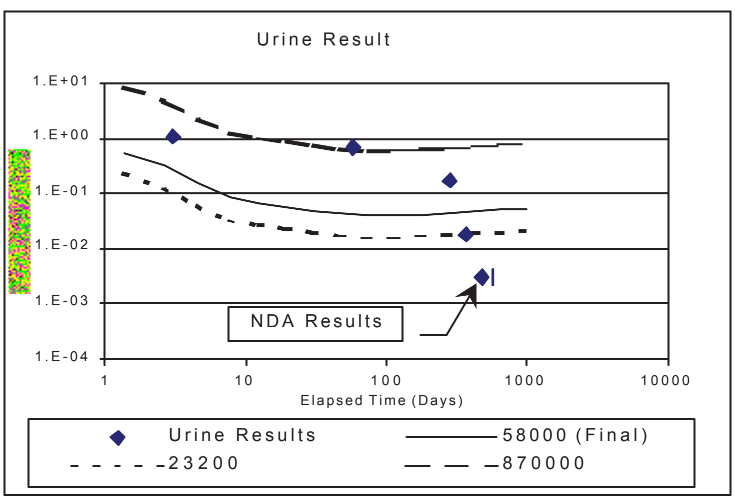


Figure E- 1. Example urinary excretion.

Regarding the conclusions about material form, numerous investigators report that plutonium produced under the conditions of the Palomares accident (i.e. explosion, and fire produce oxides of plutonium under high temperature) tend to be very insoluble (Church 2000). Furthermore, investigations at Palomares itself indicate that the material present on site consists primarily of 87% Type S (Class Y) and 13% Type M (Class W) material (Stradling 1993). Although those findings represent studies conducted at some time after the accident, it seems reasonable to expect that the solubility of plutonium would not decrease over time. Consequently, the assumption that Type S (Class Y) plutonium was the principal form present during response activities seems very reasonable.

Investigations of the behavior of the set of urine results with expected behavior involved qualitative, graphical comparisons of the dataset with the expected curve shapes for urinary excretion from inhalation of Type M (Class W) and Type S (Class Y) plutonium alone and in combination, and from ingestion of soluble and insoluble plutonium. Figure E-2 compares the urine results from the initial sampling and the re-sampling phases of the High 26 Group with the urinary excretion patterns for inhalations of Type M (Class W) plutonium, Type S (Class Y) plutonium and two combinations (one of equal amounts of Type M and Type S, and the other of 3 parts Type S and 1 part Type M). The excretion curves do not represent fits to the data. Rather they have been scaled by the amount of plutonium intake required to place them on the chart. As a matter of fact the assumed intakes are 15,000 pCi Type M, 15,000 pCi Type S, 15,000 pCi Type M plus 15,000 pCi Type S, and 5,000 pCi Type M plus 15,000 pCi Type S, respectively. The plutonium amounts are not critical for this comparison because the shapes of the curves provide the substantial observations about the behaviors.

The urine results shown in Figure E-2 seem to decrease steadily, almost monotonically, on this logarithmic presentation. However, each of the urinary excretion curves declines very rapidly at first, but then declines much more slowly. Actually, for the plutonium forms involved, there is a slight increase beginning at around 200 days that represents the continuing release of plutonium retained in the lungs combined with additional plutonium being remobilized from other organs. Most importantly, the expected excretion continues at an ever more slowly decreasing rate at times beyond 500 days after the initial rapid decrease. There are obvious differences between the data and the expected excretion.

Figure E-3, illustrates the behavior of ingested plutonium for comparison with the urine results. Again as for the inhalation case, the excretion curves differ substantially from the results. A level that seemingly predicts the excretion soon after exposure tends to over estimate excretion later. Conversely, reasonable estimates at longer times generate significant differences at the earlier times.

These discussions raise serious concerns about estimates of intake that would be derived from the data. One interpretation suggests that other, or better, models should be tried. On the other hand, the data themselves may be contribute to the difficulties; especially those from samples collected on site or soon after departing Palomares. Alternately, improvements in laboratory procedures may have contributed to the discrepancies. Conversations with USAF RHL personnel who devised and directed the urine analysis program indicated that the alpha spectrometry methods for ^{239}Pu were very much at the developmental stage for most of 1966 (Taschner 1999). Additional first-hand experience by one of this report's authors (a former director of radioanalysis at the USAF RHL from 1969 to 1976) confirms those observations as well as the difficulties in measuring such low concentrations of plutonium radioactivity (Case 2001).

Consequently methods, used in this project, excluded data from the on-site samples and attributed more significance to samples collected at later dates for the High 26 Group.

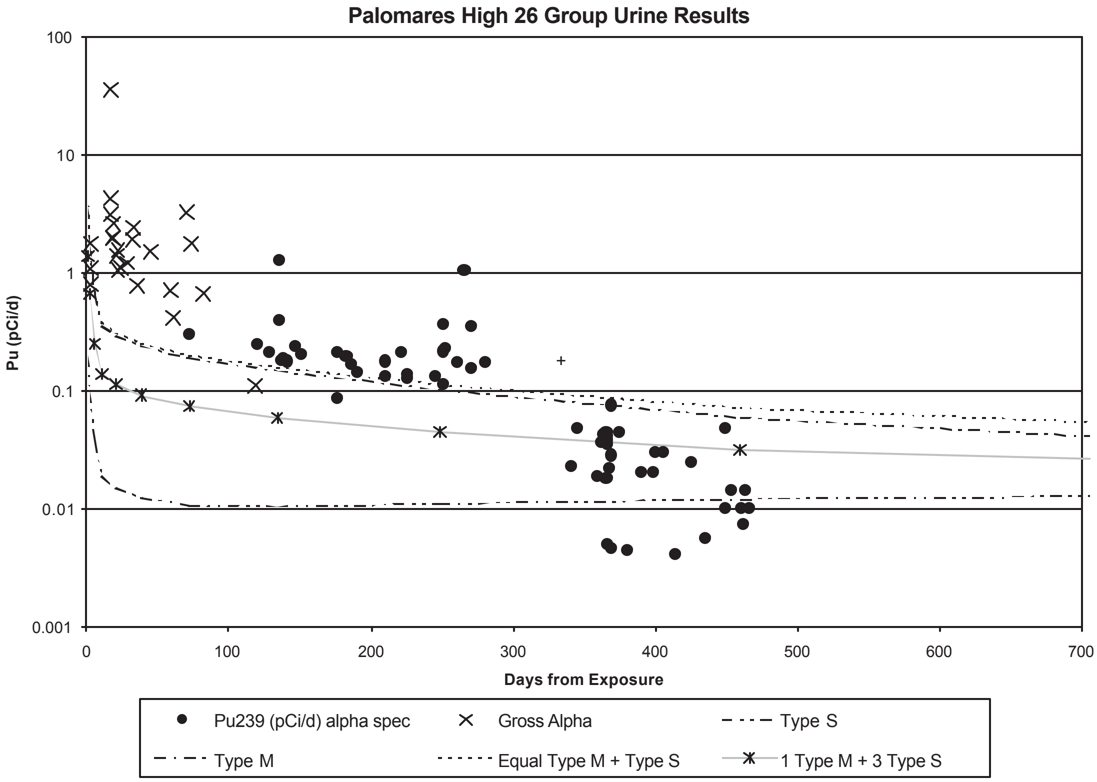


Figure E- 2. Comparison of High 26 Group urine results with excretion expected from inhalation of plutonium.

The remaining results generally fell into two categories: those with the results of some resampling; and those with one sample and often very high results. Urinary excretion results for the latter case ranged from 0.0 pCi/day to 237 pCi/day with corresponding committed effective dose equivalent of up to 6,000 rem (60 Sv) from an estimated intake of 20,000,000 pCi. If real, that intake would have produced a dose equivalent to the lung of almost 5,000 rem (50 Sv) and an effective dose equivalent of about 560 rem (5.6 Sv) in the first year alone. Both of those are 100 times higher than the applicable regulatory limits for non-stochastic (prompt) and stochastic (delayed) effects and would have produced deterministic (non-stochastic) effects. Clearly that case is extreme and alternative approaches to processing were needed.

E.2.5.2. Selection of Contamination Cutoff

Careful review of the group of data indicated that processing all of the cases would produce unrealistic estimates that would be based on potentially contaminated samples. Contamination of samples collected at the accident site continued to impact the evaluation as it did at the time of the accident. However, review of those data also indicated a substantial number of cases that had urinary results that were essentially below the detection limit or were quite low.

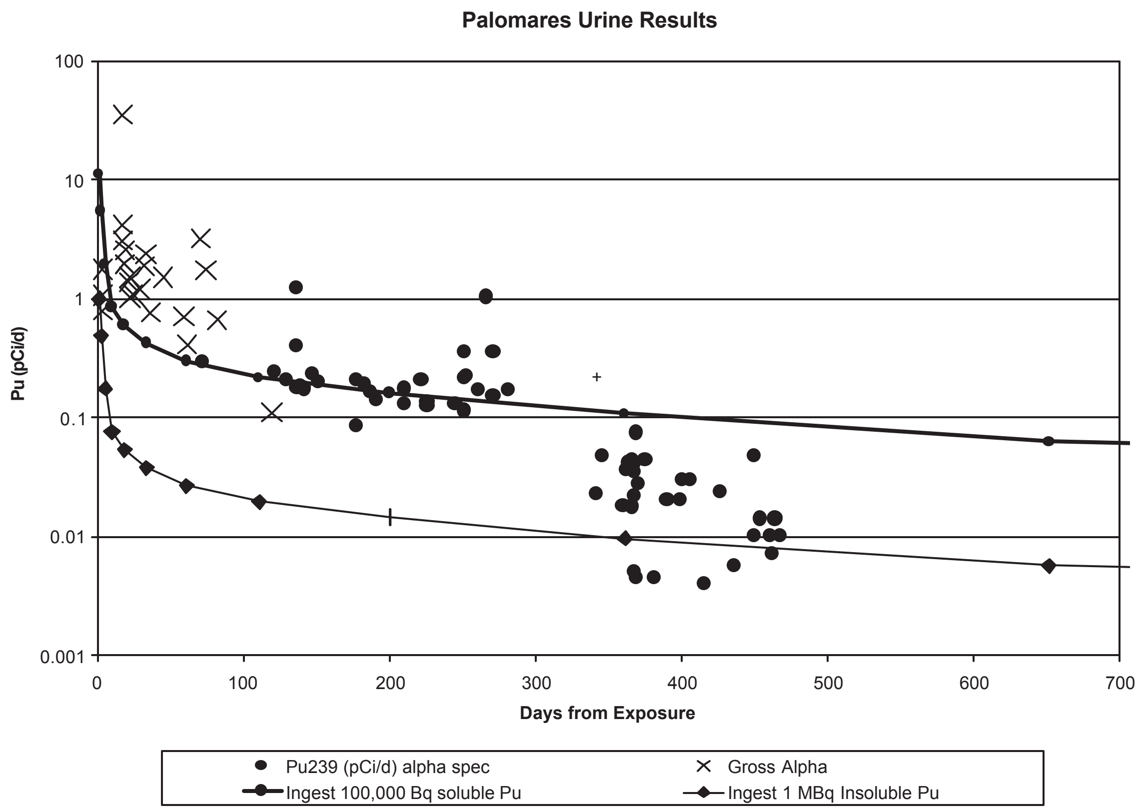


Figure E- 3. Comparison of High 26 Group Urine Results with expected excretion following ingestion.

After consultation with AFMOA, the data were reviewed again to determine whether a reasonable lower cutoff could be determined. Selection of a reasonable cutoff allows the use of professional judgement to eliminate questionable data, while at the same time, allowing reasonable estimates from apparently "uncontaminated" samples. This task was approached by evaluating selected records to calculate a Lower Limit of Detection according to current practice, and to research LLDs in use by other laboratories for similar assessments. The effort extracted sample and background counting information for 39 gross alpha samples and 3 alpha spectrometry samples. The mean and standard deviation of those were of 0.1 $\pm$ 0.1 pCi/day for gross alpha and 0.015 $\pm$ 0.003 pCi/day for alpha spectrometry. These were compared with the reported limits achieved by the combined U.S and Spanish effort to assess intakes and doses in the local population. A detection limit of 0.74 mBq/d (0.02 pCi/d) was in use from 1966 to 1985 (Iranzo 1988). That limit is essentially the same as the result obtained from Air Force data. Furthermore, the value of 0.1 pCi/day for gross alpha also seemed like a reasonable cutoff. Consequently, that value was selected as a cutoff limit. Cases with urinary excretion measurements below the level were categorized as the Contamination Cutoff Cases Group. Those with measurements above the level were categorized as the Remaining Cases Group and were not processed further in this project.

E.3 DOSE CALCULATION

E.3.1. Exposure Scenario

The type of exposure (acute or chronic; inhalation, ingestion, direct) must be known or assumed to perform a meaningful estimate of an intake of radioactive material and its associated dose equivalent. One or more of the common routes of entry (inhalation, ingestion, or direct) generally apply. Examinations of the activities that may have caused the exposure provide the clues to determining the type and route of the exposure.

As discussed above, the response to the Palomares nuclear accident involved hundreds of personnel working toward the common purpose of recovering vital materials, protecting themselves and the local populace, and restoration of the accident scene to useable and safe conditions. The accident itself released plutonium during explosions and fires that followed the impact of two of the nuclear weapons with the ground. The plutonium was released primarily as airborne dust and as residues from fire, that contaminated the ground. Since the fires essentially were out long before serious response efforts started, the main source of exposure arose from activities such as vehicle movement, handling debris during recovery, plowing fields to mix the contaminant into the soil, and vehicle movement. Persistent winds also contributed to the resuspension of contaminated soils from the ground or contaminated dusts from the surfaces of accident debris, local buildings, or agricultural crops.

Ingestion by hand to mouth transfer is a second possible route of entry. However, that route is very inefficient. Furthermore, the fraction of plutonium that enters the bloodstream from the intestines is very small (0.00001 for Type S). For reasons discussed in Sections 3.1.1.2 and 4.4.1 above, the ingestion route is not considered further.

The type of exposure was assumed to be a single acute exposure. This assumption accommodates the long time for removal of plutonium oxides from the human body. The response activity occurred from January 18, 1966 until April 3, 1966 when activities were moved from Camp Wilson to another location. Personnel on site reached a maximum in late January; tapered off during February, and then increased slightly in mid-March during the packaging of contaminated debris, soil and other wastes for disposal. Most departed the site by late March 1966. The nominal length of assignment was about two weeks. However, records indicate that some personnel stayed much longer.

E.3.2. Parameters Used in Models

Two computer methods, CINDY and LUDEP, were selected to calculate estimates of the ^{239}Pu[1] intakes and doses. CINDY applies the system described in ICRP-30 while LUDEP uses the respiratory tract model of ICRP-66 and the organ/tissue weighting factors of ICRP-60. CINDY served as the primary method and LUDEP provided alternative estimates for comparison. Both programs require selection of input parameters that control the various factors of the intake (respiratory tract), biokinetic and excretion models used in the analysis. Table E-2 contains the parameters selected for the CINDY runs. The parameters chosen represent the default values for

[1] The isotope, ^{239}Pu, is discussed as the primary isotope of interest. Commonly, ^{240}Pu that is also present in weapons material cannot be distinguished from ^{239}Pu by the counting techniques used. However, no distinction is made for this possible presence of ^{240}Pu.

an acute inhalation exposure of Class Y ^{239}Pu obtained from ICRP-30 or other recognized appropriate sources as described in the CINDY Users Guide (PNL 1992). In addition, urine sample collection times were assumed to represent a 24-hour collection unless specifically stated otherwise.

CINDY calculated the cases in a two-step process: the intake assessment mode to estimate the intake from the urine bioassay measurements, followed by the dose assessment mode to calculate the 50-year committed dose equivalent for each organ, and the 50-year committed effective dose equivalent. For some cases, CINDY was also run in the bioassay projection mode to generate a plutonium excretion curve for plotting and further analysis. Figure E-2 above represents such a plot. In addition, CINDY was run in the calendar year dose assessment mode to calculate the annual dose equivalent to specific organs for comparison with the non-stochastic limit.

For LUDEP, a similar process was used to setup the required parameters. LUDEP bases its calculations on an estimate of the intake type and intake value. Intake is estimated for a unit intake first, using a selected excretion model such as the Jones model. Then, the derived excretion model curve is fit to the measurement data to generate an estimate of the intake. Finally, the intake is used to estimate the organ dose equivalents and the committed effective dose equivalent for the exposure type (acute, inhalation), activity parameters (worker, standard worker), and model parameters. Table E-3 contains the parameters used for estimating intakes and doses for LUDEP cases.

All cases were run with standard ICRP default values for the deposition and particle transport factors except particle density, which was set at 10 g/cm^3, which is the density of PuO_2 rather than a density representative of dust. The compartment numbers for the clearance rate constant values and the deposition fractions in Table E-3 refer to Figure 5 of the main report. The compartment rate constants are the half-times (in days^{-1}) that material moves from the “From” compartment to the “To” compartment.

E.4 RESULTS

E.4.1. High 26 Cases Group

The High 26 Cases Group represents the collected measurement data from 26 responders who were identified for follow-up after the initial phase of sampling in 1966. The evaluation of the cases is presented with discussions of their urine bioassay measurement characteristics, the approach to performing the estimates, and a discussion of the results.

E.4.1.1. Urine Bioassay Measurement Characteristics

The High 26 Cases Group provided 127 urine samples during their on-site and resampling activities. Those 127 samples produced 25 measurements of gross alpha activity and 102 measurements of ^{239}Pu from alpha spectrometry. The 102 samples from alpha spectrometry were distributed among the 26 people as shown in Table -4. The gross alpha method reported 24 results above the minimum detectable and one result as no detectable activity.

Table E- 2. Parameters used in CINDY runs.

Parameter	Value
Subject identification	
Name	Specific to individual
ID	Set to dummy value of 1234567890
SSN	Specific to individual or 000-00-0000 if not available
Date of birth	Not available: set to dummy value of 01/01/1945
Sex:	Male (with few exceptions for obvious female names)
Intake information	
Intake exposure rate	Acute
Intake mode	Inhalation
Begin date	Specific to estimated acute exposure date for individual
Begin time	Left at default value of 00:00
Particle size (microns)	1
Facility	Palomares
Employer	U.S. Air Force
Edit/input bioassay data	
To exclude set non-blank	G or x entered if individual had a gross alpha result that was being excluded from the current model run
Bioassay type	u entered for urine
Bioassay radionuclide	Pu239
Sample end date	Sample date, specific to individual's sample
Sample end time	Left at default value of 00:00
Excretion period (hr)	24 unless dose card specifies otherwise (regardless of sample volume)
Measured value	Sample result (for units of pCi/sample) specific to individual's sample
Inverse of weighting factor	Variance of sample error (not used in methodology reported in final output)
Unit numerator	pCi
Units are per ...	[S] for sample
Sample size	Sample volume (for units of mL) specific to individual's sample
Sample size units	mL
Reference volumes	
Urine-male (mL)	1400 (not used in modeling--overridden by entries made to "excretion period" parameter)
Feces-male (g)	135 (not used in modeling—no bioassays of this type)
Intake Assessment Mode	
Radionuclides of concern	Pu239; Working units = pCi
Intake composition	Fraction inhaled = 1 ICRP-30 Class D = 0% ICRP-30 Class W = 0% ICRP-30 Class Y = 100%
Change default parameters	Radionuclide daughters: Consider? yes Select radiological units: pCi Error tolerance for integration: .0000001
Select models	Pu239: Jones excretion model

Table E- 2. Parameters used in CINDY runs.

Parameter	Value	
Dose Assessment Mode (specified period)		
Radionuclides of concern	Pu239 Working units = pCi	
Intake estimate	Quantity inhaled: in pCi, specific to individual based on results of intake assessment mode run ICRP-30 Class D = 0% ICRP-30 Class W = 0% ICRP-30 Class Y = 100%	
Change default parameters	Dose reporting times = 1 report time Report time in years = 50 Select radiological units: pCi Error tolerance for integration: .0000001	
Select models	Pu239: Jones excretion model	
Jones Excretion Model Parameters		
Compartment	**Fractional Rates (1/d)**	**Transfer rate constant (1/d)**
1	4.75×10^{-3}	0.558
2	2.39×10^{-4}	4.42×10^{-2}
3	8.55×10^{-5}	3.60×10^{-3}
4	1.42×10^{-5}	2.84×10^{-5}
Systemic Model – Pu		
Bone	Fraction from transfer compartment: 0.45 Transfer compartment clearance half-time (d) : 0.25 Organ clearance half-time (d): 18,200 Fraction reaching urine: 0.5 Fraction Reaching feces: 0.5	
Liver	Fraction from transfer compartment: 0.45 Transfer compartment clearance half-time (d): 0.25 Organ clearance half-time (d): 7,300 Fraction reaching urine: 0.5 Fraction Reaching feces: 0.5	
Testes	Fraction from transfer compartment: 0.00035 Transfer compartment clearance half-time (d): 0.25 Organ clearance half-time (d): 3,650,000 Fraction reaching urine: 0.5 Fraction Reaching feces: 0.5	
Pu f_1 values		
Inhalation	Class D: 0.001 Class W: 0.001 Class Y: 0.00001	
Ingestion	Soluble: 0.001 Insoluble: 0.00001	

Table E- 3. LUDEP Input Parameters.

Input parameters		
Intake regime	Exposure Subject Intake	Occupational Standard worker Acute, inhalation, 1 Bq (used to generate excretion curve)
Time	50 years	
Deposition	Exposure Subject AMAD (:m) Advanced mode	Occupational Standard worker 1 All defaults except density = 10 g/cc ICRP Defaults 1. SUBJECT: Adult Male 2. ACTIVITY: Light Exercise 3. TYPE: Nose Breather 4. DISPERSION: polydisperse Physiological Parameters a) Functional Residual Capacity: 3301 cc b) Extra-thoracic Dead Space: 50 cc c) Bronchial Dead Space: 49 cc d) Bronchiolar Dead Space: 47 cc e) Height: 176 cm f) Tracheal Diameter: 1.650 cm g) First Bronchiolar Diameter: 0.165 cm Activity Related Parameters h) Ventilation Rate: 1.50 cu.m/h i) Respiratory Frequency: 20.0 /min j) Tidal Volume: 1250 cc k) Volumetric Flow Rate: 833 cc/s l) Fraction breathed through nose: 1.000 Aerosol Size Parameters m) AMAD: 1.0000 μm (changed from default of 4) n) AMTD: 0.3407 μm o) Φg: 2.43 p) Den: 10.00 g/cc (changed from default of 3) w) SF: 1.50 Deposition q. ET1 17.54 % r. ET2 22.59 % s. BB 1.38 %* t. bb 2.22 %* u. AI 13.04 % Total = 56.78% v. Fs* (BB%) = 49.76, (bb%) = 49.98%

Table E- 3. LUDEP Input Parameters.

Particle transport (See Figure 5)		
	Compartment From – To	Rate Constant (1/d)
	1 to 4	0.02
	2 to 4	0.001
	3 to 4	0.0001
	3 to 10	0.000020
	4 to 7	2.0
	5 to 7	0.03
	6 to 10	0.01
	7 to 11	10.0
	8 to 11	0.03
	9 to 10	0.01
	11 to GI	100.0
	12 to 13	0.001
	14 Out	1.0
	Compartment	Deposition Fraction
	ET_{seq}/ET_2	0.00050
	BB_{seq}/BB	0.00700
	BB_2/BB	=Fs1
	Bb_{seq}/bb	0.00700
	Bb_2/bb	=Fs2
	AI_2/AI	0.6000
	AI_3/AI	0.1000
Absorption	Selected S for default values	
Radio-nuclides	ICRP-38 database	Pu239
Biokinetic model	ICRP-30	Part 4: Pu(Y)M.mod (for Pu, class Y, male) Organs = liver, whole skeleton, testes (default for Pu239) Bone type = surface seeker (default for Pu239) Blood half life = 0.25 d (default for Pu23)
Calculations		
Excretion/ Retention (the results of this run are then entered as the bioassay function in the intake estimate mode)	Quantity to calculate	urinary excretion rate
	Select ICRP-54 function	Pu/Am (J) (this is the Jones Plutonium Excretion Model)
	Enter own function	Used defaults as follows: A(1) = 4.75E-03 t½= 1.24E+00 d A(2) = 2.39E-04 t½= 1.57E+01 d A(3) = 8.55E-05 t½= 1.82E+02 d A(4) = 1.42E-05 t½= 2.44E+04 d A(5) = 0.00E+00 t½= 0.00E+00 d A(6) to A(10) are zero Retention t½ in blood: 1.000E-07
	Period of integration	1 day
	Time	1 day to 730 days
	Number of points	730
	Intervals	Linear

Table E- 3. LUDEP Input Parameters.

Intake estimation	Data filename	*.dat file for individual, showing days elapsed from exposure to sample, sample result in Bq/d, and sample error in Bq/d, as in the following example for an individual with three samples 10 0.005 0.0005 43 0.004 0.0014 78 0.001 0.001
	Assumed errors	errors included in data set
	Modify for DTPA?	no modification
	Bioassay function filename	File from excretion/retention mode run
	Estimate intake	command line, estimated intake appears on screen

Review of the procedures for calculating the radioactivity results and their errors revealed that the reported errors for gross alpha measurements represented the 95% confidence level while the reported errors for alpha spectrometry measurements represented the 68% confidence level. Since the criterion for reporting a result as no detectable activity was based on the 95% confidence limit, alpha spectrometry results may not have followed that convention. Therefore, some alpha spectrometry results may have been reported as positive when the estimated errors did not support that conclusion. Nevertheless, the approach was more likely to report a numerical result, which is preferable to the NDA report. Unfortunately, the numerical values for the laboratory's NDA were not discussed in any of the reports of the sampling and analysis effort reviewed for this project.

Table E- 4. Breakdown of alpha spectrometry samples.

Number of Samples	Number of Submitters
3	5
4	2
5	14
6	3
7	2

The measurement results from alpha spectrometry revealed that actual numerical values and the associated counting errors were calculated even when the sample was reported as NDA. Those results were used in developing these estimates when recorded on the individual data cards. The alpha spectrometry results contained 63 reported values while the remainder were reported as NDA or were not reported, apparently because of a laboratory error. Of the 63 results, 15 were less than their error at the 68% confidence level and 33 results were greater than the 68% level but less than the 95% confidence level. Only 15 results were above the 95% confidence level. This means that for 48 of the 63 reported results, zero was included in the range of possible results.

Reproducibility of the laboratory measurements was also evaluated using samples that were reprocessed. Although limited, five samples were reprocessed primarily to correct low chemical recovery. One of those was processed three times, reporting two numerical results that were less than the 68% confidence level error, and one result as NDA. Of the other four samples, three showed differences in reported radioactivity of two to three times. The remaining sample was a valid NDA report.

In considering the impact of these apparent analytical difficulties, the levels of radioactivity of these samples (less than 0.1 pCi/d) may produce only a few detectable events during counting periods of 100 to 400 minutes recorded. For those techniques, background counting levels are also very low, usually on the order of one count in thousands of minutes. Although these levels are quite low, they can represent plutonium intakes that require evaluation.

Figure E-4 illustrates the urine results obtained from the High 26 Cases Group. Those results show the variability in measured plutonium values. The expected behavior of urinary excretion from inhalation of Class Y (Type S) ^{239}Pu and an equal mixture of Class W (Type M) and Class Y (Type S) ^{239}Pu are also shown. The results do not correspond to the expected pattern very well at all as was previously discussed in Section 4 of the main report. Consequently, attempts to fit the urinary excretion model to the measurements were expected to be difficult.

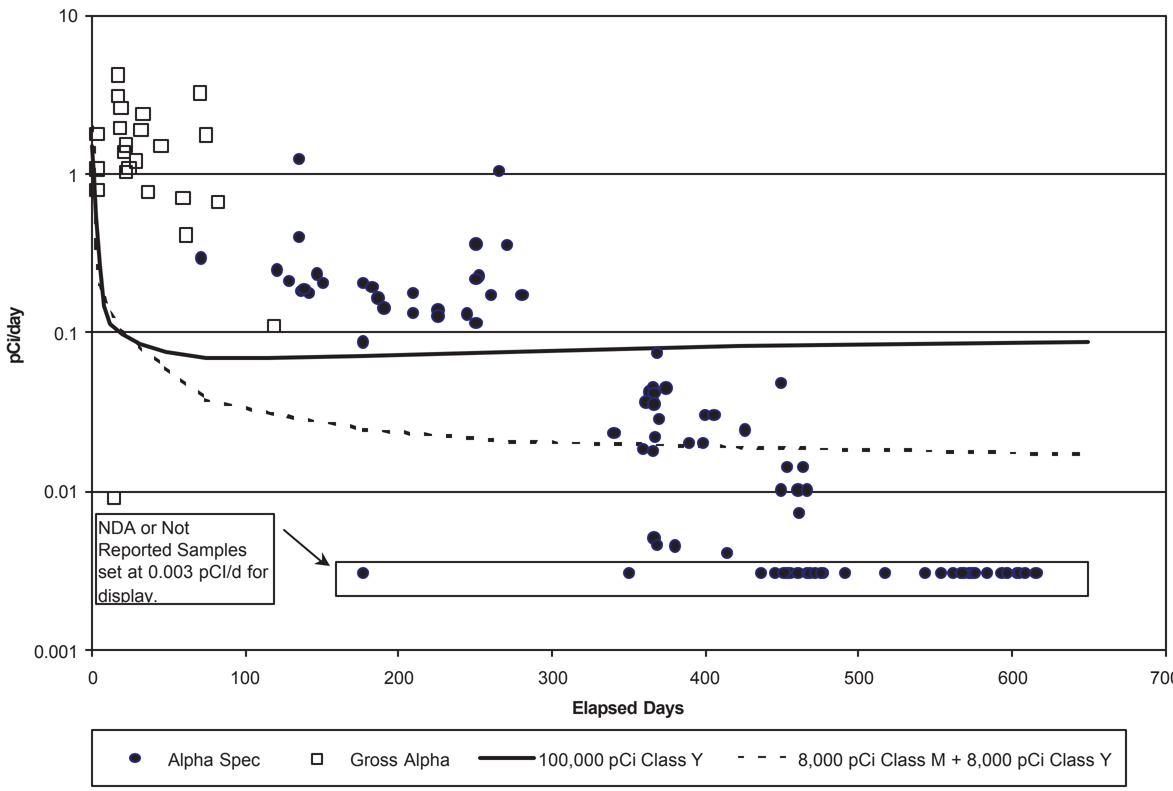


Figure E- 4. High 26 Cases Group urine results.

E.4.1.2. Approach to Estimates

The urine analysis results for the High 26 Cases Group indicated that those cases with several measurements for samples collected over the entire initial and resampling efforts could provide the best data for testing. To do this, several variations on use of the data and setup for the CINDY and LUDEP programs were used. For samples, assumptions were developed for the date of exposure, the use of gross alpha results and the use of NDA results. For the programs, the main adjustment involved the method for weighting results during intake assessment using CINDY and LUDEP.

E.4.1.2.1 Date of Exposure

The entire High 26 Cases Group arrived during the early phases of the response effort. Some arrived the day following the accident while others arrived somewhat later. All arrived in January 1966. Some remained on site for only a few days or weeks while others remained for the entire deployment. Rather than use the midpoint of the assumed on-site period as the date of exposure for this group, their arrival date at Palomares was selected. This assumption was judged conservative since it would estimate slightly higher intakes because more days would elapse between the assumed exposure and sampling. The effect would be minimal as shown by tests of both CINDY and LUDEP (Section 3.3.1).

E.4.1.2.2 Use of Gross Alpha Measurements

Twenty-two of the 25 gross alpha results (one of the group had no gross alpha results) were from samples collected on dates that represent on-site activities. The gross alpha activity of these samples ranged from NDA to 35 pCi/d. That former result represents a very high urinary level. Tests were run that included and excluded the gross alpha results, including those collected on and off site as separate cases. The results indicated that both CINDY and LUDEP tended to produce better fits for samples with lower values and taken at longer time following the exposure.

E.4.1.2.3 Use of NDA Results

Samples reported as no detectable activity do not produce a numerical result. However, these samples indicate that their radioactivity content is near or below the level that can be measured with confidence. That is, at those levels, the analysis indicates that the radioactivity may, or may not, be present. Since many of the results obtained during the resample period were reported as NDA (see Figure E-4 above), a method was needed to make them available to CINDY and LUDEP. The available choices included careful review of the data records for entries representing a calculation of a numerical quantity for the sample that was reported as NDA. Figure B-3, Appendix B illustrates such a case. Those were used whenever possible. For the remaining samples, options included recalculation from the recorded counting data, arbitrarily setting the value to zero, or arbitrarily setting the value to the lower limit of detection (0.003 pCi/day) for alpha spectrometry samples. All of those approaches were used.

E.4.1.2.4 Weighting Factors for Urine Measurements

Section 3.2.1.1 discusses the selection of weighting factors for estimating intakes from bioassay measurements and Section 3.2.2 summarizes some performance tests. Those were confirmed for the High 26 Cases Group data. Selection of the "ratio-of-the-means" method in CINDY and the "errors included in data set" method for LUDEP provided conservative estimates of intake. That is, the selected methods provided estimates that were balanced between being unreasonably high and artificially low.

E.4.1.3. Results

The methods applied to estimating intakes and doses described above were applied to the 26 individual cases. Some adjustments were necessary to accommodate the specific data qualities for each case. Although intake and committed dose equivalent dose to organs, and committed effective dose equivalent were estimated, they are not adopted as official estimates for any individual because of the difficulties discussed earlier in the report. This section summarizes the overall results and discusses approaches for developing estimates that are more reasonable.

The urine results for the 26 individuals in this group exhibited two common traits that could have substantially affected the intake estimates and doses. These traits were 1) an unexpectedly rapid decrease in urine concentration for follow-up program samples, and significant variation in replicate analyses of individual samples. Figure D-5 illustrates these two traits.

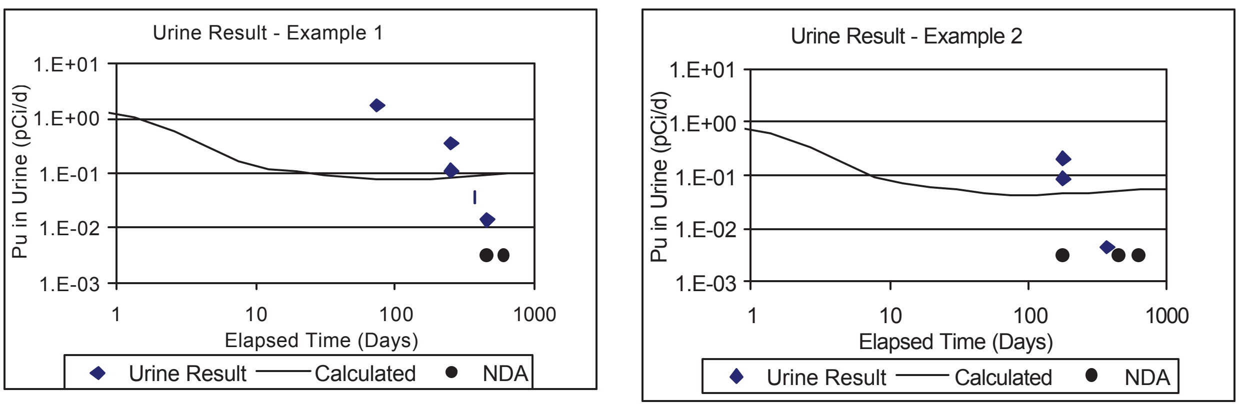


Figure E- 5. Examples of urine result characteristics.

Interestingly, most samples in this group show decreasing urinary excretion, usually reaching the non-detectable level for later samples. Of course, if those latter values are correct, then the estimated intakes and corresponding doses would be much lower than reported in this study. Alternately, the rapid decrease in value could be related to improved laboratory capability.

The variability of replicate measurements was only reported for a few samples. However, if those reported are typical of the analytical performance, then similar variability would be expected for the other samples. Unfortunately, there are no data to support this possibility.

E.4.1.3.1 Intakes and Doses from Urinalysis

For the 26 cases, the preliminary intake estimates varied from 34,000 pCi to 570,00 pCi from CINDY and 19,000 pCi to 2,600,000 pCi from LUDEP with the gross alpha results excluded in all the cases. Estimates of committed effective dose equivalent ranged from 10 rem to 170 rem (0.1 to 1.7 Sv) from CINDY and 1.3 to 180 rem (0.013 to 1.8 Sv) from LUDEP. LUDEP ranged from –83% to +150% of CINDY results. The range of differences between LUDEP results and CINDY results seems reasonable considering the variation in the data and the complexities of the assessment. In addition to the intakes and CEDE estimates, 50-year committed dose equivalents were calculated for organs using CINDY. Those results are listed in Table E-5 to illustrate the range of estimated values. However, when compared with independent estimates from environmental data and with the results of other exposure cases, these estimates seem unreasonably high.

Table E- 5. High 26 Preliminary Intake, Committed Dose Equivalent and Committed Effective Dose Equivalent Estimates.

Subject	Intake (pCi)	CEDE	Testes	Breast	R Marrow	Lung	Thyroid	Bone Sur	Liver	Other	LL Int.	UL Int.	S Int.
Data Masked	6.8E+04	21	3.0	0.0	16.3	76.9	0.0	212.9	38.4	3.5	0.0	0.0	0.0
Data Masked	8.6E+04	26	3.7	0.0	20.6	97.2	0.0	269.2	48.6	4.5	0.0	0.0	0.0
Data Masked	6.2E+04	19	2.7	0.0	14.8	70.1	0.0	194.1	35.0	3.2	0.0	0.0	0.0
Data Masked	6.3E+04	19	2.7	0.0	15.1	71.2	0.0	197.2	35.6	3.3	0.0	0.0	0.0
Data Masked	5.60E+05	170	24.3	0.0	133.9	633.0	0.0	1753.0	316.5	29.2	0.1	0.0	0.0
Data Masked	6.5E+04	20	2.8	0.0	15.5	73.5	0.0	203.5	36.7	3.4	0.0	0.0	0.0
Data Masked	1.6E+05	49	7.0	0.0	38.3	180.9	0.0	500.9	90.4	8.3	0.0	0.0	0.0
Data Masked	1.1E+05	34	4.8	0.0	26.3	124.3	0.0	344.3	62.2	5.7	0.0	0.0	0.0
Data Masked	4.2E+04	13	1.8	0.0	10.0	47.5	0.0	131.5	23.7	2.2	0.0	0.0	0.0
Data Masked	6.4E+04	20	2.8	0.0	15.3	72.3	0.0	200.3	36.2	3.3	0.0	0.0	0.0
Data Masked	5.5E+04	17	2.4	0.0	13.2	62.2	0.0	172.2	31.1	2.9	0.0	0.0	0.0
Data Masked	4.4E+04	14	1.9	0.0	10.5	49.7	0.0	137.7	24.9	2.3	0.0	0.0	0.0
Data Masked	7.6E+04	23	3.3	0.0	18.2	85.9	0.0	237.9	43.0	4.0	0.0	0.0	0.0
Data Masked	7.2E+04	22	3.1	0.0	17.2	81.4	0.0	225.4	40.7	3.8	0.0	0.0	0.0
Data Masked	1.8E+05	55	7.8	0.0	43.0	203.5	0.0	563.5	101.7	9.4	0.0	0.0	0.0
Data Masked	2.1E+05	65	9.1	0.0	50.2	237.4	0.0	657.4	118.7	11.0	0.0	0.0	0.0
Data Masked	6.6E+04	20	2.9	0.0	15.8	74.6	0.0	206.6	37.3	3.4	0.0	0.0	0.0
Data Masked	6.8E+04	21	3.0	0.0	16.3	76.9	0.0	212.9	38.4	3.5	0.0	0.0	0.0
Data Masked	6.9E+04	21	3.0	0.0	16.5	78.0	0.0	216.0	39.0	3.6	0.0	0.0	0.0
Data Masked	3.4E+04	10	1.5	0.0	8.1	38.4	0.0	106.4	19.2	1.8	0.0	0.0	0.0
Data Masked	1.00E+05	31	4.3	0.0	23.9	113.0	0.0	313.0	56.5	5.2	0.0	0.0	0.0
Data Masked	7.1E+04	22	3.1	0.0	17.0	80.3	0.0	222.3	40.1	3.7	0.0	0.0	0.0
Data Masked	4.4E+04	14	1.9	0.0	10.5	49.7	0.0	137.7	24.9	2.3	0.0	0.0	0.0
Data Masked	5.8E+04	18	2.5	0.0	13.9	65.6	0.0	181.6	32.8	3.0	0.0	0.0	0.0
Data Masked	6.4E+04	20	2.8	0.0	15.3	72.3	0.0	200.3	36.2	3.3	0.0	0.0	0.0
Data Masked	9.9E+04	30	4.3	0.0	23.7	111.9	0.0	309.9	56.0	5.2	0.0	0.0	0.0

Annual dose equivalents to the organs and effective dose equivalent per year are shown in Figure E-6 for an intake of 34,000 pCi; the lowest intake estimated by CINDY. These curves represent the accumulation of dose to the specified organ in each year following exposure. Readers should note that the lung dose dominants for the first few years. According to this estimate, the bone dose then predominates thereafter, reaching a maximum at around 13 years following exposure and then slowly declining. These curves illustrate the need to consider both the delivery of the dose and the 50-year cumulative total when assessing the potential for health effects.

E.4.2. Repeat Analysis Cases Group

Palomares responders were placed in the Repeat Analysis Cases Group if they met one or both of the following conditions:

- They submitted an initial urine sample while on site that was analyzed for gross alpha radioactivity and then reanalyzed by alpha spectrometry for ^{239}Pu; or
- They submitted an initial sample while on site that was analyzed by gross alpha counting and then submitted one or more follow-up samples after returning to their base of assignment for analysis by alpha spectrometry.

In general, the urine measurements for this group were not as robust as those for the High 26 Cases Group and follow-up did not extend beyond an initial resampling attempt. The following sections discuss the urine measurements available for this group, the process of estimating the intakes and dose equivalents, and the results.

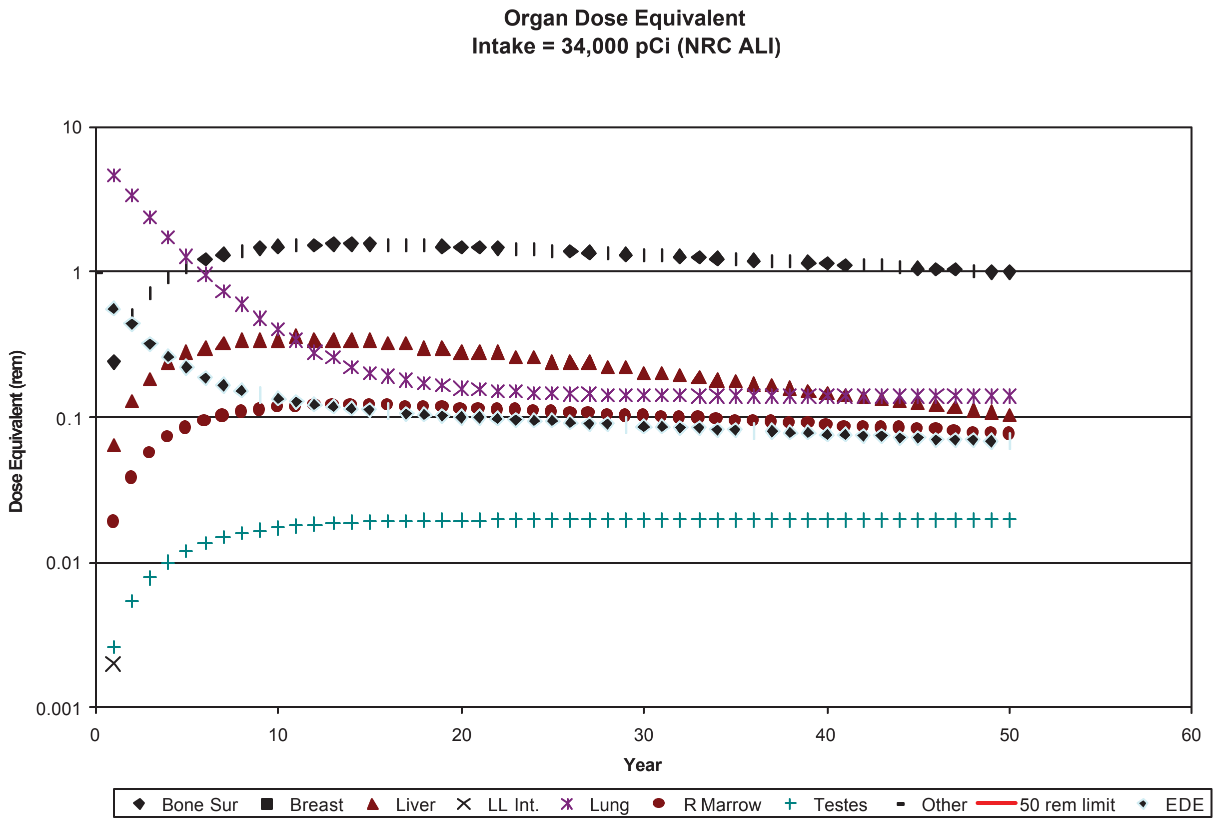


Figure E- 6. Annual organ dose equivalent for 34,000 pCi intake of ^{239}Pu.

E.4.2.1. Urine Bioassay Measurement Characteristics

The Repeat Analysis Cases Group provided 82 urine samples that produced usable results. Other samples submitted did not produce usable results for several reasons. These reasons included laboratory errors during processing and chemical recoveries that were unreported, too low to be measured or below 40%. This project established a minimum requirement for chemical recovery at 40% for alpha spectrometry samples as a reasonable lower limit for credible results. The 82 samples were collected from 54 individuals during January 17, 1966 to June 22, 1966. Figure E-7 illustrates the distribution of sample results obtained for this group. Most of the samples (88) were collected on dates (before April 3, 1966) that represent on-site activity, while 66 samples were collected after that time. The results indicate that the gross alpha and alpha spectrometry measurements are primarily greater than 0.1 pCi/d and that the two types of measurements are interspersed among one another. Gross alpha results, however, tended to have higher values than the alpha spectrometry measurements.

A more detailed review of the data indicated that the samples and analyses were distributed as shown in Table E-6. This distribution seemed to imply that most of the samples were characterized by a gross alpha measurement followed by reanalysis by alpha spectrometry in an attempt to identify the radionuclide responsible for the gross alpha result. In most cases, the alpha spectrometry result was lower than the gross alpha measurement. Twenty-three individuals were characterized by this situation. Unfortunately, resampling was not accomplished for those in this group of 23.

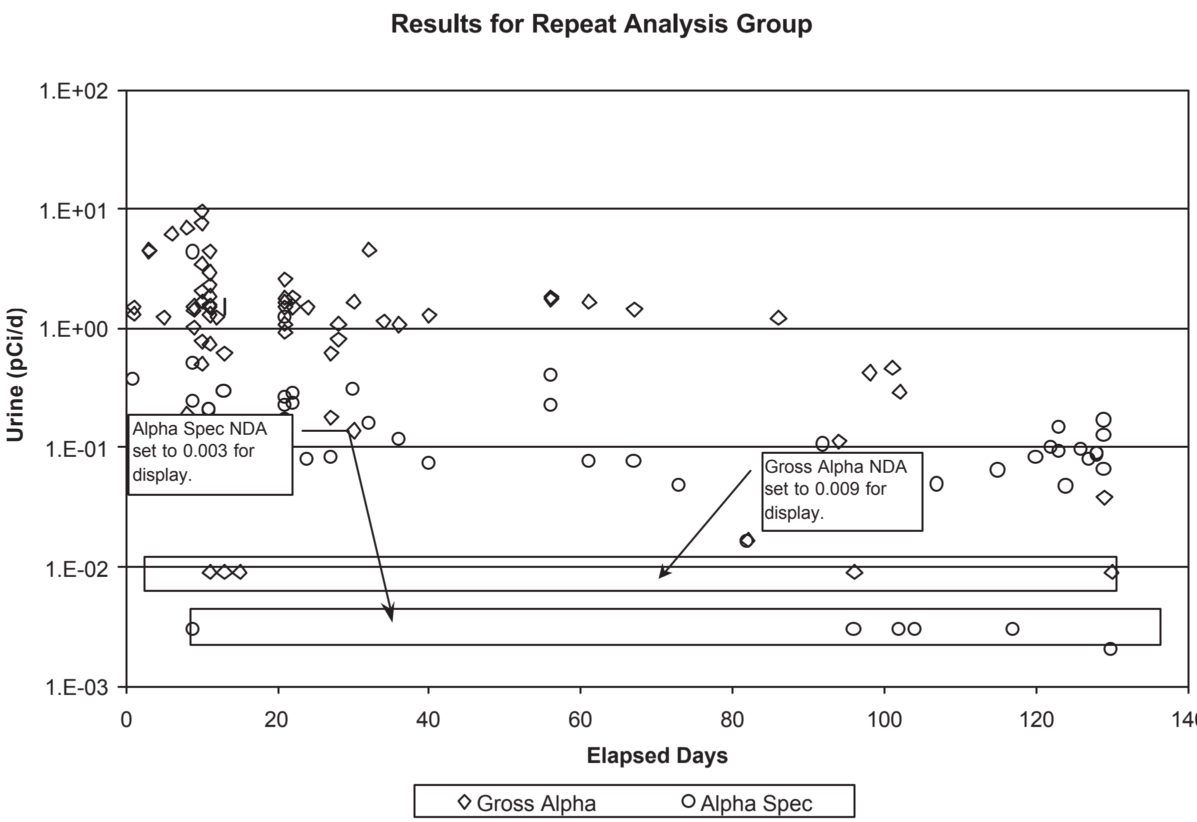


Figure E- 7. Results for Repeat Analysis Cases Group.

The remaining 31 individuals had records characterized by at least two samples with gross alpha measurements on the initial sample and gross alpha or alpha spectrometry or both on the resample. Alpha spectrometry measurements were performed on several initial samples.

Table E- 6. Distribution of Samples for the Repeat Analysis Cases Group.

Number of Samples	Number of Submitters
1	23
2	25
3	3
4	1
5	2

E.4.2.1.1 Date of Exposure

The Repeat Analysis Cases Group had exposure dates that extended over a broader range of dates than the High 26 Cases Group. However, many were among the initial responders who arrived in January 1966. Many stayed on site for one to two weeks, with some up to a month. A few may have remained until the very end of operations. Just as for the High 26 Cases Group, some sample dates were not available in their records and were assigned. Since the time on site seemed shorter and better recorded for this group, the exposure date was assumed as the midpoint of the time at Camp Wilson.

E.4.2.1.2 Use of Measurements

Many gross alpha results for resamples were not reported at all. Therefore, the approach to calculating the estimated intake assumed the following.

- Gross alpha results for samples collected on site were excluded from the analysis.
- Gross alpha results reported as NDA were included with an assumed value of 0.009 pCi/d.
- Alpha spectrometry results reported as NDA were reviewed and numerical values included if found on data cards.
- Some alpha spectrometry results that did not fit the expected urinary excretion pattern were excluded even if the sample was not collected on site.

E.4.2.1.3 Weighting Factors for Urine Measurements

Section 3.2.1.1 discusses the selection of weighting factors for estimating intakes from bioassay measurements and Section 3.2.2 summarizes some performance tests. Those were confirmed for the High 26 Cases Group data and applied to the Repeat Analysis Cases Group.

E.4.2.2. Results

The methods used for estimating intakes and doses for the High 26 Cases Group were applied to the Repeat Analysis Cases Group. Some adjustments were necessary to accommodate the specific data qualities for each case. The results are anonymously listed in Table E-7. This section summarizes the overall results and discusses approaches for developing estimates that are more reasonable.

E.4.2.2.1 Intakes and Doses

For the 54 cases, the estimated intakes varied from 2,900 pCi to 1,300,000 pCi from CINDY and 11,900 pCi to 5,240,000 pCi from LUDEP with the gross alpha results excluded in all the cases. Estimates of committed effective dose equivalent ranged from 0.9 rem to 400 rem (0.009 to 4.0 Sv) from CINDY and 0.8 to 367 rem (0.008 to 3.67 Sv) from LUDEP. LUDEP results ranged from –238% to +94% of CINDY results. In addition to the intakes and ŒDE estimates, annual dose equivalents and committed dose equivalents were calculated for organs using both CINDY and LUDEP.

Table E- 7. Repeat Analysis Group Preliminary Intake, Committed Dose Equivalent, and Committed Effective Dose Equivalent Estimates.

Name	Intake (pCi)	CEDE	Testes	Breast	R Marrow	Lung	Thyroid	Bone Sur	Liver	Other	LL Int.	UL Int.	S Int.
Data Masked	1.00E+05	31	4.3	0.0	23.9	113.0	0.0	313.0	56.5	5.2	0.0	0.0	0.0
Data Masked	1.70E+05	54	7.4	0.0	40.7	192.2	0.0	532.2	96.1	8.9	0.0	0.0	0.0
Data Masked	4.40E+03	1.4	0.2	0.0	1.1	5.0	0.0	13.8	2.5	0.2	0.0	0.0	0.0
Data Masked	6.90E+04	21	3.0	0.0	16.5	78.0	0.0	216.0	39.0	3.6	0.0	0.0	0.0
Data Masked	2.30E+04	7.1	1.0	0.0	5.5	26.0	0.0	72.0	13.0	1.2	0.0	0.0	0.0
Data Masked	1.40E+05	43	6.1	0.0	33.5	158.3	0.0	438.3	79.1	7.3	0.0	0.0	0.0
Data Masked	9.40E+05	290	40.9	0.0	224.8	1062.6	0.0	2942.6	531.3	49.0	0.1	0.0	0.0
Data Masked	1.90E+05	58	8.3	0.0	45.4	214.8	0.0	594.8	107.4	9.9	0.0	0.0	0.0
Data Masked	1.10E+05	34	4.8	0.0	26.3	124.3	0.0	344.3	62.2	5.7	0.0	0.0	0.0
Data Masked	4.30E+03	1.3	0.2	0.0	1.0	4.9	0.0	13.5	2.4	0.2	0.0	0.0	0.0
Data Masked	3.10E+05	95	13.5	0.0	74.1	350.4	0.0	970.4	175.2	16.2	0.0	0.0	0.0
Data Masked	2.00E+05	61	8.7	0.0	47.8	226.1	0.0	626.1	113.0	10.4	0.0	0.0	0.0
Data Masked	1.50E+05	46	6.5	0.0	35.9	169.6	0.0	469.6	84.8	7.8	0.0	0.0	0.0
Data Masked	3.90E+05	120	17.0	0.0	93.3	440.9	0.0	1220.9	220.4	20.3	0.0	0.0	0.0
Data Masked	3.60E+05	110	15.7	0.0	86.1	407.0	0.0	1127.0	203.5	18.8	0.0	0.0	0.0
Data Masked	2.60E+04	8	1.1	0.0	6.2	29.4	0.0	81.4	14.7	1.4	0.0	0.0	0.0
Data Masked	4.40E+03	1.4	0.2	0.0	1.1	5.0	0.0	13.8	2.5	0.2	0.0	0.0	0.0
Data Masked	1.90E+05	58	8.3	0.0	45.4	214.8	0.0	594.8	107.4	9.9	0.0	0.0	0.0
Data Masked	5.50E+05	170	23.9	0.0	131.5	621.7	0.0	1721.7	310.9	28.7	0.1	0.0	0.0
Data Masked	2.90E+03	0.89	0.1	0.0	0.7	3.3	0.0	9.1	1.6	0.2	0.0	0.0	0.0
Data Masked	1.20E+05	37	5.2	0.0	28.7	135.7	0.0	375.7	67.8	6.3	0.0	0.0	0.0
Data Masked	4.40E+03	1.4	0.2	0.0	1.1	5.0	0.0	13.8	2.5	0.2	0.0	0.0	0.0
Data Masked	1.30E+06	400	56.5	0.0	310.9	1469.6	0.0	4069.6	734.8	67.8	0.1	0.0	0.0
Data Masked	9.40E+04	29	4.1	0.0	22.5	106.3	0.0	294.3	53.1	4.9	0.0	0.0	0.0
Data Masked	4.70E+03	1.4	0.2	0.0	1.1	5.3	0.0	14.7	2.7	0.2	0.0	0.0	0.0
Data Masked	1.80E+05	55	7.8	0.0	43.0	203.5	0.0	563.5	101.7	9.4	0.0	0.0	0.0
Data Masked	4.00E+05	120	17.4	0.0	95.7	452.2	0.0	1252.2	226.1	20.9	0.0	0.0	0.0
Data Masked	4.90E+04	15	2.1	0.0	11.7	55.4	0.0	153.4	27.7	2.6	0.0	0.0	0.0
Data Masked	3.20E+04	9.8	1.4	0.0	7.7	36.2	0.0	100.2	18.1	1.7	0.0	0.0	0.0
Data Masked	9.20E+04	28	4.0	0.0	22.0	104.0	0.0	288.0	52.0	4.8	0.0	0.0	0.0
Data Masked	2.50E+05	77	10.9	0.0	59.8	282.6	0.0	782.6	141.3	13.0	0.0	0.0	0.0
Data Masked	9.30E+04	29	4.0	0.0	22.2	105.1	0.0	291.1	52.6	4.9	0.0	0.0	0.0
Data Masked	1.80E+05	55	7.8	0.0	43.0	203.5	0.0	563.5	101.7	9.4	0.0	0.0	0.0
Data Masked	1.40E+05	43	6.1	0.0	33.5	158.3	0.0	438.3	79.1	7.3	0.0	0.0	0.0
Data Masked	1.30E+05	40	5.7	0.0	31.1	147.0	0.0	407.0	73.5	6.8	0.0	0.0	0.0
Data Masked	2.70E+05	83	11.7	0.0	64.6	305.2	0.0	845.2	152.6	14.1	0.0	0.0	0.0
Data Masked	6.80E+04	21	3.0	0.0	16.3	76.9	0.0	212.9	38.4	3.5	0.0	0.0	0.0
Data Masked	2.10E+05	65	9.1	0.0	50.2	237.4	0.0	657.4	118.7	11.0	0.0	0.0	0.0
Data Masked	7.70E+03	2.4	0.3	0.0	1.8	8.7	0.0	24.1	4.4	0.4	0.0	0.0	0.0
Data Masked	2.40E+05	74	10.4	0.0	57.4	271.3	0.0	751.3	135.7	12.5	0.0	0.0	0.0
Data Masked	2.70E+05	83	11.7	0.0	64.6	305.2	0.0	845.2	152.6	14.1	0.0	0.0	0.0
Data Masked	1.40E+05	43	6.1	0.0	33.5	158.3	0.0	438.3	79.1	7.3	0.0	0.0	0.0
Data Masked	1.10E+05	34	4.8	0.0	26.3	124.3	0.0	344.3	62.2	5.7	0.0	0.0	0.0
Data Masked	2.80E+04	8.6	1.2	0.0	6.7	31.7	0.0	87.7	15.8	1.5	0.0	0.0	0.0
Data Masked	9.50E+04	29	4.1	0.0	22.7	107.4	0.0	297.4	53.7	5.0	0.0	0.0	0.0
Data Masked	3.10E+05	95	13.5	0.0	74.1	350.4	0.0	970.4	175.2	16.2	0.0	0.0	0.0
Data Masked	1.10E+05	34	4.8	0.0	26.3	124.3	0.0	344.3	62.2	5.7	0.0	0.0	0.0
Data Masked	1.90E+05	58	8.3	0.0	45.4	214.8	0.0	594.8	107.4	9.9	0.0	0.0	0.0
Data Masked	1.40E+05	43	6.1	0.0	33.5	158.3	0.0	438.3	79.1	7.3	0.0	0.0	0.0
Data Masked	1.40E+05	43	6.1	0.0	33.5	158.3	0.0	438.3	79.1	7.3	0.0	0.0	0.0
Data Masked	1.20E+05	37	5.2	0.0	28.7	135.7	0.0	375.7	67.8	6.3	0.0	0.0	0.0
Data Masked	1.85E+05	55	8.0	0.0	44.2	209.1	0.0	579.1	104.6	9.7	0.0	0.0	0.0
Data Masked	4.40E+03	1.4	0.2	0.0	1.1	5.0	0.0	13.8	2.5	0.2	0.0	0.0	0.0
Data Masked	4.00E+05	120	17.4	0.0	95.7	452.2	0.0	1252.2	226.1	20.9	0.0	0.0	0.0

E.4.3. Contamination Cutoff Cases Group

The Contamination Cutoff Cases Group of analyses was created to calculate estimated intake and dose equivalent for those whose urine measurement results indicated potentially contaminated samples collected at the accident site but were below a reasonable minimum level that did not represent unusually high exposures. While the data for this group were not found especially robust, this approach allows additional cases to be evaluated. As discussed in Section 4.4.2, a level of 0.1 pCi/d was adopted as reasonable maximum level for cases included in the Contamination Cutoff Cases Group.

E.4.3.1. Urine Bioassay Measurement Characteristics

The Contamination Cutoff Cases Group contained 313 individuals who provided 344 samples. Of the 344 samples, 30 samples were collected on site, had high results and were subsequently reanalyzed. The 314 resamples produced results that were substantially below the values of the initial group of 30 samples. Of the 314 repeat samples, 13 results were produced by alpha spectrometry. Figure E-8 illustrates the distribution of the results with sample collection date. The figure also shows that the majority of samples were collected during the period of on-site activity and were susceptible to sample contamination.

E.4.3.2. Approach to Estimates

The procedures for analysis of the High 26 Cases Group were applied to the Contamination Cutoff Cases Group, except that the intakes and dose equivalents were calculated using only the CINDY program. LUDEP was not used. NDA reports were not encountered in this group.

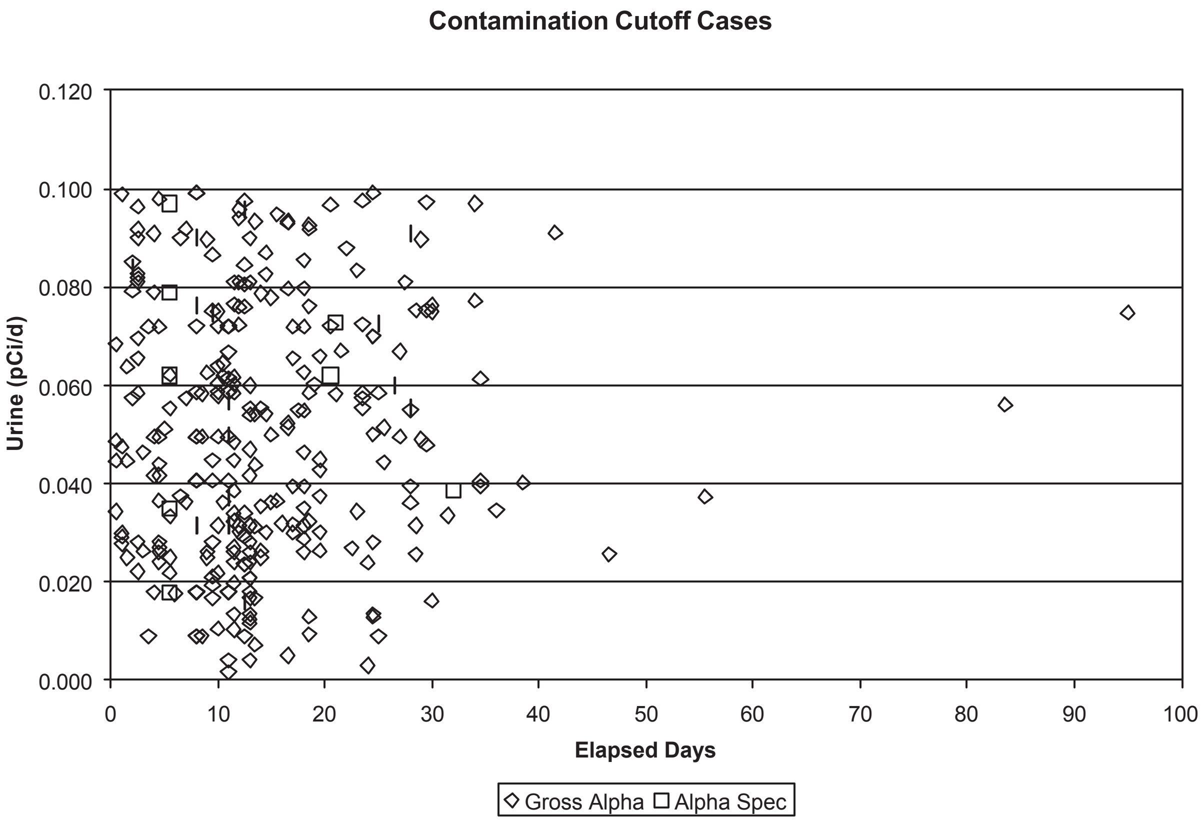


Figure E- 8. Urine results for the Contamination Cutoff Cases Group.

E.4.3.2.1 Date of Exposure

The Contamination Cutoff Cases Group had exposure dates that began over a similar range of dates to the Repeat Analysis Cases Group. Many of this group stayed on site for one to two weeks, with some up to a month. A few appeared to remain until the very end of operations. As for the High 26 Cases Group, some sample dates were assigned. Since the time on site seem shorter and better recorded for this group, the exposure date was assumed as the midpoint of the time at Camp Wilson.

E.4.3.2.2 Use of Measurements

As mentioned in Section D-4.3.1, 30 individuals submitted more than one sample. The lowest results for any individual were used regardless of whether the analysis was performed using gross alpha counting or alpha spectrometry.

E.4.3.2.3 Weighting Factors for Urine Measurements

Each individual case contained only one measurement. Consequently, weighting factors were not a consideration for this group of assessments.

E.4.3.3. Results

The methods used for estimating intakes and doses for the High 26 Cases Group were applied to the Repeat Analysis Cases Group. Some adjustments were necessary to accommodate the specific data qualities for each case. The results for each individual are listed anonymously with the pertinent data used for calculating the estimated intake and dose equivalent in Table E-8. This section summarizes the overall results and discusses approaches for developing estimates that are more reasonable.

E.4.3.3.1 Intakes and Doses

For the 313 individuals in the Contamination Cutoff Cases Group, the estimated intakes varied from 1,500 pCi to 110,000 pCi. Estimates of committed effective dose equivalent ranged from 0.46 rem to 34 rem (0.0046 to 0.34 Sv). The higher intake and dose estimate were produced by a urine sample, taken at 25 days after the assumed exposure date, which produced a result of 0.099 pCi/d of gross alpha activity. According to the excretion function derived, the urinary content on day 25 represents approximately 9×10^{-7} of the inhalation intake. This case illustrates how urine concentrations that are even slightly above detectability can lead to sizeable estimated intakes and dose equivalents.

E.4.3.4. Remaining Cases Group

The individual cases that were not evaluated in one of the previous three groups were placed in the Remaining Cases Group. These samples included those from individuals who submitted only one sample, or from cases where some follow-up was attempted but results were inadequate because of low or no chemical recovery or laboratory error. This group contains sample measurements on 1,063 individuals for 1,219 samples. Figure E-9 illustrates the distribution of the results with positive values. The remaining results were zero, NDA, or not reported.

Table E- 8. Contamination Cutoff Group Preliminary intake, committed dose equivalent, and committed effective dose equivalent estimates.

Name	Intake (pCi)	CEDE	Testes	Breast	R Marrow	Lung	Thyroid	Bone Sur	Liver	Other	LL Int.	UL Int.	S Int.
Data Masked	1.5E+03	0.46	0.1	0.0	0.4	1.7	0.0	4.7	0.8	0.1	0.0	0.0	0.0
Data Masked	2.4E+03	0.74	0.1	0.0	0.6	2.7	0.0	7.5	1.4	0.1	0.0	0.0	0.0
Data Masked	2.5E+03	0.77	0.1	0.0	0.6	2.8	0.0	7.8	1.4	0.1	0.0	0.0	0.0
Data Masked	2.6E+03	0.8	0.1	0.0	0.6	2.9	0.0	8.1	1.5	0.1	0.0	0.0	0.0
Data Masked	2.8E+03	0.86	0.1	0.0	0.7	3.2	0.0	8.8	1.6	0.1	0.0	0.0	0.0
Data Masked	2.9E+03	0.89	0.1	0.0	0.7	3.3	0.0	9.1	1.6	0.2	0.0	0.0	0.0
Data Masked	3.2E+03	0.98	0.1	0.0	0.8	3.6	0.0	10.0	1.8	0.2	0.0	0.0	0.0
Data Masked	3.3E+03	1	0.1	0.0	0.8	3.7	0.0	10.3	1.9	0.2	0.0	0.0	0.0
Data Masked	3.4E+03	1	0.1	0.0	0.8	3.8	0.0	10.6	1.9	0.2	0.0	0.0	0.0
Data Masked	3.6E+03	11	0.2	0.0	0.9	4.1	0.0	11.3	2.0	0.2	0.0	0.0	0.0
Data Masked	3.8E+03	1.2	0.2	0.0	0.9	4.3	0.0	11.9	2.1	0.2	0.0	0.0	0.0
Data Masked	3.8E+03	1.2	0.2	0.0	0.9	4.3	0.0	11.9	2.1	0.2	0.0	0.0	0.0
Data Masked	4.0E+03	1.2	0.2	0.0	1.0	4.5	0.0	12.5	2.3	0.2	0.0	0.0	0.0
Data Masked	4.1E+03	1.3	0.2	0.0	1.0	4.6	0.0	12.8	2.3	0.2	0.0	0.0	0.0
Data Masked	4.7E+03	1.4	0.2	0.0	1.1	5.3	0.0	14.7	2.7	0.2	0.0	0.0	0.0
Data Masked	4.7E+03	1.4	0.2	0.0	1.1	5.3	0.0	14.7	2.7	0.2	0.0	0.0	0.0
Data Masked	5.0E+03	1.5	0.2	0.0	1.2	5.7	0.0	15.7	2.8	0.3	0.0	0.0	0.0
Data Masked	5.5E+03	1.7	0.2	0.0	1.3	6.2	0.0	17.2	3.1	0.3	0.0	0.0	0.0
Data Masked	5.8E+03	1.8	0.3	0.0	1.4	6.6	0.0	18.2	3.3	0.3	0.0	0.0	0.0
Data Masked	6.0E+03	1.8	0.3	0.0	1.4	6.8	0.0	18.8	3.4	0.3	0.0	0.0	0.0
Data Masked	6.1E+03	1.9	0.3	0.0	1.5	6.9	0.0	19.1	3.4	0.3	0.0	0.0	0.0
Data Masked	6.4E+03	2	0.3	0.0	1.5	7.2	0.0	20.0	3.6	0.3	0.0	0.0	0.0
Data Masked	6.4E+03	2	0.3	0.0	1.5	7.2	0.0	20.0	3.6	0.3	0.0	0.0	0.0
Data Masked	6.8E+03	2.1	0.3	0.0	1.6	7.7	0.0	21.3	3.8	0.4	0.0	0.0	0.0
Data Masked	6.8E+03	21	0.3	0.0	1.6	7.7	0.0	21.3	3.8	0.4	0.0	0.0	0.0
Data Masked	7.0E+03	2.2	0.3	0.0	1.7	7.9	0.0	21.9	4.0	0.4	0.0	0.0	0.0
Data Masked	7.9E+03	2.4	0.3	0.0	1.9	8.9	0.0	24.7	4.5	0.4	0.0	0.0	0.0
Data Masked	8.0E+03	2.5	0.3	0.0	1.9	9.0	0.0	25.0	4.5	0.4	0.0	0.0	0.0
Data Masked	8.4E+03	2.6	0.4	0.0	2.0	9.5	0.0	26.3	4.7	0.4	0.0	0.0	0.0
Data Masked	8.6E+03	2.6	0.4	0.0	2.1	9.7	0.0	26.9	4.9	0.4	0.0	0.0	0.0
Data Masked	8.7E+03	2.7	0.4	0.0	2.1	9.8	0.0	27.2	4.9	0.5	0.0	0.0	0.0
Data Masked	9.2E+03	2.8	0.4	0.0	2.2	10.4	0.0	28.8	5.2	0.5	0.0	0.0	0.0
Data Masked	9.4E+03	2.9	0.4	0.0	2.2	10.6	0.0	29.4	5.3	0.5	0.0	0.0	0.0
Data Masked	9.5E+03	2.9	0.4	0.0	2.3	10.7	0.0	29.7	5.4	0.5	0.0	0.0	0.0
Data Masked	9.8E+03	3	0.4	0.0	2.3	11.1	0.0	30.7	5.5	0.5	0.0	0.0	0.0
Data Masked	1.0E+04	3.1	0.4	0.0	2.4	11.3	0.0	31.3	5.7	0.5	0.0	0.0	0.0
Data Masked	1.0E+04	3.1	0.4	0.0	2.4	11.3	0.0	31.3	5.7	0.5	0.0	0.0	0.0
Data Masked	1.1E+04	3.4	0.5	0.0	2.6	12.4	0.0	34.4	6.2	0.6	0.0	0.0	0.0
Data Masked	1.1E+04	3.4	0.5	0.0	2.6	12.4	0.0	34.4	6.2	0.6	0.0	0.0	0.0
Data Masked	1.1E+04	3.4	0.5	0.0	2.6	12.4	0.0	34.4	6.2	0.6	0.0	0.0	0.0
Data Masked	1.1E+04	3.4	0.5	0.0	2.6	12.4	0.0	34.4	6.2	0.6	0.0	0.0	0.0
Data Masked	1.1E+04	3.4	0.5	0.0	2.6	12.4	0.0	34.4	6.2	0.6	0.0	0.0	0.0
Data Masked	1.2E+04	3.7	0.5	0.0	2.9	13.6	0.0	37.6	6.8	0.6	0.0	0.0	0.0
Data Masked	1.2E+04	3.7	0.5	0.0	2.9	13.6	0.0	37.6	6.8	0.6	0.0	0.0	0.0
Data Masked	1.2E+04	3.7	0.5	0.0	2.9	13.6	0.0	37.6	6.8	0.6	0.0	0.0	0.0
Data Masked	1.2E+04	3.7	0.5	0.0	2.9	13.6	0.0	37.6	6.8	0.6	0.0	0.0	0.0
Data Masked	1.2E+04	3.7	0.5	0.0	2.9	13.6	0.0	37.6	6.8	0.6	0.0	0.0	0.0
Data Masked	1.2E+04	3.7	0.5	0.0	2.9	13.6	0.0	37.6	6.8	0.6	0.0	0.0	0.0
Data Masked	1.2E+04	3.7	0.5	0.0	2.9	13.6	0.0	37.6	6.8	0.6	0.0	0.0	0.0
Data Masked	1.3E+04	4	0.6	0.0	3.1	14.7	0.0	40.7	7.3	0.7	0.0	0.0	0.0
Data Masked	1.3E+04	4	0.6	0.0	3.1	14.7	0.0	40.7	7.3	0.7	0.0	0.0	0.0
Data Masked	1.3E+04	4	0.6	0.0	3.1	14.7	0.0	40.7	7.3	0.7	0.0	0.0	0.0
Data Masked	1.3E+04	4	0.6	0.0	3.1	14.7	0.0	40.7	7.3	0.7	0.0	0.0	0.0
Data Masked	1.3E+04	4	0.6	0.0	3.1	14.7	0.0	40.7	7.3	0.7	0.0	0.0	0.0
Data Masked	1.3E+04	4	0.6	0.0	3.1	14.7	0.0	40.7	7.3	0.7	0.0	0.0	0.0
Data Masked	1.3E+04	40	0.6	0.0	3.1	14.7	0.0	40.7	7.3	0.7	0.0	0.0	0.0
Data Masked	1.3E+04	4	0.6	0.0	3.1	14.7	0.0	40.7	7.3	0.7	0.0	0.0	0.0
Data Masked	1.4E+04	4.3	0.6	0.0	3.3	15.8	0.0	43.8	7.9	0.7	0.0	0.0	0.0
Data Masked	1.4E+04	4.3	0.6	0.0	3.3	15.8	0.0	43.8	7.9	0.7	0.0	0.0	0.0
Data Masked	1.4E+04	4.3	0.6	0.0	3.3	15.8	0.0	43.8	7.9	0.7	0.0	0.0	0.0
Data Masked	1.5E+04	4.6	0.7	0.0	3.6	17.0	0.0	47.0	8.5	0.8	0.0	0.0	0.0
Data Masked	1.5E+04	4.6	0.7	0.0	3.6	17.0	0.0	47.0	8.5	0.8	0.0	0.0	0.0
Data Masked	1.5E+04	4.6	0.7	0.0	3.6	17.0	0.0	47.0	8.5	0.8	0.0	0.0	0.0
Data Masked	1.5E+04	4.6	0.7	0.0	3.6	17.0	0.0	47.0	8.5	0.8	0.0	0.0	0.0
Data Masked	1.5E+04	4.6	0.7	0.0	3.6	17.0	0.0	47.0	8.5	0.8	0.0	0.0	0.0
Data Masked	1.5E+04	4.6	0.7	0.0	3.6	17.0	0.0	47.0	8.5	0.8	0.0	0.0	0.0
Data Masked	1.6E+04	4.9	0.7	0.0	3.8	18.1	0.0	50.1	9.0	0.8	0.0	0.0	0.0
Data Masked	1.6E+04	4.9	0.7	0.0	3.8	18.1	0.0	50.1	9.0	0.8	0.0	0.0	0.0
Data Masked	1.6E+04	4.9	0.7	0.0	3.8	18.1	0.0	50.1	9.0	0.8	0.0	0.0	0.0
Data Masked	1.6E+04	4.9	0.7	0.0	3.8	18.1	0.0	50.1	9.0	0.8	0.0	0.0	0.0
Data Masked	1.7E+04	5.2	0.7	0.0	4.1	19.2	0.0	53.2	9.6	0.9	0.0	0.0	0.0
Data Masked	1.7E+04	5.2	0.7	0.0	4.1	19.2	0.0	53.2	9.6	0.9	0.0	0.0	0.0
Data Masked	1.7E+04	5.2	0.7	0.0	4.1	19.2	0.0	53.2	9.6	0.9	0.0	0.0	0.0
Data Masked	1.7E+04	5.2	0.7	0.0	4.1	19.2	0.0	53.2	9.6	0.9	0.0	0.0	0.0

Table E- 8. Contamination Cutoff Group Preliminary intake, committed dose equivalent, and committed effective dose equivalent estimates.

Data Masked	1.9E+04	5.8	0.8	0.0	4.5	21.5	0.0	59.5	10.7	1.0	0.0	0.0	0.0
Data Masked	1.9E+04	5.8	0.8	0.0	4.5	21.5	0.0	59.5	10.7	1.0	0.0	0.0	0.0
Data Masked	1.9E+04	5.8	0.8	0.0	4.5	21.5	0.0	59.5	10.7	1.0	0.0	0.0	0.0
Data Masked	2.0E+04	5.8	0.9	0.0	4.8	22.6	0.0	62.6	11.3	1.0	0.0	0.0	0.0
Data Masked	2.1E+04	6.1	0.9	0.0	5.0	23.7	0.0	65.7	11.9	1.1	0.0	0.0	0.0
Data Masked	2.1E+04	6.5	0.9	0.0	5.0	23.7	0.0	65.7	11.9	1.1	0.0	0.0	0.0
Data Masked	2.1E+04	6.5	0.9	0.0	5.0	23.7	0.0	65.7	11.9	1.1	0.0	0.0	0.0
Data Masked	2.1E+04	6.5	0.9	0.0	5.0	23.7	0.0	65.7	11.9	1.1	0.0	0.0	0.0
Data Masked	2.1E+04	6.5	0.9	0.0	5.0	23.7	0.0	65.7	11.9	1.1	0.0	0.0	0.0
Data Masked	2.2E+04	6.5	1.0	0.0	5.3	24.9	0.0	68.9	12.4	1.1	0.0	0.0	0.0
Data Masked	2.2E+04	6.8	1.0	0.0	5.3	24.9	0.0	68.9	12.4	1.1	0.0	0.0	0.0
Data Masked	2.2E+04	6.8	1.0	0.0	5.3	24.9	0.0	68.9	12.4	1.1	0.0	0.0	0.0
Data Masked	2.2E+04	6.8	1.0	0.0	5.3	24.9	0.0	68.9	12.4	1.1	0.0	0.0	0.0
Data Masked	2.2E+04	6.8	1.0	0.0	5.3	24.9	0.0	68.9	12.4	1.1	0.0	0.0	0.0
Data Masked	2.3E+04	6.8	1.0	0.0	5.5	26.0	0.0	72.0	13.0	1.2	0.0	0.0	0.0
Data Masked	2.3E+04	7.1	1.0	0.0	5.5	26.0	0.0	72.0	13.0	1.2	0.0	0.0	0.0
Data Masked	2.3E+04	7.1	1.0	0.0	5.5	26.0	0.0	72.0	13.0	1.2	0.0	0.0	0.0
Data Masked	2.3E+04	7.1	1.0	0.0	5.5	26.0	0.0	72.0	13.0	1.2	0.0	0.0	0.0
Data Masked	2.4E+04	7.1	1.0	0.0	5.7	27.1	0.0	75.1	13.6	1.3	0.0	0.0	0.0
Data Masked	2.4E+04	7.4	1.0	0.0	5.7	27.1	0.0	75.1	13.6	1.3	0.0	0.0	0.0
Data Masked	2.4E+04	7.4	1.0	0.0	5.7	27.1	0.0	75.1	13.6	1.3	0.0	0.0	0.0
Data Masked	2.4E+04	7.4	1.0	0.0	5.7	27.1	0.0	75.1	13.6	1.3	0.0	0.0	0.0
Data Masked	2.4E+04	7.4	1.0	0.0	5.7	27.1	0.0	75.1	13.6	1.3	0.0	0.0	0.0
Data Masked	2.5E+04	7.7	1.1	0.0	6.0	28.3	0.0	78.3	14.1	1.3	0.0	0.0	0.0
Data Masked	2.6E+04	8	1.1	0.0	6.2	29.4	0.0	81.4	14.7	1.4	0.0	0.0	0.0
Data Masked	2.6E+04	8	1.1	0.0	6.2	29.4	0.0	81.4	14.7	1.4	0.0	0.0	0.0
Data Masked	2.6E+04	8	1.1	0.0	6.2	29.4	0.0	81.4	14.7	1.4	0.0	0.0	0.0
Data Masked	2.6E+04	8	1.1	0.0	6.2	29.4	0.0	81.4	14.7	1.4	0.0	0.0	0.0
Data Masked	2.7E+04	8.3	1.2	0.0	6.5	30.5	0.0	84.5	15.3	1.4	0.0	0.0	0.0
Data Masked	2.7E+04	8.3	1.2	0.0	6.5	30.5	0.0	84.5	15.3	1.4	0.0	0.0	0.0
Data Masked	2.7E+04	8.3	1.2	0.0	6.5	30.5	0.0	84.5	15.3	1.4	0.0	0.0	0.0
Data Masked	2.7E+04	8.3	1.2	0.0	6.5	30.5	0.0	84.5	15.3	1.4	0.0	0.0	0.0
Data Masked	2.8E+04	8.6	1.2	0.0	6.7	31.7	0.0	87.7	15.8	1.5	0.0	0.0	0.0
Data Masked	2.8E+04	8.6	1.2	0.0	6.7	31.7	0.0	87.7	15.8	1.5	0.0	0.0	0.0
Data Masked	2.8E+04	8.6	1.2	0.0	6.7	31.7	0.0	87.7	15.8	1.5	0.0	0.0	0.0
Data Masked	2.9E+04	8.9	1.3	0.0	6.9	32.8	0.0	90.8	16.4	1.5	0.0	0.0	0.0
Data Masked	2.9E+04	8.9	1.3	0.0	6.9	32.8	0.0	90.8	16.4	1.5	0.0	0.0	0.0
Data Masked	2.9E+04	8.9	1.3	0.0	6.9	32.8	0.0	90.8	16.4	1.5	0.0	0.0	0.0
Data Masked	2.9E+04	8.9	1.3	0.0	6.9	32.8	0.0	90.8	16.4	1.5	0.0	0.0	0.0
Data Masked	2.9E+04	8.9	1.3	0.0	6.9	32.8	0.0	90.8	16.4	1.5	0.0	0.0	0.0
Data Masked	2.9E+04	8.9	1.3	0.0	6.9	32.8	0.0	90.8	16.4	1.5	0.0	0.0	0.0
Data Masked	2.9E+04	8.9	1.3	0.0	6.9	32.8	0.0	90.8	16.4	1.5	0.0	0.0	0.0
Data Masked	2.9E+04	8.9	1.3	0.0	6.9	32.8	0.0	90.8	16.4	1.5	0.0	0.0	0.0
Data Masked	2.9E+04	8.9	1.3	0.0	6.9	32.8	0.0	90.8	16.4	1.5	0.0	0.0	0.0
Data Masked	2.9E+04	8.9	1.3	0.0	6.9	32.8	0.0	90.8	16.4	1.5	0.0	0.0	0.0
Data Masked	3.0E+04	9.2	1.3	0.0	7.2	33.9	0.0	93.9	17.0	1.6	0.0	0.0	0.0
Data Masked	3.0E+04	9.2	1.3	0.0	7.2	33.9	0.0	93.9	17.0	1.6	0.0	0.0	0.0
Data Masked	3.0E+04	9.2	1.3	0.0	7.2	33.9	0.0	93.9	17.0	1.6	0.0	0.0	0.0
Data Masked	3.1E+04	9.5	1.3	0.0	7.4	35.0	0.0	97.0	17.5	1.6	0.0	0.0	0.0
Data Masked	3.1E+04	9.5	1.3	0.0	7.4	35.0	0.0	97.0	17.5	1.6	0.0	0.0	0.0
Data Masked	3.1E+04	9.5	1.3	0.0	7.4	35.0	0.0	97.0	17.5	1.6	0.0	0.0	0.0
Data Masked	3.1E+04	9.5	1.3	0.0	7.4	35.0	0.0	97.0	17.5	1.6	0.0	0.0	0.0
Data Masked	3.1E+04	9.5	1.3	0.0	7.4	35.0	0.0	97.0	17.5	1.6	0.0	0.0	0.0
Data Masked	3.1E+04	9.5	1.3	0.0	7.4	35.0	0.0	97.0	17.5	1.6	0.0	0.0	0.0
Data Masked	3.1E+04	9.5	1.3	0.0	7.4	35.0	0.0	97.0	17.5	1.6	0.0	0.0	0.0
Data Masked	3.1E+04	9.5	1.3	0.0	7.4	35.0	0.0	97.0	17.5	1.6	0.0	0.0	0.0
Data Masked	3.2E+04	9.8	1.4	0.0	7.7	36.2	0.0	100.2	18.1	1.7	0.0	0.0	0.0
Data Masked	3.2E+04	9.8	1.4	0.0	7.7	36.2	0.0	100.2	18.1	1.7	0.0	0.0	0.0
Data Masked	3.3E+04	10	1.4	0.0	7.9	37.3	0.0	103.3	18.7	1.7	0.0	0.0	0.0
Data Masked	3.3E+04	10	1.4	0.0	7.9	37.3	0.0	103.3	18.7	1.7	0.0	0.0	0.0
Data Masked	3.3E+04	10	1.4	0.0	7.9	37.3	0.0	103.3	18.7	1.7	0.0	0.0	0.0
Data Masked	3.3E+04	10	1.4	0.0	7.9	37.3	0.0	103.3	18.7	1.7	0.0	0.0	0.0
Data Masked	3.3E+04	10	1.4	0.0	7.9	37.3	0.0	103.3	18.7	1.7	0.0	0.0	0.0
Data Masked	3.3E+04	10	1.4	0.0	7.9	37.3	0.0	103.3	18.7	1.7	0.0	0.0	0.0
Data Masked	3.4E+04	10	1.5	0.0	8.1	38.4	0.0	106.4	19.2	1.8	0.0	0.0	0.0
Data Masked	3.4E+04	10	1.5	0.0	8.1	38.4	0.0	106.4	19.2	1.8	0.0	0.0	0.0
Data Masked	3.4E+04	10	1.5	0.0	8.1	38.4	0.0	106.4	19.2	1.8	0.0	0.0	0.0
Data Masked	3.5E+04	11	1.5	0.0	8.4	39.6	0.0	109.6	19.8	1.8	0.0	0.0	0.0
Data Masked	3.5E+04	11	1.5	0.0	8.4	39.6	0.0	109.6	19.8	1.8	0.0	0.0	0.0
Data Masked	3.5E+04	11	1.5	0.0	8.4	39.6	0.0	109.6	19.8	1.8	0.0	0.0	0.0
Data Masked	3.5E+04	11	1.5	0.0	8.4	39.6	0.0	109.6	19.8	1.8	0.0	0.0	0.0
Data Masked	3.5E+04	11	1.5	0.0	8.4	39.6	0.0	109.6	19.8	1.8	0.0	0.0	0.0
Data Masked	3.6E+04	11	1.6	0.0	8.6	40.7	0.0	112.7	20.3	1.9	0.0	0.0	0.0
Data Masked	3.6E+04	11	1.6	0.0	8.6	40.7	0.0	112.7	20.3	1.9	0.0	0.0	0.0
Data Masked	3.6E+04	11	1.6	0.0	8.6	40.7	0.0	112.7	20.3	1.9	0.0	0.0	0.0

Table E- 8. Contamination Cutoff Group Preliminary intake, committed dose equivalent, and committed effective dose equivalent estimates.

Data Masked	4.1E+04	13	1.8	0.0	9.8	46.3	0.0	128.3	23.2	2.1	0.0	0.0	0.0
Data Masked	4.1E+04	13	1.8	0.0	9.8	46.3	0.0	128.3	23.2	2.1	0.0	0.0	0.0
Data Masked	4.1E+04	13	1.8	0.0	9.8	46.3	0.0	128.3	23.2	2.1	0.0	0.0	0.0
Data Masked	4.2E+04	13	1.8	0.0	10.0	47.5	0.0	131.5	23.7	2.2	0.0	0.0	0.0
Data Masked	4.2E+04	13	1.8	0.0	10.0	47.5	0.0	131.5	23.7	2.2	0.0	0.0	0.0
Data Masked	4.2E+04	13	1.8	0.0	10.0	47.5	0.0	131.5	23.7	2.2	0.0	0.0	0.0
Data Masked	4.3E+04	13	1.9	0.0	10.3	48.6	0.0	134.6	24.3	2.2	0.0	0.0	0.0
Data Masked	4.3E+04	13	1.9	0.0	10.3	48.6	0.0	134.6	24.3	2.2	0.0	0.0	0.0
Data Masked	4.3E+04	13	1.9	0.0	10.3	48.6	0.0	134.6	24.3	2.2	0.0	0.0	0.0
Data Masked	4.4E+04	14	1.9	0.0	10.5	49.7	0.0	137.7	24.9	2.3	0.0	0.0	0.0
Data Masked	4.5E+04	14	2.0	0.0	10.8	50.9	0.0	140.9	25.4	2.3	0.0	0.0	0.0
Data Masked	4.5E+04	14	2.0	0.0	10.8	50.9	0.0	140.9	25.4	2.3	0.0	0.0	0.0
Data Masked	4.6E+04	14	2.0	0.0	11.0	52.0	0.0	144.0	26.0	2.4	0.0	0.0	0.0
Data Masked	4.6E+04	14	2.0	0.0	11.0	52.0	0.0	144.0	26.0	2.4	0.0	0.0	0.0
Data Masked	4.7E+04	14	2.0	0.0	11.2	53.1	0.0	147.1	26.6	2.5	0.0	0.0	0.0
Data Masked	4.7E+04	14	2.0	0.0	11.2	53.1	0.0	147.1	26.6	2.5	0.0	0.0	0.0
Data Masked	4.7E+04	14	2.0	0.0	11.2	53.1	0.0	147.1	26.6	2.5	0.0	0.0	0.0
Data Masked	4.8E+04	15	2.1	0.0	11.5	54.3	0.0	150.3	27.1	2.5	0.0	0.0	0.0
Data Masked	4.9E+04	15	2.1	0.0	11.7	55.4	0.0	153.4	27.7	2.6	0.0	0.0	0.0
Data Masked	4.9E+04	15	2.1	0.0	11.7	55.4	0.0	153.4	27.7	2.6	0.0	0.0	0.0
Data Masked	4.9E+04	15	2.1	0.0	11.7	55.4	0.0	153.4	27.7	2.6	0.0	0.0	0.0
Data Masked	5.0E+04	15	2.2	0.0	12.0	56.5	0.0	156.5	28.3	2.6	0.0	0.0	0.0
Data Masked	5.0E+04	15	2.2	0.0	12.0	56.5	0.0	156.5	28.3	2.6	0.0	0.0	0.0
Data Masked	5.0E+04	15	2.2	0.0	12.0	56.5	0.0	156.5	28.3	2.6	0.0	0.0	0.0
Data Masked	5.0E+04	15	2.2	0.0	12.0	56.5	0.0	156.5	28.3	2.6	0.0	0.0	0.0
Data Masked	5.0E+04	15	2.2	0.0	12.0	56.5	0.0	156.5	28.3	2.6	0.0	0.0	0.0
Data Masked	5.1E+04	16	2.2	0.0	12.2	57.7	0.0	159.7	28.8	2.7	0.0	0.0	0.0
Data Masked	5.1E+04	16	2.2	0.0	12.2	57.7	0.0	159.7	28.8	2.7	0.0	0.0	0.0
Data Masked	5.1E+04	16	2.2	0.0	12.2	57.7	0.0	159.7	28.8	2.7	0.0	0.0	0.0
Data Masked	5.1E+04	16	2.2	0.0	12.2	57.7	0.0	159.7	28.8	2.7	0.0	0.0	0.0
Data Masked	5.1E+04	16	2.2	0.0	12.2	57.7	0.0	159.7	28.8	2.7	0.0	0.0	0.0
Data Masked	5.2E+04	16	2.3	0.0	12.4	58.8	0.0	162.8	29.4	2.7	0.0	0.0	0.0
Data Masked	5.2E+04	16	2.3	0.0	12.4	58.8	0.0	162.8	29.4	2.7	0.0	0.0	0.0
Data Masked	5.2E+04	16	2.3	0.0	12.4	58.8	0.0	162.8	29.4	2.7	0.0	0.0	0.0
Data Masked	5.2E+04	16	2.3	0.0	12.4	58.8	0.0	162.8	29.4	2.7	0.0	0.0	0.0
Data Masked	5.2E+04	16	2.3	0.0	12.4	58.8	0.0	162.8	29.4	2.7	0.0	0.0	0.0
Data Masked	5.2E+04	16	2.3	0.0	12.4	58.8	0.0	162.8	29.4	2.7	0.0	0.0	0.0
Data Masked	5.3E+04	16	2.3	0.0	12.7	59.9	0.0	165.9	30.0	2.8	0.0	0.0	0.0
Data Masked	5.3E+04	16	2.3	0.0	12.7	59.9	0.0	165.9	30.0	2.8	0.0	0.0	0.0
Data Masked	5.3E+04	16	2.3	0.0	12.7	59.9	0.0	165.9	30.0	2.8	0.0	0.0	0.0
Data Masked	5.4E+04	17	2.3	0.0	12.9	61.0	0.0	169.0	30.5	2.8	0.0	0.0	0.0
Data Masked	5.4E+04	17	2.3	0.0	12.9	61.0	0.0	169.0	30.5	2.8	0.0	0.0	0.0
Data Masked	5.4E+04	17	2.3	0.0	12.9	61.0	0.0	169.0	30.5	2.8	0.0	0.0	0.0
Data Masked	5.5E+04	17	2.4	0.0	13.2	62.2	0.0	172.2	31.1	2.9	0.0	0.0	0.0
Data Masked	5.5E+04	17	2.4	0.0	13.2	62.2	0.0	172.2	31.1	2.9	0.0	0.0	0.0
Data Masked	5.5E+04	17	2.4	0.0	13.2	62.2	0.0	172.2	31.1	2.9	0.0	0.0	0.0
Data Masked	5.5E+04	17	2.4	0.0	13.2	62.2	0.0	172.2	31.1	2.9	0.0	0.0	0.0
Data Masked	5.5E+04	17	2.4	0.0	13.2	62.2	0.0	172.2	31.1	2.9	0.0	0.0	0.0
Data Masked	5.5E+04	17	2.4	0.0	13.2	62.2	0.0	172.2	31.1	2.9	0.0	0.0	0.0
Data Masked	5.6E+04	17	2.4	0.0	13.4	63.3	0.0	175.3	31.7	2.9	0.0	0.0	0.0
Data Masked	5.6E+04	17	2.4	0.0	13.4	63.3	0.0	175.3	31.7	2.9	0.0	0.0	0.0
Data Masked	5.7E+04	18	2.5	0.0	13.6	64.4	0.0	178.4	32.2	3.0	0.0	0.0	0.0
Data Masked	5.7E+04	18	2.5	0.0	13.6	64.4	0.0	178.4	32.2	3.0	0.0	0.0	0.0
Data Masked	5.7E+04	18	2.5	0.0	13.6	64.4	0.0	178.4	32.2	3.0	0.0	0.0	0.0
Data Masked	5.7E+04	18	2.5	0.0	13.6	64.4	0.0	178.4	32.2	3.0	0.0	0.0	0.0
Data Masked	5.8E+04	18	2.5	0.0	13.9	65.6	0.0	181.6	32.8	3.0	0.0	0.0	0.0
Data Masked	5.9E+04	18	2.6	0.0	14.1	66.7	0.0	184.7	33.3	3.1	0.0	0.0	0.0
Data Masked	6.0E+04	18	2.6	0.0	14.3	67.8	0.0	187.8	33.9	3.1	0.0	0.0	0.0
Data Masked	6.1E+04	19	2.7	0.0	14.6	69.0	0.0	191.0	34.5	3.2	0.0	0.0	0.0
Data Masked	6.1E+04	19	2.7	0.0	14.6	69.0	0.0	191.0	34.5	3.2	0.0	0.0	0.0
Data Masked	6.1E+04	19	2.7	0.0	14.6	69.0	0.0	191.0	34.5	3.2	0.0	0.0	0.0
Data Masked	6.2E+04	19	2.7	0.0	14.8	70.1	0.0	194.1	35.0	3.2	0.0	0.0	0.0
Data Masked	6.2E+04	19	2.7	0.0	14.8	70.1	0.0	194.1	35.0	3.2	0.0	0.0	0.0
Data Masked	6.2E+04	19	2.7	0.0	14.8	70.1	0.0	194.1	35.0	3.2	0.0	0.0	0.0
Data Masked	6.3E+04	19	2.7	0.0	15.1	71.2	0.0	197.2	35.6	3.3	0.0	0.0	0.0
Data Masked	6.3E+04	19	2.7	0.0	15.1	71.2	0.0	197.2	35.6	3.3	0.0	0.0	0.0
Data Masked	6.3E+04	19	2.7	0.0	15.1	71.2	0.0	197.2	35.6	3.3	0.0	0.0	0.0
Data Masked	6.4E+04	20	2.8	0.0	15.3	72.3	0.0	200.3	36.2	3.3	0.0	0.0	0.0
Data Masked	6.4E+04	20	2.8	0.0	15.3	72.3	0.0	200.3	36.2	3.3	0.0	0.0	0.0
Data Masked	6.4E+04	20	2.8	0.0	15.3	72.3	0.0	200.3	36.2	3.3	0.0	0.0	0.0
Data Masked	6.4E+04	20	2.8	0.0	15.3	72.3	0.0	200.3	36.2	3.3	0.0	0.0	0.0
Data Masked	6.5E+04	20	2.8	0.0	15.5	73.5	0.0	203.5	36.7	3.4	0.0	0.0	0.0
Data Masked	6.5E+04	20	2.8	0.0	15.5	73.5	0.0	203.5	36.7	3.4	0.0	0.0	0.0
Data Masked	6.5E+04	20	2.8	0.0	15.5	73.5	0.0	203.5	36.7	3.4	0.0	0.0	0.0
Data Masked	6.6E+04	20	2.9	0.0	15.8	74.6	0.0	206.6	37.3	3.4	0.0	0.0	0.0

Table E- 8. Contamination Cutoff Group Preliminary intake, committed dose equivalent, and committed effective dose equivalent estimates.

Data Masked	7.2E+04	22	3.1	0.0	17.2	81.4	0.0	225.4	40.7	3.8	0.0	0.0	0.0
Data Masked	7.2E+04	22	3.1	0.0	17.2	81.4	0.0	225.4	40.7	3.8	0.0	0.0	0.0
Data Masked	7.3E+04	22	3.2	0.0	17.5	82.5	0.0	228.5	41.3	3.8	0.0	0.0	0.0
Data Masked	7.3E+04	22	3.2	0.0	17.5	82.5	0.0	228.5	41.3	3.8	0.0	0.0	0.0
Data Masked	7.4E+04	23	3.2	0.0	17.7	83.7	0.0	231.7	41.8	3.9	0.0	0.0	0.0
Data Masked	7.4E+04	23	3.2	0.0	17.7	83.7	0.0	231.7	41.8	3.9	0.0	0.0	0.0
Data Masked	7.5E+04	23	3.3	0.0	17.9	84.8	0.0	234.8	42.4	3.9	0.0	0.0	0.0
Data Masked	7.6E+04	23	3.3	0.0	18.2	85.9	0.0	237.9	43.0	4.0	0.0	0.0	0.0
Data Masked	7.6E+04	23	3.3	0.0	18.2	85.9	0.0	237.9	43.0	4.0	0.0	0.0	0.0
Data Masked	7.7E+04	24	3.3	0.0	18.4	87.0	0.0	241.0	43.5	4.0	0.0	0.0	0.0
Data Masked	7.7E+04	24	3.3	0.0	18.4	87.0	0.0	241.0	43.5	4.0	0.0	0.0	0.0
Data Masked	7.7E+04	24	3.3	0.0	18.4	87.0	0.0	241.0	43.5	4.0	0.0	0.0	0.0
Data Masked	7.8E+04	24	3.4	0.0	18.7	88.2	0.0	244.2	44.1	4.1	0.0	0.0	0.0
Data Masked	7.8E+04	24	3.4	0.0	18.7	88.2	0.0	244.2	44.1	4.1	0.0	0.0	0.0
Data Masked	7.9E+04	24	3.4	0.0	18.9	89.3	0.0	247.3	44.7	4.1	0.0	0.0	0.0
Data Masked	8.0E+04	25	3.5	0.0	19.1	90.4	0.0	250.4	45.2	4.2	0.0	0.0	0.0
Data Masked	8.0E+04	25	3.5	0.0	19.1	90.4	0.0	250.4	45.2	4.2	0.0	0.0	0.0
Data Masked	8.0E+04	25	3.5	0.0	19.1	90.4	0.0	250.4	45.2	4.2	0.0	0.0	0.0
Data Masked	8.1E+04	2.5	3.5	0.0	19.4	91.6	0.0	253.6	45.8	4.2	0.0	0.0	0.0
Data Masked	8.2E+04	25	3.6	0.0	19.6	92.7	0.0	256.7	46.3	4.3	0.0	0.0	0.0
Data Masked	8.3E+04	25	3.6	0.0	19.8	93.8	0.0	259.8	46.9	4.3	0.0	0.0	0.0
Data Masked	8.3E+04	25	3.6	0.0	19.8	93.8	0.0	259.8	46.9	4.3	0.0	0.0	0.0
Data Masked	8.3E+04	25	3.6	0.0	19.8	93.8	0.0	259.8	46.9	4.3	0.0	0.0	0.0
Data Masked	8.5E+04	26	3.7	0.0	20.3	96.1	0.0	266.1	48.0	4.4	0.0	0.0	0.0
Data Masked	8.5E+04	26	3.7	0.0	20.3	96.1	0.0	266.1	48.0	4.4	0.0	0.0	0.0
Data Masked	8.5E+04	26	3.7	0.0	20.3	96.1	0.0	266.1	48.0	4.4	0.0	0.0	0.0
Data Masked	8.6E+04	26	3.7	0.0	20.6	97.2	0.0	269.2	48.6	4.5	0.0	0.0	0.0
Data Masked	8.7E+04	27	3.8	0.0	20.8	98.3	0.0	272.3	49.2	4.5	0.0	0.0	0.0
Data Masked	8.7E+04	2.7	3.8	0.0	20.8	98.3	0.0	272.3	49.2	4.5	0.0	0.0	0.0
Data Masked	8.7E+04	27	3.8	0.0	20.8	98.3	0.0	272.3	49.2	4.5	0.0	0.0	0.0
Data Masked	8.8E+04	27	3.8	0.0	21.0	99.5	0.0	275.5	49.7	4.6	0.0	0.0	0.0
Data Masked	8.8E+04	27	3.8	0.0	21.0	99.5	0.0	275.5	49.7	4.6	0.0	0.0	0.0
Data Masked	8.9E+04	27	3.9	0.0	21.3	100.6	0.0	278.6	50.3	4.6	0.0	0.0	0.0
Data Masked	8.9E+04	27	3.9	0.0	21.3	100.6	0.0	278.6	50.3	4.6	0.0	0.0	0.0
Data Masked	9.0E+04	28	3.9	0.0	21.5	101.7	0.0	281.7	50.9	4.7	0.0	0.0	0.0
Data Masked	9.1E+04	28	4.0	0.0	21.8	102.9	0.0	284.9	51.4	4.7	0.0	0.0	0.0
Data Masked	9.2E+04	28	4.0	0.0	22.0	104.0	0.0	288.0	52.0	4.8	0.0	0.0	0.0
Data Masked	9.2E+04	28	4.0	0.0	22.0	104.0	0.0	288.0	52.0	4.8	0.0	0.0	0.0
Data Masked	9.3E+04	29	4.0	0.0	22.2	105.1	0.0	291.1	52.6	4.9	0.0	0.0	0.0
Data Masked	9.3E+04	29	4.0	0.0	22.2	105.1	0.0	291.1	52.6	4.9	0.0	0.0	0.0
Data Masked	9.3E+04	29	4.0	0.0	22.2	105.1	0.0	291.1	52.6	4.9	0.0	0.0	0.0
Data Masked	9.4E+04	29	4.1	0.0	22.5	106.3	0.0	294.3	53.1	4.9	0.0	0.0	0.0
Data Masked	9.4E+04	29	4.1	0.0	22.5	106.3	0.0	294.3	53.1	4.9	0.0	0.0	0.0
Data Masked	9.6E+04	29	4.2	0.0	23.0	108.5	0.0	300.5	54.3	5.0	0.0	0.0	0.0
Data Masked	9.7E+04	30	4.2	0.0	23.2	109.7	0.0	303.7	54.8	5.1	0.0	0.0	0.0
Data Masked	1.0E+05	31	4.3	0.0	23.9	113.0	0.0	313.0	56.5	5.2	0.0	0.0	0.0
Data Masked	1.0E+05	31	4.3	0.0	23.9	113.0	0.0	313.0	56.5	5.2	0.0	0.0	0.0
Data Masked	1.0E+05	31	4.3	0.0	23.9	113.0	0.0	313.0	56.5	5.2	0.0	0.0	0.0
Data Masked	1.0E+05	31	4.3	0.0	23.9	113.0	0.0	313.0	56.5	5.2	0.0	0.0	0.0
Data Masked	1.0E+05	31	4.3	0.0	23.9	113.0	0.0	313.0	56.5	5.2	0.0	0.0	0.0
Data Masked	1.1E+05	34	4.8	0.0	26.3	124.3	0.0	344.3	62.2	5.7	0.0	0.0	0.0
Data Masked	1.1E+05	34	4.8	0.0	26.3	124.3	0.0	344.3	62.2	5.7	0.0	0.0	0.0
Data Masked	1.1E+05	34	4.8	0.0	26.3	124.3	0.0	344.3	62.2	5.7	0.0	0.0	0.0
Data Masked	1.1E+05	34	4.8	0.0	26.3	124.3	0.0	344.3	62.2	5.7	0.0	0.0	0.0
Data Masked	1.2E+05	37	5.2	0.0	28.7	135.7	0.0	375.7	67.8	6.3	0.0	0.0	0.0
Data Masked	1.2E+05	37	5.2	0.0	28.7	135.7	0.0	375.7	67.8	6.3	0.0	0.0	0.0
Data Masked	1.2E+05	37	5.2	0.0	28.7	135.7	0.0	375.7	67.8	6.3	0.0	0.0	0.0
Data Masked	1.2E+05	37	5.2	0.0	28.7	135.7	0.0	375.7	67.8	6.3	0.0	0.0	0.0
Data Masked	1.5E+05	46	6.5	0.0	35.9	169.6	0.0	469.6	84.8	7.8	0.0	0.0	0.0
Data Masked	1.5E+05	46	6.5	0.0	35.9	169.6	0.0	469.6	84.8	7.8	0.0	0.0	0.0

E.4.3.5. Approach to Estimates

Intake and dose were not estimated for individuals in the Remaining Cases Group because sample contamination from on-site collection was suspected and because the sample data contained uncertainties about exposure dates and recorded sample collection dates. However, the lowest and the highest urine results of 0 and 237.9 pCi/d of gross alpha radioactivity were input to CINDY, and produced estimated intakes of 75,000 pCi to 20,000,000 pCi corresponding to CEDEs of about 23 rem to 6,000 rem (0.23 to 60 Sv). Results of this magnitude are clearly unrealistic, not supported by the air concentrations observed at Palomares and require careful evaluation.

E.4.3.6. Results

A range of estimates for the Remaining Cases Group showed that the intakes could range from 75,000 pCi to 20,000,000 pCi with CEDEs of 23 rem to 6,000 rem (0.23 to 60 Sv). The upper end of the range represents very substantial exposures that should not be attributed to any individual without follow-up sampling to provide confirmation of the results. Additional efforts could be made to determine more details about the specific dates of assignment and duties of the individuals. These estimates indicate the possible difficulties that may be encountered when samples, contaminated from collected on site, are analyzed. Unfortunately, the possibility of contamination prevents useful evaluation of these data, especially without the benefit of follow-up samples.

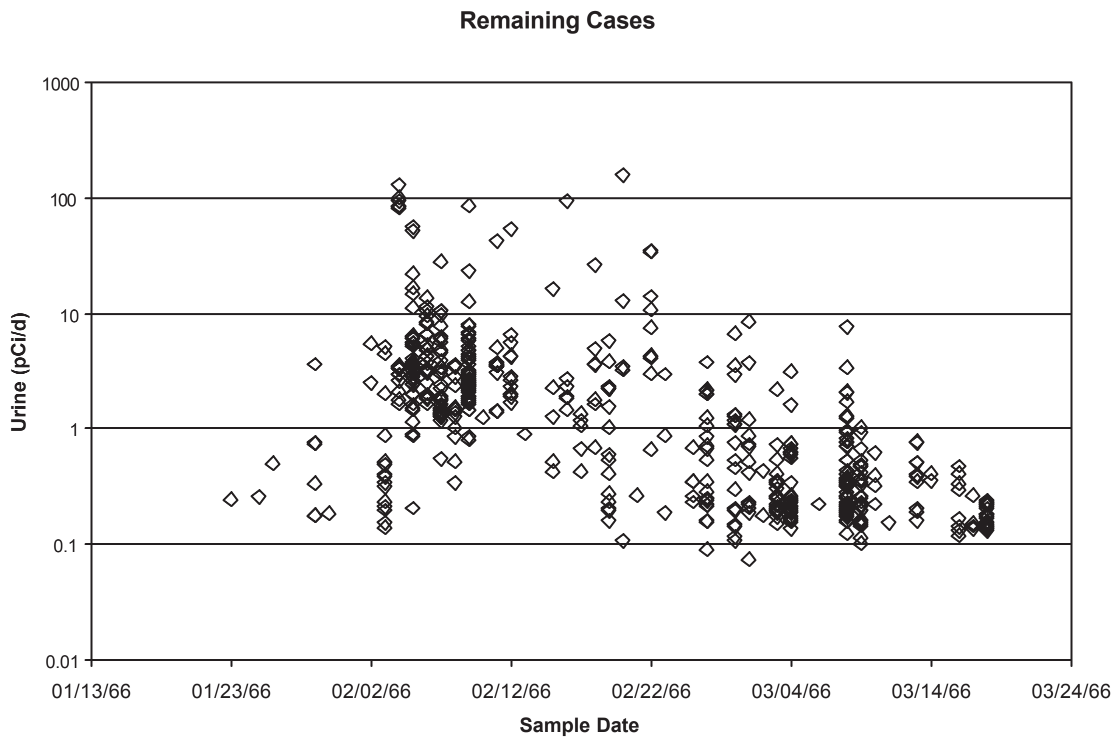


Figure E- 9. Urine results for the Remaining Cases Group.

As a final note, Figure E-9 shows a decreasing trend for the sample results. If resampling had been extended beyond the end of March 1966 as for some other groups, there is ample reason to expect that urinary excretion for this group would have followed similar patterns. Consequently, there are no more reasons to believe that this group received unusual exposures than the other groups. However, the data are simply not available to confirm the status of the individuals in this group. Therefore, follow-up sampling now for selected members of this group could provide information for re-evaluation of the possible exposures.

Exhibit 8

PALOMARES NUCLEAR WEAPONS ACCIDENT

REVISED DOSE EVALUATION REPORT

Volume III
Appendix C.2 – Repeat Analysis Cases
Appendix C.3 – Contamination Cutoff Cases
Appendix C.4 – Remaining Cases

Date: April 2001

Contract: GS-35F-4813G

Task Order: WFZ578410
T0799BG0031

Prepared For: Radiation Protection Division
Air Force Medical Operations Agency
Bolling AFB, DC 20332-7050

Prepared By: LABAT-ANDERSON INCORPORATED
8000 West Park Drive, Suite 400
McLean, VA 22102

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	140,000	43/0.43
LUDEP	383,000	27/0.27

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	6.2E+00/6.2E-02	2.5E-01	1.6E+00/1.6E-02
Breast	2.1E-04/2.1E-06	1.5E-01	3.1E-05/3.1E-07
Red Marrow	3.4E+01/3.4E-01	1.2E-01	4.0E+00/4.0E-02
Lung	1.6E+02/1.6E+00	1.2E-01	1.9E+01/1.9E-01
Thyroid	2.0E-04/2.0E-06	3.0E-02	5.9E-06/5.9E-08
Bone Surface	4.4E+02/4.4E+00	3.0E-02	1.3E+01/1.3E-01
Liver	7.8E+01/7.8E-01	6.0E-02	4.7E+00/4.7E-02
Other	7.4E+00/7.4E-02	6.0E-02	4.4E-01/4.4E-03
Lower Large Intestine	1.6E-02/1.6E-04	6.0E-02	9.5E-04/9.5E-06
Upper Large Intestine	5.3E-03/5.3E-05	6.0E-02	3.2E-04/3.2E-06
Small Intestine	1.1E-03/1.1E-05	6.0E-02	6.5E-05/6.5E-07
Effective Dose Equivalent			4.3E+01/4.3E-01

One urine sample was analyzed by gross alpha counting only, and the other was analyzed by both gross alpha counting and alpha spectrometry. For the sample analyzed with both methods, the gross alpha analysis was not included in the modeling since no result was reported and an alpha spectrometry result was available for the same sample. The sample analyzed by gross alpha counting only was not included in the analysis since it was an on-site sample with a result >0.1 pCi, leading to a suspicion of sample contamination. The result was fit using CINDY and the Jones excretion model, to estimate an intake (140,000 pCi), organ doses, and a CEDE (43 rem/0.43 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 383,000 pCi and a CEDE (ICRP-60) of 27 rem (0.27 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 140,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 43 rem (0.43 Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the current level (0.100 rem) for members of the public. It is less than the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). Serious health effects are not associated with that dose level. However, follow-up urine sampling now could be considered to provide additional assessment of the exposure.

Prepared By:

Name: ______________________________

Signature: ______________________________ Date: ____________________

Peer Reviewed By:

Name: ______________________________

Signature: ______________________________ Date: ____________________

FEB 21 1966

[redacted]TERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20) [redacted] TSgT	SOC. SEC. NO. (21-29) [redacted]	TYPE SAMPLE (30)	TYPE ANAL. (31-32) GROSS ALPHA
SAMPLE NO. (33-38) 66-446	SAMPLE DATE (39-44) FROM (24 hr) ~ 16 Feb '66 TO		EXPOSURE DATE 19 Jan '66 TYPE
BASE (57-60) ~~Torrejon~~ Ramstein	OCCUPATION (61-62)	REQUESTED BY	
DATE RECEIVED FEB 21 1966	SAMPLE VOLUME 2200 ml.	VOLUME ANALYZED 200 ml.	DATE ANALYZED
TECHNICIAN (SIGNATURE AND DATE) [redacted] 9 MAR 1966			

URINE	GROSS ALPHA			RADON		FECES/BLOOD	
Counter Number	H			Chamber Number		Counter Number	
Counter Bkg. (cpm)	.14			Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)	.51			Counter Eff. (%)		Counter Eff.	
Date/Time – Start	9 MAR 1966			Millivolt – Start		Date/Time – Start	
– Stop				Millivolt – Stop		– Stop	
Total Counts	47			Total Millivots		Total Counts	
Counting Time	55			Total Drift Time		Counting Time	
Gross cpm	.85			Gross mv/sec		Gross cpm	
Bkg. Cpm	.14			Bkg. Mv/sec		Bkg. cpm	
Net cpm	.71			Net mv/sec		net cpm	
~~dpm~~ Pci/L	3.14 ± 1.18			curies/mv		dpm	
dpm/24 hr. (69-74)				liter (69-74)		dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
~~Net Gam~~ Pci/Spl	6.91 ± 2.60			D(q) (63-68)		uc/mg (69-74)	
D(q) (63-68)						D(q) (63-68)	

$t = 23$ D $D_A = 3.26 \times 10^{-2}$ μc   174

[redacted] [redacted]

RESAMPLE JUL 14 1966 3415

AFSN: [redacted]

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20) [redacted] TSgt	SOC. SEC. NO. (21-29) [redacted]	TYPE SAMPLE (30) Urine	TYPE ANAL. (31-32)
SAMPLE NO. (33-38) 66-3415	SAMPLE DATE (39-44) FROM 0600 7 Jun TO 0559 8 Jun 66		EXPOSURE DATE Jan & Feb 66 TYPE
BASE (57-60) Ramstein	OCCUPATION (61-62)	REQUESTED BY	
DATE RECEIVED 14 June 1966	SAMPLE VOLUME 1680 ml	VOLUME ANALYZED 890 ml	DATE ANALYZED
TECHNICIAN (SIGNATURE AND DATE)		Checked off Master List	

URINE	236	239		RADON	Gross	FECES/BLOOD	
Counter Number				Chamber Number		Counter Number	
Counter Bkg. (cpm)	3	1		~~Cham. Bkg. (mv/sec)~~ Counter	C	Counter Bkg.	
Counter Eff. (%)	31.8	31.8	x 115	Counter Eff. (%)	51	Counter Eff.	
Date/Time – Start	15SEP66	1152		Millivolt – Start		Date/Time – Start	
– Stop				Millivolt – Stop		– Stop	
Total Counts	117	4		Total ~~Millivolts~~ time	55	Total Counts	
Counting Time	100	100		Total ~~Disintegrations~~ cts	118	Counting Time	
Gross cpm				Gross mv/sec		Gross cpm	
Bkg. Cpm				Bkg. ~~Mv/Sec~~ cts	45 (918)	Bkg. cpm	
Net cpm				Net mv/sec		net cpm	
~~dpm~~ % REC.	106%			curies/mv		dpm	
dpm/24 hr. (69-74)				~~liter (69-74)~~ % REC	122%	dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
~~Net Beta~~ PC/SPL	0.0949 ±	0.0499		D(q) (63-68)		uc/mg (69-74)	
D(q) (63-68)						D(q) (63-68)	

NAME:	SOCIAL SECURITY NUMBER:	SAMPLE NUMBER:
AIR FORCE BASE		

RESULTS OF ANALYSIS

Pci/spl - 0.0949 ± 0.0499
Total Vol - 1680 ml
Vol Anal - 890 ml

% Rec - 106%
Body Burden - 0.03

Previous Results
3.14 pc/l 0.74 BB

☐ Repeat the sample for the following reason:

( ) Significant activity in recently analyzed sample(s)
( ) Data required to establish dose
( ) Improper flask used
( ) Other ______
( ) Suggested sampling schedule ______

SIGNATURE: DATE:

ONE TIME FORM. OBSOLETE AFTER 30 JUN 66. (MCGSCPF, RAG, 4 APR 66) AFLC–WPAFB–APR 66 2500

3415

[redacted] 94 ± 50. [illegible]

1. .094 ±.05

2. 106

3. 1.68

4. 115

5. 6246

6. 0.03

(b) (6) [redacted]

Internal Dosimetry Evaluation Form

NAME: [redacted] SSN: [redacted]

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
1/20/66 through 2/7/66, onsite
1/29/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 μm AMAD
Date or Period of Evaluated Data: 2 samples, 2/7/66 and 6/1/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☐ Attached	☐ In Process	☒ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ______	
Decorporation:	☐ Yes	☒ No	Agent: ______	Date: ______
Catharsis:	☐ Yes	☒ No	Agent: ______	Date: ______
Surgical excision:	☐ Yes	☒ No	Date: ______	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 μm AMAD particle size on 1/29/66

Code/Model used for: Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 130000
50 YR CEDE (rem) : 40 (0.4 Sv)

Organ Dose Equivalent Summary	**50 YR CDE (rem/Sv)**
Bone Surface	410/4.1
Lung	150/1.5
Liver	72/0.72
Red Marrow	31/0.31
Other	6.9/0.069
Testes	5.8/0.058

DOSE ASSESSOR: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

PEER REVIEWER: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ______
Work Restrictions: N/A

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 μm AMAD particle size on 1/29/66. The date is the midpoint of the period on station from 1/20/66 to 2/7/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-442	G	2/7/66	1.24	0.950	
66-3267	AS	6/1/66	0.091	0.065	✓
66-3267	G	6/1/66	NR	NR	

* G means gross alpha counting; AS means alpha spectrometry; NR means no result reported.

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	130,000	40/0.4
LUDEP	370,000	26/0.26

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	5.8E+00/5.8E-02	2.5E-01	1.5E+00/1.5E-02
Breast	1.9E-04/1.9E-06	1.5E-01	2.9E-05/2.9E-07
Red Marrow	3.1E+01/3.1E-01	1.2E-01	3.8E+00/3.8E-02
Lung	1.5E+02/1.5E+00	1.2E-01	1.8E+01/1.8E-01
Thyroid	1.8E-04/1.8E-06	3.0E-02	5.4E-06/5.4E-08
Bone Surface	4.1E+02/4.1E+00	3.0E-02	1.2E+01/1.2E-01
Liver	7.2E+01/7.2E-01	6.0E-02	4.3E+00/4.3E-02
Other	6.9E+00/6.9E-02	6.0E-02	4.1E-01/4.1E-03
Lower Large Intestine	1.5E-02/1.5E-04	6.0E-02	8.9E-04/8.9E-06
Upper Large Intestine	5.0E-03/5.0E-05	6.0E-02	3.0E-04/3.0E-06
Small Intestine	1.0E-03/1.0E-05	6.0E-02	6.1E-05/6.1E-07
Effective Dose Equivalent			4.0E+01/4.0E-01

One urine sample was analyzed by gross alpha counting only, and the other was analyzed by both gross alpha counting and alpha spectrometry. For the sample analyzed with both methods, the gross alpha analysis was not included in the modeling since no result was reported and an alpha spectrometry result was available for the same sample. The sample analyzed by gross alpha counting only was not included in the analysis since it was an on-site sample with a result >0.1 pCi, leading to a suspicion of sample contamination. The result was fit using CINDY and the Jones excretion model, to estimate an intake (130,000 pCi), organ doses, and a CEDE (40 rem/0.4 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 370,000 pCi and a CEDE (ICRP-60) of 26 rem (0.26 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 130,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 40 rem (0.4 Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the current level (0.100 rem) for members of the public. It is less than the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). Serious health effects are not associated with that dose level. However, follow-up urine sampling now could be considered to provide additional assessment of the exposure.

Prepared By:

Name: ____________________

Signature: ____________________ Date: ____________

Peer Reviewed By:

Name: ____________________

Signature: ____________________ Date: ____________

RESAMPLE JUN 6 1966

AFSN: [redacted]

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20): [redacted] TSgt	SOC. SEC. NO.: [redacted]	TYPE SAMPLE (30): Urine	TYPE ANAL. (31-32)	
SAMPLE NO. (33-38): 66-3267	SAMPLE DATE (39-44): FROM 1 June 66 TO	EXPOSURE DATE Jan 66 TYPE		
BASE (57-60): Toul Rosieres	OCCUPATION (61-62)	REQUESTED BY		
DATE RECEIVED: 6 June 1966	SAMPLE VOLUME: 1620 ml	VOLUME ANALYZED: 1000 ml	DATE ANALYZED: 23 SEP 1966	
TECHNICIAN (SIGNATURE AND DATE)				

URINE	236	239	GROSS α	RADON		FECES/BLOOD	
Counter Number			C	Chamber Number		Counter Number	
Counter Bkg. (cpm) 800	3	1	157 (386)	Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)	31.8	31.8	51	Counter Eff. (%)		Counter Eff.	
Date/Time – Start	23 Sept	23 Sept	19 Sept	Millivolt – Start		Date/Time – Start	
– Stop				Millivolt – Stop		– Stop	
Total Counts			79	Total Millivolts		Total Counts	
Counting Time	100	100	55	Total Drift Time		Counting Time	
Gross cpm				Gross mv/sec		Gross cpm	
Bkg. Cpm				Bkg. Mv/sec		Bkg. cpm	
Net cpm				Net mv/sec		net cpm	
dpm				curies/mv		dpm	
dpm/24 hr. (69-74)				litter (69-74)		dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
Net Beta				D(q) (63-68)		uc/mg (69-74)	
D(q) (63-68)			82.2% Rec			D(q) (63-68)	

NAME: | SOCIAL SECURITY NUMBER: | SAMPLE NUMBER:

AIR FORCE BASE

RESULTS OF ANALYSIS Pci/spl –
Total vol – 1620
Vol anal – 1000

% Rec –
Body Burden –

CONTAM. WITH. PU-238

☐ Repeat the sample for the following reason:
( ) Significant activity in recently analyzed sample (s)
( ) Data required to establish dose
( ) Improper flask used
( ) Other
( ) Suggested sampling schedule

SIGNATURE: | DATE:

ONE TIME FORM. OBSOLETE AFTER 30 JUN 66. (MCGSCPF, RAG, 4 APR 66) AFLC—WPAFB—APR 66 2500

3267 91.±65 fci

1. .091 ± .065

2. 84.1

3. 1.62

4. 127

5. 6278

6. 0.03

RADIOLOGICAL SAMPLE DATA

[redacted]E OR REQUESTOR'S ID (1-20)	GRADE	AFSN	SOCIAL SECURITY NUMBER	RHL SAMPLE NUMBER 66-3267 B

TYPE SAMPLE (23-32)	OCCUPATION (34-35)	ANALYSIS DESIRED	REQUESTED BY	AIR FORCE BASE (68-71)
DATE RECEIVED (37-42)	DATE ANALYZED (51-56)	DATE COUNTED 5 OCT 66	DATE COLLECTED	EXPOSURE DATE
SAMPLE WEIGHT/VOLUME	WEIGHT/VOLUME ANALYZED 600	TECH [redacted]		

OTHER DATA: checked off website list

ENVIRONMENTAL SAMPLES				
COUNTER & EFFICIENCY				
TOTAL COUNTS & MINUTES				
GROSS CPM				
BKG CPM & MINUTES		E=127		
NET CPM				
YIELD				
	236	239		
BIOLOGICAL SAMPLES			RADON	
COUNTER & EFFICIENCY Spec	31.8			
TOTAL COUNTS & MINUTES 100	88	2		
GROSS CPM				
BKG CPM & MINUTES 440	1	0		
NET CPM				
YIELD				

SUMMARY OF RESULTS: PCi/spl = 0.091 ± 0.065 % Rec = 84.1
TOT Vol = 1620 Body Burden =
VOL ANAL = 600

AFLC FORM MAY 66 1165 FC 5400 AFLC-WPAFB-MAY 66 4500

Release of this document is restricted under the provisions of the Privacy Act, 5 U.S.C. 552(a). C.2-248

FEB 10 1966

INTERNAL DOSE DATA

[redacted]) TSgt	SOC. SEC. NO. (21-29) [redacted]		TYPE SAMPLE (30) Urine	TYPE ANAL. (31-32) GROSS ALPHA
SAMPLE NO. (33-38) 66-442	SAMPLE DATE (39-44) FROM Submitted - 7 Feb 66 TO		EXPOSURE DATE Arriv. - 20 Jan 66 TYPE	
BASE (57-60) Toul - Rosieres, France	OCCUPATION (61-62) [illegible]	REQUESTED BY		
DATE RECEIVED FEB 10 1966	SAMPLE VOLUME 970 ml	VOLUME ANALYZED 200 ml	DATE ANALYZED	
TECHNICIAN (SIGNATURE AND DATE)	[redacted] SSGT, USAF		11 FEB 1966	

URINE GROSS ALPHA			
Counter Number	C		
Counter Bkg. (cpm)	0.20		
Counter Eff. (%)	51		
Date/Time – Start	11 FEB 1966		
– Stop			
Total Counts	27		
Counting Time	55		
Gross cpm	0.49		
Bkg. Cpm	0.20		
Net cpm	0.29		
~~dpm~~ pCi/l	1.28 ± 0.98		
dpm/24 hr. (69-74)			
K 40 Correction			
~~Net Beta~~ pCi/24 hr	1.24 ± 0.95		
D(q) (63-68)			

RADON	
Chamber Number	
Cham. Bkg. (mv/sec)	
Counter Eff. (%)	
Millivolt – Start	
Millivolt – Stop	
Total Millivots	
Total Drift Time	
Gross mv/sec	
Bkg. Mv/sec	
Net mv/sec	
curies/mv	
litter (69-74)	
D(q) (63-68)	

FECES/BLOOD	
Counter Number	
Counter Bkg.	
Counter Eff.	
Date/Time – Start	
– Stop	
Total Counts	
Counting Time	
Gross cpm	
Bkg. cpm	
net cpm	
dpm	
dps/cc	
Neutron Dose (rads) (63-68)	
uc/mg (69-74)	
D(q) (63-68)	

$D_R = 4.69 \times 10^{-3}$ µc

15 Feb 66

(b) (6) [redacted]

Internal Dosimetry Evaluation Form

NAME: [redacted] **SSN:** [redacted]

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
2/4/66 through 3/1/66, onsite
2/16/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 µm AMAD
Date or Period of Evaluated Data: 1 sample, 3/1/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☐ Attached	☐ In Process	☒ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ______	
Decorporation:	☐ Yes	☒ No	Agent: ______	Date: ______
Catharsis:	☐ Yes	☒ No	Agent: ______	Date: ______
Surgical excision:	☐ Yes	☒ No	Date: ______	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 µm AMAD particle size on 2/16/66

Code/Model used for: Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 270000
50 YR CEDE (rem) : 83 (0.83 Sv)

Organ Dose Equivalent Summary	**50 YR CDE (rem/Sv)**
Bone Surface	840/8.4
Lung	310/3.1
Liver	150/1.5
Red Marrow	65/0.65
Other	14/0.14
Testes	12/0.12

DOSE ASSESSOR: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

PEER REVIEWER: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ______
Work Restrictions: N/A

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 µm AMAD particle size on 2/16/66. The date is the midpoint of the period on station from 2/4/66 to 3/1/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-1855	AS	3/1/66	0.294	0.007	✓
66-1855	G	3/1/66	1.52	0.310	

* G means gross alpha counting; AS means alpha spectrometry.

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	270,000	83/0.83
LUDEP	1,270,000	89/0.89

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	1.2E+01/1.2E-01	2.5E-01	3.0E+00/3.0E-02
Breast	4.0E-04/4.0E-06	1.5E-01	6.0E-05/6.0E-07
Red Marrow	6.5E+01/6.5E-01	1.2E-01	7.8E+00/7.8E-02
Lung	3.1E+02/3.1E+00	1.2E-01	3.7E+01/3.7E-01
Thyroid	3.8E-04/3.8E-06	3.0E-02	1.1E-05/1.1E-07
Bone Surface	8.4E+02/8.4E+00	3.0E-02	2.5E+01/2.5E-01
Liver	1.5E+02/1.5E+00	6.0E-02	9.0E+00/9.0E-02
Other	1.4E+01/1.4E-01	6.0E-02	8.6E-01/8.6E-03
Lower Large Intestine	3.1E-02/3.1E-04	6.0E-02	1.8E-03/1.8E-05
Upper Large Intestine	1.0E-02/1.0E-04	6.0E-02	6.2E-04/6.2E-06
Small Intestine	2.1E-03/2.1E-05	6.0E-02	1.3E-04/1.3E-06
Effective Dose Equivalent			8.3E+01/8.3E-01

One urine sample was analyzed by gross alpha counting and alpha spectrometry. The gross alpha analysis was not included in the modeling since an alpha spectrometry result was available for the same sample. The result was fit using CINDY and the Jones excretion model, to estimate an intake (270,000 pCi), organ doses, and a CEDE (83 rem/0.83 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 1,270,000 pCi and a CEDE (ICRP-60) of 89 rem (0.89 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 270,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 83 rem (0.83 Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the current level (0.100 rem) for members of the public. It is more than the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). These dose levels are significant, although they were based on very limited data. However, follow-up urine sampling should be considered to provide additional assessment of the exposure.

Prepared By:

Name: ______________________________

Signature: ______________________________ Date: ______________

Peer Reviewed By:

Name: ______________________________

Signature: ______________________________ Date: ______________

27

AFSN: [redacted]

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20): [redacted] Capt	SOC. SEC. NO. (21-29): [redacted]	TYPE SAMPLE (30): Urine	TYPE ANAL. (31-32)
SAMPLE NO. (33-38): 66-1855	SAMPLE DATE (39-44): FROM 1 Mar 66 TO	EXPOSURE DATE 4 Feb 66 TYPE	
BASE (57-60): Toul Rosiers	OCCUPATION (61-62): 9124	REQUESTED BY	
DATE RECEIVED: 28 March 1966	SAMPLE VOLUME: 550	VOLUME ANALYZED: 550	DATE ANALYZED
TECHNICIAN (SIGNATURE AND DATE)			

URINE			
Counter Number	D		
Counter Bkg. (cpm)	0.03 (900)		
Counter Eff. (%)	.51		t=20
Date/Time – Start	1.3 May 66		
– Stop		Reported value corrected for spike of 0.965 pc/sample	
Total Counts	96		
Counting Time	.55		
Gross cpm	1.75		
Bkg. Cpm	0.03		
Net cpm	1.72		
~~dpm~~ pci/l	2.75 ± 0.57		
dpm/24 hr. (69-74)			
K 40 Correction			
~~Net Beta~~ pci/Sgl	1.52 ± 0.31		
D (q) (63-68)			

RADON	
Chamber Number	
Cham. Bkg. (mv/sec)	
Counter Eff. (%)	
Millivolt – Start	
Millivolt – Stop	
Total Millivots	
Total Drift Time	
Gross mv / sec	
Bkg. Mv / sec	
Net mv / sec	
curies/mv	
litter (69-74)	
D(q) (63-68)	

FECES/BLOOD	
Counter Number	
Counter Bkg.	
Counter Eff.	
Date/Time – Start	✓
– Stop	
Total Counts	
Counting Time	
Gross cpm	
Bkg. cpm	1.10 PC
net cpm	NSEB
dpm	
dps / cc	
Neutron Dose (rads) (63-68)	
uc / mg (69-74)	
D (q) (63-68)	

(b) (6) [redacted]

RADIOLOGICAL SAMPLE DATA

NAME OR REQUESTOR'S ID (1–20)	GRADE	AFSN	SOCIAL SECURITY NUMBER	RHL SAMPLE NUMBER 66-1855
TYPE SAMPLE (23–32)	OCCUPATION (34–35)	ANALYSIS DESIRED	REQUESTED BY	AIR FORCE BASE (66–71)
DATE RECEIVED (37–42)	DATE ANALYZED (51–56)	DATE COUNTED 11 July 66	DATE COLLECTED	EXPOSURE DATE
SAMPLE WEIGHT/VOLUME	WEIGHT/VOLUME ANALYZED		TECHNICIAN	
OTHER DATA .950				

ENVIRONMENTAL SAMPLES				
COUNTER & EFFICIENCY				
TOTAL COUNTS & MINUTES				
GROSS CPM				
BKG CPM & MINUTES				
NET CPM				
YIELD				
BIOLOGICAL SAMPLES	236	279		
COUNTER & EFFICIENCY spec	27.3		RADON	
TOTAL COUNTS & MINUTES /100	68	27.3	2.96 dpm	5.57 DPM
GROSS CPM	0.6800	13	0.66	
BKG CPM & MINUTES 800	0 0	0.13		
NET CPM		2 . 0.0013		
YIELD	0.68	0.1287		
			0.294 ± 0.007	
% Rec	71.58			

SUMMARY OF RESULTS:

AFLC FORM MAY 66 1165 FC 5400

AFLC–WPAFB–MAY 66 4500

(b) (6) [redacted]

(b) (6) [redacted]

Internal Dosimetry Evaluation Form

NAME: [redacted] SSN: [redacted]

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
1/18/66 through 2/7/66, onsite
1/28/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 μm AMAD
Date or Period of Evaluated Data: 2 samples, 2/7/66 and 6/1/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☐ Attached	☐ In Process	☒ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ______	
Decorporation:	☐ Yes	☒ No	Agent: ______	Date: ______
Catharsis:	☐ Yes	☒ No	Agent: ______	Date: ______
Surgical excision:	☐ Yes	☒ No	Date: ______	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 μm AMAD particle size on 1/28/66

Code/Model used for: Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 68000
50 YR CEDE (rem) : 21 (0.21 Sv)

Organ Dose Equivalent Summary	50 YR CDE (rem/Sv)
Bone Surface	210/2.1
Lung	78/0.78
Liver	38/0.38
Red Marrow	16/0.16
Other	3.6/0.036
Testes	3/0.03

DOSE ASSESSOR: DATE: ______
Signature: ______
Print Name: ______
SSN: ______

PEER REVIEWER: DATE: ______
Signature: ______
Print Name: ______
SSN: ______

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ______
Work Restrictions: N/A

[redacted] [redacted]

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 µm AMAD particle size on 1/28/66. The date is the midpoint of the period on station from 1/18/66 to 2/7/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-499	G	2/7/66	1.66	0.700	
66-3271	AS	6/1/66	0.047	0.047	✓
66-3271	G	6/1/66	NR	NR	

* G means gross alpha counting; AS means alpha spectrometry; NR means no result reported.

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	68,000	21/0.21
LUDEP	191,000	13/0.13

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	3.0E+00/3.0E-02	2.5E-01	7.6E-01/7.6E-03
Breast	1.0E-04/1.0E-06	1.5E-01	1.5E-05/1.5E-07
Red Marrow	1.6E+01/1.6E-01	1.2E-01	2.0E+00/2.0E-02
Lung	7.8E+01/7.8E-01	1.2E-01	9.3E+00/9.3E-02
Thyroid	9.5E-05/9.5E-07	3.0E-02	2.8E-06/2.8E-08
Bone Surface	2.1E+02/2.1E+00	3.0E-02	6.4E+00/6.4E-02
Liver	3.8E+01/3.8E-01	6.0E-02	2.3E+00/2.3E-02
Other	3.6E+00/3.6E-02	6.0E-02	2.2E-01/2.2E-03
Lower Large Intestine	7.7E-03/7.7E-05	6.0E-02	4.6E-04/4.6E-06
Upper Large Intestine	2.6E-03/2.6E-05	6.0E-02	1.6E-04/1.6E-06
Small Intestine	5.3E-04/5.3E-06	6.0E-02	3.2E-05/3.2E-07
Effective Dose Equivalent			2.1E+01/2.1E-01

One urine sample was analyzed by gross alpha counting only, and the other was analyzed by both gross alpha counting and alpha spectrometry. For the sample analyzed with both methods, the gross alpha analysis was not included in the modeling since an alpha spectrometry result was available for the same sample. The sample analyzed by gross alpha counting only was not included in the analysis since it was an on-site sample with a result >0.1 pCi, leading to a suspicion of sample contamination. The result was fit using CINDY and the Jones excretion model, to estimate an intake (68,000 pCi), organ doses, and a CEDE (21 rem/0.21 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 191,000 pCi and a CEDE (ICRP-60) of 13 rem (0.13 Sv).

[redacted] [redacted]

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 68,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 21 rem (0.21 Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the current level (0.100 rem) for members of the public. It is less than half the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). Serious health effects are not associated with that dose level.

Prepared By:

Name: ________________________________

Signature: ________________________________ Date: ________________

Peer Reviewed By:

Name: ________________________________

Signature: ________________________________ Date: ________________

[redacted] [redacted]

RESAMPLE JUN 6 1966

AFSN: [redacted]

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20)	SOC. SEC. NO. (21-29)	TYPE SAMPLE (30)	TYPE ANAL. (31-32)
[redacted] A1C	[redacted]	Urine	

SAMPLE NO. (33-38)	SAMPLE DATE (39-44)	EXPOSURE
66-3271	FROM 1 June 66 TO	DATE Jan 66 TYPE

BASE (57-60)	OCCUPATION (61-62)	REQUESTED BY
Toul Rosieres		

DATE RECEIVED	SAMPLE VOLUME	VOLUME ANALYZED	DATE ANALYZED
6 June 1966	670 ml	370 ml	

TECHNICIAN (SIGNATURE AND DATE)

URINE	2J6	239	GROSS α	RADON		FECES/BLOOD	
Counter Number			F	Chamber Number		Counter Number	
Counter Bkg. (cpm)			425 (38 LP)	Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)	31.8		51	Counter Eff. (%)		Counter Eff.	
Date/Time – Start	24 SEPT 66		19 Sept	Millivolt – Start		Date/Time – Start	
– Stop				Millivolt – Stop		– Stop	
Total Counts			194	Total Millivots		Total Counts	
Counting Time 100	250	/	55	Total Drift Time		Counting Time	
Gross cpm				Gross mv/sec		Gross cpm	
Bkg. Cpm 466	3	/		Bkg. Mv/sec		Bkg. cpm	
Net cpm				Net mv/sec		net cpm	
dpm			%REC	curies/mv		dpm	
dpm/24 hr. (69-74)			= 207%	litter (69-74)		dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
Net Beta				D(q) (63-68)		uc/mg (69-74)	
D (q) (63-68)			~~D~~			D (q) (63-68)	

NAME:	SOCIAL SECURITY NUMBER:	SAMPLE NUMBER:

AIR FORCE BASE

RESULTS OF ANALYSIS LABORATORY ACCIDENT "A" SAMPLE 2 SEPT
pc/SPL= %REC. = 237%
TOT. VOL. = 670 ML. VOL. ANAL. = 370 ML. BODY BURDEN=

☐ Repeat the sample for the following reason:
( ) Significant activity in recently analyzed sample(s)
( ) Data required to establish dose
( ) Improper flask used
( ) Other
( ) Suggested sampling schedule

DO OVER
TOO MUCH SPIKE

SIGNATURE: DATE:

ONE TIME FORM. OBSOLETE AFTER 30 JUN 66. (MCGSCPF, RAG, 4 APR 66) AFLC—WPAFB—APR 66 2500

[redacted]

[redacted]

RADIOLOGICAL SAMPLE DATA

[redacted]E OR REQUESTOR'S ID (1–20)	GRADE	AFSN	SOCIAL SECURITY NUMBER	RHL SAMPLE NUMBER 66-3271 B
TYPE SAMPLE (23–32)	OCCUPATION (34–35)	ANALYSIS DESIRED	REQUESTED BY	AIR FORCE BASE (69–71)
DATE RECEIVED (37–42)	DATE ANALYZED (51–56)	DATE COUNTED 5 Oct 66	DATE COLLECTED	EXPOSURE DATE
SAMPLE WEIGHT/VOLUME	WEIGHT/VOLUME ANALYZED 300	TECHNICI[redacted]		

OTHER DATA: Checked off [illegible]

ENVIRONMENTAL SAMPLES				
COUNTER & EFFICIENCY				
TOTAL COUNTS & MINUTES				
GROSS CPM				
BKG CPM & MINUTES				
NET CPM		t = 140		
YIELD				
	236	279		

BIOLOGICAL SAMPLES			RADON	
COUNTER & EFFICIENCY Spec	31.8			
TOTAL COUNTS & MINUTES 100	70	1		
GROSS CPM				
BKG CPM & MINUTES 440	1	0		
NET CPM				
YIELD				
0.047 ±	0.047			

SUMMARY OF RESULTS: Pci/spl – NDA
Tot Vol – 670
Vol Anal – 300

%Rec – 66.9
Body Burden –

AFLC FORM MAY 66 1165 FC 5400 AFLC–WPAFB–MAY 66 4500

FEB 10 1966

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20) [redacted]

SOC. SEC. NO. (21-29)

TYPE SAMPLE (30) Urine

TYPE ANAL. (31-32) GROSS ALPHA

[redacted] A/1c

SAMPLE DATE (39-44) FROM 7 Feb TO

EXPOSURE DATE 18 Jan. TYPE

66-499

BASE (57-60) Toul Rosierre, France

OCCUPATION (61-62)

REQUESTED BY

DATE RECEIVED FEB 10 1966

SAMPLE VOLUME 560 ml

VOLUME ANALYZED 200 ml

DATE ANALYZED 14 FEB 1966

TECHNICIAN (SIGNATURE AND DATE) [redacted] SSGT, USAF

URINE			
Counter Number	NMC A		
Counter Bkg. (cpm)	0.24		
Counter Eff. (%)	.51		
Date/Time – Start			
– Stop	14 FEB 1966		
Total Counts	50		
Counting Time	55		
Gross cpm	0.91		
Bkg. Cpm	0.24		
Net cpm	0.67		
~~dpm~~ Pci/l	2.96 ± 1.25		
dpm/24 hr. (69-74)			
K 40 Correction			
~~Net Bsrg~~ Pci/Spl	1.66 ± 0.70		
D(q) (63-68)			

RADON	
Chamber Number	
Cham. Bkg. (mv/sec)	
Counter Eff. (%)	
Millivolt – Start	
Millivolt – Stop	
Total Millivots	
Total Drift Time	
Gross mv/sec	
Bkg. Mv/sec	
Net mv/sec	
curies/mv	
litter (69-74)	
D(q) (63-68)	

FECES/BLOOD	
Counter Number	
Counter Bkg.	
Counter Eff.	
Date/Time – Start	
– Stop	
Total Counts	
Counting Time	
Gross cpm	
Bkg. cpm	
net cpm	
dpm	
dps/cc	
Neutron Dose (rads) (63-68)	
uc/mg (69-74)	
D(q) (63-68)	

$D_R = 1.15 \times 10^{-2} \mu c$ .2 16 Feb 66

3271 47. ± 47 [redacted]

1. .047 ± .047
2. 66.9
3. .67
4. 140
5. 6278
6. 0.02

(b) (6) [redacted]

[redacted] [redacted]

Internal Dosimetry Evaluation Form

NAME: [redacted] SSN: [redacted]

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
1/20/66 through 2/7/66, onsite
1/29/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 µm AMAD
Date or Period of Evaluated Data: 2 samples, 2/7/66 and 6/1/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☐ Attached	☐ In Process	☒ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ________	
Decorporation:	☐ Yes	☒ No	Agent: ________	Date: ________
Catharsis:	☐ Yes	☒ No	Agent: ________	Date: ________
Surgical excision:	☐ Yes	☒ No	Date: ________	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 µm AMAD particle size on 1/29/66

Code/Model used for: Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 210000
50 YR CEDE (rem): 65 (0.65 Sv)

Organ Dose Equivalent Summary	50 YR CDE (rem/Sv)
Bone Surface	650/6.5
Lung	240/2.4
Liver	120/1.2
Red Marrow	51/0.51
Other	11/0.11
Testes	9.4/0.094

DOSE ASSESSOR: DATE: ________
Signature: ________
Print Name: ________
SSN: ________

PEER REVIEWER: DATE: ________
Signature: ________
Print Name: ________
SSN: ________

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ________
Work Restrictions: N/A

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 μm AMAD particle size on 1/29/66. The date is the midpoint of the period on station from 1/20/66 to 2/7/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-464	G	2/7/66	0.500	0.350	
66-3270	AS	6/1/66	0.146	0.147	✓
66-3270	G	6/1/66	NR	NR	

* G means gross alpha counting; AS means alpha spectrometry.

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	210,000	65/0.65
LUDEP	591,000	42/0.42

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	9.4E+00/9.4E-02	2.5E-01	2.3E+00/2.3E-02
Breast	3.1E-04/3.1E-06	1.5E-01	4.7E-05/4.7E-05
Red Marrow	5.1E+01/5.1E-01	1.2E-01	6.1E+00/6.1E-02
Lung	2.4E+02/2.4E+00	1.2E-01	2.9E+01/2.9E-01
Thyroid	2.9E-04/2.9E-06	3.0E-02	8.8E-06/8.8E-06
Bone Surface	6.5E+02/6.5E+00	3.0E-02	2.0E+01/2.0E-01
Liver	1.2E+02/1.2E+00	6.0E-02	7.0E+00/7.0E-02
Other	1.1E+01/1.1E-01	6.0E-02	6.7E-01/6.7E-03
Lower Large Intestine	2.4E-02/2.4E-04	6.0E-02	1.4E-03/1.4E-05
Upper Large Intestine	8.0E-03/8.0E-05	6.0E-02	4.8E-04/4.8E-06
Small Intestine	1.6E-03/1.6E-05	6.0E-02	9.8E-07/9.8E-07
Effective Dose Equivalent			6.5E+01/6.5E-01

One urine sample was analyzed by gross alpha counting only, and the other was analyzed by both gross alpha counting and alpha spectrometry. For the sample analyzed with both methods, the gross alpha analysis was not included in the modeling since no result was reported and an alpha spectrometry result was available for the same sample. The sample analyzed by gross alpha counting only was not included in the analysis since it was an on-site sample with a result >0.1 pCi, leading to a suspicion of sample contamination. The result was fit using CINDY and the Jones excretion model, to estimate an intake (210,000 pCi), organ doses, and a CEDE (65 rem/0.65 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 591,000 pCi and a CEDE (ICRP-60) of 42 rem (0.42 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 210,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 65 rem (0.65 Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the current level (0.100 rem) for members of the public. It is more than the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). Serious health effects are not normally associated with these dose levels. However, follow-up urine sampling should be considered to provide additional assessment of the exposure.

Prepared By:

Name: ______________________

Signature: ______________________ Date: ____________

Peer Reviewed By:

Name: ______________________

Signature: ______________________ Date: ____________

[redacted] [redacted]

RESAMPLE JUN 6 1966

AFSN: [redacted]

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20)	SOC. SEC. NO. (21-29)	TYPE SAMPLE (30)	TYPE ANAL. (31-32)
[redacted] SSgt	[redacted]	Urine	-

SAMPLE NO. (33-38)	SAMPLE DATE (39-44)	EXPOSURE
66-3270	FROM 1 June 66 TO	DATE Jan 66 TYPE

BASE (57-60)	OCCUPATION (61-62)	REQUESTED BY
Toul Rosieres		

DATE RECEIVED	SAMPLE VOLUME	VOLUME ANALYZED	DATE ANALYZED
6 June 1966	~~[illegible]~~ 1860	~~[illegible]~~ 1060	

TECHNICIAN (SIGNATURE AND DATE)

URINE				RADON		FECES/BLOOD	
Counter Number				Chamber Number		Counter Number	
Counter Bkg. (cpm)				Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)				Counter Eff. (%)		Counter Eff.	
Date/Time – Start				Millivolt – Start		Date/Time – Start	
– Stop				Millivolt – Stop		– Stop	
Total Counts				Total Millivots		Total Counts	
Counting Time				Total Drift Time		Counting Time	
Gross cpm				Gross mv/sec		Gross cpm	
Bkg. Cpm				Bkg. Mv/sec		Bkg. cpm	
Net cpm				Net mv/sec		net cpm	
dpm				curies/mv		dpm	
dpm/24 hr. (69-74)				litter (69-74)		dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
Net Beta				D(q) (63-68)		uc/mg (69-74)	
D(q) (63-68)						D(q) (63-68)	

Repeat: Recovery [illegible] 608

NAME:	SOCIAL SECURITY NUMBER:	SAMPLE NUMBER:

AIR FORCE BASE

RESULTS OF ANALYSIS

Tol [illegible] – Repeat

☐ Repeat the sample for the following reason:

( ) Significant activity in recently analyzed sample(s)
( ) Data required to establish dose
( ) Improper flask used
( ) Other ______
( ) Suggested sampling schedule ______

SIGNATURE: DATE:

ONE TIME FORM. OBSOLETE AFTER 30 JUN 66. (MCGSCPF, RAG, 4 APR 66) AFLC-WPAFB-APR 66 2500

FEB 10 1966

[redacted] NTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20) [redacted]	SOC. SEC. NO. (21-29) 5/sgt [redacted]	TYPE SAMPLE (30)	TYPE ANAL. (31-32) GROSS ALPHA
SAMPLE NO. (33-38) 66-464	SAMPLE DATE (39-44) FROM Submitted – 7 Feb '66 TO	EXPOSURE DATE Arr – 20 Jan 66	TYPE
BASE (57-60) Toul - Rosières	OCCUPATION (61-62)	REQUESTED BY	
DATE RECEIVED FEB 10 1966	SAMPLE VOLUME 375 ml.	VOLUME ANALYZED 200 ml.	DATE ANALYZED
TECHNICIAN (SIGNATURE AND DATE)	WALTER G. EDWARDS SSGT. USAF	11 FEB 1966	

URINE	GROSS ALPHA		
Counter Number	B		
Counter Bkg. (cpm)	0.15		
Counter Eff. (%)	51		
Date/Time – Start	11 FEB 1966		
– Stop			
Total Counts	25		
Counting Time	55		
Gross cpm	0.45		
Bkg. Cpm	0.15		
Net cpm	0.30		
~~dpm~~ Pci/l	1.33±0.92		
dpm/24 Hr. (69-74)	[illegible]		
K 40 Correction			
~~Net Beta~~ Pci/Spl	0.50±0.35		
D (q) (63-68)			

RADON	
Chamber Number	
Cham. Bkg. (mv/sec)	
Counter Eff. (%)	
Millivolt – Start	
Millivolt – Stop	
Total Millivots	
Total Drift Time	
Gross mv / sec	
Bkg. Mv / sec	
Net mv / sec	
curies/mv	
litter (69-74)	
D(q) (63-68)	

FECES/BLOOD	
Counter Number	
Counter Bkg.	
Counter Eff.	
Date/Time – Start	
– Stop	
Total Counts	
Counting Time	
Gross cpm	
Bkg. cpm	
net cpm	
dpm	
dps / cc	
Neutron Dose (rads) (63-68)	
uc / mg (69-74)	
D (q) (63-68)	

$D_R = 4.88 \times 10^{-3}$ μc

15 Feb 66

[redacted]

RADIOLOGICAL SAMPLE DATA

NAME OR REQUESTOR'S ID (1–20)	GRADE	AFSN	SOCIAL SECURITY NUMBER	RHL SAMPLE NUMBER 66-3270 B
TYPE SAMPLE (23–32)	OCCUPATION (34–35)	ANALYSIS DESIRED	REQUESTED BY	AIR FORCE BASE (68–71)
DATE RECEIVED (37–42)	DATE ANALYZED (51–56)	DATE COUNTED 4 Oct 66	DATE COLLECTED	EXPOSURE DATE
SAMPLE WEIGHT/VOLUME	WEIGHT/VOLUME ANALYZED 400 ml		TECHNICIAN [redacted]	
OTHER DATA				

checked off master list

ENVIRONMENTAL SAMPLES				
COUNTER & EFFICIENCY				
TOTAL COUNTS & MINUTES				
GROSS CPM				
BKG CPM & MINUTES				
NET CPM				
YIELD		t>140		

BIOLOGICAL SAMPLES	236	239		
COUNTER & EFFICIENCY Face #4	23.8		RADON	
TOTAL COUNTS & MINUTES 100	48	/	E-51	
GROSS CPM			55-75	
BKG CPM & MINUTES 445	3	0		
NET CPM			935-78	
YIELD				
0.146 ÷ 0.147				
			%Rec = 76.3	

465

SUMMARY OF RESULTS: Pu/spl = NDA · TOT VOL = 1860 · VOL ANAL = 400 · % Rec = 61.3 · Body Burden = · HEAVY ORANGE DEPOSIT

AFLC FORM MAY 66 1165 FC 5400 AFLC–WPAFB–MAY 66 4500

Release of this document is restricted under the provisions of the Privacy Act, 5 U.S.C. 552(a). C.2-270

Palomares Nuclear Weapons Accident [redacted]

Dose Evaluation Report April 28, 2000 [redacted]

3270

1. .15 ± .15 PC
2. 61.3
3. 1.86
4. 140
5. 6277
6. 0.06

(b) (6) [redacted]

Internal Dosimetry Evaluation Form

NAME: [redacted] **SSN:** [redacted]

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
2/5/66 through 2/26/66, onsite
2/15/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 µm AMAD
Date or Period of Evaluated Data: 1 sample, 2/26/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☐ Attached	☐ In Process	☒ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ________	
Decorporation:	☐ Yes	☒ No	Agent: ________	Date: ________
Catharsis:	☐ Yes	☒ No	Agent: ________	Date: ________
Surgical excision:	☐ Yes	☒ No	Date: ________	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 µm AMAD particle size on 2/15/66

Code/Model used for: Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 7700
50 YR CEDE (rem): 2.4 (0.024 Sv)

Organ Dose Equivalent Summary	**50 YR CDE (rem/Sv)**
Bone Surface	24/0.24
Lung	8.8/0.088
Liver	4.3/0.043
Red Marrow	1.9/0.019
Other	0.41/0.0041
Testes	0.34/0.0034

DOSE ASSESSOR: **DATE:** ________
Signature: ________________
Print Name: ________________
SSN: ________________

PEER REVIEWER: **DATE:** ________
Signature: ________________
Print Name: ________________
SSN: ________________

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ________________
Work Restrictions: N/A

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 µm AMAD particle size on 2/15/66. The date is the midpoint of the period on station from 2/5/66 to 2/26/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-1430	AS	2/26/66	NR	NR	
66-1430	G	2/26/66	ND	ND	✓

* G means gross alpha counting; AS means alpha spectrometry.

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	7,700	2.4/0.024
LUDEP	38,300	2.7/0.027

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	3.4E-01/3.4E-03	2.5E-01	8.6E-02/8.6E-04
Breast	1.1E-05/1.1E-07	1.5E-01	1.7E-06/1.7E-08
Red Marrow	1.9E+00/1.9E-02	1.2E-01	2.2E-01/2.2E-03
Lung	8.8E+00/8.8E-02	1.2E-01	1.1E+00/1.1E-02
Thyroid	1.1E-05/1.1E-07	3.0E-02	3.2E-07/3.2E-09
Bone Surface	2.4E+01/2.4E-01	3.0E-02	7.2E-01/7.2E-03
Liver	4.3E+00/4.3E-02	6.0E-02	2.6E-01/2.6E-03
Other	4.1E-01/4.1E-03	6.0E-02	2.4E-02/2.4E-04
Lower Large Intestine	8.7E-04/8.7E-06	6.0E-02	5.2E-05/5.2E-07
Upper Large Intestine	2.9E-04/2.9E-06	6.0E-02	1.8E-05/1.8E-07
Small Intestine	6.0E-05/6.0E-07	6.0E-02	3.6E-06/3.6E-08
Effective Dose Equivalent			2.4E+00/2.4E-02

One urine sample was analyzed by gross alpha counting and alpha spectrometry. The alpha spectrometry analysis was not included in the modeling since no result was reported. The gross alpha counting result was reported as No Detectable Activity. A value of 0.009 pCi was used to represent this outcome. The result was fit using CINDY and the Jones excretion model, to estimate an intake (7,700 pCi), organ doses, and a CEDE (2.4 rem/0.024 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 38,300 pCi and a CEDE (ICRP-60) of 2.7 rem (0.027 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 7,700 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 2.4 rem (0.024 Sv). That dose is less than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the current level (0.100 rem) for members of the public. It is far less than the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). Serious health effects are not associated with that dose level.

Prepared By:

Name: ______________________________

Signature: ______________________________ Date: ____________________

Peer Reviewed By:

Name: ______________________________

Signature: ______________________________ Date: ____________________

MAR 9 1966 A

AFSN: [redacted]

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20) [redacted] TSGT.	SOC. SEC. NO. (21-29) [redacted]	TYPE SAMPLE (30) Urine	TYPE ANAL. (31-32) GROSS ALPHA
SAMPLE NO. (33-38) 66-1430	SAMPLE DATE (39-44) FROM 26 FEB 66 TO	EXPOSURE DATE 5-2-66 TYPE	
BASE (57-60) TORREJON	OCCUPATION (61-62) 90870	REQUESTED BY	
DATE RECEIVED 9 MAR 66	SAMPLE VOLUME 780	VOLUME ANALYZED 811	DATE ANALYZED
TECHNICIAN (SIGNATURE AND DATE)			

URINE	239	236		RADON		FECES/BLOOD	
Counter Number				Chamber Number		Counter Number	
Counter Bkg. (cpm)				Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)				Counter Eff. (%)		Counter Eff.	
Date/Time – Start	11 MAR 66			Millivolt – Start		Date/Time – Start	
– Stop				Millivolt – Stop		– Stop	
Total Counts	0	11		Total Millivots		Total Counts	
Counting Time	100	100		Total Drift Time		Counting Time	alpha Spect
Gross cpm	0	0.11		Gross mv/sec		Gross cpm	
Bkg. Cpm	0.002	0.004		Bkg. Mv/sec		Bkg. cpm	NDA
Net cpm	0	0.106		Net mv/sec		net cpm	
~~dpm~~ %AEC		49%		curies/mv		dpm	
dpm/24 hr. (69-74)				liter (69-74)		dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
~~Net Beta~~ Mi/SDL				D(q) (63-68)		uc/mg (69-74)	
D(q) (63-68)	N.D.A.					D(q) (63-68)	

RADIOLOGICAL SAMPLE DATA

NAME OR REQUESTOR'S ID (1-20)	GRADE	AFSN	SOCIAL SECURITY NUMBER	RHL SAMPLE NUMBER 66-1430
TYPE SAMPLE (23-32)	OCCUPATION (34-35)	ANALYSIS DESIRED	REQUESTED BY	AIR FORCE BASE (68-71)
DATE RECEIVED (37-42)	DATE ANALYZED (51-56)	DATE COUNTED 28 JUL 1966	DATE COLLECTED	EXPOSURE DATE
SAMPLE WEIGHT/VOLUME	WEIGHT/VOLUME ANALYZED		TECHNICIAN	

OTHER DATA .939

ENVIRONMENTAL SAMPLES				
COUNTER & EFFICIENCY				
TOTAL COUNTS & MINUTES				
GROSS CPM				
BKG CPM & MINUTES				
NET CPM				
YIELD				

BIOLOGICAL SAMPLES		236	239	RADON	
COUNTER & EFFICIENCY	Spec	27.3	27.3	2.11dpm	
TOTAL COUNTS & MINUTES	100	56	4		
GROSS CPM		0.5600	0.0400		
BKG CPM & MINUTES	800	12 0.0150	8 0.0100		
NET CPM		0.5450	0.0300		
YIELD					
	% Rec.	58.04			

SUMMARY OF RESULTS:

AFLC FORM MAY 66 1165 FC 5400 AFLC-WPAFB-MAY 66 4500

(b) (6) [redacted]

[redacted] [redacted]

Internal Dosimetry Evaluation Form

NAME: [redacted] **SSN:** [redacted]

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
1/18/66 through 1/31/66, onsite
1/24/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 μm AMAD
Date or Period of Evaluated Data: 4 samples, 1/21/66 through 6/2/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☐ Attached	☐ In Process	☒ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ______	
Decorporation:	☐ Yes	☒ No	Agent: ______	Date: ______
Catharsis:	☐ Yes	☒ No	Agent: ______	Date: ______
Surgical excision:	☐ Yes	☒ No	Date: ______	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 μm AMAD particle size on 1/24/66

Code/Model used for: Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 240,000
50 YR CEDE (rem) : 74 (0.74 Sv)

Organ Dose Equivalent Summary	**50 YR CDE (rem/Sv)**
Bone Surface	750/7.5
Lung	270/2.7
Liver	130/1.3
Red Marrow	58/0.58
Other	13/0.13
Testes	11/0.11

DOSE ASSESSOR: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

PEER REVIEWER: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ______
Work Restrictions: N/A

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 μm AMAD particle size on 1/24/66. The date is the midpoint of the period on station from 1/18/66 to 1/31/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-267	G	1/21/66	NR	NR	
66-409	G	2/2/66	1.02	0.750	
66-568	G	2/4/66	1.86	0.089	
66-3407	AS	6/2/66	0.168	0.089	✓
66-3407	G	6/2/66	NR	NR	

* G means gross alpha counting; AS means alpha spectrometry.

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	240,000	74/0.74
LUDEP	680,000	48/0.48

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	1.1E+01/1.1E-01	2.5E-01	2.7E+00/2.7E-02
Breast	3.6E-04/3.6E-06	1.5E-01	5.3E-05/5.3E-07
Red Marrow	5.8E+01/5.8E-01	1.2E-01	6.9E+00/6.9E-02
Lung	2.7E+02/2.7E+00	1.2E-01	3.3E+01/3.3E-01
Thyroid	3.3E-04/3.3E-06	3.0E-02	1.0E-05/1.0E-07
Bone Surface	7.5E+02/7.5E+00	3.0E-02	2.2E+01/2.2E-01
Liver	1.3E+02/1.3E+00	6.0E-02	8.0E+00/8.0E-02
Other	1.3E+01/1.3E-01	6.0E-02	7.6E+00/7.6E-02
Lower Large Intestine	2.7E-02/2.7E-04	6.0E-02	1.6E-03/1.6E-05
Upper Large Intestine	9.1E-03/9.1E-05	6.0E-02	5.5E-04/5.5E-06
Small Intestine	1.9E-03/1.9E-05	6.0E-02	1.1E-04/1.1E-06
Effective Dose Equivalent			7.4E+01/7.4E-01

Three urine samples were analyzed by gross alpha counting only, and the fourth was analyzed by both gross alpha counting and alpha spectrometry. For the sample analyzed with both methods, the gross alpha analysis was not included in the modeling since no result was reported and an alpha spectrometry result was available for the same sample. One of the samples analyzed by gross alpha counting only was not included in the analysis since no result was reported. The other gross alpha results were excluded from the analysis because they did not fit the expected pattern of plutonium excretion and because they may have been contaminated during sample collection on the site. The remaining result was fit using CINDY and the Jones excretion model, to estimate an intake (240,000 pCi), organ doses, and a CEDE (74 rem/0.74 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 680,000 pCi and a CEDE (ICRP-60) of 48 rem (0.48 Sv).

When all results were included in a separate evaluation, CINDY produced estimated intake and CEDE of 970,000 pCi and 300 rem (3.0 Sv). LUDEP estimated intake and CEDE at 4,100,000 pCi and 290 rem (2.9 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 240,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 74 rem (0.74 Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the current level (0.100 rem) for members of the public. It is more than the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). These doses are significant, although they are based in part, on samples collected on-site and potentially contaminated. However, follow-up urine sampling should be considered to provide additional assessment of the exposure.

Prepared By:

Name: ______________________________

Signature: ______________________________ Date: ________________

Peer Reviewed By:

Name: ______________________________

Signature: ______________________________ Date: ________________

RESAMPLE JUL 14 1966 3407 R

INTERNAL DOSE DATA

AFSN: [redacted]

NAME (LAST, FIRST, M.I.) (1-20)	SOC. SEC. NO. (21-29)	TYPE SAMPLE (30)	TYPE ANAL. (31-32)
[redacted] SSGT	[redacted]	Urine	

SAMPLE NO. (33-38)	SAMPLE DATE (39-44)	EXPOSURE
66-3407	FROM 0600 1 Jun TO 0559 2 Jun 66	DATE Jan 66 TYPE

BASE (57-60)	OCCUPATION (61-62)	REQUESTED BY
Ramstein		

DATE RECEIVED	SAMPLE VOLUME	VOLUME ANALYZED	DATE ANALYZED
14 June 1966	1200 ml	600 ~~300~~ ml	

TECHNICIAN (SIGNATURE AND DATE) Spee 15 Sept — Checked off master list

URINE	236	239		RADON		FECES/BLOOD	
Counter Number				Chamber Number	E	Counter Number	
Counter Bkg. (cpm)	7	1	t=128	Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)	31.8	31.8		Counter Eff. (%)	51	Counter Eff.	
Date/Time – Start				Millivolt – Start		Date/Time – Start	
– Stop				Millivolt – Stop		– Stop	
Total Counts	70	4		Total Millivolts		Total Counts	
Counting Time	100	100		Total ~~Count~~ Time	55	Counting Time	
Gross cpm				Gross ~~mv/sec~~ cts	84	Gross cpm	
Bkg. Cpm				Bkg. ~~Mv/sec~~ cts	34(908)	Bkg. cpm	
Net cpm				Net mv/sec		net cpm	
~~dpm~~ % Rec	65.2%			curies/mv		dpm	
dpm/24 hr. (69-74)				~~liter (69-74)~~ % REC	86.9	dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
~~Net Beta~~ Pci/Spl	0.168 ± 0.089			D(q) (63-68)		uc/mg (69-74)	
D(q) (63-68)						D(q) (63-68)	

NAME:	SOCIAL SECURITY NUMBER:	SAMPLE NUMBER:

AIR FORCE BASE

RESULTS OF ANALYSIS
Pu/Spl – .168 ± 0.089   % Rec – 65.2   Previous Results
Total Vol – 1200 ml   Body Burden – 0.06   1.90 pc/l   0.11 BB
Vol Analyzed – 600 ml

☐ Repeat the sample for the following reason:
- ( ) Significant activity in recently analyzed sample(s)
- ( ) Data required to establish dose
- ( ) Improper flask used
- ( ) Other ______
- ( ) Suggested sampling schedule ______

SIGNATURE: DATE:

ONE TIME FORM. OBSOLETE AFTER 30 JUN 66. (MCGSCPF, RAG, 4 APR 66)   AFLC–WPAFB–APR 66 2500

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20)	SOC. SEC. NO. (21-29)	TYPE SAMPLE (30)	TYPE ANAL. (31-32)
[redacted]		URINE	GROSS ALPHA

SAMPLE NO. (33-38)	SAMPLE DATE (39-44) FROM	TO	EXPOSURE DATE	TYPE
(66-267)				

BASE (57-60)	OCCUPATION (61-62)	REQUESTED BY
TORREJON		

DATE RECEIVED	SAMPLE VOLUME	VOLUME ANALYZED	DATE ANALYZED
JAN 25 1966	750 ml	200 ml	

TECHNICIAN (SIGNATURE AND DATE)

URINE	GROSS ALPHA			RADON		FECES/BLOOD	
Counter Number				Chamber Number		Counter Number	
Counter Bkg. (cpm)				Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)				Counter Eff. (%)		Counter Eff.	
Date/Time – Start				Millivolt – Start		Date/Time – Start	
– Stop				Millivolt – Stop		– Stop	
Total Counts				Total Millivots		Total Counts	
Counting Time				Total Drift Time		Counting Time	
Gross cpm				Gross mv/sec		Gross cpm	
Bkg. Cpm				Bkg. Mv/sec		Bkg. cpm	
Net cpm				Net mv/sec		net cpm	
dpm				curies/mv		dpm	
dpm/24 hr. (69-74)				litter (69-74)		dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
Net Beta				D(q) (63-68)		uc/mg (69-74)	
D(q) (63-68)						D(q) (63-68)	

26 Jan 66

[redacted] S/Sgt **INTERNAL DOSE DATA**

[redacted] SOC. SEC. NO. [redacted] TYPE SAMPLE (30) Urine TYPE ANAL. (31-32) Pu 239

SAMPLE NO. (33-38) 66-409 — SAMPLE DATE FROM 1300 1 Feb 66 TO 1300 2 Feb 66 — EXPOSURE DATE / TYPE

BASE (57-60) Ramstein AB, Ger. — OCCUPATION (61-62) — REQUESTED BY

DATE RECEIVED 9 Feb 66 — SAMPLE VOLUME 640 — VOLUME ANALYZED 200 — DATE ANALYZED

TECHNICIAN (SIGNATURE AND DATE) WALTER G. EDWARDS SSGT. USAF 11 FEB 1966

URINE	GROSS ALPHA		
Counter Number	D		
Counter Bkg. (cpm)	0.31		
Counter Eff. (%)	51		
Date/Time – Start	10 FEB 1966		
– Stop			
Total Counts	37		
Counting Time	55		
Gross cpm	0.67		
Bkg. Cpm	0.31		
Net cpm	0.36		
~~dpm~~ Pc/l	1.59 ±1.17		
dpm/24 hr. (69-74)			
K 40 Correction			
Net Beta Pc/24 hr. vol	1.02±0.75		
D (q) (63-68)			

RADON	
Chamber Number	
Cham. Bkg. (mv/sec)	
Counter Eff. (%)	
Millivolt – Start	
Millivolt – Stop	
Total Millivots	
Total Drift Time	
Gross mv/sec	
Bkg. Mv/sec	
Net mv/sec	
curies/mv	
litter (69-74)	
D(q) (63-68)	

FECES/BLOOD	
Counter Number	
Counter Bkg.	
Counter Eff.	
Date/Time – Start	
– Stop	
Total Counts	
Counting Time	
Gross cpm	
Bkg. cpm	
net cpm	
dpm	
dps/cc	
Neutron Dose (rads) (63-68)	
uc/mg (69-74)	
D(q) (63-68)	

$D_R = 403 \times 10^{-3}$ μc

15 Feb 66

[redacted] [redacted]

86 TAC HOSP. 9 FEB. 66
APO NY 09012

409 #4 [redacted] SSG.
[redacted]
Det 0401 7401 EOD SQ.
SSN. [redacted]

1300 1 FEB — 1300 2 FEB.

1 BOTTLE

TOTAL SAMPLE VOL 640 mL

AMT USED 200 mL
NITRIC ACID 50 mL

[redacted]

3407
168. ± 20. ...

1. 0.168 ± .08

2. 65.2

3. 1.2

4. 128

5. 6245

6. 0.06

...mg. mestranol and 2 mg.
A More Physiological Approach to Oral Contraception

(b) (6) [redacted]

Internal Dosimetry Evaluation Form

NAME: [redacted] **SSN:** [redacted]

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
1/18/66 through 3/1/66, onsite
2/8/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 μm AMAD
Date or Period of Evaluated Data: 1 sample, 3/1/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☐ Attached	☐ In Process	☒ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ______	
Decorporation:	☐ Yes	☒ No	Agent: ______	Date: ______
Catharsis:	☐ Yes	☒ No	Agent: ______	Date: ______
Surgical excision:	☐ Yes	☒ No	Date: ______	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 μm AMAD particle size on 2/8/66

Code/Model used for: Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 270000
50 YR CEDE (rem) : 83 (0.83 Sv)

Organ Dose Equivalent Summary	50 YR CDE (rem/Sv)
Bone Surface	840/8.4
Lung	310/3.1
Liver	150/1.5
Red Marrow	65/0.65
Other	14/0.14
Testes	12/0.12

DOSE ASSESSOR: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

PEER REVIEWER: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ______
Work Restrictions: N/A

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 μm AMAD particle size on 2/8/66. The date is the midpoint of the period on station from 1/18/66 to 3/1/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-1849	AS	3/1/66	0.259	0.151	✓
66-1849	G	3/1/66	0.924	0.249	

* G means gross alpha counting; AS means alpha spectrometry.

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	270,000	83/0.83
LUDEP	1,110,000	78/0.78

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	1.2E+01/1.2E-01	2.5E-01	3.0E+00/3.0E-02
Breast	4.0E-04/4.0E-06	1.5E-01	6.0E-05/6.0E-07
Red Marrow	6.5E+01/6.5E-01	1.2E-01	7.8E+00/7.8E-02
Lung	3.1E+02/3.1E+00	1.2E-01	3.7E+01/3.7E-01
Thyroid	3.8E-04/3.8E-06	3.0E-02	1.1E-05/1.1E-07
Bone Surface	8.4E+02/8.4E+00	3.0E-02	2.5E+01/2.5E-01
Liver	1.5E+02/1.5E+00	6.0E-02	9.0E+00/9.0E-02
Other	1.4E+01/1.4E-01	6.0E-02	8.6E-01/8.6E-03
Lower Large Intestine	3.1E-02/3.1E-04	6.0E-02	1.8E-03/1.8E-05
Upper Large Intestine	1.0E-02/1.0E-04	6.0E-02	6.2E-04/6.2E-06
Small Intestine	2.1E-03/2.1E-05	6.0E-02	1.3E-04/1.3E-06
Effective Dose Equivalent			8.3E+01/8.3E-01

One urine sample was analyzed by gross alpha counting and alpha spectrometry. The gross alpha analysis was not included in the modeling since an alpha spectrometry result was available for the same sample. The result was fit using CINDY and the Jones excretion model, to estimate an intake (270,000 pCi), organ doses, and a CEDE (83 rem/0.83 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 1,110,000 pCi and a CEDE (ICRP-60) of 78 rem (0.78 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 270,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 83 rem (0.83 Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the

current level (0.100 rem) for members of the public. It is more than the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). These dose levels are significant although base on only one data point. However, follow-up urine sampling should be considered to provide additional assessment of the exposure.

Prepared By:

Name: ______________________________

Signature: ______________________________ Date: ____________

Peer Reviewed By:

Name: ______________________________

Signature: ______________________________ Date: ____________

X 40

INTERNAL DOSE DATA

AFSN: [redacted]

NAME (LAST, FIRST, M.I.) (1-20) [redacted] A1C	SOC. SEC. NO. (21-29) [redacted]	TYPE SAMPLE (30) Urine	TYPE ANAL. (31-32)
SAMPLE NO. (33-38) 66-1849	SAMPLE DATE (39-44) FROM 1 Mar 66 TO	EXPOSURE DATE	TYPE
BASE (57-60) Móron	OCCUPATION (61-62) 17150	REQUESTED BY	
DATE RECEIVED 28 March 1966	SAMPLE VOLUME 959 ml	VOLUME ANALYZED 959 ml	DATE ANALYZED
TECHNICIAN (SIGNATURE AND DATE)			

URINE			
Counter Number	B		
Counter Bkg. (cpm)	0.04 (900		
Counter Eff. (%)	51		Ez 45
Date/Time – Start	13 May 66		
– Stop			
Total Counts	60	Reported value corrected for spike of 0.965 pc/sample	
Counting Time	55		
Gross cpm	1.09		
Bkg. Cpm	0.04		
Net cpm	1.05		
dpm pci/l	0.964	± 0.260	
dpm/24 hr. (69-74)			
K 40 Correction			
Net Beta pci/spl	0.924	± 0.249	
D (q) (63-68)			

RADON		
Chamber Number		
Cham. Bkg. (mv/sec)		
Counter Eff. (%)		
Millivolt – Start		
Millivolt – Stop		
Total Millivolts		
Total Drift/Time		
Gross mv/sec		
Bkg. Mv/sec		
Net mv/sec		
curies/mv		
litter (69-74)		
D(q) (63-68)		

FECES/BLOOD	
Counter Number	
Counter Bkg.	
Counter Eff.	
Date/Time – Start	
– Stop	✓
Total Counts	
Counting Time	
Gross cpm	NDA
Bkg. cpm	
net cpm	
dpm	
dps/cc	
Neutron Dose (rads) (63-68)	
uc/mg (69-74)	
D (q) (63-68)	

RADIOLOGICAL SAMPLE DATA

NAME OR REQUESTOR'S ID (1-20)	GRADE	AFSN [illegible]	SOCIAL SECURITY NUMBER [illegible]	RHL SAMPLE NUMBER 66-1849	
TYPE SAMPLE (23-32)	OCCUPATION (34-35)	ANALYSIS DESIRED	REQUESTED BY	AIR FORCE BASE (66-71)	
DATE RECEIVED (37-42)	DATE ANALYZED (51-56)	DATE COUNTED 29 June 66	DATE COLLECTED	EXPOSURE DATE	
SAMPLE WEIGHT/VOLUME	WEIGHT/VOLUME ANALYZED	TECHNICIAN			
OTHER DATA .956					

ENVIRONMENTAL SAMPLES					
COUNTER & EFFICIENCY					
TOTAL COUNTS & MINUTES					
GROSS CPM					
BKG CPM & MINUTES					
NET CPM					
YIELD					
BIOLOGICAL SAMPLES		236	239	RADON 2-60 [illegible]	3.09 DPM
COUNTER & EFFICIENCY	Spec	27.3	27.[illegible]		
TOTAL COUNTS & MINUTES	100	61	11	[illegible]	
GROSS CPM		0.6100	0.1100		
BKG CPM & MINUTES	800	1 0.0012	8 0.0099		
NET CPM		0.6088	0.1001	0.259 ± 0.151 pc/SPL	
YIELD					
	% Rec	63.68			

SUMMARY OF RESULTS:

AFLC FORM MAY 66 1165 FC 8400 AFLC-WPAFB-MAY 66 4500

(b) (6) [redacted]

[redacted] [redacted]

Internal Dosimetry Evaluation Form

NAME: [redacted] **SSN:** [redacted]

MODE OF INTAKE:
- ☒ Inhalation ☐ Injection
- ☐ Ingestion ☐ Absorption
- ☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
1/23/66 through 2/9/66, onsite
1/31/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 µm AMAD
Date or Period of Evaluated Data: 2 samples, 2/9/66 and 6/2/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☐ Attached	☐ In Process	☒ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ______	
Decorporation:	☐ Yes	☒ No	Agent: ______	Date: ______
Catharsis:	☐ Yes	☒ No	Agent: ______	Date: ______
Surgical excision:	☐ Yes	☒ No	Date: ______	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 µm AMAD particle size on 1/31/66

Code/Model used for: Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 140000
50 YR CEDE (rem): 43 (0.43 Sv)

Organ Dose Equivalent Summary	50 YR CDE (rem/Sv)
Bone Surface	440/4.4
Lung	160/1.6
Liver	78/0.78
Red Marrow –	34/0.34
Other	7.4/0.074
Testes	6.2/0.062

DOSE ASSESSOR: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

PEER REVIEWER: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ______
Work Restrictions: N/A

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 µm AMAD particle size on 1/31/66. The date is the midpoint of the period on station from 1/23/66 to 2/9/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-814	G	1/29/66	1.31 (12-hr)	0.510	
66-3401	AS	6/2/66	0.099	0.047	✓
66-3401	G	6/2/66	NR	NR	

* G means gross alpha counting; AS means alpha spectrometry; NR means no result recorded.

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	140,000	43/0.43
LUDEP	402,000	28/0.28

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	6.2E+00/6.2E-02	2.5E-01	1.6E+00/1.6E-02
Breast	2.1E-04/2.1E-06	1.5E-01	3.1E-05/3.1E-07
Red Marrow	3.4E+01/3.4E-01	1.2E-01	4.0E+00/4.0E-02
Lung	1.6E+02/1.6E+00	1.2E-01	1.9E+01/1.9E-01
Thyroid	2.0E-04/2.0E-06	3.0E-02	5.9E-06/5.9E-08
Bone Surface	4.4E+02/4.4E+00	3.0E-02	1.3E+01/1.3E-01
Liver	7.8E+01/7.8E-01	6.0E-02	4.7E+00/4.7E-02
Other	7.4E+00/7.4E-02	6.0E-02	4.4E-01/4.4E-03
Lower Large Intestine	1.6E-02/1.6E-04	6.0E-02	9.5E-04/9.5E-06
Upper Large Intestine	5.3E-03/5.3E-05	6.0E-02	3.2E-04/3.2E-06
Small Intestine	1.1E-03/1.1E-05	6.0E-02	6.5E-05/6.5E-07
Effective Dose Equivalent			4.3E+01/4.3E-01

One urine sample was analyzed by gross alpha counting only, and the other was analyzed by both gross alpha counting and alpha spectrometry. For the sample analyzed with both methods, the gross alpha analysis was not included in the modeling since no result was reported and an alpha spectrometry result was available for the same sample. The sample analyzed by gross alpha counting only was not included in the analysis since it was an on-site sample with a result >0.1 pCi, leading to a suspicion of sample contamination. The result was fit using CINDY and the Jones excretion model, to estimate an intake (140,000 pCi), organ doses, and a CEDE (43 rem/0.43 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 402,000 pCi and a CEDE (ICRP-60) of 28 rem (0.28 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 140,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 43 rem (0.43 Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the current level (0.100 rem) for members of the public. It is less than the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). Serious health effects are not associated with that dose level. However, follow-up urine sampling now could be considered to provide additional assessment of the exposure.

Prepared By:

Name: ______________________________

Signature: ______________________________ Date: ______________

Peer Reviewed By:

Name: ______________________________

Signature: ______________________________ Date: ______________

FEB 1? 1966

INTERNAL DOSE DATA

1/LT [redacted]

NAME (LAST, FIRST, INITIAL): [redacted]

SOC. SEC. NO.: [redacted]

TYPE SAMPLE (30): Urine

TYPE ANAL. (31-32): GROSS [illegible]

SAMPLE NO. (33-38): 66-814

SAMPLE DATE (39-44) FROM 12 hr TO 9 feb 66

EXPOSURE DATE 23 Jan 66 TYPE ARA

BASE (57-60): Germany

OCCUPATION (61-62): 0503

REQUESTED BY:

DATE RECEIVED: FEB [illegible] 1966

SAMPLE VOLUME: 470

VOLUME ANALYZED: 200

DATE ANALYZED:

TECHNICIAN (SIGNATURE AND DATE): [signature] / 25 FEB 1966

URINE	GROSS [illegible]		
Counter Number	D	D	
Counter Bkg. (cpm)	0.13	.11	
Counter Eff. (%)	0.51	51	
Date/Time – Start	25 FEB 1966	4 MAR 1966	
– Stop			
Total Counts	317	41	
Counting Time	55 min	55 min	
Gross cpm	5.76	0.74	
Bkg. Cpm	0.13	0.11	
Net cpm	5.63	0.63	
~~dpm~~ Pci/L	~~[illegible]~~	24.9±2.9	2.78±1.09
dpm/24 hr. (69-74)			
K 40 Correction			
~~Net Dose~~ Pci/spl	~~[illegible]~~		1.31±0.57
D (q) (63-68)	11.7±1.4		

RADON	
Chamber Number	
Cham. Bkg. (mv/sec)	
Counter Eff. (%)	
Millivolt – Start	
Millivolt – Stop	
Total Millivots	
Total Drift Time	
Gross mv/sec	
Bkg. Mv/sec	
Net mv/sec	
curies/mv	
litter (69-74)	
D(q) (63-68)	.28

FECES/BLOOD	
Counter Number	
Counter Bkg.	
Counter Eff.	
Date/Time – Start	
– Stop	
Total Counts	
Counting Time	
Gross cpm	
Bkg. cpm	
net cpm	
dpm	
dps/cc	
Neutron Dose (rads) (63-68)	
uc/mg (69-74)	
D (q) (63-68)	

t = 16 D $D_k = 1.20 \times 10^{-2}$ μe (USED 2ND COUNT)

Release of this document is restricted under the provisions of the Privacy Act, 5 U.S.C. 552(a). C.2-297

Palomares Nuclear Weapons Accident [redacted]

Dose Evaluation Report April 28, 2000 [redacted]

[redacted] [redacted]

ARMY RESAMPLE JUL 14 1966

ARMY: [redacted] INTERNAL DOSE DATA ARMY

NAME (LAST, FIRST, M.I.) (1-20)		SOC. SEC. NO. (21-29)	TYPE SAMPLE (30)	TYPE ANAL. (31-32)
[redacted]	1Lt		Urine	

SAMPLE NO. (33-38)	SAMPLE DATE (39-44)		EXPOSURE
66-3401	FROM 2 June 66	TO	DATE Jan 66 TYPE
BASE (57-60) 229 Signal Co APO NY 09189 Pirmasens	OCCUPATION (61-62)	REQUESTED BY	
DATE RECEIVED 14 June 1966	SAMPLE VOLUME 1230 ml	VOLUME ANALYZED 820 ml	DATE ANALYZED

TECHNICIAN (SIGNATURE AND DATE) checked off master list

URINE	236	239		RADON		FECES/BLOOD	
Counter Number				Chamber Number	NMC C5	Counter Number	
Counter Bkg. (cpm)	3	1	980	Cham. Bkg. (mv/sec)	407-45	Counter Bkg.	
Counter Eff. (%)	31.8	318		Counter Eff. (%)		Counter Eff.	
Date/Time – Start	1 SEP 66	1350	t=129	Millivolt – Start	55–108	Date/Time – Start	
– Stop				Millivolt – Stop	1.9636	– Stop	
Total Counts	112	5		Total Millivolts	0495	Total Counts	
Counting Time	100	100		Total Drift Time	1.9141	Counting Time	
Gross cpm				Gross mv/sec		Gross cpm	
Bkg. Cpm				Bkg. Mv/sec		Bkg. cpm	
Net cpm				Net mv/sec		net cpm	
~~dpm~~ % REC	104%			curies/mv		dpm	
dpm/24 hr. (69-74)				litter (69-74)		dps/cc	
K 40 Correction				% REC	112%	Neutron Dose (rads) (63-68)	
~~Net Sam~~ PC/SPL	0.0991 ±	0.0465		D(q) (63-68)		uc/mg (69-74)	
D(q) (63-68)						D(q) (63-68)	

NAME:	SOCIAL SECURITY NUMBER:	SAMPLE NUMBER:

AIR FORCE BASE

RESULTS OF ANALYSIS
Pc/spl – 0.0991 ± 0.0465
Total Vol – 1230
Vol Analyzed – 820

% Rec – 104%
Body Burden – 0.03

Previous Results
2.78 pc/l
0.28 BB

☐ Repeat the sample for the following reason:
( ) Significant activity in recently analyzed sample (s)
( ) Data required to establish dose
( ) Improper flask used
( ) Other
( ) Suggested sampling schedule

SIGNATURE: DATE:

ONE TIME FORM. OBSOLETE AFTER 30 JUN 66. (MCGSCPF, RAG, 4 APR 66) AFLC–WPAFB–APR 66 2500

[redacted] 3401

99 ± 40 fci

1. .099 ± .04

2. .104

3. 1.23

4. 129

5. 6245

6. 0.03

(b) (6) [redacted]

Internal Dosimetry Evaluation Form

NAME: [redacted] **SSN:** [redacted]

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
1/18/66 through 1/29/66, onsite
1/23/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 μm AMAD
Date or Period of Evaluated Data: 2 samples, 1/29/66 and 5/30/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☐ Attached	☐ In Process	☒ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ______	
Decorporation:	☐ Yes	☒ No	Agent: ______	Date: ______
Catharsis:	☐ Yes	☒ No	Agent: ______	Date: ______
Surgical excision:	☐ Yes	☒ No	Date: ______	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 μm AMAD particle size on 1/23/66

Code/Model used for: Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 110000
50 YR CEDE (rem) : 34 (0.34 Sv)

Organ Dose Equivalent Summary	50 YR CDE (rem/Sv)
Bone Surface	340/3.4
Lung	130/1.3
Liver	61/0.61
Red Marrow	26/0.26
Other	5.8/0.058
Testes	4.9/0.049

DOSE ASSESSOR: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

PEER REVIEWER: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ______
Work Restrictions: N/A

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 µm AMAD particle size on 1/23/66. The date is the midpoint of the period on station from 1/18/66 to 1/29/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-1209	G	1/29/66	6.20	2.18	
66-3400	AS	5/30/66	0.078	0.057	✓
66-3400	G	5/30/66	NR	NR	

* G means gross alpha counting; AS means alpha spectrometry; NR means no result reported.

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	110,000	34/0.34
LUDEP	316,000	22/0.22

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	4.9E+00/4.9E-02	2.5E-01	1.2E+00/1.2E-02
Breast	1.6E-04/1.6E-06	1.5E-01	2.4E-05/2.4E-07
Red Marrow	2.6E+01/2.6E-01	1.2E-01	3.2E+00/3.2E-02
Lung	1.3E+02/1.3E+00	1.2E-01	1.5E+01/1.5E-01
Thyroid	1.5E-04/1.5E-06	3.0E-02	4.6E-06/4.6E-08
Bone Surface	3.4E+02/3.4E+00	3.0E-02	1.0E+01/1.0E-01
Liver	6.1E+01/6.1E-01	6.0E-02	3.7E+00/3.7E-02
Other	5.8E+00/5.8E-02	6.0E-02	3.5E-01/3.5E-03
Lower Large Intestine	1.2E-02/1.2E-04	6.0E-02	7.5E-04/7.5E-06
Upper Large Intestine	4.2E-03/4.2E-05	6.0E-02	2.5E-04/2.5E-06
Small Intestine	8.6E-04/8.6E-06	6.0E-02	5.1E-05/5.1E-07
Effective Dose Equivalent			3.4E+01/3.4E-01

One urine sample was analyzed by gross alpha counting only, and the other was analyzed by both gross alpha counting and alpha spectrometry. For the sample analyzed with both methods, the gross alpha analysis was not included in the modeling since no result was reported and an alpha spectrometry result was available for the same sample. The sample analyzed by gross alpha counting only was not included in the analysis since it was an on-site sample with a result >0.1 pCi, leading to a suspicion of sample contamination. The result was fit using CINDY and the Jones excretion model, to estimate an intake (110,000 pCi), organ doses, and a CEDE (34 rem/0.34 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 316,000 pCi and a CEDE (ICRP-60) of 22 rem (0.22 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 110,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 34 rem (0.34 Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the current level (0.100 rem) for members of the public. It is less than the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). Serious health effects are not associated with that dose level. However, follow-up urine sampling now could be considered to provide additional assessment of the exposure.

Prepared By:

Name: ______________________________

Signature: ______________________________ Date: ______________

Peer Reviewed By:

Name: ______________________________

Signature: ______________________________ Date: ______________

AFSN: [redacted]

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20) [redacted] 1C		SOC. SEC. NO. (21-29) [redacted]	TYPE SAMPLE (30) Urine	TYPE ANAL. (31-32)
SAMPLE NO. (33-38) 66-1209	SAMPLE DATE (39-44) FROM 29 Jan 66	TO	EXPOSURE DATE	TYPE
BASE (57-60) Zaragoza	OCCUPATION (61-62) 62250	REQUESTED BY		
DATE RECEIVED 3 March 1966	SAMPLE VOLUME 980	VOLUME ANALYZED 1000	DATE ANALYZED	
TECHNICIAN (SIGNATURE AND DATE)				

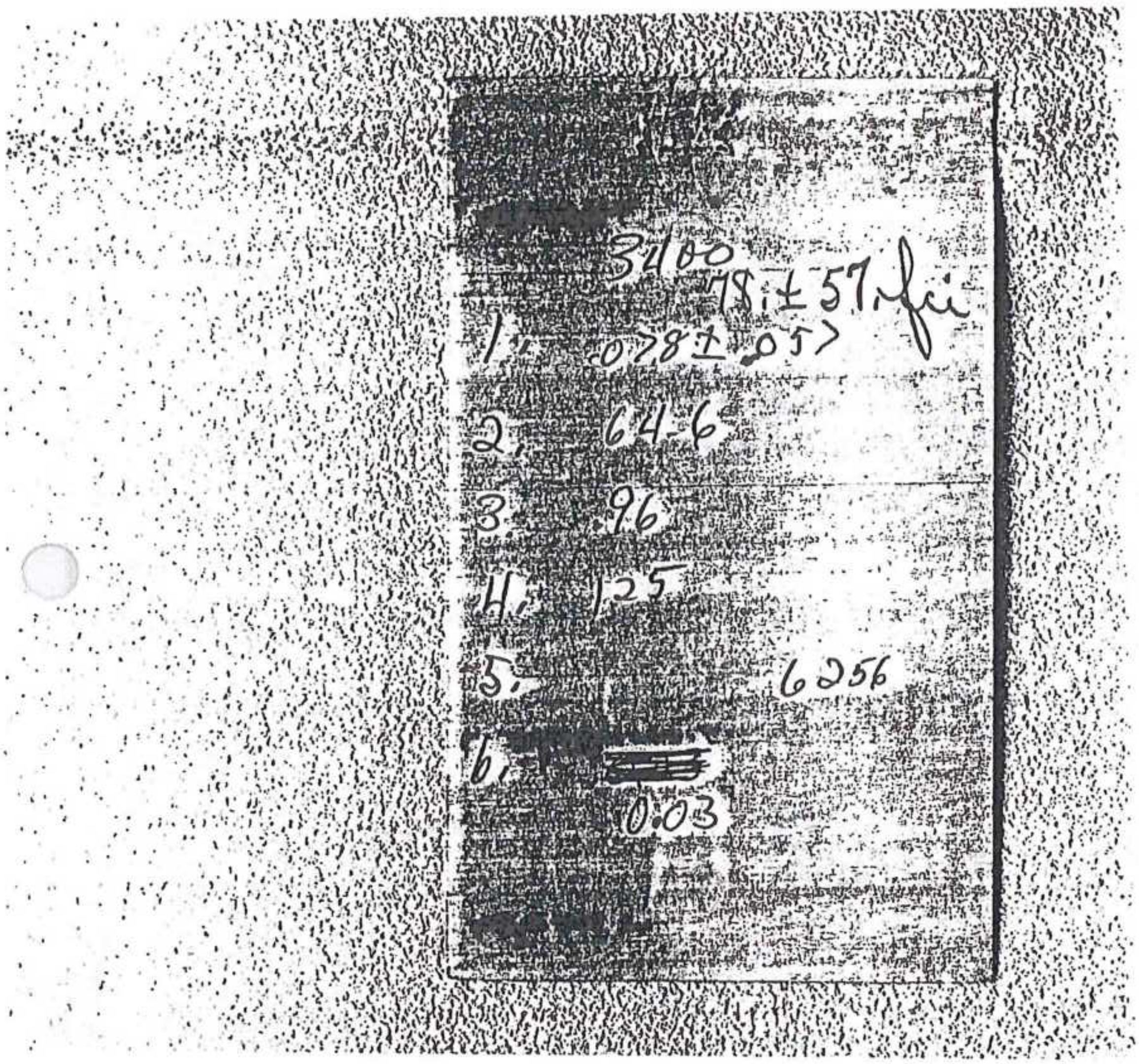
URINE	239	236		RADON		FECES/BLOOD	
Counter Number				Chamber Number		Counter Number	
Counter Bkg. (cpm)				Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)				Counter Eff. (%)		Counter Eff.	
Date/Time – Start	? May 66			Millivolt – Start		Date/Time – Start	✓
– Stop				Millivolt – Stop		– Stop	
Total Counts	10	3		Total Millivots		Total Counts	
Counting Time	100	100		Total Drift Time		Counting Time	
Gross cpm	0.10	0.03		Gross mv/sec		Gross cpm alpha	Spect
Bkg. Cpm	0.002	0.004		Bkg. Mv/sec		Bkg. cpm	6.20 PC
Net cpm	0.098	0.026		Net mv/sec		net cpm	D.81 BB
~~dpm~~ % REC		12		curies/mv		dpm	
dpm/24 hr. (69-74)				litter (69-74)		dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
~~Net Gross~~ PC/SPL	6.20 ± 2.18			D(q) (63-68)		uc/mg (69-74)	
~~D(q) (63-68)~~ PC/L	620 ± 2.18 (6-30D) $D_A = 3.58 \times 10^{-2}$ uc					D(q) (63-68)	

AFSN: [redacted]

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20) [redacted] A1C		SOC. SEC. NO. (21-29) [redacted]	TYPE SAMPLE (30) Urine	TYPE ANAL. (31-32)
SAMPLE NO. (33-38) 66-1209	SAMPLE DATE (39-44) FROM 29 Jan 66	TO	EXPOSURE DATE	TYPE
BASE (57-60) Zaragoza	OCCUPATION (61-62) 62250	REQUESTED BY		
DATE RECEIVED 3 March 1966	SAMPLE VOLUME 980	VOLUME ANALYZED 1000	DATE ANALYZED	
TECHNICIAN (SIGNATURE AND DATE)				

URINE	239	236		RADON		FECES/BLOOD	
Counter Number				Chamber Number		Counter Number	
Counter Bkg. (cpm)				Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)				Counter Eff. (%)		Counter Eff.	
Date/Time – Start	? May 66			Millivolt – Start		Date/Time – Start	
– Stop				Millivolt – Stop		– Stop	✓
Total Counts	10	3		Total Millivots		Total Counts	
Counting Time	100	100		Total Drift Time		Counting Time	
Gross cpm	0.10	0.03		Gross mv/sec		Gross cpm	alpha Spect
Bkg. Cpm	0.002	0.004		Bkg. Mv/sec		Bkg. cpm	6.20 PC
Net cpm	0.098	0.026		Net mv/sec		net cpm	0.81 BB
~~dpm~~ % REC		12		curies/mv		dpm	
dpm/24 hr. (69-74)				litter (69-74)		dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
~~Net Gross~~ PC/SPL	6.20 ± 2.18			D(q) (63-68)		uc/mg (69-74)	
~~D(q) (63-68)~~ PC/L	620 ± 2.18 (6-30D) DA = 3.58 × 10⁻² μc					D(q) (63-68)	


3400
78. ± 57. fci
1. .078 ± .057
2. 64.6
3. 96
4. 125
5. 6256
6. 0.03

(b) (6) [redacted]

Internal Dosimetry Evaluation Form

NAME: [redacted] **SSN:** [redacted]

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
1/18/66 through 2/14/66, onsite
1/31/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 µm AMAD
Date or Period of Evaluated Data: 2 samples, 2/5/66 and 4/8/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☒ Attached	☐ In Process	☐ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ______	
Decorporation:	☐ Yes	☒ No	Agent: ______	Date: ______
Catharsis:	☐ Yes	☒ No	Agent: ______	Date: ______
Surgical excision:	☐ Yes	☒ No	Date: ______	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 µm AMAD particle size on 1/31/66

Code/Model used for: Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 28000
50 YR CEDE (rem) : 8.6 (0.086 Sv)

Organ Dose Equivalent Summary	50 YR CDE (rem/Sv)
Bone Surface	87/0.87
Lung	32/0.32
Liver	16/0.16
Red Marrow	6.7/0.067 –
Other	1.5/0.015
Testes	1.2/0.012

DOSE ASSESSOR: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

PEER REVIEWER: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ______
Work Restrictions: N/A

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 µm AMAD particle size on 1/31/66. The date is the midpoint of the period on station from 1/18/66 to 2/14/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-1149	G	2/5/66	ND	ND	✓
66-2871	AS	4/8/66	0.076	0.007	✓
66-2871	G	4/8/66	1.45	0.310	

* G means gross alpha counting; AS means alpha spectrometry.

A nasal swipe (sample #66-1334) was recorded for [redacted] as being taken on 2/14/66. No result was available.

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	28,000	8.6/0.086
LUDEP	42,400	3.0/0.03

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	1.2E+00/1.2E-02	2.5E-01	3.1E-01/3.1E-03
Breast	4.1E-05/4.1E-07	1.5E-01	6.2E-06/6.2E-08
Red Marrow	6.7E+00/6.7E-02	1.2E-01	8.1E-01/8.1E-03
Lung	3.2E+01/3.2E-01	1.2E-01	3.8E+00/3.8E-02
Thyroid	3.9E-05/3.9E-07	3.0E-02	1.2E-06/1.2E-08
Bone Surface	8.7E+01/8.7E-01	3.0E-02	2.6E+00/2.6E-02
Liver	1.6E+01/1.6E-01	6.0E-02	9.4E-01/9.4E-03
Other	1.5E+00/1.5E-02	6.0E-02	8.9E-02/8.9E-04
Lower Large Intestine	3.2E-03/3.2E-05	6.0E-02	1.9E-04/1.9E-06
Upper Large Intestine	1.1E-03/1.1E-05	6.0E-02	6.4E-05/6.4E-07
Small Intestine	2.2E-04/2.2E-06	6.0E-02	1.3E-05/1.3E-07
Effective Dose Equivalent			8.6E+00/8.6E-02

One urine sample was analyzed by gross alpha counting, and the other was analyzed by both gross alpha counting and alpha spectrometry. The gross alpha analysis for the second sample was not included in the modeling since an alpha spectrometry result was available for the same sample. The sample result that was analyzed using gross alpha counting only was reported as No Detectable Activity. A value of 0.009 pCi was used to represent this outcome. The results were fit using CINDY and the Jones excretion model, to estimate an intake (28,000 pCi), organ doses, and a CEDE (8.6 rem/0.086 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 42,400 pCi and a CEDE (ICRP-60) of 3.0 rem (0.03 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 28,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 8.6 rem (0.086 Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the current level (0.100 rem) for members of the public. It is less than half the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). Serious health effects are not associated with that dose level.

Prepared By:

Name: ______________________

Signature: ______________________ Date: ______________

Peer Reviewed By:

Name: ______________________

Signature: ______________________ Date: ______________

Army [redacted]

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20)	SOC. SEC. NO. (21-29)	TYPE SAMPLE (30)	TYPE ANAL. (31-32)
[redacted] E-5	[redacted]	Urine	

SAMPLE NO. (33-38)	SAMPLE DATE (39-44)		EXPOSURE DATE / TYPE
66-1149	FROM 5 Feb 66	TO	
BASE (57-60)	OCCUPATION (61-62)	REQUESTED BY	
656 Eng. Bn. APO 09081	82D20		
DATE RECEIVED	SAMPLE VOLUME	VOLUME ANALYZED	DATE ANALYZED
1 March 1966	430	430	MAR 17 1966

TECHNICIAN (SIGNATURE AND DATE)

URINE				RADON		FECES/BLOOD	
Counter Number				Chamber Number		Counter Number	
Counter Bkg. (cpm)				Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)				Counter Eff. (%)		Counter Eff.	
Date/Time – Start				Millivolt – Start		Date/Time – Start	
– Stop				Millivolt – Stop		– Stop	
Total Counts				Total Millivolts		Total Counts	
Counting Time				Total Drift Time		Counting Time	
Gross cpm				Gross mv/sec		Gross cpm	
Bkg. Cpm				Bkg. Mv/sec		Bkg. cpm	
Net cpm				Net mv/sec		net cpm	
dpm				curies/mv		dpm	
dpm/24 hr. (69-74)				liter (69-74)		dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
Net Beta				D(q) (63-68)		uc/ml (69-74)	
D(q) (63-68)						D(q) (63-68)	

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20)	SOC. SEC. NO. (21-29)	TYPE SAMPLE (30)	TYPE ANAL. (31-32)
ARMY: [redacted]		NASAL SWIPE	
[redacted] SP5 E-5			

SAMPLE NO. (33-38)	SAMPLE DATE (39-44)		EXPOSURE DATE	TYPE
66-1334	FROM 14 FEB 66	TO		
BASE (57-60)	OCCUPATION (61-62)	REQUESTED BY		
656 ENG. BN. APO 09081				
DATE RECEIVED	SAMPLE VOLUME	VOLUME ANALYZED	DATE ANALYZED	
9 MARCH 1966				
TECHNICIAN (SIGNATURE AND DATE)				

URINE				RADON		FECES/BLOOD	
Counter Number	TRICARB			Chamber Number		Counter Number	
Counter Bkg. (cpm)				Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)				Counter Eff. (%)		Counter Eff.	
Date/Time – Start	10 MAR 66			Millivolt – Start		Date/Time – Start	
– Stop				Millivolt – Stop		– Stop	
Total Counts	3354			Total Millivots		Total Counts	
Counting Time	20			Total Drift Time		Counting Time	
Gross cpm	168			Gross mv/sec		Gross cpm	
Bkg. Cpm	164			Bkg. Mv/sec		Bkg. cpm	
Net cpm	4±10			Net mv/sec		net cpm	
dpm	NDA			curies/mv		dpm	
dpm/24 hr. (69-74)				litter (69-74)		dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
Net Beta				D(q) (63-68)		uc/mg (69-74)	
D(q) (63-68)						D(q) (63-68)	

Release of this document is restricted under the provisions of the Privacy Act, 5 U.S.C. 552(a). C.2-313

Palomares Nuclear Weapons Accident [redacted]

Dose Evaluation Report [redacted]
April 28, 2000

[redacted] INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20) [redacted]	SOC. SEC. NO. (21-29) Not Listed	TYPE SAMPLE (30) Urine	TYPE ANAL. (31-32)
SAMPLE NO. (33-38) 66-2871	SAMPLE DATE (39-44) FROM Not Listed TO	EXPOSURE DATE Not Listed	TYPE
BASE (57-60) Not Listed	OCCUPATION (61-62) Not Listed	REQUESTED BY	
DATE RECEIVED 22 April 1966	SAMPLE VOLUME 700	VOLUME ANALYZED 700	DATE ANALYZED
TECHNICIAN [redacted]			

URINE			
Counter Number	C		
Counter Bkg. (cpm)	0.04 (800)		t=60
Counter Eff. (%)	51		
Date/Time – Start	13 may 66		
– Stop		Reported value	
Total Counts	93	corrected for spike	
Counting Time	55	of 0.965 pc/sample	
Gross cpm	1.69		
Bkg. Cpm	0.04		
Net cpm	1.65		
~~dpm~~ pci/l	2.08	± 0.44	
dpm/24 hr. (69-74)			
K 40 Correction			
~~Net Beta~~ pci/gl	1.45	± 0.31	
D(q) (63-68)			

RADON	
Chamber Number	
Cham. Bkg. (mv/sec)	
Counter Eff. (%)	
Millivolt – Start	
Millivolt – Stop	
Total Millivolts	
Total Drift Time	
Gross mv/sec	
Bkg. Mv/sec	
Net mv/sec	
curies/mv	
liter (69-74)	
D(q) (63-68)	

FECES/BLOOD	
Counter Number	
Counter Bkg.	
Counter Eff.	
Date/Time – Start	
– Stop	✓
Total Counts	
Counting Time	
Gross cpm	
Bkg. cpm	1.04 PC
net cpm	0.10 BB
dpm	
dps/cc	
Neutron Dose (rads) (63-68)	
uc/mg (69-74)	
D(q) (63-68)	

RADIOLOGICAL SAMPLE DATA

NAME OR REQUESTOR'S ID (1–20)		GRADE	AFSN	SOCIAL SECURITY NUMBER	RHL SAMPLE NUMBER 66-2877
TYPE SAMPLE (23–32)	OCCUPATION (34–35)	ANALYSIS DESIRED		REQUESTED BY	AIR FORCE BASE (68–71)
DATE RECEIVED (37–42)	DATE ANALYZED (51–56)	DATE COUNTED 5 July 66		DATE COLLECTED	EXPOSURE DATE
SAMPLE WEIGHT/VOLUME		WEIGHT/VOLUME ANALYZED		TECHNICIAN	
OTHER DATA .953					

ENVIRONMENTAL SAMPLES					
COUNTER & EFFICIENCY					
TOTAL COUNTS & MINUTES					
GROSS CPM					
BKG CPM & MINUTES					
NET CPM					
YIELD					
BIOLOGICAL SAMPLES		276	239		
COUNTER & EFFICIENCY	Spec	27.3	27.3	RADON	
TOTAL COUNTS & MINUTES	100	92	5	353 dpm	3.2 X [illegible]
GROSS CPM		0.9200	0.0500	[illegible]	
BKG CPM & MINUTES	800	1 0.0013	4 0.0050		
NET CPM		0.9187	0.0450		
YIELD				0.076±0.007	
	%Rec	96.40			

SUMMARY OF RESULTS:

AFLC FORM MAY 66 1165 FC 8400 AFLC–WPAFB–MAY 66 4500

Release of this document is restricted under the provisions of the Privacy Act, 5 U.S.C. 552(a). C.2-314

(b) (6) [redacted]

[redacted] [redacted]

Internal Dosimetry Evaluation Form

NAME: [redacted] SSN: [redacted]

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
1/18/66 through 4/8/66, onsite
2/27/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 μm AMAD
Date or Period of Evaluated Data: 1 sample, 4/8/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☐ Attached	☐ In Process	☒ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ______	
Decorporation:	☐ Yes	☒ No	Agent: ______	Date: ______
Catharsis:	☐ Yes	☒ No	Agent: ______	Date: ______
Surgical excision:	☐ Yes	☒ No	Date: ______	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 μm AMAD particle size on 2/27/66

Code/Model used for: Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 95000
50 YR CEDE (rem) : 29 (0.29 Sv)

Organ Dose Equivalent Summary	**50 YR CDE (rem/Sv)**
Bone Surface	300/3
Lung	110/1.1
Liver	53/0.53
Red Marrow	23/0.23
Other	5/0.05
Testes	4.2/0.042

DOSE ASSESSOR: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

PEER REVIEWER: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ______
Work Restrictions: N/A

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 µm AMAD particle size on 2/27/66. The date is the midpoint of the period on station from 1/18/66 to 4/8/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-2861	AS	4/8/66	0.074	0.011	✓
66-2861	G	4/8/66	1.29	0.290	

* G means gross alpha counting; AS means alpha spectrometry.

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	95,000	29/0.29
LUDEP	316,000	22/0.22

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	4.2E+00/4.2E-02	2.5E-01	1.1E+00/1.1E-02
Breast	1.4E-04/1.4E-06	1.5E-01	2.1E-05/2.1E-07
Red Marrow	2.3E+01/2.3E-01	1.2E-01	2.7E+00/2.7E-02
Lung	1.1E+02/1.1E+00	1.2E-01	1.3E+01/1.3E-01
Thyroid	1.3E-04/1.3E-06	3.0E-02	4.0E-06/4.0E-08
Bone Surface	3.0E+02/3.0E+00	3.0E-02	8.9E+00/8.9E-02
Liver	5.3E+01/5.3E-01	6.0E-02	3.2E+00/3.2E-02
Other	5.0E+00/5.0E-02	6.0E-02	3.0E-01/3.0E-03
Lower Large Intestine	1.1E-02/1.1E-04	6.0E-02	6.5E-04/6.5E-06
Upper Large Intestine	3.6E-03/3.6E-05	6.0E-02	2.2E-04/2.2E-06
Small Intestine	7.4E-04/7.4E-06	6.0E-02	4.4E-05/4.4E-07
Effective Dose Equivalent			2.9E+01/2.9E-01

One urine sample was analyzed by gross alpha counting and alpha spectrometry. The gross alpha analysis was not included in the modeling since an alpha spectrometry result was available for the same sample. The result was fit using CINDY and the Jones excretion model, to estimate an intake (95,000 pCi), organ doses, and a CEDE (29 rem/0.29 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 316,000 pCi and a CEDE (ICRP-60) of 22 rem (0.22 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 95,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 29 rem (0.29 Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the current level (0.100 rem) for members of the public. It is less than the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). Serious health effects are not associated with that dose level.

Prepared By:

Name: ______________________________

Signature: ______________________________ Date: ________________

Peer Reviewed By:

Name: ______________________________

Signature: ______________________________ Date: ________________

40

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20): [redacted] SSgt

SOC. SEC. NO. (21-29): [redacted]

TYPE SAMPLE (30): Urine

TYPE ANAL. (31-32):

SAMPLE NO. (33-38): 66-2861

SAMPLE DATE (39-44): FROM 8 Apr 66 TO

EXPOSURE DATE 18 Jan 66 TYPE

BASE (57-60): Moron

OCCUPATION (61-62): Not Listed

REQUESTED BY:

DATE RECEIVED: 22 April 1966

SAMPLE VOLUME: 1425

VOLUME ANALYZED: 1425

DATE ANALYZED:

TECHNICIAN (SIGNATURE AND DATE):

URINE			
Counter Number	C		
Counter Bkg. (cpm)	0.04 (900)		
Counter Eff. (%)	51		
Date/Time – Start	13 May 66		
– Stop			
Total Counts	83		t=82
Counting Time	55	Reported value corrected	
Gross cpm	1.51	for spike of 0.965pc	
Bkg. Cpm	0.04	per sample	
Net cpm	1.47		
~~dpm~~ pci/l	0.908	± 0.206	
dpm/24 hr. (69-74)			
K 40 Correction			
~~Net Beta~~ pci/Spl	1.29	± 0.29	
D (q) (63-68)			

RADON	
Chamber Number	[illegible]
Cham. Bkg. (mv/sec)	[illegible]
Counter Eff. (%)	[illegible]
Millivolt – Start	[illegible]
Millivolt – Stop	[illegible]
Total Millivots	[illegible]
Total Drift Time	[illegible]
Gross mv/sec	[illegible]
Bkg. Mv/sec	[illegible]
Net mv/sec	[illegible]
curies/mv	[illegible]
liter (69-74)	[illegible]
	[illegible]
D(q) (63-68)	[illegible]

FECES/BLOOD	
Counter Number	
Counter Bkg.	
Counter Eff.	
Date/Time – Start	✓
– Stop	
Total Counts	
Counting Time	
Gross cpm	
Bkg. cpm	0.22PC
net cpm	NSBB
dpm	
dps/cc	
Neutron Dose (rads) (63-68)	
uc/mg (69-74)	
D (q) (63-68)	

Release of this document is restricted under the provisions of the Privacy Act, 5 U.S.C. 552(a). C.2-320

RADIOLOGICAL SAMPLE DATA

NAME OR REQUESTOR'S ID (1-20)	GRADE	AFSN	SOCIAL SECURITY NUMBER	RHL SAMPLE NUMBER 66-2861
TYPE SAMPLE (23-32)	OCCUPATION (34-35)	ANALYSIS DESIRED	REQUESTED BY	AIR FORCE BASE (68-71)
DATE RECEIVED (37-42)	DATE ANALYZED (51-56)	DATE COUNTED 28 June 66	DATE COLLECTED	EXPOSURE DATE
SAMPLE WEIGHT/VOLUME		WEIGHT/VOLUME ANALYZED	TECHNICIAN	
OTHER DATA .956				

ENVIRONMENTAL SAMPLES						
COUNTER & EFFICIENCY						
TOTAL COUNTS & MINUTES						
GROSS CPM						
BKG CPM & MINUTES						
NET CPM						
YIELD						
BIOLOGICAL SAMPLES		236		Pu 239	RADON	1.88 DPM
COUNTER & EFFICIENCY	Spec	27.3		27.3	7.26	
TOTAL COUNTS & MINUTES	100	85		25	± 0.69	
GROSS CPM			0.8500	0.0500		
BKG CPM & MINUTES	800	1	0.0012	8 0.0099		
NET CPM			0.8488	0.0401	0.074 ± 0.011	
YIELD						
% Rec		88.79				

SUMMARY OF RESULTS:

AFLC FORM MAY 66 1165 FC 5400

AFLC-WPAFB-MAY 66 4500

Palomares Nuclear Weapons Accident

Dose Evaluation Report
April 28, 2000

(b)(6) [redacted]

(b)(6) [redacted]

(b) (6) [redacted]

Internal Dosimetry Evaluation Form

NAME: [redacted] **SSN:** [redacted]

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
1/18/66 through 3/4/66, onsite
2/9/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 μm AMAD
Date or Period of Evaluated Data: 1 sample, 4/6/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☐ Attached	☐ In Process	☒ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ________	
Decorporation:	☐ Yes	☒ No	Agent: ________	Date: ________
Catharsis:	☐ Yes	☒ No	Agent: ________	Date: ________
Surgical excision:	☐ Yes	☒ No	Date: ________	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 μm AMAD particle size on 2/9/66

Code/Model used for:
Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 310000
50 YR CEDE (rem) : 95 (0.95 Sv)

Organ Dose Equivalent Summary	**50 YR CDE (rem/Sv)**
Bone Surface	970/9.7
Lung	350/3.5
Liver	170/1.7
Red Marrow	75/0.75
Other	16/0.16
Testes	14/0.14

DOSE ASSESSOR: **DATE:** ________
Signature: ________
Print Name: ________
SSN: ________

PEER REVIEWER: **DATE:** ________
Signature: ________
Print Name: ________
SSN: ________

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ________
Work Restrictions: N/A

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 µm AMAD particle size on 2/9/66. The date is the midpoint of the period on station from 1/18/66 to 3/4/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-2869	AS	4/6/66	0.224	0.007	✓
66-2869	G	4/6/66	1.75	0.340	

* G means gross alpha counting; AS means alpha spectrometry.

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	310,000	95/0.95
LUDEP	950,000	67/0.67

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	1.4E+01/1.4E-01	2.5E-01	3.5E+00/3.5E-02
Breast	4.6E-04/4.6E-06	1.5E-01	6.9E-05/6.9E-07
Red Marrow	7.5E+01/7.5E-01	1.2E-01	9.0E+00/9.0E-02
Lung	3.5E+02/3.5E+00	1.2E-01	4.2E+01/4.2E-01
Thyroid	4.3E-04/4.3E-06	3.0E-02	1.3E-05/1.3E-07
Bone Surface	9.7E+02/9.7E+00	3.0E-02	2.9E+01/2.9E-01
Liver	1.7E+02/1.7E+00	6.0E-02	1.0E+01/1.0E-01
Other	1.6E+01/1.6E-01	6.0E-02	9.8E-01/9.8E-03
Lower Large Intestine	3.5E-02/3.5E-04	6.0E-02	2.1E-03/2.1E-05
Upper Large Intestine	1.2E-02/1.2E-04	6.0E-02	7.1E-04/7.1E-06
Small Intestine	2.4E-03/2.4E-05	6.0E-02	1.5E-04/1.5E-06
Effective Dose Equivalent			9.5E+01/9.5E-01

One urine sample was analyzed by gross alpha counting and alpha spectrometry. The gross alpha analysis was not included in the modeling since an alpha spectrometry result was available for the same sample. The result was fit using CINDY and the Jones excretion model, to estimate an intake (310,000 pCi), organ doses, and a CEDE (95 rem/0.95 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 950,000 pCi and a CEDE (ICRP-60) of 67 rem (0.67 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 310,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 95 rem (0.95 Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the

current level (0.100 rem) for members of the public. It is more than the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). These dose levels are significant, although they were based on only one sample. However, follow-up urine sampling should be considered to provide additional assessment of the exposure.

Prepared By:

Name: ______________________________

Signature: ______________________________ Date: ____________________

Peer Reviewed By:

Name: ______________________________

Signature: ______________________________ Date: ____________________

33

AFSN: (b) (6) [redacted]

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20) (b) (6) [redacted] A2C		SOC. SEC. NO. (21-29) (b) (6) [redacted]	TYPE SAMPLE (30) Urine	TYPE ANAL. (31-32)
SAMPLE NO. (33-38) 66-2869	SAMPLE DATE (39-44) FROM 0700 5 Apr	TO 0700 6 Apr 66	EXPOSURE DATE 18 Jan - 4 Mar 66	TYPE
BASE (57-60) Torrejon	OCCUPATION (61-62) Searcher	REQUESTED BY		
DATE RECEIVED 22 April 1966	SAMPLE VOLUME 1400	VOLUME ANALYZED 1400	DATE ANALYZED	
TECHNICIAN (SIGNATURE AND DATE)				

URINE			
Counter Number	A		
Counter Bkg. (cpm)	0.04 (900)		t=33
Counter Eff. (%)	51		
Date/Time – Start	13may66		
– Stop			
Total Counts	111	Reported value	
Counting Time	55	corrected for spike	
Gross cpm	2.02	of 0.965 pc/sample	
Bkg. Cpm	0.04		
Net cpm	1.98		
~~dpm~~ pci/l	1.25 ± 0.24		
dpm/24 hr. (69-74)			
K 40 Correction			
~~Net Beta~~ pci/Spl	1.75 ± 0.34		
D (q) (63-68)			

RADON		
Chamber Number		
Cham. Bkg. (mv/sec)		
Counter Eff. (%)		
Millivolt – Start		
Millivolt – Stop		
Total Millivots		
Total Drift Time		
Gross mv/sec		
Bkg. Mv/sec		
Net mv/sec		
curies/mv		
litter (69-74)		
D(q) (63-68)		

FECES/BLOOD	
Counter Number	
Counter Bkg.	
Counter Eff.	
Date/Time – Start	
– Stop	
Total Counts	✓
Counting Time	
Gross cpm	
Bkg. cpm	0.90 PC
net cpm	0.10 BB
dpm	
dps/cc	
Neutron Dose (rads) (63-68)	
uc/mg (69-74)	
D (q) (63-68)	

RADIOLOGICAL SAMPLE DATA

NAME OR REQUESTOR'S ID (1–20)	GRADE	AFSN	SOCIAL SECURITY NUMBER	RHL SAMPLE NUMBER CC-2869
TYPE SAMPLE (23–32)	OCCUPATION (34–35)	ANALYSIS DESIRED	REQUESTED BY	AIR FORCE BASE (68–71)
DATE RECEIVED (37–42)	DATE ANALYZED (51–56)	DATE COUNTED 6 July 66	DATE COLLECTED	EXPOSURE DATE
SAMPLE WEIGHT/VOLUME	WEIGHT/VOLUME ANALYZED		TECHNICIAN	
OTHER DATA .953				

ENVIRONMENTAL SAMPLES				
COUNTER & EFFICIENCY				
TOTAL COUNTS & MINUTES				
GROSS CPM				
BKG CPM & MINUTES				
NET CPM				
YIELD				
BIOLOGICAL SAMPLES	236	239		
COUNTER & EFFICIENCY SPEC	27.3	27.3	RADON	
TOTAL COUNTS & MINUTES 100	88	13	324 min	3.88 DPM
GROSS CPM	0.8800	0.1300	±0.16	
BKG CPM & MINUTES 800	1 0.0013	4 0.0050		
NET CPM	0.8787			
YIELD			0.224±0.007	
% Rec	92.20			

SUMMARY OF RESULTS:

AFLC FORM MAY 66 1165 FC 5400 AFLC–WPAFB–MAY 66 4500

[redacted]

Internal Dosimetry Evaluation Form

NAME: [redacted] **SSN:** [redacted]

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
1/29/66 through 2/14/66, onsite
2/6/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 µm AMAD
Date or Period of Evaluated Data: 2 samples, 2/14/66 and 4/8/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☒ Attached	☐ In Process	☐ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ____	
Decorporation:	☐ Yes	☒ No	Agent: ____	Date: ____
Catharsis:	☐ Yes	☒ No	Agent: ____	Date: ____
Surgical excision:	☐ Yes	☒ No	Date: ____	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 µm AMAD particle size on 2/6/66

Code/Model used for: Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 110000
50 YR CEDE (rem): 34 (0.34 Sv)

Organ Dose Equivalent Summary	**50 YR CDE (rem/Sv)**
Bone Surface	340/3.4
Lung	130/1.3
Liver	61/0.61
Red Marrow	26/0.26
Other	5.8/0.058
Testes	4.9/0.049

DOSE ASSESSOR: **DATE:** ____
Signature: ____
Print Name: ____
SSN: ____

PEER REVIEWER: **DATE:** ____
Signature: ____
Print Name: ____
SSN: ____

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ____
Work Restrictions: N/A

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 μm AMAD particle size on 2/6/66. The date is the midpoint of the period on station from 1/29/66 to 2/14/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-1147	G	2/14/66	NR	NR	
66-2872	AS	4/8/66	0.076	0.007	✓
66-2872	G	4/8/66	1.66	0.330	

* G means gross alpha counting; AS means alpha spectrometry; NR means no result reported.

A nasal swipe (sample #66-1333) was reported to have been taken for [redacted] on 2/14/66. No result was available for this sample.

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	110,000	34/0.34
LUDEP	321,000	22/0.22

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	4.9E+00/4.9E-02	2.5E-01	1.2E+00/1.2E-02
Breast	1.6E-04/1.6E-06	1.5E-01	2.4E-05/2.4E-07
Red Marrow	2.6E+01/2.6E-01	1.2E-01	3.2E+00/3.2E-02
Lung	1.3E+02/1.3E+00	1.2E-01	1.5E+01/1.5E-01
Thyroid	1.5E-04/1.5E-06	3.0E-02	4.6E-06/4.6E-08
Bone Surface	3.4E+02/3.4E+00	3.0E-02	1.0E+01/1.0E-01
Liver	6.1E+01/6.1E-01	6.0E-02	3.7E+00/3.7E-02
Other	5.8E+00/5.8E-02	6.0E-02	3.5E-01/3.5E-03
Lower Large Intestine	1.2E-02/1.2E-04	6.0E-02	7.5E-04/7.5E-06
Upper Large Intestine	4.2E-03/4.2E-05	6.0E-02	2.5E-04/2.5E-06
Small Intestine	8.6E-04/8.6E-06	6.0E-02	5.1E-05/5.1E-07
Effective Dose Equivalent			3.4E+01/3.4E-01

One urine sample was analyzed by gross alpha counting only, and the other was analyzed by both gross alpha counting and alpha spectrometry. For the sample analyzed with both methods, the gross alpha analysis was not included in the modeling since an alpha spectrometry result was available for the same sample. The sample analyzed by gross alpha counting only was not included in the analysis since no result was reported for it. The result was fit using CINDY and the Jones excretion model, to estimate an intake (110,000 pCi), organ doses, and a CEDE (34 rem/0.34 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 321,000 pCi and a CEDE (ICRP-60) of 22 rem (0.22 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 110,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 34 rem (0.34 Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the current level (0.100 rem) for members of the public. It is less than the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). Serious health effects are not associated with that dose level. However, follow-up urine sampling now could be considered to provide additional assessment of the exposure.

Prepared By:

Name: [redacted]

Signature: ______________ Date: ______________

Peer Reviewed By:

Name: [redacted]

Signature: ______________ Date: ______________

Army

[redacted]

27

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) STETSON, RONALD [redacted]	SOC. SEC. NO. (21-29) Not Listed	TYPE SAMPLE (30) Urine	TYPE ANAL. (31-32)
SAMPLE NO. (33-38) 66-2872	SAMPLE DATE (39-44) FROM Not Listed	TO	EXPOSURE DATE Not Listed TYPE
BASE (57-60) Not Listed	OCCUPATION (61-62) Not Listed	REQUESTED BY	
DATE RECEIVED 22 April 1966	SAMPLE VOLUME 1500	VOLUME ANALYZED 1500	DATE ANALYZED
TECHNICI[redacted]			

URINE			
Counter Number	D		
Counter Bkg. (cpm)	0.03 (900)		t=60
Counter Eff. (%)	51		
Date/Time – Start	13 May 66		
– Stop			
Total Counts	105	Reported value	
Counting Time	55	corrected for spike	
Gross cpm	1.91	of 0.965	pc/sample
Bkg. Cpm	0.03		
Net cpm	1.89		
~~dpm~~ pci/l	1.11 ± 0.22		
dpm/24 hr. (69-74)			
K 40 Correction			
~~Net Beta~~ pci/Spl	1.66 ± 0.33		
D (q) (63-68)			

RADON		
Chamber Number		
Cham. Bkg. (mv/sec)		
Counter Eff. (%)		
Millivolt – Start		
Millivolt – Stop		
Total Millivots		
Total Drift Time		
Gross mv/sec		
Bkg. Mv/sec		
Net mv/sec		
curies/mv		
litter (69-74)		
D(q) (63-68)		

FECES/BLOOD	
Counter Number	
Counter Bkg.	
Counter Eff.	
Date/Time – Start	✓
– Stop	
Total Counts	
Counting Time	
Gross cpm	
Bkg. cpm	0.83 Pc
net cpm	0.15 BB
dpm	
dps/cc	
Neutron Dose (rads) (63-68)	
uc/mg (69-74)	
D(q) (63-68)	

[redacted]

RADIOLOGICAL SAMPLE DATA

NAME OR REQUESTOR'S ID (1–20)	GRADE	AFSN	SOCIAL SECURITY NUMBER	RHL SAMPLE NUMBER
				66-2872

TYPE SAMPLE (23–32)	OCCUPATION (34–35)	ANALYSIS DESIRED	REQUESTED BY	AIR FORCE BASE (66–71)

DATE RECEIVED (37–42)	DATE ANALYZED (51–56)	DATE COUNTED	DATE COLLECTED	EXPOSURE DATE
		6 July 66		

SAMPLE WEIGHT/VOLUME	WEIGHT/VOLUME ANALYZED	TECHNICIAN

OTHER DATA ,953

ENVIRONMENTAL SAMPLES				
COUNTER & EFFICIENCY				
TOTAL COUNTS & MINUTES				
GROSS CPM				
BKG CPM & MINUTES				
NET CPM				
YIELD				

BIOLOGICAL SAMPLES		236	239	RADON	
COUNTER & EFFICIENCY	Spec	27.3	27.3	3.57 dpm	3.69 DPM
TOTAL COUNTS & MINUTES	100	93	5	±0.17	
GROSS CPM		0.9300	0.0500		
BKG CPM & MINUTES	800	1 0.0013	4 0.0050		
NET CPM		0.9287	0.0450		
YIELD				0.076 ± 0.007	
% Rec		97.40			

SUMMARY OF RESULTS:

AFLC FORM MAY 66 1165 FC 5400 AFLC-WPAFB-MAY 66 4500

Dose Evaluation Report April 28, 2000

[redacted]

Release of this document is restricted under the provisions of the Privacy Act, 5 U.S.C. 552(a). C.2-332

ARMY: [redacted]
NAME (LAST, FIRST, M.I.) (1-20)
[redacted]

INTERNAL DOSE DATA

SAMPLE NO. (33-38) 66-1333	E-3	SOC. SEC. NO. (21-29)	TYPE SAMPLE (30) Nasal Swipe / TYPE ANAL. (31-32)
BASE (57-60) 65th Eng. Bn. APO 09081	SAMPLE DATE (39-44) FROM 14 FEB 66	TO	EXPOSURE DATE / TYPE
DATE RECEIVED 9 March 1966	OCCUPATION (61-62)	REQUESTED BY	
TECHNICIAN (SIGNATURE AND DATE)	SAMPLE VOLUME	VOLUME ANALYZED	DATE ANALYZED

~~URINE~~				RADON		FECES/BLOOD	
Counter Number	TRICARB			Chamber Number		Counter Number	
Counter Bkg. (cpm)				Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)				Counter Eff. (%)		Counter Eff.	
Date/Time – Start	10 MAR 66			Millivolt – Start		Date/Time – Start	
– Stop				Millivolt – Stop		– Stop	
Total Counts	4439			Total Millivots		Total Counts	
Counting Time	20			Total Drift Time		Counting Time	
Gross cpm	222			Gross mv/sec		Gross cpm	
Bkg. Cpm	164			Bkg. Mv/sec		Bkg. cpm	
Net cpm	58 ± 11			Net mv/sec		net cpm	
dpm	58 ± 11			curies/mv		dpm	
dpm/24 hr. (69-74)				liter (69-74)		dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
Net Beta				D(q) (63-68)		uc/mg (69-74)	
D(q) (63-68)						D(q) (63-68)	

Army [redacted]

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20) [redacted] G. E-3		SOC. SEC. NO. (21-29) [redacted]	TYPE SAMPLE (30) Urine / TYPE ANAL. (31-32)
SAMPLE NO. (33-38) 66-1147	SAMPLE DATE (39-44) 14-2-66 FROM ~~29 Jan 66~~ TO		EXPOSURE DATE 29 Jan 66 TYPE
BASE (57-60) 656 Eng. Bn. APO 09081	OCCUPATION (61-62) 82D20	REQUESTED BY	
DATE RECEIVED 1 March 1966	SAMPLE VOLUME 510	VOLUME ANALYZED 530	DATE ANALYZED
TECHNICIAN (SIGNATURE AND DATE)			

URINE	238	236		
Counter Number				
Counter Bkg. (cpm)				
Counter Eff. (%)				
Date/Time – Start	27 MAR 66			
– Stop	1255 – 1435			
Total Counts	0	0		
Counting Time	100	100		
Gross cpm	0	0		
Bkg. Cpm	0.0025	0,0075		
Net cpm	0	0		
dpm				
dpm/24 hr. (69-74)				
K 40 Correction				
Net Beta				
D(q) (63-68)				

RADON		
Chamber Number		
Cham. Bkg. (mv/sec)		
Counter Eff. (%)		
Millivolt – Start		
Millivolt – Stop		
Total Millivolts		
Total Drift Time		
Gross mv/sec		
Bkg. Mv/sec		
Net mv/sec		
curies/mv		
liter (69-74)		
D(q) (63-68)		

FECES/BLOOD	
Counter Number	
Counter Bkg.	
Counter Eff.	
Date/Time – Start	
– Stop	
Total Counts	
Counting Time	
Gross cpm	
Bkg. cpm	
net cpm	
dpm	
dps/cc	
Neutron Dose (rads) (63-68)	
uc/mg (69-74)	
D(q) (63-68)	

(b) (6)
[redacted]

[redacted] [redacted]

Internal Dosimetry Evaluation Form

NAME: [redacted] SSN: [redacted]

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
2/1/66 through 2/27/66, onsite
2/13/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 μm AMAD
Date or Period of Evaluated Data: 2 samples, 2/27/66 and 2/28/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☐ Attached	☐ In Process	☒ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ______	
Decorporation:	☐ Yes	☒ No	Agent: ______	Date: ______
Catharsis:	☐ Yes	☒ No	Agent: ______	Date: ______
Surgical excision:	☐ Yes	☒ No	Date: ______	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 μm AMAD particle size on 2/13/66

Code/Model used for: Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 190000
50 YR CEDE (rem) : 58 (0.58 Sv)

Organ Dose Equivalent Summary	50 YR CDE (rem/Sv)
Bone Surface	590/5.9
Lung	220/2.2
Liver	110/1.1
Red Marrow	46/0.46
Other	10/0.1
Testes	8.5/0.085

DOSE ASSESSOR: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

PEER REVIEWER: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ______
Work Restrictions: N/A

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 µm AMAD particle size on 2/13/66. The date is the midpoint of the period on station from 2/1/66 to 2/27/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-3411	AS	2/27/66	0.122	0.045	✓
66-3411	G	2/27/66	NR	NR	
66-1494	AS	2/28/66	0.282	0.116	✓
66-1494	G	2/28/66	1.52	0.310	

* G means gross alpha counting; AS means alpha spectrometry; NR means no result reported.

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	190,000	58/0.58
LUDEP	616,000	43/0.43

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	8.5E+00/8.5E-02	2.5E-01	2.1E+00/2.1E-02
Breast	2.8E-04/2.8E-06	1.5E-01	4.2E-05/4.2E-07
Red Marrow	4.6E+01/4.6E-01	1.2E-01	5.5E+00/5.5E-02
Lung	2.2E+02/2.2E+00	1.2E-01	2.6E+01/2.6E-01
Thyroid	2.7E-04/2.7E-06	3.0E-02	8.0E-06/8.0E-08
Bone Surface	5.9E+02/5.9E+00	3.0E-02	1.8E+01/1.8E-01
Liver	1.1E+02/1.1E+00	6.0E-02	6.4E+00/6.4E-02
Other	1.0E+01/1.0E-01	6.0E-02	6.0E-01/6.0E-03
Lower Large Intestine	2.2E-02/2.2E-04	6.0E-02	1.3E-03/1.3E-05
Upper Large Intestine	7.2E-03/7.2E-05	6.0E-02	4.3E-04/4.3E-06
Small Intestine	1.5E-03/1.5E-05	6.0E-02	8.9E-05/8.9E-07
Effective Dose Equivalent			5.8E+01/5.8E-01

Two urine samples were analyzed by gross alpha counting and alpha spectrometry. The gross alpha analyses was not included in the modeling since an alpha spectrometry result was available for the each sample. The results were fit using CINDY and the Jones excretion model, to estimate an intake (190,000 pCi), organ doses, and a CEDE (58 rem/0.58 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 616,000 pCi and a CEDE (ICRP-60) of 43 rem (0.43 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 190,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 58 rem (0.58 Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the

current level (0.100 rem) for members of the public. It is more than the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). Serious health effects are not normally associated with these dose levels. However, follow-up urine sampling should be considered to provide additional assessment of the exposure.

Prepared By:

Name: ______________________________

Signature: ______________________________ Date: ______________

Peer Reviewed By:

Name: ______________________________

Signature: ______________________________ Date: ______________

[redacted] [redacted]

RESAMPLE JUL 14 1966 NAVY R

Civilian: GS-12

INTERNAL DOSE DATA Not Resample!

NAME (LAST, FIRST, M.I.) [redacted]	SOC. SEC. NO. (21-29) [redacted]	TYPE SAMPLE Urine	TYPE ANAL. (31-32) Process as resample
SAMPLE NO. (33-38) 66-3411	SAMPLE DATE (39-44) FROM 5 June 66 TO		EXPOSURE DATE Feb 66 TYPE
BASE (57-60) US Naval Oceanographic Office	OCCUPATION (61-62)	REQUESTED BY	
DATE RECEIVED 14 June 1966	SAMPLE VOLUME ~1100 ml	VOLUME ANALYZED 490 ml	DATE ANALYZED 16 Sept
[redacted] (SIGNATURE AND DATE) CAPT	16 Sept	t=110	

URINE	236	239		RADON		FECES/BLOOD	
Counter Number	Spec. 3 (800)	Spec. 6 (800)		Chamber Number	H-57	Counter Number	
Counter Bkg. (cpm)				Cham. Bkg. ~~(mv/sec)~~	136	Counter Bkg.	
Counter Eff. (%)	31.8	31.8		~~Counter Eff. (%)~~ 549	5806	Counter Eff.	
Date/Time – Start				Millivolt – Start		Date/Time – Start	
– Stop				Millivolt – Stop		– Stop	
Total Counts	48	8		Total ~~Millivolts~~ Cts	129	Total Counts	
Counting Time	100	100		Total ~~Date~~ Time	65	Counting Time	
Gross cpm				Gross mv/sec		Gross cpm	
Bkg. Cpm				Bkg. Mv/sec		Bkg. cpm	
Net cpm				Net mv/sec		net cpm	
dpm				curies/mv		dpm	
dpm/24 hr. (69-74)				liter (69-74)		dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
Net Beta				D(q) (63-68)		uc/mg (69-74)	
D(q) (63-68)				%Rec = 135.6		D(q) (63-68)	

NAME:	SOCIAL SECURITY NUMBER:	SAMPLE NUMBER:
AIR FORCE BASE		

RESULTS OF ANALYSIS Pci/SPL = 0.122 ± 0.045 %REC = 95.6%
TOT. VOL. = 1100
VOL. ANALYZED = 490 BODY BURDEN = 0.043

☐ Repeat the sample for the following reason:
( ) Significant activity in recently analyzed sample (s)
( ) Data required to establish dose
( ) Improper flask used
( ) Other
( ) Suggested sampling schedule

This is a repeat sample but not part of resampling program. [redacted]
Process as resample

SIGNATURE: | DATE:

ONE TIME FORM. OBSOLETE AFTER 30 JUN 66. (MCGSCPF, RAG, 4 APR 66) AFLC–WPAFB–APR 66 2500

MAR 11 1966 MAR 11 1966 X 51

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20) Civilian [redacted]	SOC. SEC. NO. (21-29)	TYPE SAMPLE (30) Urine	TYPE ANAL. (31-32) Pu 239
SAMPLE NO. (33-38) 66-1494	SAMPLE DATE (39-44) FROM 7:00 AM 27 FEB TO 7:00 AM 28 FEB 66		EXPOSURE DATE / TYPE
BASE (57-60) US Naval Ocean Beach	OCCUPATION (61-62)	REQUESTED BY	
DATE RECEIVED 11 MAR 66	SAMPLE VOLUME 250	VOLUME ANALYZED 260	DATE ANALYZED
TECHNICIAN (SIGNATURE AND DATE)			

URINE	GROSS ALPHA		
Counter Number	C		
Counter Bkg. (cpm)	0.05 (990)		tc 30
Counter Eff. (%)	51		
Date/Time – Start	12 May 66		
– Stop		Reported value	
Total Counts	101	corrected for spike	
Counting Time	55	of 0.965 pc/sample	
Gross cpm	1.84		
Bkg. Cpm	0.05		
Net cpm	1.79		
~~dpm~~ pci/l	6.06	± 1.24	
dpm/24 hr. (69-74)			
K 40 Correction			
~~Net Beta~~ pci/Spl	1.52	± 0.31	
D(q) (63-68)			

RADON	
Chamber Number	
Cham. Bkg. (mv/sec)	
Counter Eff. (%)	
Millivolt – Start	
Millivolt – Stop	
Total Millivots	
Total Drift Time	
Gross mv/sec	
Bkg. Mv/sec	
Net mv/sec	
curies/mv	
litter (69-74)	
D(q) (63-68)	

FECES/BLOOD	
Counter Number	
Counter Bkg.	
Counter Eff.	
Date/Time – Start	✓
– Stop	
Total Counts	
Counting Time	
Gross cpm	
Bkg. cpm	2.18 PC
net cpm	NSBB
dpm	
dps/cc	
Neutron Dose (rads) (63-68)	
uc/mg (69-74)	
D(q) (63-68)	

(b)(6) [redacted]

(b)(6) [redacted]

RADIOLOGICAL SAMPLE DATA

NAME OR REQUESTOR'S ID (1-20)	GRADE	AFSN	SOCIAL SECURITY NUMBER	RHL SAMPLE NUMBER 66-1494
TYPE SAMPLE (23-32)	OCCUPATION (34-35)	ANALYSIS DESIRED	REQUESTED BY	AIR FORCE BASE (68-71)
DATE RECEIVED (37-42)	DATE ANALYZED (51-56)	DATE COUNTED 22 July 66	DATE COLLECTED	EXPOSURE DATE
SAMPLE WEIGHT/VOLUME	WEIGHT/VOLUME ANALYZED	TECHNICIAN		
OTHER DATA .942				

ENVIRONMENTAL SAMPLES				
COUNTER & EFFICIENCY				
TOTAL COUNTS & MINUTES				
GROSS CPM				
BKG CPM & MINUTES				
NET CPM				
YIELD				
BIOLOGICAL SAMPLES	236	239	RADON	
COUNTER & EFFICIENCY Spec	27.3	27.3	2.93 dpm	3.51 DPM
TOTAL COUNTS & MINUTES 100	68	13	±0.65	
GROSS CPM	0.6800	0.1300		
BKG CPM & MINUTES 800	3 0.0038	6 — 0.0075		
NET CPM	0.6762	0.1225	0.282 ± 0.116	
YIELD				
% Rec	71.78			

SUMMARY OF RESULTS:

AFLC FORM MAY 66 1165 FC 5400

AFLC-WPAFB-MAY 66 4500

 C.2-341

[redacted] 3411, 22 ± 40 fci

1. 0.122 ± .04
2. 95.6
3. 1.1
4. 110
5. 6259
6. 0.04

(b) (6)

[redacted]

Internal Dosimetry Evaluation Form

NAME [redacted] **SSN:** [redacted]

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
2/5/66 through 2/26/66 on-site
2/16/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 μm AMAD
Date or Period of Evaluated Data: 1 urine sample, 2/26/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☐ Attached	☐ In Process	☒ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ______	
Decorporation:	☐ Yes	☒ No	Agent: ______	Date: ______
Catharsis:	☐ Yes	☒ No	Agent: ______	Date: ______
Surgical excision:	☐ Yes	☒ No	Date: ______	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 μm AMAD particle size on 2/15/66

Code/Model used for: Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 140000
50 YR CEDE (rem) : 43 (0.43 Sv)

Organ Dose Equivalent Summary	**50 YR CDE (rem/Sv)**
Bone Surface	440/4.4
Lung	160/1.6
Liver	78/0.78
Red Marrow	34/0.34
Other	7.4/0.074
Testes	6.2/0.062

DOSE ASSESSOR: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

PEER REVIEWER: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ______
Work Restrictions: N/A

[redacted] [redacted]

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 µm AMAD particle size on 2/15/66. The date is the midpoint of the period on station from 2/5/66 to 2/26/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-1419	AS	2/26/66	0.163	0.024	✓
66-1419	G	2/26/66	0.731	0.216	

* G means gross alpha counting; AS means alpha spectrometry.

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	140,000	43/0.43
LUDEP	697,000	49/0.49

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	6.2E+00/6.2E-02	2.5E-01	1.6E+00/1.6E-02
Breast	2.1E-04/2.1E-06	1.5E-01	3.1E-05/3.1E-07
Red Marrow	3.4E+01/3.4E-01	1.2E-01	4.0E+00/4.0E-02
Lung	1.6E+02/1.6E+00	1.2E-01	1.9E+01/1.9E-01
Thyroid	2.0E-04/2.0E-06	3.0E-02	5.9E-06/5.9E-08
Bone Surface	4.4E+02/4.4E+00	3.0E-02	1.3E+01/1.3E-01
Liver	7.8E+01/7.8E-01	6.0E-02	4.7E+00/4.7E-02
Other	7.4E+00/7.4E-02	6.0E-02	4.4E-01/4.4E-03
Lower Large Intestine	1.6E-02/1.6E-04	6.0E-02	9.5E-04/9.5E-06
Upper Large Intestine	5.3E-03/5.3E-05	6.0E-02	3.2E-04/3.2E-06
Small Intestine	1.1E-03/1.1E-05	6.0E-02	6.5E-05/6.5E-07
Effective Dose Equivalent			4.3E+01/4.3E-01

One urine sample was analyzed by gross alpha counting and alpha spectrometry. The gross alpha analysis was not included in the modeling since an alpha spectrometry result was available for the same sample. The result was fit using CINDY and the Jones excretion model, to estimate an intake (140,000 pCi), organ doses, and a CEDE (43 rem/0.43 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 697,000 pCi and a CEDE (ICRP-60) of 49 rem (0.49 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 140,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 43 rem (0.43 Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the current level (0.100 rem) for members of the public. It is less than the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). Serious health effects are not associated with that dose level. However, follow-up urine sampling now could be considered to provide additional assessment of the exposure.

Prepared By:

Name: ______________________________

Signature: ________________________________ Date: ________________

Peer Reviewed By:

Name: ___________________________________

Signature: ________________________________ Date: ________________

MAR 9 1966 X 30

AFSN: [redacted]

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20) [redacted] SSGT	SOC. SEC. NO. (21-29) [redacted]	TYPE SAMPLE (30) URINE	TYPE ANAL. (31-32) GROSS ALPHA
SAMPLE NO. (33-38) 66-1419	SAMPLE DATE (39-44) FROM 26 FEB 66 TO		EXPOSURE DATE 5 F[illegible]
BASE (57-60) Moron	OCCUPATION (61-62) 43171E	REQUESTED BY	
DATE RECEIVED 9 MAR 66	SAMPLE VOLUME 880	VOLUME ANALYZED 915	DATE ANALYZED
TECHNICIAN (SIGNATURE AND DATE)			

URINE				RADON			FECES/BLOOD	
Counter Number	G			Chamber Number			Counter Number	
Counter Bkg. (cpm)	F403 (990)		xc21	Cham. Bkg. (mv/sec)			Counter Bkg.	
Counter Eff. (%)	51			Counter Eff. (%)			Counter Eff.	
Date/Time – Start	12 mar 66			Millivolt – Start			Date/Time – Start	
– Stop		Reported value		Millivolt – Stop			– Stop	✓
Total Counts	49	adjusted for spike		Total Millivolts			Total Counts	
Counting Time	55	of 0.965 pc/sample		Total Drift Time			Counting Time	
Gross cpm	0.89			Gross mv/sec			Gross cpm	
Bkg. Cpm	0.03			Bkg. Mv/sec			Bkg. cpm	NDA
Net cpm	0.86			Net mv/sec			net cpm	
~~dpm~~ pci/l	0.831	± 0.246		curies/mv			dpm	
dpm/24 hr. (69-74)				liter (69-74)			dps/cc	
K 40 Correction							Neutron Dose (rads) (63-68)	
~~Net Beta~~ pci/spl	0.731	± 0.216		D(q) (63-68)			uc/mg (69-74)	
D(q) (63-68)							D(q) (63-68)	

RADIOLOGICAL SAMPLE DATA

NAME OR REQUESTOR'S ID (1–20)	GRADE	AFSN	SOCIAL SECURITY NUMBER	RHL SAMPLE NUMBER 66-1419
TYPE SAMPLE (23–32)	OCCUPATION (34–35)	ANALYSIS DESIRED	REQUESTED BY	AIR FORCE BASE (66–71)
DATE RECEIVED (37–42)	DATE ANALYZED (51–56)	DATE COUNTED 27 June 66	DATE COLLECTED	EXPOSURE DATE
SAMPLE WEIGHT/VOLUME		WEIGHT/VOLUME ANALYZED	TECHNICIAN	

OTHER DATA .958

ENVIRONMENTAL SAMPLES						
COUNTER & EFFICIENCY						
TOTAL COUNTS & MINUTES						
GROSS CPM						
BKG CPM & MINUTES						
NET CPM						
YIELD						
BIOLOGICAL SAMPLES		236				
COUNTER & EFFICIENCY	Spec	27.3		239	RADON	
TOTAL COUNTS & MINUTES	100	39		27.7	1.57 dpm	1.69 DPM
GROSS CPM				6		
BKG CPM & MINUTES	807		0.3900	0.0500	±01%	
NET CPM		1	0.0012	8 0.0099		
YIELD			0.3888	0.0401		
					0.163 ± 0.024 pCi/SPL	
	% Rec	40.58				

SUMMARY OF RESULTS:

AFLC FORM MAY 66 1165 FC 5400

AFLC–WPAFB–MAY 66 4500

(b) (6) [redacted]

[redacted] [redacted]

Internal Dosimetry Evaluation Form

NAME: [redacted] **SSN:** [redacted]

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
1/27/66 through 3/13/66, onsite
2/18/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 µm AMAD
Date or Period of Evaluated Data: 2 samples, 3/14/66 and 6/5/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☐ Attached	☐ In Process	☒ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ________	
Decorporation:	☐ Yes	☒ No	Agent: ________	Date: ________
Catharsis:	☐ Yes	☒ No	Agent: ________	Date: ________
Surgical excision:	☐ Yes	☒ No	Date: ________	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 µm AMAD particle size on 2/18/66

Code/Model used for: Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 140000
50 YR CEDE (rem) : 43 (0.43 Sv)

Organ Dose Equivalent Summary	**50 YR CDE (rem/Sv)**
Bone Surface	440/4.4
Lung	160/1.6
Liver	78/0.78
Red Marrow	34/0.34
Other	7.4/0.074
Testes	6.2/0.062

DOSE ASSESSOR: **DATE:** ________
Signature: ________
Print Name: ________
SSN: ________

PEER REVIEWER: **DATE:** ________
Signature: ________
Print Name: ________
SSN: ________

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ________
Work Restrictions: N/A

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 µm AMAD particle size on 2/18/66. The date is the midpoint of the period on station from 1/27/66 to 3/13/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-2007	G	3/14/66	0.180	0.100	✓
66-3402	AS	6/5/66	0.049	0.037	✓
66-3402	G	6/5/66	NR	NR	

* G means gross alpha counting; AS means alpha spectrometry; NR means no result reported.

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	140,000	43/0.43
LUDEP	265,000	19/0.19

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	6.2E+00/6.2E-02	2.5E-01	1.6E+00/1.6E-02
Breast	2.1E-04/2.1E-06	1.5E-01	3.1E-05/3.1E-07
Red Marrow	3.4E+01/3.4E-01	1.2E-01	4.0E+00/4.0E-02
Lung	1.6E+02/1.6E+00	1.2E-01	1.9E+01/1.9E-01
Thyroid	2.0E-04/2.0E-06	3.0E-02	5.9E-06/5.9E-08
Bone Surface	4.4E+02/4.4E+00	3.0E-02	1.3E+01/1.3E-01
Liver	7.8E+01/7.8E-01	6.0E-02	4.7E+00/4.7E-02
Other	7.4E+00/7.4E-02	6.0E-02	4.4E-01/4.4E-03
Lower Large Intestine	1.6E-02/1.6E-04	6.0E-02	9.5E-04/9.5E-06
Upper Large Intestine	5.3E-03/5.3E-05	6.0E-02	3.2E-04/3.2E-06
Small Intestine	1.1E-03/1.1E-05	6.0E-02	6.5E-05/6.5E-07
Effective Dose Equivalent			4.3E+01/4.3E-01

One urine sample was analyzed by gross alpha counting only, and the other was analyzed by both gross alpha counting and alpha spectrometry. For the sample analyzed with both methods, the gross alpha analysis was not included in the modeling since no result was reported and an alpha spectrometry result was available for the same sample. The results were fit using CINDY and the Jones excretion model, to estimate an intake (140,000 pCi), organ doses, and a CEDE (43 rem/0.43 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 265,000 pCi and a CEDE (ICRP-60) of 19 rem (0.19 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 140,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 43 rem (0.43 Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the

current level (0.100 rem) for members of the public. It is less than the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). Serious health effects are not associated with that dose level. However, follow-up urine sampling now could be considered to provide additional assessment of the exposure.

Prepared By:

Name: ______________________________

Signature: ______________________________ Date: ______________

Peer Reviewed By:

Name: ______________________________

Signature: ______________________________ Date: ______________

[redacted] [redacted]

NAVY RESAMPLE JUL 14 1966 3402

Civilian: GS-12

INTERNAL DOSE DATA NAVY

NAME (LAST, FIRST, M.I.) (1-20) [redacted]	SOC. SEC. NO. (21-29) [redacted]	TYPE SAMPLE (30) Urine	TYPE ANAL. (31-32)
SAMPLE NO. (33-38) 66-3402	SAMPLE DATE (39-44) FROM 5 June 66 TO	EXPOSURE DATE 27 Jan 66 TYPE	
BASE (57-60) US Naval Oceanographic Office	OCCUPATION (61-62)	REQUESTED BY	
DATE RECEIVED 14 June 1966	SAMPLE VOLUME 1760 ml	VOLUME ANALYZED 1260 ml	DATE ANALYZED
TECHNICIAN (SIGNATURE AND DATE)			

URINE	236	238		RADON		FECES/BLOOD	
Counter Number				Chamber Number	6	Counter Number	
Counter Bkg. (cpm)	3	1		Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)	31.8	31.8		Counter Eff. (%)		Counter Eff.	
Date/Time — Start	25EP66		t=129	Millivolt — Start		Date/Time — Start	
— Stop				Millivolt — Stop		— Stop	
Total Counts	82	2		Total Millivolts		Total Counts	
Counting Time	100	100		Total Time	55	Counting Time	
Gross cpm				Gross	83	Gross cpm	
Bkg. Cpm				Bkg.	73 (908)	Bkg. cpm	
Net cpm				Net mv/sec		Net cpm	
~~dpm~~ % REC	76.4			curies/mv		dpm	
dpm/24 hr. (69-74)				liter (69-74)		dps/cc	
K 40 Correction				% REC	84.0	Neutron Dose (rads) (63-68)	
~~Net Data~~ PC/SPL	0.0486 ±	0.0372		D(q) (63-68)		uc/mg (69-74)	
D(q) (63-68)						D(q) (63-68)	

NAME:	SOCIAL SECURITY NUMBER:	SAMPLE NUMBER:
AIR FORCE BASE		

RESULTS OF ANALYSIS

PC/SPL = 0.0486 ± 0.0372 %REC = 76.4

TOTAL VOLUME = 1760 BODY BURDEN = 0.01

VOL. ANALYZED = 1260

Previous Results
0.72 pc/l
0.16 BB

☐ Repeat the sample for the following reason:

( ) Significant activity in recently analyzed sample(s)

( ) Data required to establish dose

( ) Improper flask used

( ) Other

( ) Suggested sampling schedule

Code "Navy"

SIGNATURE: DATE:

ONE TIME FORM. OBSOLETE AFTER 30 JUN 66. (MCGSCPF, RAG, 4 APR 66) AFLC-WPAFB-APR 66 2500

[redacted] C3968

56

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20)	SOC. SEC. NO. (21-29)	TYPE SAMPLE (30)	TYPE ANAL. (31-32)
[redacted]		Urine	

SAMPLE NO. (33-38)	SAMPLE DATE (39-44)		EXPOSURE DATE	TYPE
66-2007	FROM 0700 13 Mar	TO 0700 14 Mar 66		
BASE (57-60) US. Naval Oceangraphic Office	OCCUPATION (61-62)	REQUESTED BY		
DATE RECEIVED 30 March 1966	SAMPLE VOLUME 250 ml	VOLUME ANALYZED 250 ml	DATE ANALYZED	
TECHNICIAN (SIGNATURE AND DATE) SS-t [redacted]	U^AF	11 APR 1966		

URINE				RADON		FECES/BLOOD	
Counter Number	C			Chamber Number		Counter Number	
Counter Bkg. (cpm)	0.07	850 min		Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)	51			Counter Eff. (%)		Counter Eff.	
Date/Time – Start	8 APR 1966			Millivolt – Start		Date/Time – Start	
–Stop				Millivolt – Stop		– Stop	
Total Counts	25			Total Millivots		Total Counts	
Counting Time	100			Total Drift Time		Counting Time	
Gross cpm	0.25			Gross mv/sec		Gross cpm	
Bkg. Cpm	0.07			Bkg. Mv/sec		Bkg. cpm	
Net cpm	0.18			Net mv/sec		net cpm	
~~dpm~~ Pci/liter	0.721 ± 0.398			curies/mv		dpm	
dpm/24 hr. (69-74)	0.72 ± 0.40			liter (69-74)		dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
~~Net Beta~~ Pci/Spl	0.180 ± 0.10			D(q) (63-68)		uc/mg (69-74)	
D (q) (63-68)	(ASSUMED T=60 D + USED PC/L)			$D_e = 2.0 \times 10^{-3}$ µc		D (q) (63-68)	

[redacted] 3402
49 ± 40. fci

1. 0.049 ± .04
2. 76.4
3. 1.76
4. 129
5. 6245
6. 0.01

(b) (6) [redacted]

[redacted] [redacted]

Internal Dosimetry Evaluation Form

NAME: [redacted] SSN: [redacted]

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
2/4/66 through 2/14/66, onsite
2/9/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 μm AMAD
Date or Period of Evaluated Data: 2 samples, 2/17/66 and 3/5/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☒ Attached	☐ In Process	☐ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ________	
Decorporation:	☐ Yes	☒ No	Agent: ________	Date: ________
Catharsis:	☐ Yes	☒ No	Agent: ________	Date: ________
Surgical excision:	☐ Yes	☒ No	Date: ________	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 μm AMAD particle size on 2/9/66

Code/Model used for: Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 120000
50 YR CEDE (rem): 55 (0.55 Sv)

Organ Dose Equivalent Summary	50 YR CDE (rem/Sv)
Bone Surface	370/3.7
Lung	140/1.4
Liver	67/0.67
Red Marrow	29/0.29
Other	6.3/0.063
Testes	5.4/0.054

DOSE ASSESSOR: **DATE:** ________
Signature: ________
Print Name: ________
SSN: ________

PEER REVIEWER: **DATE:** ________
Signature: ________
Print Name: ________
SSN: ________

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ________
Work Restrictions: N/A

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 µm AMAD particle size on 2/9/66. The date is the midpoint of the period on station from 2/4/66 to 2/14/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-1122	G	2/17/66	0.190	0.160	✓
66-1554	AS	3/5/66	0.080	0.016	✓
66-1554	G	3/5/66	1.50	0.330	

* G means gross alpha counting; AS means alpha spectrometry.

A nasal swipe was also reported (sample #66-1656) from [redacted] on 3/1/66; however, no result was available.

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	120,000	37/0.37
LUDEP	348,000	24/0.24

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	5.4E+00/5.4E-02	2.5E-01	1.3E+00/1.3E-02
Breast	1.8E-04/1.8E-06	1.5E-01	2.7E-05/2.7E-07
Red Marrow	2.9E+01/2.9E-01	1.2E-01	3.5E+00/3.5E-02
Lung	1.4E+02/1.4E+00	1.2E-01	1.6E+01/1.6E-01
Thyroid	1.7E-04/1.7E-06	3.0E-02	5.0E-06/5.0E-08
Bone Surface	3.7E+02/3.7E+00	3.0E-02	1.1E+01/1.1E-01
Liver	6.7E+01/6.7E-01	6.0E-02	4.0E+00/4.0E-02
Other	6.3E+00/6.3E-02	6.0E-02	3.8E-01/3.8E-03
Lower Large Intestine	1.4E-02/1.4E-04	6.0E-02	8.2E-04/8.2E-06
Upper Large Intestine	4.6E-03/4.6E-05	6.0E-02	2.7E-04/2.7E-06
Small Intestine	9.4E-04/9.4E-06	6.0E-02	5.6E-05/5.6E-07
Effective Dose Equivalent			3.7E+01/3.7E-01

One urine sample was analyzed by gross alpha counting, and the other was analyzed by both gross alpha counting and alpha spectrometry. The gross alpha analysis for the second sample was not included in the modeling since an alpha spectrometry result was available for the same sample. The results were fit using CINDY and the Jones excretion model, to estimate an intake (120,000 pCi), organ doses, and a CEDE (37 rem/0.37 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 348,000 pCi and a CEDE (ICRP-60) of 24 rem (0.24 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 120,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 37 rem (0.37 Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the current level (0.100 rem) for members of the public. It is less than the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). Serious health effects are not associated with that dose level. However, follow-up urine sampling now could be considered to provide additional assessment of the exposure.

Prepared By:

Name: ______________________________

Signature: ______________________________ Date: ______________

Peer Reviewed By:

Name: ______________________________

Signature: ______________________________ Date: ______________

AFSN: [redacted]

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20): [redacted] SSGT	SOC. SEC. NO. (21-29): [redacted]	TYPE SAMPLE (30): Urine	TYPE ANAL. (31-32): GROSS ALPHA
SAMPLE NO. (33-38): 66-1122	SAMPLE DATE (39-44) FROM 17 FEB 66 TO	EXPOSURE DATE 4 FEB 66	TYPE
BASE (57-60): Wheeles	OCCUPATION (61-62): 27470	REQUESTED BY	
DATE RECEIVED: 1 March 1966	SAMPLE VOLUME: 228	VOLUME ANALYZED: 228	DATE ANALYZED: MAR 17 1966
TECHNICIAN (SIGNATURE AND DATE): [redacted] 16 MAR 1966			

URINE					RADON		FECES/BLOOD	
Counter Number	D				Chamber Number		Counter Number	
Counter Bkg. (cpm)	6				Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)	51				Counter Eff. (%)		Counter Eff.	
Date/Time – Start	16 MAR 1966				Millivolt – Start		Date/Time – Start	
– Stop					Millivolt – Stop		– Stop	
Total Counts	18				Total Millivolts		Total Counts	
Counting Time	55				Total Drift Time		Counting Time	
Gross cpm					Gross mv/sec		Gross cpm	
Bkg. Cpm					Bkg. Mv/sec		Bkg. cpm	
Net cpm	–				Net mv/sec		net cpm	
~~dpm~~ pCi/L	0.84± 0.69				curies/mv		dpm	
dpm/24 hr. (69-74)					liter (69-74)		dps/cc	
K 40 Correction							Neutron Dose (rads) (63-68)	
~~Net Rate~~ pCi/bd	0.19± 0.16				D(q) (63-68)		uc/mg (69-74)	
D (q) (63-68)	t = 13 D				D_h = 3.09 X 10⁻³ ... 07		D(q) (63-68)	

MAR 16 1966   X-17 ✓

INTERNAL DOSE DATA

NAME (LAST, FIRST...): AFSN: [redacted]	SOC. SEC. NO. (21-29): [redacted]	TYPE SAMPLE (30): URINE	TYPE ANAL. (31-32): Pu^{239}
[redacted] SSgt			
SAMPLE NO. (37-38): 66-1554	SAMPLE DATE (39-44): FROM 0800 4 MAR 66 TO 0800 5 MAR 66		EXPOSURE 15-00 ... 1715 DATE 4 FEB 66 ~~TYPE~~ 14 FEB 66
BASE (57-60): WHEELUS	OCCUPATION (61-62):	REQUESTED BY:	
DATE RECEIVED: 16 MAR 66	SAMPLE VOLUME: 1100	VOLUME ANALYZED: 1000	DATE ANALYZED:
TECHNICIAN (SIGNATURE AND DATE)			

GROSS ALPHA

URINE	GROSS ALPHA			RADON		FECES/BLOOD	
Counter Number	D			Chamber Number		Counter Number	
Counter Bkg. (cpm)	0.02 (990)			Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)	51		E=19	Counter Eff. (%)		Counter Eff.	
Date/Time – Start	12 may			Millivolt – Start		Date/Time – Start	✓
– Stop		Reported value		Millivolt – Stop		– Stop	
Total Counts	86	corrected for spike		Total Millivolts		Total Counts	
Counting Time	55	of 0.965 pc per		Total Drift Time		Counting Time	
Gross cpm	1.56	sample		Gross mv/sec		Gross cpm	
Bkg. Cpm	0.02			Bkg. Mv/sec		Bkg. cpm	1.37 PC
Net cpm	1.54			Net mv/sec		net cpm	NSBB
~~dpm~~ pci/l	1.37	± 0.30		curies/mv		dpm	
dpm/24 hr. (69-74)				litter (69-74)		dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
~~Net Beta~~ pci/spl	1.50	± 0.33		D(q) (63-68)		uc/mg (69-74)	
D(q) (63-68)						D(q) (63-68)	

RADIOLOGICAL SAMPLE DATA

NAME OR REQUESTOR'S ID (1–20)	GRADE	AFSN	SOCIAL SECURITY NUMBER	RHL SAMPLE NUMBER 66-1554
TYPE SAMPLE (23–32)	OCCUPATION (34–35)	ANALYSIS DESIRED	REQUESTED BY	AIR FORCE BASE (68–71)
DATE RECEIVED (37–42)	DATE ANALYZED (51–56)	DATE COUNTED 27 July 66	DATE COLLECTED	EXPOSURE DATE
SAMPLE WEIGHT/VOLUME	WEIGHT/VOLUME ANALYZED		TECHNICIAN	
OTHER DATA .939				

ENVIRONMENTAL SAMPLES				
COUNTER & EFFICIENCY				
TOTAL COUNTS & MINUTES				
GROSS CPM				
BKG CPM & MINUTES				
NET CPM				
YIELD				
BIOLOGICAL SAMPLES	276	275	RADON	
COUNTER & EFFICIENCY Spec	27.3	27.3	2.25	3.02
TOTAL COUNTS & MINUTES 100	60		±0.15	
GROSS CPM	0.6000	0.0400		
BKG CPM & MINUTES 800	12 0.0150	8 0.0180		
NET CPM	0.5850	0.0300		
YIELD			0.2080 ± 0.016	
% Rec	62.30			

SUMMARY OF RESULTS:

AFLC FORM MAY 66 1165 FC 5400 AFLC—WPAFB—MAY 66 4500

Palomares Nuclear Weapons Accident [redacted]

Dose Evaluation Report April 28, 2000 [redacted]

Release of this document is restricted under the provisions of the Privacy Act, 5 U.S.C. 552(a). C.2-362

(b) (6) [redacted]

Internal Dosimetry Evaluation Form

NAME: [redacted] SSN: NA

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
2/5/66 through 2/26/66, onsite
2/15/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 μm AMAD
Date or Period of Evaluated Data: 1 sample, 2/26/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☐ Attached	☐ In Process	☒ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ______	
Decorporation:	☐ Yes	☒ No	Agent: ______	Date: ______
Catharsis:	☐ Yes	☒ No	Agent: ______	Date: ______
Surgical excision:	☐ Yes	☒ No	Date: ______	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 μm AMAD particle size on 2/15/66

Code/Model used for:
Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 185000
50 YR CEDE (rem) : 55 (0.55 Sv)

Organ Dose Equivalent Summary	**50 YR CDE (rem/Sv)**
Bone Surface	560/5.6
Lung	210/2.1
Liver	100/1
Red Marrow	43/0.43
Other	9.5/0.095
Testes	8/0.08

DOSE ASSESSOR: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

PEER REVIEWER: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ______
Work Restrictions: N/A

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN: NA

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 µm AMAD particle size on 2/15/66. The date is the midpoint of the period on station from 2/5/66 to 2/26/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-1438	AS	2/26/66	0.208	0.086	✓
66-1438	G	2/26/66	1.51	0.310	

* G means gross alpha counting; AS means alpha spectrometry.

(b) (6) [redacted]

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	185,000	55/0.55
LUDEP	888,000	62/0.62

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	8.0E+00/8.0E-02	2.5E-01	2.0E+00/2.0E-02
Breast	2.7E-04/2.7E-06	1.5E-01	4.0E-05/4.0E-07
Red Marrow	4.3E+01/4.3E-01	1.2E-01	5.2E+00/5.2E-02
Lung	2.1E+02/2.1E+00	1.2E-01	2.5E+01/2.5E-01
Thyroid	2.5E-04/2.5E-06	3.0E-02	7.5E-06/7.5E-08
Bone Surface	5.6E+02/5.6E+00	3.0E-02	1.7E+01/1.7E-01
Liver	1.0E+02/1.0E+00	6.0E-02	6.0E+00/6.0E-02
Other	9.5E+00/9.5E-02	6.0E-02	5.7E-01/5.7E-03
Lower Large Intestine	2.0E-02/2.0E-04	6.0E-02	1.2E-03/1.2E-05
Upper Large Intestine	6.9E-03/6.9E-05	6.0E-02	4.1E-04/4.1E-06
Small Intestine	1.4E-03/1.4E-05	6.0E-02	8.4E-05/8.4E-07
Effective Dose Equivalent			5.5E+01/5.5E-01

One urine sample was analyzed by gross alpha counting and alpha spectrometry. The gross alpha analysis was not included in the modeling since an alpha spectrometry result was available for the same sample. The result was fit using CINDY and the Jones excretion model, to estimate an intake (185,000 pCi), organ doses, and a CEDE (55 rem/0.55 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 888,000 pCi and a CEDE (ICRP-60) of 62 rem (0.62 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 185,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 55 rem (0.55 Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the current level (0.100 rem) for members of the public. It is 10% more than the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). Serious health effects are not normally associated with these dose levels. However, follow-up urine sampling should be considered to provide additional assessment of the exposure.

Prepared By:

Name: ______________________________

Signature: ______________________________ Date: ______________

Peer Reviewed By:

Name: ______________________________

Signature: ______________________________ Date: ______________

(b) (6) [redacted]

[redacted] [redacted]

Internal Dosimetry Evaluation Form

NAME: [redacted] SSN: [redacted]

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
2/6/66 through 2/28/66, onsite
2/17/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 µm AMAD
Date or Period of Evaluated Data: 2 samples, 3/8/66 and 6/1/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☐ Attached	☐ In Process	☒ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ________	
Decorporation:	☐ Yes	☒ No	Agent: ________	Date: ________
Catharsis:	☐ Yes	☒ No	Agent: ________	Date: ________
Surgical excision:	☐ Yes	☒ No	Date: ________	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 µm AMAD particle size on 2/17/66

Code/Model used for: Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 4,400
50 YR CEDE (rem) : 1.4 (0.014 Sv)
Organ Dose Equivalent Summary

	50 YR CDE (rem/Sv)
Bone Surface	14/0.14
Lung	5/0.05
Liver	2.5/0.025
Red Marrow	1.1/0.011
Other	0.2/0.002
Testes	0.2/0.002

DOSE ASSESSOR: DATE: ________
Signature: ________
Print Name: ________
SSN: ________

PEER REVIEWER: DATE: ________
Signature: ________
Print Name: ________
SSN: ________

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ________
Work Restrictions: N/A

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 μm AMAD particle size on 2/17/66. The date is the midpoint of the period on station from 2/6/66 to 2/28/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-2446	G	3/8/66	1.49	0.790	
66-3273	AS	6/1/66	ND	ND	✓
66-3273	G	6/1/66	NR	NR	

* G means gross alpha counting; AS means alpha spectrometry.

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	4,400	1.4/0.014
LUDEP	12,400	0.9/0.009

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	2.0E-01/2.0E-03	2.5E-01	4.9E-02/4.9E-04
Breast	6.5E-06/6.5E-08	1.5E-01	9.8E-07/9.8E-09
Red Marrow	1.1E+00/1.1E-02	1.2E-01	1.3E-01/1.3E-03
Lung	5.0E+00/5.0E-02	1.2E-01	6.0E-01/6.0E-03
Thyroid	6.1E-06/6.1E-08	3.0E-02	1.8E-07/1.8E-09
Bone Surface	1.4E+01/1.4E-01	3.0E-02	4.1E-01/4.1E-03
Liver	2.5E+00/2.5E-02	6.0E-02	1.5E-01/1.5E-03
Other	2.3E-01/2.3E-03	6.0E-02	1.4E-02/1.4E-04
Lower Large Intestine	5.0E-04/5.0E-06	6.0E-02	3.0E-05/3.0E-07
Upper Large Intestine	1.7E-04/1.7E-06	6.0E-02	1.0E-035/1.0E-037
Small Intestine	3.4E-05/3.4E-07	6.0E-02	2.1E-06/2.1E-08
Effective Dose Equivalent			1.4E+00/1.4E-02

One urine sample was analyzed by gross alpha counting only, and the other was analyzed by both gross alpha counting and alpha spectrometry. For the sample analyzed with both methods, the gross alpha analysis was not included in the modeling since no result was reported and an alpha spectrometry result was available for the same sample. The alpha spectrometry sample result was reported as No Detectable Activity. A value of 0.003 pCi was used to represent this outcome. The gross alpha sample was also excluded because it was suspected of contamination during sample collection on the site and because it did not fit the expected pattern of urinary excretion. The result was fit using CINDY and the Jones excretion model, to estimate an intake (4,400 pCi), organ doses, and a CEDE (1.4 rem/0.14 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 12,400 pCi and a CEDE (ICRP-60) of 0.9 rem (0.009 Sv).

In a separate run that used the gross alpha result, CINDY produced estimated intake and CEDE of 890,000 pCi and 270 rem (2.7 Sv) respectively. However, these estimates were not considered realistic for the reasons stated above.

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 4,400 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 1.4 rem (0.014 Sv). That dose is much less than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the current level (0.100 rem) for members of the public. Serious health effects are not normally associated with these dose levels.

Prepared By:

Name: ______________________________

Signature: ______________________________ Date: ______________

Peer Reviewed By:

Name: ______________________________

Signature: ______________________________ Date: ______________

[redacted] [redacted]

RESAMPLE JUN 6 1966

ARMY: [redacted]

INTERNAL DOSE DATA

[redacted] Pvt. | SOC. SEC. NO. (25-29) [redacted] | TYPE SAMPLE (30) Urine | TYPE ANAL. (31-32)

SAMPLE NO. (33-38) 66-3273	SAMPLE DATE (39-44) FROM 1 June 66 TO	EXPOSURE DATE Feb 66 TYPE	
BASE (57-60) Giessen	OCCUPATION (61-62)	REQUESTED BY	
DATE RECEIVED 6 June 1966	SAMPLE VOLUME 760 ml	VOLUME ANALYZED 420 ml	DATE ANALYZED
TECHNICIAN (SIGNATURE AND DATE)			

URINE				RADON		FECES/BLOOD	
Counter Number				Chamber Number		Counter Number	
Counter Bkg. (cpm)				Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)				Counter Eff. (%)		Counter Eff.	
Date/Time – Start				Millivolt – Start		Date/Time – Start	
– Stop				Millivolt – Stop		– Stop	
Total Counts				Total Millivolts		Total Counts	
Counting Time				Total Drift Time		Counting Time	
Gross cpm				Gross mv/sec		Gross cpm	
Bkg. Cpm				Bkg. Mv/sec		Bkg. cpm	
Net cpm				Net mv/sec		net cpm	
dpm				curies/mv		dpm	
dpm/24 hr. (69-74)				liter (69-74)		dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
Net Beta				D(q) (63-68)		uc/mg (69-74)	
D (q) (63-68)						D (q) (63-68)	

[illegible handwriting]

NAME:	SOCIAL SECURITY NUMBER:	SAMPLE NUMBER:
AIR FORCE BASE		

RESULTS OF ANALYSIS LABORATORY ACCIDENT – A SAMPLE 2 SEPT

☐ Repeat the sample for the following reason:
- ( ) Significant activity in recently analyzed sample(s)
- ( ) Data required to establish dose
- ( ) Improper flask used
- ( ) Other
- ( ) Suggested sampling schedule

SIGNATURE: DATE:

ONE TIME FORM. OBSOLETE AFTER 30 JUN 66. (MCGSCPF, RAG, 4 APR 66) AFLC–WPAFB–APR 66 2500

(b) (6) [redacted]

RADIOLOGICAL SAMPLE DATA

[redacted] OR REQUESTOR'S ID (1–20)	GRADE	AFSN	SOCIAL SECURITY NUMBER	RHL SAMPLE NUMBER 66-3273 B
TYPE SAMPLE (23–32)	OCCUPATION (34–35)	ANALYSIS DESIRED	REQUESTED BY	AIR FORCE BASE (68–71)
DATE RECEIVED (37–42)	DATE ANALYZED (51–56)	DATE COUNTED 5 OCT 66	DATE COLLECTED	EXPOSURE DATE
SAMPLE WEIGHT/VOLUME	WEIGHT/VOLUME ANALYZED 340 ml	TECHNIC (b) (6) [redacted]		
OTHER DATA				

ENVIRONMENTAL SAMPLES					
COUNTER & EFFICIENCY					
TOTAL COUNTS & MINUTES					
GROSS CPM					
BKG CPM & MINUTES					
NET CPM					
YIELD					
					229
		236	239		
BIOLOGICAL SAMPLES				RADON	
COUNTER & EFFICIENCY	Spec #3	238		6-51	
TOTAL COUNTS & MINUTES	1000	71	0	55-84	
GROSS CPM					
BKG CPM & MINUTES	440	1	0	935-94	
NET CPM					
YIELD					

SUMMARY OF RESULTS:
Pci/spl = NDA
ToT Vol = 760
Vol ANAL = 340

AFLC FORM MAY 66 1165 FC 5400 AFLC–WPAFB–MAY 66 4500

Release of this document is restricted under the provisions of the Privacy Act, 5 U.S.C. 552(a). C.2-373

Palomares Nuclear Weapons Accident (b) (6) [redacted]

29

ARMY: (b) (6) [redacted]

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20)	SOC. SEC. NO. (21-29)	TYPE SAMPLE (30)	TYPE ANAL. (31-32)
(b) (6) [redacted] PVT	(b) (6) [redacted]	Urine	

SAMPLE NO. (33-38)	SAMPLE DATE (39-44)		EXPOSURE
66-2446	FROM	TO	DATE 6 Feb 66 TYPE
BASE (57-60) Giessen	OCCUPATION (61-62) 57E20	REQUESTED BY	
DATE RECEIVED 7 April 1966	SAMPLE VOLUME 750	VOLUME ANALYZED 750	DATE ANALYZED

TECHNICIAN (SIGNATURE) (b) (6) [redacted]

URINE				RADON			FECES/BLOOD	
Counter Number	3B#7			Chamber Number			Counter Number	
Counter Bkg. (cpm)	0.03			Cham. Bkg. (mv/sec)			Counter Bkg.	
Counter Eff. (%)	0.45			Counter Eff. (%)			Counter Eff.	
Date/Time – Start	4-28-66			Millivolt – Start			Date/Time – Start	
– Stop				Millivolt – Stop			– Stop	
Total Counts	1411			Total Millivolts			Total Counts	✓
Counting Time	960			Total Drift Time			Counting Time	
Gross cpm	1.47			Gross mv/sec			Gross cpm	
Bkg. Cpm	0.03			Bkg. Mv/sec			Bkg. cpm	1.92 PC
Net cpm	1.44			Net mv/sec			net cpm	0.28 BB
dpm	3.20			curies/mv			dpm	
dpm/24 hr. (69-74)				liter (69-74)			dps/cc	
~~K-40 Correction~~ Pc/l	1.92±0.11						Neutron Dose (rads) (63-68)	
~~Net Beta~~ Pc/l	1.44±0.79			D(q) (63-68)			uc/mg (69-74)	
D(q) (63-68)							D(q) (63-68)	

Dose Evaluation Report
April 28, 2000 (b) (6) [redacted]

(b) (6) [redacted]

(b) (6) [redacted]

3273

0.± fci

1. 0.000
2. 90.7
3. 76
4. 151
5. 6278
6. 0.00

(b) (6) [redacted]

Internal Dosimetry Evaluation Form

NAME [redacted] **SSN:** [redacted]

MODE OF INTAKE:
☒ Inhalation ☐ Injection
☐ Ingestion ☐ Absorption
☐ Unknown ☐ Not applicable

INTAKE DATE OR PERIOD:
3/14/66 through 4/08/66, on-site
3/26/66

SUMMARY OF EXPOSURE CONDITIONS:
Radionuclides/Respiratory Class/Particle Size: ^{239}Pu/100% Class Y/1 μm AMAD
Date or Period of Evaluated Data: 2 samples, 4/8/66 and 5/26/66
Duration of Exposure: Unknown
Location of Exposure: Camp Wilson, near Palomares, Spain

EVALUATION DATA:

Air Sampling	☐ Attached	☐ In Process	☒ Unavailable
Health Physics Survey Data	☐ Attached	☐ In Process	☒ Unavailable
Bioassay – Urinalysis	☒ Attached	☐ In Process	☐ Unavailable
Fecal	☐ Attached	☐ In Process	☒ Unavailable
Nasal Smears	☐ Attached	☐ In Process	☒ Unavailable
In Vivo	☐ Attached	☐ In Process	☒ Unavailable

Medical Treatment:

Skin Decontamination:	☐ Yes	☒ No	Date: ______	
Decorporation:	☐ Yes	☒ No	Agent: ______	Date: ______
Catharsis:	☐ Yes	☒ No	Agent: ______	Date: ______
Surgical excision:	☐ Yes	☒ No	Date: ______	

EVALUATION METHODOLOGY:
Assumptions: Acute inhalation intake of ^{239}Pu, 100% Class Y, 1 μm AMAD particle size on 3/26/66

Code/Model used for: Intake Estimate: CINDY, Ver. 1.4/JONES
Dose Estimate: CINDY, Ver. 1.4/ICRP 30, Part 4, General Systemic Model

RESULTS SUMMARY
Estimated Intake Activity (pCi): 400000
50 YR CEDE (rem) : 120 (1.2 Sv)

Organ Dose Equivalent Summary	50 YR CDE (rem/Sv)
Bone Surface	1200/12
Lung	460/4.6
Liver	220/2.2
Red Marrow	96/0.96
Other	21/0.21
Testes	18/0.18

DOSE ASSESSOR: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

PEER REVIEWER: **DATE:** ______
Signature: ______
Print Name: ______
SSN: ______

RECOMMENDATIONS:
Additional Bioassay Required ☐ Urinalysis ☐ Fecal ☐ In Vivo
Suggested Sampling Frequency: ______
Work Restrictions: N/A

Internal Dosimetry Case Narrative

Identification:

Name: [redacted]
SSN:

Incidents:

Individual participated on site in response duties resulting from an accident involving three nuclear weapons at Palomares, Spain on January 17, 1966. Individual may have been exposed to weapons materials (primarily plutonium-239) by inhalation and ingestion from contaminated weapon and aircraft debris, lands, and vegetation. Primary activities included search, radiological monitoring, recovery of accident debris, and processing for disposal.

Previous Intake/Dose Assessments:

This assessment applies to Palomares accident activities only. No previous intakes or doses were considered.

Other Information:

None.

Radionuclide(s): ^{239}Pu.

Assumptions/Basis/Data Sources:

Acute inhalation intake of Pu-239; 100% Class Y; 1 μm AMAD particle size on 3/26/66. The date is the midpoint of the period on station from 3/14/66 to 4/8/66.

Inhalation was assumed as the major route of entry because the primary contaminant was created by explosion and fire and deposited in sandy soil and on buildings and plants. Conditions were generally windy and significant activity was underway.

Dose was determined entirely from modeling intake based on the following urinalysis results for this individual. This individual's sample was identified for a follow-up analysis using alpha spectrometry after the initial gross alpha result was reviewed. That is, the initial urine sample for this individual was reprocessed radiochemically for alpha spectrometry. Results of the follow-up alpha spectrometry analysis are reported below and were used in preparing the dose estimate.

Sample	Analysis*	Sample Date	Result (pCi/day)	Error (pCi/day)	Included
66-2860	AS	4/8/66	0.296	0.016	✓
66-2860	G	4/8/66	0.619	0.203	
66-3241	AS	5/26/66	NR	NR	
66-3241	G	5/26/66	0.423	0.423	✓

* G means gross alpha counting; AS means alpha spectrometry.

[redacted] [redacted]

Intakes and estimates of dose were prepared using CINDY Version 1.4 and LUDEP Version 2.05.

Intake was estimated using the Jones excretion model in CINDY and LUDEP.

Inhalation intake was estimated using the ICRP 66 respiratory tract model in LUDEP.

CINDY estimated dose derived using the ICRP 30, Part 4, General Systemic Model and weighting factors; and LUDEP used the recommendations of ICRP 60.

Modeling:

CINDY and LUDEP were used to estimate the intake and dose with the following results:

Model	Intake (pCi)	CEDE (rem/Sv)
CINDY	400,000	120/1.2
LUDEP	1,280,000	90/0.9

Doses to individual organs and estimation of the effective dose equivalent using CINDY reported the following results:

Organ	Dose Equivalent (rem/Sv)	Weighting Factors	Weighted Organ Dose Equivalent (rem/Sv)
Testes	1.8E+01/1.8E-01	2.5E-01	4.5E+00/4.5E-02
Breast	5.9E-04/5.9E-06	1.5E-01	8.9E-05/8.9E-07
Red Marrow	9.6E+01/9.6E-01	1.2E-01	1.2E+01/1.2E-01
Lung	4.6E+02/4.6E+00	1.2E-01	5.5E+01/5.5E-01
Thyroid	5.6E-04/5.6E-06	3.0E-02	1.7E-05/1.7E-07
Bone Surface	1.2E+03/1.2E+01	3.0E-02	3.7E+01/3.7E-01
Liver	2.2E+02/2.2E+00	6.0E-02	1.3E+01/1.3E-01
Other	2.1E+01/2.1E-01	6.0E-02	1.3E+00/1.3E-02
Lower Large Intestine	4.5E-02/4.5E-04	6.0E-02	2.7E-03/2.7E-05
Upper Large Intestine	1.5E-02/1.5E-04	6.0E-02	9.1E-04/9.1E-06
Small Intestine	3.1E-03/3.1E-05	6.0E-02	1.9E-04/1.9E-06
Effective Dose Equivalent			1.2E+02/1.2E+00

Two urine samples were analyzed by gross alpha counting and alpha spectrometry. For the first sample, the gross alpha analysis was not included in the modeling since an alpha spectrometry result was available for the same sample. For the second sample, no result was reported for the alpha spectrometry analysis, so the gross alpha counting result was used. The results were fit using CINDY and the Jones excretion model, to estimate an intake (400,000 pCi), organ doses, and a CEDE (120 rem/1.2 Sv; ICRP-30) as shown above. LUDEP was also used to estimate an intake of 1,280,000 pCi and a CEDE (ICRP-60) of 90 rem (0.9 Sv).

Conclusion:

Based on the results of intake estimates and dose calculations, this individual received an estimated intake of about 400,000 pCi of ^{239}Pu resulting in a 50-year committed effective dose equivalent of 120 rem (1.2

Sv). That dose is more than the cumulative dose (7 rem) from a lifetime (70 years) of exposure at the current level (0.100 rem) for members of the public. It is more than the working lifetime limit of 50 rem recommended by the National Council on Radiation Protection and Measurements (NCRP). These estimated dose levels are significant, although they were based on one sample that may have been collected on-site. However, follow-up urine sampling should be considered to provide additional assessment of the exposure.

Prepared By:

Name: ______________________________

Signature: ______________________________ Date: ______________

Peer Reviewed By:

Name: ______________________________

Signature: ______________________________ Date: ______________

24

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20)	SOC. SEC. NO. (21-29)	TYPE SAMPLE (30)	TYPE ANAL. (31-32)
[redacted] A2C	[redacted]	Urine	

SAMPLE NO. (33-38)	SAMPLE DATE (39-44)		EXPOSURE
66-2860	FROM 8 Apr 66	TO	DATE 14 Mar 66 TYPE
BASE (57-60)	OCCUPATION (61-62)	REQUESTED BY	
Moron	Not Listed		
DATE RECEIVED	SAMPLE VOLUME	VOLUME ANALYZED	DATE ANALYZED
22 Apr 66	2000	2000	

TECHNICIAN (SIGNATURE AND DATE)

URINE			
Counter Number	H		
Counter Bkg. (cpm)	0.03 (900)		t, 25
Counter Eff. (%)	51		
Date/Time — Start	13 May 66		
— Stop			
Total Counts	40	Reported value	
Counting Time	55	corrected for spike	
Gross cpm	0.73	of 0.965 pc) sample	
Bkg. Cpm	0.03		
Net cpm	0.70		
~~dpm~~ pci/l	0.309	± 0.102	
dpm/24 hr. (69-74)			
K 40 Correction			
~~Net Beta~~ pci/sgl	0.619	± 0.203	
D(q) (63-68)			

RADON		
Chamber Number		
Cham. Bkg. (mv/sec)		
Counter Eff. (%)		
Millivolt — Start		
Millivolt — Stop		
Total Millivolts		
Total Drift Time		
Gross mv/sec		
Bkg. Mv/sec		
Net mv/sec		
curies/mv		
liter (69-74)		
D(q) (63-68)		

FECES/BLOOD	
Counter Number	N/A
Counter Bkg.	
Counter Eff.	
Date/Time — Start	
— Stop	
Total Counts	
Counting Time	
Gross cpm	
Bkg. cpm	
net cpm	
dpm	
dps/cc	
Neutron Dose (rads) (63-68)	
uc/mg (69-74)	
D(q) (63-68)	

RADIOLOGICAL SAMPLE DATA

NAME OR REQUESTOR'S ID (1–20)	GRADE	AFSN	SOCIAL SECURITY NUMBER	RHL SAMPLE NUMBER 66-2860
TYPE SAMPLE (23–32)	OCCUPATION (34–35)	ANALYSIS DESIRED	REQUESTED BY	AIR FORCE BASE (68–71)
DATE RECEIVED (37–42)	DATE ANALYZED (51–56)	DATE COUNTED 7 July 66	DATE COLLECTED	EXPOSURE DATE
SAMPLE WEIGHT/VOLUME		WEIGHT/VOLUME ANALYZED		TECHNICIAN

OTHER DATA .953

ENVIRONMENTAL SAMPLES					
COUNTER & EFFICIENCY					
TOTAL COUNTS & MINUTES					
GROSS CPM					
BKG CPM & MINUTES					
NET CPM					
YIELD					
BIOLOGICAL SAMPLES		236	239	RADON	
COUNTER & EFFICIENCY	Spec	27.3	27.3	1.94 dpm	1.37 DPM
TOTAL COUNTS & MINUTES	100	40		± 0.151	
GROSS CPM		0.40	.08		
BKG CPM & MINUTES	800	1 0.0013	4 0.005.04		
NET CPM		0.3987	0.0750		
YIELD				0.296 ± 0.016	
	%Rec	41.84			

SUMMARY OF RESULTS:

AFLC FORM MAY 66 1165 FC 5400 AFLC–WPAFB–MAY 66 4500

Dose Evaluation Report [redacted]
April 28, 2000

Release of this document is restricted under the provisions of the Privacy Act, 5 U.S.C. 552(a). C.2-380

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20): [redacted] A2C	SOC. SEC. NO. (21-29): [redacted]	TYPE SAMPLE (30): Urine	TYPE ANAL. (31-32)
SAMPLE NO. (33-38): 66-3241	SAMPLE DATE (39-44): FROM 1300 25 May TO 1300 26 May 66	EXPOSURE DATE 14 MAR 66	TYPE
BASE (57-60): Moron	OCCUPATION (61-62): Not Stated	REQUESTED BY	
DATE RECEIVED: 6 June 1966	SAMPLE VOLUME: 2280 ml	VOLUME ANALYZED: 1140 ml	DATE ANALYZED: 9 JUN 1966
TECHNICIAN (SIGNATURE AND DATE): SSgt [redacted] USAF			

URINE				RADON		FECES/BLOOD	
Counter Number	B			Chamber Number		Counter Number	
Counter Bkg. (cpm)	78 (926)			Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)	51			Counter Eff. (%)		Counter Eff.	
Date/Time — Start	9 June			Millivolt — Start		Date/Time — Start	✓
— Stop				Millivolt — Stop		— Stop	
Total Counts	36			Total Millivolts		Total Counts	
Counting Time	120			Total Drift Time		Counting Time	
Gross cpm	0.30			Gross mv/sec		Gross cpm	0.19 PC
Bkg. Cpm	0.08			Bkg. Mv/sec		Bkg. cpm	0.10 BB
Net cpm	0.22			Net mv/sec		net cpm	
~~dpm~~ pCi/liter	0.185 ±	0.087		curies/mv		dpm	
dpm/24 hr. (69-74)				litter (69-74)		dps/cc	
K 40 Correction						Neutron Dose (rads) (63-68)	
~~Net Beta~~ pCi/24hr	0.423 ±	0.199		D(q) (63-68)		uc/mg (69-74)	
D(q) (63-68)						D(q) (63-68)	

δ = .72 D D_R = 4.75 x 10 μc

Spiked c̄ 1ml Pu^{239} (Labeled 4.57 DPM/ml)

INTERNAL DOSE DATA

NAME (LAST, FIRST, M.I.) (1-20) [redacted] A2C	SOC. SEC. NO. (21-29)	TYPE SAMPLE (30) URINE	TYPE ANAL. (31-32) Alpha
SAMPLE NO. (33-38) 66-3241-S	SAMPLE DATE (39-44) FROM TO	EXPOSURE DATE TYPE	
BASE (57-60)	OCCUPATION (61-62)	REQUESTED BY SGHW	
DATE RECEIVED	SAMPLE VOLUME 2280 ml	VOLUME ANALYZED 1140 ml	DATE ANALYZED
TECHNICIAN (SIGNATURE AND DATE)			

URINE				RADON		FECES/BLOOD	
Counter Number	C			Chamber Number		Counter Number	
Counter Bkg. (cpm)	39 (92d)			Cham. Bkg. (mv/sec)		Counter Bkg.	
Counter Eff. (%)	51			Counter Eff. (%)		Counter Eff.	
Date/Time – Start	9 June		5.20	Millivolt – Start		Date/Time – Start	
– Stop			5.588	Millivolt – Stop		– Stop	
Total Counts	349			Total Millivolts		Total Counts	
Counting Time	120			Total Drift Time		Counting Time	
Gross cpm	2.91			Gross mv/sec		Gross cpm	Recovery
Bkg. Cpm	0.04			Bkg. Mv/sec		Bkg. cpm	
Net cpm	2.87			Net mv/sec		net cpm	93%
dpm	0.22			curies/mv		dpm	
dpm/24 hr. (69-74)	2.65			liter (69-74)		dps/cc	
K 40 Correction	5.20					Neutron Dose (rads) (63-68)	
Net Beta				D(q) (63-68)		uc/mg (69-74)	
D(q) (63-68)	93.1% Rec					D(q) (63-68)	

(b) (6) [redacted] (b) (6) [redacted]

(b) (6) [redacted]

PATIENT'S LAST NAME—FIRST NAME—MIDDLE NAME

REGISTER OR UNIT NO. | WARD NO. | BED PATIENT / AMBULATORY

REQUESTED BY AND DATE

SPECIMEN AND SOURCE: 24 hr Urine

RESULT

0.19 PC/liter
0.10 Body Burden

SIGNATURE (Specify requesting facility) (b) (6) [redacted]

NAME OF MEDICAL FACILITY: USAF (b) (6) [redacted]

Standard Form 514—M—Rev. June 1959
Bureau of the Budget Circular A-32

MISCELLANEOUS

APPENDIX C.3

CONTAMINATION CUTOFF CASES

Portions of this report have been designated records subject to the restriction of the Privacy Act, 5 U.S.C. 552(a) and are so marked.

APPENDIX C.3 CONTAMINATION CUTOFF CASES

This section contains the intake and dose estimates for individuals whose urinalysis results were categorized as below a "contamination cutoff" of 0.1 picocuries per day (pCi/d). These individuals primarily submitted samples while on-site at Palomares. Most of these initial samples were analyzed by the gross alpha procedure. The results of the analysis were less than 0.1 pCi/d and were evaluated for intake and dose. Most samples collected became contaminated with plutonium because of limited controls on spread of the very low amounts required to indicate a positive urinalysis result. The main body of the report contains a discussion on the problem of sample contamination and the "contamination cutoff".

This "contamination cutoff" group consisted of 314 individuals. Their urinalysis results ranged from 0.002 to 0.099 pCi/d for those processed by the gross alpha procedure and from 0.018 to 0.097 pCi/day for those processed by alpha spectrometry. Intakes ranged from 1,500 to 150,000 picocuries and produced 50-year committed effective dose equivalents (CEDEs) of 0.46 to 46 rem (0.0046 to 0.46 Sv). Table C.3-1 shows the distribution of CEDE for this group and indicates that most individuals' doses were relatively low. This section contains a listing of the results of the assessments. Individual narrative summaries were not prepared for these

Table C.3-1 Distribution of effective doses.

CEDE Range (rem)	Number of Cases
0-10	149
10-20	94
20-30	55
30-40	14
40-50	2

individuals.

The listing requires some explanatory notes to clarify features of the data presented. These notes include the following.

- An entry of "n/a" means that data were not available in any of the records reviewed generally because no entry was recorded.
- An entry of "NR" means that a result for an analysis was not recorded on the appropriate data form.
- An entry of "ND" means that an analytical result was recorded as No Detectable Activity (NDA).
- An entry of "(12-hr)" in a Sample Volume cell means that a data form for the sample noted that the sample was collected for 12 hours.
- A shaded cell represents a result for a sample (collected on site) that exceeded 0.1 pCi/day; the established maximum for modeling individuals in the "Contamination Cutoff" category.
- An entry of "mean" represents the average value for intake or CEDE from two or more sample results for the same person.

Results of Modeling Individuals with Samples Assumed to be "Uncontaminated."

Cell shaded = Additional sample for Indiv not modeled since >0.1 pCi/sample, NR, or ND

NAME	SSN	START EXPOSURE DATE	END EXPOSURE DATE	ESTIMATED ACUTE EXPOSURE DATE	SAMPLE #	SAMPLE DATE	ELAPSED DAYS	SAMPLE VOLUME (mL)	ANALYSIS	RESULT (pCi/ sample)	+/- (pCi/ sample)	INTAKE (1000s pCi)	50-YEAR CEDE (rem/Sv)
(b) (6) [redacted]	(b) (6) [redacted]	02/27/66	03/19/66	03/09/66	66-2049	03/19/66	10	430	Gross Alpha	0.064	7.930E-02	52 0	16/0.16
		01/18/66	02/03/66	01/26/66	66-1811	02/03/66	8	720	Gross Alpha	0.041	1.013E-02	29 0	8 9/0 089
		03/14/66	03/19/66	03/16/66	66-2332	03/19/66	3	890	Gross Alpha	0.092	9 890E-02	19 0	5 8/0 058
												mean =	7 35/0 0735
(b) (6) [redacted]	(b) (6) [redacted]	01/19/66	03/23/66	02/19/66	66-2581	03/23/66	32	1000	Gross Alpha	0.034	6 230E-02	40 0	12/0.12
					66-888	02/05/66		970	Gross Alpha	3.77	1 360E+00		
(b) (6) [redacted]	(b) (6) [redacted]	02/09/66	03/09/66	02/23/66	66-2057	03/09/66	14	650	Gross Alpha	0.079	6 220E-02	73 0	22/0 22
		01/24/66	02/08/66	01/31/66	66-2684	03/28/66	56	1100	Gross Alpha	0.037	1 030E-01	52 0	16/0 16
		02/11/66	03/19/66	03/01/66	66-2232	03/19/66	18	700	Gross Alpha	0.032	7 875E-03	32 0	9 8/0 098
		01/18/66	01/26/66	01/22/66	66-1943	01/26/66	4	1300	Gross Alpha	0.018	4 500E-03	5 5	1 7/0 017
		01/24/66	01/24/66	01/24/66	66-1249	02/27/66	34	1525	Gross Alpha	0.077	2 390E-02	94 0	29/0 29
		01/18/66	03/04/66	02/09/66	66-2379	03/04/66	23	1350	Gross Alpha	0.027	8 010E-02	29 0	8 9/0 089
		01/23/66	03/19/66	02/19/66	66-2170	03/19/66	28	900	Gross Alpha	0.081	2 025E-02	93 0	29/0 29
		02/13/66	03/08/66	02/24/66	66-2508	03/08/66	12	950	Gross Alpha	0.027	6 750E-03	24 0	7.4/0.074
		01/18/66	03/08/66	02/11/66	66-2457	03/08/66	25	1000	Gross Alpha	0.028	2 120E-02	31.0	9 5/0 095
		01/16/66	02/23/66	02/05/66	66-1247	02/23/66	18	1180	Gross Alpha	0.026	1 890E-02	26 0	8/0 08
		01/16/66	02/03/66	01/26/66	66-1818	02/03/66	8	890	Gross Alpha	0.009	2 250E-03	6 4	2/0 02
		02/24/66	03/19/66	03/07/66	66-2172	03/19/66	12	350	Gross Alpha	0.059	1.463E-02	52 0	16/0 16
		02/13/66	03/09/66	02/25/66	66-2055	03/09/66	12	550	Gross Alpha	0.072	6 230E-02	64.0	20/0 2
		01/18/66	02/03/66	01/26/66	66-1838	02/03/66	8	600	Gross Alpha	0.032	7.875E-03	22 0	6 8/0.068
		01/23/66	03/03/66	02/11/66	66-1923	03/03/66	20	510	Gross Alpha	0.038	2.870E-02	39 0	12/0.12
		02/13/66	03/08/66	02/24/66	66-2452	03/08/66	12	350	Gross Alpha	0.014	1.490E-02	12 0	3 7/0.037
		01/18/66	02/11/66	01/30/66	66-1237	02/11/66	12	1600	Gross Alpha	0.030	2.510E-02	27.0	8 3/0.083
		02/11/66	03/19/66	03/01/66	66-2134	03/19/66	18	730	Gross Alpha	0.063	1.570E-02	63 0	19/0.19
		01/21/66	03/03/66	02/10/66	66-1917	03/03/66	21	800	Gross Alpha	0.097	6.850E-02	100 0	31/0.31
		01/18/66	01/24/66	01/21/66	66-1117	01/24/66	3	1250	Gross Alpha	0.047	2.290E-02	9 8	3/0.03
		01/30/66	03/18/66	02/22/66	66-2104	03/18/66	24	870	Gross Alpha	0.073	8.340E-02	79 0	24/0.24
		02/13/66	03/08/66	02/24/66	66-1891	03/08/66	12	925	Gross Alpha	0.045	2.460E-02	40 0	12/0.12
		02/17/66	03/08/66	02/26/66	66-2430	03/08/66	10	700	Gross Alpha	0.028	1.680E-02	23 0	7.1/0.071
		02/09/66	03/03/66	02/20/66	66-1925	03/03/66	11	910	Gross Alpha	0.067	2.300E-02	57.0	18/0.18
		02/18/66	03/18/66	03/04/66	66-2118	03/18/66	14	880	Gross Alpha	0.055	5.630E-02	52 0	16/0.16
		02/09/66	03/08/66	02/22/66	66-2424	03/08/66	14	500	Gross Alpha	0.007	1.680E-02	6 8	2 1/0.021
					66-1896	03/08/66		n/a	Gross Alpha	NR	NR		
		02/06/66	02/28/66	02/17/66	66-1365	02/28/66	11	915 (12-hr)	Gross Alpha	0.032	7.875E-03	54 0	17/0.17
		02/22/66	03/08/66	03/01/66	66-2434	03/08/66	7	950	Gross Alpha	0.057	3.140E-02	36 0	11/0.11
		02/13/66	03/04/66	02/22/66	66-2897	04/05/66	42	700	Gross Alpha	0.091	1 200E-01	120 0	37/0 37

NR - Not Reported; ND - No Detectable Activity; n/a - not available

Results of Modeling Individuals with Samples Assumed to be "Uncontaminated."

Cell shaded = Additional sample for indiv not modeled since >0.1 pCi/sample, NR, or ND

NAME	SSN	START EXPOSURE DATE	END EXPOSURE DATE	ESTIMATED ACUTE EXPOSURE DATE	SAMPLE #	SAMPLE DATE	ELAPSED DAYS	SAMPLE VOLUME (mL)	ANALYSIS	RESULT (pCi/ sample)	+/- (pCi/ sample)	INTAKE (1000s pCi)	50-YEAR CEDE (rem/Sv)
(b) (6) [redacted]	(b) (6) [redacted]	02/11/66	03/19/66	03/01/66	66-2200	03/19/66	18	900	Gross Alpha	0.035	8.750E-03	35.0	11/0.11
		02/05/66	02/25/66	02/15/66	66-1340	02/25/66	10	1300	Gross Alpha	0.022	1.850E-02	18.0	5.5/0.055
		02/21/66	03/18/66	03/05/66	66-2258	03/18/66	13	780	Gross Alpha	0.034	7.260E-02	31.0	9.5/0.095
		02/21/66	03/19/66	03/06/66	66-2329	03/19/66	13	700	Gross Alpha	0.021	7.350E-02	19.0	5.8/0.058
		02/13/66	03/08/66	02/24/66	66-2425	03/08/66	12	1000	Gross Alpha	0.010	2.740E-02	9.2	2.8/0.028
		02/21/66	03/18/66	03/05/66	66-2245	03/18/66	13	1000	Gross Alpha	0.098	1.090E-01	89.0	27/0.27
		02/08/66	02/28/66	02/18/66	66-1357	02/28/66	10	950 (12-hr)	Gross Alpha	0.032	7.875E-03	52.0	16/0.16
		03/14/66	03/19/66	03/16/66	66-2333	03/19/66	3	900	Gross Alpha	0.096	1.017E-01	20.0	6.1/0.061
					66-2357	03/04/66		900	Gross Alpha	0.15	1.190E-01		
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/03/66	01/26/66	66-1823	02/03/66	8	800	Gross Alpha	0.018	4.500E-03	13.0	4/0.04
		02/11/66	03/08/66	02/23/66	66-2454	03/08/66	13	1000	Gross Alpha	0.085	2.460E-02	77.0	24/0.24
					66-3121	04/13/66		700	Gross Alpha	0.364	1.340E-01		
(b) (6) [redacted]	(b) (6) [redacted]	02/09/66	03/08/66	02/22/66	66-1889	03/08/66	14	940	Gross Alpha	0.031	1.960E-02	29.0	8.9/0.089
		01/18/66	03/08/66	02/11/66	66-2615	03/08/66	25	850	Gross Alpha	0.070	7.900E-02	77.0	24/0.24
		02/13/66	03/08/66	02/24/66	66-2471	03/08/66	12	1000	Gross Alpha	0.077	1.913E-02	68.0	21/0.21
		02/09/66	03/08/66	02/22/66	66-1882	03/08/66	14	750	Gross Alpha	0.017	2.000E-02	16.0	4.9/0.049
	(b) (6) [redacted]	02/10/66	03/19/66	02/28/66	66-2208	03/19/66	19	900	Gross Alpha	0.093	1.017E-01	94.0	29/0.29
		01/17/66	01/27/66	01/22/66	66-1234	02/19/66	28	1000	Gross Alpha	0.036	2.120E-02	41.0	13/0.13
		01/18/66	02/03/66	01/26/66	66-1835	02/03/66	8	750	Gross Alpha	0.018	4.500E-03	13.0	4/0.04
		02/24/66	03/19/66	03/07/66	66-2552	03/19/66	12	820	Gross Alpha	0.049	7.140E-02	43.0	13/0.13
		02/21/66	03/18/66	03/05/66	66-2088	03/18/66	13	860	Gross Alpha	0.096	7.640E-02	87.0	27/0.27
		01/18/66	01/20/66	01/19/66	66-1132	01/20/66	1	n/a	Gross Alpha	0.029	1.930E-02	2.5	0.77/0.0077
		01/18/66	03/19/66	02/17/66	66-2337	03/19/66	30	800	Gross Alpha	0.016	9.120E-02	19.0	5.8/0.058
		02/10/66	03/29/66	03/05/66	66-2593	03/29/66	24	1475	Gross Alpha	0.057	8.040E-02	63.0	19/0.19
		02/11/66	03/08/66	02/23/66	66-2453	03/08/66	13	750	Gross Alpha	0.024	3.820E-02	21.0	6.5/0.065
		02/17/66	03/08/66	02/26/66	66-1892	03/08/66	10	930	Gross Alpha	0.021	2.800E-02	17.0	5.2/0.052
		01/18/66	02/03/66	01/26/66	66-1820	02/03/66	8	390	Gross Alpha	0.050	1.238E-02	35.0	11/0.11
		02/24/66	03/19/66	03/07/66	66-2566	03/19/66	12	800	Gross Alpha	0.060	8.030E-02	53.0	16/0.16
		02/09/66	03/09/66	02/23/66	66-2398	03/09/66	14	1200	Gross Alpha	0.026	7.150E-02	25.0	7.7/0.077
		02/10/66	03/19/66	02/28/66	66-2046	03/19/66	19	695	Gross Alpha	0.013	8.480E-02	13.0	4/0.04
		02/06/66	03/08/66	02/21/66	66-1869	03/08/66	15	1020	Gross Alpha	0.050	1.250E-02	47.0	14/0.14
		01/18/66	03/08/66	02/11/66	66-2623	03/08/66	25	1100	Gross Alpha	0.070	7.900E-02	77.0	24/0.24
		01/18/66	01/22/66	01/20/66	66-1136	01/22/66	2	975	Gross Alpha	0.057	2.560E-02	7.9	2.4/0.024
		02/26/66	03/18/66	03/08/66	66-2112	03/18/66	10	580	Gross Alpha	0.058	6.960E-01	47.0	14/0.14
					66-1157	02/15/66		645	Gross Alpha	ND	ND		
					66-3128	04/13/66		1650	Gross Alpha	NR	NR		
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	03/28/66	02/21/66	66-2681	03/28/66	35	1520	Gross Alpha	0.061	7.140E-02	75.0	23/0.23

NR - Not Reported; ND - No Detectable Activity; n/a - not available

Results of Modeling Individuals with Samples Assumed to be "Uncontaminated."

Cell shaded = Additional sample for indiv not modeled since >0.1 pCi/sample, NR, or ND

NAME	SSN	START EXPOSURE DATE	END EXPOSURE DATE	ESTIMATED ACUTE EXPOSURE DATE	SAMPLE #	SAMPLE DATE	ELAPSED DAYS	SAMPLE VOLUME (mL)	ANALYSIS	RESULT (pCi/ sample)	+/- (pCi/ sample)	INTAKE (1000s pCi)	50-YEAR CEDE (rem/Sv)
(b) (6) [redacted]	(b) (6) [redacted]	01/19/66	03/18/66	02/17/66	66-2240	03/18/66	29	700	Gross Alpha	0.090	8.800E-02	100.0	31/0.31
[redacted]	[redacted]	01/31/66	03/19/66	02/23/66	66-2165	03/19/66	24	800	Gross Alpha	0.059	1.463E-02	64.0	20/0.2
[redacted]	[redacted]	01/17/66	01/22/66	01/19/66	66-3105	04/13/66	84	800	Gross Alpha	0.058	4.800E-02	81.0	2.5/0.025
[redacted]	[redacted]	01/21/66	03/18/66	02/18/66	66-2251	03/18/66	28	1000	Gross Alpha	0.040	8.130E-02	45.0	14/0.14
[redacted]	[redacted]	01/18/66	01/29/66	01/23/66	66-1140	01/29/66	6	560	Gross Alpha	0.025	1.890E-02	13.0	4/0.04
[redacted]	[redacted]	02/03/66	02/28/66	02/15/66	66-1358	02/28/66	13	550 (12-hr)	Gross Alpha	0.009	2.250E-03	16.0	4.9/0.049
[redacted]	[redacted]	02/13/66	03/08/66	02/24/66	66-2429	03/08/66	12	1000	Gross Alpha	0.039	2.220E-02	34.0	10/0.1
[redacted]	[redacted]	01/18/66	01/22/66	01/20/66	66-1131	01/22/66	2	950	Gross Alpha	0.085	2.620E-02	12.0	3.7/0.037
[redacted]	[redacted]	02/21/66	03/19/66	03/06/66	66-2206	03/19/66	13	850	Gross Alpha	0.090	2.250E-02	82.0	25/0.25
[redacted]	[redacted]	01/18/66	04/05/66	02/25/66	66-2696	04/05/66	39	1000	Gross Alpha	0.040	7.210E-02	51.0	16/0.16
[redacted]	[redacted]	02/13/66	03/08/66	02/24/66	66-2445	03/08/66	12	1250	Gross Alpha	0.026	1.900E-02	23.0	7.1/0.071
[redacted]	[redacted]	01/18/66	02/03/66	01/26/66	66-1821	02/03/66	8	700	Gross Alpha	0.090	2.253E-02	64.0	20/0.2
[redacted]	[redacted]	01/21/66	02/19/66	02/04/66	66-1229	02/19/66	15	1200	Gross Alpha	0.054	2.190E-02	51.0	16/0.16
[redacted]	[redacted]	03/14/66	03/19/66	03/16/66	66-2187	03/19/66	3	850	Gross Alpha	0.059	1.463E-02	12.0	3.7/0.037
[redacted]	[redacted]	02/06/66	02/28/66	02/17/66	66-1361	02/28/66	11	625 (12-hr)	Gross Alpha	0.059	1.465E-02	100.0	31/0.31
[redacted]	[redacted]	01/18/66	01/29/66	01/23/66	66-1080	01/29/66	6	2050	Pu239	0.079	1.975E-02	42.0	13/0.13
[redacted]	[redacted]	01/18/66	02/03/66	01/26/66	66-1808	02/03/66	8	540	Gross Alpha	0.099	2.478E-02	70.0	22/0.22
[redacted]	[redacted]	01/22/66	03/19/66	02/19/66	66-2141	03/19/66	28	500	Gross Alpha	0.056	5.650E-02	64.0	20/0.2
[redacted]	[redacted]	01/18/66	02/03/66	01/26/66	66-1826	02/03/66	8	900	Gross Alpha	0.059	1.465E-02	83.0	25/0.25
[redacted]	[redacted]	02/06/66	02/28/66	02/17/66	66-1366	02/28/66	11	950 (12-hr)	Gross Alpha	0.050	1.245E-02	85.0	26/0.26
[redacted]	[redacted]	02/10/66	03/08/66	02/23/66	66-2464	03/08/66	13	850	Gross Alpha	0.021	1.840E-02	19.0	27/0.27
[redacted]	[redacted]	02/13/66	03/18/66	03/01/66	66-2103	03/18/66	17	640	Gross Alpha	0.051	6.020E-02	51.0	16/0.16
[redacted]	[redacted]	02/13/66	03/29/66	03/07/66	66-2594	03/29/66	22	1900	Gross Alpha	0.088	9.500E-02	93.0	29/0.29
[redacted]	[redacted]	02/21/66	03/19/66	03/06/66	66-2230	03/19/66	13	550	Gross Alpha	0.054	7.210E-02	49.0	15/0.15
[redacted]	[redacted]	01/18/66	03/27/66	02/21/66	66-2587	03/27/66	34	1300	Gross Alpha	0.097	1.020E-01	120.0	37/0.37
[redacted]	[redacted]	01/18/66	03/08/66	02/11/66	66-1873	03/08/66	25	910	Gross Alpha	0.099	2.478E-02	110.0	34/0.34
[redacted]	[redacted]	01/18/66	03/08/66	02/11/66	66-2438	03/08/66	25	350	Gross Alpha	0.013	1.700E-02	14.0	4.3/0.043
[redacted]	[redacted]	01/18/66	02/03/66	01/26/66	66-1813	02/03/66	8	940	Gross Alpha	0.032	7.875E-03	22.0	6.8/0.068
[redacted]	[redacted]	01/18/66	03/19/66	02/17/66	66-2227	03/19/66	30	925	Gross Alpha	0.075	1.160E-01	88.0	27/0.27
[redacted]	[redacted]	01/18/66	01/21/66	01/19/66	66-1135	01/21/66	2	n/a	Gross Alpha	0.025	2.110E-02	3.4	1/0.01
[redacted]	[redacted]	02/09/66	03/08/66	02/22/66	66-1895	03/08/66	14	900	Gross Alpha	0.044	2.270E-02	41.0	13/0.13
[redacted]	[redacted]	02/25/66	03/18/66	03/07/66	66-2259	03/18/66	11	500	Gross Alpha	0.065	8.100E-02	55.0	17/0.17
[redacted]	[redacted]	01/18/66	01/30/66	01/24/66	66-1481	02/25/66	32	1720	Pu239	0.039	1.560E-01	46.0	14/0.14
[redacted]	[redacted]	01/24/66	02/05/66	01/30/66	66-1248	02/23/66	24	1345	Gross Alpha	0.024	1.880E-02	26.0	8/0.08
[redacted]	[redacted]	02/06/66	02/28/66	02/17/66	66-1364	02/28/66	11	610 (12-hr)	Gross Alpha	0.032	7.875E-03	54.0	17/0.17
[redacted]	[redacted]	02/27/66	03/28/66	03/13/66	66-2675	03/28/66	15	1600	Gross Alpha	0.087	9.500E-02	83.0	25/0.25
[redacted]	[redacted]	02/27/66	03/08/66	03/03/66	66-2462	03/08/66	5	1000	Gross Alpha	0.024	2.910E-02	10.0	3.1/0.031

NR - Not Reported; ND - No Detectable Activity; n/a - not available

Results of Modeling Individuals with Samples Assumed to be "Uncontaminated."

Cell shaded = Additional sample for Indiv not modeled since >0 1 pCi/sample, NR, or ND

NAME	SSN	START EXPOSURE DATE	END EXPOSURE DATE	ESTIMATED ACUTE EXPOSURE DATE	SAMPLE #	SAMPLE DATE	ELAPSED DAYS	SAMPLE VOLUME (mL)	ANALYSIS	RESULT (pCi/ sample)	+/- (pCi/ sample)	INTAKE (1000s pCi)	50-YEAR CEDE (rem/Sv)
[redacted]	[redacted]	03/02/66	03/19/66	03/10/66	66-2218	03/19/66	9	400	Gross Alpha	0 058	1 096E-01	45 0	14/0 14
		02/24/66	03/18/66	03/07/66	66-2119	03/18/66	11	990	Gross Alpha	0 057	6 990E-02	49 0	15/0 15
		01/18/66	02/03/66	01/26/66	66-1833	02/03/66	8	910	Gross Alpha	0 041	1 013E-02	29 0	8 9/0.089
		01/18/66	03/16/66	02/15/66	66-2645	03/16/66	29	450	Gross Alpha	0 026	5 090E-02	36 0	11/0.11
					66-2646	03/17/66	24183	850	Gross Alpha	0 048	8 840E-02		
[redacted]	[redacted]	01/20/66	02/22/66	02/05/66	66-2671	03/24/66	47	910	Gross Alpha	0 026	5 080E-02	34 0	10/0 1
					66-1088	01/29/66		1250	Gross Alpha	118	3 000E+00		
[redacted]	[redacted]	03/26/66	04/11/66	04/03/66	66-3204	04/21/66	18	1160	Gross Alpha	0 080	1 121E-01	80 0	25/0.25
					66-3204-5	04/21/66		1160	Gross Alpha	580	1.450E+02		
[redacted]	[redacted]	01/18/66	02/12/66	01/30/66	66-1125	02/12/66	13	950	Gross Alpha	0 024	2 080E-02	3 2	0 98/0.0098
		01/31/66	02/26/66	02/13/66	66-1417	02/26/66	13	940	Gross Alpha	0 060	1 500E-02	55.0	17/0.17
		03/12/66	03/20/66	03/16/66	66-2288	03/20/66	4	900	Gross Alpha	0 091	9 540E-02	28 0	8.6/0.086
		01/17/66	02/25/66	02/05/66	66-1338	02/25/66	20	1200	Gross Alpha	0 043	1 850E-02	44 0	14/0.14
		02/18/66	03/08/66	02/27/66	66-2436	03/08/66	9	1000	Gross Alpha	0.025	1 640E-02	19 0	5 8/0.058
		02/27/66	03/08/66	03/03/66	66-2442	03/08/66	5	1000	Gross Alpha	0 037	2 010E-02	15 0	4 6/0.046
		02/21/66	03/03/66	02/26/66	66-1922	03/03/66	5	450	Gross Alpha	0 051	2 330E-02	21.0	6 5/0.065
		02/25/66	03/18/66	03/07/66	66-2273	03/18/66	11	850	Gross Alpha	0 036	6 270E-02	31 0	9 5/0.095
		02/27/66	03/19/66	03/09/66	66-2193	03/19/66	10	960	Gross Alpha	0 050	1 238E-02	41.0	13/0.13
		01/18/66	02/03/66	01/26/66	66-1812	02/03/66	8	490	Gross Alpha	0 072	1 803E-02	51.0	16/0.16
		02/11/66	03/03/66	02/21/66	66-1914	03/03/66	10	825	Gross Alpha	0 075	5 930E-02	62 0	19/0.19
		02/13/66	03/18/66	03/01/66	66-2246	03/18/66	17	320	Gross Alpha	0 080	1 030E-01	78 0	24/0 24
		02/13/66	03/03/66	02/22/66	66-1924	03/03/66	9	850	Gross Alpha	0 063	2 770E-02	48 0	15/0 15
		02/21/66	03/09/66	03/01/66	66-2050	03/09/66	8	900	Gross Alpha	0 076	7 120E-02	54 0	17/0 17
		02/13/66	03/25/66	03/05/66	66-2287	03/20/66	15	560	Gross Alpha	0 036	6 270E-02	34 0	10/0 1
					66-3126	04/13/66		1150	Gross Alpha	NR	NR		
					66-3126-S	04/13/66		1100	Gross Alpha	NR	NR		
[redacted]	[redacted]	02/10/66	03/08/66	02/23/66	66-2518	03/08/66	13	400	Gross Alpha	0 014	3 375E-03	12 0	3 7/0 037
		01/23/66	03/20/66	02/20/66	66-2300	03/20/66	28	800	Gross Alpha	0 055	1 040E-01	63 0	19/0 19
		01/17/66	02/03/66	01/25/66	66-1841	02/03/66	9	800	Gross Alpha	0.009	2 250E-03	7 0	2 2/0 022
		01/17/66	03/09/66	02/11/66	66-2598	03/09/66	26	600	Gross Alpha	0 051	8 040E-02	57.0	18/0.18
		01/20/66	03/18/66	02/17/66	66-2254	03/18/66	29	950	Gross Alpha	0 075	1 160E-01	87.0	2 7/0 027
		01/23/66	03/20/66	02/20/66	66-2288	03/20/66	28	900	Gross Alpha	0 091	1 150E-01	100 0	31/0 31
		02/17/66	02/17/66	02/17/66	66-2673	03/25/66	36	1410	Gross Alpha	0.035	7 220E-02	43 0	13/0 13
		03/14/66	03/19/66	03/18/66	66-2149	03/19/66	3	300	Gross Alpha	0 082	1 023E-01	17 0	5 2/0 052
		03/17/66	03/18/66	03/17/66	66-2437	03/18/66	1	300	Gross Alpha	0 049	5 900E-02	4.1	1.3/0 013
		02/10/66	03/18/66	02/28/66	66-2248	03/18/66	18	800	Gross Alpha	0 072	8 080E-02	72 0	22/0 22
		02/17/66	03/08/66	02/26/66	66-1880	03/08/66	10	910	Gross Alpha	0 045	2 400E-02	37 0	11/0.11

NR - Not Reported; ND - No Detectable Activity; n/a - not available

Results of Modeling Individuals with Samples Assumed to be "Uncontaminated."

Cell shaded = Additional sample for indiv not modeled since >0.1 pCi/sample, NR, or ND

NAME	SSN	START EXPOSURE DATE	END EXPOSURE DATE	ESTIMATED ACUTE EXPOSURE DATE	SAMPLE #	SAMPLE DATE	ELAPSED DAYS	SAMPLE VOLUME (mL)	ANALYSIS	RESULT (pCi/sample)	+/- (pCi/sample)	INTAKE (1000s pCi)	50-YEAR CEDE (rem/Sv)
(b) (6) [redacted]	(b) (6) [redacted]	01/17/66	02/25/66	02/05/66	66-1341	02/25/66	20	600	Gross Alpha	0 030	2 330E-02	31.0	9 5/0 095
		02/10/66	03/04/66	02/21/66	66-2376	03/04/66	11	220	Gross Alpha	0 004	1 010E-01	3 6	11/0 11
		01/18/66	01/29/66	01/23/66	66-1077	01/29/66	6	1415	Pu239	0 079	1 975E-02	42 0	13/0 13
		01/17/66	01/18/66	01/17/66	66-1134	01/18/66	1	n/a	Gross Alpha	0 034	2 200E-02	2 9	0 89/0 0089
		01/18/66	02/03/66	01/26/66	66-1834	02/03/66	8	280	Gross Alpha	0 018	4 500E-03	13 0	4/0 04
		02/18/66	03/04/66	02/25/66	66-2342	03/04/66	7	900	Gross Alpha	0.092	1.060E-01	58 0	18/0 18
		03/12/66	03/19/66	03/15/66	66-2189	03/19/66	4	1000	Gross Alpha	0 009	2 250E-03	2 8	0 86/0 0086
		01/18/66	01/20/66	01/19/66	66-1128	01/20/66	1	800	Gross Alpha	0 028	2.120E-02	2.4	0.74/0 0074
		02/21/66	03/19/66	03/06/66	66-2330	03/19/66	13	920	Gross Alpha	0 047	8 110E-02	43 0	13/0 13
		01/18/66	01/29/66	01/23/66	66-1070	01/29/66	6	2200	Pu239	0 035	8 750E-03	19 0	5 8/0 058
		01/29/66	03/18/66	02/22/66	66-2099	03/18/66	24	870	Gross Alpha	0 003	8 270E-02	3 3	1/0 01
		02/13/66	03/08/66	02/24/66	66-2426	03/08/66	12	1000	Gross Alpha	0 034	1.990E-02	30 0	9 2/0 092
		01/21/66	03/08/66	02/13/66	66-2449	03/08/66	23	600	Gross Alpha	0 034	1 990E-02	37 0	11/0 11
		03/01/66	03/08/66	03/04/66	66-2450	03/08/66	4	1150	Gross Alpha	0 072	2 510E-02	22 0	6 8/0 068
		02/10/66	03/08/66	02/23/66	66-2447	03/08/66	13	1300	Gross Alpha	0 026	1 660E-02	24 0	7 4/0 074
		02/06/66	02/28/66	02/17/66	66-1369	02/28/66	11	960 (12-hr)	Gross Alpha	0 018	4 500E-03	31 0	9 5/0 095
		03/15/66	03/19/66	03/17/66	66-2570	03/19/66	2	700	Gross Alpha	0 084	9 520E-02	12 0	3 7/0 037
		03/08/66	03/19/66	03/13/66	66-2325	03/19/66	6	910	Gross Alpha	0 082	9 760E-02	33 0	10/0 1
		03/16/66	03/19/66	03/17/66	66-2556	03/19/66	2	950	Gross Alpha	0 045	8 760E-02	6 1	1 9/0 019
		02/23/66	03/08/66	03/01/66	66-2509	03/08/66	7	900	Gross Alpha	0 090	2 250E-02	57 0	18/0.18
		01/18/66	01/29/66	01/23/66	66-1073	01/29/66	6	510	Pu239	0.097	2 425E-02	51.0	16/0.16
		02/27/66	03/08/66	03/03/66	66-2456	03/08/66	5	700	Gross Alpha	0.098	2 570E-02	41.0	13/0.13
		02/27/66	03/08/66	03/03/66	66-2465	03/08/66	5	550	Gross Alpha	0 072	2.350E-02	30 0	9 2/0.092
		01/17/66	01/18/66	01/17/66	66-1138	01/18/66	1	725	Gross Alpha	0 068	2 490E-02	5 8	1.8/0.018
		02/25/66	03/18/66	03/07/66	66-2237	03/18/66	11	340	Gross Alpha	0.062	9.660E-02	53 0	16/0.16
					66-772	02/11/66		360	Gross Alpha	1	4.000E-01		
(b) (6) [redacted]	(b) (6) [redacted]	02/27/66	03/16/66	03/07/66	66-2670	03/27/66	20	820	Gross Alpha	0 086	9 510E-02	88 0	21/0.21
		02/17/66	03/08/66	02/26/66	66-1894	03/08/66	10	900	Gross Alpha	0 075	2 380E-02	62.0	19/0.19
		02/25/66	03/19/66	03/08/66	66-2228	03/19/66	11	920	Gross Alpha	0 002	1.060E-01	1.5	0 46/0.0046
		02/27/66	03/19/66	03/09/66	66-2313	03/19/66	10	1350	Gross Alpha	0.061	8 870E-02	50 0	15/0.15
		02/10/66	03/08/66	02/23/66	66-2451	03/08/66	13	1250	Gross Alpha	0 012	1.420E-02	11.0	3.4/0.034
		02/13/66	03/23/66	03/04/66	66-2583	03/23/66	19	1600	Gross Alpha	0 060	8.030E-02	61 0	19/0.19
		02/25/66	03/19/66	03/08/66	66-2225	03/19/66	11	1000	Gross Alpha	0 037	9.770E-02	32 0	9 8/0.098
		01/25/66	03/13/66	02/17/66	66-2547	03/13/66	24	750	Gross Alpha	0.098	1.010E-01	110 0	34/0.34
		02/13/66	03/08/66	02/24/66	66-2467	03/08/66	12	1000	Gross Alpha	0.032	1.970E-02	29.0	8 9/0.089
		01/18/66	02/03/66	01/26/66	66-1825	02/03/66	8	600	Gross Alpha	0 050	1.238E-02	35 0	11/0.11
		02/13/66	03/19/66	03/02/66	66-2182	03/19/66	17	900	Gross Alpha	0.072	1 800E-02	71.0	22/0 22

NR - Not Reported; ND - No Detectable Activity; n/a - not available

Results of Modeling Individuals with Samples Assumed to be "Uncontaminated."

Cell shaded = Additional sample for indiv not modeled since >0.1 pCi/sample, NR, or ND

NAME	SSN	START EXPOSURE DATE	END EXPOSURE DATE	ESTIMATED ACUTE EXPOSURE DATE	SAMPLE #	SAMPLE DATE	ELAPSED DAYS	SAMPLE VOLUME (mL)	ANALYSIS	RESULT (pCi/ sample)	+/- (pCi/ sample)	INTAKE (1000s pCi)	50-YEAR CEDE (rem/Sv)
(b) (6) [redacted]	(b) (6) [redacted]	02/21/66	03/10/66	03/01/66	66-1946	03/18/66	17	1690	Gross Alpha	0.093	7.460E-02	92.0	28/0.28
		01/18/66	01/20/66	01/19/66	66-1130	01/20/66	1	780	Gross Alpha	0.048	2.310E-02	4.0	1.2/0.012
		02/10/66	03/18/66	02/28/66	66-2262	03/18/66	18	988	Gross Alpha	0.055	9.120E-02	55.0	17/0.17
		01/18/66	02/23/66	02/05/66	66-1246	02/23/66	18	1340	Gross Alpha	0.040	2.410E-02	40.0	12/0.12
		02/13/66	03/18/66	03/01/66	66-2234	03/18/66	17	780	Gross Alpha	0.093	1.220E-01	91.0	28/0.28
		03/12/66	03/13/66	03/12/66	66-2387	03/13/66	1	1300	Gross Alpha	0.045	8.760E-02	3.8	1.2/0.012
		01/18/66	02/03/66	01/26/66	66-1815	02/03/66	8	190 (12-hr)	Gross Alpha	0.018	4.500E-03	26.0	8/0.08
		03/26/66	04/07/66	04/01/66	66-3104	04/13/66	12	900	Gross Alpha	0.094	5.500E-02	83.0	25/0.25
		02/25/66	03/19/66	03/08/66	66-2317	03/19/66	11	790	Gross Alpha	0.072	8.850E-02	62.0	19/0.19
		02/10/66	03/19/66	02/28/66	66-2149	03/19/66	19	800	Gross Alpha	0.009	7.360E-02	8.0	2.5/0.025
		02/10/66	03/06/66	02/22/66	66-2386	03/09/66	15	450	Gross Alpha	0.078	1.215E-01	74.0	23/0.23
		01/18/66	01/29/66	01/23/66	66-1142	01/29/66	6	380	Gross Alpha	0.022	2.080E-02	12.0	3.7/0.037
		02/18/66	03/08/66	02/27/66	66-2455	03/08/66	9	550	Gross Alpha	0.028	2.460E-02	21.0	6.5/0.065
		03/14/66	03/20/66	03/17/66	66-2303	03/20/66	3	420	Gross Alpha	0.026	8.270E-02	4.7	1.4/0.014
					66-1093	02/22/66		520	Gross Alpha	7.08	6.900E-01		
(b) (6) [redacted]	(b) (6) [redacted]	03/14/66	03/19/66	03/16/66	66-2334	03/19/66	3	900	Gross Alpha	0.022	7.310E-02	4.7	1.4/0.014
		02/13/66	03/08/66	02/24/66	66-2431	03/08/66	12	750	Gross Alpha	0.024	2.280E-02	21.0	6.5/0.065
		01/18/66	02/28/66	02/07/66	66-1078	02/28/66	21	1100	Pu239	0.062	1.550E-02	65.0	20/0.2
		02/25/66	03/19/66	03/08/66	66-2196	03/19/66	11	1000	Gross Alpha	0.041	1.013E-02	35.0	11/0.11
		02/11/66	03/08/66	02/23/66	66-2443	03/08/66	13	650	Gross Alpha	0.016	3.160E-02	15.0	4.6/0.046
		01/24/66	03/08/66	02/14/66	66-2599	03/08/66	22	1250	Gross Alpha	0.067	8.800E-02	80.0	25/0.25
		02/18/66	03/19/66	03/04/66	66-2329	03/19/66	15	875	Gross Alpha	0.083	9.540E-02	78.0	24/0.24
		02/06/66	02/28/66	02/17/66	66-1363	02/28/66	11	730 (12-hr)	Gross Alpha	0.018	4.500E-03	31.0	9.5/0.095
		02/06/66	02/28/66	02/17/66	66-1370	02/28/66	11	920 (12-hr)	Gross Alpha	0.050	1.238E-02	85.0	26/0.26
		01/18/66	02/23/66	02/05/66	66-1244	02/23/66	18	1200	Gross Alpha	0.086	2.280E-02	86.0	26/0.26
		01/18/66	03/28/66	02/21/66	66-1992	03/28/66	35	1350	Gross Alpha	0.041	1.013E-02	50.0	15/0.15
					66-910	02/18/66		1900	Gross Alpha	3.44	2.090E+00		
					66-1396	03/02/66		1620	Gross Alpha	0.444	3.840E-01		
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	03/01/66	02/08/66	66-1847	03/01/66	21	520	Gross Alpha	0.058	8.910E-02	61.0	19/0.19
		02/21/66	03/19/66	03/06/66	66-2204	03/19/66	13	1000	Gross Alpha	0.032	7.875E-03	29.0	8.9/0.089
		01/21/66	03/19/66	02/18/66	66-2188	03/19/66	29	1500	Gross Alpha	0.032	7.875E-03	36.0	11/0.11
		02/17/66	03/08/66	02/26/66	66-1893	03/08/66	10	700	Gross Alpha	0.017	3.010E-02	14.0	4.3/0.043
		03/14/66	03/19/66	03/18/66	66-2326	03/19/66	3	880	Gross Alpha	0.083	9.500E-01	17.0	5.2/0.052
					66-1072	01/29/66		1040	Pu239	ND	ND		
(b) (6) [redacted]	(b) (6) [redacted]	02/27/66	03/08/66	03/03/66	66-2433	03/08/66	5	500	Gross Alpha	0.042	2.250E-02	17.0	5.2/0.052
		02/10/66	03/06/66	02/22/66	66-1956	03/06/66	12	1100	Gross Alpha	0.076	7.520E-02	67.0	21/0.21
		03/14/66	03/19/66	03/16/66	66-2151	03/19/66	3	925	Gross Alpha	0.070	8.800E-02	15.0	4.6/0.046

NR - Not Reported; ND - No Detectable Activity; n/a - not available

Results of Modeling Individuals with Samples Assumed to be "Uncontaminated."

Cell shaded = Additional sample for indiv not modeled since >0.1 pCi/sample, NR, or ND

NAME	SSN	START EXPOSURE DATE	END EXPOSURE DATE	ESTIMATED ACUTE EXPOSURE DATE	SAMPLE #	SAMPLE DATE	ELAPSED DAYS	SAMPLE VOLUME (mL)	ANALYSIS	RESULT (pCi/sample)	+/- (pCi/sample)	INTAKE (1000s pCi)	50-YEAR CEDE (rem/Sv)
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	03/18/66	02/16/66	66-2260	03/18/66	30	700	Gross Alpha	0 097	1 092E-01	110 0	34/0 34
		02/23/66	03/19/66	03/07/66	66-2202	03/19/66	12	600	Gross Alpha	0 032	7 875E-03	28 0	8 6/0 086
		02/11/66	03/18/66	02/28/66	66-2275	03/18/66	18	950	Gross Alpha	0 055	8.100E-02	55 0	17/0 17
		01/18/66	01/29/66	01/23/66	66-1143	01/29/66	6	590	Gross Alpha	0 033	2.360E-02	18 0	5 5/0 055
		02/21/66	03/19/66	03/06/66	66-2201	03/19/66	13	650	Gross Alpha	0 032	7.875E-03	29 0	8 9/0 089
		02/08/66	02/28/66	02/18/66	66-1359	02/28/66	10	850 (12-hr)	Gross Alpha	0 072	1 803E-02	120 0	37/0 37
		01/24/66	02/22/66	02/07/66	66-1337	02/22/66	15	425	Gross Alpha	0.030	1 940E-02	29 0	8 9/0 089
		01/25/66	04/11/66	03/04/66	66-3413	06/07/66	95	980	Gross Alpha	0 075	4 590E-02	110 0	34/0 34
					66-258	01/21/66		1160	Gross Alpha	6.33	1 960E+00		
					66-406	02/02/66		4822	Gross Alpha	ND	ND		
					66-558	02/03/66		1440	Gross Alpha	2.66	1 840E+00		
					66-564	02/04/66		1660	Gross Alpha	6.97	1.743E+00		
(b) (6) [redacted]	(b) (6) [redacted]	02/13/66	03/19/66	03/02/66	66-2195	03/19/66	17	950	Gross Alpha	0.032	7 950E-03	31.0	9 5/0.095
		02/08/66	02/28/66	02/18/66	66-1360	02/28/66	10	900 (12-hr)	Gross Alpha	0 059	1 465E-02	96 0	29/0 29
		01/30/66	03/18/66	02/22/66	66-2106	03/18/66	24	900	Gross Alpha	0 055	5 650E-02	60 0	18/0 18
		03/14/66	03/19/66	03/16/66	66-2331	03/19/66	3	910	Gross Alpha	0 028	1 359E-01	6 0	1.8/0 018
		01/18/66	03/01/66	02/08/66	66-1515	03/01/66	21	1315	Pu239	0 073	1 356E-01	76 0	23/0 23
					66-347	02/04/66		900	Pu239	83.8	4 900E+00		
					66-2233	03/18/66		900	Gross Alpha	0.2	6 540E-01		
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	01/29/66	01/23/66	66-1081	01/29/66	6	870	Pu239	0 018	4.500E-03	9 5	2.9/0 029
		02/18/66	03/04/66	02/25/66	66-2340	03/04/66	7	860	Gross Alpha	0 036	7 258E-02	23 0	7.1/0.071
		01/18/66	01/20/66	01/19/66	66-1129	01/20/66	1	450	Gross Alpha	0 030	1.710E-02	2 6	0 8/0.008
		01/18/66	03/10/66	02/12/66	66-1954	03/10/66	26	1100	Gross Alpha	0 044	2 409E-02	50 0	15/0.15
		02/23/66	03/19/66	03/07/66	66-2191	03/19/66	12	600	Gross Alpha	0 081	2 025E-02	72 0	22/0.22
		02/27/66	03/08/66	03/03/66	66-2458	03/08/66	5	1000	Gross Alpha	0 028	1.680E-02	12 0	3 7/0.037
		01/18/66	03/08/66	02/11/66	66-2439	03/08/66	25	750	Gross Alpha	0 014	1.755E-02	15.0	4 6/0.046
		02/23/66	03/19/66	03/07/66	66-2081	03/19/66	12	960	Gross Alpha	0 096	7 640E-02	85 0	26/0.26
		02/10/66	03/19/66	02/28/66	66-2043	03/19/66	19	830	Gross Alpha	0 092	6 810E-02	93 0	29/0.29
		01/21/66	03/16/66	02/17/66	66-2027	03/16/66	27	630	Gross Alpha	0 067	6 310E-02	76 0	23/0.23
		02/21/66	03/18/66	03/05/66	66-2098	03/18/66	13	290	Gross Alpha	0 076	6 600E-02	69 0	21/0.21
		02/27/66	03/18/66	03/08/66	66-2271	03/18/66	10	750	Gross Alpha	0 020	1.120E-01	16 0	4 9/0.049
		01/18/66	04/11/66	02/28/66	66-3203	04/25/66	56	1080	Gross Alpha	0 421	0 184	580 0	180/1.8
												mean =	92 45/0.9245
(b) (6) [redacted]	(b) (6) [redacted]	02/11/66	03/19/66	03/01/66	66-2231	03/19/66	18	750	Gross Alpha	0 029	6 315E-02	29 0	8 9/0.089
		01/18/66	02/03/66	01/26/66	66-1840	02/03/66	8	650	Gross Alpha	0 009	2 250E-03	6.4	2/0.02
		02/06/66	02/28/66	02/17/66	66-1313	02/28/66	11	800 (12-hr)	Gross Alpha	0 018	4 500E-03	28 0	8 6/0.086
		02/27/66	03/08/66	03/03/66	66-2463	03/08/66	5	975	Gross Alpha	0.044	1.640E-02	18.0	5 5/0 055

NR - Not Reported; ND - No Detectable Activity; n/a - not available

Results of Modeling Individuals with Samples Assumed to be "Uncontaminated."

Cell shaded = Additional sample for indiv not modeled since >0.1 pCi/sample, NR, or ND

NAME	SSN	START EXPOSURE DATE	END EXPOSURE DATE	ESTIMATED ACUTE EXPOSURE DATE	SAMPLE #	SAMPLE DATE	ELAPSED DAYS	SAMPLE VOLUME (mL)	ANALYSIS	RESULT (pCi/sample)	+/- (pCi/sample)	INTAKE (1000s pCi)	50-YEAR CEDE (rem/Sv)
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	01/29/66	01/23/66	66-1083	01/29/66	6	690	Pu239	0.062	1.550E-02	33.0	10/0.1
		02/18/66	03/08/66	02/27/66	66-2466	03/08/66	9	450	Gross Alpha	0.090	2.320E-02	69.0	21/0.21
		03/26/66	04/10/66	04/02/66	66-3206	04/21/66	19	875 (12-hr)	Gross Alpha	0.076	6.240E-02	150.0	46/0.46
		02/09/66	02/28/66	02/18/66	66-1362	02/28/66	10	675 (12-hr)	Gross Alpha	0.041	1.013E-02	66.0	20/0.2
		02/11/66	03/19/66	03/01/66	66-2169	03/19/66	18	650	Gross Alpha	0.047	1.163E-02	47.0	14/0.14
		01/22/66	03/13/66	02/16/66	66-2541	03/13/66	25	1400	Gross Alpha	0.059	1.463E-02	65.0	20/0.2
		02/17/66	03/08/66	02/26/66	66-1890	03/08/66	10	890	Gross Alpha	0.087	3.460E-02	71.0	22/0.22
		01/18/66	01/29/66	01/23/66	66-1076	01/29/66	6	510	Pu239	0.079	1.975E-02	42.0	13/0.13
		02/25/66	03/19/66	03/08/66	66-2203	03/19/66	11	950	Gross Alpha	0.032	7.875E-03	27.0	8.3/0.083
		02/21/66	03/18/66	03/05/66	66-2255	03/18/66	13	720	Gross Alpha	0.081	1.022E-01	73.0	22/0.22
		01/18/66	03/19/66	02/17/66	66-2042	03/19/66	30	300	Gross Alpha	0.076	7.120E-02	89.0	27/0.27
		02/13/66	03/16/66	02/28/66	66-2029	03/16/66	16	620	Gross Alpha	0.095	8.590E-02	92.0	28/0.28
		02/09/66	03/04/66	02/20/66	66-2382	03/04/66	12	600	Gross Alpha	0.062	8.760E-02	55.0	17/0.17
		01/18/66	01/21/66	01/19/66	66-1127	01/21/66	2	590	Gross Alpha	0.064	2.270E-02	8.7	2.7/0.027
		02/05/66	03/08/66	02/20/66	66-1888	03/08/66	16	810	Gross Alpha	0.037	2.010E-02	35.0	11/0.11
		02/24/66	03/08/66	03/02/66	66-1884	03/08/66	6	600	Gross Alpha	0.018	2.010E-02	9.4	2.9/0.029
		03/14/66	03/19/66	03/16/66	66-2138	03/19/66	3	550	Gross Alpha	0.066	8.040E-02	14.0	4.3/0.043
		02/10/66	03/08/66	02/23/66	66-2435	03/08/66	13	400	Gross Alpha	0.024	1.390E-02	22.0	6.8/0.068
		02/10/66	03/08/66	02/23/66	66-2432	03/08/66	13	1000	Gross Alpha	0.013	2.170E-02	11.0	3.4/0.034
		02/10/66	03/19/66	02/28/66	66-2185	03/19/66	19	400	Gross Alpha	0.059	1.463E-02	59.0	18/0.18
		02/13/66	03/18/66	03/01/66	66-2250	03/18/66	17	830	Gross Alpha	0.005	9.047E-02	5.0	1.5/0.015
		02/06/66	02/28/66	02/17/66	66-1374	02/28/66	11	930 (12-hr)	Gross Alpha	0.072	1.803E-02	120.0	37/0.37
		02/27/66	03/19/66	03/09/66	66-2321	03/19/66	10	550	Gross Alpha	0.010	5.176E-02	8.6	2.6/0.026
		01/18/66	02/03/66	01/26/66	66-1824	02/03/66	8	760	Gross Alpha	0.018	4.500E-03	13.0	4/0.04
		01/24/66	03/04/66	02/12/66	66-2374	03/04/66	20	1300	Gross Alpha	0.026	7.150E-02	27.0	8.3/0.083
		01/18/66	02/03/66	01/26/66	66-1818	02/03/66	8	930	Gross Alpha	0.041	1.013E-02	29.0	8.9/0.089
		01/18/66	02/03/66	01/26/66	66-1828	02/03/66	8	300	Gross Alpha	0.099	2.478E-02	70.0	22/0.22
					66-2400	03/09/66		350	Gross Alpha	0.343	1.850E-01		
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	03/13/66	02/14/66	66-2540	03/13/66	27	400	Gross Alpha	0.050	1.238E-02	56.0	17/0.17
		01/31/66	03/18/66	02/23/66	66-2272	03/18/66	23	300	Gross Alpha	0.083	1.029E-01	90.0	28/0.28
		02/10/66	03/08/66	02/23/66	66-2441	03/08/66	13	950	Gross Alpha	0.004	1.642E-02	3.8	1.2/0.012
		02/13/66	03/19/66	03/02/66	66-2222	03/19/66	17	900	Gross Alpha	0.066	8.046E-02	65.0	20/0.2
		02/13/66	03/19/66	03/02/66	66-2197	03/19/66	17	600	Gross Alpha	0.030	7.500E-03	30.0	9.2/0.092
		02/24/66	03/19/66	03/07/66	66-2171	03/19/66	12	750	Gross Alpha	0.081	2.025E-02	72.0	22/0.22
		02/03/66	02/25/66	02/14/66	66-1339	02/25/66	11	490	Gross Alpha	0.062	2.420E-02	53.0	16/0.16
		02/18/66	03/09/66	02/27/66	66-2054	03/09/66	10	1480	Gross Alpha	0.075	7.120E-02	61.0	19/0.19
		02/08/66	03/08/66	02/22/66	66-1881	03/08/66	14	900	Gross Alpha	0.036	2.190E-02	33.0	10/0.1

NR - Not Reported; ND - No Detectable Activity; n/a - not available

Results of Modeling Individuals with Samples Assumed to be "Uncontaminated."

Cell shaded = Additional sample for Indiv not modeled since >0.1 pCi/sample, NR, or ND

NAME	SSN	START EXPOSURE DATE	END EXPOSURE DATE	ESTIMATED ACUTE EXPOSURE DATE	SAMPLE #	SAMPLE DATE	ELAPSED DAYS	SAMPLE VOLUME (mL)	ANALYSIS	RESULT (pCi/ sample)	+/- (pCi/ sample)	INTAKE (1000s pCi)	50-YEAR CEDE (rem/Sv)
(b) (6) [redacted]	(b) (6) [redacted]	02/13/66	03/08/66	02/24/66	66-2468	03/08/66	12	350	Gross Alpha	0.020	1.580E-02	18.0	5.5/0.055
		01/20/66	03/20/66	02/18/66	66-2298	03/20/66	30	870	Gross Alpha	0.075	1.157E-01	88.0	27/0.27
		02/11/66	03/08/66	02/23/66	66-2428	03/08/66	13	1000	Gross Alpha	0.029	1.920E-02	27.0	8.3/0.083
		02/21/66	03/19/66	03/06/66	66-2145	03/19/66	13	470	Gross Alpha	0.081	1.020E-01	74.0	23/0.23
		02/08/66	03/19/66	02/27/66	66-2199	03/19/66	20	400	Gross Alpha	0.045	1.125E-02	48.0	14/0.14
		01/18/66	02/03/66	01/26/66	66-1842	02/03/66	8	280	Gross Alpha	0.018	4.500E-03	13.0	40/0.4
		02/09/66	03/09/66	02/23/66	66-2405	03/09/66	14	1500	Gross Alpha	0.025	1.640E-02	23.0	7.1/0.071
		03/11/66	03/19/66	03/15/66	66-2190	03/19/66	4	700	Gross Alpha	0.050	1.238E-02	15.0	4.6/0.046
		01/18/66	01/29/66	01/23/66	66-1205	01/29/66	6	1440	Gross Alpha	0.055	2.230E-01	29.0	8.9/0.089
		02/09/66	03/08/66	02/22/66	66-1902	03/08/66	14	850	Gross Alpha	0.093	7.460E-02	87.0	27/0.27
		03/11/66	03/19/66	03/15/66	66-2550	03/19/66	4	320	Gross Alpha	0.079	8.700E-02	24.0	7.4/0.074
		01/18/66	01/22/66	01/20/66	66-1137	01/22/66	2	925	Gross Alpha	0.079	2.890E-02	11.0	3.4/0.034
												mean =	5.4/0.054
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	03/08/66	02/11/66	66-2444	03/08/66	25	1500	Gross Alpha	0.050	2.150E-02	55.0	17/0.17
		02/25/66	03/23/66	03/10/66	66-2591	03/23/66	13	1000	Gross Alpha	0.055	1.150E-01	50.0	15/0.15
		01/18/66	03/09/66	02/12/66	66-2404	03/09/66	25	900	Gross Alpha	0.009	2.253E-03	10.0	3.1/0.031
		01/17/66	02/03/66	01/25/66	66-1827	02/03/66	9	400	Gross Alpha	0.050	1.238E-02	38.0	12/0.12
		01/18/66	03/12/66	02/13/66	66-2039	03/12/66	27	1240	Gross Alpha	0.060	5.620E-02	6.8	21/0.21
		03/14/66	03/19/66	03/16/66	66-2316	03/19/66	3	760	Gross Alpha	0.090	9.500E-02	19.0	5.8/0.058
		01/18/66	03/28/66	02/21/66	66-2676	03/28/66	35	1450	Gross Alpha	0.040	7.210E-02	49.0	15/0.15
		01/25/66	02/21/66	02/07/66	66-1242	02/26/66	19	2000	Gross Alpha	0.032	2.530E-02	33.0	10/0.1
					66-1105	01/24/66		1010	Gross Alpha	ND	ND		
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	03/17/66	02/16/66	66-2644	03/17/66	29	750	Gross Alpha	0.049	8.100E-02	57.0	18/0.18
					66-805	02/09/66		530	Gross Alpha	NR	NR		
					66-2643	03/16/66		550	Gross Alpha	0.14	1.130E-01		
(b) (6) [redacted]	(b) (6) [redacted]	02/06/66	02/08/66	02/07/66	66-1376	02/08/66	1	920	Gross Alpha	0.099	2.475E-02	8.4	2.6/0.026
		02/27/66	03/08/66	03/03/66	66-2494	03/08/66	5	1000	Gross Alpha	0.027	6.750E-03	11.0	3.4/0.034
		03/14/66	03/19/66	03/16/66	66-2184	03/19/66	3	960	Gross Alpha	0.081	2.025E-02	17.0	5.2/0.052
		02/27/66	03/08/66	03/03/66	66-2440	03/08/66	5	600	Gross Alpha	0.026	1.660E-02	11.0	3.4/0.034
		02/06/66	02/28/66	02/17/66	66-1387	02/28/66	11	675 (12-hr)	Gross Alpha	0.059	1.465E-02	100.0	31/0.31
		03/14/66	03/19/66	03/16/66	66-2075	03/19/66	3	940	Gross Alpha	0.091	1.020E-01	19.0	5.8/0.058
		02/10/66	03/08/66	02/23/66	66-2427	03/08/66	13	1000	Gross Alpha	0.042	2.610E-02	38.0	12/0.12
		02/11/66	03/16/66	02/27/66	66-2585	03/16/66	17	1000	Gross Alpha	0.052	8.050E-02	52.0	16/0.16
					66-1920	03/03/66		900	Gross Alpha	0.188	8.400E-02		
(b) (6) [redacted]	(b) (6) [redacted]	02/13/66	03/19/66	03/02/66	66-2587	03/19/66	17	850	Gross Alpha	0.040	7.210E-02	39.0	12/0.12
		01/18/66	03/09/66	02/12/66	66-2065	03/09/66	25	550	Gross Alpha	0.073	8.400E-02	80.0	25/0.25
		01/18/66	01/29/66	01/23/66	66-1075	01/29/66	6	1335	Pu239	0.062	1.550E-02	33.0	10/0.1

NR - Not Reported; ND - No Detectable Activity; n/a - not available

Results of Modeling Individuals with Samples Assumed to be "Uncontaminated."

Cell shaded = Additional sample for indiv not modeled since >0.1 pCi/sample, NR, or ND

NAME	SSN	START EXPOSURE DATE	END EXPOSURE DATE	ESTIMATED ACUTE EXPOSURE DATE	SAMPLE #	SAMPLE DATE	ELAPSED DAYS	SAMPLE VOLUME (mL)	ANALYSIS	RESULT (pCi/sample)	+/- (pCi/sample)	INTAKE (1000s pCi)	50-YEAR CEDE (rem/Sv)
(b) (6) [redacted]	(b) (6) [redacted]	01/19/66	02/03/66	01/26/66	66-2683	03/27/66	60	1720	Gross Alpha	0.069	8.800E-02	97.0	30/0.3
		01/18/66	02/03/66	01/26/66	66-1819	02/03/66	8	410	Gross Alpha	0.032	7.875E-03	22.0	6.8/0.068
		02/09/66	03/08/66	02/22/66	66-1885	03/08/66	14	1300	Gross Alpha	0.054	1.980E-02	50.0	15/0.15
		01/18/66	01/26/66	01/22/66	66-1120	01/26/66	4	410	Gross Alpha	0.042	1.900E-02	13.0	4/0.04
		01/18/66	01/29/66	01/23/66	66-1084	01/29/66	6	650	Pu239	0.062	1.550E-02	33.0	10/0.1
		01/18/66	02/28/66	02/07/66	66-1371	02/28/66	21	915 (12-hr)	Gross Alpha	0.072	1.803E-02	150.0	46/0.46
		01/20/66	02/15/66	02/02/66	66-1232	02/18/66	16	790	Gross Alpha	0.032	1.280E-01	31.0	9.5/0.095
		02/10/66	03/08/66	02/23/66	66-1886	03/08/66	13	1250	Gross Alpha	0.017	3.150E-02	15.0	4.6/0.046
		02/21/66	03/19/66	03/06/66	66-2192	03/19/66	13	900	Gross Alpha	0.018	4.500E-03	16.0	4.9/0.049
		01/18/66	03/18/66	02/16/66	66-2238	03/18/66	30	500	Gross Alpha	0.048	9.000E-02	56.0	17/0.17
		02/10/66	03/08/66	02/23/66	66-2459	03/08/66	13	650	Gross Alpha	0.026	2.310E-02	26.0	8/0.08
		02/27/66	03/08/66	03/03/66	66-2507	03/08/66	5	400	Gross Alpha	0.050	1.238E-02	21.0	6.5/0.065
		02/09/66	02/16/66	02/12/66	66-1235	02/19/66	7	1400	Gross Alpha	0.036	2.210E-02	24.0	7.4/0.074
		01/18/66	01/29/66	01/23/66	66-1068	01/29/66	6	1000	Pu239	0.035	8.750E-03	19.0	5.8/0.058

NR - Not Reported; ND - No Detectable Activity; n/a - not available

APPENDIX C.4

REMAINING CASES

Portions of this report have been designated records subject to the restriction of the Privacy Act, 5 U.S.C. 552(a) and are so marked.

APPENDIX C.4 REMAINING CASES

Most of those who responded to the Palomares Broken Arrow submitted one urine sample that was collected during their time on site at Camp Wilson, or nearby. Furthermore, these generally were collected with containers designed for other purposes and under conditions that provided only limited protection against contamination with plutonium in blowing dust. Also, analysis of most of the samples by the gross alpha counting method served primarily as a screening for further study. Since most of the responders were not identified for follow-up, their initial samples were their only sample.

A small number of those in this group initially qualified for assessment in the "Contamination Cutoff" Cases. However, the chemical recovery for the samples processed for alpha spectrometry did not meet the criterion established for this study. Therefore, the data for these individuals are reported in this Remaining Cases category.

Intake and dose assessments were not performed for the cases in this category because the data were considered unreliable. Possible sample contamination, laboratory contamination, and uncertain recording of collection information limit the usefulness of these data for assessing intake and dose. The urine results ranged from 0 to 237.9 pCi per sample. The latter sample, collected three days after the first airmen arrived at the accident site, represents a prime example of possible contamination. That sample was the only sample available for the individual concerned. Personal discussions with one of the first responders indicated that the initial samples were collected using wine, milk, and any other type of bottle available in the village. (Skaar 1999).

The following pages provide a listing of the results for the Remaining Cases. If evaluated, the results documented would produce intakes ranging from about 75,000 pCi to 20,000,000 pCi corresponding to CEDEs of about 23 rem to 6,000 rem (0.23 to 60 Sv). Results of this magnitude require careful evaluation. The listings contain the basic sample identifying, collection and result information. Hardcopy laboratory records support each of the entries and are maintained by the Air Force.

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
[redacted]	[redacted]	01/18/66	03/08/66	02/11/66	66-2475	03/08/66	1000	Torrejon	1000	N/A	0.131	0.157	n/a
		02/12/66	02/12/66	02/12/66	66-2867	04/11/66	1800	Torrejon	1800	N/A	1.10+/-0.27	1.1	
					66-2867	04/11/66	1800 (22-hr)			08/30/66	NR	NR	
[redacted]	[redacted]	01/24/66	02/26/66	02/09/66	66-1428	02/26/66	600	Moron	624	N/A	ND	ND	0
		03/12/66	03/19/66	03/15/66	66-2146	03/19/66	850	Torrejon	850	N/A	0.179+/-0.118	0.253	0.000335
		02/09/66	03/23/66	03/02/66	66-2866	04/06/66	1100	Torrejon	1100	N/A	1.04+/-0.26	1.135	n/a
				03/02/66	66-2866	04/06/66	1100			07/21/66	1.21+/-0.030	1.320	
[redacted]	[redacted]	01/17/66	02/26/66	02/06/66	66-1403	02/26/66	660	Torrejon	685	N/A	ND	ND	0
		02/20/66	03/09/66	02/28/66	66-2885	04/02/66	1500	Torrejon	1500	N/A	0.137+/-0.107	0.137	n/a
					66-2885	04/02/66	1500			08/16/66	NR	NR	
[redacted]	[redacted]	01/18/66	01/25/66	01/21/66	66-1097	01/25/66	850	Wiesbaden	850	03/17/66	ND	ND	0
		03/14/66	03/19/66	03/16/66	66-2912	03/19/66	550	Torrejon	550	N/A	0.189+/-0.124	0.412	0.000274
		01/18/66	01/21/66	01/19/66	66-213	01/21/66	430	Torrejon	200	N/A	NR	NR	n/a
		01/18/66	01/21/66	01/19/66	66-231	01/21/66	475	Torrejon	200	N/A	0.225 +/- 0.111	0.568	n/a
		01/18/66	01/21/66	01/19/66	66-233	01/21/66	475	Torrejon	200	N/A	0.225 +/- 0.111	0.568	n/a
		01/28/66	02/26/66	02/11/66	66-1402	02/26/66	1000	Torrejon	1000	N/A	1.04+/-1.88	1.248	0
		01/18/66	02/07/66	01/28/66	66-496	02/07/66	600	Moron	200	N/A	3.89+/-1.05	7.760	0.0252
		03/12/66	03/19/66	03/15/66	66-2073	03/19/66	490	Torrejon	490	N/A	0.141+/-0.083	0.345	0
		02/13/66	03/08/66	02/24/66	66-2498	03/08/66	950	Moron	950	N/A	ND	ND	0
		02/08/66	02/28/66	02/17/66	66-1379	02/28/66	500	Torrejon	520	N/A	ND	ND	0
					66-1379	02/28/66	500			08/29/66	NR	NR	
[redacted]	[redacted]	03/14/66	03/20/66	03/17/66	66-2294	03/20/66	950	Moron	950	N/A	0.162+/-0.136	0.205	0.00027
		01/25/66	02/09/66	02/01/66	66-732	02/09/66	860	Hanaw, Germany	200	N/A	2.82+/-1.07	3.656	0.0125
		01/25/66	02/09/66	02/01/66	66-813	02/09/66	680 (12-hr)	Hanaw, Germany	200	N/A	1.48+/-0.60	1.480	0.00927
		01/25/66	02/09/66	02/01/66	66-739	02/09/66	940	Hanaw, Germany	200	N/A	1.37+/-0.74	1.749	0.00596
		01/24/66	03/08/66	02/14/66	66-1872	03/08/66	940	Naval Station Rota, Spain	978	N/A	0.344	0.439	0.002
[redacted]	[redacted]	01/18/66	02/04/66	01/26/66	66-365	02/04/66	550	Moron	200	N/A	1.38+/-0.59	2.967	0.00681
		01/18/66	03/16/66	02/15/66	66-2024	03/16/66	300	American Embassy, Madrid	300	N/A	0.103 +/-0.077	0.412	0
[redacted]	[redacted]	01/18/66	02/08/66	01/28/66	66-834	02/08/66	740 (12-hr)	Moron	200	N/A	1.47+/-0.81	1.470	0.00773
		01/18/66	01/21/66	01/19/66	66-266	01/21/66	900	Torrejon	200	N/A	0.612 +/- 0.211	0.816	n/a
		01/18/65	02/08/66	01/28/66	66-551	02/08/66	1040	Offutt AFB, NE	200	N/A	3.11+/-0.99	3.588	0.0101
		01/20/66	02/06/66	01/28/66	66-915	02/06/66	610	Torrejon	200	N/A	ND	ND	0
		01/18/66	01/30/66	01/24/66	66-1146	01/30/66	700	656 Eng. Bn., APO09081	700	N/A	ND	ND	0
[redacted]	[redacted]	01/17/66	01/17/66	01/17/66	66-1350	01/17/66	610	Moron	634	N/A	0.271+/-0.157	0.533	0.000682
		01/18/66	01/21/66	01/19/66	66-209	01/21/66	300	Torrejon	86	N/A	3.51 +/- 0.96	14.040	n/a
		01/18/66	01/21/66	01/19/66	66-212	01/21/66	480	Torrejon	200	N/A	NR	NR	n/a
		02/04/66	02/25/66	02/14/66	66-1483	03/04/66	1200	USS Amphion AR-13	1000	N/A	0.1884 +/- 0.6132	0.188	0
[redacted]	[redacted]	01/20/66	02/07/66	01/29/66	66-481	02/07/66	850	Toul Rosieres	200	N/A	ND	ND	0
		02/18/66	03/04/66	02/25/66	66-2339	03/04/66	400	Moron	400	N/A	ND	ND	0
		02/06/66	02/27/66	02/16/66	66-1387	02/28/66	440	Torrejon	457	N/A	1.3	3.545	0.005
		02/25/66	03/18/66	03/07/66	66-2214	03/18/66	900	Moron	900	N/A	0.105+/-0.102	0.140	0.000448
		01/16/66	01/21/66	01/19/66	66-237	01/21/66	425	Torrejon	200	N/A	NR	NR	n/a
					66-240	01/21/66	425	Torrejon	200	N/A	NR	NR	n/a
[redacted]	[redacted]	02/03/66	03/14/66	02/22/66	66-3113	04/13/66	1525	Moron	762	N/A	0.429+/-0.153	0.429	n/a
		02/10/66	03/19/66	02/28/66	66-2157	03/19/66	910	Torrejon	190	N/A	0.129+/-0.114	0.170	0.00084
		01/18/66	02/13/66	01/31/66	66-1443	02/15/66	570	Moron	570	03/17/66	0.25+/-0.22	0.526	0.00246
		02/25/66	03/29/66	03/13/66	66-2284	03/29/66	875	Moron	875	N/A	0.119+/-0.115	0.163	0.00097
		01/18/66	03/13/66	02/14/66	66-2537	03/13/66	800	Moron	800	N/A	0.342	0.513	
		02/11/66	03/19/66	03/01/66	66-2217	03/19/66	950	Moron	950	N/A	0.260+/-0.152	0.328	0.00212
		02/13/66	03/18/66	03/01/66	66-2268	03/18/66	500	Torrejon	500	N/A	0.100+/-0.95	0.240	0.0006
		01/18/66	03/09/66	02/12/66	66-2079	03/09/66	850	Torrejon	850	N/A	0.474+/-0.146	0.669	0.00545
		01/25/66	04/11/66	03/04/66	66-3112	04/13/66	1310	Moron	655	05/17/66	0.348+/-0.130	0.348	
		01/18/66	02/07/66	01/28/66	66-451	02/07/66	580	Torrejon	200	N/A	0.69+/-0.48	1.428	0.00436
		01/18/66	02/07/66	01/28/66	66-471	02/07/66	550	Torrejon	200	N/A	1.02+/-0.58	2.225	0.00721
		02/20/66	02/20/66	02/20/66	66-2689	03/27/66	900	Torrejon	900	N/A	0.150+/-0.107	0.200	
		02/08/66	02/28/66	02/17/66	66-1407	02/26/66	760	Moron	790	N/A	ND	ND	

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
					66-1407	02/26/66	760			07/29/66	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	03/04/66	02/09/66	66-2359	03/04/66	950	Albuquerque, NM	950	N/A	0.188+/-0.174	0.237	0.00059
		01/20/66	02/08/66	01/29/66	66-836	02/08/66	905	Toul Rosieres	200	N/A	ND	ND	
		01/30/66	03/01/66	02/14/66	66-1846	03/01/66	1600	Giessen	1600	N/A	0.417+/-0.170	0.417	
					66-1846	03/01/66	1600			07/05/66	0.187+/-0.098	0.187	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/08/66	01/28/66	66-610	02/08/66	880 (12-hr)	Moron	200	N/A	NR	NR	
		03/03/66	03/18/66	03/10/66	66-2101	03/18/66	590	Torrejon	590	N/A	0.351+/-0.128	0.714	0.00186
		02/13/66	03/03/66	02/22/66	66-1919	03/03/66	600	Moron	600	N/A	0.302+/-0.142	0.724	
		01/18/66	03/03/66	02/09/66	66-1940	03/03/66	1500	Torrejon	1580	N/A	0.252+/-0.112	0.252	
		01/18/66	02/16/66	02/01/66	66-982	02/16/66	650	Torrejon	200	N/A	ND	ND	
		01/23/66	03/17/66	02/18/66	66-1104	02/21/66	1000	Pirmasens	1000	03/11/66	0.22+/-0.21	0.264	0.00148
					66-2847	03/17/66	2000	229 Signal BN	2000	N/A	0.144+/-0.135	0.144	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/07/66	01/28/66	66-478	02/07/66	560	Torrejon	200	N/A	ND	ND	
		01/18/66	02/09/66	01/29/66	66-754	02/09/66	540	Moron	200	N/A	2.17+/-0.85	4.822	0.0172
		02/07/66	04/11/66	03/10/66	66-2997	04/27/66	850	Scott	850	N/A	0.802+/-0.232	1.132	
		01/18/66	02/03/66	01/26/66	66-1829	02/03/66	900	Torrejon	900	N/A	0.149	0.199	
		01/17/66	01/17/66	01/17/66	66-452	01/17/66	430	Torrejon	200	02/11/66	0.89+/-0.45	2.484	0.00763
		01/18/66	03/01/66	02/08/66	66-1477	03/01/66	1880	Offutt AFB, NE	1000	N/A	0.207+/-0.168	0.207	0.00141
		01/18/66	04/04/66	02/25/66	66-2892	04/04/66	1050	Vandenburg	1050	N/A	ND	ND	
		01/18/66	01/23/66	01/20/66	66-1103	01/23/66	1340	Pirmasens	1340	03/17/66	ND	ND	
		01/18/66	02/15/66	02/01/66	66-1155	02/15/66	280	Wheelus AF, Libya	280	03/17/66	0.30+/-0.14	1.286	0.00597
		03/14/66	03/19/66	03/16/66	66-2338	03/19/66	610	Moron	610	N/A	0.233+/-0.161	0.458	0.00034
		01/22/66	02/10/66	01/31/66	66-948	02/10/66	905	Torrejon	200	N/A	0.95+/-0.92	1.260	0.00476
		01/18/66	01/20/66	01/19/66	66-1116	01/20/66	810	Toul Rosieres	810	03/23/66	NR	NR	
		03/14/66	03/19/66	03/16/66	66-2320	03/19/66	900	Moron	900	N/A	0.292+/-0.156	0.389	0.00042
		01/18/66	03/13/66	02/14/66	66-2534	03/13/66	1000	Moron	1000	N/A	0	0.000	
		02/27/66	03/19/66	03/09/66	66-2327	03/19/66	700	Torrejon	700	N/A	0.349+/-0.204	0.598	0.00143
		02/21/66	03/18/66	03/05/66	66-2212	03/18/66	820	Zaragoza	820	N/A	0.472+/-0.196	0.691	0.00326
		02/18/66	03/04/66	02/25/66	66-2363	03/04/66	900	Moron	900	N/A	0	0.000	
		02/25/66	03/20/66	03/08/66	66-2290	03/20/66	950	Torrejon	950	N/A	0.482+/-0.213	0.609	0.0022
		02/25/66	03/19/66	03/08/66	66-2223	03/18/66	750	Moron	750	N/A	0.508+/-0.202	0.813	0.00283
		02/11/66	03/01/66	02/20/66	66-2384	03/10/66	1775	Torrejon	1775	N/A	0.325+/-0.182	0.325	0.00167
		01/18/66	02/05/66	01/27/66	66-693	02/05/66	900	Moron	200	N/A	4.13+/-1.29	5.507	0.0159
		01/18/66	02/12/66	01/30/66	66-878	02/12/66	1200	Torrejon	200	N/A	NR	NR	
		02/11/66	03/04/66	02/21/66	66-2368	03/04/66	1300	Moron	1300	N/A	ND	ND	
		02/01/66	04/11/66	03/07/66	66-2542	04/13/66	800	Giessen	800	N/A	0.266	0.399	
		01/18/66	01/28/66	01/23/66	66-2008	03/10/66	500	Norton	500	N/A	0.165+/-0.088	0.396	
		02/10/66	03/19/66	02/28/66	66-2216	03/19/66	580	Torrejon	580	N/A	0.147+/-0.135	0.304	0.00129
		01/18/66	02/11/66	01/30/66	66-770	02/11/66	890	Torrejon	200	N/A	ND	ND	
		02/17/66	03/08/66	02/26/66	66-1887	03/08/66	n/a	Toul Rosieres	n/a	N/A	NR	NR	
					66-2161	03/08/66	925	Toul Rosieres	925	N/A	0.134+/-0.120	0.174	0.00053
(b) (6) [redacted]	(b) (6) [redacted]	01/29/66	02/19/66	02/08/66	66-1222	02/09/66	950	San Pablo	950	N/A	0.644+/-0.607	0.813	
					66-1222	02/19/66	1000	San Pablo	1000	N/A	0.164+/-0.124	0.197	0.0007
(b) (6) [redacted]	(b) (6) [redacted]	02/06/66	02/08/66	02/07/66	66-1398	02/28/66	980 (12-hr)	Torrejon	980	N/A	NR	NR	
		01/18/66	02/05/66	01/27/66	66-889	02/05/66	900	Moron	200	N/A	4.85+/-1.27	6.467	0.0188
		01/31/66	03/20/66	02/24/66	66-2304	03/20/66	750	Norfolk	750	N/A	0.108+/-0.102	0.173	0.00088
		01/17/66	02/10/66	01/29/66	66-1163	02/17/66	1730	Torrejon	1730	03/21/66	NR	NR	
		01/18/66	02/18/66	02/02/66	66-971	02/18/66	440	Torrejon	440	N/A	ND	ND	
		02/09/66	03/08/66	02/22/66	66-1900	03/08/66	700	Moron	700	N/A	0.218+/-0.092	0.370	
		02/06/66	02/28/66	02/17/66	66-1389	02/28/66	660 (12-hr)	Torrejon	687	N/A	1.1	1.100	0.004
		01/18/66	03/25/66	02/20/66	66-2590	03/25/66	1550	USAH Wurzburg, Germany	1550	N/A	0.859+/-0.252	0.859	0.00734
(b) (6) [redacted]	(b) (6) [redacted]	02/27/66	03/08/66	03/03/66	66-2448	03/08/66	1300	Moron	1300	N/A	0.19+/-0.033	0.190	
		01/18/66	01/21/66	01/19/66	66-262	01/21/66	1150	Torrejon	200	N/A	36.5 +/- 3.7	38.067	
					66-408	02/02/66	232	Ramstein	200	N/A	0.48+/-0.24	2.483	0.0055
					66-556	02/03/66	930	Ramstein	200	N/A	3.49+/-1.10	4.503	0.00806
					66-562	02/03/66	1300	Ramstein	200	N/A	5.11+/-1.65	5.110	0.0128
(b) (6) [redacted]	(b) (6) [redacted]	02/27/66	03/19/66	03/09/66	66-2121	03/19/66	470	Torrejon	470	N/A	0.144+/-0.107	0.388	0.000592
		02/27/66	03/18/66	03/08/66	66-2211	03/18/66	810	Torrejon	810	N/A	0.401+/-0.197	0.594	0.00281
		01/17/66	01/26/66	01/21/66	66-2679	03/27/66	900	Torrejon	900		0.125+/-0.094	0.167	

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/05/66	01/27/66	66-923	02/05/66	767	Moron	200	N/A	2.33+/-0.79	3.645	0.0105
		01/18/66	02/26/66	02/06/66	66-1948	03/17/66	1550	Torrejon	1550	N/A	0.151+/-0.098	0.151	
		02/11/66	03/20/66	03/01/66	66-2293	03/20/66	800	Torrejon	800	N/A	0.251+/-0.143	0.377	0.00202
		02/18/66	03/04/66	02/25/66	66-2387	03/04/66	850	Moron	850	N/A	ND	ND	
		01/18/66	02/08/66	01/28/66	66-515	02/08/66	930	Torrejon	200	N/A	2.18+/-1.12	2.813	0.00858
		03/11/66	03/19/66	03/15/66	66-2150	03/19/66	780	Moron	780	N/A	0.129+/-0.114	0.198	0.00027
		02/13/66	03/08/66	02/24/66	66-2516	03/08/66	900	Torrejon	900	N/A	0	0.000	
		03/09/66	03/19/66	03/14/66	66-2137	03/19/66	450	Dreux	450	N/A	0.330+/-0.184	0.880	0.00081
		01/18/66	01/23/66	01/20/66	66-1202	01/23/66	1240	Torrejon	1000	N/A	NR	NR	
		02/12/66	03/18/66	03/01/66	66-2102	03/18/66	880	Moron	880	N/A	0.126+/-0.087	0.172	0.00079
		01/22/66	02/16/66	02/03/66	66-949	02/16/66	980	Torrejon	200	N/A	1.51+/-1.07	1.849	0.0088
		01/18/66	03/03/66	02/09/66	66-1942	03/03/66	2125	Moron	2125	N/A	0.214+/-0.098	0.214	
		01/17/66	02/12/66	01/30/66	66-775	02/12/66	850	Torrejon	200	N/A	3.56+/-0.98	6.572	0.0258
		01/18/66	02/05/66	01/27/66	66-2929	02/18/66	800	Torrejon	800	N/A	1.09+/-0.27	1.635	
		01/18/66	02/08/66	01/28/66	66-829	02/08/66	400	Torrejon	200	N/A	ND	ND	
		01/25/66	02/09/66	02/01/66	66-744	02/09/66	730	Hanaw, Germany	200	N/A	1.42+/-0.64	2.334	0.0079
		02/10/66	03/08/66	02/23/66	66-2500	03/08/66	900	Torrejon	900	N/A	0	0.000	
		02/19/66	03/19/66	03/05/66	66-2041	03/19/66	1240	Torrejon	1240	N/A	0.484+/-0.185	0.484	0.00122
		01/18/66	02/03/66	01/26/66	66-1830	02/03/66	300	Torrejon	300	N/A	0.131	0.524	0.00427
		01/18/66	02/09/66	01/29/66	66-755	02/09/66	690	Torrejon	200	N/A	7.31+/-1.31	12.713	0.0079
		03/14/66	03/19/66	03/16/66	66-2324	03/19/66	600	Torrejon	600	N/A	0.288+/-0.156	0.576	0.00042
(b) (6) [redacted]	(b) (6) [redacted]	01/19/66	02/05/66	01/27/66	66-941	02/05/66	935	Torrejon	200	N/A	ND	ND	
		01/21/66	02/05/66	01/28/66	66-934	02/05/66	750	Moron	200	N/A	2.18+/-0.82	3.488	0.01
		01/25/66	02/09/66	02/01/66	66-798	02/09/66	680	Hanaw, Germany	200	N/A	ND	ND	
		02/18/66	03/04/66	02/25/66	66-2355	03/04/66	900	Moron	900	N/A	0.118+/-0.108	0.157	0.00037
		01/26/66	03/13/66	02/18/66	66-2538	03/13/66	1000	Torrejon	1000	N/A	0	0.000	
		01/18/66	02/08/66	01/28/66	66-1343	02/08/66	810	Torrejon	842	N/A	0.581+/-0.162	0.861	0.00567
		01/18/66	01/18/66	01/18/66	66-1203	01/18/66	820	Torrejon	853	N/A	0.91	1.332	0.005
		01/17/66	03/11/66	02/12/66	66-1167	02/16/66	960	Torrejon	1000	N/A	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]				66-1944	03/18/66	950	Torrejon	950	N/A	0.145+/-0.091	0.183	
		02/10/66	03/01/66	02/19/66	66-1848	03/01/66	900	Torrejon	900	N/A	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]				66-1848	03/01/66	900			07/11/66	0.392+/-0.152	0.523	
		01/25/66	02/09/66	02/01/66	66-741	02/09/66	895	Hanaw, Germany	200	N/A	3.01+/-1.34	4.036	0.00137
		03/04/66	04/11/66	03/23/66	66-2993	04/23/66	1100	Furth , Ger. US Army, 20th Sta Hosp.	1100	N/A	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]	01/17/66	02/18/66	02/02/66	66-950	02/18/66	3140	Torrejon	200	N/A	4.99+/-3.87	4.990	
		01/18/66	01/23/66	01/20/66	66-1102	01/23/66	1530	Pirmasens	1530	03/17/66	ND	ND	
		01/18/66	02/07/66	01/28/66	66-483	02/07/66	595	Torrejon	200	N/A	0.81+/-0.66	1.634	0.0053
		01/18/66	03/09/66	02/12/66	66-2393	03/09/66	650	Torrejon	650	N/A	0.227+/-0.133	0.419	0.00183
		01/18/66	01/24/66	01/21/66	66-1156	01/24/66	1440	Toul Rosieres	1000	N/A	0	0.000	
		01/18/66	01/24/66	01/21/66	66-1108	01/24/66	720	Wiesbaden	720	N/A	ND	ND	
		01/18/66	02/05/66	01/27/66	66-928	02/05/66	600	Torrejon	200	N/A	1.01+/-0.66	2.020	0.00581
		01/22/66	02/11/66	02/01/66	66-774	02/11/66	815	Torrejon	200	N/A	28.7+/-2.93	42.258	0.00734
		01/18/66	01/22/66	01/20/66	66-1099	01/22/66	1470	Pirmasens	1470	03/17/66	ND	ND	
		02/27/66	03/19/66	03/09/66	66-2561	03/19/66	700	Torrejon	700	N/A	0.476+/-0.192	0.816	
		02/06/66	03/09/66	02/21/66	66-2056	03/09/66	1600	Torrejon	1600	N/A	0.161+/-0.102	0.161	0.00092
		01/25/66	03/08/66	02/15/66	66-2505	03/08/66	200	Charleston	200	N/A	0	0.000	
		02/06/66	02/08/66	02/07/66	66-1392	02/28/66	420 (12-hr)	Torrejon	437	N/A	1.3	1.300	0.005
		01/18/66	02/03/66	01/26/66	66-1814	02/03/66	880	Torrejon	880	N/A	ND	ND	
		02/10/66	03/04/66	02/21/66	66-2352	03/04/66	900	Torrejon	900	N/A	ND	ND	
		01/17/66	03/23/66	02/18/66	66-2672	03/23/66	1200	Torrejon	1200	N/A	0.198+/-0.118	0.198	
		02/11/66	03/19/66	03/01/66	66-2045	03/19/66	900	Torrejon	900	N/A	0.168+/-0.086	0.224	0.00101
		01/18/66	01/18/66	01/18/66	66-1646	03/01/66	1050	Torrejon	1050	N/A	0.192+/-0.121	0.221	
	(b) (6) [redacted]				66-1646	03/01/66	1050			07/05/66	0.204+/-0.076	0.233	
		01/18/66	02/05/66	01/27/66	66-938	02/05/66	540	Torrejon	200	N/A	ND	ND	
		03/26/66	04/11/66	04/03/66	66-3106	04/13/66	900	Moron	900	N/A	0.151+/-0.057	0.201	
		01/18/66	02/12/66	01/30/66	66-879	02/12/66	1800	Torrejon	200	N/A	ND	ND	
		01/28/66	02/06/66	02/01/66	66-510	02/06/66	815	Torrejon	200	N/A	3.31+/-1.23	4.874	0.0149
		02/23/66	03/03/66	02/27/66	66-1921	03/03/66	900	Torrejon	900	N/A	0.263+/-0.110	0.351	

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
[redacted]	[redacted]	01/20/66	02/09/66	01/30/66	66-820	02/09/66	680	Toul Rosieres	200	N/A	2.41+/-1.29	4.253	0.0112
					66-3264	06/01/66	2010	Toul Rosieres	1160	N/A	0	0.000	
[redacted]	[redacted]	02/09/66	03/09/66	02/23/66	66-2059	03/09/66	420	Torrejon	420	N/A	0.327+/-0.124	0.934	0.00427
		02/08/66	03/01/66	02/16/66	66-1851	03/01/66	750	Moron	750	N/A	0.443+/-0.176	0.709	
				02/16/66	66-1851	03/01/66	750			07/11/66	0.46+/-0.020	0.736	
[redacted]	[redacted]	02/05/66	03/08/66	02/20/66	66-2461	03/08/66	900	Little Creek	900	N/A	0.132+/-0.030	0.176	
		01/18/66	02/10/66	01/29/66	66-489	02/07/66	310	Moron	200	N/A	7.32+/-0.87	28.335	0.0915
					66-1442	03/02/66	1920	Moron	1800	03/17/66	0.432+/-0.27	0.432	0.00291
[redacted]	[redacted]	01/18/66	03/17/66	02/16/66	66-2021	03/17/66	1400	24th Avn Bn	1400	N/A	ND	ND	
		01/18/66	02/06/66	01/27/66	66-511	02/06/66	920	Torrejon	200	N/A	1.46+/-1.32	1.904	0.00584
		01/25/66	02/09/66	02/01/66	66-794	02/09/66	930	Hanaw, Germany	200	N/A	1.60+/-1.24	2.323	0.0079
		02/05/66	02/26/66	02/15/66	66-1437	02/26/66	820	Torrejon	852	N/A	0.237+/-0.128	0.347	
					16-1437	02/26/66	820			06/23/66	1.512+/-0.113	2.213	
[redacted]	[redacted]	02/13/66	03/19/66	03/02/66	66-2152	03/19/66	380	Torrejon	380	N/A	0.208+/-0.129	0.657	0.00127
		03/11/66	03/19/66	03/15/66	66-2219	03/19/66	1050	Torrejon	1050	N/A	0.197+/-0.124	0.225	0.000958
		03/28/66	04/10/66	04/03/66	66-2900	04/26/66	1875	Furth , Ger. US Army, 20th Sta Hosp.	1875	N/A	ND	ND	
[redacted]	[redacted]	02/09/66	03/08/66	02/22/66	66-1875	03/08/66	560	Moron	582	N/A	0.958	2.053	0.0049
		01/18/66	03/08/66	02/11/66	66-2618	03/08/66	1750	Vandenburg	1750	N/A	0.319+/-0.156	0.319	
		01/18/66	02/10/66	01/29/66	66-768	02/11/66	440	Torrejon	200	N/A	0.52+/-0.48	1.418	0.00536
		01/18/66	03/08/66	02/11/66	66-2620	03/08/66	1350	Vandenburg	1350	N/A	ND	ND	
		01/18/66	01/22/66	01/20/66	66-1107	01/22/66	1170	Pirmasens	1000	03/17/66	ND	ND	
		02/08/66	02/17/66	02/12/66	66-1113	02/17/66	960	San Pablo	960	03/23/66	0.539+/-0.251	0.674	0.00125
		03/14/66	03/19/66	03/16/66	66-2154	03/19/66	490	Torrejon	490	N/A	0.135+/-0.119	0.331	0.000196
		01/18/66	04/11/66	02/28/66	66-2945	04/22/66	1000	B097	1000	N/A	ND	ND	
					66-2945	04/22/66	1000			08/01/66	NR	NR	
[redacted]	[redacted]	01/18/66	02/08/66	01/28/66	66-838	02/08/66	620	Moron	200	N/A	ND	ND	
		01/18/66	03/17/66	02/16/66	66-2020	03/17/66	1450	24th Avn Bn	1450	N/A	0.137+/-0.079	0.137	0.000948
		03/01/66	04/11/66	03/21/66	66-3199	05/12/66	890	Torrejon	890	N/A	0.186+/-0.082	0.251	
		01/28/66	02/28/66	02/12/66	66-2884	03/31/66	1750	Zaragoza	1750	N/A	0	0.000	
					66-2884	03/31/66	1750			08/17/66	NR	NR	
[redacted]		01/22/66	04/11/66	03/02/66	66-2991	04/21/66	600	Furth , Ger. US Army, 20th Sta Hosp.	600	N/A	ND	ND	
[redacted]	[redacted]	01/18/66	02/04/66	01/26/66	66-350	02/04/66	700	Torrejon	200	N/A	ND	ND	
		01/18/66	02/06/66	01/27/66	66-501	02/06/66	440	Moron	200	N/A	2.43+/-0.67	6.627	0.0202
		01/18/66	03/03/66	02/09/66	66-1938	03/03/66	1700	625TH MASS (MAC)	1780	N/A	2.20+/-0.29	2.200	0.0215
[redacted]	[redacted]	02/27/66	03/18/66	03/08/66	66-2265	03/18/66	780	Torrejon	780	N/A	0.173+/-0.130	0.266	0.00101
		01/29/66	02/19/66	02/08/66	66-1219	02/19/66	940	Torrejon	940	N/A	ND	ND	
		03/14/66	03/19/66	03/16/66	66-2582	03/19/66	n/a	Torrejon	n/a	N/A	NR	NR	
[redacted]	[redacted]	01/18/66	04/11/66	02/28/66	66-3108	04/13/66	1900	Moron	950	N/A	0.364+/-0.135	0.364	
		02/06/66	03/08/66	02/21/66	66-1883	03/08/66	720	Torrejon	720	N/A	0.120+/-0.030	0.200	0.000669
		02/04/66	03/18/66	02/25/66	66-2092	03/18/66	780	USS Ft. Snelling	780	N/A	0.261+/-0.108	0.402	0.00187
		03/14/66	03/20/66	03/17/66	66-2301	03/20/66	750	Torrejon	750	N/A	0.129 +/- 0.131	0.206	
		01/18/66	02/09/66	01/29/66	66-817	02/09/66	680	Germany	200	N/A	ND	ND	
		01/19/66	02/19/66	02/03/66	66-2881	03/31/66	900	Torrejon	900	N/A	1.68 +/- 0.33	2.240	
					66-2881	03/31/66	900			08/23/66	NR	NR	
[redacted]	[redacted]	01/21/66	02/28/66	02/08/66	66-1439	02/26/66	760	Torrejon	790	N/A	ND	ND	
					66-1439	02/26/66	760			06/23/66	0.678+/-0.107	1.071	
[redacted]	[redacted]	02/21/66	03/04/66	02/26/66	66-2350	03/04/66	600	Torrejon	600	N/A	ND	ND	
		01/17/66	02/25/66	02/05/66	66-1351	02/25/66	720	Moron	748	N/A	0.410+/-0.586	0.683	
		01/31/66	03/18/66	02/23/66	66-2115	03/18/66	890	Giessen	890	N/A	0.131+/-0.096	0.177	0.00099
		01/18/66	02/16/66	02/01/66	66-960	02/16/66	760	Torrejon	200	N/A	NR	NR	
		02/18/66	03/19/66	03/04/66	66-2198	03/19/66	800	Torrejon	800	N/A	0.202	0.303	
		01/25/66	02/09/66	02/01/66	66-734	02/09/66	510	Hanaw, Germany	200	N/A	0.78+/-0.55	1.835	0.0063
		02/06/66	02/08/66	02/07/66	66-1381	02/26/66	330 (12-hr)	Moron	343	N/A	1.32	1.320	0.005
		02/04/66	03/03/66	02/17/66	66-1912	03/03/66	900	USS Charleston	900	N/A	0.199+/-0.089	0.265	
		02/25/66	03/17/66	03/07/66	66-2700	03/30/66	950	Moron	950	N/A	0.158+/-0.113	0.200	

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
[redacted]	[redacted]	01/18/66	02/07/66	01/28/66	66-485	02/07/66	950	Torrejon	200	N/A	1.43+/-1.14	1.806	0.00582
[redacted]	[redacted]	03/14/66	03/19/66	03/16/66	66-2140	03/19/66	960	Torrejon	960	N/A	0.278+/-0.156	0.348	0.000404
		01/18/66	02/08/66	01/28/66	66-831	02/08/66	430	Torrejon	20	N/A	ND	ND	
		01/18/66	03/04/66	02/09/66	66-2353	03/04/66	1050	Torrejon	105	N/A	0.200+/-0.134	0.229	0.00149
		03/12/66	03/19/66	03/15/66	66-2156	03/19/66	800	Torrejon	800	N/A	0.105+/-0.102	0.158	0.000596
		02/19/66	03/03/66	02/25/66	66-2038	03/21/66	1020	Torrejon	1020	N/A	0.346+/-0.128	0.407	
		03/03/66	04/01/66	03/17/66	66-2702	03/30/66	820	Moron	820	N/A	0.114+/-0.101	0.167	
		02/06/66	02/19/66	02/12/66	66-1210	02/19/66	900	Moron	936	N/A	ND	ND	
		01/18/66	01/18/66	01/18/66	66-1214	01/18/66	970	Wheelus AF, Libya	970	N/A	1.74	2.153	0.009
		01/25/66	02/15/66	02/04/66	66-1154	02/15/66	910	Toul Rosieres	946	N/A	0	0.000	
		01/18/66	02/10/66	01/29/66	66-765	02/11/66	760	Torrejon	200	N/A	2.28+/-0.98	3.600	0.0135
		02/08/66	03/13/66	02/24/66	66-2544	03/13/66	1200	Pirmasens	1200	N/A	0.518	0.518	
		01/18/66	02/06/66	01/27/66	66-1074	02/06/66	960	Moron	960	N/A	4	5.000	
		02/06/66	02/28/66	02/16/66	66-1427	02/26/66	600	Moron	624	N/A	ND	ND	
					66-1427	02/26/66	600			06/23/66	0.337+/-0.075	0.674	
[redacted]	[redacted]	01/19/66	01/19/66	01/19/66	66-2677	03/26/66	2300	Torrejon	2300	N/A	0.112+/-0.101	0.112	
		02/18/66	03/09/66	02/27/66	66-2395	03/09/66	770	Torrejon	770	N/A	0.303+/-0.167	0.472	0.0019
		01/18/66	01/29/66	01/23/66	66-1191	01/29/66	n/a	Torrejon	n/a	N/A	0	0.000	
		01/18/66	02/08/66	01/28/66	66-360	02/04/66	750	Torrejon	200	N/A	62.9+/-3.9	100.640	0.315
					66-1233	02/18/66	2050	Torrejon	2050	03/03/66	26.5+/-1.3	26.500	0.126
					66-2032	03/19/66	2300	Torrejon	2300	N/A	0.143+/-0.032	0.143	0.00132
[redacted]	[redacted]	02/06/66	02/08/66	02/07/66	66-1380	02/28/66	710 (12-hr)	Torrejon	738	N/A	0.459	0.459	0.002
		01/18/66	02/03/66	01/26/66	66-1843	02/03/66	915	Torrejon	915	N/A	ND	ND	NSBB
		01/18/66	02/03/66	01/26/66	66-1810	02/03/66	920	Moron	920	N/A	0.261	0.340	NSBB
		02/11/66	03/19/66	03/01/66	66-2205	03/19/66	500	Torrejon	500	N/A	0.144	0.346	
		02/21/66	03/14/66	03/03/66	66-2037	03/21/66	980	Torrejon	980	N/A	0.355+/-0.152	0.435	NSBB
		01/18/66	02/06/66	01/27/66	66-523	02/06/66	350	Torrejon	200	N/A	3.08+/-0.68	10.560	0.0324
		02/10/66	03/20/66	03/01/66	66-2289	03/20/66	300	Moron	300	N/A	0.173+/-0.130	0.692	0.00141
		01/18/66	02/07/66	01/28/66	66-492	02/07/66	810	Toul Rosieres	200	N/A	0.67+/-0.62	1.318	0.00427
		01/25/66	02/09/66	02/01/66	66-729	02/09/66	880	Hanaw, Germany	200	N/A	ND	ND	
		01/17/66	02/12/66	01/30/66	66-784	02/12/66	524	Torrejon	200	N/A	23.7+/-2.01	54.275	0.0054
		01/25/66	02/09/66	02/01/66	66-752	02/09/66	940	Hanaw, Germany	200	N/A	ND	ND	
		01/25/66	02/09/66	02/01/66	66-608	02/09/66	600	Hanaw, Germany	200	N/A	NR	NR	
		01/18/66	02/06/66	01/27/66	66-532	02/06/66	705	Torrejon	200	N/A	1.09+/-0.97	1.855	0.00568
		02/24/66	03/07/66	03/01/66	66-2699	04/05/66	1700	Moron	1700	N/A	0.216+/-0.157	0.216	
		02/10/66	03/08/66	02/23/66	66-2479	03/08/66	1000	Moron	1000	N/A	ND	ND	
		03/14/66	03/19/66	03/16/66	66-2318	03/19/66	820	Moron	820	N/A	0.126 +/- 0.136	0.184	
		01/18/66	02/03/66	01/26/66	66-1807	02/03/66	700	Moron	700	N/A	0.288	0.494	0.00402
		02/07/66	03/04/66	02/19/66	66-2375	03/04/66	400	Torrejon	400	N/A	0.200+/-0.128	0.600	0.000972
		01/29/66	02/19/66	02/08/66	66-1198	02/19/66	1320	San Pablo	1000	N/A	.5412 +/- 0.7735	0.541	0
		02/06/66	02/07/66	02/06/66	66-447	02/07/66	510	Moron	200	N/A	0.79+/-0.53	1.859	0.00137
		02/10/66	03/19/66	02/28/66	66-2315	03/19/66	640	Torrejon	640	N/A	0.215+/-0.157	0.403	0.0014
		01/29/66	02/19/66	02/08/66	66-1200	02/19/66	460	Zaragoza	478	N/A	0.398+/-0.514	1.033	0.00394
		01/18/66	02/05/66	01/27/66	66-935	02/05/66	655	Moron	200	N/A	2.11+/-0.92	3.866	0.0111
		01/18/66	02/07/66	01/28/66	66-488	02/07/66	80	Torrejon	80	N/A	0.65+/-0.26	9.750	0.0317
		02/24/66	03/18/66	03/07/66	66-2094	03/18/66	820	Moron	820	N/A	0.861+/-0.078	1.260	0.0048
		01/29/66	02/19/66	02/08/66	66-1223	02/19/66	1195	Torrejon	1195	N/A	.593+/-.224	0.595	0.00253
		02/03/66	02/04/66	02/03/66	66-2887	04/03/66	800	Torrejon	800	N/A	ND	ND	
					66-2887	04/04/66	800 (12-hr)			08/31/66	NR	NR	
[redacted]	[redacted]	02/16/66	02/08/66	02/12/66	66-1399	02/28/66	900 (12-hr)	Torrejon	936	N/A	0.203	0.203	0.0008
		02/13/66	03/08/66	02/24/66	66-2484	03/08/66	1000	Moron	1000	N/A	0.104	0.125	
		01/18/66	02/13/66	01/31/66	66-1096	02/13/66	1400	Wiesbaden	1400	03/17/66	ND	ND	
		02/17/66	03/10/66	02/27/66	66-3109	04/13/66	900	Moron	450	N/A	0.446+/-0.141	0.595	
		01/18/66	04/11/66	02/28/66	66-3109-S	04/13/66	900	Norfolk	450	N/A	0.446 +/- 0.141	0.595	n/a
		01/17/66	03/04/66	02/09/66	66-2351	03/04/66	900	Torrejon	900	N/A	ND	ND	
					66-2688	03/26/66	900	Torrejon	900	N/A	0.209+/-0.134	0.279	
[redacted]	[redacted]	01/22/66	02/07/66	01/30/66	66-450	02/07/66	500	Torrejon	200	N/A	ND	ND	
		01/18/66	02/10/66	01/29/66	66-768	02/11/66	590	Moron	200	N/A	1.75+/-0.63	3.559	0.0133
		02/13/66	03/18/66	03/01/66	66-2113	03/18/66	700	Moron	700	N/A	0.140+/-0.084	0.240	0.000989
		02/10/66	03/18/66	02/28/66	66-2097	03/18/66	890	Torrejon	890	N/A	0.116+/-0.077	0.156	0.000647

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/08/66	01/28/66	66-847	02/08/66	370	Torrejon	200	N/A	ND	ND	
		03/14/66	03/19/66	03/16/66	66-2551	03/19/66	900	Torrejon	900	N/A	0.178+/-0.138	0.237	0.000258
		02/09/66	02/28/66	02/18/66	66-1356	02/28/66	800 (12-hr)	Torrejon	800	N/A	0.149	0.149	0.000758
		01/18/66	02/06/66	01/27/66	66-533	02/06/66	670	Torrejon	200	N/A	1.63+/-0.76	3.278	0.0101
		01/18/66	02/04/66	01/26/66	66-342	02/04/66	550	Moron	200	N/A	1.51+/-0.64	3.295	0.00756
		01/18/66	03/09/66	02/12/66	66-2070	03/09/66	1200	Moron	650	N/A	1.03+/-0.20	1.030	0.00842
		01/20/66	02/08/66	01/29/66	66-2011	02/26/66	1400 (12-hr)	Torrejon	1400	N/A	0.298+/-0.124	0.298	
		01/18/66	02/09/66	01/29/66	66-748	02/09/66	725	Hanaw, Germany	200	N/A	1.47+/-0.84	2.433	
		02/11/66	03/04/66	02/21/66	66-2343	03/04/66	900	Chateauroux, France	900	N/A	0.473+/-0.225	0.631	0.00201
(b) (6) [redacted]	(b) (6) [redacted]	02/03/66	03/08/66	02/19/66	66-1908	03/08/66	825	Offutt AFB, NE	825	N/A	0.218+/-0.103	0.317	
		01/18/66	02/16/66	02/01/66	66-965	02/16/66	1250	Torrejon	200	N/A	2.70+/-1.97	2.700	0.0127
		02/17/66	03/08/66	02/26/66	66-1877	03/08/66	780	Toul Rosieres	811	N/A	0.637	0.980	0.002
		02/10/66	03/18/66	02/28/66	66-2091	03/18/66	n/a	Torrejon	n/a	N/A	ND	ND	
		01/18/66	02/07/66	01/28/66	66-487	02/07/66	930	Torrejon	200	N/A	1.02+/-0.88	1.316	0.00373
		02/18/66	03/04/66	02/25/66	66-2372	03/04/66	800	Torrejon	800	N/A	0.143+/-0.129	0.215	0.00045
		01/18/66	01/21/66	01/19/66	66-242	01/21/66	1200	Torrejon	200	N/A	1.45 +/- 1.24	1.450	
		01/17/66	02/08/66	01/28/66	66-849	02/08/66	450	Moron	200	N/A	0.52+/-0.42	1.387	0.0047
		02/11/66	03/23/66	03/03/66	66-2642	03/28/66	1000	09698 "A" Co. 504th Avn Bn	1000	N/A	0.201+/-0.129	0.241	
(b) (6) [redacted]	(b) [redacted]	01/18/66	03/14/66	02/14/66	66-2009	03/14/66	300	US Naval Ocean Graph	300	N/A	0.103+/-0.077	0.412	
(b) (6) [redacted]	(b) (6) [redacted]	02/07/66	02/17/66	02/12/66	66-1440	02/25/66	2030	Moron	1000	N/A	0.35+/-0.26	0.350	0.00137
		02/12/66	03/03/66	02/21/66	66-1555	03/10/66	2250	Wiesbaden	1150	N/A	NR	NR	0.001
		03/12/66	03/19/66	03/15/66	66-2142	03/19/66	920	Torrejon	920	N/A	ND	ND	
		01/18/66	01/29/66	01/23/66	66-3117	04/13/66	1025	Moron	1025	N/A	0.168+/-0.068	0.197	
		03/14/66	03/19/66	03/16/66	66-2569	03/19/66	750	Moron	750	N/A	0.105+/-0.095	0.168	
		01/18/66	02/07/66	01/28/66	66-481	02/07/66	790	Moron	200	N/A	0.94+/-0.81	1.428	0.00462
		01/25/66	02/09/66	02/01/66	66-742	02/09/66	860	Hanaw, Germany	200	N/A	3.19+/-1.19	4.451	0.0152
		01/18/66	02/05/66	01/27/66	66-1199	02/05/66	1510	Sembach	1000	N/A	0.206+/-0.233	0.206	
		02/11/66	03/01/66	02/20/66	66-1861	03/01/66	1250	Moron	1250	N/A	0.876+/-0.245	0.876	
					66-1861	03/01/66	1250			07/18/66	8.528+/-0.285	8.528	
(b) (6) [redacted]	(b) (6) [redacted]	01/29/66	03/08/66	02/17/66	66-2483	03/08/66	350	Moron	350	N/A	0.27	0.926	
		02/01/66	03/01/66	02/15/66	66-1859	03/01/66	956	Torrejon	956	N/A	ND	ND	
					66-1859	03/01/66	956			08/28/66	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	01/23/66	02/09/66	01/31/66	66-800	02/09/66	920	Torrejon	200	N/A	ND	ND	
		01/18/66	02/05/66	01/27/66	66-937	02/05/66	500	Moron	200	N/A	ND	ND	
		01/18/66	02/05/66	01/27/66	66-918	02/05/66	815	Torrejon	200	N/A	0.59 +/- 0.48	0.889	0.00245
		02/24/66	03/08/66	03/02/66	66-2514	03/08/66	1000	Moron	1000	N/A	0	0.000	
		02/02/66	02/15/66	02/08/66	66-1152	02/15/66	590	Panama City, FL	614	N/A	NR	NR	
		01/25/66	02/09/66	02/01/66	66-751	02/09/66	720	Hanaw, Germany	200	N/A	1.78+/-0.82	2.967	0.0101
		01/18/66	02/16/66	02/01/66	66-959	02/16/66	1390	Torrejon	200	N/A	1.47+/-1.32	1.470	0.00693
		01/18/66	01/24/66	01/21/66	66-1111	01/24/66	1010	Wiesbaden	1000	N/A	NR	NR	
		02/09/66	03/09/66	02/23/66	66-2396	03/09/66	700	Torrejon	700	N/A	0.150+/-0.113	0.257	0.000794
		02/10/66	03/19/66	02/28/66	66-2220	03/19/66	950	Torrejon	950	N/A	ND	ND	
		01/18/66	01/21/66	01/19/66	66-215	01/21/66	475	Torrejon	200	N/A	NR	NR	
		02/13/66	03/03/66	02/22/66	66-1915	03/03/66	900	Moron	900	N/A	0.148+/-0.089	0.197	
		01/18/66	02/05/66	01/27/66	66-895	02/05/66	870	Moron	200	N/A	ND	ND	
		01/18/66	02/06/66	01/27/66	66-517	02/06/66	905	Torrejon	200	N/A	5.00+/-1.30	8.630	0.0202
		02/09/66	03/09/66	02/23/66	66-2078	03/09/66	650	Torrejon	650	N/A	0.200+/-0.096	0.369	0.000112
		01/18/66	02/09/66	01/29/66	66-793	02/09/66	910	Torrejon	200	N/A	4.94+/-1.56	6.514	0
		01/24/66	02/09/66	02/01/66	66-825	02/09/66	870	Germany	200	N/A	ND	ND	
		02/13/66	03/08/66	02/24/66	66-2495	03/08/66	1000	Torrejon	1000	N/A	0.284	0.341	
		01/18/66	02/03/66	01/28/66	66-2886	03/30/66	1800	Torrejon	1800	N/A	1.21+/-0.282	1.210	
					66-2886	03/30/66	1800			08/17/66	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/03/66	01/28/66	66-1821	02/03/66	700	Torrejon	700	N/A	0.0901	0.154	
		01/18/66	04/11/66	02/28/66	66-1207	08/29/66	1450	Torrejon	1000	N/A	1.6	1.600	0.008
		02/14/66	02/14/66	02/14/66	66-2940	04/24/66	1200	Wiesbaden	1200	N/A	ND	ND	
					66-2940	04/24/66	1200			08/01/66	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/05/66	01/27/66	66-942	02/05/66	960	Moron	200	N/A	ND	ND	

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
(b) (6) [redacted]	(b) (6) [redacted]	03/14/66	03/19/66	03/16/66	66-2071	03/19/66	950	Moron	950	N/A	0.254+/-0.181	0.321	0.000369
		02/21/66	03/18/66	03/05/66	66-2210	03/18/66	1344	Moron	790	N/A	0.226+/-0.134	0.226	0.00109
		02/09/66	03/09/66	02/23/66	66-2391	03/09/66	900	Torrejon	900	N/A	0.147+/-0.113	0.196	0.000778
		01/18/66	02/06/66	01/27/66	66-509	02/08/66	930	Torrejon	200	N/A	1.27+/-0.88	1.639	0.00501
		01/18/66	02/11/66	01/30/66	66-764	02/11/66	320	Torrejon	200	N/A	0.82+/-0.45	3.075	0.0115
		02/03/66	02/21/66	02/12/66	66-1645	03/01/66	n/a	Reuters News Agency AYA LA 5 Madrid, Spain	n/a	N/A	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]	01/20/66	02/19/66	02/08/66	66-1220	02/19/66	1390	Moron	1390	N/A	0.162+/-0.113	0.162	0.000891
(b) (6) [redacted]	(b) (6) [redacted]				66-1220	02/19/66	880	Moron	880	N/A	1.64+/-1.97	2.236	0
		02/06/66	02/26/66	02/16/66	66-1384	02/26/66	440	Torrejon	457	N/A	1.39	3.791	0.005
		02/15/66	03/12/66	02/27/66	66-2036	03/18/66	2000	Torrejon	2000	N/A	0.300+/-0.115	0.300	0
		01/18/66	02/09/66	01/29/66	66-750	02/09/66	980	Moron	200	N/A	2.14+/-0.71	2.675	0.0103
		02/06/66	03/08/66	02/21/66	66-1868	03/08/66	750	San Pablo	780	N/A	0.451	0.722	0.002
		02/18/66	03/18/66	03/04/66	66-2266	03/18/66	900	Chambley	900	N/A	0.197+/-0.145	0.263	0.00104
		02/06/66	02/26/66	02/16/66	66-1410	02/26/66	590	Moron	613	N/A	ND	ND	
		02/10/66	03/18/66	02/26/66	66-2267	03/18/66	410	Torrejon	410	N/A	0.378+/-0.187	1.106	0.00241
		01/18/66	01/21/66	01/19/66	66-220	01/21/66	325	Torrejon	200	N/A	NR	NR	
		01/18/66	01/21/66	01/19/66	66-218	01/21/66	250	Torrejon	38	N/A	0.2625 +/- 1.07	1.280	
		01/18/66	01/21/66	01/19/66	66-230	01/21/66	375	Torrejon	200	N/A	0.604 +/- 0.341	1.933	
		01/18/66	01/21/66	01/19/66	66-224	01/21/66	375	Torrejon	200	N/A	6.15 +/- 0.9	19.680	
		01/18/66	01/21/66	01/19/66	66-226	01/21/66	450	Torrejon	200	N/A	1.45 +/- 0.522	3.887	
		02/18/66	03/08/66	02/27/66	66-2489	03/08/66	800	Torrejon	800	N/A	0	0.000	
		03/01/66	03/08/66	03/04/66	66-2517	03/08/66	950	Torrejon	950	N/A	0.221	0.279	
		01/18/66	02/12/66	01/30/66	66-1065	02/12/66	840	Athens	840	03/13/66	ND	ND	
		02/09/66	03/09/66	02/23/66	66-2060	03/09/66	700	Torrejon	700	N/A	ND	ND	0
		01/18/66	03/25/66	02/20/66	66-2596	03/25/66	1250	USAH Wurzburg, Germany	1250	N/A	0.142+/-0.113	0.142	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/05/66	01/27/66	66-885	02/05/66	840	Torrejon	200	N/A	NR	NR	
		01/18/66	02/04/66	01/26/66	66-363	02/04/66	750	Moron	200	N/A	59.2+/-3.8	94.720	0.271
		01/18/66	03/19/66	02/17/66	66-2034	03/19/66	920	Torrejon	920	N/A	0.207+/-110	0.270	0
		01/18/66	01/30/66	01/24/66	66-261	01/21/66	1300	Torrejon	200	N/A	237.9 +/- 10.4	237.900	
					66-1479	02/25/66	1560	Sembach	1000	N/A	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]										ND	ND	
		01/18/66	01/21/66	01/19/66	66-259	01/21/66	850	Torrejon	200	N/A	NR	NR	
		02/09/66	03/03/66	02/20/66	66-1926	03/03/66	800	Torrejon	800	N/A	0.135+/-0.082	0.203	0
		01/18/66	02/05/66	01/27/66	66-901	02/05/66	540	Torrejon	200	N/A	ND	ND	
		01/18/66	02/03/66	01/26/66	66-1822	02/03/66	410	Moron	410	N/A	0.131	0.383	0
		01/18/66	02/05/66	01/27/66	66-900	02/05/66	400	Moron	200	N/A	0.94+/-0.41	2.820	0.00808
		01/18/66	02/05/66	01/27/66	66-894	02/05/66	945	Moron	200	N/A	2.88+/-1.15	3.657	0.0105
		01/18/66	02/05/66	01/27/66	66-883	02/05/66	550	Torrejon	200	N/A	1.68+/-0.59	3.665	0.0105
		01/18/66	02/09/66	01/29/66	66-733	02/09/66	375	Torrejon	200	N/A	0.53+/-0.38	1.696	0.00605
		02/21/66	03/18/66	03/05/66	66-2269	03/18/66	910	Torrejon	910	N/A	0.204+/-0.140	0.269	0.000992
		01/18/66	02/05/66	01/27/66	66-932	02/05/66	490	Torrejon	200	N/A	1.08+/-0.63	2.645	0.00762
		02/10/66	03/08/66	02/23/66	66-2496	03/08/66	1000	Moron	1000	N/A	0.45	0.540	n/a
		01/25/66	02/09/66	02/01/66	66-806	02/09/66	400	Hanaw, Germany	200	N/A	28.5+/-1.9	85.500	0.00526
		02/06/66	03/03/66	02/18/66	66-1642	03/06/66	1040	Wiesbaden	1000	N/A	0.194+/-0.156	0.224	0.000238
					66-3054	04/27/66	1900	Lindsey AS, Germany	950	N/A	0.735+/-0.165	0.735	
(b) (6) [redacted]	(b) (6) [redacted]	01/25/66	02/26/66	02/10/66	66-1415	02/26/66	760	Torrejon	790	N/A	0.152	0.240	0.0008
		02/27/66	03/08/66	03/03/66	66-2488	03/08/66	900	Moron	900	N/A	0.149	0.199	
		01/18/66	03/25/66	02/20/66	66-2589	03/25/66	1500	USAH Wurzburg, Germany	1500	N/A	0.141+/-0.113	0.141	n/a
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/11/66	01/30/66	66-352	02/04/66	850	Torrejon	200	N/A	60.4+/-4.1	65.271	0.302
(b) (6) [redacted]	(b) (6) [redacted]				66-1162	02/18/66	1730	Torrejon	1730	03/02/66	0.690+/-0.241	0.690	0.00336
		02/09/66	02/26/66	02/17/66	66-1418	02/26/66	780	Moron	811	N/A	ND	ND	n/a
(b) (6) [redacted]	(b) (6) [redacted]				66-1418	02/26/66	780			08/01/66	NR	NR	
		02/10/66	02/26/66	02/18/66	66-1420	02/26/66	840	Torrejon	673	N/A	ND	ND	0
		01/31/66	03/20/66	02/24/66	66-2297	03/20/66	900	Norfolk	900	N/A	0.258+/-0.153	0.344	0.00205
		01/18/66	01/23/66	01/20/66	66-1101	01/23/66	1455	Pirmasens	1455	03/17/66	ND	ND	0

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/06/66	01/27/66	66-530	02/06/66	670	Torrejon	200	N/A	1.72+/-0.87	3.081	0.00938
		01/18/66	02/04/66	01/26/66	66-357	02/04/66	550	Moron	200	N/A	0.97+/-0.52	2.116	0.00486
		01/18/66	02/16/66	02/01/66	66-1005	02/16/66	1500	Kirtland AFB BO97	200	N/A	ND	ND	0
		02/18/66	03/08/66	02/27/66	66-2485	03/08/66	1500	Dreux	1500	N/A	0	0.000	0
		02/06/66	02/26/66	02/16/66	66-1409	02/26/66	920	Moron	958	N/A	0	0.000	0
		01/25/66	03/24/66	02/23/66	66-2535	03/13/66	450	Charleston	450	N/A	0.293	0.781	n/a
					66-2577	03/24/66	1400	USS Everglades AD 24	1400	N/A	0	0.000	0
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/04/66	01/26/66	66-351	02/04/66	500	Torrejon	200	N/A	0.75+/-0.59	1.800	0.00375
		02/10/66	03/18/66	02/26/66	66-2110	03/18/66	900	Torrejon	900	N/A	0.655+/-0.168	0.873	0.00478
		01/18/66	01/21/66	01/19/66	66-227	01/21/66	152	Torrejon	152	N/A	0.233 +/- 0.176	1.839	n/a
		01/18/66	02/09/66	01/29/66	66-757	02/09/66	680	Torrejon	200	N/A	ND	ND	0
		01/18/66	02/09/66	01/29/66	66-749	02/09/66	640	Torrejon	200	N/A	2.15+/-1.09	3.071	0.011
		01/18/66	01/21/66	01/19/66	66-258	01/21/66	1400	Torrejon	200	N/A	18.2 +/- 3.08	18.200	n/a
		01/18/66	02/07/66	01/28/66	66-449	02/07/66	900	Torrejon	200	N/A	2.94+/-1.04	3.920	0.012
		02/04/66	03/13/66	02/22/66	66-2545	03/13/66	530	Charleston	530	N/A	0.178+/-0.138	0.403	0.00116
		01/18/66	02/09/66	01/29/66	66-607	02/09/66	620	Torrejon	200	N/A	4.17+/-1.39	6.102	0.0208
		01/18/66	03/24/66	02/19/66	66-2578	03/24/66	1000	USS Everglades AD 24	1000	N/A	0.109 +/- 0.130	0.131	0
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/05/66	01/27/66	66-898	02/05/66	670	Torrejon	200	N/A	3.15+/-0.89	5.642	0.0161
		03/14/66	03/19/66	03/16/66	66-2128	03/19/66	1000	Torrejon	1000	N/A	0.105+/-0.102	0.126	0.000153
		02/27/66	03/18/66	03/08/66	66-2274	03/18/66	600	Torrejon	600	N/A	0.798 +/- 0.1032	1.596	0
		01/25/66	02/09/66	02/01/66	66-745	02/09/66	880	Hanaw, Germany	200	N/A	2.28+/-1.42	3.181	0.0108
		03/14/66	03/19/66	03/16/66	66-2549	03/19/66	600	San Pablo	600	N/A	ND	ND	0
		01/18/66	02/09/66	01/29/66	66-821	02/09/66	520	Moron	200	N/A	ND	ND	0
		02/08/66	02/08/66	02/08/66	66-1390	02/28/66	900 (12-hr)	Moron	936	N/A	0.757	0.757	0.003
		01/18/66	02/28/66	02/07/66	66-1490	02/28/66	250	US Naval Ocean Graph	260	N/A	ND	ND	0
(b) (6) [redacted]	(b) (6) [redacted]	02/09/66	03/08/66	02/22/66	66-1866	03/08/66	n/a	Moron	n/a	N/A	NR	NR	n/a
					66-2160	03/08/66	770	Moron	770	N/A	0.116+/-0.114	0.181	0.000597
(b) (6) [redacted]	(b) (6) [redacted]	02/06/66	02/08/66	02/07/66	66-1398	02/28/66	930 (12-hr)	Torrejon	967	N/A	ND	ND	0
		01/18/66	02/06/66	01/27/66	66-524	02/06/66	450	Torrejon	200	N/A	1.19+/-0.64	3.173	0.00972
		01/20/66	02/12/66	01/31/66	66-788	02/12/66	630	Moron	200	N/A	1.00+/-0.74	1.905	0.00941
		01/18/66	02/05/66	01/27/66	66-925	02/05/66	810	Moron	200	N/A	4.18+/-1.10	6.193	0.0178
					66-1400	02/28/66	620 (12-hr)	Moron	644	N/A	0.143	0.143	0.001
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/07/66	01/28/66	66-474	02/07/66	400	Torrejon	200	N/A	ND	ND	0
		02/27/66	03/19/66	03/09/66	66-2126	03/19/66	940	Torrejon	940	N/A	0.116+/-0.114	0.148	0.000477
		01/18/66	02/04/66	01/26/66	66-754	02/04/66	950	Moron	200	N/A	ND	ND	0
		01/29/66	02/19/66	02/08/66	66-1201	02/19/66	1360	San Pablo	1000	N/A	ND	ND	0
		01/18/66	02/08/66	01/28/66	66-832	02/08/66	475	Moron	200	N/A	ND	ND	0
		01/18/66	02/09/66	01/29/66	66-759	02/09/66	550	Torrejon	200	N/A	1.14+/-0.61	2.487	0.00887
		01/18/66	02/05/66	01/27/66	66-944	02/05/66	430	Torrejon	200	N/A	6.00+/-0.96	16.744	0.0483
					66-2580	03/23/66	n/a	Moron	n/a	N/A	NR	NR	n/a
(b) (6) [redacted]	(b) (6) [redacted]	02/11/66	03/08/66	02/23/66	66-2501	03/08/66	975	Torrejon	975	N/A	0	0.000	0
		01/18/66	02/07/66	01/28/66	66-497	02/07/66	810	Torrejon	200	N/A	1.29+/-1.00	1.911	0.00617
		01/19/66	02/19/66	02/03/66	66-1213	02/19/66	960	Moron	998		NR	NR	n/a
					66-3125	04/13/66	900	Moron	450	N/A	0.452+/-0.223	0.603	n/a
					66-3125-S	04/13/66	900	Moron	450	N/A	NR	NR	n/a
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	01/21/66	01/19/66	66-257	01/21/66	1060	Torrejon	200	N/A	11.02 +/- 2.12	12.475	n/a
		01/18/66	01/24/66	01/21/66	66-1003	02/15/66	1475	Kirtland AFB BO97	200	N/A	16.5+/-3.1	16.500	0
		01/18/66	02/02/66	01/25/66	66-407	02/02/66	2828	Ramstein	200	N/A	5.47+/-2.87	5.470	0.0118
		01/29/66	01/29/66	01/29/66	66-2277	01/29/66	1420	Torrejon	1420	04/15/66	.3333+/-0.168	0.333	0.00272
		01/18/66	04/11/66	02/28/66	66-2946	04/22/66	1500	B097	1500	N/A	0.142+/-0.102	0.142	n/a
					66-2946	04/22/66	1500			08/18/66	1.93+/-0.334	1.930	
(b) (6) [redacted]	(b) (6) [redacted]	02/13/66	03/18/66	03/01/66	66-2109	03/18/66	890	Moron	890	N/A	0.197+/-0.092	0.266	0.00136
		03/04/66	03/08/66	03/06/66	66-2488	03/08/66	800	Wheelus AF, Libya	800	N/A	0	0.000	0
		01/18/66	02/06/66	01/27/66	66-518	02/06/66	670	Torrejon	200	N/A	7.64+/-1.41	13.684	0.419
		01/18/66	02/16/66	02/01/66	66-961	02/16/66	780	Torrejon	200	N/A	ND	ND	0
		02/24/66	03/17/66	03/06/66	66-2015	03/17/66	1320	Torrejon	1320	N/A	0.266+/-0.109	0.266	0
		01/18/66	02/07/66	01/28/66	66-480	02/07/66	870	Moron	200	N/A	ND	ND	0

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
[redacted]	[redacted]	01/20/66	02/09/66	01/30/66	66-812	02/09/66	510	Torrejon	200	N/A	0.94+/-0.45	2.212	0.00794
		02/10/66	02/08/66	02/09/66	66-1393	02/28/66	600 (12-hr)	Moron	624	N/A	1.09	1.090	0.004
		01/18/66	02/08/66	01/28/66	66-830	02/08/66	552	Torrejon	200	N/A	ND	ND	0
		01/31/66	04/11/66	03/07/66	66-3123	04/13/66	970	Moron	485	N/A	0.225+/-0.161	0.278	n/a
					66-3123-S	04/13/66	970	Moron	485	N/A	NR	NR	n/a
[redacted]	[redacted]	01/18/66	02/12/66	01/30/66	66-789	02/12/66	540	Moron	200	N/A	1.05+/-0.66	2.333	0.00912
[redacted]	[redacted]	03/26/66	04/11/66	04/03/66	66-3122	04/13/66	650	Moron	650	N/A	0.528+/-0.158	0.975	0
		02/06/66	02/08/66	02/07/66	66-1388	02/28/66	390 (12-hr)	Torrejon	390	N/A	0	0.000	0
		01/18/66	02/04/66	01/28/66	66-340	02/04/66	490	Torrejon	200	N/A	1.39+/-0.58	3.404	0.00946
		02/11/66	03/18/66	02/28/66	66-2213	03/18/66	600	Torrejon	600	N/A	0.242+/-0.149	0.484	0.00206
		02/04/66	02/04/66	02/04/66	66-3116	04/13/66	1125	Moron	582	N/A	0.404+/-0.145	0.431	n/a
		02/13/66	03/08/66	02/24/66	66-2499	03/08/66	1000	Moron	1000	N/A	0	0.000	0
		01/18/66	01/28/66	01/23/66	66-1095	01/28/66	610	Zaragoza	610	N/A	ND	ND	0
		01/18/66	03/03/66	02/09/66	66-1941	03/03/66	1650	625TH MASS (MAC)	1730	N/A	0.173+/-0.091	0.173	0
[redacted]	[redacted]	01/18/66	02/08/66	01/28/66	66-835	02/08/66	815	Moron	200	N/A	ND	ND	0
		02/06/66	02/08/66	02/07/66	66-1378	02/28/66	780 (12-hr)	Torrejon	812	N/A	ND	ND	0
		01/18/66	02/09/66	01/29/66	66-824	02/09/66	915	Torrejon	200	N/A	1.98+/-1.01	2.597	0.00882
		01/18/66	03/20/66	02/17/66	66-2017	03/20/66	1500	Tinker AFB	1500	N/A	0.102+/-0.088	0.102	0
		02/12/66	03/01/66	02/20/66	66-1882	03/01/66	700	Ramstein	700	N/A	0.706+/-0.218	1.210	n/a
					66-1882	03/01/66	700			06/28/66	0.043+/-0.025	0.074	
[redacted]	[redacted]	01/19/66	03/08/66	02/12/66	66-2476	03/08/66	850	Torrejon	850	N/A	0.27	0.381	n/a
		01/18/66	02/03/66	01/26/66	66-1838	02/03/66	800	Torrejon	800	N/A	1.36	2.040	0.0166
		02/11/66	03/14/66	02/26/66	66-1945	03/14/66	n/a	Torrejon	n/a	N/A	0.357+/-0.130	0.357	0
		01/25/66	02/22/66	02/08/66	66-1084	02/22/66	705	Moron	705	03/17/66	4.46+/-0055	7.591	0.0416
		02/06/66	02/08/66	02/07/66	66-1382	02/28/66	900 (12-hr)	Torrejon	936	N/A	1.18	1.180	0.005
		01/28/66	02/08/66	02/02/66	66-850	02/08/66	810	Toul Rosieres	200	N/A	ND	ND	0
		02/11/66	03/28/66	03/05/66	66-1927	03/28/66	800	Torrejon	800	N/A	0.210+/-0.092	0.315	0
		01/18/66	02/05/66	01/27/66	66-897	02/05/66	780	Torrejon	200	N/A	2.65+/-1.06	4.077	0.0117
		01/18/66	02/05/66	01/27/66	66-906	02/05/66	910	Torrejon	200	N/A	ND	ND	0
		02/09/66	03/09/66	02/23/66	66-2389	03/09/66	850	Torrejon	850	N/A	0.188+/-0.123	0.263	0.0017
		01/18/66	02/09/66	01/29/66	66-827	02/09/66	880	Moron	200	N/A	1.83+/-1.02	2.495	0.00852
		03/02/66	03/18/66	03/10/66	66-2087	03/18/66	890	Lindsey AS, Germany	890	N/A	0.133+/-0.086	0.179	0
[redacted]	[redacted]	01/23/66	02/19/66	02/05/66	66-1218	02/19/66	1260	Torrejon	1000	N/A	2.31+/-0.32	2.310	0.012
		01/20/66	02/17/66	02/03/66	66-1115	02/17/66	990	Toul Rosieres	990	03/23/66	0	0.000	0
		01/18/66	02/08/66	01/28/66	66-1345	02/08/66	660	Toul Rosieres	685	N/A	0.286+/-0.148	0.520	0.0165
		01/18/66	02/05/66	01/27/66	66-904	02/05/66	540	Torrejon	200	N/A	2.34+/-0.70	5.200	0.015
		01/20/66	03/18/66	02/17/66	66-2257	03/18/66	600	Torrejon	600	N/A	0.180+/-0.155	0.360	0.00164
		01/18/66	03/19/66	02/17/66	66-2155	03/19/66	900	Torrejon	900	N/A	0.385+/-0.190	0.487	
		02/27/66	03/08/66	03/03/66	66-2512	03/08/66	960	Moron	960	N/A	NR	NR	n/a
		01/18/66	03/04/66	02/09/66	66-2362	03/04/66	700	Torrejon	700	N/A	0.150+/-0.119	0.257	0.000472
		02/08/66	03/10/66	02/23/66	66-1955	03/10/66	1000	Moron	1000	N/A	0.186+/-0.115	0.223	0
		01/18/66	02/12/66	01/30/66	66-786	02/12/66	950	Torrejon	200	N/A	ND	ND	0
		01/18/66	02/06/66	01/27/66	66-520	02/06/66	980	Moron	200	N/A	9.12+/-2.03	11.400	0.0349
		02/13/66	03/19/66	03/02/66	66-2328	03/19/66	820	Moron	820	N/A	0.206+/-0.129	0.301	0.00128
		03/02/66	03/08/66	03/05/66	66-3057	04/27/66	300	Ramstein	300	N/A	0.200+/-0.080	0.800	n/a
		01/18/66	02/18/66	02/02/66	66-973	02/18/66	1600	Torrejon	200	N/A	ND	ND	0
		01/31/66	03/19/66	02/23/66	66-2553	03/19/66	600	Giessen	600	N/A	0.307+/-0.179	0.614	0.00239
		02/13/66	03/18/66	03/01/66	66-2108	03/18/66	780	San Pablo	780	N/A	0.297+/-0.135	0.457	0.00205
		01/29/66	02/19/66	02/08/66	66-1197	02/19/66	n/a	San Pablo	n/a	N/A	0	0.000	n/a
					66-3114	04/13/66	1450	San Pablo	725	N/A	0.446+/-0.139	0.446	n/a
[redacted]	[redacted]	01/18/66	02/04/66	01/26/66	66-349	02/04/66	750	Moron	200	N/A	2.06+/-1.10	3.296	0.0103
		03/10/66	03/19/66	03/14/66	66-2164	03/19/66	620	Sembach	620	N/A	0.131	0.254	n/a
		01/18/66	02/08/66	01/28/66	66-828	02/08/66	390	Torrejon	195	N/A	0.48+/-0.44	1.477	0.00471
		01/17/66	03/04/66	02/09/66	66-260	01/21/66	700	Torrejon	200	N/A	1.86 +/- 0.76	3.169	n/a
					66-2380	03/04/66	1420	Torrejon	1420	N/A	0.339+/-0.175	0.339	0.00256
[redacted]	[redacted]	02/27/66	03/19/66	03/09/66	66-2127	03/19/66	790	Torrejon	790	N/A	ND	ND	0
		01/18/66	02/07/66	01/28/66	66-476	02/07/66	680	Toul Rosieres	200	N/A	ND	ND	0
		03/14/66	03/19/66	03/16/66	66-2131	03/19/66	900	Moron	900	N/A	ND	ND	0

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/05/66	01/27/66	66-917	02/05/66	780	Moron	200	N/A	1.61+/-0.74	2.477	0.00713
		01/18/66	02/09/66	01/29/66	66-756	02/09/66	890	Torrejon	200	N/A	2.20+/-1.23	2.966	0.00973
		02/21/66	03/18/66	03/05/66	66-2236	03/18/66	950	Torrejon	950	N/A	0.108+/-0.102	0.136	0.000719
		02/13/66	03/18/66	03/01/66	66-2243	03/18/66	810	Moron	810	N/A	0.230+/-0.139	0.341	0.00215
		02/09/66	03/08/66	02/22/66	66-1899	03/08/66	600	Moron	600	N/A	0.181+/-0.085	0.362	0
		01/18/66	02/18/66	02/01/66	66-966	02/16/66	800	Torrejon	200	N/A	1.27+/-0.69	1.905	0.00948
		01/18/66	03/24/66	02/19/66	66-2574	03/24/66	n/a	USS Everglades AD 24	n/a	N/A	NR *	NR	n/a
					66-2971	04/24/66	600	USS Everglades AD 24	600	N/A	ND	ND	0
(b) (6) [redacted]	(b) (6) [redacted]	01/29/66	02/19/66	02/08/66	66-1211	02/19/66	760	San Pablo	790	N/A	NR	NR	n/a
		01/17/66	02/05/66	01/26/66	66-918	02/05/66	730	Torrejon	200	N/A	1.71+/-0.94	2.811	0.00608
		02/08/66	02/08/66	02/08/66	66-1355	02/28/66	500 (12-hr)	Toul Rosieres	500	N/A	0.117	0.117	0.000954
		01/18/66	02/08/66	01/28/66	66-842	02/08/66	760	Torrejon	200	N/A	0.81+/-0.59	1.279	0.00433
		01/17/66	02/20/66	02/03/66	66-1957	02/20/66	1650	Moron	1650	N/A	0.107+/-0.071	0.107	0
		02/06/66	02/26/66	02/16/66	66-1435	02/26/66	760	Moron	789	N/A	ND	ND	0
		02/24/66	03/19/66	03/07/66	66-2085	03/19/66	350	Toul Rosieres	350	N/A	0.112+/-0.074	0.384	0
		01/18/66	02/12/66	01/30/66	66-787	02/12/66	440	Moron	200	N/A	ND	ND	0
		02/09/66	03/08/66	02/22/66	66-1906	03/08/66	800	San Pablo	800	N/A	0.135+/-0.088	0.203	0
		01/18/66	03/13/66	02/14/66	66-2539	03/13/66	1000	Moron	1000	N/A	0.293	0.352	n/a
		01/25/66	02/09/66	02/01/66	66-602	02/09/66	700	Hanaw, Germany	200	N/A	2.75+/-1.01	4.714	0.0161
		01/18/66	03/16/66	02/15/66	66-2028	03/16/66	870	Moron	870	N/A	0.216+/-0.099	0.298	0
		01/18/66	01/21/66	01/19/66	66-263	01/21/66	900	Torrejon	200	N/A	NR	NR	n/a
		03/13/66	03/19/66	03/16/66	66-2175	03/19/66	700	Torrejon	700	N/A	0.131	0.225	n/a
		01/25/66	03/13/66	02/17/66	66-2548	03/13/66	800	Charleston	800	N/A	0.129+/-0.107	0.194	0.000991
					66-2573	03/24/66	700	USS Everglades AD 24	700	N/A	.133+/-0.113	0.228	n/a
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/04/66	01/26/66	66-358	02/04/66	1000	Torrejon	200	N/A	108+/-5.9	129.600	0.541
					66-2354	03/04/66	800	Torrejon	800	N/A	0.153+/-0.113	0.230	0.000481
(b) (6) [redacted]	(b) (6) [redacted]	02/01/66	03/08/66	02/18/66	66-1864	03/08/66	500	Moron	500	N/A	1.41+/-0.31	3.384	n/a
				02/18/66	66-1864	03/08/66	500			08/29/66	NR	NR	
(b) (6)	(b) (6) [redacted]	01/18/66	02/04/66	01/26/66	66-346	02/04/66	600	Torrejon	200	N/A	ND	ND	0
					66-2685	03/27/66	1400	Torrejon	1400	N/A	0.477+/-0.192	0.477	n/a
(b) (6) [redacted]	(b) (6) [redacted]	02/13/66	03/08/66	02/24/66	66-2473	03/08/66	450	Moron	450	N/A	0.131	0.349	n/a
		01/18/66	02/06/66	01/27/66	66-528	02/06/66	370	Torrejon	200	N/A	0.98+/-0.41	3.178	0.00972
		01/20/66	02/08/66	01/29/66	66-844	02/08/66	780	Toul Rosieres	200	N/A	ND	ND	0
		03/13/66	03/14/66	03/13/66	66-2876	04/01/66	1600	Torrejon	1600	N/A	1.44+/-0.31	1.440	n/a
					66-2876	04/01/66	1600			07/13/66	2.701+/-0.020	2.701	
(b) (6) [redacted]	(b) (6) [redacted]	01/26/66	02/09/66	02/03/66	66-801	02/09/66	950	Torrejon	200	N/A	1.51+/-1.26	1.907	0.00651
		01/18/66	02/03/66	01/26/66	66-1644	02/03/66	925	Moron	925	N/A	0.108	0.140	0
		01/18/66	02/05/66	01/27/66	66-890	02/05/66	900	Moron	200	N/A	1.23+/-0.96	1.840	0.00472
		02/10/66	03/19/66	02/28/66	66-2147	03/19/66	830	Moron	830	N/A	ND	ND	0
		02/26/66	03/18/66	03/08/66	66-2095	03/18/66	n/a	Torrejon	n/a	N/A	0.132+/-0.095	0.132	0.000736
		02/09/66	03/09/66	02/23/66	66-2068	03/09/66	n/a	Torrejon	n/a	N/A	0.351 +/- 0.123	0.351	0.00196
		01/17/66	02/11/66	01/29/66	66-760	02/11/66	665	Torrejon	200	N/A	ND	ND	0
		01/18/66	02/05/66	01/27/66	66-899	02/05/66	480	Moron	200	N/A	1.48+/-0.66	3.700	0.0107
		02/11/66	03/08/66	02/23/66	66-2481	03/08/66	900	Torrejon	900	N/A	ND	ND	0
		02/09/66	02/28/66	02/18/66	66-2385	03/11/66	1875	Torrejon	1875	N/A	0.155+/-0.113	0.155	
		02/11/66	03/08/66	02/23/66	66-2482	03/08/66	100	Torrejon	100	N/A	0	0.000	0
		02/21/66	03/18/66	03/05/66	66-2263	03/18/66	550	Zaragoza	550	N/A	0.322+/-0.484	0.703	0.00156
		01/21/66	03/16/66	02/17/66	66-2026	03/16/66	n/a	Torrejon	n/a	N/A	NR	NR	n/a
					66-2144	03/19/66	780	Torrejon	780	N/A	0.112 +/- 0.126	0.172	0
(b) (6) [redacted]	(b) (6) [redacted]	01/17/66	02/07/66	01/27/66	66-459	02/07/66	915	Torrejon	800	N/A	ND	ND	0
		01/18/66	02/07/66	01/28/66	66-484	02/07/66	560	Moron	200	N/A	1.59+/-0.66	3.407	0.011
		01/18/66	01/29/66	01/23/66	66-1226	01/29/66	1210	San Pablo	1000	N/A	3.63+/-0.29	3.630	0.021
		02/24/66	03/08/66	03/02/66	66-1879	03/08/66	300	Toul Rosieres	312	N/A	1.92	7.680	0.00538
		01/18/66	02/07/66	01/28/66	66-498	02/07/66	760	Moron	200	N/A	6.85+/-1.59	10.500	0.034
		01/18/66	02/09/66	01/29/66	66-819	02/09/66	410	Torrejon	200	N/A	2.65+/-0.67	7.756	0.0264
		01/16/66	02/05/66	01/26/66	66-902	02/05/66	750	Torrejon	502	03/17/66	35.47+/-0.73	58.752	
		03/11/66	03/19/66	03/15/66	66-2174	03/19/66	700	Torrejon	700	N/A	0.431	0.739	

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
[redacted] (b) (6)	[redacted] (b) (6)	02/09/66	03/08/66	02/22/66	66-1909	03/08/66	550	Moron	550	N/A	0.357+/-0.125	0.779	
		01/18/66	02/11/66	01/30/66	66-767	02/11/66	590	Torrejon	200	N/A	1.75+/-0.87	3.559	0.0133
		01/18/66	02/04/66	01/26/66	66-348	02/04/66	900	Moron	200	N/A	ND	ND	
		02/01/66	02/16/66	02/08/66	66-1947	03/03/66	1650	Torrejon	1650	N/A	0.195+/-0.092	0.195	NSBB
		04/02/66	04/10/66	04/06/66	66-2938	04/19/66	1500	Torrejon	1500	N/A	1.40+/-0.30	1.400	
[redacted] (b) (6)	[redacted] (b) (6)				66-2938	04/19/66	1500			n/a	NR	NR	
		03/01/66	03/20/66	03/10/66	66-2299	03/20/66	880	Torrejon	880	N/A	0.126 +/- 0.126	0.172	
		01/18/66	02/06/66	01/27/66	66-507	02/06/66	590	Torrejon	200	N/A	2.61+/-0.90	5.308	0.0162
		02/10/66	03/19/66	02/28/66	66-2565	03/19/66	500	Moron	500	N/A	0.150+/-0.113	0.360	0.000978
		02/24/66	03/04/66	02/26/66	66-2381	03/04/66	1450	US Bureau of Mines, Pills, PA	1450	04/01/66	0.168+/-0.118	0.168	0.00035
[redacted] (b) (6)	[redacted] (b) (6)	01/25/66	02/19/66	02/06/66	66-1054	02/19/66	1550	Wiesbaden	1550	03/17/66	ND	ND	
		02/17/66	02/28/66	02/22/66	66-3103	05/13/66	1400	HQ Altantic Air Rescue	700	N/A	0.700 +/- 0.163	0.700	
					66-3103	05/13/66	1400	HQ Altantic Air Rescue	700	N/A	0.700+/-0.163	0.700	
[redacted] (b) (6)	[redacted] (b) (6)	02/14/66	02/26/66	02/20/66	66-1432	02/26/66	500	Wiesbaden	520	N/A	0	0.000	
		01/18/66	02/03/66	01/26/66	66-1639	02/03/66	910	Torrejon	910	N/A	0.239	0.315	
		01/18/66	02/07/66	01/28/66	66-473	02/07/66	870	Toul Rosieres	200	N/A	ND	ND	
		02/11/66	04/11/66	03/12/66	66-3130	04/13/66	880	Wheelus AF, Libya	860	N/A	NR	NR	
					66-3130	04/13/66	1720	Wheelus AF, Libya	860	N/A	1.19+/-0.34	1.190	
[redacted] (b) (6)	[redacted] (b) (6)	02/21/66	03/20/66	03/06/66	66-2306	03/20/66	700	Torrejon	700	N/A	0.119+/-0.115	0.204	0.000613
		03/16/66	03/19/66	03/18/66	66-2076	03/19/66	980	Moron	980	N/A	0.239+/-0.102	0.293	
		01/18/66	02/11/66	01/30/66	66-364	02/04/66	825	Torrejon	200	N/A	58.4+/-3.9	84.945	0.292
[redacted] (b) (6)	[redacted] (b) (6)				66-1181	02/18/66	1680	Torrejon	1680	03/02/66	3.61+/-0.50	3.610	0.0176
		02/08/66	02/17/66	02/12/66	66-1112	02/17/66	910	Toul Rosieres	910	03/23/66	0.896+/-0.515	1.182	0.00207
		01/18/66	02/05/66	01/27/66	66-936	02/05/66	880	Torrejon	200	N/A	0.83+/-0.8	1.158	0.00334
		02/09/66	03/09/66	02/23/66	66-2403	03/09/66	1300	Torrejon	1300	N/A	0.152+/-0.124	0.152	0.000847
		01/25/66	02/09/66	02/01/66	66-740	02/09/66	980	Hanaw, Germany	200	N/A	1.18 +/- 1.11	1.450	0.00613
		02/13/66	03/09/66	02/25/66	66-2401	03/09/66	1350	Torrejon	1350	N/A	0.102+/-0.094	0.102	0.00048
		02/10/66	03/08/66	02/23/66	66-2493	03/08/66	950	Moron	950	N/A	0	0.000	
		01/18/66	03/09/66	02/12/66	66-2062	03/09/66	890	Moron	890	N/A	0.164+/-0.095	0.221	0.00134
		02/06/66	02/08/66	02/07/66	66-1372	02/28/66	910 (12-hr)	Moron	910	N/A	0	0.000	
		01/18/66	01/29/66	01/23/66	66-1079	01/29/66	960	Torrejon	960	N/A	0.141	0.176	0.00026
		01/27/66	02/19/66	02/07/66	66-1221	02/19/66	860	San Pablo	860	N/A	0.296+/-0.160	0.413	0.00135
[redacted] (b) (6)	[redacted] (b) (6)				66-1221	02/19/66	950	San Pablo	950	N/A	0.185+/-0.259	0.234	
		03/08/66	03/19/66	03/13/66	66-2167	03/19/66	930	Toul Rosieres	930	N/A	0.162	0.209	
		01/18/66	01/24/66	01/21/66	66-1159	01/24/66	1260	Toul Rosieres	1000	N/A	0	0.000	
		02/25/66	03/19/66	03/08/66	66-2148	03/19/66	900	Moron	900	N/A	0.100+/-0.074	0.133	0.000441
		02/12/66	03/16/66	02/28/66	66-2859	04/18/66	1400	Chateauroux, France	1400	N/A	ND	ND	
[redacted] (b) (6)	[redacted] (b) (6)				66-2859	04/18/66	1400			07/07/66	NR	NR	
		01/18/66	02/06/66	01/27/66	66-508	02/06/66	870	Torrejon	200	N/A	ND	ND	
		01/21/66	03/03/66	02/10/66	66-1916	03/03/66	850	Charleston	850	N/A	0.292+/-0.107	0.412	
		01/16/66	02/19/66	02/02/66	66-1951	02/23/66	1900	Torrejon	1900	N/A	0.882+/-0.169	0.882	0.00597
					66-2040	03/20/66	2900	Torrejon	2000	N/A	0.155+/-0.120	0.155	0.000435
[redacted] (b) (6)	[redacted] (b) (6)				66-2927	04/21/66	1200	Torrejon	1200	N/A	1.02+/-0.26	1.020	
		02/04/66	03/02/66	02/17/66	66-1918	03/02/66	825	USS Simon Lake	825	N/A	0.122+/-0.087	0.177	
		01/18/66	03/09/66	02/12/66	66-2067	03/09/66	n/a	Torrejon	n/a	N/A	NR	NR	
		01/18/66	02/06/66	01/27/66	66-914	02/06/66	940	Moron	200	N/A	ND	ND	
		01/18/66	02/05/66	01/27/66	66-905	02/05/66	650	Moron	200	N/A	ND	ND	
		01/18/66	02/08/66	01/28/66	66-848	02/08/66	600	Moron	200	N/A	ND	ND	
		01/19/66	02/09/66	01/29/66	66-747	02/09/66	790	Torrejon	200	N/A	1.08+/-0.79	1.841	0.00587
		01/18/66	01/21/66	01/19/66	66-216	01/21/66	500	Torrejon	200	N/A	NR	NR	
		01/18/66	01/21/66	01/19/66	66-211	01/21/66	113	Torrejon	113	N/A	NR	NR	
					66-221	01/21/66	250	Torrejon	190	N/A	48.8 +/- 2	234.240	
[redacted] (b) (6)	[redacted] (b) (6)	01/18/66	02/05/66	01/27/66	66-903	02/05/66	570	Moron	200	N/A	0.94+/-0.43	1.979	0.0061
		01/18/66	03/24/66	02/19/66	66-2576	03/24/66	1400	USS Everglades AD 24	1400	N/A	0.292+/-0.151	0.292	
[redacted] (b) (6)	[redacted] (b) (6)	01/21/66	02/18/66	02/04/66	66-1444	02/26/66	790	Moron	790	03/17/66	ND	ND	

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
(b) (6) [redacted]	(b) (6) [redacted]	01/21/66	03/04/66	02/11/66	66-2371	03/04/66	1300	Moron	1300	N/A	NR	NR	
		03/11/66	03/19/66	03/15/66	66-2133	03/19/66	790	Moron	790	N/A	ND	ND	
		01/18/66	02/12/66	01/30/66	66-783	02/12/66	770	Torrejon	200	N/A	1.29+/-0.73	2.010	0.00791
		01/18/66	02/06/66	01/27/66	66-526	02/06/66	930	Moron	200	N/A	1.44+/-0.93	1.858	0.00568
		01/18/66	02/18/66	02/02/66	66-972	02/18/66	1500	Torrejon	200	N/A	ND	ND	
		02/09/66	03/09/66	02/23/66	66-2058	03/09/66	680	Torrejon	680	N/A	0.149+/-0.086	0.263	0.000831
		01/18/66	03/10/66	02/12/66	66-2388	03/10/66	2275	Torrejon	2275	N/A	0.623+/-0.225	0.623	0.00347
		01/18/66	02/13/66	01/31/66	66-1133	02/13/66	1030	Torrejon	1000	03/23/66	0.772+/-0.494	0.899	0.00327
		01/20/66	02/08/66	01/29/66	66-845	02/08/66	570	Toul Rosieres	200	N/A	1.64+/-0.62	3.453	0.0111
		02/11/66	03/08/66	02/23/66	66-2492	03/08/66	200	Torrejon	200	N/A	0	0.000	
		02/04/66	02/25/66	02/14/66	66-1486	03/04/66	3780	USS Paprgo ATF-160	1000	N/A	0.176+/-0.574	0.176	
(b) (6) [redacted]	(b) (6) [redacted]	02/08/66	03/04/66	02/19/66	66-2369	03/04/66	500	Torrejon	500	N/A	0.309+/-0.159	0.742	0.00155
		01/17/66	01/25/66	01/21/66	66-1168	02/17/66	1490	Torrejon	1000	N/A	NR	NR	
		01/18/66	02/18/66	02/01/66	66-963	02/18/66	1780	Torrejon	200	N/A	94.45+/-7.67	94.450	
		01/18/66	03/09/66	02/12/66	66-2066	03/09/66	1400	Torrejon	1400	N/A	0.488+/-0.148	0.488	0.00399
		01/25/66	02/09/66	02/01/66	66-795	02/09/66	480	Hanaw, Germany	200	N/A	2.07+/-0.66	5.175	0.0185
		01/18/66	01/25/66	01/21/66	66-3120	04/13/66	795	Moron	795	N/A	0.483+/-0.145	0.699	
		03/14/66	03/19/66	03/16/66	66-2554	03/19/66	900	Moron	900	04/19/66	ND	ND	
		02/13/66	03/18/66	03/01/66	66-2105	03/18/66	790	Torrejon	790	N/A	0.189+/-0.134	0.287	0.00154
		01/18/66	02/07/66	01/28/66	66-1098	02/07/66	685	Wiesbaden	685	N/A	ND	ND	
		02/13/66	03/03/66	02/22/66	66-1913	03/03/66	800	Moron	800	N/A	0.232+/-0.106	0.348	
		02/01/66	03/02/66	02/15/66	66-3027	05/05/66	1350	Ramstein	1350	N/A	0.306+/-0.091	0.306	
		01/18/66	02/09/66	01/29/66	66-818	02/09/66	360	Torrejon	200	N/A	2.03+/-0.63	6.767	0.0231
		02/21/66	03/19/66	03/06/66	66-2209	03/19/66	600	San Pablo	600	N/A	0.148+/-0.135	0.296	0.00108
		02/13/66	03/04/66	02/22/66	66-2349	03/04/66	620	Torrejon	820	N/A	0.110+/-0.108	0.161	0.000435
		01/18/66	01/28/66	01/23/66	66-3118	04/13/66	1500	Moron	750	N/A	0.218+/-0.113	0.218	
		01/20/66	02/09/66	01/30/66	66-798	02/09/66	750	Torrejon	200	N/A	ND	ND	
		01/18/66	01/21/66	01/19/66	66-235	01/21/66	480	Torrejon	200	N/A	0.227 +/- 0.112	0.568	
		01/18/66	01/21/66	01/19/66	66-232	01/21/66	480	Torrejon	200	N/A	0.227 +/- 0.112	0.568	
		01/18/66	01/21/66	01/19/66	66-223	01/21/66	475	Torrejon	200	N/A	NR	NR	
		02/01/66	02/19/66	02/10/66	66-1204	02/19/66	900	Moron	936	N/A	1.16+/-0.90	1.547	0.00454
		01/18/66	01/21/66	01/19/66	66-228	01/21/66	410	Torrejon	200	N/A	1.71 +/- 0.60	5.005	
		01/23/66	03/20/66	02/20/66	66-2308	03/20/66	760	Pirmasens	760	N/A	0.144+/-0.114	0.227	0.00123
		02/10/66	03/09/66	02/23/66	66-2053	03/09/66	790	Zaragoza	790	N/A	0.218+/-0.101	0.331	0.00112
		01/19/66	01/27/66	01/23/66	66-3131	04/13/66	2000	Wheelus AF, Libya	1000	N/A	1.17 +/- 0.33	1.170	
					66-3131	04/13/66	2000	Wheelus AF, Libya	1000	N/A	1.17+/-0.33	1.170	
					66-3131	04/13/66	2000			06/03/66	0.590	0.590	
(b) (6) [redacted]	(b) (6) [redacted]	02/18/66	03/04/66	02/25/66	66-2360	03/04/66	650	Moron	650	N/A	0.117+/-0.101	0.216	0.000368
		01/18/66	02/05/66	01/27/66	66-891	02/05/66	860	Torrejon	200	N/A	ND	ND	
		01/18/66	02/07/66	01/28/66	66-457	02/07/66	820	Moron	200	N/A	0.94+/-0.77	1.376	0.00422
		02/13/66	03/04/66	02/22/66	66-2364	03/04/66	900	Torrejon	900	N/A	0.147+/-0.119	0.196	0.000581
		01/23/66	02/08/66	01/31/66	66-848	02/08/66	930	Toul Rosieres	200	N/A	ND	ND	
		02/02/66	02/15/66	02/08/66	66-1156	02/15/66	340	Panama City, FL	340	03/17/66	0.65+/-0.21	2.294	0.00712
		02/09/66	03/09/66	02/23/66	66-2061	03/09/66	1200	Torrejon	1200	N/A	0.212+/-0.096	0.212	0.00118
		01/28/66	02/12/66	02/04/66	66-947	02/12/66	1060	Torrejon	200	N/A	ND	ND	
		02/13/66	03/18/66	03/01/66	66-2252	03/18/66	980	Moron	980	N/A	0.189+/-0.135	0.231	0.00177
		02/03/66	02/25/66	02/14/66	66-1346	02/25/66	540	Toul Rosieres	562	N/A	0.118+/-0.385	0.262	
		02/11/66	03/04/66	02/21/66	66-2368	03/04/66	1000	Wiesbaden	1000	N/A	ND	ND	
		01/18/66	02/06/66	01/27/66	66-522	02/06/66	540	Torrejon	200	N/A	1.96+/-0.64	4.356	0.0127
		01/18/66	03/08/66	02/11/66	66-1910	03/08/66	n/a	Torrejon	n/a	N/A	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	03/08/66	02/11/66	66-2159	03/08/66	730	Torrejon	730	N/A	0.129+/-0.114	0.212	0.00103
		01/18/66	03/08/66	02/11/66	66-1907	03/08/66	875	Torrejon	875	N/A	0.236+/-0.120	0.324	
		01/29/66	02/22/66	02/10/66	66-1089	02/22/66	755	Torrejon	755	03/17/66	8.86+/-0.78	14.082	0.0682
		01/29/66	02/23/66	02/10/66	66-2939	04/14/66	500	Torrejon	500	N/A	ND	ND	
					66-2939	04/14/66	500			08/01/66	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	02/06/66	03/04/66	02/19/66	66-2356	03/04/66	900	Moron	900	N/A	ND	ND	
		02/10/66	03/19/66	02/28/66	66-2130	03/19/66	800	Torrejon	800	N/A	0.223+/-0.162	0.335	0.00145
		01/18/66	03/08/66	02/11/66	66-2480	03/08/66	900	Torrejon	900	N/A	ND	ND	
		01/25/66	02/09/66	02/01/66	66-737	02/09/66	940	Hanaw, Germany	200	N/A	ND	ND	

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
(b) (6) [redacted]	(b) (6) [redacted]	02/14/66	02/26/66	02/20/66	66-1421	02/26/66	940	Moron	978	N/A	0	0.000	
(b) (6) [redacted]	(b) (6) [redacted]				66-1421	02/26/66	940			08/29/66	NR	NR	
		01/17/66	02/07/66	01/27/66	66-248	01/21/66	750	Torrejon	200	N/A	2.23 +/- 0.863	3.568	
(b) (6) [redacted]	(b) (6) [redacted]				66-469	02/07/66	760	Torrejon	200	N/A	0.84+/-0.72	1.328	0.00427
		02/25/66	03/18/66	03/07/66	66-2249	03/18/66	1300	Torrejon	1300	N/A	0.144+/-0.114	0.144	0.000614
		01/18/66	01/21/66	01/19/66	66-229	01/21/66	126	Torrejon	126	N/A	4.41 +/- 0.58	42.000	
		02/09/66	03/09/66	02/23/66	66-2402	03/09/66	600	Torrejon	600	N/A	0.238+/-0.143	0.476	0.00133
		01/18/66	01/26/66	01/22/66	66-1227	01/26/66	1460	Torrejon	1000	N/A	0.504+/-0.159	0.504	0.00123
		01/25/66	02/09/66	02/01/66	66-603	02/09/66	770	Hanaw, Germany	200	N/A	ND	ND	
		01/18/66	02/07/66	01/28/66	66-472	02/07/66	965	Moron	200	N/A	ND	ND	
		01/18/66	03/16/66	02/15/66	66-2025	03/16/66	700	Torrejon	700	N/A	0.278+/-0.121	0.477	
		02/11/66	03/24/66	03/03/66	66-3205	04/21/66	1720	Torrejon	860	N/A	0.275+/-0.163	0.275	
					66-3205-5	04/21/66	1720	Torrejon	860	N/A	0.275 +/- 0.163	0.275	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	03/03/66	02/09/66	66-1937	03/03/66	1100	Torrejon	1180	N/A	0.138+/-0.078	0.151	
		01/18/66	01/18/66	01/18/66	66-1106	01/18/66	1110	Torrejon	1000	N/A	ND	ND	
		02/15/66	03/08/66	02/25/66	66-2515	03/08/66	980	Zaragoza	980	N/A	0.131	0.160	
		03/08/66	03/19/66	03/13/66	66-2311	03/19/66	750	Toul Rosieres	750	N/A	0.384+/-0.211	0.614	0.001
		01/17/66	02/12/66	01/30/66	66-782	02/12/66	550	Torrejon	200	N/A	1.29+/-0.66	2.815	0.011
		02/24/66	03/08/66	03/02/66	66-1905	03/08/66	550	Dreux	550	N/A	0.121+/-0.074	0.264	
		02/21/66	03/18/66	03/05/66	66-2117	03/18/66	900	Torrejon	900	N/A	0.223+/-0.162	0.297	0.0015
		01/17/66	02/03/66	01/25/66	66-2880	04/01/66	800	Torrejon	800	N/A	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]				66-2880	04/01/66	800			08/23/66	NR	NR	
		02/16/66	03/04/66	02/25/66	66-2344	03/04/66	900	Torrejon	900	N/A	ND	ND	
		02/13/66	03/19/66	03/02/66	66-2560	03/19/66	700	Moron	700	N/A	0.152+/-0.124	0.261	0.00093
		01/18/66	02/11/66	01/30/66	66-773	02/11/66	980	Torrejon	200	N/A	1.17+/-.84	1.433	0.00536
		02/08/66	03/08/66	02/22/66	66-1878	03/08/66	925	Toul Rosieres	956	N/A	0.538	0.698	0.002
		03/27/66	04/04/66	03/31/66	66-2988	04/26/66	1200	Furth, Ger. US Army, 20th Sta Hosp.	1200	N/A	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]				66-2988	04/26/66	1200			07/15/66	NR	NR	
		02/07/66	03/04/66	02/19/66	66-2347	03/04/66	700	Bitburg	700	N/A	0.387+/-0.280	0.629	0.00178
		03/04/66	03/08/66	03/06/66	66-2511	03/08/66	1000	Torrejon	1000	N/A	0	0.000	
		01/18/66	02/06/66	01/27/66	66-534	02/06/66	360	Torrejon	200	N/A	0.55+/-0.18	1.833	0.00565
(b) (6) [redacted]	(b) (6) [redacted]				66-2503	03/08/66	1500	Torrejon	1500	N/A	0	0.000	
		01/18/66	04/04/66	02/25/66	66-2893	04/04/66	800	Vandenburg	800	N/A	ND	ND	
		01/18/66	03/08/66	02/11/66	66-1698	03/08/66	700	Torrejon	700	N/A	0.764+/-0.167	1.310	0.00913
		01/19/66	02/05/66	01/27/66	66-939	02/05/66	500	Torrejon	200	N/A	1.45+/-0.79	3.480	0.01
		01/25/66	02/09/66	02/01/66	66-792	02/09/66	770	Hanaw, Germany	200	N/A	0.55+/-0.72	0.857	
		02/09/66	03/08/66	02/22/66	66-1871	03/08/66	940	Moron	978	N/A	0.611	0.780	0.003
		01/18/66	02/12/66	01/30/66	66-790	02/12/66	800	Moron	200	N/A	ND	ND	
		02/09/66	03/08/66	02/22/66	66-1876	03/08/66	720	San Pablo	720	N/A	NR	NR	
		01/18/66	02/07/66	01/28/66	66-445	02/07/66	370	Moron	200	N/A	0.50+/-0.31	1.622	0.00501
		01/25/66	02/09/66	02/01/66	66-822	02/09/66	530	Germany	200	N/A	0.93+/-0.76	2.106	0.00722
		02/15/66	03/25/66	03/06/66	66-2930	04/18/66	900	Torrejon	900	N/A	1.50+/-0.31	2.000	
		01/18/66	01/29/66	01/23/66	66-1067	01/29/66	1245	Torrejon	1245	N/A	ND	ND	
		01/17/66	02/07/66	01/27/66	66-462	02/07/66	620	Torrejon	200	N/A	0.79+/-0.50	1.529	0.00469
		02/20/66	04/11/66	03/17/66	66-3196	05/09/66	690	Torrejon	690	N/A	0.190+/-0.087	0.330	
		02/18/66	03/19/66	03/04/66	66-2047	03/19/66	460	Torrejon	460	N/A	0.190+/-0.100	0.498	
		01/18/66	02/05/66	01/27/66	66-933	02/05/66	840	Moron	200	N/A	2.12+/-1.13	3.029	0.00868
		01/18/66	02/03/66	01/26/66	66-1832	02/03/66	920	Moron	920	N/A	0.18	0.235	
		02/09/66	03/08/66	02/22/66	66-1867	03/08/66	800	Torrejon	800	N/A	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]				66-1867	03/08/66	800			07/07/66	0.273+/-0.228	0.410	
		02/07/66	03/04/66	02/19/66	66-2358	03/04/66	375	Bitburg	375	N/A	ND	ND	
		01/18/66	02/07/66	01/28/66	66-475	02/07/66	820	Torrejon	200	N/A	ND	ND	
		01/17/66	02/07/66	01/27/66	66-454	02/07/66	795	Torrejon	200	N/A	ND	ND	
		01/18/66	02/04/66	01/26/66	66-353	02/04/66	800	Torrejon	200	N/A	1.10+/-0.92	1.650	0.00551
		03/28/66	04/11/66	04/04/66	66-2989	04/23/66	600	Furth, Ger. US Army, 20th Sta Hosp.	600	N/A	ND	ND	
				04/04/66	66-2989	04/23/66	600			07/15/66	4.288+/-0.455	8.572	

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
(b) (6) [redacted]	(b) (6) [redacted]	01/25/66	02/17/66	02/05/66	66-1123	02/17/66	970	Toul Rosieres	970	03/23/66	ND	ND	
		02/09/66	03/09/66	02/23/66	66-2074	03/09/66	700	Torrejon	700	N/A	0.308+/-0.121	0.528	0.00172
		01/18/66	01/30/66	01/24/66	66-3127	04/13/66	2090	Moron	1045	N/A	NR	NR	
					66-3127-S	04/13/66	2090	Moron	1045	N/A	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	04/04/66	02/25/66	66-2890	04/04/66	720	Vandenburg	720	N/A	ND	ND	
		03/28/66	04/11/66	04/04/66	66-2994	04/23/66	1600	Furth , Ger. US Army, 20th Sta Hosp.	1600	N/A	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]	01/21/66	02/01/66	01/26/66	66-2878	04/04/66	1300	Torrejon	1300	N/A	0.249+/-0.133	0.249	
					66-2878	04/04/66	1300			07/13/66	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	03/08/66	02/11/66	66-2616	03/08/66	650	Vandenburg	650	N/A	ND	ND	
		01/18/66	01/27/66	01/22/66	66-1139	01/27/66	148	US Naval Ocean Graph	148	03/17/66	ND	ND	
					66-1493	02/28/66	250	US Naval Ocean Graph	260	N/A	1.40+/-0.17	6.720	0.00888
(b) (6) [redacted]	(b) (6) [redacted]	02/20/66	03/29/66	03/10/66	66-2279	03/29/66	1000	Torrejon	1000	N/A	0.214+/-0.129	0.257	0.00119
		02/16/66	03/19/66	03/03/66	66-2322	03/19/66	870	Torrejon	870	N/A	0.117 +/- 0.159	0.161	
		02/13/66	03/09/66	02/25/66	66-2051	03/09/66	440	Torrejon	440	N/A	0.137+/-0.079	0.374	
		01/19/66	02/19/66	02/03/66	66-1208	02/19/66	860	Toul Rosieres	894	N/A	ND	ND	
		01/18/66	03/03/66	02/09/66	66-1929	03/03/66	850	Albuquerque, NM	850	N/A	0.255+/-0.099	0.360	
		02/28/66	03/18/66	03/09/66	66-2096	03/18/66	900	Lindsey AS, Germany	900	N/A	0.115+/-0.085	0.153	0.000487
(b) (6) [redacted]	(b) (6) [redacted]	02/24/66	03/19/66	03/07/66	66-2335	03/19/66	890	Toul Rosieres	890	N/A	0.221+/-0.139	0.298	0.001
		02/21/66	03/27/66	03/10/66	66-2595	03/27/66	7510	Moron	750	N/A	0.102+/-0.102	0.102	
		02/18/66	03/18/66	03/04/66	66-2239	03/18/66	950	Toul Rosieres	950	N/A	0.180+/-0.155	0.227	0.00168
		01/17/66	02/12/66	01/30/66	66-776	02/12/66	340	Torrejon	200	N/A	1.21+/-0.80	4.271	0.0106
		02/13/66	03/19/66	03/02/66	66-2559	03/19/66	700	Torrejon	700	N/A	0.167+/-0.124	0.286	0.00102
		01/18/66	02/07/66	01/28/66	66-470	02/07/66	990	Moron	200	N/A	1.05+/-0.78	1.273	0.00411
		02/25/66	03/11/66	03/04/66	66-3132	04/13/66	740	Wheelus AF, Libya	740	N/A	0.168+/-0.087	0.272	
					66-3132	04/13/66	740			n/a	0.230	0.373	
(b) (6) [redacted]	(b) (6) [redacted]	02/13/66	03/16/66	02/28/66	66-2030	03/16/66	980	Torrejon	980	N/A	0.136+/-0.079	0.167	
		01/25/66	02/09/66	02/01/66	66-804	02/09/66	810	Hanaw, Germany	200	N/A	2.07+/-1.05	3.067	0.0105
		01/17/66	04/01/66	02/23/66	66-2879	04/01/66	900	Torrejon	900	N/A	1.48+/-1.31	1.973	
					66-2879	04/01/66	900			08/22/66	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/12/66	01/30/66	66-785	02/12/66	420	Torrejon	200	N/A	0.94+/-0.62	2.886	0.0106
		02/27/66	03/08/66	03/03/66	66-2502	03/08/66	1000	Torrejon	1000	N/A	0	0.000	
		01/18/66	03/09/66	02/12/66	66-2064	03/09/66	830	Torrejon	830	N/A	0.161+/-0.088	0.233	
		02/09/66	03/08/66	02/22/66	66-1897	03/08/66	825	San Pablo	825	N/A	0.183+/-0.112	0.266	
		01/24/66	01/29/66	01/26/66	66-1190	01/29/66	n/a	San Pablo	n/a	N/A	0	0.000	
		02/11/66	03/19/66	03/01/66	66-2086	03/19/66	550	Moron	550	N/A	0.172+/-0.103	0.375	n/a
		01/24/66	02/12/66	02/02/66	66-781	02/12/66	670	Toul Rosieres	200	N/A	0.94+/-0.78	1.684	0.00681
					66-3265	06/01/66	1780	Toul Rosieres	1060	N/A	0	0.000	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	01/21/66	01/19/66	66-225	01/21/66	350	Torrejon	200	N/A	0.662 +/- 0.385	2.270	
		01/31/66	03/28/66	02/28/66	66-2674	03/28/66	1000	Torrejon	1000	N/A	ND	ND	
		01/18/66	01/21/66	01/19/66	66-219	01/21/66	275	Torrejon	84	N/A	5.45 +/- 1.18	23.762	
		01/19/66	02/23/66	02/05/66	66-1047	02/23/66	960	Ramstein	980	05/17/66	2.39+/-0.40	2.988	0.0173
		02/12/66	03/08/66	02/24/66	66-2497	03/08/66	500	Moron	500	N/A	0.14	0.336	
		02/13/66	03/19/66	03/02/66	66-2207	03/19/66	600	Moron	600	N/A	1.45	2.900	
		02/11/66	03/24/66	03/03/66	66-2701	03/30/66	1300	Moron	1300	N/A	0.209+/-0.134	0.209	n/a
		01/20/66	03/21/66	02/19/66	66-2008	03/21/66	300	US Naval Ocean Graph	300	04/11/66	0.203+/-0.103	0.812	0.00663
(b) (6) [redacted]	(b) (6) [redacted]	01/30/66	03/18/66	02/22/66	66-2118	03/18/66	900	Giessen	900	N/A	0.162+/-0.113	0.216	0.00151
		02/09/66	03/06/66	02/22/66	66-1911	03/08/66	850	Torrejon	850	N/A	0.230+/-0.096	0.325	n/a
		01/16/66	02/08/66	01/28/66	66-1348	02/08/66	400	Toul Rosieres	416	N/A	0.115 +/- 0.154	0.345	
		02/03/66	02/15/66	02/09/66	66-1164	02/15/66	1875	American Embassy, Madrid	1000	N/A	0	0.000	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/07/66	01/28/66	66-500	02/07/66	970	Torrejon	200	N/A	3.72+/-1.45	4.602	0.0149
		01/18/66	01/21/66	01/19/66	66-252	01/21/66	1275	Torrejon	200	N/A	2.04 +/- 1.44	2.040	
		01/18/66	02/12/66	01/30/66	66-1002	02/12/66	1500	Kirtland AFB BO97	200	N/A	ND	ND	
		01/18/66	03/04/66	02/09/66	66-1953	03/04/66	1825	Moron	1825	N/A	0.560+/-0.152	0.560	0.0044

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
(b) (6) [redacted]	(b) (6) [redacted]	01/17/66	03/19/66	02/16/66	66-1934	03/03/66	1875	Torrejon	1875	N/A	0.25+/-0.106	0.250	
(b) (6) [redacted]	(b) (6) [redacted]				66-2572	03/19/66	900	Torrejon	900	N/A	1.21+/-0.31	1.613	0.01163
		01/25/66	03/13/66	02/17/66	66-2546	03/13/66	1500	Charleston	1500	N/A	0.382+/-0.171	0.382	0.00317
		01/18/66	02/07/66	01/28/66	66-494	02/07/66	970	Torrejon	200	N/A	8.49+/-1.84	10.503	0.034
		02/25/66	03/08/66	03/02/66	66-2478	03/08/66	300	Torrejon	300	N/A	0.311	1.244	
		01/29/66	03/18/66	02/22/66	66-2090	03/18/66	890	Torrejon	890	N/A	0.327+/-0.130	0.441	0.00259
		02/27/66	03/19/66	03/09/66	66-2228	03/19/66	920	Moron	920	N/A	ND	ND	
		01/18/66	02/09/66	01/29/66	66-816	02/09/66	290	Moron	200	N/A	0.46+/-0.32	1.903	0.00651
		01/18/66	01/29/66	01/23/66	66-1144	01/29/66	194	856 Eng. Bn., APO09081	194	03/17/66	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]	01/29/66	02/19/66	02/08/66	66-1206	02/19/66	1400	San Pablo	1000	N/A	ND	ND	
		02/25/66	03/08/66	03/02/66	66-2490	03/08/66	1000	San Pablo	1000	N/A	ND	ND	
		01/18/66	01/17/66	01/17/66	66-1150	01/17/66	465	Torrejon	465	03/17/66	ND	ND	
		01/18/66	02/28/66	02/07/66	66-1495	02/28/66	260	US Naval Ocean Graph	270	N/A	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]	02/27/66	03/14/66	03/08/66	66-2080	03/28/66	900	Torrejon	900	N/A	0.178+/-0.113	0.237	
		01/19/66	02/08/66	01/29/66	66-843	02/08/66	650	Toul Rosieres	200	N/A	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]	03/08/66	03/19/66	03/13/66	66-2178	03/19/66	250	Toul Rosieres	250	N/A	0.212	1.018	
		02/13/66	03/08/66	02/24/66	66-2460	03/08/66	850	Moron	850	N/A	ND	ND	
		02/08/66	02/08/66	02/08/66	66-1375	02/28/66	840 (12-hr)	Torrejon	840	N/A	0.108	0.108	
		02/08/66	03/01/66	02/18/66	66-1850	03/01/66	760	Moron	760	N/A	ND	ND	
		02/18/66	03/04/66	02/25/66	66-2345	03/04/66	910	Moron	910	N/A	ND	ND	
		02/25/66	03/18/66	03/07/66	66-2253	03/18/66	900	Moron	900	N/A	0.233+/-0.134	0.311	0.000994
		03/14/66	03/19/66	03/16/66	66-2072	03/19/66	960	Moron	960	N/A	1.23+/-0.23	1.539	0.00179
		01/18/66	02/05/66	01/27/66	66-920	02/05/66	420	Torrejon	200	N/A	1.33+/-0.49	3.800	0.0011
		03/17/66	03/17/66	03/17/66	66-2937	04/20/66	500	Torrejon	500	N/A	ND	ND	
					66-2937	04/20/66	500			07/18/66	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	02/04/66	02/25/66	02/14/66	66-1487	03/04/66	3700	USS Masopelea ATF-158	1000	N/A	NR	NR	
					66-2874	03/04/66	1000	USS Masopelea ATF-158	1000	04/15/66	0.171+/-0.119	0.205	
(b) (6) [redacted]	(b) (6) [redacted]	01/25/66	02/09/66	02/01/66	66-799	02/09/66	910	Hanaw, Germany	200	N/A	ND	ND	
		01/18/66	02/15/66	02/01/66	66-951	02/15/66	2100	Torrejon	200	N/A	ND	ND	
		02/27/66	03/08/66	03/03/66	66-2474	03/08/66	900	Torrejon	900	N/A	0.27	0.380	
		01/18/66	02/05/66	01/27/66	66-892	02/05/66	540	Torrejon	200	N/A	6.63+/-1.12	14.733	0.0426
		01/25/66	02/09/66	02/01/66	66-730	02/09/66	980	Hanaw, Germany	200	N/A	ND	ND	
		02/08/66	03/19/66	02/27/66	66-2084	03/19/66	990	Moron	990	N/A	0.254+/-0.112	0.308	0.00176
		02/18/66	03/18/66	03/04/65	66-2089	03/18/66	800	Torrejon	800	N/A	0.191+/-0.106	0.287	
		01/25/66	02/09/66	02/01/66	66-743	02/09/66	725	Hanaw, Germany	200	N/A	1.34+/-0.77	2.218	0.00756
		01/29/66	02/19/66	02/08/66	66-1195	02/19/66	1395	San Pablo	1000	N/A	3.85+/-9.56	3.850	
		01/18/66	01/29/66	01/23/66	66-1110	01/29/66	980	Moron	980	N/A	NR	NR	
		02/10/66	03/12/66	02/25/66	66-2035	03/19/66	900	Torrejon	900	04/07/66	NR	NR	
		01/29/66	02/22/66	02/10/66	66-1083	02/22/66	910	Torrejon	910	03/17/66	8.22+/-0.78	10.840	0.0526
					66-2928	04/21/66	600	Torrejon	600	N/A	1.37+/-0.30	2.740	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/06/66	01/27/66	66-505	02/06/66	930	Torrejon	200	N/A	5.05+/-1.66	6.516	0.0199
		03/12/66	03/19/66	03/15/66	66-2181	03/19/66	500	Torrejon	500	N/A	0.54	1.296	
		01/19/66	02/08/66	01/29/66	66-833	02/08/66	775	Toul Rosieres	200	N/A	NR	NR	
		01/18/66	02/05/66	01/27/66	66-887	02/05/66	870	Torrejon	200	N/A	1.06+/-0.67	1.462	0.00443
		01/18/66	01/29/66	01/23/66	66-1066	01/29/66	440	Zaragoza	440	N/A	ND	ND	
		02/10/66	03/19/66	02/28/66	66-2166	03/19/66	1150	Moron	1150	N/A	0.329	0.343	
		02/01/66	02/18/66	02/09/66	66-1198	02/18/66	n/a	Moron	n/a	N/A	NR	NR	
		01/24/66	04/11/66	03/03/66	66-1038	02/20/66	495	Torrejon	200	N/A	1.42+/-0.55	3.442	0.0183
					66-3404	06/10/66	590	HQ 8 AF Westover AFB, Mass	330	N/A	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	02/10/66	03/20/66	03/01/66	66-2309	03/20/66	860	Torrejon	860	N/A	0.199+/-0.134	0.278	0.000132
		01/20/66	02/08/66	01/29/66	66-443	02/08/66	600	Toul Rosieres	200	N/A	0.76+/-0.48	1.520	0.00403
		02/26/66	03/28/66	03/13/66	66-2583	03/19/66	n/a	Moron	n/a	N/A	NR	NR	
					66-3111	04/13/66	550	Moron	550	N/A	0.233+/-0.072	0.508	
(b) (6) [redacted]	(b) (6) [redacted]	02/25/66	03/18/66	03/07/66	66-2247	03/18/66	510	Torrejon	510	N/A	0.126+/-0.126	0.296	
		01/18/66	02/19/66	02/03/66	66-1225	02/19/66	650	Torrejon	650	N/A	NR	NR	

Individuals with Urine Samples Classified as Remaining Cases

μCi ?

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/07/66	01/28/66	66-493	02/07/66	950	Torrejon	200	N/A	1.43+/-1.11	1.806	0.00582
		01/18/66	02/08/66	01/28/66	66-1395	02/28/66	980 (12-hr)	Torrejon	1000	N/A	0.539	0.539	0.003
		01/18/66	03/04/66	02/09/66	66-341	02/04/66	1000	Torrejon	200	N/A	2.16+/-1.25	2.592	0.0108
(b) (6) [redacted]	(b) (6) [redacted]				66-2373	03/04/66	700	Torrejon	700	N/A	0.435+/-0.182	0.746	0.00137
		02/09/66	03/09/66	02/23/66	66-2392	03/09/66	1200	Torrejon	1200	N/A	0.147+/-0.143	0.147	0.000778
		01/18/66	02/07/66	01/28/66	66-491	02/07/66	830	Torrejon	200	N/A	3.93+/-1.31	5.882	0.0183
		03/12/66	03/19/66	03/15/66	66-2179	03/19/66	600	Torrejon	600	N/A	0.108	0.216	
		01/18/66	02/07/66	01/28/66	66-477	02/07/66	625	Torrejon	200	N/A	ND	ND	
		01/18/66	02/14/66	01/31/66	66-289	01/21/66	790	Torrejon	200	N/A	1.074+/-0.7031	1.631	
(b) (6) [redacted]	(b) (6) [redacted]				66-1006	02/14/66	1170	Kirtland AFB BO97	200	N/A	NR	NR	
		01/29/66	02/22/66	02/10/66	66-1092	02/22/66	1150	Torrejon	1150	03/17/66	3.93+/-0.54	4.101	0.0192
		01/18/66	01/21/66	01/19/66	66-210	01/21/66	300	Torrejon	200	N/A	NR	NR	
		01/18/66	01/21/66	01/19/66	66-217	01/21/66	400	Torrejon	200	N/A	NR	NR	
		02/25/66	03/18/66	03/07/66	66-2261	03/18/66	880	Moron	880	N/A	0.1338+/-0.1408	0.182	
		02/06/66	02/26/66	02/16/66	66-1385	02/26/66	900	Torrejon	930	N/A	1.51	2.013	0.006
		03/14/66	03/19/66	03/16/66	66-2123	03/19/66	900	Torrejon	900	N/A	0.240+/-0.165	0.320	0.00035
		01/22/66	03/07/66	02/13/66	66-2992	04/26/66	750	Furth , Ger. US Army, 20th Sta Hosp.	750	N/A	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]	01/25/66	02/09/66	02/01/66	66-735	02/09/66	970	Hanaw, Germany	200	N/A	1.68+/-0.87	2.326	0.0079
		03/14/66	03/19/66	03/16/66	66-2077	03/19/66	310	Torrejon	310	N/A	0.128+/-0.076	0.495	
		02/09/66	03/09/66	02/23/66	66-2399	03/09/66	980	Torrejon	980	N/A	0.129+/-0.107	0.158	0.000719
		01/18/66	02/05/66	01/27/66	66-886	02/05/66	840	Moron	200	N/A	0.83+/-0.34	0.900	0.00259
		03/11/66	03/19/66	03/15/66	66-2180	03/19/66	950	Moron	950	N/A	0.342	0.432	
		02/25/66	03/19/66	03/08/66	66-2224	03/19/66	730	Moron	730	N/A	0.1015+/-0.1088	0.167	
		01/31/66	03/03/66	02/15/66	66-2012	03/03/66	690	Torrejon	890	N/A	0.401+/-0.147	0.541	
		01/18/66	04/11/66	02/28/66	66-3115	04/13/66	1450	San Pablo	725	N/A	0.217+/-0.120	0.217	
		01/28/66	02/09/66	02/02/66	66-815	02/09/66	910	Hanaw, Germany	200	N/A	ND	ND	
		01/18/66	02/07/66	01/28/66	66-456	02/07/66	520	Torrejon	200	N/A	0.55+/-0.40	1.269	0.00389
		01/18/66	02/03/66	01/26/66	66-1817	02/03/66	875	Torrejon	875	N/A	0.64	0.878	0.00714
		01/18/66	02/06/66	01/27/66	66-512	02/06/66	570	Torrejon	200	N/A	1.19+/-0.74	2.505	0.00764
		01/18/66	03/17/66	02/16/66	66-2019	03/17/66	1750	Blytheville AFB, AR	1750	N/A	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]	01/24/66	02/19/66	02/06/66	66-1952	02/23/66	1350	Torrejon	1350	N/A	0.187+/-0.093	0.187	
		01/18/66	02/04/66	01/26/66	66-344	02/04/66	800	Torrejon	200	N/A	2.37+/-0.92	3.555,	0.0112
		03/14/66	03/14/66	03/14/66	66-2069		960	Moron	960	N/A	0.571+/-0.171	0.714	0.00235
		01/17/66	02/05/66	01/27/66	66-913	02/08/66	945	Torrejon	200	N/A	ND	ND	
		02/06/66	03/19/66	02/26/66	66-2129	03/19/66	600	Torrejon	600	N/A	0.159+/-0.119	0.318	0.000231
					66-1377	02/28/66	840 (12-hr)	Torrejon	872	N/A	ND	ND	
					66-1377	02/28/66	840 (12-hr)			08/29/66	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	02/10/66	03/19/66	02/28/66	66-2136	03/19/66	860	Moron	860	N/A	ND	ND	
		02/01/66	02/19/66	02/10/66	66-1216	02/19/66	970	Sandia Base	970	N/A	4.67+/-1.29	5.777	0.0183
		02/06/66	02/26/66	02/16/66	66-1386	02/26/66	1520	Torrejon	1000	N/A	2.13	2.130	0.009
		01/19/66	02/08/66	01/29/66	66-840	02/08/66	780	Moron	200	N/A	ND	ND	
		02/01/66	02/26/66	02/13/66	66-1406	02/26/66	800	Torrejon	832	N/A	0.363+/-0.212	0.545	0.00182
		01/29/66	02/22/66	02/10/66	66-1085	02/22/66	510	Torrejon	510	03/17/66	1.28+/-0.34	3.012	0.0147
		01/18/66	02/05/66	01/27/66	66-931	02/05/66	860	Moron	200	N/A	18.2+/-2.2	22.091	0.0834
		01/18/66	02/07/66	01/28/66	66-488	02/07/66	845	Torrejon	200	N/A	0.90+/-0.78	1.278	0.00411
		02/15/66	04/11/66	03/14/66	66-1949	03/18/66	1550	Torrejon	1550	N/A	1.31+/-0.23	1.310	0.00756
					66-2936	04/15/66	1000	Torrejon	1000	N/A	ND	ND	
					66-2938	04/14/66	1000			07/05/66	7.403+/-0.455	8.916	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	01/21/66	01/19/66	66-243	01/21/66	510	Torrejon	200	N/A	0.8528+/-0.8375	1.536	
		02/06/66	02/26/66	02/16/66	66-1425	02/26/66	820	Moron	644	N/A	0.440+/-1.81	0.852	
		02/06/66	02/26/66	02/16/66	66-1431	02/26/66	900	Moron	938	N/A	NR	NR	
		02/21/66	03/19/66	03/06/66	66-2082	03/19/66	870	Moron	870	N/A	0.163+/-0.088	0.225	0.000937
		01/18/66	02/08/66	01/28/66	66-1342	02/08/66	1210	Toul Rosieres	1000	N/A	NR	NR	
		01/17/66	01/24/66	01/20/66	66-2588	03/23/66	1200	Norton AFB, CA	1200	N/A	0.221+/-0.134	0.221	
		02/11/66	03/19/66	03/01/66	66-2314	03/19/66	550	Torrejon	550	N/A	0.111+/-0.108	0.242	0.000852
		01/18/66	02/07/66	01/28/66	66-490	02/07/66	920	Torrejon	200	N/A	4.64+/-1.48	8.052	0.0195
		01/18/66	02/05/66	01/27/66	66-940	02/05/66	350	Torrejon	200	N/A	0.70+/-0.57	2.400	0.00687

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
(b) (6) [redacted]	(b) (6) [redacted]	02/11/66	03/19/66	03/01/66	66-2132	03/19/66	880	Torrejon	880	N/A	0.212+/-0.134	0.289	0.00133
		01/25/66	02/21/66	02/07/66	66-1114	01/24/66	980	Ramstein	980	03/23/66	NR	NR	
					66-1013	02/21/66	1870	Torrejon	200	N/A	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]				66-2586	03/16/66	2325	Ramstein	2325	N/A	0.120+/-0.108	0.120	
		01/18/66	02/08/66	01/28/66	66-388	02/04/66	900	Torrejon	200	N/A	61.4+/-4.3	81.867	0.307
(b) (6) [redacted]	(b) (6) [redacted]				66-1160	02/18/66	2120	Torrejon	2120	N/A	ND	ND	
		01/18/66	01/21/66	01/19/66	66-236	01/21/66	500	Torrejon	200	N/A	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]				66-239	01/21/66	425	Torrejon	200	N/A	NR	NR	
		01/18/66	02/07/66	01/28/66	66-460	02/07/66	395	Moron	200	N/A	2.08+/-0.71	6.258	0.0202
		01/18/66	03/18/66	02/16/66	66-2244	03/18/66	440	Torrejon	440	N/A	ND	ND	
		01/18/66	02/04/66	01/26/66	66-339	02/04/66	900	Torrejon	200	N/A	2.22+/-0.99	2.960	0.0111
		02/13/66	03/19/66	03/02/66	66-2153	03/19/66	940	Torrejon	940	N/A	0.137+/-0.107	0.175	0.000839
		01/18/66	02/07/66	01/28/66	66-465	02/07/66	960	Torrejon	200	N/A	1.23+/-0.82	1.538	0.00469
		01/18/66	02/04/66	01/26/66	66-338	02/04/66	660	Torrejon	200	N/A	ND	ND	
		01/18/66	03/03/66	02/09/66	66-1936	03/03/66	1825	625TH MASS (MAC)	1905	N/A	0.225+/-0.118	0.225	
(b) (6) [redacted]	(b) (6) [redacted]	02/08/66	02/25/66	02/16/66	66-1354	02/25/66	500	Toul Rosieres	520	N/A	ND	ND	
		01/29/66	03/19/66	02/22/66	66-2044	03/19/66	790	Torrejon	790	04/06/66	NR	NR	
		01/18/66	02/26/66	02/06/66	66-1414	02/26/66	880	Torrejon	915	N/A	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]				66-1414	02/26/66	880			07/29/66	NR	NR	
		01/18/66	01/21/66	01/19/66	66-265	01/21/66	1100	Torrejon	200	N/A	NR	NR	
		01/18/66	01/31/66	01/24/66	66-381	02/01/66	2800	Sembach	200	N/A	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]				66-381	02/01/66	2800			n/a	ND	ND	
		01/18/66	03/02/66	02/08/66	66-912	02/18/66	2760	Seymour Johnson	200	02/23/66	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]				66-1298	03/02/66	2910	Seymour Johnson	1000	N/A	ND	ND	
		01/18/66	02/07/66	01/28/66	66-1353	02/07/66	340	Moron	353	N/A	0.156+/-0.209	0.551	
		01/20/66	02/07/66	01/29/66	66-466	02/07/66	655	Toul Rosieres	200	N/A	0.64+/-0.52	1.173	0.00375
		01/31/66	03/20/66	02/24/66	66-2291	03/20/66	550	Norfolk	550	N/A	0.133+/-0.120	0.290	0.00124
		01/18/66	02/22/66	02/04/66	66-1243	02/22/66	810	Offutt AFB, NE	842	N/A	ND	ND	
		02/06/66	02/26/66	02/16/66	66-1423	02/25/66	760	Moron	790	N/A	0.453+/-0.175	0.715	
(b) (6) [redacted]	(b) (6) [redacted]				66-1423	02/26/66	760			06/23/66	0.057+/-0.023	0.090	
		01/18/66	02/16/66	02/01/66	66-967	02/16/66	2570	Torrejon	200	N/A	ND	ND	
		02/18/66	03/18/66	03/04/66	66-2114	03/18/66	430	Moron	430	N/A	0.179+/-0.118	0.500	0.00137
		02/08/66	02/26/66	02/16/66	66-1433	02/26/66	720	Moron	748	N/A	0.131+/-0.176	0.218	
		02/10/66	03/08/66	02/23/66	66-2510	03/08/66	1000	Moron	1000	N/A	0.45	0.540	
		01/18/66	03/25/66	02/20/66	66-2597	03/25/66	950	USAH Wurzburg, Germany	950	N/A	0.371+/-0.210	0.469	
(b) (6) [redacted]	(b) (6) [redacted]	02/27/66	03/19/66	03/09/66	66-2125	03/19/66	940	Torrejon	940	N/A	ND	ND	
		02/05/66	02/25/66	02/15/66	66-1349	02/25/66	600	Sembach	624	N/A	0.176+/-0.574	0.352	
		02/09/66	03/01/66	02/19/66	66-1852	03/01/66	600	San Pablo	600	N/A	1.88+/-0.35	3.720	
		02/25/66	03/18/66	03/07/66	66-2264	03/18/66	950	Moron	950	N/A	0.161+/-0.113	0.203	0.000986
		01/18/66	02/12/66	01/30/66	66-778	02/12/66	785	Torrejon	200	N/A	2.77+/-0.96	4.234	0.0166
		02/02/66	02/22/66	02/12/66	66-1088	02/22/66	370	San Pablo	370	03/17/66	10.8+/-0.8	34.378	0.146
(b) (6) [redacted]	(b) (6) [redacted]				66-2592	03/28/66	1750	San Pablo	1750	N/A	0.229+/-0.184	0.229	
		02/18/66	03/19/66	03/04/66	66-2048	03/19/66	800	Moron	800	N/A	0.269+/-0.109	0.404	
		02/21/66	03/18/66	03/05/66	66-2579	03/18/66	1000	Torrejon	1000	N/A	.398+/-0.175	0.475	
		02/18/66	03/12/66	03/01/66	66-2033	03/19/66	1500	Torrejon	1500	N/A	0.167+/-0.093	0.167	
		02/06/66	02/08/66	02/07/66	66-1397	02/28/66	880 (12-hr)	Moron	915	N/A	0.195	0.195	0.0008
		01/18/66	03/08/66	02/11/66	66-2477	03/08/66	250	Torrejon	250	N/A	0.38	1.728	
		01/18/66	02/06/66	01/27/66	66-502	02/06/66	860	Torrejon	200	N/A	2.36+/-0.99	3.293	0.01
		01/29/66	02/22/66	02/10/66	66-1090	02/22/66	1460	Torrejon	1460	03/17/66	4.35+/-0.53	4.350	0.0212
		03/14/66	03/19/66	03/16/66	66-2158	03/19/66	900	Torrejon	900	N/A	0.148+/-0.135	0.197	0.000215
		03/21/66	04/11/66	03/31/66	66-3198	05/09/66	950	Torrejon	950	N/A	0.191+/-0.089	0.241	
		01/18/66	02/06/66	01/27/66	66-503	02/06/66	900	Torrejon	200	N/A	4.89+/-1.43	6.520	1.99
		02/27/66	03/24/66	03/11/66	66-2698	04/05/66	800	Moron	800	N/A	0.133+/-0.113	0.200	
		03/14/66	03/19/66	03/16/66	66-2555	03/19/66	950	Torrejon	950	N/A	0.147+/-0.143	0.186	0.000213
		01/17/66	02/02/66	01/25/66	66-3211	05/16/66	450	67th ARS Prestwick MOA, Scotland	450	N/A	0.161+/-0.078	0.429	
(b) (6) [redacted]	(b) (6) [redacted]	02/11/66	02/15/66	02/13/66	66-3208	04/20/66	1340	Torrejon	670	N/A	0.500+/-0.198	0.500	

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
[redacted]	[redacted]	01/18/66	04/11/66	02/28/66	66-3208-5	04/20/66	1340	n/a	670	N/A	NR	NR	
		02/09/66	03/09/66	02/23/66	66-2083	03/09/66	1000	Torrejon	1000	N/A	0.136+/-0.082	0.163	0.000758
		02/11/66	02/11/66	02/11/66	66-2867	03/25/66	1350	Torrejon	1350	N/A	0.105+/-0.102	0.105	
		02/12/66	03/16/66	02/28/66	66-2031	03/16/66	960	Moron	960	N/A	0.114+/-0.081	0.143	0.000714
		02/13/66	03/19/66	03/02/66	66-2135	03/19/66	920	Moron	920	N/A	0.151+/-0.100	0.197	0.000925
		02/27/66	03/19/66	03/09/66	66-2139	03/19/66	950	Torrejon	950	N/A	0.1302+/-0.1302	0.164	
		01/18/66	02/04/66	01/26/66	66-355	02/04/66	560	Torrejon	200	N/A	ND	ND	
		02/17/66	03/10/66	02/27/66	66-2014	03/16/66	630	Torrejon	630	N/A	0.176+/-0.114	0.335	
		01/16/66	03/03/66	02/09/66	66-1930	03/03/66	845	Albuquerque, NM	845	N/A	0.183+/-0.093	0.260	
		01/18/66	02/06/66	01/27/66	66-513	02/06/66	640	Moron	200	N/A	4.53+/-1.06	8.494	0.0259
		01/18/66	02/09/66	01/29/66	66-738	02/09/66	970	Hanaw, Germany	200	N/A	ND	ND	
		01/16/66	03/20/66	02/17/66	66-2018	03/20/66	1320	Tinker AFB	1320	N/A	0.156+/-0.084	0.156	
		01/18/66	02/06/66	01/27/66	66-525	02/06/66	460	Torrejon	200	N/A	1.44+/-0.71	3.757	0.0115
		01/23/66	03/20/66	02/20/66	66-2305	03/20/66	680	Pirmasens	680	N/A	0.214+/-0.129	0.292	0.00183
		02/21/66	03/18/66	03/05/66	66-2256	03/18/66	920	Zaragoza	920	N/A	0.225+/-0.134	0.293	0.00109
		01/16/66	02/05/66	01/27/66	66-682	02/05/66	950	Moron	200	N/A	1.22+/-0.73	1.541	0.00443
		02/21/66	03/18/66	03/05/66	66-2100	03/18/66	980	Moron	980	N/A	0.119+/-0.074	0.146	0.000864
		02/13/66	03/19/66	03/02/66	66-2229	03/19/66	500	San Pablo	500	N/A	0.226+/-0.134	0.542	0.00184
		02/09/66	03/08/66	02/22/66	66-1901	03/08/66	880	Moron	880	N/A	0.186+/-0.085	0.254	
		01/18/66	01/21/66	01/19/66	66-238	01/21/66	475	Torrejon	200	N/A	NR	NR	
					66-241	01/21/66	350	Torrejon	200	N/A	NR	NR	
[redacted]	[redacted]	01/18/66	01/29/66	01/23/66	66-1212	01/29/66	680	San Pablo	707	N/A	0.427+/-0.159	0.754	0.00108
		01/18/66	01/21/66	01/19/66	66-234	01/21/66	490	Torrejon	200	N/A	NR	NR	
		02/24/66	03/19/66	03/07/66	66-2168	03/19/66	1000	Toul Rosieres	1000	N/A	0.64	0.768	
		02/06/66	02/26/66	02/16/66	66-1424	02/26/66	860	Moron	894	N/A	0.205+/-0.124	0.286	
					66-1424	02/26/66	860			06/28/66	NR	NR	
[redacted]	[redacted]	02/13/66	03/13/66	02/27/66	66-2678	03/25/66	2000	Torrejon	2000	N/A	0.125+/-0.094	0.125	
		01/17/66	02/12/66	01/30/66	66-777	02/12/66	292	Torrejon	200	N/A	0.49+/-0.45	2.014	0.00791
		01/18/66	02/05/66	01/27/66	66-924	02/05/66	465	Torrejon	200	N/A	1.42+/-0.65	3.665	0.0105
		01/22/66	02/20/66	02/05/66	66-1040	02/20/66	2200	Furth , Ger. US Army, 20th Sta Hosp.	200	03/17/66	12.91+/-3.17	12.910	
[redacted]	[redacted]	02/06/66	02/26/66	02/16/66	66-1411	02/26/66	640	Moron	665	N/A	1.07+/-0.13	2.006	0.00454
		02/22/66	03/19/66	03/06/66	66-2194	03/19/66	800	Moron	800	N/A	ND	ND	
		01/18/66	01/28/66	01/23/66	66-3026	05/06/66	1400	Ramstein	1400	N/A	0.131+/-0.057	0.131	
		02/08/66	03/19/66	02/27/66	66-2183	03/19/66	802	Toul Rosieres	800	N/A	0.829	1.240	
		01/18/66	02/05/66	01/27/66	66-884	02/05/66	880	Torrejon	200	N/A	ND	ND	
		02/06/66	02/26/66	02/16/66	66-1412	02/28/66	650	Moron	676	N/A	0.135+/-0.103	0.249	
					66-1412	02/28/66	650			06/27/66	NR	NR	
[redacted]	[redacted]	03/14/66	03/26/66	03/20/66	66-2280	03/29/66	710	Torrejon	710	N/A	ND	ND	
					66-2865	04/06/66	1500	Torrejon	1500	N/A	1.16+/-0.28	1.160	
					66-2865	04/06/66	1500			08/30/66	NR	NR	
[redacted]	[redacted]	02/09/66	03/08/66	02/22/66	66-1865	03/08/66	800	Moron	800	N/A	ND	ND	
					66-1865	03/08/66	800			07/07/66	0.273+/-0.226	0.410	
[redacted]	[redacted]	01/18/66	02/09/66	01/29/66	66-656	02/09/66	1950	Blytheville AFB, AR	n/a	N/A	NR	NR	
[redacted]	[redacted]	01/18/66	02/05/66	01/27/66	66-922	02/05/66	820	Torrejon	200	N/A	NR	NR	
		03/26/66	04/11/66	04/03/66	66-3110	04/13/66	625	Moron	625	N/A	0.330+/-0.087	0.634	
		02/11/66	03/12/66	02/25/66	66-2641	03/28/66	600	09696 "D" Trp, 2/4 1966	600	N/A	0.287+/-0.166	0.574	
[redacted]	[redacted]	02/06/66	02/18/66	02/12/66	66-1388	02/18/66	700	Torrejon	728	N/A	1.05	1.800	0.004
		01/18/66	02/13/66	01/31/66	66-1441	03/02/66	930	Moron	930	03/17/66	ND	ND	
		01/25/66	02/09/66	02/01/66	66-811	02/09/66	810	Hanaw, Germany	200	N/A	1.64+/-.74	2.430	0.00873
		01/17/66	02/26/66	02/08/66	66-1418	02/26/66	880	Torrejon	915	N/A	0.117+/-0.157	0.160	
		01/18/66	01/17/66	01/17/66	66-1100	01/17/66	1160	Torrejon	1160	03/17/66	ND	ND	
		03/26/66	03/29/66	03/27/66	66-3124	04/13/66	980	Moron	490	N/A	0.212+/-0.161	0.260	
					66-3124-S	04/13/66	980	Moron	490	N/A	NR	NR	
[redacted]	[redacted]	01/24/66	01/30/66	01/27/66	66-2688	03/28/66	1800	Torrejon	1800	N/A	0.112+/-0.101	0.112	
		02/18/66	03/08/66	02/27/66	66-2472	03/08/66	900	Torrejon	900	N/A	0.194	0.259	
		01/16/66	02/04/66	01/26/66	66-336	02/04/66	950	Moron	200	N/A	ND	ND	

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
(b) (6) [redacted]	(b) (6) [redacted]	02/09/66	02/13/66	02/11/66	66-1165	02/15/66	1840	American Embassy, Madrid	1000	N/A	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	01/17/66	02/12/66	01/30/66	66-780	02/12/66	710	Torrejon	200	N/A	ND	ND	
		01/17/66	02/03/66	01/25/66	66-1837	02/03/66	750	Moron	750	N/A	0.252	0.403	
		02/08/66	03/29/66	03/04/66	66-2278	03/29/66	1000	Torrejon	1000	N/A	0.136+/-0.108	0.163	0.00094
					66-3207	04/25/66	845	Torrejon	845	N/A	0.125+/;-0.074	0.178	
(b) (6) [redacted]	(b) (6) [redacted]	02/13/66	03/08/66	02/24/66	66-2508	03/08/66	970	Moron	970	N/A	ND	ND	
		01/18/66	02/07/66	01/28/66	66-455	02/07/66	625	Torrejon	200	N/A	1.27+/-0.65	2.438	0.00744
		02/10/66	03/08/66	02/23/66	66-2487	03/08/66	950	Moron	950	N/A	0.153	0.193	
		01/23/66	02/15/66	02/03/66	66-1151	02/15/66	660	Toul Rosieres	688	N/A	NR	NR	
		01/18/66	02/07/66	01/28/66	66-482	02/07/66	595	Moron	200	N/A	2.39+/-0.87	4.820	0.0156
		02/11/66	02/18/66	02/14/66	66-3056	04/27/66	1000	Ramstein	1000	N/A	0.290+/-0.086	0.348	
		02/12/66	03/04/66	02/22/65	66-2383	03/04/66	550	Chaumont	550	N/A	0.307+/-155	0.674	0.00171
		01/18/66	02/07/66	01/28/66	66-444	02/07/66	395	Torrejon	195	N/A	0.61+/-0.35	1.853	0.00568
		01/18/66	01/29/66	01/23/66	66-1228	01/29/66	900	San Pablo	900	N/A	0.563	0.751	
		02/08/66	02/08/66	02/08/65	66-1383	02/28/66	860 (12-hr)	Torrejon	893	N/A	2.95	2.950	0.012
		01/18/66	02/12/66	01/30/55	66-361	02/04/66	875	Torrejon	200	N/A	63+/-4.3	66.400	0.315
					66-1166	02/18/66	960	Torrejon	960	N/A	2.93+/-1.23	3.663	0.0178
(b) (6) [redacted]	(b) (6) [redacted]	01/25/66	02/17/66	02/05/66	66-1124	02/17/66	780	Torrejon	780	03/23/66	0.276+/-0.241	0.425	0.00126
		02/10/66	03/19/66	02/28/66	66-2120	03/19/66	800	Torrejon	800	N/A	ND	ND	
		01/18/66	04/04/66	02/25/66	66-2895	04/04/66	550	Vandenburg	550	N/A	ND	ND	
		01/25/66	03/13/66	02/17/66	66-2543	03/13/66	450	Charleston	450	N/A	0.284	0.757	
		03/11/66	03/19/66	03/15/66	66-2319	03/19/66	900	Moron	900	N/A	0.200+/-0.134	0.267	0.000413
		02/04/65	02/10/66	02/07/66	66-3212	05/09/66	1300	814 Civil Eng. Sq. Westover AFB	650	N/A	0.234+/-0.136	0.234	
					66-3213-s	n/a	650	N/A	n/a	N/A	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/03/66	01/26/66	66-1831	02/03/66	550	Torrejon	550	N/A	NR	NR	
		01/29/66	02/19/66	02/08/66	66-1217	02/19/66	570	Torrejon	570	N/A	NR	NR	
					66-3209	04/21/66	1000	Torrejon	500	N/A	0.302+/-0.162	0.362	
					66-3209-S	04/21/66	1000	N/A	500	N/A	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/13/66	01/31/66	66-1109	02/13/66	1490	Moron	1000	N/A	ND	ND	
		02/14/66	02/26/66	02/20/66	66-1422	02/26/66	940	Moron	978	N/A	ND	ND	
		01/18/66	02/05/66	01/27/66	66-930	02/05/66	650	Moron	450	03/17/66	28.11+/-0.53	51.895	
		01/18/66	02/06/66	01/27/66	66-516	02/06/66	960	Moron	200	N/A	6.53+/-1.48	8.163	0.0249
		01/29/66	02/19/66	02/08/66	66-1192	02/19/66	1140	San Pablo	1000	N/A	2.11+/-0.68	2.221	0.00929
		02/06/66	02/25/66	02/15/66	66-1352	02/25/66	1400	Moron	1000	N/A	0.232+/-0.760	0.232	
		01/19/66	02/08/66	01/29/66	66-823	02/08/66	975	Torrejon	200	N/A	ND	ND	
					66-2295	03/20/66	980	Torrejon	980	N/A	0.331+/-0.160	0.405	0.0031
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	03/03/66	02/09/66	66-1933	03/03/66	1875	Torrejon	1875	N/A	0.337+/-0.114	0.337	
(b) (6) [redacted]	(b) (6) [redacted]				66-250	01/21/66	190	Torrejon	190	N/A	0.5225+/-0.2261	3.300	
		01/18/66	02/06/66	01/27/66	66-504	02/06/66	960	Moron	200	N/A	1.61+/-1.18	2.013	0.00617
		01/18/66	03/03/66	02/09/66	66-1939	03/03/66	1450	625TH MASS (MAC)	1530	N/A	0.189+/-0.102	0.189	
(b) (6) [redacted]	(b) (6) [redacted]	02/10/66	03/18/66	02/28/66	66-2093	03/18/66	700	Moron	700	N/A	ND	ND	
		01/25/66	02/09/66	02/01/66	66-736	02/09/66	960	Hanaw, Germany	200	N/A	3.22+/-1.23	4.025	0.0137
		02/04/66	02/25/66	02/14/66	66-1484	03/04/66	1920	USS Recovery ARS-43	1000	N/A	1.61+/-0.75	1.610	
(b) (6) [redacted]	(b) (6) [redacted]	01/30/66	01/31/66	01/30/66	66-3107	04/13/66	850	Moron	850	N/A	0.136+/-0.057	0.192	
		02/13/66	03/19/66	03/02/66	66-2584	03/19/66	1200	Moron	1200	N/A	0.176+/-0.118	0.176	
		02/27/66	03/19/66	03/09/66	66-2124	03/19/66	860	Moron	860	N/A	0.119+/-0.101	0.166	0.00049
		01/18/66	01/21/66	01/19/66	66-245	01/21/66	890	Torrejon	200	N/A	5.9363+/-1.4665	8.004	
		01/18/66	03/04/66	02/09/66	66-2370	03/04/66	1450	Torrejon	1450	N/A	0.187+/-0.133	0.187	0.00139
(b) (6) [redacted]	(b) (6) [redacted]				66-1874	03/08/66	960	Torrejon	582	N/A	1.67	2.088	0.013
		01/18/66	02/09/66	01/29/66	66-609	02/09/66	570	Moron	200	N/A	11.1+/-1.65	23.368	
		01/25/66	02/17/66	02/05/66	66-1121	02/17/66	220	Torrejon	220	03/17/66	0.25+/-0.21	1.364	0.0066
		02/10/66	03/19/66	02/28/66	66-2122	03/19/66	800	Torrejon	800	N/A	ND	ND	
		01/20/66	02/09/66	01/30/66	66-826	02/09/66	800	Toul Rosieres	200	N/A	ND	ND	
		03/14/66	03/18/66	03/16/66	66-2932	03/18/66	1800	Torrejon	1800	N/A	ND	ND	
					66-2932	03/18/66	1800			08/19/66	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	01/19/66	02/05/66	01/27/66	66-945	02/05/66	930	Moron	200	N/A	4.64+/-1.77	5.987	0.0172

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
(b) (6) [redacted]	(b) (6) [redacted]	02/13/66	03/19/66	03/02/66	66-2571	03/19/66	975	Torrejon	975	N/A	0.133+/-0.113	0.164	
		01/18/66	02/11/66	01/30/66	66-771	02/11/66	771	Moron	200	N/A	2.42+/-1.13	3.767	0.0141
		01/24/66	02/20/66	02/06/66	66-1046	02/20/66	1410	Torrejon	200	N/A	3.24+/-1.51	3.240	0.017
		01/18/66	01/21/66	01/19/66	66-222	01/21/66	450	Torrejon	200	N/A	NR	NR	
		03/10/66	04/08/66	03/24/66	66-2987	04/26/66	1100	Furth , Ger. US Army, 20th Sta Hosp.	1100	N/A	ND	ND	
					66-2987	04/26/66	1100			07/14/66	0.437+/-0.027	0.477	
(b) (6) [redacted]	(b) (6) [redacted]	03/05/66	03/19/66	03/12/66	66-2336	03/19/66	890	Giessen	890	N/A	0.165+/-0.125	0.222	0.000519
		01/18/66	03/19/66	02/17/66	66-2163	03/19/66	480	Torrejon	480	N/A	0.108	0.270	
		01/18/66	02/08/66	01/28/66	66-837	02/08/66	690	Torrejon	200	N/A	ND	ND	
		01/18/66	03/20/66	02/17/66	66-2307	03/20/66	930	Torrejon	930	N/A	0.411+/-0.201	0.530	0.0035
		02/08/66	02/26/66	02/16/66	66-1413	02/26/66	920	Moron	956	N/A	0.194+/-0.156	0.253	0.00108
		03/14/66	03/19/66	03/16/66	66-2173	03/19/66	750	Moron	750	N/A	0.108	0.173	
		02/09/66	03/09/66	02/23/66	66-2397	03/09/66	450	Torrejon	450	N/A	ND	ND	
		02/21/66	03/18/66	03/05/66	66-2235	03/18/66	940	Torrejon	940	N/A	ND	ND	
		03/11/66	03/29/66	03/20/66	66-2283	03/29/66	700	Pirmasens	700	N/A	0.147+/-0.136	0.252	0.000332
		02/01/66	02/10/66	02/05/66	66-3197	05/07/66	520	Torrejon	520	N/A	0.145+/-0.079	0.335	
		02/07/66	03/13/66	02/24/66	66-2538	03/13/66	1000	Torrejon	1000	N/A	0.135	0.182	
		02/10/66	03/08/66	02/23/66	66-2491	03/08/66	700	Moron	700	N/A	0	0.000	
		02/21/66	03/18/66	03/05/66	66-2215	03/18/66	630	Zaragoza	630	N/A	10.205+/-0.158	19.438	0.000997
		02/28/66	03/19/66	03/09/66	66-2568	03/19/66	500	Torrejon	500	N/A	0.229+/-0.164	0.550	
		01/18/66	01/29/66	01/23/66	66-1094	01/29/66	1030	Torrejon	1030	N/A	ND	ND	
		01/18/66	02/22/66	02/04/66	66-1245	02/22/66	2000	Offutt AFB, NE	1000	N/A	ND	ND	
		01/29/66	02/22/66	02/10/66	66-1087	02/22/66	555	Torrejon	555	03/17/66	16.1+/-1.0	34.811	0.17
					66-2935	03/18/66	1600	Torrejon	1600	N/A	1.32+/-0.29	1.320	
					66-2935	03/18/66	1600			08/27/66	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/07/66	01/28/66	66-488	02/07/66	550	Moron	200	N/A	1.46+//-0.71	3.185	0.0103
		01/18/66	02/16/66	02/01/66	66-964	02/16/66	1050	Torrejon	200	N/A	2.04+/-1.11	2.331	0.011
		01/18/66	01/30/66	01/24/66	66-1069	01/30/66	750	Moron	750	N/A	0.115	0.184	0.000312
		01/17/66	03/04/66	02/09/66	66-2378	03/04/66	1400	Torrejon	1400	N/A	0.238+/-0.143	0.238	0.00179
		01/17/66	01/21/66	01/19/66	66-253	01/21/66	800	Torrejon	200	N/A	17.76 +/- 6.88	26.640	
(b) (6) [redacted]		02/24/66	03/19/66	03/07/66	66-2558	03/19/66	800	Toul Rosieres	800	N/A	0.173+/-0.118	0.260	0.00079
		02/13/66	03/23/66	03/04/66	66-2582	03/23/66	1400	Moron	1400	N/A	0.976+/-0.295	0.976	0.005977
		01/18/66	02/05/66	01/27/66	66-1347	02/05/66	610	Torrejon	634	N/A	NR	NR	
		01/18/66	02/08/66	01/28/66	66-1344	02/08/66	720	Toul Rosieres	750	N/A	0.820+/-0.161	1.033	0.00255
		01/18/66	01/23/66	01/20/66	66-1935	01/23/66	1200	Torrejon	1250	N/A	0.247+/-0.104	0.247	
		01/18/66	01/25/66	01/21/66	66-1991	01/25/66	1000	Torrejon	1000	N/A	0.217+/-0.099	0.260	
		01/18/66	01/22/66	01/20/66	66-2883	04/03/66	1600	Torrejon	1600	N/A	ND	ND	
					66-2883	04/03/66	1600			08/17/66	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	01/19/66	02/11/66	01/30/66	66-769	02/11/66	117	Torrejon	117	N/A	0.38+/-0.29	3.692	0.0139
		01/18/66	02/07/66	01/28/66	66-453	02/07/66	460	Moron	200	N/A	0.51+/-0.40	1.330	0.00373
		01/18/66	04/08/66	02/27/66	66-2862	04/08/66	800	Moron	800	N/A	ND	ND	
					66-2862	04/08/66	800			07/20/66	1.306+/-0.098	1.959	
(b) (6) [redacted]	(b) (6) [redacted]	03/10/66	03/20/66	03/15/66	66-2292	03/20/66	750	Sembach	750	N/A	0.161+/-0.118	0.258	0.000687
		01/25/66	02/09/66	02/01/66	66-797	02/09/66	930	Hanaw, Germany	200	N/A	4.47+/-1.35	5.768	0.0197
		01/18/66	02/07/66	01/28/66	66-446	02/07/66	960	Moron	200	N/A	1.53+/-0.92	1.913	0.00583
		01/18/66	03/02/66	02/08/66	66-1445	03/02/66	350	Moron	350	N/A	ND	ND	
		01/18/66	01/29/66	01/23/66	66-1141	01/29/66	340	656 Eng. Bn., APO09081	340	N/A	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]	02/05/66	02/25/66	02/15/66	66-1419	02/26/66	880			06/27/66	0.163+/-0.024	0.222	
											0.731+/-0.216		
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	01/21/66	01/19/66	66-214	01/21/66	325	Torrejon	200	N/A	NR	NR	
		01/25/66	02/09/66	02/01/66	66-753	02/09/66	690	Hanaw, Germany	200	N/A	4.60+/-1.32	8.000	0.0273
		01/18/66	03/08/66	02/11/66	66-2829	03/08/66	1350	Vandenburg	1350	N/A	0.222+/-0.115	0.222	
		01/18/66	01/29/66	01/23/66	66-1082	01/29/66	1540	Torrejon	1540	N/A	0.177	0.177	
		01/24/66	02/17/66	02/05/66	66-1119	02/17/66	530	Rein-Main	530	03/23/66	0.473+/-0.334	1.071	0.00231
		01/18/66	02/06/66	01/27/66	66-514	02/06/66	820	Torrejon	200	N/A	6.52+/-1.42	9.541	0.0291
		01/18/66	03/08/66	02/11/66	66-1870	03/08/66	500	Torrejon	520	N/A	NR	NR	
		02/24/66	03/16/66	03/06/66	66-2013	03/16/66	980	Torrejon	980	N/A	0.108+/-0.074	0.132	

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
(b) (6) [redacted]	(b) (6) [redacted]	02/09/66	03/09/66	02/23/66	66-2052	03/09/66	1450	Torrejon	1450	N/A	0.194+/-0.129	0.194	0.00102
		01/18/66	02/04/66	01/26/66	66-356	02/04/66	370	Torrejon	200	N/A	ND	ND	
		01/18/66	02/05/66	01/27/66	66-919	02/05/66	375	Torrejon	200	N/A	0.99+/-0.40	3.168	0.00914
		02/11/66	03/18/66	02/28/66	66-2089	03/18/66	820	Moron	820	N/A	0.169+/-0.091	0.247	0.00106
		02/11/66	03/19/66	03/01/66	66-2221	03/19/66	900	Moron	900	N/A	ND	ND	
		03/12/66	03/18/66	03/15/66	66-2270	03/18/66	640	Moron	640	N/A	0.126+/-0.105	0.236	0.00021
		01/18/66	02/07/66	01/28/66	66-458	02/07/66	180	Torrejon	180	N/A	0.203 +/- 0.23	1.353	
		02/10/66	03/04/66	02/21/66	66-2341	03/04/66	820	Torrejon	820	N/A	0.181+/-0.129	0.265	0.000799
		01/18/66	02/02/66	01/25/66	66-1071	02/02/66	400	Moron	400	N/A	ND	ND	
		02/10/66	03/09/66	02/23/66	66-2390	03/09/66	1400	Moron	1400	N/A	0.115+/-0.107	0.116	0.00059
		02/04/66	03/20/66	02/26/66	66-2016	03/20/66	2000	USAH Numberg, Germany	2000	N/A	0.386+/-0.134	0.386	
		02/04/66	02/20/66	02/12/66	66-1039	02/20/66	700	Furth , Ger. US Army, 20th Sta Hosp.	200	N/A	92+/-5	157.714	0.813
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/07/66	01/28/66	66-487	02/07/66	500	Moron	200	N/A	0.75+/-0.59	1.800	0.00582
		02/18/66	03/04/66	02/25/66	66-2348	03/04/66	900	Torrejon	900	N/A	ND	ND	
		01/18/66	02/04/66	01/26/66	66-345	02/04/66	800	Torrejon	200	N/A	ND	ND	
		01/18/66	02/05/66	01/27/66	66-928	02/05/66	480	Moron	200	N/A	1.06+/-1.02	2.650	0.00365
		02/13/66	04/11/66	03/13/66	66-3119	04/13/66	725	Moron	725	N/A	0.133+/-0.066	0.220	
		02/11/66	03/18/66	02/28/66	66-2111	03/18/66	950	Torrejon	950	N/A	0.251+/-0.138	0.317	0.00157
		01/18/06	01/31/66	01/24/66	66-1091	01/31/66	625	Torrejon	625	N/A	ND	ND	
		02/18/66	03/04/66	02/25/66	66-2361	03/04/66	900	San Pablo	900	N/A	ND	ND	
		01/23/66	03/20/66	02/20/66	66-2296	03/20/66	820	Pirmasens	820	N/A	0.289+/-0.169	0.423	
		01/18/66	02/05/66	01/27/66	66-927	02/05/66	845	Torrejon	200	N/A	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	03/08/66	02/11/66	66-1903	03/08/66	1025	Torrejon	1025	N/A	0.199+/-0.093	0.233	
		02/08/66	03/04/66	02/19/66	66-2377	03/04/66	900	Ramstein	900	N/A	0.102+/-0.094	0.136	0.00051
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/18/66	02/02/66	66-911	02/18/66	1085	Seymour Johnson	200	02/23/66	ND	ND	
		01/18/66	03/02/66	02/08/66	66-1297	03/02/66	2150	Seymour Johnson	1000	N/A	ND	ND	
		01/25/66	02/09/66	02/01/66	66-746	02/09/66	980	Hanaw, Germany	200	N/A	2.20+/-1.35	2.694	0.0092
		02/13/66	03/18/66	03/01/66	66-2276	03/18/66	800	Torrejon	800	N/A	0.376+/-0.195	0.564	0.00235
		01/18/66	02/07/66	01/28/66	66-440	02/07/66	380	Moron	200	N/A	0.52+/-0.37	1.842	0.00533
		01/18/66	04/08/66	02/27/66	66-2864	04/08/66	1800	Moron	1800	N/A	ND	ND	
(b) (6) [redacted]	(b) (6) [redacted]				66-2864	04/08/66	1800			07/20/66	1.428+/-0.181	1.428	
		01/18/66	03/08/66	02/11/66	66-1904	03/08/66	850	Torrejon	850	N/A	0.151+/-0.079	0.213	
(b) (6) [redacted]	(b) (6) [redacted]				66-2310	03/19/66	660	Torrejon	660	N/A	0.136+/-0.114	0.247	0.000887
		01/18/66	02/06/66	01/27/66	66-529	02/06/66	945	Torrejon	200	N/A	ND	ND	
		01/18/66	03/24/66	02/19/66	66-2575	03/24/66	1100	USS Everglades AD 24	1100	N/A	0.208+/-0.139	0.227	
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/05/66	01/27/66	66-929	02/05/66	400	Moron	200	N/A	1.08+/-0.68	3.240	0.00929
		02/06/66	02/26/66	02/16/66	66-1401	02/26/66	800	Torrejon	832	N/A	ND	ND	
		01/18/66	02/08/66	01/28/66	66-839	02/08/66	620	Torrejon	200	N/A	1.23+/-0.82	2.381	0.00773
		01/18/66	02/05/66	01/27/66	66-943	02/05/66	720	Torrejon	200	N/A	6.71+/-1.30	11.183	0.0322
		02/07/66	03/04/66	02/19/66	66-2365	03/04/66	850	Wiesbaden	850	N/A	ND	ND	
		01/19/66	01/24/66	01/21/66	66-1482	03/03/66	1080	Ramstein	1000	N/A	0	0.000	
		02/11/66	03/18/66	02/28/66	66-2107	03/18/66	970	Torrejon	970	N/A	0.253+/-0.106	0.313	0.00175
		01/18/66	02/06/66	01/27/66	66-531	02/06/66	310	Torrejon	200	N/A	ND	ND	
		02/14/66	03/13/66	02/27/66	66-2533	03/13/66	800	Torrejon	800	N/A	0.135	0.203	
		03/11/66	03/19/66	03/15/66	66-2557	03/19/66	800	Moron	800	N/A	0.202+/-0.133	0.303	0.000417
		01/18/66	02/04/66	01/26/66	66-359	02/04/66	490	Torrejon	200	N/A	ND	ND	
		01/18/66	02/07/66	01/28/66	66-479	02/07/66	610	Torrejon	200	N/A	1.73+/-0.81	3.403	0.011
		01/18/66	01/13/66	01/15/66	66-1126	01/13/66	875	Torrejon	875	N/A	ND	ND	
		01/18/66	02/06/66	01/27/66	66-506	02/06/66	920	Torrejon	200	N/A	3.82+/-1.30	4.983	0.0152
		01/18/66	02/03/66	01/26/66	66-1809	02/03/66	740	Moron	740	N/A	0.131	0.212	
		01/18/66	02/07/66	01/28/66	66-448	02/07/66	945	Torrejon	200	N/A	2.67+/-1.04	3.390	0.0104
		01/17/66	03/13/66	02/13/66	66-2532	03/13/66	950	Torrejon	950	N/A	0	0.000	
(b) (6) [redacted]	(b) (6) [redacted]				66-2182	04/05/66	850	Torrejon	850	N/A	0.108	0.152	
		02/04/66	02/25/66	02/14/66	66-1485	03/04/66	2710	USS Recovery ARS-43	1000	N/A	3.14 +/- 12.20	3.140	
(b) (6) [redacted]	(b) (6) [redacted]	02/13/66	03/08/66	02/24/66	66-2469	03/08/66	1000	Wheelus AF, Libya	1000	N/A	0.689+/-0.056	0.827	

Individuals with Urine Samples Classified as Remaining Cases

Name	SSN	Estimated Start Exposure Date	Estimated End Exposure Date	Estimated Acute Exposure Date	Sample No.	Sample Date	Sample Vol (mL)	Base	Sample Anal	Date Anal	Result (pCi/sample)	24hr Activity (pCi/day)	Recorded Systemic Body Burden
(b) (6) [redacted]	(b) (6) [redacted]	01/18/66	02/12/66	01/30/66	66-791	02/12/66	655	Moron	200	N/A	ND	ND	
		02/21/66	03/18/66	03/05/66	66-2241	03/18/66	630	Zaragoza	630	N/A	0.182+/-0.145	0.347	0.000885
		01/17/66	01/19/66	01/18/66	66-1950	02/22/66	1900	Torrejon	1900	N/A	0.660+/-0.169	0.660	0.00428
		01/18/66	02/12/66	01/30/66	66-779	02/12/66	720	Torrejon	200	N/A	3.34+/-1.11	5.567	
		01/19/66	02/11/66	01/30/66	66-783	02/11/66	670	Torrejon	200	N/A	1.98+/-0.82	3.546	0.0133
		02/01/66	03/29/66	03/01/66	66-2282	03/29/66	970	Torrejon	970	N/A	0.367+/-0.166	0.454	
		01/18/66	02/06/66	01/27/66	66-519	02/06/66	810	Moron	200	N/A	2.86+/-1.24	4.237	0.013
		02/13/66	03/08/66	02/24/66	66-2513	03/08/66	1300	Torrejon	1300	N/A	0	0.000	
		03/14/66	03/29/66	03/21/66	66-2281	03/29/66	820	Moron	820	N/A	0.449+/-0.200	0.657	0.000552
		01/18/66	02/07/66	01/28/66	66-441	02/07/66	570	Torrejon	200	N/A	1.44+/-0.66	3.032	0.00924
		01/18/66	02/04/66	01/26/66	66-335	02/04/66	260	Torrejon	260	02/07/66	ND	ND	
		02/13/66	03/19/66	03/02/66	66-2177	03/19/66	570	Torrejon	570	N/A	n/a	n/a	
		01/25/66	02/09/66	02/01/66	66-731	02/09/66	700	Hanaw, Germany	200	N/A	1.70+/-1.14	2.914	0.00995
		03/28/66	04/11/66	04/04/66	66-2986	04/26/66	900	Furth , Ger. US Army, 20th Sta Hosp.	900	N/A	ND	ND	
					66-2986	04/26/66	900			07/13/66	NR	NR	
(b) (6) [redacted]	(b) [redacted]	01/18/66	03/11/66	02/13/66	66-1643	03/11/66	260	US Naval Ocean Graph	270	N/A	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	02/18/66	03/19/66	03/04/66	66-2564	03/19/66	850	Torrejon	850	N/A	0.178+/-0.138	0.251	0.000967
		01/18/66	02/05/66	01/27/66	66-896	02/05/66	820	Moron	200	N/A	ND	ND	
		01/18/66	04/04/66	02/25/66	66-2894	04/04/66	1500	Vandenburg	1500	N/A	ND	ND	
		01/24/66	03/04/66	02/12/66	66-2346	03/04/66	600	Torrejon	600	N/A	ND	ND	
		01/27/66	02/19/66	02/07/66	66-1224	02/19/66	1140	San Pablo	1190	N/A	0.261+/-0.143	0.275	0.00119
					66-1224	02/19/66	1030	San Pablo	1000	N/A	0.176+/-0.574	0.205	
(b) (6) [redacted]	(b) (6) [redacted]	02/09/66	03/09/66	02/23/66	66-2394	03/09/66	750	San Pablo	750	N/A	0.220+/-139	0.352	0.00116
		01/18/66	01/21/66	01/19/66	66-268	01/21/66	690	Torrejon	200	N/A	0.72 +/- 0.89	1.252	
(b) (6) [redacted]	(b) (6) [redacted]	02/12/66	02/26/66	02/19/66	66-1404	02/26/66	860	Torrejon	893	N/A	0.116+/-0.156	0.162	
		01/18/66	02/05/66	01/27/66	66-2682	03/25/66	1500	Torrejon	1500	N/A	0.155+/-0.124	0.155	
		01/17/66	02/11/66	01/29/66	66-761	02/11/66	940	Torrejon	n/a	N/A	3.95+/-1.61	5.043	0.0189
		03/27/66	04/08/66	04/02/66	66-2933	04/20/66	900	Torrejon	900	N/A	0.135+/-0.107	0.181	
					66-2933	04/20/66	900			08/19/66	NR	NR	
(b) (6) [redacted]	(b) (6) [redacted]	01/24/66	02/13/66	02/03/66	66-1231	02/15/66	1390	Torrejon	700	N/A	0.427+/-0.0207	0.427	0.000368
		01/25/66	03/29/66	02/25/66	66-2285	03/29/66	620	n/a	620	N/A	0.119+/-0.115	0.230	0.000973
		02/13/66	03/03/66	02/22/66	66-1928	03/03/66	800	Moron	800	N/A	0.203+/-0.110	0.305	
		02/10/66	03/19/66	02/28/66	66-2080	03/19/66	890	Torrejon	890	N/A	0.143+/-0.088	1.541	
		02/06/66	02/26/66	02/16/66	66-1405	02/26/66	540	Moron	582	N/A	NR	NR	

Exhibit 9

Taschner

338917

DEPARTMENT OF THE AIR FORCE
AIR FORCE LOGISTICS COMMAND
WRIGHT-PATTERSON AFB, OHIO

PLUTONIUM DEPOSITION REGISTRY BOARD

PROCEEDINGS
First Annual Meeting
26 - 28 October 1966

Prepared by:
L. T. Odland, LtCol, USAF, MC

AFLC-WPAFB-DEC 66 30

PROCEEDINGS

First Annual Meeting

PLUTONIUM DEPOSITION REGISTRY BOARD

PURPOSE: To review results of bio-assay data collected in support of Palomares Broken Arrow operation, and related matters.

PLACE: Room B-98, USAF Hospital Wright-Patterson, Air Force Logistics Command, Wright-Patterson AFB, Ohio.

TIME: 0830 hours.

DATE: 27 Oct 1966.

ATTENDEES:

Guest Speaker

BrigGen John M. Talbot, USAF, MC, Special Assistant to The Surgeon General for Medical Research
Hq USAF, Wash DC

Registry Board Members

Col Louis B. Arnoldi, USAF, MC - Chairman
Command Surgeon, Hq AFLC
Wright-Patterson AFB Ohio

W. H. Langham, Ph.D.
Los Alamos Scientific Laboratory
Los Alamos NMex

W. D. Norwood, M. D.
Medical Director, Hanford Occupational Health Foundation
Richland Wash

Col J. A. Hennessen, USAF, MC
Commander, USAF Hospital Wright-Patterson
Wright-Patterson AFB Ohio

LtCol W. E. Froemming, USA, MC
Preventive Medicine Division, Office of The Surgeon General
Dept of the Army, Wash DC

Cmdr C. F. Tedford, MSC, USN
Office of the Director, Submarine & Radiation Medicine Div
Dept of the Navy, Wash DC
(for Capt J. Schulte, MC, USN)

LtCol L. T. Odland, USAF, MC
Commander, USAF Radiological Health Laboratory
Wright-Patterson AFB Ohio

Consultants

M. A. Quaife, M. D.
Chief, Special Laboratory of Nuclear Medicine & Biology
Veterans Administration Hospital, Omaha Nebr

LtCol D. R. Lindall, USAF, MC
Chief, Bionucleonics, Office of the Surgeon General
Hq USAF, Wash DC

LtCol K. T. Woodward, USA, MC
Director, Division of Nuclear Medicine
Walter Reed Army Institute of Research, Wash DC

Capt R. K. Skow, MSC, USN
Radiation Safety Officer
National Naval Medical Center, Bethesda Md

G. M. Dunning, Ph.D.
Deputy Director, Division of Operational Safety
Atomic Energy Commission, Germantown, Md

Mr. W. E. Sheehan
Health Physics Department
Mound Laboratory, Miamisburg Ohio

Maj J. McBain, USAF, MC
Department of Medicine, USAF Hosp
Wright-Patterson AFB Ohio

Capt J. Pizzuto, USAF, BSC
Office of the Director of Nuclear Safety
Inspector General's Office, Kirtland AFB NMex

W. B. Johnston, Ph.D.
Office of the Director of Nuclear Safety
Inspector General's Office, Kirtland AFB NMex

Speakers

BrigGen J. M. Talbot
Col L. B. Arnoldi
LtCol L. T. Odland
Maj J. C. Taschner
Capt J. Pizzuto
Capt R. G. Thomas
Lt H. R. Kaufman

Observers

LtCol R. E. Benson, USAF, VC
Deputy Commander
USAF Radl Health Lab, Wright-Patterson AFB Ohio

Capt G. S. Kush, USAF, BSC
OIC Film Dosimetry Section
USAF Radl Health Lab, Wright-Patterson AFB Ohio

Ltjg R. T. Bell, USN
Radiation Safety Officer
National Naval Medical Center, Bethesda Md

Mr. W. R. Wood, Jr.
Health Physics Department
Mound Laboratory, Miamisburg, Ohio

Dr. C. E. Newton
Battelle-Northwest
Pacific Northwest Laboratory, Richland Wash

W. E. Lotz, Ph.D.
Medical Branch, Division of Biology & Medicine
Hq USAEC, Wash DC

Capt R. G. Conrad, USAF, BSC
Chief, Special Activities Branch
USAF Radl Health Lab, Wright-Patterson AFB Ohio

FORMAL PRESENTATIONS:

Opening Address - Brig Gen J. M. Talbot, USAF, MC

On behalf of the Surgeon General and the United States Air Force Medical Service, I want to add my welcome to the participants in this first meeting of the USAF Plutonium Deposition Registry Board. The Air Force is particularly grateful to those of you from our sister military services, the Atomic Energy Commission, the Veterans Administration, and the civilian scientific community who have consented to serve as members or as consultants to this board.

The large number of observers at this meeting is also gratifying to us. It indicates the continuing interest in Plutonium-239 inhalation and internal deposition, and further reinforces our belief that establishing and maintaining this permanent registry and its associated board, are, indeed, essential. For those of you who are visiting Wright-Patterson Air Force Base for the first time, I would urge you to visit the USAF Radiological Health Laboratory, if your time permits. This laboratory is unique in being the only military laboratory within the free world exclusively devoted to handling all laboratory aspects of occupational radiological health. In addition, the Radioisotope Clinic here in the hospital, the Nuclear Engineering Test Facility reactor on the other side of the base, and the various component laboratories of the USAF Aerospace Medical Research Laboratories are also worth visiting. In terms of personnel, the Air Force has concentrated a pool of its finest talent in health physics, applied radiobiology, reactor technology, and nuclear medicine here at Wright-Patterson, in support of these various laboratories and their headquarters.

Little needs to be said about the more dramatic aspects of the Broken Arrow of last January 17. In the nine months which have elapsed since that tragic day, "Palomares" has become virtually a household word, at least, within the military. Television news coverage and special programs in the first three months following the accident were widely viewed. Reams of articles concerning this Broken Arrow have poured from the popular press, and as recently as last month The Reader's Digest magazine published an excellent 35-page special feature on this subject, in lieu of its usual best-seller condensation. A Broadway play on Palomares and the missing bomb is (or was) scheduled to go into production this coming winter. (Who, one wonders, will be cast in the role of Dr. Wright Langham?)

We, here today, are concerned with less dramatic but equally-significant sequelae to the Palomares Broken Arrow. Shortly after the accident it became evident that the plutonium contamination problem in Palomares was going to be far more extensive than initially supposed--and that, despite protective measures, a large number of military personnel involved in the clean-up operation were receiving or would receive, at least, a fraction of a body burden of Plutonium-239. Concerned individuals in the USAF Medical Service were aware that there was little information in the literature on which to predict medical disability or complications which may arise subsequent to the inhalation and deposition of Plutonium-239 in the lungs and other organ systems of man. They were further aware that many medical authorities are of the opinion that small amounts of Plutonium-239 detectable in the urine; i.e., amounts less than acceptable body burden, are of biological significance, since permissible burdens as assayed by urinalysis may only vaguely indicate the amount of the isotope which may be deposited in the lungs. They knew that the present acceptable body burden of Plutonium-239 is based on extrapolations from experience with radium-dial painters and small animals. Until the present, we have not had a group of human exposures of statistically-significant size which we could study, in an attempt to better define the medical hazards subsequent to inhalation of Plutonium-239, and such reports as do appear in the literature for the most part describe chronic occupational exposures. Since Plutonium-239 was not discovered until 25 years ago, no cases have been followed for longer periods of time. While it seemed highly unlikely that any individual involved in the clean-up operation in Palomares had, or would receive, sufficient internal deposition of Plutonium-239 to warrant consideration of clinical treatment, it was felt that the Air Force Medical Service could be in a precarious position were the question of treatment to arise following any future Broken Arrow. No physician in the Air Force has, to date, ever treated an individual for plutonium deposition. Further, although techniques of treatment are available, there is no unanimity of opinion, even in the civilian scientific community, as to when treatment should be initiated and as to the duration of treatment.

The medicolegal aspects involved in a large number of military personnel with internal deposition of Plutonium-239, even though at levels below one body burden, also concerned us. As most of you are well aware, instances of disease or injury due to alleged ionizing radiation exposures during prior military service are increasing in frequency. True, many such claims are absurd, but all of them require at least minimal investigation in order to forestall further unnecessary, time-consuming, and expensive action over non-valid claims. Some such claims are total frauds, perpetrated for individual publicity, financial gain or other factors. As often as not, however, the claims are submitted by well-meaning individuals, who are grasping at straws to explain the origin of their disease. The latest such case in which my staff became involved concerned a schizophrenic beatnik in San Francisco, who was a sometime in-patient at a California State Mental Hospital. During his more lucid intervals, when he would be released on out-patient status, he proved to be an inveterate letter-writer, particularly after he decided that his schizophrenia had been induced by ionizing radiation exposure received during a 4-year tour of duty with the Air Force between 1954-1958. Where and when had he been exposed to this ionizing radiation? In his own words, he had flown over a portion of the State of Nevada en route from Oxnard Air Force Base, near Ventura, California, to a brief TDY at Nellis Air Force Base in Las Vegas, during Operation Plumbob. Review of his records revealed that he had no connection with weapons testing in Operation Plumbob or any other nuclear test. His service medical record was negative for everything except mumps and athlete's foot, both incurred while in service. I might add that this chap wrote letters to the Atomic Energy Commission, the Veterans Administration, and DASA, before settling on the Air Force as the agency responsible for his recent schizophrenia.

With all of the above factors in mind, a small group of USAF Medical Service officers concerned with nuclear weapon accidents met in Omaha, Nebraska, during a spring blizzard late last March, to review the medical aspects of the Palomares Broken Arrow. It was unanimously decided that the USAF Medical Service needed to develop a detailed and long-range program to provide adequate follow-up and treatment, when and if required, for military personnel with internal plutonium deposition resulting from the Palomares Broken Arrow, as well as from any future weapons or laboratory accidents involving internal deposition of plutonium. The concept of a Plutonium Deposition Registry and Registry Board was felt to be the best approach to conducting this program. The program would have three primary purposes:

(1) It would provide adequate follow-up of personnel with internal deposition of plutonium, in order that any possible biological injury would be detected at the earliest possible date, and it would provide, when required, the best possible treatment to reduce body burdens of Plutonium-239.

(2) It would provide the government with complete factual data upon which to evaluate claims for compensation which might subsequently arise.

(3) It would provide the medical profession with additional urgently-needed data with which to manage medical problems resulting in future Broken Arrow or laboratory accidents of a similar nature.

1956

Since that meeting in Omaha last March, the Plutonium Deposition Registry and Board have become a reality. As originally conceived, the Board was to be tri-service in nature, with non-voting liaison members from the Atomic Energy Commission, the Veterans Administration, and Defense Atomic Support Agency. However, to expedite establishment of the Registry and the Registry Board, they were created within the Air Force, and the selection of the USAF Radiological Health Laboratory as the permanent location for the Registry was, of course, an obvious choice since almost all of the plutonium bio-assays following the Palomares Broken Arrow were performed here. Further, the USAF Hospital Wright-Patterson is the single USAF Hospital designated as a specialty center in the treatment of occupational disease. Finally, we have a unique, and, for the purposes of this Registry and its Board, a highly-desirable management situation in the Office of the Surgeon, Air Force Logistics Command here at Wright-Patterson Air Force Base, to which both the USAF Radiological Health Laboratory and this hospital report directly. Colonel Arnoldi and his highly-competent staff are deeply involved and personally interested in all aspects of occupational medicine. Thanks to their cooperation and administrative support, establishment of this Registry and its Board entailed no financial complications whatsoever.

The function of this Registry is, of course, to maintain permanent records of Plutonium-239 bio-assay and other pertinent laboratory and medical data on all military personnel who have received or who will receive internal deposition of Plutonium-239 above such limit as may be established by the Registry Board. Because it was essential to establish some limit within which the USAF Radiological Health Laboratory might operate in the months prior to formal establishment of this Registry and the initial meeting of the Board, the Air Force Medical Service unilaterally selected a cut-off of 9% of one body burden of Plutonium-239 as the level above which personnel would be included in this Registry. This figure is not irrevocably fixed, and it may be raised or lowered at the discretion of the Registry Board. The Registry will have to maintain permanent contact with individuals included in the Registry, and will, at the request of the Board, schedule and perform follow-up laboratory procedures on these individuals. The administrative problems involved in such permanent follow-up are self-evident in view of the increasing mobility of the civilian population in the United States. In the past few months the mobility of military personnel has also proven to be a large problem for the Board. Many of the personnel who received internal deposition of Plutonium-239 in the Palomares clean-up operation have already completed military tours and returned to civilian life. Further, because of the emergency nature of the clean-up operation, large numbers of military personnel were sent to provide assistance in Palomares on emergency temporary duty orders, some of which did not become formalized on paper until a later date. This has entailed administrative problems for the Registry in establishing with certainty the home base of certain personnel on whom urine specimens were forwarded to the laboratory for bio-assay. The current military action in Southeast Asia, the current military withdrawal from France, and the recent withdrawal of the Air Force's Strategic Air Command from Spain, have increased the numbers of personnel transfers, and have further compounded the problem of follow-up of personnel involved in the Palomares Broken Arrow. Thus, long-term follow-up of large numbers of personnel cannot be assumed to be an easy task.

The Registry Board will be responsible for determining who shall be included in the Registry, and what shall be the nature of routine long-term follow-up. The Board will determine when treatment for Plutonium-239 internal deposition is required, will determine the type of treatment indicated, and will supervise treatment, as required. In the event that an individual on the Registry develops a pathologic process related or potentially related to Plutonium-239 internal deposition, the Board will, insofar as possible, insure that complete postmortem studies are performed, the exact nature of these studies to be determined by the Board in cooperation with the Radiation Pathology Register of the Armed Forces Institute of Pathology.

This Board will be required to make some difficult and far-reaching decisions. Fortunately, for the three military services, the Board includes two of the world's most knowledgable scientists in the area of internal deposition of plutonium--Dr. Langham and Dr. Norwood. I want to extend special appreciation to these two gentlemen for consenting to serve on the Board, in view of their already heavy schedules in their own laboratories and elsewhere in the scientific community. I hope that the data available to them through this Registry will prove of value in the programs and studies underway in their own laboratories. Since this Registry and Board are envisioned as completely "non-partisan", we welcome participation by, and free exchange of, information with all interested governmental and quasigovernmental agencies.

Wright-Patterson AFB as a Nuclear Center

Col L. B. Arnoldi, USAF, MC

Col Arnoldi urged the Board and consultants to consider adopting a common format for the recording of radiation exposure (internal and external) data, and that a central repository be set up to maintain this information and retrieve it as desired. Within limits imposed by operating policies, Col Arnoldi placed at the disposal of the Board, the computer and ancillary facilities of Hq Air Force Logistics Command for whatever use they might suggest. Because of the unique resources in the nuclear energy field available at Wright-Patterson AFB, he urged that this base be considered as a nuclear medicine research and operational center.

The USAF Hospital, Wright-Patterson, the Nuclear Engineering Test Facility, and the USAF Radiological Health Laboratory were singled out as the keystones upon which such a center could be built.

Field Operations

Capt J. S. Pizzuto, USAF, BSC

On 17 Jan 66 a B-52 bomber and KC-135 tanker aircraft collided in flight over or near Spanish territory. The resulting impact permitted the uncontrolled dispersion of four nuclear weapons, three of which fell on Spanish soil and one in the Mediterranean Sea.

Immediate search operations located the three devices on the ground and verified that the integrity of two was destroyed. High winds permitted dispersal of 239-plutonium over a wide area.

Because the whereabouts of the fourth weapon remained a matter for speculation, a large-scale search operation continued on land and sea until 26 Mar 66, when it was removed from the sea. Nearly 2000 American personnel participated in the search, and many Spanish Nationals were also involved. During this period the 239-plutonium constituted an inhalation hazard, even though precautions were taken to prevent gross exposure.

Before completion of the task, several tons of topsoil were collected, sealed in barrels, and removed to a national nuclear burial ground in the United States.

Sample Control System

1Lt Harold R. Kaufman, USAF

The sample control system permitted the laboratory to keep accurate records on all samples received for analysis. In addition, it provided a simple, fast, method of recalling data for report generation and statistical analysis.

The combined resources of the punch-card equipment and the Mathatron desk calculator located in the laboratory, and the IBM 7094 DCS located at Aeronautical Systems Division, gives this laboratory a formidable data-processing capability that should be able to meet any requirement placed on it by the Plutonium Deposition Registry Board.

Analytical Chemistry Methods Used in Processing Samples

Maj J. C. Taschner, USAF, BSC

Initial urine samples from personnel involved in the Palomares search and recovery operation were processed, using a gross alpha screening procedure. The steps in this procedure were:

(1) wet ashing of an aliquot of the urine sample with concentrated nitric acid and hydrogen-peroxide to a white ash;

(2) Solubilizing the white ash and coprecipitation of plutonium with bismuth salts;

(3) dissolution with hydrochloric acid followed by the addition of lanthanum carrier before hydrofluoric acid precipitation;

(4) direct mounting of the precipitate on a 2" steel planchet; and,

(5) counting for 120 minutes in an internal proportional counter.

Plutonium-239 spiked pooled urine samples were processed in a like manner to obtain quality control data. Plutonium recoveries of 75.6 ± 19.6 percent (68% confidence) were obtained.

Because of field contamination of initial samples, a resampling program was initiated 2-3 months after the personnel returned to their home base. A procedure which is specific for plutonium was adopted for the resample urines. One-half of the total urine sample was adjusted to pH 2 with concentrated nitric acid. A plutonium-236 internal tracer was added to each sample for quality control. The sample was then heated to boiling to break any metabolic complex-binding plutonium. The plutonium was coprecipitated with the alkaline earth phosphates by adjusting the urine sample to pH 10 with concentrated ammonium-hydroxide. The salts were dissolved in nitric acid and coprecipitated with radio-chemically-pure cerium by adjusting to pH 4.5. This precipitate was dissolved in hydrochloric acid and passed through an anion-exchange column which adsorbs the plutonium. Interfering anions adsorbed on the column were removed by washing with hydrochloric acid. Hydriodic acid was used to elute the plutonium from the ion-exchange column. The plutonium was changed to the sulfate salt by heating the evaporated column residue in sulfuric acid. The solution was adjusted to approximately pH 3 and electroplated on a one-half inch steel planchet. A solid state alpha spectrometer was used to measure the plutonium alpha activity present. Plutonium recoveries of 75.6 ± 16.2 percent (68% confidence) were obtained.

Counting Procedures for 239-Plutonium in Urine

Capt R. G. Thomas, USAF, BSC

I. Counting procedures used for initial samples:

Samples were counted, using Nuclear Measurement Corporation PC-3A, windowless, gas-flow proportional counters. Daily checks were made on instrument performance by counting reference standards of 239-Pu, to insure constancy of counting efficiency. Samples were counted for 120 minutes and backgrounds were counted daily, normally for 960 minutes. The daily background counts also served as checks on contamination; the counting chambers were decontaminated when background became greater than 0.1 count per minute. Normal backgrounds ranged from 0.02-0.06 count per minute.

Sample activity was calculated from the following expression:

pCi/sample =

$$\frac{(\text{gross counts/gross ctg time}) - (\text{bkg counts/bkg ctg time})}{(\text{counting efficiency})(2.22)\,(\text{procedural yield})}$$

II. Counting procedures used for resamples:

The detectors were solid-state surface-barrier types mounted in a vacuum chamber. Charge sensitive preamplifiers, designed and built by Mr. Robert L. Farr of the laboratory staff, were used to amplify signals from the detector. Output from the preamplifiers was fed to a Nuclear Data 130 AT multichannel analyzer. Readout from the analyzer was in the form of typewriter printout.

Using an electroplated source containing known activities of 239-Pu and 236-Pu, instrument performance was checked each morning before beginning counting, and normally, an additional time each afternoon. The performance check consisted of observing the peak channels for 239-Pu and 236-Pu, and adjusting the gain of the amplifier system, if necessary, to correct for any gain shifts. Additionally, the counting efficiency of the system was checked at the same time, to insure constancy.

Background counts were made each night for 800 minutes' duration, with a blank planchet in the counting chamber. The daily background count also served as a check for any possible contamination in the counting chamber. Samples were routinely counted for 100 minutes.

The data was collected in an analyzer memory of 255 storage positions. Total counts in two bands, centered on the peak channels of 239-Pu and 236-Pu, and each containing 11 storage locations, were totaled and used for the sample activity calculations. The same bands were used for both sample and background determinations. Sample activity was calculated from the following expression:

$$\text{pCi/sample} = \frac{(\text{net cpm in 239-Pu band}) \times (\text{dpm 236-Pu added})}{(\text{net cpm in 236-Pu band} \times (2.22)}$$

where
$$\text{net cpm in 239-Pu band} = \left[\frac{\text{gross cts 239-Pu band}}{\text{gross ctg time}} - \frac{\text{bkg cts in 239-Pu band}}{\text{bkg ctg time}}\right]$$

$$\text{net cpm in 236-Pu band} = \left[\frac{\text{gross cts 236-Pu band}}{\text{gross ctg time}} - \frac{\text{bkg cts 236-Pu band}}{\text{bkg ctg time}}\right]$$

dpm 236-Pu added = activity of 236-Pu spike added to sample corrected for decay to date of count.

RESULTS

Initial Urine Samples--Alpha Activity

LtCol L. T. Odland, USAF, MC

	Air Force	Army	Navy	Other	Total
Number analyzed	1389	107	37	38	1571
BB* greater 100%**	19(0)	1(0)	0	0	20
BB 0.99 to 0.09	361	33	5	8	407
BB 0.09 to 0.009	487	23	20	7	537
BB less than 0.009	522	50	12	23	607

* Systemic body burden (bone, critical organ)--calculated on the basis of urinary excretion according to expression

$$D = 435\ U\ t^{0.76}$$

where D = systemic body burden

U = 239-Pu activity in 24-hour sample

t = time in days from exposure to sampling

** Value of 0.044 µCi 239-Pu for D represents one body burden or 100%.

RESULTS

Miscellaneous Samples

LtCol L. T. Odland, USAF, MC

WATER

Samples analyzed	40
No detectable activity	7
Range of 0.1 to 633 pCi/liter	33
Median value of 1.64 pCi/liter	

VEGETATION SWIPES

Total swipes counted	78
No detectable activity	63
Range of 0.1 to 4.3 pCi	13

NASAL SWIPES

Total swipes counted	120
No detectable activity	70
Range of 1.0 to 337 dpm	50
Mean 24.4, S.D. 48.0, median 13 dpm	

SOIL

Total samples -- gamma scan	23

Peaks at 60, 27, 16, 110, 185 Kev

VEGETATION

Samples too active for processing

RESULTS

Resampling Program
(As of 1 Nov 1966)

LtCol L. T. Odland, USAF, MC

	Air Force	Army	Navy	Other	Total
BB* greater 10%	6	0	0	0	6
BB 1 to 10%	162	10	5	0	177
BB less 1%	36	11	1	1	49
BB zero	124	9	2	6	141
	328	30	8	7	373
Number requested	(363)	(33)	(5)	(8)	(409)

*BB defined as systemic body burden (bone, critical organ).

Analysis of BB Greater 1% Group

(183 Samples)

	Mean	SD	Median	Range
239-Pu (curies x 10^{-15})	93	63	77	26-390
236-Pu spike (% recovery)	76	13	75	43-109
Sample volume (liters)	1.3	0.5	1.2	.29-3.1
Elapsed time (days)	147	25	140	110-237
BB (%)	4	3	3	1-16

SUMMARY OF DISCUSSIONS:

Use of the term "body burden. Dr. Norwood expressed objection to the use of the term "body burden" in presenting results. He stated the term is misleading since it could be interpreted to include the entire body when, in reality, it refers only to that portion of 239-Pu distributed by systemic circulation, and, in no way, reflects that which may be fixed in thoracic viscera. Dr. Norwood further stated that correction values have been suggested to permit estimating lung burden from system burden. Depending on various factors, a correction of 10-100 could be applied to systemic burden to estimate lung burden.

Dr. Langham stated that the formula he developed for use in estimating body burden was never intended to apply to lung burdens. He related some of the history of his early work and that of colleagues on this problem, and questioned the whole concept of critical organ in relation to inhalation exposures of 239-Pu. Systemically, the bone is considered the critical organ, while in the chest it may be lung or lymph nodes, or both, but in the case of inhalation exposures, the thoracic viscera may be the important tissue with bone receiving only an insignificant dose. In summary, Dr. Langham stated that he did not like the application of corrective factors to body burden to estimate lung burdens, particularly when the corrective factor varies by at least a factor of 10, and the basis upon which this value is derived is somewhat nebulous. Dr. Norwood agreed that it was difficult to assign a corrective factor to body burden in order to arrive at the lung burden. Several other attendees voiced their feelings on this problem, and the consensus was that lung burdens, under conditions of uncontrolled acute inhalation exposures, are impossible to accurately measure at this time.

In an effort to more accurately present analytical results, the term body burden will be modified to reflect its reference to systemic with bone as the critical organ, and, in addition, absolute terms of activity per sample will also be reported along with sample volume, elapsed time, etc.

Reporting of Results. The question was raised whether or not the individual results should be reported back to appropriate units of assignment and entered in medical records. One objection to reporting results was that they may be misinterpreted at the local level, and perhaps set the stage for legal action. Dr. Norwood felt the results should be reported because the doctors involved must be given this information. LtCol Froemming stated that the Army wanted something entered in the medical records, but was not firm on just what form the entry should take. Cmdr Tedford stated the Navy did not want their results entered in medical records, and that the USAF Radiological Health Laboratory should maintain these records as a part of a repository from which the data could readily be retrieved when desired. General Talbot stated that the question, insofar as the Air Force was concerned, should be studied by legal advisors prior to a decision.

It was decided that the USAF Radiological Health Laboratory would send results of bio-assay work to the appropriate Surgeon General for deposition and recording, as he saw fit. Dr. Johnston pointed out that exposures or body burdens of 239-Pu do not have to be given to the individual concerned since this material does not come under the provisions of 10CFR.

GENERAL DISCUSSION:

Item Nr 1 -- Should continued efforts be made to secure initial and/or repeat samples on all personnel who have not been tested but who were in the area?

The board recommended that continued efforts should be made to secure initial samples from individuals who participated in the operation and departed the area without submitting a specimen. In addition, it recommended that continued effort be made to secure a second sample from individuals whose initial sample contained sufficient activity to suggest a systemic body burden in excess of 9%, and who failed to respond to the resampling program. The maximum extent of this effort should consist of two letters soliciting cooperation, and one telephone call. Accurate records will be kept of the communications, since the primary reason for the continued effort is to demonstrate a reasonable effort to screen every individual involved. The board felt that it was extremely unlikely that any individual would display excretion values at significant variance from those obtained to date.

Item Nr 2 -- Does the board recommend resampling of individuals whose initial urine samples showed less than 9% of one body burden?

The board recommended that no further effort be devoted to resampling individuals whose initial urine sample showed activity suggesting a systemic body burden less than 9%.

Item Nr 3 -- At what level of body burden, if any, obtained on resampling does the board recommend continued follow-up? What should be the nature and frequency of such follow-up, if recommended?

Dr. Langham pointed out that the results of the bio-assay program were very good in terms of preventive medicine and risks to individual patients, but insofar as providing a basis for follow-up and long-term study, they provided little reason for enthusiasm. Dr. Norwood concurred in this observation, as did other attendees, all agreeing that the bio-assay data showed levels of activity far below those necessary for a meaningful follow-on program to assess excretion patterns, use of whole-body counting techniques, etc. Capt Skow stated that no follow-up effort should be devoted to any individual whose systemic body burden was less than 50%. Dr. Norwood suggested continued bio-assay studies on all individuals whose systemic body burden was 9% or greater. After more discussion on this point, it was agreed that continued follow-up bio-assay studies at a frequency of once every two months would be done on the highest 10% of the resampling group that showed a systemic body burden of between 1-10%. This number would be about 17, and would include some with systemic body burdens as low as 7%. Considerable discussion centered around the possibility of inciting undue concern in these individuals, perhaps to the point of legal action for compensation. However, this was realized, and a certain probability of risk had to be accepted if any follow-up program was to be pursued. All attendees agreed that whole-body counting techniques are not sufficiently refined to be utilized in any follow-up program on this group, and, certainly, there was no indication for treatment.

Item Nr 4 -- Should whole-body counting techniques be developed by the U. S. Air Force for detection of 239-Pu-241-Am as an additional tool, in the event of future similar incidents? If affirmative, what type of hardware is recommended?

This subject stimulated a lengthy and detailed discussion on the whole problem of in vivo assay of 239-Pu-241-Am using whole-body counting techniques. Dr. Norwood and Mr. Newton discussed the advances that have been made on the problem, and felt that it was just a matter of months before the hardware would be perfected. Dr. Langham related the experience of his group and others in building a device suitable for detection of 239-Pu in vivo and the application of it to the Spanish incident. He further related that detection can be done, but the problem of quantitating what is detected is still formidable. Apparently, levels on the order of nanocuries in the thorax can be detected, either by counting 239-Pu or via extrapolation of 241-Am content. It became obvious, as the discussions continued, that whole-body counting was possible, but that no one is willing to categorically state their limits of detectability, or advertise as being operational and ready to accept candidates. Dr. Dunning expressed a personal opinion that the USAF Radiological Health Laboratory should develop a capability in this area if it is to be more adequately prepared for the next Broken Arrow. Dr. Langham and Mr. Newton advised caution on development of whole-body counting techniques by the USAF because of the developmental effort going forth in other quarters. However, Dr. Langham felt such experience would be valuable for the USAF in that it would place it in a much more ready position for future incidents, but certainly could be of no value in this (Palomares) incident.

LtCol Woodward asked where assistance would be available in the event the Army experienced a Broken Arrow of significant proportions. Specifically, he wanted to know what one group had facilities for whole-body counting, treatment and bio-assay. Dr. Norwood stated his group had capability to handle a small (5-8) number of patients, could do bio-assay tests in large numbers, and would soon have whole-body counting facilities. Col Hennessen stated his hospital census was running over 90%, but he could handle perhaps up to 20 patients at any given time.

No specific recommendations were obtained with respect to the type of hardware that should be used.

Item Nr 5 -- By using ratios of 239-Pu to 241-Am in the weapon, soil, and urine, is it possible to determine the 239-Pu content of the lungs using 241-Am values determined by whole-body counting techniques?

Mr. Newton reviewed data on recent studies of 241-Am and 239-Pu in laboratory animals following inhalation exposures which indicated that americium may move out of the lungs faster than 239-Pu under certain experimental conditions. In these studies the ratio of 239-Pu to 241-Am varied by a factor of 2 from what it was in the inhaled material.

Messrs Sheehan and Wood presented bio-assay (urine) excretion data on five individuals who have appreciable systemic body burdens of 238-Pu as a result of inhalation exposures. The information suggested that at about 150 days after an acute exposure the urinary excretion values parallel quite closely with those predicted by a computer model, and that both follow Langham's equation quite well, subsequent to this time period.

While certainly not applicable to exposures under consideration, it was conceded that if future Broken Arrow incidents resulted in inhalation and retention of nanocuries or more of 239-Pu and the attendant 241-Am, using the ratio of the two in the weapon, and determining a similar relationship in soil and urine, estimates based on whole-body assay of 241-Am by in vivo counting would give an estimate of thoracic burden no farther removed from reality than other methods or extrapolations currently available.

Exhibit 10

106814

Files April 5, 1967

THRU: C. L. Dunham, M.D., Director, Division of Biology & Medicine

H. D. Bruner, M.D., Assistant Director for Medical & Health Research, Division of Biology & Medicine

NOTES ON PHONE CONVERSATION WITH COL. ODLAND, WRIGHT-PATTERSON AIR FORCE BASE, DAYTON, OHIO, MARCH 31, 1967

ADMHR:HDB

BEST AVAILABLE COPY

Colonel Odland is the officer in charge of the Plutonium Registry for the U. S. Air Force vis-a-vis the 1800 or so USAF people who went into the Palomares area or who were potentially exposed. Of the 1800 he still has about 50 to collect samples from and he is trying hard because they have been discharged, are being discharged, or are reassigned all over the world.

No one has received a body burden greater than 15% of an MPBB as calculated from urine samples. Twenty-five have had burdens between 7% and 11%. Some are being examined every two months or so up now to a year.

Only one man has died so far, and by the best of luck an 8 gram sample of unspecified lung tissue was found to have 3 pci ($\sim$600 pc or 0.0006 μc for the 2 lungs).

He is not able to get the support of the Department of Defense to go after these people or set up a real registry because of the Sleeping-dog policy. His number at Wright Patterson Air Force Base is AC 513, 257-6672.

OFFICE ▶	ADMHR				
SURNAME ▶	HDBruner:pwg				
DATE ▶	4/6/67				

Exhibit 11

The New York Times | https://nyti.ms/2jIkRXf

U.S.

Troops Who Cleaned Up Radioactive Islands Can't Get Medical Care

By DAVE PHILIPPS JAN. 28, 2017

RICHLAND, Wash. — When Tim Snider arrived on Enewetak Atoll in the middle of the Pacific Ocean to clean up the fallout from dozens of nuclear tests on the ring of coral islands, Army officers immediately ordered him to put on a respirator and a bright yellow suit designed to guard against plutonium poisoning.

A military film crew snapped photos and shot movies of Mr. Snider, a 20-year-old Air Force radiation technician, in the crisp new safety gear. Then he was ordered to give all the gear back. He spent the rest of his four-month stint on the islands wearing only cutoff shorts and a floppy sun hat.

"I never saw one of those suits again," Mr. Snider, now 58, said in an interview in his kitchen here as he thumbed a yellowing photo he still has from the 1979 shoot. "It was just propaganda."

Today Mr. Snider has tumors on his ribs, spine and skull — which he thinks resulted from his work on the crew, in the largest nuclear cleanup ever undertaken by the United States military.

Roughly 4,000 troops helped clean up the atoll between 1977 and 1980. Like Mr. Snider, most did not even wear shirts, let alone respirators. Hundreds say they are now plagued by health problems, including brittle bones, cancer and birth defects in their children. Many are already dead. Others are too sick to work.

The military says there is no connection between these illnesses and the cleanup. Radiation exposure during the work fell well below recommended thresholds, it says, and safety precautions were top notch. So the government refuses to pay for the veterans' medical care.

Congress long ago recognized that troops were harmed by radiation on Enewetak during the original atomic tests, which occurred in the 1950s, and should be cared for and compensated. Still, it has failed to do the same for the men who cleaned up the toxic debris 20 years later. The disconnect continues a longstanding pattern in which the government has shrugged off responsibility for its nuclear mistakes.

On one cleanup after another, veterans have been denied care because shoddy or intentionally false radiation monitoring was later used as proof that there was no radiation exposure.

A report by The New York Times last spring found that veterans were exposed to plutonium during the cleanup of a 1966 accident involving American hydrogen bombs in Palomares, Spain. Declassified documents and a recent study by the Air Force said the men might have been poisoned, and needed new testing.

But in the months since the report, nothing has been done to help them.

For two years, the Enewetak veterans have been trying, without success, to win medical benefits from Congress through a proposed Atomic Veterans Healthcare Parity Act. Some lawmakers hope to introduce a bill this year, but its fate is uncertain. Now, as new cases of cancer emerge nearly every month, many of the men wonder how much longer they can wait.

'Plutonium Problems'

The cleanup of Enewetak has long been portrayed as a triumph. During the operation, officials told reporters that they were setting a new standard in safety. One report from the end of the cleanup said safety was so strict that "it would be difficult to identify additional radsafe precautions that could have been taken."

Documents from the time and interviews with dozens of veterans tell a different story.

Most of the documents were declassified and made publicly available in the 1990s, along with millions of pages of other files relating to nuclear testing, and sat unnoticed for years. They show that the government used troops instead of professional nuclear workers to save money. Then it saved even more money by skimping on safety precautions.

Records show that protective equipment was missing or unusable. Troops requesting respirators couldn't get them. Cut-rate safety monitoring systems failed. Officials assured concerned members of Congress by listing safeguards that didn't exist.

And though leaders of the cleanup told troops that the islands emitted no more radiation than a dental X-ray, documents show they privately worried about "plutonium problems" and areas that were "highly radiologically contaminated."

Tying any disease to radiation exposure years earlier is nearly impossible; there has never been a formal study of the health of the Enewetak cleanup crews. The military collected nasal swabs and urine samples during the cleanup to measure how much plutonium troops were absorbing, but in response to a Freedom of Information Act request, it said it could not find the records.

Hundreds of the troops, though, almost all now in their late 50s, have found one another on Facebook and discovered remarkably similar problems involving deteriorating bones and an incidence of cancer that appears to be far above the norm.

A tally of 431 of the veterans by a member of the group shows that of those who stayed on the southernmost island, where radiation was low, only 2 percent reported having cancer. Of those who worked on the most contaminated islands in the north, 20 percent reported cancer. An additional 34 percent from the contaminated islands reported other health problems that could be related to radiation, like failing bones, infertility and thyroid problems.

Budget Cuts and the Cleanup

Between 1948 and 1958, 43 atomic blasts rocked the tiny atoll — part of the Marshall Islands, which sit between Hawaii and the Philippines — obliterating the native groves of breadfruit trees and coconut palms, and leaving an apocalyptic wreckage of twisted test towers, radioactive bunkers and rusting military equipment.

Four islands were entirely vaporized; only deep blue radioactive craters in the ocean remained. The residents had been evacuated. No one thought they would ever return.

In the early 1970s, the Enewetak islanders threatened legal action if they didn't get their home back. In 1972, the United States government agreed to return the atoll and vowed to clean it up first, a project shared by the Atomic Energy Commission, now called the Department of Energy, and the Department of Defense.

The biggest problem, according to Energy Department reports, was Runit Island, a 75-acre spit of sand blitzed by 11 nuclear tests in 1958. The north end was gouged by a 300-foot-wide crater that documents from the time describe as "a special problem" because of "high subsurface contamination."

The island was littered with a fine dust of pulverized plutonium, which if inhaled or otherwise absorbed can cause cancer years or even decades later. A millionth of a gram is potentially harmful, and because the isotopes have a half-life of 24,000 years, the danger effectively never goes away.

The military initially quarantined Runit. Government scientists agreed that other islands might be made habitable, but Runit would most likely forever be too toxic, memos show.

So federal officials decided to collect radioactive debris from the other islands and dump it into the Runit crater, then cap it with a thick concrete dome.

The government intended to use private contractors and estimated the cleanup would cost $40 million, documents show. But Congress balked at the price and approved only half the money. It **ordered** that "all reasonable economies should be realized" by using troops to do the work.

Safety planners intended to use protective suits, respirators and sprinklers to keep down dust. But without adequate funding, simple precautions were scrapped.

Paul Laird was one of the first service members to arrive for the atoll's cleanup, in 1977. Then a 20-year-old bulldozer driver, he began scraping topsoil that records show contained plutonium. He was given no safety equipment.

"That dust was like baby powder. We were covered in it," said Mr. Laird, now 60, during an interview in rural Maine, where he owns a small auto repair shop. "But we couldn't even get a paper dust mask. I begged for one daily. My lieutenant said the masks were on back order so use a T-shirt."

By the time Mr. Laird left the islands, he was throwing up and had a blisterlike rash. He got out of the Army in 1978 and moved home to Maine. When he turned 52, he found a lump that turned out to be kidney cancer. A scan at the hospital showed he also had bladder cancer. A few years later he developed a different form of bladder cancer.

His private health insurance covered the treatment, but co-payments left him deep in debt. He applied repeatedly for free veterans' health care for radiation but was denied. His medical records from the military all said he had not been exposed.

"When the job was done, they threw my bulldozer in the ocean because it was so hot," Mr. Laird said. "If it got that much radiation, how the hell did it miss me?"

Scant Avenues for Help

As the cleanup continued, federal officials tried to institute safety measures. A shipment of yellow radiation suits arrived on the islands in 1978, but in interviews veterans said that they were too hot to wear in the tropical sun and that the military told them that it was safe to go without them.

The military tried to monitor plutonium inhalation using air samplers. But they soon broke. According to an Energy Department memo, in 1978, only a third of the samplers were working.

All troops were issued a small film badge to measure radiation exposure, but government memos note that humid conditions destroyed the film. Failure rates often reached 100 percent.

Every evening, Air Force technicians scanned workers for plutonium particles before they left Runit. Men said dozens of workers each day had screened positive for dangerous levels of radiation.

"Sometimes we'd get readings that were all the way to the red," said one technician, David Roach, 57, who now lives in Rockland, Me.

None of the high readings were recorded, said Mr. Roach, who has since had several strokes.

Two members of Congress wrote to the secretary of defense in 1978 with concerns, but his office told them not to worry: Suits and respirators ensured the cleanup was conducted in "a manner as to assure that radiation exposure to individuals is limited to the lowest levels practicable."

Even after the cleanup, many of the islands were still too radioactive to inhabit.

In 1988, Congress passed a law providing automatic medical care to any troops involved in the original atomic testing. But the act covers veterans only up to 1958, when atomic testing stopped, excluding the Enewetak cleanup crews.

If civilian contractors had done the cleanup and later discovered declassified documents that show the government failed to follow its own safety plan, they could sue for negligence. Veterans don't have that right. A 1950 Supreme Court ruling bars troops and their families from suing for injuries arising from military service.

The veterans' only avenue for help is to apply individually to the **Department of Veterans Affairs** for free medical care and disability payments. But the department bases decisions on old military records — including defective air sampling and radiation badge data — that show no one was harmed. It nearly always denies coverage.

"A lot of guys can't survive anymore, financially," said Jeff Dean, 60, who piloted boats loaded with contaminated soil.

Mr. Dean developed cancer at 43, then again two years later. He had to give up his job as a carpenter as the bones in his spine deteriorated. Unpaid medical bills left him $100,000 in debt.

"No one seems to want to admit anything," Mr. Dean said. "I don't know how much longer we can wait, we have guys dying all the time."

Correction: February 5, 2017

An article last Sunday about medical problems among soldiers who cleaned up the fallout from nuclear tests on Enewetak Atoll misstated, in some editions, the type of cancer that one service member, Paul Laird, learned he had after turning 52. It was kidney — not testicular — cancer. An accompanying picture caption also misstated Mr. Laird's age in some editions. As the article correctly noted, he is 60, not 59.

A version of this article appears in print on January 29, 2017, on Page A1 of the New York edition with the headline: Veterans Feel Cost of U.S. Nuclear Tests.

Exhibit 12

The New York Times | https://nyti.ms/2OLw7DS

Legal Win Is Too Late for Many Who Got Cancer After Nuclear Clean-Up

Air Force veterans who dealt with a Cold War-era atomic accident in Spain have won the right to sue collectively for health benefits — but not before many had lost battles with cancer or other ailments.

By Dave Philipps

Feb. 11, 2020

SPRINGFIELD, Mo. — On Christmas Eve, Victor Skaar mailed a stack of letters to Air Force veterans he had served with in Palomares, Spain, scrawling a simple headline at the top of each one: “Great News!”

Mr. Skaar, a retired chief master sergeant, was one of 1,600 troops scrambled by the Air Force in 1966 to clean up a classified nuclear disaster by collecting debris and shoveling up plutonium-laced soil. Many were later stricken with cancer and other ailments, and tried without success to get the federal government to take responsibility and pay for their medical care.

He wanted to spread the word about an encouraging development: A lawsuit he had filed against the Department of Veterans Affairs had been certified as a class action, meaning that there was finally a chance to set the plutonium case straight, not just for him but for everyone who was there.

But his letters soon began trickling back to him: Undeliverable. No forwarding address. One brought a reply from a widow. Each one in his mailbox made his heart sink.

“For many of them, it’s too late,” he said of his comrades. “They’re gone.”

As one of the first cases ever granted class-action status by the Court of Appeals for Veterans Claims, the Skaar lawsuit represents a major step forward for veterans with long-term health issues linked to toxic exposure in the service.

‘First they told me there were no records, which I knew was a lie because I helped make them.’

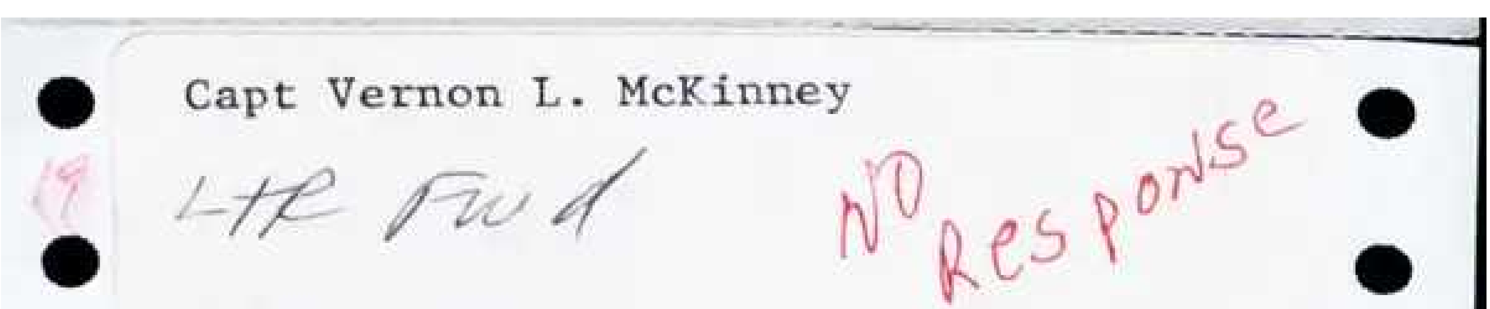
Until now, even in situations where thousands of troops were exposed to hazards like radioactive fallout, burn pits or Agent Orange and then faced similar problems afterward, each one has generally had to grapple with the vast military and veterans’ bureaucracies alone.

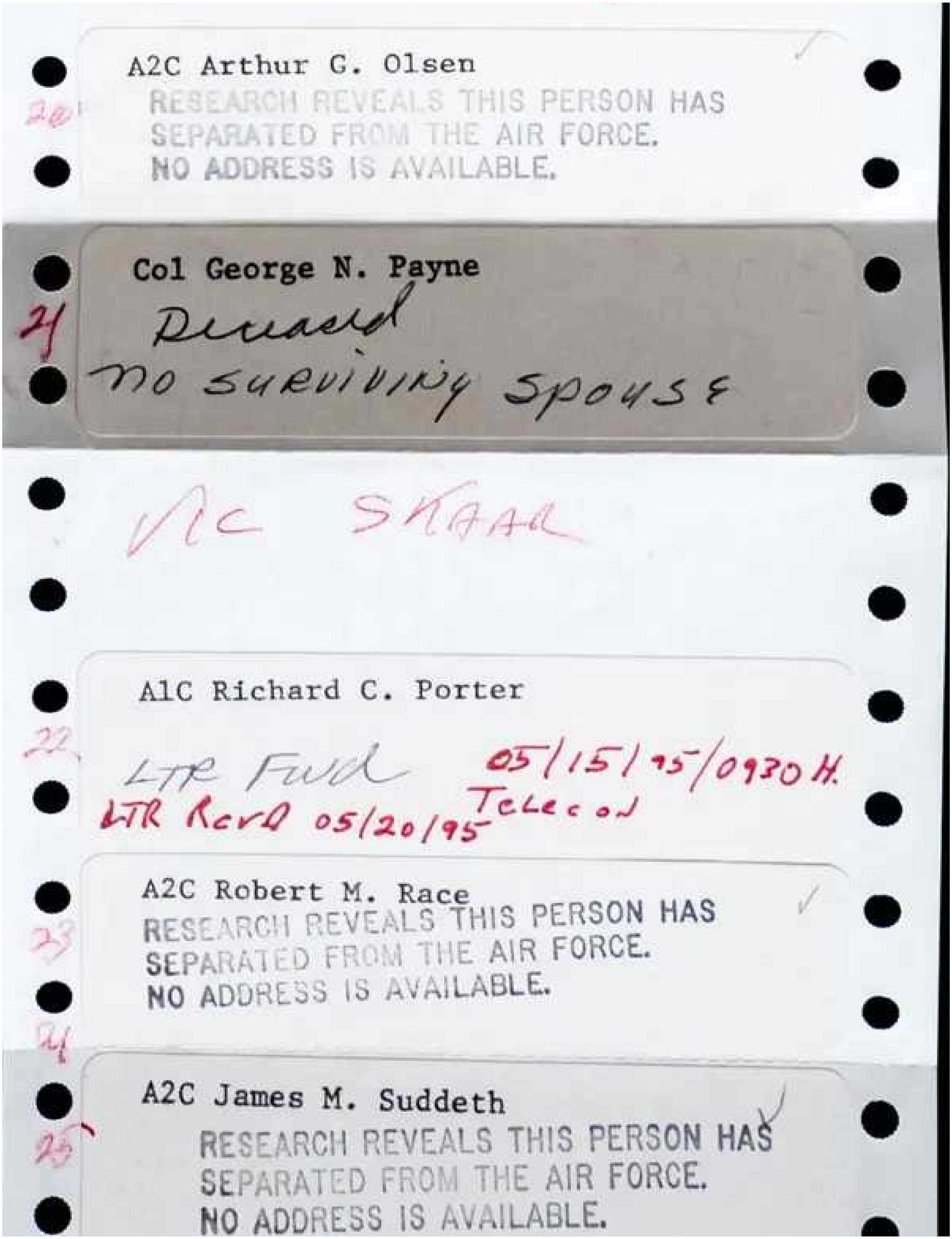
“It’s a huge difference, and will only make it easier for veterans,” Bart Stichman, director of the National Veterans Legal Services Program, said of the ruling. His organization is a nonprofit group that helps veterans pursue claims.

Mr. Skaar, 83, learned during his Air Force exit physical in 1982 that his white blood cell count was way off. He has been fighting ever since to get the military to acknowledge his condition as service related.

“First they told me there were no records, which I knew was a lie because I helped make them,” he said as he sorted through brittle and yellowing documents in his home office outside Springfield, Mo. On the wall was tacked a hand-drawn map he had used in the cleanup, marked with high radiation readings he had jotted in black ink. “Then they told me I had been exposed, but the levels were so low that it didn’t matter,” he said.

In a statement this month, the Air Force maintained its assessment that the Palomares troops had not suffered harmful exposure to radiation.





A2C Arthur G. Olsen
20 RESEARCH REVEALS THIS PERSON HAS
SEPARATED FROM THE AIR FORCE.
NO ADDRESS IS AVAILABLE.

Col George N. Payne
21 Deceased
no surviving spouse

A1C SKAAR

A1C Richard C. Porter
22 LTR Fwd 05/15/95/0930 H.
LTR Rcvd 05/20/95 Telecon

A2C Robert M. Race
23 RESEARCH REVEALS THIS PERSON HAS
SEPARATED FROM THE AIR FORCE.
NO ADDRESS IS AVAILABLE.

24

A2C James M. Suddeth
25 RESEARCH REVEALS THIS PERSON HAS
SEPARATED FROM THE AIR FORCE.
NO ADDRESS IS AVAILABLE.

Through a Freedom of Information Act request in 1992, Mr. Skaar obtained a list of 26 airmen who had tested high for radiation exposure during the 1966 cleanup of a nuclear disaster at Palomares, Spain. One of the names was his own.

A veterans' legal services clinic at Yale Law School helped Mr. Skaar pursue his lawsuit. The clinic, which is run by students, has a track record of winning precedent-setting victories in court.

The decision to try for class-action status was a "no-brainer," said Meghan Brooks, a clinic member who has since graduated. "The bunk science the Air Force was using was not just harming Mr. Skaar, but all the other Palomares veterans," she said. "Mr. Skaar really wanted to fight on behalf of others."

Even so, each letter returned to Mr. Skaar was a reminder that the wheels of justice can grind so agonizingly slowly that by the time they churn out a resolution, many who needed relief are gone.

The Palomares disaster occurred on Jan. 17, 1966, when an American B-52 bomber on a Cold War patrol exploded during a midair refueling accident, sending four hydrogen bombs hurtling toward the ground. They were not armed, so there was no nuclear detonation, but the conventional explosives in two of the bombs blew up on impact, scattering pulverized plutonium over a patchwork of farm fields and stucco houses.

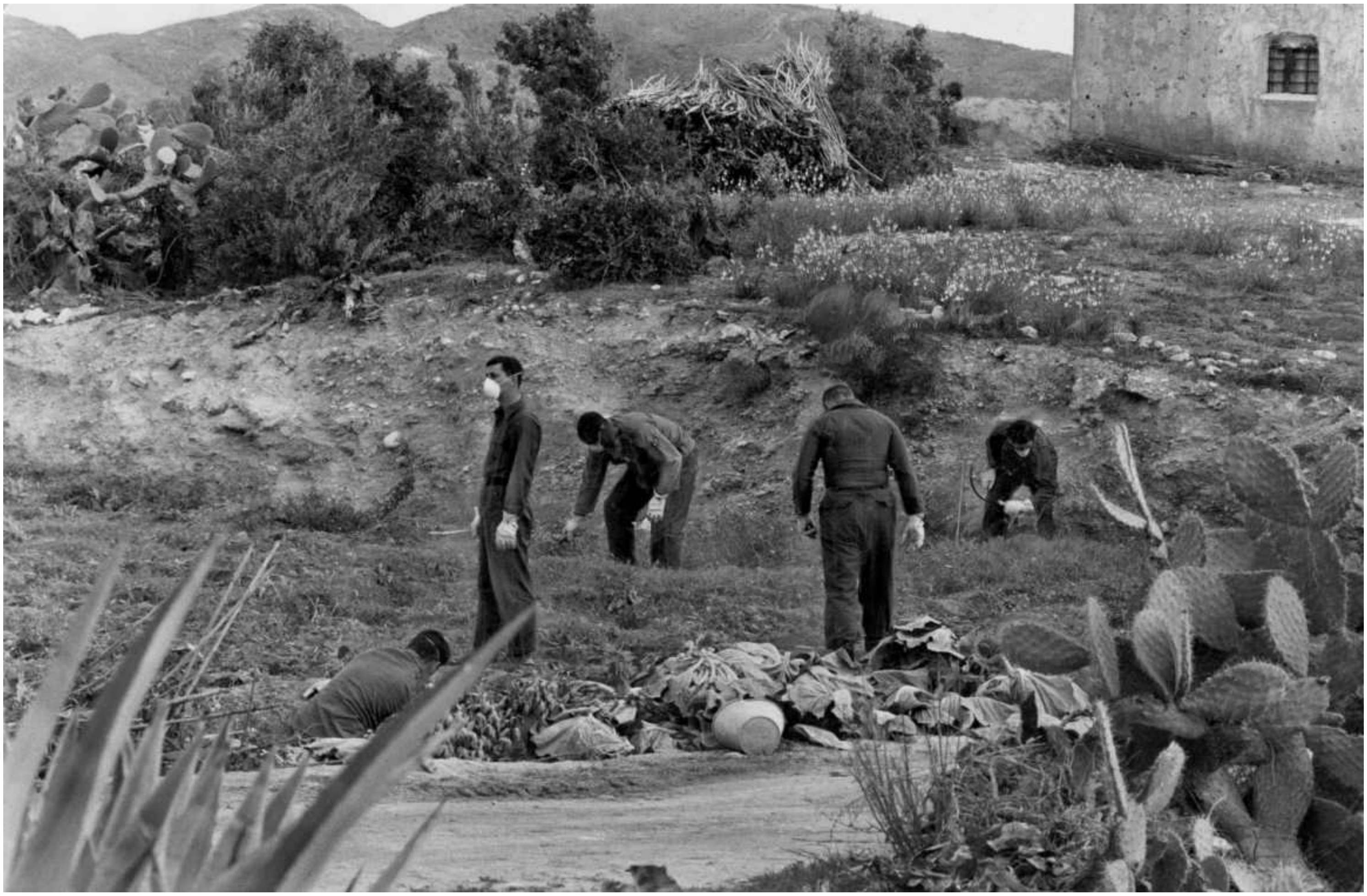
Plutonium is extremely toxic, but it often acts slowly. The alpha-particle radiation it gives off travels only a few inches and would not penetrate skin. But inhaled plutonium dust can lodge in the lungs and steadily irradiate surrounding tissue, gradually inflicting damage that can cause cancer and other ailments, sometimes decades later. A single microgram absorbed in the body is enough to be harmful; according to declassified Atomic Energy Commission reports, the bombs that blew apart at Palomares contained more than 3 billion micrograms.

The Air Force sought to clean up the disaster quickly but quietly. It threw together a response crew made up of low-ranking airmen with no special training — cooks, grocery clerks, even musicians from an Air Force band — and rushed them to the scene. Wearing nothing more protective than cotton coveralls and sometimes a paper dust mask, they cut down contaminated crops, scooped up contaminated soil, and packed the material in 5,300 steel barrels that were shipped back to the United States to be buried in a secure nuclear waste storage site in South Carolina.

'We had to find all the bombs and do the cleanup — that took priority.'

Officials assured the public at the time that everything was fine, claiming that only one of the bombs had "cracked" (in fact, two had been blown up), and that only a "small amount of basically harmless radiation" had been released. But documents that have since been declassified showed that Defense Nuclear Agency experts knew there was considerable risk.

Veterans of the cleanup who filed claims were blocked by a bureaucratic Catch-22. There was so much plutonium floating around during the cleanup that it kept the Air Force from getting accurate contamination readings, and most of the collected data was discarded. But the Air Force went on to conclude that since it did not have readings showing otherwise, none of the troops were exposed to damaging levels of radiation. Based on that assertion, the Department of Veterans Affairs has consistently denied nearly every claim related to Palomares.



Air Force personnel wore masks and gloves as they worked in 1966 in the fields around Palomares where three hydrogen bombs had accidentally fallen. Conventional explosives in two of the bombs went off, scattering plutonium dust. A fourth bomb fell into the sea. U.S. Air Force

In 2016, dozens of veterans described the cleanup and the health problems they had afterward to The New York Times. Many of them have since died of cancer or related illnesses.

Nolan Watson, who slept by one of the bomb craters the night after the blast, had bone and joint problems for the rest of his life, along with multiple cancers. He died in 2017.

Arthur Kindler, a supply clerk who got so covered in plutonium-laced dust a few days after the blast that the Air Force took his clothes and made him scrub in the ocean, developed testicular cancer in 1970, and later had three bouts of cancer of the lymph nodes. He died in 2017 from complications of cancer.

Frank B. Thompson was a 22-year-old trombone player who spent days searching contaminated fields, and later struggled for years with liver cancer. He died in 2018.

John H. Garman, a former security-forces airman who was one of the first on the scene and secured the area around one of the bomb craters, died of respiratory disease in 2019.

It is impossible to definitively connect individual cancers to a single exposure to radiation. And no formal mortality study has been done to determine whether there has been an elevated incidence of disease among the Palomares veterans. All they know is what they have seen happen to their comrades and themselves.

“It’s a sad, sad thing,” said Janice Slone, who recently put her husband, Larry Slone, in hospice care. She said that Mr. Slone, who picked up bomb fragments at Palomares with his bare hands, watched friends die of cancer while he suffered for years with a progressive neurological disorder.


23 JAN 62

A portrait of Mr. Skaar taken in 1962.

If Mr. Skaar's suit is successful in forcing the government to recognize that the Palomares veterans were exposed to damaging radiation, many would be entitled to free health care. As it is, some of their families have drained their savings trying to pay for care. Ms. Slone said her family had spent $35,000 in recent months to keep Mr. Slone in hospice.

"Larry was very proud of his service," she said. "We have a flag up in his room. But when you serve and then the Air Force lies about it —" She paused, and began to cry. "There's no other way to say it, it's a betrayal."

For decades, the Air Force has cited urine samples taken in the field in 1966 to support its claim that the cleanup troops were not harmed, even after its own analysis raised alarms about the data. Mr. Skaar was the health technician in charge of collecting the samples; he said conditions at the scene made it impossible to do the job according to protocol.

"There was no time," he said. "We had to find all the bombs and do the cleanup — that took priority."

Plutonium in the air, on the equipment and on technicians' hands probably contaminated at least some of the urine samples. When the test results came in alarmingly high, Air Force scientists attributed the readings to such contamination and discarded two-thirds of them, keeping only the lowest readings.

The doctor in charge of the testing, Lawrence T. Odland, said in a 2016 interview that the retained data was useless, and that the scientists had agreed that the cleanup troops should be monitored for health problems for life. But the registry he set up for them was almost immediately shut down. Dr. Odland died in 2019.

The Air Force said it stood by its conclusion, based in part on the urine tests, that no troops were exposed to harmful radiation at Palomares. It said that the danger of contamination was minimal and that the troops were protected by strict safety measures.

The data was recently reviewed by Frank von Hippel, a nuclear physicist and professor emeritus at Princeton University. In an interview, he called the Air Force's findings "completely arbitrary."

"This stuff is not easy to get right, and in the past, when the government wasn't sure, they just presumed everyone was exposed," he said. "Here they've basically done the opposite."

The question before the court in Mr. Skaar's lawsuit is whether the government's conclusion that the cleanup troops had no service-related radiation exposure was so arbitrary and capricious that it violates the law. Mr. Skaar knows the answer will come too late for many. He doesn't plan to give up.

"I want to go to my grave knowing I've done the best I could," he said.

Dave Philipps covers veterans and the military, and is a winner of the Pulitzer Prize for National Reporting. Since joining the Times in 2014, he has covered the military community from the ground up. @David_Philipps • Facebook

A version of this article appears in print on , Section A, Page 14 of the New York edition with the headline: Long Wait for Aid After Rush to Clear Atomic Mess

Exhibit 13

FRIDAY AFTERNOON SESSION

October 6, 1967

UPTON: I am told that our film has been rethreaded now and is ready to roll. I believe that Dr. Langham and Dr. Donaldson have suggested that we take the film next.

FREMONT-SMITH: Good.

UPTON: So if all is in order, let's proceed.

[Showing of film "Return to Bikini."] [Applause]

DUNHAM: Lauren, this isn't the way I heard the story. There was a movie I saw a few years ago that was announced to the public by Ian Fleming with a four-page spread in the London Sunday Times which showed little fish that had become disoriented, losing their way, trying to climb trees, which showed sea turtles who tried to find where to lay their eggs. They laid great quantities of eggs which were sterile and then couldn't find their way back to the sea. It showed piles and piles of tern eggs which were also sterile and very few terns. Now, which is the true story, sir?

DONALDSON: I don't think I've ever seen these people in Bikini. If they were there, it was at some time when we didn't happen to be about. But if they want to have a contest, I'll match my skin scars against theirs any day and coral cuts against theirs.

DUNHAM: This was supposed to be an authentic movie of the aftermath of the atomic bomb in Bikini. Maybe you selected different parts of the atoll.

DONALDSON: I think one would have to do more than select in this particular case because the real problem here about the fish that were supposedly displayed there is that in all the years we've worked there we've never seen these particular fish in this place because that particular kind of fish can't live in an atoll; they can't live in an atoll because the environment isn't right for them and I think even John

Wolfe with his great accomplishments in environmental control couldn't built a mangrove swamp out in Bikini without an outflow of fresh water.

We could relate this on and on but this sort of popular release is nothing but disgusting.

TAYLOR: Who made that particular movie, do you remember?

DUNHAM: It was an Italian movie. It had a lot of other stuff in it. There were beautiful pictures, though. I must admit there were beautiful pictures of wildlife. As Lauren says, undoubtedly these ones of these mudskippers, as they call them, were taken in the mangrove swamps somewhere and there were lovely pictures of giant sea turtles laying eggs. Again they're apparently authentic pictures.

FREMONT-SMITH: Maybe it was the photographer that was disoriented; thought he was in Bikini but wasn't.

DUNHAM: That could be quite possible.

BUSTAD: Are there any natives now on Eniwetok and Bikini or are there any residents there?

DONALDSON: There are no residents on Bikini. The place is delightfully deserted. It's a place that one can go to and become completely isolated from the outside world. The native Bikini people were evacuated in the spring of 1946 and moved to Rongerik. Rongerik was one of the islands downwind, you recall, on the chart that Bob had on the board. We visited Rongerik in the summer of 1947 and they were rather hard put inasmuch as they had had a fire and burned off much of the environment. They were limited in food supply because the atoll they were living on was smaller than the one they had left when they were evacuated. This was reported with some force, as strong as we could make it, to the Trust Territory--it wasn't Trust Territory at that time. The Navy had responsibility, they moved them to Kwajalein and from Kwajalein they moved them to Kili, a small island south of Kwajalein and there they remained.

Now, the people from Eniwetok, on the other hand, were evacuated to Ujelang, another island. They're not happy with Ujelang, again because it's not their ancestral home. It's a smaller island than Eniwetok and they would very much like to go home. Of course, going home to them would be something as comparable with the atoll they left. This would take a great deal of doing to restore one of these atolls to a living environment for the Marshallese, not the fact that life can go on there but that they base their economy on coconuts, which is essential to their survival, which would take maybe some 10 or 12 years to replenish and get the crop going. Of course, each year it's postponed that means the 10 or 12 years are pushed back a bit farther.

Now, we who have worked there have many friends among these people. We know them, as Bob and others who have been out there know. We hope that it will be possible to get them back home again. I think this is a blight on our national record that we don't do something about getting them back.

CONARD: We certainly are trying to, aren't we?

DONALDSON: I have no knowledge of it.

TAYLOR: One gets the impression that the ebb and flow of the sea plays at least a major role in restoring the island, restoring the atolls to their states. Do you want to say anything about the relevance to this, to a similar situation on land, for example, in Nevada?

DONALDSON: Again you go back to the three-dimensional effect we talked about before and you have a completely different ecology, a completely different set of syndromes, of areas that you are talking about.

UPTON: Maybe this is a logical point to shift them to Dr. Langham's presentation, but we are dealing in this case with a land problem. If there isn't further discussion of the film, in order not to cut short Wright's presentation, let's go ahead with that then.

LANGHAM: As a proper beginning I would like to invite Merril to pipe up with "incredible!" at any time he feels the urge.

FREMONT-SMITH: Or even with "credible!"

BUSTAD: Are you restricting it to Merril?

LANGHAM: Maybe I'm intimidating Merril. I'm sure I haven't the rest of you.

In listening to the discussions yesterday with regard to the sociophyscological reactions among the Japanese, I would just thinking about how the reporting of this incident is so different from the things that Merril was saying. That was why he was saying "incredible" because my experience has been quite different from Merril's. The problem perhaps we faced was not nearly as great, but I am sure that one cannot help but think why the reactions of these two situations was so different, and I have eliminated a few pictures that deal with the details of the health physics and how we cleaned up the mess and what we did in order that I can merely present those things which I think have some bearing or which point out some of the differences, and I'm sure that these differences lie in the psychological reaction of the people.

Now, the question is why was the psychological reaction so much different, because many of the problems were quite the same. There was goof at both nations involved admitting there had been an accident that involved radioactive material, just exactly as there was in the other case. There was a serious economic problem in so far as the people in this limited area were concerned.

FREMONT-SMITH: You mean the nations didn't admit that there had been.

Stafford Warren
DOE/UCLA 4

LANGHAM: No. This was so typical.

FREMONT-SMITH: How long?

LANGHAM: It wasn't even funny.

FREMONT-SMITH: How long was it? Are you going to come to that?

LANGHAM: Yes. I think it will be brought out in the discussion rather strongly..

FREMONT-SMITH: Physically.

LANGHAM: Because I think this is one of the very interesting points. In other words, I had none of the problems Merril had and I don't think it's that I'm that much better than he is! [Laughter] Of course, I think the problem was not nearly as great either.

Now I would like to show just a few slides to get this show on the road, and I don't intend to make any long speech but I want to set it up and then I want to see you wrestle with why the problems I faced were different than the ones that Merril did.

[Slides] As all of you know, there was an incident involving the loss of four nuclear weapons each rated in the megaton class and it has attracted its share of publicity, this being three examples. The Saturday Review gave it a great play. There were two books written on it in this country and an Englishman came out with a paperback within two months after the incident was over. These two books are rather good and they're not bad accounts of the incident if you'll give, of course, the author's privilege of introducing a little trauma here and there.

Flora Lewis' "One of Our H-Bombs Is Missing" con- centrated more on the sea search than the one that was l... Schultz "The Bombs of Palomares" concentrated more on the operation and went a little more deeply into the philos... and where and why than did Flora Lewis. They both relat...

are good books. There are mistakes, of course, like calling a scintillation counter an oscillation counter. It's obvious that Flora Lewis didn't know anything about how hydrogen bombs go off, and I read her manuscript before and when I sent in my corrections to her manuscript, they were all classified and she never got them! [Laughter] So if you want to know how a hydrogen works, Flora is not a very good authority because she didn't get any help on this particular aspect. The English book is absolutely abominable. It gives everything wrong and it's the type of unfortunate thing that so frequently occurs.

The Reader's Digest carried a very nice article on the incident.

I show this primarly to show where the incident occurred. It occurred about 40 kilometers from Grenada, about 80 miles up the coast, the Mediterranean coast from Gibraltar, about 70 miles west of Cartagena and it occurred in a very remote area right on the Mediterranean shore.

The incident involved the refueling operation of one of six B-52's as part of Operation Chrome Dome. I imagine most of you know about Operation Chrome Dome.

FREMONT-SMITH: No.

LANGHAM: It's given in great detail in Flora's book as well as in Ted Schultz'. But since about 1962 a certain percentage of the SAC B-52's have been airborne at all times carrying weapons, this being part of the deterring philosophy, meaning that if SAC was entirely wiped out, still a certain percentage of the SAC force would be able to zero in on its prescribed target. These flights were being made constantly and there was elaborate pains, of course, taken to see that Dr. Screan's philosophy could not predominate, that some person should not take the war into his own hands, and so forth.

The final act of fusing the bomb was in the hands of the President of the United States so there was no chance of a mishap of that kind.

Flying nuclear weapons of the megaton class over people's heads is serious business, of course, and so these bombs have built into them safeguards which if you take a multiplicity of combinations, the chance of one of them giving a critical yield on an accidental situation like a plane crash is probably about 10^{-7}. In other words, there is not one chance in 10 million that a criticality could actually occur, and this is because of combinations of interlocks, and so forth, which would have to be thrown in the right sequence and everything before you would have an armed weapon.

Essentially the United States has no agreement which allows it to land a nuclear-carrying aircraft in any country which is armed. These aircraft must take off in United States soil, fly their route and return with and land in the United States. So this means refueling operations at various points along the route. And we have a refueling operation agreement with the Spanish Government. The 16th Air Force was in charge of the refueling planes which would take off from Spanish territory, meet the bomber supposedly out over the Mediterranean and refuel it, as you see going on here, and the bomber would continue on its way. These, of course, were always called practice flights. They could, of course, be changed from a practice flight into the real thing by the right combination of messages, including one from the President. So this is Operation Chrome Dome.

As a result of the accident that occurred, Spain immediately withdrew or requested that no more weapons be flown over Spain, and Mr. McNamara I think has now just about done away with Operation Chrome Dome. I don't think it's even going on. If so, to a very limited extent at the present time.

It was his idea that this had about outlived its usefulness; that the intercontinental ballistic missile had replaced it. And so Operation Chrome Dome was being phased out.

TAYLOR: Excuse me. Are you equating Operation Chrome Dome with air alert? You mean he's decided to stop all air alerts?

LANGHAM: No. He was stopping this type of operation in which an armed bomber with a target in mind is flying a practice flight in the direction of that target and then turned around and coming back and this has been going on since 1962. This particular operation had been done 140,000 times with nuclear weapons aboard without a single accident.

According to an Englishman who had a 8 millimeter movie camera he saw the vapor trail overhead and when he looked up he saw a big puff of smoke and fire, and this is blown up from a 8 millimeter movie camera.

Immediately in the path of the falling debris was the little village of Palomares, approximately 400 inhabitants. Palomares had been there since the time of the Romans. In Roman times they mined the nearby hills for lead, zinc and various other minerals. At the turn of the century the mines began to run out. Many of the people left Palomares, but a few of the hardy citizens stayed behind growing tomatoes, raising pigs, sheep, goats, alfalfa and other things, agricultural products of that variety.

When something like this happens, of course, I mean when the planes exploded, the four weapons came tumbling out in all directions as well as pieces of airplane fell absolutely all over the village. It was not too long that the disappearance of the planes from the radar screens at the refueling station let them know that an accident had occurred. There were two bombers on this run and two fueling planes. The other bombers reported that the accident had occurred. So the accident was known within a few minutes after it occurred.

Immediately contacts with the area was established by the 16th Air Force. The principal way to get there was over a very narrow bad road or fly in by helicopter.

The first thing, of course, that one should do in a situation of this kind is look for any indication of a criticality yield and, indeed, this was done. So the first group that flew in by helicopter looked to see if there had been any indication of a criticality yield and then started rounding up the injured and the dead. There were seven American Air Force people killed and three injured. So they rounded up the bodies and the injured and got them to the hospitals and then the question, of course, came up of where are these precious weapons, primarily because they included a lot of secrets, so-called, of our weapon technology and so this we must find at all costs.

Within two or three days a base camp was organized on the shores of the Mediterranean which grew to house some 850 people before the operation was over. Almost immediately a search was started on land with these people lining up finger tip to finger tip and walking across the countryside looking for something that looked like a nuclear weapon even though, of course, nobody in the crowd had ever seen a nuclear weapon. At least they thought they would recognize an unusual object and reports. They searched 49 square miles three times by this technique and part of that 49 square miles they searched seven times trying to find the weapon. The Bureau of Mines flew out a team which even inspected all of the old mine shafts and all of the old wells just in case the weapons had decided to drop in the holes. So the search was on.

It was obvious that some of the weapons could, or one or two of them could have dropped in the sea. So the Navy was brought in on the operation and within two or three weeks the Navy Task Force had grown to 14 ships. They brought in the ALVIN and the ALUMINAUT and the experimental devices that are used for deep sea recovery and this turned out probably to be the greatest Navy exercise in deep sea salvaging and recovery that has ever occurred.

Notice the sandy beach, because this is part of the economic and psychological aspects of the territory. The mines having run out, this was a depressed region. It has eight miles of the most beautiful Mediterranean beach you could ever see. All you would have to do was clean up some of the slag dumps and things left by the miners and one would have a resort possibility that could actually rival the French Riveria and the Spanish Government had actually underway a developmental program to develop this into one of the tourist resorts which is doing so much now for the economy in Spain. And so you can imagine the great concern of the Spanish Government that here was this development and if there was a hydrogen bomb lurking around somewheres just waiting to go off when you got there, you might not come. And so this would have scuttled their entire program to relieve this depressed area by making it a tourist area.

After some time, within several hours, three of the weapons were found. One was found in the dry river bed just to our right on the screen there, right where the dry river bed joins the Mediterranean. Palomares sits on the mesa about a mile from the beach. Between Palomares and the beach are the ruins of the smelters which have fallen into great de this actually, to show that theitem had some political pr ganda, pictures of these wrecked and ruined smelters were in the Iron Curtain country newspapers as part of the aftermath of the American accident. And not only was that of international political flavor but the Nuclear Disarmament Conference was meeting in Geneva at the time of the accident and when it became known, even though it was not announced officially by either the Spanish or the United States Governments, the Disarmament Conference, the Western blocs just walked out and that was the end of the 1966 Nuclear Disarmament Conference.

EISENBUD: The Western blocs walked out?

LANGHAM: The Eastern blocs.

EISENBUD: How long after the accident was that?

LANGHAM: They walked out immediately upon hearing of the accident even though it was not reported that nuclear weapons were involved. The Russians walked out of the Disarmament Conference and so it was disrupted. So this had international political trauma as well, as much as did the Japanese incident.

When they found the second weapon, it had completely overshot the village. I forgot to say the first weapon, the one that fell in the dried river bed, one of the chutes popped off, came out of the cannister, just about the time it hit the ground and broke its fall and the weapon sustained a dented nose and lost one fin. So this was picked up by the helicopter, put on a truck bed and rolled away.

The second weapon complete overshot the village and landed in the hills over to the left where the red spot is, landed in the hills. The chute didn't deploy; it impacted its full velocity in the side of the mountain. When the high explosive charge in the warhead went off the plutonium therein, of course, was converted to the oxide, a fine dust of oxide, was thrown up with the dirt and bits and pieces of bomb casing into the air, the wind was blowing down the valley toward the village at about 30 knots. So the plutonium cloud drifted down towards the little village of Palomares.

The third weapon to be found impacted right in the edge of the village, 100 yards from city hall. One part and wing of the B-52 fell within 80 yards of a schoolyard where there were 70 or 80 children playing. There are bits and pieces of airplane all over this village. It was just absolutely unbelievable that that much material could fall down in a populated area and somebody not got hit. But nobody did. In this case again the weapon impacted in a rock wall to a man's tomato patch and it went off, the high explosive charge, and the plutonium was thrown into a cloud which drifted away from the village but down across their principal agricultural area. Their prime cash crop was tomatoes, and they get two crops a year. The last one they harvest about the middle of January. And they were just waiting to get into harvest their last crop of tomatoes and it wasn't quite time. It incidentally happened to be a holiday for a patron saint or something for this village. So religion enters into this. Those of you who like to think of the theological aspects, the statement was made "The hand of God was out in Palomares." So there is even a religious connotation.

FREMONT-SMITH: The hand of God protecting the village or punishing it?

LANGHAM: Protecting it, because this is the only village that's had over 4 megatons of weapons dropped on it and nobody got hurt. So it does look like the hand of God was out, and this was what the Spanish thought, the people that lived in this area.

In this case the contamination went down across their principal cash crop, their fine ripened tomatoes, and so economics are involved here. They have a fishing industry also and there was a question of what about the fish? What about the tomatoes? Exactly the same thing that Merril was talking about.

This is a picture of the family that was involved. They are a very friendly, nice people. They like to have their pictures taken. That was their principal mode of transportation. Many of the tomato fields were fertilized with soil that had been brought in in those baskets and the soil has been brought in over the years to make the tomato field a little better, and that was their principal mode of transportation, at least there were a few people that had carts as well.

Another example. Here is a family and the livestock always lived in the end room to the house and if the family increased they built on another room for the livestock and then turned the other room into an increased living quarters. Plutonium counts probably of the order of two or three thousand counts per minute per alpha probe area could be measured in the front yard and there was 500 counts or so sometimes on the living room floor inside the house.

DUNHAM: Is that the family doctor?

LANGHAM: That's one of the atomic Spanish AEC colleagues and they were extremely knowledgeable and extremely cooperative and they said, "We'll worry about the people; you worry about the tomatoes and the contaminated fields and all of that. We'll take care of our people," and they did a beautiful job. Here was cooperation, as you see, that was unbelievable and knowledgeable. There were only three or four of these people, but the two principals had spent a year or two in this country at Rochester and at Brookhaven and so they knew something about what they were dealing with and some people took it quite lightly.

Here you see the local barber who immediately picked up his shaving mug, a coffee can full of water, a sponge and a piece of soap and some scissors and moved right into the mess hall area and started to set up his barber shop. And the price of a shave was 10 pesetas, the price of a haircut was 10 pesetas, the price of a shave and a haircut was 10 pesetas [laughter] and part of the humor was to get him out of the mess hall. They took some of those plywood boxes and built him a little enclosure about 100 yards away from the mess hall. He didn't like this very much because people couldn't see him practicing his trade. So he felt he desired to write a sign on the wall. So he had written "shave, hair-cut, everything, 10 pesetas." Some disgruntled G.I. had written right below the sign, "Everything but girls!" [Laughter] So I'm sure that the barber had never had so much business in his life. Even I got a haircut, you see.

If one looks away from the impact point of the third weapon to be found, he sees their principal agricultural area. You see one of the farmers in the background. He received the biggest settlement I think, which was something like $16,000 was the settlement with that particular one. Every home has one of those cactus hedgerows around it and you haven't had an experience yet unless you have tried to take contaminants out of hedgerows! [Laughter] In fact, it's better to plow it up and pay the man to do it himself. So this was the situation.

Here are their alfalfa and tomato fields. These tomato stocks or these tomato plants are trained gently by hand to grow up a tripod of stocks. They'll grow seven feet high and they were just loaded with fine ripened tomatoes and in January on the European market they bring a nice price. So this was what was going to keep them going until their next crop.

Here is the way their tomato patches looked in a little while because you could hold an alpha counter up to the tomato vines and get readings of 10, 15, 20,000 counts per minute. So what do you do in this case? Well, your first thought is to get the stuff rigged up in a pile so that the plutonium won't blow around and if there are some of you that wonder why we worry about plutonium, it's known, of course, that enough plutonium taken into the lung or the liver or bone will produce cancer. We've done this hundreds of times in animals. Plutonium, if taken in systemically is indeed bad. There's no doubt about that. And some people have referred to it as the most toxic substance known to man. I think this is erroneous, but you can get that belief by looking into the industrial heightening tables at the maximum tolerable levels of various things and when you get to plutonium you'll find that plutonium-239 has one-half of a microgram. That's one-half of a millionth of a gram as the maximum permissible body weight. If you're worrying about the plutonium-238, it's 250 times over that still.

BUSTAD: I think that you should point out that ingestion as such---

LANDHAM: I would, yes. But the whole idea, as I said, is its systemic. The reason I don't think plutonium shouldn't be given this terrible reputation is that it's extremely difficult to get into your body and you can eat it and absorb only about 3/1000 of 1 per cent of what passes through the gastrointestinal tract will be absorbed in the blood. On the lung the absorption is a little bit higher perhaps.

EISENBUD: I've heard a statement made many times. I don't understand the basis for it since the maximum permissible body burden for radium is 1/10 of a microgram.

LANGHAM: If we put it on the microcurie basis, then it's 4/100 of a microcurie as compared with 1/10. that on that basis it's still---

EISENBUD: Yes.

LANGHAM: These are the tomato patches in a fe.

days. Tomatoes, vines, gain stocks and all were taken to the edges of the field and hauled away to decide what to do with later. So here's their cash crop lying by the side of the road. Here is the economics of the picture comparable to the Japanese.

UPTON: These weren't killed by radiation?

LANGHAM: These were killed by the Americans.

FREMONT-SMITH: At this time was there any knowledge yet locally or internationally that---

LANGHAM: Yes, but neither country had admitted it.

FREMONT-SMITH: It was just known but not admitted?

LANGHAM: Yes. It leaked out very fast but neither country would admit it. They admitted there was an accident, an airplane accident but they wouldn't admit that any nuclear materials or nuclear weapons were involved.

FREMONT-SMITH: Even though all of this was being swept up?

LANGHAM: That's right.

DOBSON: Wright, what were the local people told, in what detail and by whom were they informed of the nature of the operation?

LANGHAM: They were informed by the Civil Guard who seem to crawl out of the woodwork in Spain any time something happens. They were told by these representatives of the Spanish AEC and by our own people to stay out of the field until we tell you to go in. And so they were excluded from going into their fields where their tomatoes were about ready to pick. Obviously this caused the usual bit of concern and talk and gossip and why and pretty soon it began to get around that there was a radioactive substance in the field. So you begin to hear the villagers talking about radioactivity. And their knowledge of radiation effects stemmed from knowing that in Hiroshima and Nagasaki thousands of people died from an atomic bomb and one was occasionally asked the question whether as a matter of fact are we going to die? And you told them no, and this satisfied them so they went away. There was usual turmoil. Naturally this was a big field. It was place where nothing had happened since the Romans and all of a sudden everything seems to happen. And so visitors came in from nearby villages even though there were 400 people approximately living there. The Spanish ended up monitoring 1800 people because it became quite a tourist attraction and besides about everybody had a cousin or an uncle living in the nearby towns, so cousin or uncle came over to check on them to see if they were all right. So it was practically a tourist resort.

FREMONT-SMITH: With no restriction on local travel?

LANGHAM: Not except right in certain areas where we posted the Civil Guard and told the Civil Guard not to enter.

Here's one of those areas. This is the tomato patch. You can see the crater, the hole blown in the rock wall in the tomato patch and the gentleman who owned the tomato patch was standing in the door of his home which is the white one in the background. The blast from the explosion blew him down into his living room floor, tore one door off the hinge and knocked out one of his windows and that was the closest we came to having a Spanish casualty. Seven Americans had already died and eight more were killed flying in supplies to Sinavia to help clean up the mess. So 15 Americans lost their lives. Not a single Spanish life was lost.

EISENBUD: How soon after the event was it known to the local residents that their crops would be bought?

LANGHAM: Probably 24 to 48 hours. I mean the first thing they know of it they were restricted from going into their fields.

EISENBUD: They were sure they would get a good price for their crop.

LANGHAM: Some of them had been overlooking in the hole and looking at that funny object down in the hole and the Frenchman claimed he got a radiation burn on his knee from looking into the hole. He got down on one knee, looked into the crater and then his knee got sore after that and he said he had a radiation burn on his knee. Of course, this is alpha activity and it got on his pants and we knew he didn't have a radiation burn.

Here are some of the psychological aspects of this problem. The manual says--and I helped write it--and it's funny that you can never write a manual that can take into consideration the actual event once it's happened. But the manual says you determine the hazardous area and you stake it off with red flags! [Laughter] So we actually did that. We staked off the area with red flags. Unfortunately, the guy who wrote the manual and many of us who made the decision didn't know. Red is the color of the cape with which they fight the bull and it has a far more significant meaning for some reason to the Spanish than it does to us. It means danger to us, but for the Spaniard the red flag has a great deal of meaning. So we quickly took down the red flags and replaced them with white flags.

FREMONT-SMITH: What kind of a meaning? Did you mean a dangerous meaning?

LANGHAM: Yes.

FREMONT-SMITH: Much worse than just ordinary danger?

LANGHAM: Yes.

FREMONT-SMITH: Practically radioactive.

LANGHAM: They hardly knew what radioactivity was, you see. To us a red flag means danger, "Don't enter," but to them it means much more danger than it means to us, I guess.

FREMONT-SMITH: "Very dangerous. Don't enter at all."

LANGHAM: Yes, "Or run the other way";I don't know except that the red flag created enough commotion and our psychology friends can explain this, I think.

DUNHAM: I think Merril's point about it having political significance may be important.

EISENBUD: The red flag is what the Loyalists carried during the Spanish Revolution.

LANGHAM: Yes. Maybe that did. All I know is that we had to get the red flags down fast for some reason or another. And this was all right and you can see the beginning of the clean up and scraping up the plutonium contamination where we felt it was present even though no agreements had been made with the Spanish Government with what we would do with regard to cleanup. In other words,this is going on starting to do something about the situation even before there's any agreement.

FREMONT-SMITH: Yes. Starting to occupy a bit of Spain, so to speak, by the soil.

LANGHAM: Yes. By the time we were through with the land operation, Palomares began to look like that. The houses had been hosed down in many places; some of them had been re-whitewashed. The fields had been plowed clean with the exception of the irrigation ditches which we finally got the Spanish to let us agree to leave because the soil is so bad that it takes 10 years to stablize an irrigation ditch and if we would have stripped the vegetation at the irrigation ditch we would have had a problem there. So the Spanish agreed to let the irrigation ditches stay, and you'll notice the field in the background has not been stripped. In other words, we had agreement with the Spanish finally as to what we would strip and what we would plow and what we would compensate for, and so forth.

This is my favorite story. All of this material, primarily because it shows it when you begin to get into the international area and attract other people's attention is when your headaches begin. We had accumulated up at the site too, as it was called back in the hills where there was no vegetation but a big contaminated area, a weapon that broke open there. We had accumulated this great pile of contaminated soil and trash. The question was what do you do with it? So we talked to the Spanish and asked them if we could bury it. So we started digging a trench. Well, the Spanish became concerned about, well, they'd better have their geologists and hydrologists look the situation over to see if there was any possibility that this could eventually get into the watershed. So this delayed things a week or so. We've still got this pile of contaminated trash there.

FREMONT-SMITH: Is this the pile we see?

LANGHAM: That's some of it. We had many piles all over the place. That's just the beginning. That's how far we go on digging the trench.

The size of this pit would resemble something approaching the length of a football field, half the width and 40 feet deep depending on what kind of agreement we can get with the Spanish as to how much we had to remove. But we started digging anyway.

DOBSON: Wright, may I interrupt. May I ask is that rainwater collected in the beginning of your embryo period

LANGHAM: No. Before you started dusting anywhere you came in with tank trucks and sprinkled it theoretical to hold down the inhalation hazard of the people working

UPTON: Did the people wear respirators doing the job?

Staffo DOE

LANGHAM: Some of them did, some of them didn't.

Most of the respirators were surgical masks, and if it did something for your psychology to wear one, you are privileged to wear one. It wouldn't do you any good in the way of protection but if you felt better, we let you wear it. We ran into such psychological problems. The manual says you will dress up in coveralls, booties, cover your hair, wear a respirator, wear gloves. That's what the manual says. So some people tried to do this where you could find something that resembled this type of equipment and before long you found this caused consternation in the village. They said, "How come you dress up like that and you let us walk around in the village with our street clothes on?" And so even little things like that that I never even thought of before becomes a problem psychologically. Why shouldn't we be protecting them if we were doing all of this protection in the area? So most of the time it would hardly meet the standards of the health physics manuals the way this operation was done, and I think it's fine because I think there was not anything wrong with this operation. I think it seems wrong with the manual.

EISENBUD: How soon after did you arrive?

LANGHAM: I guess I got there at about noon on the third day, something like that.

FREMONT-SMITH: Where were you when you started?

LANGHAM: I was in Washington.

FREMONT-SMITH: A good place!

WARREN: Did you go home first?

LANGHAM: No, I didn't go home. They told me to proceed to Madrid and I didn't even have a passport. I was in Spain all this time without a passport and a pair of pajamas and a shaving kit. They did sent me a little gear. I only stayed five days and came home. I was home four days and they sent me back for six weeks because when I got there it was obvious there was no real health problem. This was not a health problem. The psychology, economics, international agreement, these are things with which I claim no competence whatsoever. So at the end of five days I came home only to be sent back, assigned to the American Embassy. So these negotiations were started.

The Spanish wanted this pit finally lined with asphalt, so this was agreed to. Then they decided that they wanted a concrete slab put over it and a fence put around it with the United States to take a lease on it. I kiddingly asked them if they wanted the lease to run for five half-lives, that would be 120,000 years. When the State Department heard that we were contemplating building a monument to this unfortunate incident, the explosion was much larger than the one that occurred in Palomares! [Laughter] So we were told to take this material out of Spain. So a barrel factory was leased in Naples, put on 24-hour duty and in two weeks produced 5000 steel drums which met the specifications that if filled with soil and if dropped from a height of 50 feet from a helicopter, they would not break open. So they met the specifications. We started the barreling operation; we packed up 4789 barrels of this material, hauled it down to the beach and put it on board a freighter out in the Mediterranean off shore aways and then the question came up of, "Well, you have it on a freighter. What do you do with it?" So the obvious thing to do is to haul it off a few miles into the Mediterranean and kick it overboard. Well, you'd be surprised how many people can object to this! [Laughter] Mr. De Gaulle's government just went right through the roof, as did everybody, whether they owned even remotely a shore on the Mediterranean of not. In fact people objected that had no coastline whatsoever on the Mediterranean. So the Spanish said, "Why don't you take it three or four hundred miles out into the ocean off the coast of Portugal and kick it off in the ocean?" [Laughter] And you'd be surprised. Even our British friends objected to that, to say nothing of Portugal. So the decision was made to bring it home. [Laughter] And you may think our problem ends there, but the Agricultural Department heard about it and said, "That's Mediterranean fruit fly country and you can't bring it in!" [Laughter] I tell that partly as a joke. It so happens that the Agricultural Department did object and they did say that we would first have to sterilize it and they suggested ways and means of doing this and then after a while they did agree that if it was brought in and buried in the steel drums and buried to a depth of 20 feet, there would be no possibility of fruit fly larvae, and so forth, getting to the surface.

FREMONT-SMITH: How about the Governor of the receiving state?

LANGHAM: He didn't like it too much. So then it ended up at Savannah River in the AEC's burial ground, and I guess the Governor felt he couldn't protest too strongly. But there were protests from that area of bringing this back into the United States.

Some statement was made about how the State Department's antiquated operation once in a while causes trouble. The Ambassador, Angier Biddle Duke, who is very, very liked by the Spanish people and he was a very competent person, but it was just absolutely traumatic to see him try to do something, primarily because it just seemed that even the Ambassador doesn't dare do anything, even give out a news release without a check to Washington, and I think this thing could be more simply done. I think Angier Biddle Duke could have been much more of a help than he was if he had just been able to.

FREMONT-SMITH: Function.

LANGHAM: To initiate a bit of action himself. And so this is the story except for a lot of details and the psychology of the news releases; the many, many things that I would much rather see or hear discussed here than have you see a few more slides. In other words, I think the interesting thing here was something that had all of the qualities that the situation Merril was talking about did. There was never a panic or anything resembling it. There were little flareups. There was a little hour or so's demonstration at the University in Madrid which was nicely timed. They were allowed to demonstrate and then they were told to quit, and when they were told to quit, they did so. And there were a few days when fish were not being bought. There was a little rough time when any tomatoes from the south of Spain, whether it came from Palomares or not, was not being picked up by the distributor, the middleman. And some of you are not going to like the conclusion that comes out of some of this.

In the high level meeting in which the Vice President of Spain participated, it was pointed out that their distributors were not buying the tomatoes from the south. You see, he's the middleman. He goes down and buys them and brings them to the city. Now, he was afraid to buy them for fear when he got to the city he wouldn't be able to sell them. So they were more or less not buying tomatoes from that whole area. And the hint was dropped to the Vice President, and since the government licenses these people, the government just said, "Those tomatoes are all right," which indeed they were. "You fellows get back on the job and start buying tomatoes." In three days there were more people down there buying tomatoes than you could imagine.

Another thing that in the foul up over the release of this information tells something, too, that Miss Root is not going to like, I imagine. We had a bilateral piece of paper that we actually handed to Munoz Grandes. This was something that the State Department had agreed upon and we were going to get this bilaterally released in which the two governments simultaneously admitted that the accident had involed nuclear weapons. Well, the old gentleman looked at the piece of paper and it was a very benign little thing. It had been completely emasculated, as you might expect, and stuck it in his pocket. Three days later unilaterally, on the second page of their leading newspaper came out a beautiful article written by Otera, head of the Spanish AEC, in which he told the details, what the situation was. It was absolutely just the most magnificent bit of factual reporting I've ever seen in my life and I came into the Embassy that morning and the people were running up and down the halls and one gentleman said, "We're having a meeting. Otera has blown his top. The whole thing is out in the newspapers." And so we had this big meeting, you see. The cat was now out of the bag.

EISENBUD: On what day was this?

LANGHAM: This must have been the 1st of March, somewhere along in there. It had occurred the 16th of January.

SCHULL: Six weeks.

LANGHAM: Yes, something like six weeks. I don't know. I guess I don't have--I'm a little bit too whimsical maybe for this business. Part of my job with the Embassy was to read all the newspapers. I mean I could not read Spanish but I would get translations of every little artic- that I was to advise on whether it was technically accurate and whether it reflected in any way on the American image. And so they handed me this article. We went into this mee- and they turned to me and said, "Langham, what about this article?" And I said, "Gentlemen, it's wonderful. I wi- had written it myself," and you could just hear a pin dr-nobody laughed whatsoever, and I thought that was clever! [Laughter] And it was a good one and I do wish I had written it myself. But it just seems that when the American image is involved, people have no sense of humor whatsoever.

FREMONT-SMITH: Did they send you home the next day?

LANGHAM: No, but I wasn't invited to go on Duke's swimming party! [Laughter] In fact, I wasn't even invited to advise him on that. I might have advised him not to do it because it didn't I think accomplish anything but I think it drew adverse criticism rather than accomplishing what was intended. I've heard it criticized especially by the English.

FREMONT-SMITH: What was the criticism?

LANGHAM: The Ambassador and the Minister of Industry went down to Palomares and had a press conference on the beach, and he went in swimming even though the temperature was 54 degrees and then they had a big news release, and so forth, and this was a stunt to show people that we weren't afraid, you see, that this wasn't going to hurt the tourism. All of the government--I mean at any level of the government, the greatest concern seemed to be "Are you going to find that lost weapon?" Because of the possible impact that this could presumably have on the development of this area for a tourist resort. And it's going along fine. If anything, I think now it has received a little added push. They're developing it like crazy. The people seem to be back to normal. We're following them to see if they have any plutonium in them. So far it appears they do not, and I think this is an incident which in terms of importance will not even be a grain in the sand on the beaches in time.

FREMONT-SMITH: How long was it before the fourth weapon was dredged up from the ocean?

LANGHAM: It was about nine weeks or so. They had a terrible time finding it. Admiral Guest drew some criticism because of the Spaniard who said he knew right where it went down and, indeed, they found it right where he told them it would be. But Admiral Guest came in and started a systematic sea search in which he started from the beach with the men and then he went to skin divers and then he went to hard hat divers as he was going out. He was making a systematic search of the entire bottom. They found old cannon balls, pieces of airplanes, you just name it, and they found it and brought it up. They literally searched the bottom of the sea systematically and then finally it got so deep that they had to get experimental equipment like the ALVIN and the ALUMINAUT and when they finally got this, they could then search the area told them the bomb went down, and that's where they found it. They got hold of it, lost it, and it slid down a little further and they got hold of it again and finally got the thing up. Of course, the criticism of the Admiral not searching where the Spanish fisherman advised is unjust. The Admiral had no capability to search at the depth where the fisherman advised, and while waiting for deeper sea equipment the Admiral and his staff felt it would be advisable to make a systematic search of the shallower water in the event the fisherman was wrong so that the shallow areas would have been already searched.

Part of the good humor going on between the Navy and the Air Force was the rule book says the person who has custody of the weapon is responsible for the clean up and the recovery in the event of an accident. So the question was did the Navy on the first try have hold of it long enough to establish custody? If so, they would have to pay the bill thereafter! [Laughter]

FREMONT-SMITH: Did they?

LANGHAM: No. You never put one over on the Navy, not even here! [Laughter] So I think the land operation probably cost of the order of $1,800,000 and the Navy charged the Air Force $5,200,000 for the sea search. There was x number of dollars in banged-up weapons and three aircraft. So the taxpayer probably inherited a bill, counting the cost of the aircraft, approaching $50 million. But not a single---

AYRES: Thirty of 50?

LANGHAM: Counting the one that crashed in the mountain flying in supplies.

FREMONT-SMITH: A little less than Vietnam for one day.

LANGHAM: Yes. Not even that.

WOLFE: That Spaniard that knew, was he a fisherman?

LANGHAM: He was a fisherman. He was the one that pulled the pilot out of the sea. What happened, when the plane broke up and this pilot and the bomb popped up, they both popped their chutes immediately and this happened at about 30,000 feet and there was a strong wind blowing. So one bomb and the pilot drifted almost five miles out to sea and this fisherman swore that he saw two chutes and that one of them, if it had a man on it, it was a dead man and he kept trying to tell them where he saw the second chute. He even drew them pictures. He said the chute was different. And he had a SANDIA man come out and sketched the chutes, and he said, "Now, sketch several chutes. Now, which one did you see?" And the guy looked at them and said, "This is close to it but it's not quite correct," and he corrected the guy's drawing! [Laughter]

BUSTAD: Another interesting part of this is that he described it to them and on one day he took them out to where it was and then to test them he took them out to the same place.

LANGHAM: Yes. This was his fishing ground. So they doubted his credibility. So they said, "Now, you go out where you said you saw the weapon." So they triangulated in on him with all of their high-powered gear and got a fix on him. Then the next day they would say, "We didn't get all we wanted. You go out again," and he went to the same spot within 200 feet.

FREMONT-SMITH: Good enough.

MILLER: Why would the chutes open for two but not for four?

LANGHAM: The chutes were not supposed to open on any of them unless it's signaled to do so, and what happened is that the plane, evidentally, when this plane fell apart, I mean it must have been something because that plane was just literally shredded and evidently these weapons got banged in the chute cannister enough that it popped a lid off of a couple of them and then it was a matter of aerodynamics whether the chute was dragged out. They found the tail plate off the chute cannister to the weapon that drifted out to sea. They found the tail cap to the chute cannister and this is all they could find anywhere.

DOBSON: Wright, in the early and less certain part of the whole episode, when you got there was it difficult to find out whether or not there was a health hazard?

LANGHAM: No. The monitoring team, of course, SAC has a response crew. Albuquerque has a response crew. These people were all arriving at about that time. There was the usual meter problem. At one time we had 12 alpha meters, one of which was working, and you can't do much monitoring with one instrument. But the Spanish, believe it or not, had four or five instruments. So the Spanish came in with their instruments and by the time I got there they already had a crude outline of the levels.

DOBSON: The Spaniards had a better monitoring data when you got there than the Americans had? Is that what you mean?

LANGHAM: Not necessarily better but they had contributed to the fact that there was quite a bit of data of a preliminary nature by the time I got there. They could show crude contour plots and where the accident occurred and what way the wind was blowing in all of this.

DOBSON: How did you find out whether anybody had a real snootful of this stuff?

LANGHAM: Largely on intuition. I mean within an hour after I was there I was completely relaxed. This was one of these situations where the circumstances were all just right. If you do this again, you're in trouble because you've had all your luck on this one. The wind was blowing right, the people weren't in the field and pieces of the airplane fell besides people but not on them. It's just one of these things where everything broke right and there are, of course, the lasting effects, as you might expect. From the pyschological point of view it may interest you that here was a community in which there's no class distinction whatsoever and now there is class distinction. The man who got compensated as opposed to the man who didn't. The man who didn't is a forgotten kind of a second class citizen, at least he feels that way. So there's social stratification now where it didn't exist before. One woman has been deathly sick ever since and, of course, it's due to plutonium. This was the woman who was standing in her front yard and a burning American body fell right at her feet and she tried to put it out by scraping [illegible] putting sand on it and she's been sick ever since and I th[illegible] if I had done that I would probably be sick, too. But, of course, they think the logical thing in this is plutonium making her sick because she was down in the dust scooping [illegible] up and so she must be full of plutonium and she'll not re[illegible] to her home. In other words, even though they cleaned up place and got the dead bodies out of her front yard, she will not return to her home. There are all of these things. Every time an animal dies, of course, the question does come up. There have been agitators in and the population will flare up and there will be a little demonstration. Some of their own authorities come in and quiet it down. So this is a game, you see, and there are a lot of psychological implications to all of this that I would just like to hear you people speak about later on a bit.

SPEAR: Was there any period when the farmers were looking out and seeing their prized cash crop being bulldozed into piles and not having any idea that they would be compensated for it?

LANGHAM: This was not done. In other words, one of the things that I think has something to do with this difference in the reaction: The Spaniard, believe it or not--I don't know whether he likes it, but he respects his officials and he believes them, and these Spanish AEC people came in and they said, "Now, we may have to destroy your crops. Don't worry about it. I'm sure you'll be paid."

"Fine." They believe their officials; they respect their officials. Now I get in my remark here. This isn't a country that at that time and still doesn't completely have a free press! [Laughter] And when I was finally leaving, my wife and I had gone back to the same place to eat for a few weeks now, and she immediately started in the Berlitz system and was taking Spanish. So she got to trying her Spanish out on our waiter and he, of course, wouldn't let her order in English; he would make her order in Spanish. So with this we became great friends. When we were ready to leave, I said to him, "You never asked why we were here. Has it ever occurred to you?" He said, "No, no, no, not particularly. A lot of people come here, a lot of nice people." I said, "Well, we've been associated with Palomares, you know, this weapons accident."

"Oh," he said, "yes, Palomares. It's somewhere down on the coast." He said, "Yes, I saw something in the paper like this but," he said, "we never get excited about anything we read in the papers!" [Laughter] So their whole attitude was fine. The only time you could find a head of steam was with the Red Duchess, who's definitely a Communist, she's three times a grandee. Franco can't even do anything with her. He threw her in jail for 24 hours once but she's a real agitator. She showed up down there with two doctors she had hired herself to give these people physical exams; went on taking blood samples on them, you see, strictly on her own, and, of course, telling them that they had been mistreated, they may be sick, they may be going to die. So then there was a flare up in the community and so the Spanish officials and authorities had to go down there and quiet this down. And they quieted it down. The people will go up and down depending on how much they're agitated and if you can just keep the agitation low, the problem is low. And this seemed to not be the situation at least in Japan. It just seems that there is always something agitating over there.

EISENBUD: There were a lot of differences, I think, that are quite apparent. But one of them, as you asked me to do, what about the press? How large a press corps did you have? Did you have the foreign press?

LANGHAM: You had the foreign press, a few wandered in and out.

EISENBUD: What was the total press corps at the height of the excitement?

LANGHAM: You never knew. They just wandered in and out. The people were too busy to give them any information. So they wandered away again and then in fact much of the criticism of the way this was handled has come from the press. I mean we were too busy. We didn't bother with them and they got tired and went away. Furthermore, the sea search stole the show, you see. I mean those H-bombs sitting out there just ready to go off, they stole the show. So they really didn't bother with us so much.

WOLFE: The gentleman, the fisherman who knew where the bomb was, did he get a prize?

LANGHAM: He got money, he got a decoration. He got his boat painted. Then a lawyer got a hold of him and he's suing the American government for $5 million.

MILLER: What for?

LANGHAM: He says the value of the weapon was at least $5 million. Well, that's inflated prices. I happen to know that it didn't cost that much. Some lawyers got hold of him and they're actually trying to file a suit that he really saved the American government $5 million.

BUSTAD: Another aspect of it that I heard and I wanted to check it out with you. I heard that there was a lot of discussion as to whether they should picture the weapon after they retrieved it and decided for publicity purposes to have it pictured. That might be interesting to get the background on that.

LANGHAM: Well, of course, the international propaganda was that these stinking Americans just might sneak in a dummy bomb on you and say, "See, we found it." So the question was how would you prove that indeed you found it? So they finally decided to actually let the photographers have a crack at it and take its picture as they were bringing it up, and so forth, and so this was done.

WOLFE: How did this accident start? Did the two planes collide during the refueling operation?

LANGHAM: Yes, evidently. I'm sure this has been investigated by the military and by the Air Force at great length and about the last word I think one heard was of a man guiding the refueling pipe yelled at the pilot and said he was approaching too fast. I don't know what happened, but the plane broke in two, the bomber broke in two right in the middle and there was a spilling of fuel and the tanker exploded and everything exploded. I've heard that there's been a real serious investigation of this accident but I think the Air Force is not saying the specific details.

WOLFE: It's much too early for that. We won't get that until 1980!

FREMONT-SMITH: Right.

UPTON: I think it's time for a break now, but Mrs. Purcell, I believe has a couple of announcements.

[Announcements by Mrs. Purcell.]

UPTON: Shall we recess then for 15 minutes?

[After coffee break]

WYCKOFF: Wright, what's the name of that medal they gave you for this operation?

LANGHAM: The name of what?

WYCKOFF: The medal they gave you for this operation. Didn't they give you a medal?

LANGHAM: The Department of Defense Distinguished Service Award.

FREMONT-SMITH: What? The Purple Heart?

LANGHAM: They gave me the Department of Defense Distinguished Award as a decoration.

FREMONT-SMITH: Isn't that wonderful!

WARREN: Why don't you wear it with the ribbons and everything! [Laughter]

FREMONT-SMITH: We are very proud.

WARREN: That was a very touchy assignment.

FREMONT-SMITH: In spite of the fact that you said you wish you had written that! [Laughter]

AYRES: I think he was sorry they didn't ask him on the swimming party.

FREMONT-SMITH: Exactly.

LANGHAM: Are we back in business?

FREMONT-SMITH: Apparently we are. We've got all this on the record so far! [Laughter]

DUNHAM: Wright, did you or did you not write Otera's articles for him?

LANGHAM: No, but this Dr. Serlano and Romsein collaborated in the writing. They didn't tell me they were doing it. I was in contact with them every day.

DUNHAM: You couldn't understand why they kept discussing the same thing all the time.

CONARD: Where did you get all the top soil to put back on the land that you scraped off the earth?

LANGHAM: I don't know exactly myself where it did come from because I was in Madrid most of the time during that phase of it. But what they were going to do was to let the farmers themselves pick the area they wanted it brought in from. So they picked an area that wasn't too far away.

FREMONT-SMITH: You mean we don't have any USA soil over there?

LANGHAM: No, it wasn't shipped from this country. It was local soil that wasn't contaminated.

BUSTAD: I think one of the most disturbing things about this whole thing is--and I guess it shows how naive I am--many years ago when I was with General Electric Company they decentralized and I had recently joined the Universit[illegible] California and I thought they were the last people in the [illegible] to decentralize and they are going through it now and I'[illegible] shocked to find out that the State Department hasn't don[illegible] thing about decentralizing. This has become so evident [illegible] last few days. It's very disturbing to me.

FREMONT-SMITH: And they have a tremendous built-in resistance to change and this would be a change.

AYRES: They used to be more decentralized.

SPEAR: One of the disturbing things about it, if I read this correctly, is that apparently the suppression of news, the suppression of information was a very healthful factor in holding down any kind of panic reaction; that if this had been a more sophisticated local population they would not have been as ready to accept the simple word, that, "you're going to be all right, you'll be taken care of." This I find disturbing.

ROOT: Well, they had had a controlled press in Spain for so long that even if it got decontrolled people would take a long time before they would begin to read it. Newspapers in Spain are very rarely read because they are government handouts and have been known to be for a great many years, whereas in Japan, as Dr. Schull pointed out, there's the most terrible competition for news. The newspapers themselves are so rich that Yomiuri, for instance, has a whole pool of automobiles and when a reporter was taking me out, we just went into the pool and commandeered a car with a chauffer and went. Period. You don't even have that in New York. And also they send two or three reporters out on the same story so that they can cut each other's throats and get the very best report possible.

DUNHAM: The best in what sense?

ROOT: The best and the most detailed and the most intimate pictures. They were piling in through the windows in the hospital, where you're not even supposed to come in without permission. They were climbing up the walls and falling into the windows to get pictures.

EISENBUD: They carry aluminum scaffolds with them.

They will think nothing of just rigging a scaffold up to a second story building and look in a window, and nobody stops them! [Laughter]

WARREN: With a camera, too.

EISENBUD: Yes, with a camera. They use them in crowds so that they can get up above the crowds and they just rig them up and take them down. Frankly, I don't see, except that this was--I see very few similarities between the two incidents. You have a situation in one case where nobody was hurt. In the other case you have 23 sick people. You have a relatively unsophisticated country under strong essential control in one case. In the other case you've got a highly sophisticated scientific corps totally disorganized and all seeing in the Japanese incident a first opportunity that they have postwar for any kind of self-recognition, and they were jockeying for power, as part of it all, of seeing who could say the strongest anti-American things because this was a kind of thing people wanted to hear at that particular time. You had an AEC in Spain which they didn't have in Japan. You had a Dr. Ramos whom we all know, who was very friendly. The nearest counterpart to Ramos in Japan would be, I suppose, Tsuzuki, who at least by reason of age and long accomplishment was recognized as a senior person and he was fundamentally anti-American for reasons which maybe Stafford Warren would want to expand on. He was a former Japanese admiral who I think in his later years came around for opportunistic reasons to be friendly to us, but I think under it all was not. You had a situation in which the barber found that business was good. There must have been other people besides the barbers that maybe benefited economically, whereas in Japan all of a sudden the bottom dropped out of one of their major industries.

FREMONT-SMITH: It did also in Spain because all the crops were lost.

EISENBUD: Within 24 hours after it was dropped, Wright said that they had agreed to buy the crop.

FREMONT-SMITH: Yes, that is true.

EISENBUD: Which is a good thing. The crop is sold; you don't have to worry about the spoiling, you don't have to worry about finding a market.

DOBSON: Isn't perhaps the most enormous difference the fact that perhaps the Japanese--and again one remembers Jack's little introduction of the general social structure--felt that there was something hazardous about fish. All Japanese essentially look to fish for their sustenance.

EISENBUD: Yes.

DOBSON: And these so-called crops in the Palomares thing were not, even a tomato crop of a country, which I would differ a little bit, I think is not exactly unsophisticated, was not the Spanish tomato crop but it was relatively a few patches, so to speak. So there was not national threat.

EISENBUD: Yes.

DOBSON: Or imagined national threat.

WARREN: It wasn't there for a while until the word went down from headquarters that they'd better buy up the tomatoes in the south because there was nothing wrong with them. It was there for a few days or so.

LANGHAM: Yes. You saw elements.

WARREN: Of the possibilities.

LANGHAM: You saw the elements of such a development as you saw in Japan. That's the only thing I'll agree to. This was of great economic importance for the local area. I don't think it was of economic importance to the nation necessarily except for tourism a bit, which was definitely concerning the high officials of the government. But there was great economic hardship brought to bear on the whole area in so far as that goes. So that element was the same and you could see indications of this causing considerable trouble but it was kept so localized that it never attracted any attention particularly at all compared to what the Japanese did.

MILLET: I think the question of the relation of the populous to the leaders is a terribly important thing here and I think it is, and I was very, very much struck by the statement that these persons believed in their leaders and what happens in the case of panic. If the leader comes out whom everybody trusts before the panic gets started and says, "You're going to be all right, don't worry. Now you go about your business, we'll take care of the crop for you," that's one kind of thing. But, on the other hand, in the Japanese instance you've got some criminals here to begin with and you've got a very dubious relationship between them and the governing group in Japan, to say the least. So there is a lot of psychological differences here that make it quite clear that there would be a different kind of reaction, I think.

FREMONT-SMITH: How did you mean criminals?

MILLET: These sailors who didn't want to come home because they were going to get in trouble.

FREMONT-SMITH: I see. You mean because they had been in jail before.

MILLET: They had been and these were all good virtuous peasants.

ROOT: I think another thing, too, you've got very little press information until it became absorbed in the search, and that was widespread and everybody was with the drama of it in Spain. In the Japanese incident you got no knowledge of it at all until burned bodies came home. Then you got worldwide reports and the whole horror part of it with no explanation and no preparation which I think had a lot to do with the global impact of it.

CASARETT: Certainly one large difference between the two incidents is the previous experience on the receiving end of nuclear weapons.

ROOT: Of course.

CASARETT: I should imagine the sensitization here would be much greater in Japan.

FREMONT-SMITH: You mean if Hiroshima had been in Spain, you would have expected an entirely different response?

CASARETT: Yes.

MILLER: Jack Shaw called it "anaphylactic shock," the Bikini experience.

ROOT: Yes.

WOLFE: Is there any record of anybody but the United States dumping radioactive material or bombs or what not on other nations?

LANGHAM: No.

WARREN: The Russian further fallouts, that's all. That's not a weapon.

WOLFE: But there's been no large incidents. If they had one we do not know about it yet. They would be slow in letting it loose.

LANGHAM: This was a little bit of an unusual situation.

WOLFE: Yes. I just wondered why we're always getting in the unusual situation.

ROOT: You know, another thing in here is this was so obviously a terrible accident. You know, the first seven pilots or seven of the crew were killed, Americans, and it an explosion in the air. There was hardly any deliberate, you know, guilt that can be pinned on a thing like that whereas as far as the world knew the Bikini shot was a deliberately planned test without due regard--this is as far they knew--because there was no build-up and there was no explanation of the circumstances. It was portrayed throughout the world as simply a careless determination of the sorcerer's apprentices and their governments to find out something regards of what it cost. I'm only giving you the press repercussions and the impressions on people.

LANGHAM: Some of our friends in other countries seemed to think that it's a bit of a deliberate act to be flying over people's heads with things of this nature and this came in for a great deal of international political harangue as you might expect.

ROOT: Yes, you would get that.

TAYLOR: "The Sword of Damocles" talk was revived for a while during the Palomares incident.

ROOT: Yes, that's true.

CONARD: Couldn't they have re-fueled over the Mediterranean more rather than over this village?

LANGHAM: Yes. And in all probability this was their instructions, but you've done this so many times and so you make contact a little bit closer to shore than you had expected. But you've done this many times before. So you'll go ahead and refuel. I think this has been a big part of the investigation on the part of the Air Force to quite an extent: Wasn't there actual human negligence or error on the part of the crews? As far as I know, no action was taken. It was just an unfortunate action, and to put two planes together at 30,000 feet is probably not something you always do right on a set spot each time. I'm sure it has all been hashed over very, very thoroughly by the Air Force.

WOLFE: Does Russia maintain a Chrome Dome, or what did you call it?

LANGHAM: Not that I know of. I think this is an American innovation.

MILLER: There is a manual as to what to do in an event like this but it's mainly regarding threats to health and I suppose directs you as to procedures to be followed, measurements, staking out contaminated areas and getting rid of them. But can't there be perhaps not a manual but some rules of thumb that could be devised to take care of the psychological problems, political problems, the economic ones? Is this something that should get some thought on the basis of your experience?

LANGHAM: Well, I'm pretty sure it's getting thought. It's just almost impossible to sit down and write a manual that's going to fit a situation. You have to visualize the situation and then you write the manual to fit it.

FREMONT-SMITH: This means every potential situation the manual has to cover.

LANGHAM: Yes, and invariably it occurs where you don't expect or under conditions you don't expect.

FREMONT-SMITH: And the manual would have to say "Use good judgment."

LANGHAM: That's right. There's no manual for a situation like this. For example, I finally ended up with some dear, dear friends amongst the Spanish people. I mean they are wonderful people, at least the ones I dealt with and I have no reason to think that they all are not. But we started out bargaining. Now, how much would we clean up? And one of the gentlemen said, "Well, we think you should pick up every atom of plutonium you dropped in Spain and remove it," to which I replied, "You know, of course, that's an impossibility, don't you?" He says, "Yes, but it's a good position to start from!" [Laughter] And then we made this decision that if the contamination was above a certain level, the soil and crops would be removed. And then if it was between other levels the land would be plowed and then at the lower levels it would be sprinkled and at still lower nothing would be done with it. So we set a level at which plowing should occur. No one really thought about it. I mean this was our agreement. So when we got into this area back in the mountains where the contaminated cloud had come down in the valley, it was just sheer rocky mountainsides that were contaminated above the level that we said that we would plow.

FREMONT-SMITH: You can't plow a mountain.

LANGHAM: So how do you plow a rocky mountain? So we went to the Spanish with another problem. This was a rather big crisis and the Spanish replied, "Well, as we recall, plowing was your idea, so plow!" [Laughter] So it was finally agreed in this case that they would elevate their standards a bit and we would resurvey the whole area and if we found areas contaminated above this newly agreed limit we would actually work it in with pick and shovel and stir it around, the idea being to get the plutonium beneath the ground so that when it blew it wouldn't become an inhalation hazard by resuspension, and some of these hillsides were pick-and-shovel-worked into the soil instead of being plowed. They were reasonable people.

Now, this doesn't mean they don't drive a hard bargain. They took the recommendations that were first proposed and essentially divided them by two and made us go to one-half the level we had proposed. That's all right. You certainly, if you're writing manuals--and I've written a few--you know, you decide on what the standards of cleanup are. But it comes as a bit of a shock to find out that if it's the other fellow's backyard that you have dirtied up, maybe he has something to say about the standards. You don't come in and tell him, "You'll clean it up according to your's; you'll clean it up according to his," and these people drove a hard bargain, but they were nevertheless reasonable. And I had a great respect for the Spanish AEC group. I think they have some highly competent people. The only thing is the whole Spanish AEC isn't as big as the group Chuck Dunham used to have in the Division of Biology and Medicine alone. I mean that's their whole AEC and yet in it they have a few highly competent people.

WOLFE: Wouldn't it have been much cheaper to haul soil in there and cover it over than to carry it out?

LANGHAM: Of course, it was carried out and then fresh soil replaced on top of it. I think it's just as well, right around the crater areas that that was removed. I mean at least you know it's no longer there. They let us plow under, you see, a lot of it and they asked us to give them a soil followup program because we had plowed something with a 24,000 yield half-life into their soil and I'm sure they would have objected if you had just buried it there, too. They felt happier about having it removed, and so do I, where the levels were high.

UPTON: Will there be a followup of some kind?

LANGHAM: There is a followup program and this was part of the bargain that we would set them up a followup program.

UPTON: What are the objectives in the scope of this?

LANGHAM: They've got a people's program, a soil's program, a vegetation or a produce program, an air sampling program, and they were extremely cute in the way they approached you on this. They said, "Now, we've taken your advice and we're sure that you have given us the right advice. Will you please set us up with a program and equipment so we could prove to our authorities we were right in following your advice." So how do you turn a man down on something like this? So they have a followup program, yes.

UPTON: Under their own auspices or do they furnish advisers?

LANGHAM: This was very strong in their minds. They wanted this to be their program with us providing the backup and giving them the equipment, teaching them the techniques which we've done, and occasionally advice and even let them send people to this country. And I've had two or three of them at Los Alamos already.

I think you'll find that Spain wants to get back into the swing of things and they want above all to use this to maintain a contact and they want contacts, and I would bet that if you counted the number of friends we have now in Spain as compared to what we had before this accident, we have more friends there than we had before. This is an opportunity for them to get outside contacts.

FREMONT-SMITH: That's why you got your medal!

LANGHAM: Well, I never quite figured why I got a medal because this is a rather sober thing within itself. What you find is circumstances place you in a position that you can't get out of and you are the focal point of the effort of an awful lot of people. So winning medals is just being at the right place at the right time.

FREMONT-SMITH: I think making friends was the crucial thing. That's why we have more friends. Anyway, I think there's a very interesting comment, because I think we don't have more friends probably--I'm not sure; am I right, in Japan as a result of the thing there?

EISENBUD: I think that we had the same reaction the scientific community. There are a lot of opportunis among them. It was quite common during those first few for the younger people to sidle up to me and ask how the could go about getting fellowships in the States or coul when I go back, send them some reprints and how could t learn about a certain piece of equipment and, as Chuck will recall, starting with Tsuzuki's visit to the States in May, which was precipitated by this accident which had occurred two months before, there was a long series of exchanges. We had that radiobiology conference in the fall. The Divison of Biology and Medicine began to support research in Japan and any number of the young people began to come to this country as the result of that incident.

FREMONT-SMITH: So it was comparable in a way.

EISENBUD: So I think we really have the same types of ties but this I think is a form of opportunism. I gave these people, presented them with the first sodium iodide crystal that they had ever seen and they appreciated it very much. But I'm sure that we could not say that the same was true at the level of the people where I think there are some scars.

There was one other difference that I should mention, and that is that at the height of the Japanese furor which was, say, a week or two after the boat got into Japan--I think it was the 26th of the month but I'm not sure; it might have been a few days later--the AEC resumed testing in the Pacific and all through that spring until the end of May there was a series of tests and each one of those, of course, precipitated new rumors and new concern and all through that spring there were rumors of fishing boats that had been heavily irradiated apart from the question of contaminated fish. They were concerned, too, about the health of their fishermen.

FREMONT-SMITH: I didn't mean to interrupt you. I think you were right in the middle when I made my remark.

LANGHAM: No. I thought I had finished.

MILLER: Merril, when you went to Japan, what kind of experts do you wish you had had with you that were not available? I can think of two offhand that sound as if they might have helped you. One would have been a public relations man experienced in this sort of thing and another might have been one who knew Japanese culture exceedingly well.

EISENBUD: The Embassy presumably had this. I think your Allison had a good feel for Japanese culture. As I recall, he spoke the language. As far as public relations was concerned, this was controlled out of Washington. We held an off-the-record briefing for the American press and this was helpful in the way the news was reported in the States. But we were not permitted to meet the Japanese press; Washington would not let us. And we had no formal contact, no confrontation with the Japanese press until the following November when we had some very successful news conferences in which a lot of this was rehashed, and I think it did some good. But all through the period that he was in Japan, neither Ambassador Allison nor myself met with the press. The only direct announcements from the Americans were people that just were passing through that had no relationship with the thing but felt that they would like to be spokesman. All they did was muddy the water.

MILLET: You had a very high level of camaraderie between the American psychiatric and the Japanese profession, too. I went over there for a short conference and brought them back the next year and hosted them to go down to Mexico for an international congress with the Mexicans. That's been a very profitable experience for everybody.

EISENBUD: When it was all over, John Morton and I decided to go to Eniwetok because he was interested in finding out what he could about the natives there. Me and Bob Conard and Chuck Dunham and others thought it was a secret that we were leaving. Well, we learned in retrospect there really weren't any secrets all through there, that almost every move we made was pretty well known to the Japanese. But when I got to the airport, the whole scientific corps turned out to say good-bye to us. My house is decorated from one end to the other with lovely presents that were given to us, and I think it was quite sincere.

SCHULL: I think one has to be careful in placing too much emphasis upon that because courtesy in Japan is so much a part of the custom. Everybody gets welcomed and sent off, even people that you don't like. It's a reflection on yourself not to do it.

WARREN: Is he supposed to give presents in return?

SCHULL: No, he doesn't.

WARREN: Reciprocated?

SCHULL: No. It seems to me as we talk increasingly we are groping towards the idea that if there are answers to be found to situations like this or predictive stands that one might take, the answers have to be sought in the culture of the country that's on the receiving end of one of these events, and perhaps the ten years of historical events which had preceded the action itself--and Japan would certainly be a marvelous illustration in this respect because it's more than just the relationship of a defeated to a defeater in this particular instance.

Japan's image of herself has been shaken to an extent that probably no contemporary country has had. This was a nation that prided itself on the fact that they had never been invaded, they had never lost a war. Their image was strong, virile, and so on, and they were still groping around for some kind of national identity. The Peace Treaty had been signed three years earlier, not quite three years earlier but almost. But for the average Japanese, he wasn't even aware of that because there were still as many foreign troops in his country in 1954 as there had been during most of the occupation because it was being used as a staging area for

Korea. So that he still really didn't have the kind of identity, let's say, that the Spaniard has if one accepts certain generalizations and they are obviously dangerous, one's image of the Spaniard is of a sort of a stoic pride and this is alleged to be one of his sins. The Japanese isn't of that kind at all. If anything, it's a nation of people who seem to need constant assurance. They seek self-assurance at times, and I think it's still visible in their foreign policy. Japan doesn't play the role in foreign policy today that she should in view of the fact that they have 100 millions of people and that they have one of the highest standards of living in the Orient and are a powerful manufacturing nation. But they are still hiding behind U.S. skirts. It's a convenient stance for them to take.

But to try to put all these things together and think, well, now if this was to happen in France, what might we predict about the French reaction? I don't think that there was anything to be learned in Japan or possibly in the Spanish situation that would be relevant except to seek the answer in the culture.

FREMONT-SMITH: Right. Very nice statement because I think this is one of the things we are weakest on, is seeking answers in cultures.

LANGHAM: I wholeheartedly agree with that. I am convinced if had this happened not far away in France, we would be on our knees in front of De Gaulle even right now. So I think what is found in the culture as well as the national philosophy of these places and indeed what he says about the Spaniard being a person of great pride; in fact, he is, and I think probably part of their failure to make the progress that they have that they can rely on this great pride and do perhaps too much. I think you'll find that Spain is changing and I think you're going to find Spain bidding once more to become somebody in the family of nations. It's coming slowly but definitely they are progressing and tourism is one of their great commodities now. It's absolutely impossible to get tourist accommodations during the season in the vicinity of Madrid. So they are developing this as one of their commodities, so to speak. It's why Palomares was a rather important factor all related to the Vice President of the country sitting down and finding out about this and once he heard that there was no real health problem, his next question was, "Are you going to find that lost bomb?"

SCHULL: There's at least one other important difference between the Japanese situation that I don't think has been mentioned yet or if it has I've forgotten it. But it has strong racial overtones in the Orient, which is not true in Spain. Fortunately, both nations are Caucasians involved. But there are racial problems in the Orient and this was white against yellow and some of this was already I think beginning to become apparent in Japan because I can remember seeing the first of the bars that began to sprout in Toyko with signs on the doors that they don't want anyone except Japanese business and this didn't used to be. I mean they still exist, many of them, but they were beginning to draw racial lines and racial distinctions that might not have been as obvious of the problems that exist in our own country at the moment but, nonetheless, these things were present in the minds of some people.

ROOT: I think that's corroborated by the lack [illegible] furor when the Chinese dropped their bomb, you know. I was being attacked on all sides because I was being taken ar[illegible] by a member of the press who had come. The Overseas Press Club had invited a group of Japanese science writers as guests. So that when I got back I got special treatment [illegible] the press. But going around with him, I was perhaps let [illegible] a little more to the anti-American hostility and I began to get it from him and from the people in the newspaper and from the professors that he took me to see. It became more and more overt. And just at that time the Chinese bomb was exploded and there was a kind of a concealed elation behind the expressed fear of fallout and the expressed reaction. So that definitely was a racial thing, I think.

FREMONT-SMITH: The notion that another yellow race had gotten a bomb.

ROOT: Right. There's really great identification with China as having done it.

MILLET: It seems to me there's a matter of nascent pride in Japan. I think there's been tremendous pride in the culture of Japan in the past. Think of their walking out of the League of Nations meetings, for example, in the militaristic days. It would seem to me rather that the State of Germany is one where there is a lack of identification in Germany at the present time completely. They are completely split into two nations. They don't know how they can get back into one. That's a genuine fear of loss of identity I think there. I don't think there's any fear of loss of identity among the Japanese as far as I know.

SCHULL: I think you are wrong. It's of a different kind than one sees in Europe. I think there's more of an isolation of the young people in Japan from their elders than there is even in our own country where there has been almost a total rejection of the sense of value that the parents had. The Children of the Sun and all that sort of business that has characterized Japan in the last 15 years are things which their parents are unable to cope with.

MILLET: Is that the same as identity? Would you say that we have no identity of the Americans? We have a loss of identity?

SCHULL: I would say that in this case lack of a national identity because the young people really don't create the image that Japan has and they don't have much identification with the older types.

MILLET: Yes.

SCHULL: And I'm still terribly uncertain about the directions that they want to go. They pick up one fad after another. I suppose they began to have their hippies even in a sense even before we did. They didn't dress in the same way but the student movement in Japan began in the years immediately following the war which range all over the map. The Communist movement itself on the campus ranges from a main stream of Sen Don Grand down to lesser and lesser streams, some of whom find the Chinese much too liberal from their point of view and they have isolated themselves from all of the Communist currents except their own. This doesn't seem to be much of an image that they can project for themselves and though they have made tremendous progress in material things, I'm not really sure that Japan has yet taken on some of the self-assurance that she may have had. That was a strongly religious nation and they could look toward their Emporer as a figure. Sure he still exists, but the young people don't think very much of him really. They are polite but he doesn't have much pull, and the reaction is often I think terribly difficult to get through.

A year or so ago we lived on a little island known as Yawata in the western part of Kyushu and there were about 40,000 people living on this island and we were the only foreigners on it. I take that back. There was a Korean on the island also. But we were the only non-Japanese except for this Korean on the island. There weren't ten people on the island that could speak English well enough to carry on a conversation with them. But we did manage to establish some means of communication with a few of the families and you could get some idea of the difficulties their children were having. They are torn between wanting certain material things that they see, trying to retain some sense of parent-child relationship but not really respecting some of the values that their parents have. They are a confused group of kids and you have a suicide rate, if this is any measure of uncertainty, Japan does not have to take a back seat to anyone in terms of the number.

MILLET: How need to migrate is there in Japan? How much desire to live in other countries and become citizens of other countries?

SCHULL: The thrust today certainly is toward the big cities and there is some thrust elsewhere. It's kind of a romantic idea, I think. There has been recruitment throughout Japan, Kyushu in particular, for people to go to Brazil, Colombia and several of the countries in South America, but they are usually oversubscribed. There may come in 100 families, let's say, from an area, and 500 will volunteer, but I think some of the thing is a fantasizing that's going on. The interesting thing is that the movement to the cities that's taking place in Japan. Our island, for example, between 1960, when it had its census, national census in 1964, when we censused it again, they lost about 10 per cent of its population. And this was almost all at the expense of the young people who were moving out. They simply could not take the old form. The number of farms, for example, hadn't decreased at all on the island. So that you weren't getting larger farms growing out of this movement or anything like that. It was just that with the mechanization that was beginning to take place on Japanese farms, even though it was on a small scale variety, you didn't need the manpower, and the first inclination was to move to the city, and the movement would start of wave-like lines. They went from Yawata to Fukuoka, which was the first city that they would encounter, and from there this would be a stepping stone and the next city was Hiroshima or Tokyo or some place like this.

It's an extremely difficult sort of situation to try to, it seems, get hold of the thread, and I talked to Bob Miller and some of the others. The interesting part about the study of Japan in this context is not perhaps what we can extrapolate but learning how one has weaved this complex cultural fabric into which, if an answer lies, it is to be found, and Japan may be more difficult for us to read because it is so alien, than would be Spain or some other European country.

FREMONT-SMITH: Did you feel that the alienation of the young people had started several years earlier in Japan before it became evident over here?

SCHULL: Its' my impression, yes. At a time, let's say, when our students at the University of Michigan were still primarily interested in panty raids, the Japanese students had begun to be more active politically, but then they have a long tradition of political activity which doesn't exist in the United States.

ROOT: Think of the students who made it impossible for Eisenhower to take his visit over there. That was pretty far back. And overturned the plane and demonstrated at the airport so that it was inadvisable for the President of the United States to visit Japan, which is in great contrast to the classic image of the Japanese that we have.

BUSTAD: The Japanese are going to be really confused, especially the youngsters, if they go on down to South Africa to Capetown where they have a lot of business and find out they are considered whites there and they are the only oriental that is considered a white. The rest of them are not considered white! [Laughter]

MILLER: Merril, Wright has said that there was a headman who could issue a statement and that pacified the people. You said that you talked to Dr. Tsuzuki because he was the headman and he wasn't head enough. In retrospect who could you have talked to that might have yielded greater

EISENBUD: I don't talk to Dr. Tsuzuki because I thought he was the headman. He clearly wasn't. By the time that I arrived there already had been constituted a committee which was headed up by Kobayashi, who was, as I recall it, a microbiologist and statistician from the National Institute of Health. The only physician on the committee--there were two. There was the head of Toyko Hospital whose name escapes me and Dr. Maki Asumi, the radiologist, and the others were geneticits and physicists and marine biologists, and it was agreed between our Embassy and the Japanese Foreign Office that all communications to the people would be through this committee. This would have worked all right. We stuck to our part of the bargain, which was made easy that even later on when we wanted to hold press conferences, even the Ambassador was not permitted to hold one. But while we were coming to agreement as to what the facts were, the individual Japanese scientists were going out on their own and vying for public attention, and Tsuzuki in particular, was not a member of the committee, was using his very prestigous position in Japan to get to the press and there was just no way that it [illegible] be done because this was obviously something that was going on which I never understood, between Tsuzuki and the rest the medical community in Japan.

He finally left Japan and went to Geneva in [illegible] middle of the furor, for which he was critized because said--could I go off the record on this?

[Off the record]

MILLER: But the reason for containing un[illegible] fears, or even justified fears was that there was someone to reassure the people in Spain and there was no one to reassure them in Japan. So apparently the situation was out of control and could not possibly have been brought under control under any circumstances even in retrospect.

EISENBUD: There are some things that a man with political sensitivity just can't say. Just like during the Korean war, if Truman had tried to settle the Korean war on the terms it was finally settled on, I think he would have been impeached, but I think Eisenhower at that time looked very good. It was a right time to say something.

FREMONT-SMITH: A politically right time.

EISENBUD: A politically right time, and I think that if Kobayashi, for example, had tried to make a statement at that time which was reassuring, they would have found another chairman for that committee. It's as simple as that. Now, who they are I don't know. It might have been the Foreign Office.

MILLER: What I was trying to get around to is what happens if there's another such incident, whether it's here or there or wherever it might be? It would seem to me that one rule of thumb would be to try to get to somebody that can reassure the people as to what the real circumstance is. Is this not right? Isn't this the big difference between you?

EISENBUD: That's right. That's why I think it's important that in the nuclear field we maintain good contacts with our counterpart overseas, and there are innumerable instances where potential difficulties have been aborted by just letters or short visits either from government to government or by representatives. I could enumerate half a dozen. But in Japan there was no organization. Japanese science at that point was a pretty amorphous structure. You didn't have an Atomic Energy Commission. Dr. Sukamoto, I don't know where he was in those days. He is now the head of the biological part of the AEC over there and if this incident came up, he would be the man they would listen to, but I don't know. There was no such person in those days.

Also I get the feeling--and I think that both you and Jack would have better judgment on this perhaps than I-- but I get the feeling that Japanese medicine at that particular stage had not yet emerged from the somewhat feudal structure that existed prior to the war and for some time postwar. And one reason was the physicians were not welcome on the Japanese committees was that Tsuzuki was really the No. 2 man in Japanese medicine and it was amazing, an amazing thing to see what happened with Tsuzuki when his professor walked into the room, which happened a few times. I've forgotten what his name was, but this professor was the No. 1 and he was the one man that could get Tsuzuki to be quiet. This didn't occur among the geneticists or the physicists, the young men were coming to the forefront and the old fellows were going off into industry and they were becoming deans and, well, it's the normal course of human events that we have around here. So that the people we were dealing with from physics, lets say, or from genetics, were a relatively young group of people with whom we could communicate well, whereas there's a structure in medicine there that these other disciplines found it difficult to deal with.

You may or may not agree with me on that.

FREMONT-SMITH: Isn't the implication of Dr. Miller's question, which I think is a very good one, that the State Department should have a very detailed study of cultural anthropology of the cultures of all the different countries and make this a primary concern of the State Department, which they've done to some extent but not really and part of the difficulty has been that our cultural attaches all over the world are isolated in the embassies and in the little enclaves and do not move into the people, live with the people, and that we don't have a suggestion that had been made at the time the conference for the State Department back in 1946 and early '47, that there should be a systematic effort to put students in cultural anthropology who are writing their theses, doing their field work, in the field in association with embassies in different countries but living among the people and with a liaison both back to the State Department, both to their university and back to the local embassy so that there would be a constant feedback of cultural understanding which would flow back both to the university and to the State Department. These students would then be good candidates for cultural attaches some years later. Actually I believe the Foreign Service Institute does make some effort to give some cultural anthropology to the Foreign Service people but in actuality the cultural attaches who are supposed to be the people to do this are by and large, unless it's coming in the last few years, almost completely isolated from the community in which they serve.

So I think that in a broad sense the question you raised is if we are concerned with a variety of incidents and we are going to have incidents, not all nuclear, but we are going to have incidents with other countries all over the world, if we're going to meet these incidents appropriately, we've got to have a great deal of cultural insight with respect to every other country that we can bring to the fore. How do you meet this situation that has to do with Thailand and their culture which is such-and-such, and it's going to be quite different from meeting it in Spain?

MILLER: Yes. I think that, for one thing, the adviser, the expert, might be able to tell you who can influence the people and might be able to tell you that no one can and that you need a second line of defense and what should that be? I don't know what he would advise.

FREMONT-SMITH: But at least there should be a current awareness of the cultural attitudes with respect to a variety of things in any country with which we have any dealings at all.

EISENBUD: It might be worth noting that shortly after that Japanese episode both the State Department and AEC had a scientific liaison in the Toyko Embassy. Of course, this was done in other parts of the world as well. I don't know whether we have anybody over there now. I presume we do as a scientific attache.

FREMONT-SMITH: Yes a scientific attache is not a cultural anthropologist. This is a different story. He'll be an expert in physics, you see, or possibly in biochemistry and in the social sciences I think they are very, very rare. I think we had one in India and a couple of other places for a short time and then this was caput. But the concept of using social science insights and especially cultural anthropology, which I think ought to be one of the key ones, I don't think it's penetrated.

WARREN: You are aware of the upset in the anthropologists association, weren't you, about their being used as tools by the CIA?

FREMONT-SMITH: Yes, I know, and the story that was in Peru, what was it called, Camelot, which raised an awful mess. But there was also not a great deal of wisdom used, I would think.

WARREN: No, that's right.

BRUES: You mean that even the cultural anthropologists can have a colonial attitude when they go somewhere?

AYRES: I don't think the Camelot story has been very well presented. Most people are not aware of what really happened.

FREMONT-SMITH: Yes. I'm sure I am not.

WARREN: I think the anthropologists, too, have calmed down about this. It wasn't quite as bad as they at first thought.

AYRES: No. What you had was the graduate student at the American University who happened to be a Communist or was very nearly a Communist sympathizer. He somehow heard about it because we do have a fairly open society, and he just made the thing look altogether different than what it was.

FREMONT-SMITH: Yes, and it raised the dickens in Congress.

AYRES: Yes. He got in touch directly with the foreign press.

SCHULL: It's certainly interesting, though, in Wright's case, where it seemed as though all circumstances were contriving to get together in a very happy sort of frame of reference. In Japan it was completely the opposite way. The one organization that could conceivably have made a statement, as Merril talked to you about Dr. Kobayashi. I think if he had made a statement at that time and tried to make a forceful one, it's questionable how well it would have been received by the Japanese public because the National Institutes of Health of Japan at that time were still viewed essentially as an occupation-created agency and so it didn't project itself as a Japanese organization and the traditional spokesman had been in the Japanese Science Council and in the NIH so that the one contact we had used could not be used even if they had prepared to make a statement.

EISENBUD: The medical schools were under the of Education, the hospitals were under the Ministry of and they were jockeying between the politicians in these groups. It was a mess.

DUNHAM: Frank, you made a statement to the effect that the cultural attaches were isolated. Is this by job or by simply the type of people that had been appointed?

FREMONT-SMITH: Well, I get the impression---

DUNHAM: I've seen this happen to science attaches.

FREMONT-SMITH: I get the impression that the whole embassy group, the cultural attaches and the science attaches, they all lived together, they all spoke English. They live in special housing arrangements for them. I think this was true in Germany, and they are not systematically organized to live with the local people or even talk their language, and this is talked about a lot, this isolation, and I'm not in a position to know that it is true, but I have no reason to believe it isn't true, that the whole enclave of the embassy, the families, the children go to American schools to a large extent, that are set up especially for them. So I think that there is a failure to take advantage of the opportunity, and I believe that this has been pointed out in quite contrast to what the Soviet Union does, where they send their people over who roll up their sleeves and speak the language and mix with the people and live at the level of the people. It would be very difficult for us to get Americans to go over there and live at the level of the community at which they are supposedly working.

DUNHAM: On the other hand, the British charge-d'affaires in Peking conducted a seminar in Washington ten years ago when he came back before he went to Harvard to do some special studies and he pointed out that the Russians had isolated themselves from the people and they were not allowing their children to associate with the Chinese children. So their approach is not uniform across the board.

FREMONT-SMITH: That's a comfort.

EISENBUD: They certainly have isolated themselves in New York and in Washington.

DUNHAM: Yes.

FREMONT-SMITH: Yes, but certainly the story has been about that in the African nations and the Asian nations. At least in the African nations they have kind of gotten right in with the people.

EISENBUD: I would like to add that---

FREMONT-SMITH: I can be wrong on this. I'm talking from hearsay.

DUNHAM: I think these things are uneven and a lot I think affects the personality of the people involved. I say that I know of a science attache, and I won't say what country he was in, who almost deliberately isolated himself from the scientific community and expected it ought to come to him and if you have a cultural attache of that type he isn't going to learn anything. Even if he doesn't know the language, he should be outgoing.

FREMONT-SMITH: But there had been a policy here at the State Department with respect to this in order to encourage in every possible way a relationship of these particular attaches to the community.

DUNHAM: Yes.

TAYLOR: This is apropos of nuclear accidents or what?

FREMONT-SMITH: I'm talking about apropos of international relations of which nuclear accident is only one. We spoke of what would we do in the future if we had an incident in France and I'm raising the issue, what would we do in the future with any kind of incident? We are bound to have a conflict as we are having many right today. We are bound to have conflicts with nations, and the way to deal with these conflicts is to at least know as much as possible about the culture and the attitude and the mood of the people and not to be insensible.

EISENBUD: We've had many incidents of many kinds, mostly of considerably less severity in terms of hurt but potentially of sensitivity, equal sensitivity in relation to people, and there was a period in the late 50's where there was worldwide concern about fallout and the subject would come up before parliaments all over the world. I had a number of opportunities to visit capitols on short notice, I don't know, maybe ten or fifteen of them around the world, to meet, and I found that the guidance that I was getting from the State Department people was good, and I think it was good in Japan. I spent, oh, I guess nine or ten weeks there and I've had many opportunities over the years to just reminisce with Japanese friends now about this incident and I've thought about it a great deal and I really can't think of a single bad lead that they gave me. I think that their appraisals of the people I would have to deal with were good. I think they seemed to have a very good understanding of the Japanese culture. A number of them had been there before the war and a number of them had learned the language and a number of the senior people did live in the Japanese community.

SCHULL: I would like to support Merril on that general statement. I think Japan has been one of the few embassies to which we've tried consistently to appoint professionals as witness the fact that all of our ambassadors to Japan speak Japanese.

FREMONT-SMITH: Right, yes.

EISENBUD: Reischauer has a Japanese wife.

SCHULL: Right.

FREMONT-SMITH: Isn't this somewhat of an exception, one of the few; right?

SCHULL: That's right. We even have been fortunate to have science attaches. I can think of one in particular, Otto Leporte. But Leporte is a physicist of competence. Probably one of the very few in the United States who speaks Japanese well enough that he can really communicate with them, and certainly at the cultural level we've had a steady procession of outstanding people, Herbert Passim and all the others. So that the competence was there on the State Department side, I think.

FREMONT-SMITH: This is very good news.

BUSTAD: Your criticism, Merril, isn't that when you had criticism it was directed at the fact that he should have been allowed to speak out?

EISENBUD: I think that if he had been allowed to work out his arrangements with the Prime Minister then--who incidentally told us he recalled saying, "Mr. Ambassador", he said--he spoke very good English--"Mr. Ambassador, it was you folks who thought we ought to have a free press when we were complaining about what the press was saying," which was a very good point! [Laughter] This was their first experience with a free press, at least their first decade of experience. I think that Katayama and Allison could have worked out an agreement which would have nipped this in the bud within the first few days and I think that it would literally have bought the good will of everybody from fishermen on to the rest.

FREMONT-SMITH: But it was the State Department policy that prevented this?

EISENBUD: I can't speak for that.

FREMONT-SMITH: I assume it was.

EISENBUD: But I do know that there did seem to be the kind of latitude in the field that was required in order to work out the arrangements presumably.

BUSTAD: I vote for decentralization! [Laughter]

WOLFE: Wright, when you were in Spain and you had to make the decisions, did you have to go to the Ambassador and then to Washington, and then all the way back before you decided to plow or not plow or something like that?

LANGHAM: No. In so far as those decisions to do things immediately were concerned, these were made by General Wilson, head of the 16th Air Force in whose territory this thing had occurred and in dealing with him you begin to realize why he was a general. He certainly made decisions, and his way of making a decision was to get the people around him that he thought could advise him, listen to him, and when they were through talking he made the decision. You see, that was the experience the first week in the field.

Now, the second time I went back I was assigned to the American Embassy. Now you found here that decisions in which we were trying to get down to really get decisions, what the final cleanup and compensation, and so forth, would be, you found here that this now had to be checked all the way back through Washington, and I think if there is one thing that surprises me it's how dependent on Washington the Embassy seems to be when it starts to make a decision, and yet Duke was a highly respected man among the Spanish. Yet as far as I know decisions must be stamped in Washington before action was taken. I just got the idea that there was too much centralization of opinion. In other words, does it do you a great deal of good to have a fine man in the fie.. that's respected if you give him no authority to do anythi.. And I rather sensed this. Now, I could be wrong. The ... that set me off on this was when Miss Root made the re... about this, and this was really just what was botherin.. .. when I was there. It seemed that there was a rather c... some chain of command in so far as the American Embas.. concerned in a decision-making way and I rather gathe.. Merril, that you had said about the same thing.

EISENBUD: Yes. It was ridiculous. For e...

if I wanted to send a cable to John Bugher just telling him that I was going to remain another week, this was a communication from the Ambassador to Secretary Dulles.

WOLFE: You don't just send one with a carbon copy?

EISENBUD: No.

TAYLOR: Isn't it true that every communication today from the State Department to an overseas post is from the Secretary of State, signed "Rusk"?

EISENBUD: It was when I was there.

TAYLOR: Every communication, even a transfer of a clerk from one office to another.

DUNHAM: And vice versa.

SPEAR: You can always look down the lower left and find out who it really came from, but it's signed "Rusk."

TAYLOR: Why go through this charade, or whatever it was?

LANGHAM: I never sent a message. All of my messages were sent by Duke. So you almost find yourself, I mean, this fellow is the man who sends out messages. Evidently that's his job.

WARREN: I can see a certain reason for this administratively. The Ambassador is playing the hand of the President really in his international relationships. So there should be appropriate consultation. But something should be allowed to the Ambassador for the use of his judgment in the situations. The trouble is that the minute it's a nuclear power, a sort of paralysis goes over everybody and particularly those who are not scientists and are politicians or people in the administrative hierarchy who are unfamiliar with the situation, they just didn't dare move, and I imagine the President's office called up Mr. Seaborg and he was consulted on the question all the time and, of course, the Department of Defense had to be consulted. So they had a small Cabinet meeting about this, and this took a long time. Not that I'm in favor of a complete block of responsibility, I am not. I think there's a time and a place for it and the local man ought to have enough sensitivity to his situation to be allowed to meet what is really an emergency situation. Now, if his judgment turns out to be wrong, then he should be jerked home and he does it at his own peril, but a good man knows where the perils are and what the goals are. Isn't that a beautiful thought! [Laughter] It just doesn't work out quite this way.

CONARD: I feel like I've been sitting in a State Department briefing! [Laughter] I wonder really how relevant some of this stuff is to nuclear warfare and the long-range effects? We've laid an awful lot of stress on incidents that have occurred in foreign countries and how we might handle those in the future. But what about what would happen in this country as an aftermath of the war and the psychosocial reactions there? I think that's the real point we have to get at.

FREMONT-SMITH: Start again nine o'clock tomorrow morning.

MRS. PURCELL: Eight-thirty.

FREMONT-SMITH: Eight-thirty, excuse me. Thank you.

BURES: Eight-thirty in the morning. We'll meet at eight-thirty in the morning.

Now, I have left notes for all of the regular group and would like to have them remain here after five o'clock. We want to have a little consultation.

[The session was adjourned at five o'clock.]

Exhibit 14

~~SECRET~~ UNCLASSIFIED SHA 200913600000

Office of the Historian

P1

United States Department of State
Bureau of Public Affairs

DOE/OSS CENTRAL FILE ROOM

DOCUMENT No. 0SS8804797

This document consists of 58 pages

No. 1 of 1 copies, Series SS-A.

DOCUMENTED 8/14/90 HRT

~~SECRET~~

Historical Research Project No. 1421

NUCLEAR ACCIDENTS AT PALOMARES, SPAIN IN 1966 AND THULE, GREENLAND IN 1968

~~RELEASED IN PART~~
~~B1, 1.4(A), 1.4(B), 1.4(D), 1.4(F), B3, ATOMIC~~

UNITED STATES DEPARTMENT OF STATE
REVIEW AUTHORITY: FRANK H PEREZ
CLASSIFICATION: SECRET REASON: 25X2, 25X4, 25X6
DECLASSIFY AFTER: 11 APR 2035
DATE/CASE ID: 04 SEP 2008 200504115

DEPARTMENT OF ENERGY DECLASSIFICATION REVIEW
1ST REVIEW DATE: [illegible] | DETERMINATION (CIRCLE NUMBER(S))
AUTHORITY: ☐ DC ☒ DD | 1. CLASSIFICATION RETAINED
NAME: [signature] | 2. CLASSIFICATION CHANGED TO: NSI
2ND REVIEW DATE: 1/9/01 | 3. CONTAINS NO DOE CLASSIFIED INFO
AUTHORITY: | 4. COORDINATE WITH: DOS
NAME: Betty N[illegible] | 5. CLASSIFICATION CANCELLED
| 6. CLASSIFIED INFO BRACKETED
| 7. OTHER (SPECIFY):

UNITED STATES DEPARTMENT OF STATE
REVIEW AUTHORITY: APPEALS REVIEW PANEL
APPEAL ACTION: ADDITIONAL INFORMATION RELEASED
REASON(S): B1, 1.4(A), 1.4(D), B3, ATOMIC
DATE/CASE ID: 04 NOV 2010 200504115

WITH ATTACH(S)/ENCL(S) A-F

~~FORMERLY RESTRICTED DATA~~ 11-30-06
~~Unauthorized Disclosure Subject to Administrative and Criminal Sanctions. Handle as Restricted Data in Foreign Dissemination. Section 144.b, Atomic Energy Act of 1954.~~

~~SECRET~~

20050789

A-535

~~SECRET~~ UNCLASSIFIED

NUCLEAR ACCIDENTS AT PALOMARES, SPAIN IN 1966 AND THULE, GREENLAND IN 1968

FOREWARD

(U)This brief account of the diplomatic history of the Palomares, Spain and Thule, Greenland nuclear weapon accidents was commissioned for the purpose of providing some insight into the demands which could be made on United States' ambassadors and their staffs should such an accident happen again.

(U)We have been fortunate that we have not had a major overseas accident of the scale of Palomares or Thule since 1968. One of the unfortunate by-products of this excellent nuclear safety record has been the atrophying of expertise and consciousness of the lessons learned from those accidents.

(U)In a number of important respects today's environment overseas is different from that of the late 1960's. A small but vocal opposition to Intermediate Nuclear Force deployments--quiescent now--is lurking just below the surface lacking a cause celebre. A potentially widening "nuclear allergy" exists, brought about through emerging, left of center-nuclear-free minded second generation leaderships in the post-World War II international system. These adverse "trends" are fueled by a concerted effort by the Soviet Union to undermine allied support for U.S. nuclear deployments.

~~(S)~~U.S. nuclear weapon deployments will remain a feature of deterrence in our alliance system for the forseeable future. Deployed weapons are subject to accidents and incidents. It is simply a fact of life. Although every effort is made to reduce the risk of an accident with the deployed stockpile, the simple fact that deployed weapons must be maintained, modernized, trained with, and exercised means that some accident risk remains. ~~B1~~

~~(S)~~In addition to reducing accident risk to a minimum, we must be prepared to deal with the consequences of an accident should one happen. The Washington interagency group is convinced that the degree of damage to U.S. national security from any future nuclear accident or incident would depend in large measure on the quality of U.S. Government and host ~~B1~~

government management of the emergency. In short, if handled smoothly and effectively, the political costs could be minimized. If managed poorly, negative effects will be magnified. B1

~~(S)~~The United States' ambassador and his staff will play a key role in effective management of the U.S. Government response to an accident. As noted herein, embassies are generally ill-equipped to deal with such exigencies. The Department of State recently transmitted guidance to [redacted] key posts in the form of a mdoel plan each ambassador will adapt to local conditions and install as part of his emergency action plan. Although modest, the plan constitutes a first step toward the goal of embassy preparedness--in partnership with the Departments of Defense and Energy, and host nation officials--to minimize any adverse impact on Alliance solidarity resulting from a nuclear accident or incident. B1 B1

(U)Dr. James E. Miller of the Office of the Historian, Department of State, has done an outstanding job of surfacing the diplomatic problems of Palomares and Thule in a paper which is interesting reading. I hope this contribution to our understanding of the kinds of demands which could be made on our embassies is useful but continues to be unused.

Colonel Michael Barrett Seaton
Bureau of Political-Military Affairs
April 1985

SUMMARY

~~(S)~~The January 17, 1966 and January 21, 1968 crashes of nuclear-weapons-equipped SAC B-52 bombers on the territory of two U.S. allies thrust the Embassies in Spain and Denmark into complex and ultimately unsuccessful negotiations to retain rights for SAC overflights and for the storage of nuclear weapons. Other important and interrelated responsibilities assumed by the Embassies included managing a public relations effort designed to influence the citizens of the host state, assisting in efforts to clean up the contaminated crash sites, and settling the damage claims filed by the nationals of the host nation. All of these functions were carried out in cooperation with the Department of Defense. A clear division of responsibility emerged: the military concentrated on clean-up and claims settlement while the Embassy or Department of State assumed primary responsibility for retaining U.S. nuclear weapons rights. In Spain public relations matters constituted the major cause of conflict between the Embassy and military, while geographic separation gave the Department of Defense primary control of public relations in Greenland. The role of the American Ambassador and the depth of Embassy involvement during these crises varied in accordance with the circumstances of the accidents, the form of government of the host nation, and the character of the U.S. chief of mission.

(U)Certain clear lessons emerge from the two accidents. Within the limits imposed by atomic weapons information security, the United States should seek to provide the press with with all available information as quickly as possible. Expert technical assistance should be provided both at the crash site and at the Embassy as soon as possible after an accident. The United States should be ready to provide quick service for claims arising from an accident. The U.S. Ambassador must be in a position to assert his responsibility for all political activities in the host nation.

~~B1, B3~~

PALOMARES, SPAIN, JANUARY 1966

The Incident

(U)At approximately 10:22 a.m., January 17, 1966, a KC 135 refueling aircraft operating from Moron AFB collided with a B-52 bomber of the Strategic Air Command in the skies over the southern Spanish village of Palomares. Seven U.S. airmen were killed. The four unarmed nuclear devices which the aircraft was carrying apparently broke lose from their moorings during the disintegration of the B-52. One bomb fell with other wreckage into the sea off Palomares; the other three bombs landed around the village. The non-nuclear charges on two of these devices exploded releasing quantities of plutonium into the air and onto the ground. Wreckage of the two aircraft was strewn over a wide area around the village, but, fortunately no townspeople were injured by the falling debris or by plutonium contamination.

(S)The U.S. Air Force took full control of on-site efforts to recover the wreckage and nuclear armament and to decontaminate the crash site. The Department of Defense also took charge of the settlement of claims arising from the accident. The U.S. Embassy in Spain initially had an exclusively political role: dealing with the impact of the accident on U.S.-Spanish relations. Subsequently, it moved into areas which initially had been under exclusive control of the Department of Defense: the settlement of claims arising from the accident, and the clean-up operations. The objective of American diplomacy was to retain Spanish defense cooperation even at the cost of modifying existing arrangements for nuclear overflights and accepting damaging restrictions on the release of information concerning Palomares imposed by the Spanish Government. B1

(S)The U.S. Embassy at Madrid was informed of the accident at Palomares by phone by its military liaison group within an hour of the crash. In turn it notified the Department of State of the available details of the crash and initial Spanish Government and public reaction. Ambassador Angier Biddle Duke had been attending a meeting of a major business association when an aide arrived to verbally inform him of the accident. He immediately left the meeting and drove to the Spanish Foreign Office to seek a meeting with Foreign Minister Ferdinando Maria Castiella. However, the Foreign Minister was not in his office and Duke reported the available details of the accident to the Under Secretary for Political Affairs, Adolfo Cortina. In his meetings with Cortina and other senior officials of the Spanish Foreign Office Duke attempted to coordinate aresponse to the accident and expressed U.S. apologies for the incident. Despite the fact that many of the details of the accident were known to both the Spanish and foreign press, Spanish officials requested that the "nuclear aspect" be "played down . . . in any public releases" and that Spain be "disassociated from any nuclear implications." Ambassador Duke instructed all U.S. agencies in Spain to follow the press guidance set out in a March 1964 "USAFE nuclear accident information plan" and withheld authorization for any public reference to the B-52's nuclear armament.[1] An initial press statement which did not mention the nuclear aspects of the accident was cleared with the Government of Spain and released at Torrejon AFB at 9:45 p.m. local time on January 17.

Initial Public Relations

(U)From the start of the Palomares recovery operation, the Embassy faced two interconnected public relations problems: 1) insuring accurate reporting in the media and 2) winning the agreement of Spanish authorities to provide as complete information on the operation as security considerations permitted. Without access to more information, the tendency of the press toward misrepresentation and sensationalism increased. The Franco regime, however, in spite of a certain mellowing of its authoritarian nature after a quarter century in power, saw the press as an adversary to be fended off rather than placated.

(~~S~~)From the beginning, Department of State officials wanted to deal publicly with the nuclear issue. The Spanish Government, however, strenuously objected to providing any details to the press, an attitude initially shared by U.S. military representatives on the scene at Palomares.[2] U.S. officials recognized that holding on to the trust and cooperation of the Franco regime was critical to the successful conclusion of the recovery of the bombs and to maintaining its basing and overflight rights. ~~B1, B3~~ ~~B1, B3~~ Thus, the Spanish Government held a veto power over the release of information. In order to maintain Spanish confidence, the Embassy and recovery teams at Palomares made conscious efforts to assure that the Spanish Government was kept fully informed of all apsects of the recovery operation. Ambassador Duke met frequently with Spanish officials, JUSMG kept the High General Staff informed of the Defense Department's actions at Palomares, while Secretary of State Rusk and General Earl Wheeler, the Chairman of the Joint Chiefs of Staff, sent personal messages to their Spanish counterparts thanking them for their cooperation and assuring them that the recovery operation was receiving constant attention at the highest levels of the U.S. Government.[3]

(S) The Franco regime's efforts to avoid mention of the B-52's nuclear armament collapsed on January 19 when United Press International reported not only that the B-52 was carrying nuclear bombs but that one was missing and hundreds of geiger counter equipped U.S. troops were combing the countryside around Palomares searching for signs of radioactivity. On January 20, the Spanish Government authorized release of a statement which admitted the B-52 carried nuclear armament but insisted that initial radiological surveys had established that no public health danger existed in the Palomares area. The statement represented a Spanish redrafting of an Embassy-proposed press release which provided fuller details of the nuclear aspects of the accident.[4] By January 21 the nuclear contamination issue was receiving full play in the Spanish press. The failure of the U.S. and Spanish Governments to provide accurate information on the crash combined with the problem of the missing nuclear weapon created serious public relations problems for the Embassy for months afterwards.

(S)The concern of Spanish officials with the public relations aspects increased as the size of the foreign press corps covering the accident grew. In an effort to impose censorship on the Spanish public, the Franco Government banned the sale of foreign newspapers and news magazines. On January 21, the Spanish Foreign Office called in Duke to complain about an alarmist American wireservice story which attributed its sources to the U.S. Embassy. Franco had read the article and was upset. The Spanish Government threatened to take unspecified "independent action," in retaliation for the leak. Duke was able to refute that story's attribution to U.S. sources by contacting the UPI bureau chief in Madrid and thus to preserve close intergovernmental cooperation.[5]

(S)The key motivations for the Franco Government's sensitivity were its concern about the impact which stories about nuclear contamination would have on southern Spain's lucrative tourist industry and its fears that the underground and semi-legal opposition forces, including the outlawed Communist Party, would effectively exploit the incident in their campaign to topple the regime. Ironically, the sensationalism of the Communist-controlled and clandestine "Independent Spanish Radio" would have considerable effect on the populace of Palomares precisely because the information provided by their own government was both sketchy and believed unreliable. U.S. officials also suspected that the Government of Spain intended to use the bomb accident as a bargaining chip in the next round of base negotiations scheduled for 1968.[6] B1, B3

(S)For U.S. officials, the critical issue was limiting adverse publicity which could trigger a formal Spanish demand for the cessation of overflights of its territory by nuclear armed aircraft. The threat that such permission would be withdrawn first surfaced on January 19 when Spanish Vice President Munoz Grandes suggested that in future the United States conduct its refueling operations over international waters. Officials at the Spanish Foreign Office also complained to Embassy officials about holding refueling operations over their territory. Duke warned Washington that the speedy recovery of the missing fourth nuclear device was the key to reducing press coverage which could force the Spanish Government to suspend overflight permission. Continued intense press coverage would force the Spanish Government to take dramatic action to reassure restive domestic public opinion.[7]

(S)Duke's warning proved instantly prophetic. On January 22 Munoz Grandes met with the Chief of the U.S. JUSMG, Major General Stanley J. Donovan, to request the suspension of the overflight of Spanish territory by nuclear-armed U.S. aircraft. The Spanish Foreign Office initially told reporters that any changes in the flight paths of its aircraft were unilaterally made by U.S. authorities. However, in the face of continued intense press coverage of Palomares and rising discontent among influential segments of the Spanish intelligentsia and bureaucracy, Spanish Information Minister M. Fraga Iribarne told a January 29 press conference that U.S. nuclear armed overflights of Spain had been "permanently" suspended, adding that all U.S. medium bombers were being withdrawn from Torrejon AFB and that no nuclear armaments were stored on that base. Fraga did not hold any consultations with U.S. officials prior to making this statement.[8] B1, B3

The Question of a Joint Statement

(S)The United States, following its established policy, refrained from public comment on issues relating to its nuclear defense operations. The Embassy, however, was actively attempting to counter misinformation originating from the recovery site. Because of the isolated location of the recovery operation, security measures enforced by the government, and the limited value of news relating to the land clean-up operation, the majority of the foreign press covering the Palomares story stayed in Madrid, awaiting fresh developments in the recovery operations. All of these conditions produced misinformation and sensationalism.

The Embassy was also concerned about the lack of information being provided by the Department of Defense's on site press-spokesman. The paucity of factual information provided correspondents visiting the scene tended to exacerbate already unfavorable reporting. In an effort to counter these factors, Ambassador Duke toured the recovery site on February 3 and upon his return to Madrid held a news conference at which he explained the progress of the clean-up operation as well as the technical difficulties facing the Navy in its search for the missing bomb. Duke's continued concern over accurate press coverage of the clean-up and salvage operations led him to strongly endorse a suggestion by the DOD press representative at the crash site for a press conference, jointly sponsored by the Embassy and Spanish government, and preferably held at Palomares, which would dispell rumors about contamination. The Spanish Government did not act upon this suggestion due to internal disagreements. After State Department-DOD consultations the idea was vetoed as "undesirable" by the U.S. Government.[9]

(~~C~~) Inaccurate reporting dogged U.S. officials. The day after Duke's February 3 press conference, the New York Times erroneously quoted him as identifying the missing bomb as an hydrogen device. In view of Spanish sensitivity to any discussion of the bomb's characteristics (particularly its killing power and radius), Duke obtained a retraction from the Times' Spanish correspondent, Tad Szulc.[10]

(~~S~~) Meanwhile the Embassy continued to press the Spanish Government for the release of a joint statement which would clarify the details of the Palomares accident and clean-up. In mid-February 1966, the Embassy submitted to the Foreign Office, the Spanish Atomic Energy Commission (JEN), and Vice President Munoz Grandes a State Department draft of a joint U.S.-Spanish statement. While initial reaction to the U.S. proposal was generally favorable, all three forwarded suggestions for changes in the text. An internal Spanish Government debate on the text effectively blocked the issuance of any statement. Vice President Munoz Grandes, in particular, was opposed to any public statement on the accident at a time when the Soviet Union had initiated a major propaganda offensive. He feared that the Soviet Union would simply exploit additional information to keep the issue before world public opinion. Information Minister Fraga and the JEN favored release of the text, while the Ministry of Foreign Affairs was divided on the issue. Finally, Franco vetoed any further disclosures. On February 25, the Embassy suggested that the United States considerd issuing a unilateral statement.[11]

~~(S)~~On March 1, the press impasse was finally broken by the action of the Chairman of the JEN, Jose Maria Otero. Without clearance from either the Foreign Office or High General Staff of the Spanish Army, he discussed the contamination issue, outlined clean up operations, and confirmed that one of the nuclear weapons was still missing in a press interview. U.S. officials speculated that Otero's actions were encouraged by Information Minister Fraga, a leading proponent of openness with the press.[12] The following day, the Department of State released a previously prepared statement stressing the safety features of U.S. nuclear weapons and confirming the details of Otero's interview.

~~(C)~~On March 8 Ambassador Duke, Information Minister Fraga, and members of their families went swimming in the sea off Palomares to demonstrate the safety of the area for tourists. The germ of this idea may have originated with Spanish Desk Officer Frank Ortiz who in January 1966 suggested that "newsworthy" visitors patronize hotels near the crash site. The Spanish Government had scheduled a new hotel for opening in March at Mojacar close by Palomares and was very concerned that the adverse publicity would destroy the tourist season in that area. Duke conceived the idea of attending the opening and taking a swim. Joined by most of his staff, he took the plunge into the icy waters in the morning. Later that afternoon, Fraga and Duke took a second swim. The impact on world public opinion was immediate and highly favorable. This vivid proof that the sea was not endangered by contamination probably saved the tourist season in Southern Spain.[13]

~~(C)~~As the clean-up operation progressed successfully and local claims procedures began operating effectively, the major public relations problem facing Embassy officials was providing information on the effort to recover the missing nuclear weapon. In view of security considerations and the difficulties of securing Spanish agreement to the release of information, the Embassy secured the concurrance of the Air Force command in Spain for its recommendation that the United States inform the Franco Government that it intended to make appropriate information on recovery operations available to the press without prior consultations.[14]

<u>Location of the Missing Bomb</u>

~~(S)~~After an exhausting search, the missing bomb was finally located and tentatively identified on March 15, 1966. However, the reluctance of the commander on the scene, Rear Admiral William Guest, to release information without definite confirmation that the object was in fact the missing bomb forced the Embassy to cancel precipitously an early morning press conference on March 16. At the same time, leaks within the military chain of command outside Spain put increasing pressure on the Embassy and military recovery operation to provide some sort of information. Finally, on March 17 after confirmation that the bomb had been located, the Embassy issued a statement which had previously been prepared through consultations with the Department of State. Equipment problems and the loss of contact with the bomb for 9 days delayed final recovery.[15]

(~~S~~)The long search and subsequent recovery problems combined with the scarcity of information available reinforced press tendencies toward sensationalism. At the urging of U.S. representatives in Spain, including Ambassador Duke, the Department of Defense approved a plan to permit representatives of the press to view the bomb shortly after it was hauled aboard a U.S. Navy recovery vessel. The Embassy had apparently initially wanted the press to be present during the recovery operation to establish U.S. credibility but accepted military objections to this plan. As an alternative it suggested that Spanish officials and press pool representatives view the recovered bomb and that the press then receive a formal briefing on the recovery operation.[16]

(~~S~~)During the recovery operation, leaks from the Spanish representative at Palomares created additional press problems and Ambassador Duke sent an Embassy representative to the recovery site to "insure . . . press treatment . . . recovery operations protects and advances U.S. interests," through strict control of the information released. In a largely unsuccessful effort to minimize speculation, the United States had established a daily Navy-Air Force joint briefing at Palomares. However, the long delay in recovery of the missing bomb, the limited information being provided by military officials, isolation of the site, and the attendant growth of rumors defeated this aspect of the public relations effort and spawned sensationalistic accounts, particularly in the Western European press. In addition, the long simmering differences between the Embassy staff and the DOD press representatives at Palomares surfaced when Embassy officers made their unhappiness known to members of the press, complaining that the military treated them as "nuisances."[17]

(U)The Navy's inability to retrieve quickly the lost nuclear weapon after its discovery created additional problems for the Embassy. On the international level the Soviet Union was exploiting U.S. difficulties to attack the stationing of nuclear weapons outside U.S. national territory and demanding international verification of the recovery. Meanwhile a large and growing group of journalists was waiting in Madrid for permission to visit the crash site and view the results of the recovery operation. Press coverage of the clean up and recovery was limited, first by the need to keep everyone not associated with the operation away from areas of potential contamination at the land sites and then by security considerations and the practical impossibility of accomodating large numbers of press representatives on the recovery ships. The Franco Government, of course, preferrred to keep the press away from the site entirely. Its aims were facilitated by the isolation of Palomares and the slow progress and generally unnewsworthy nature of daily recovery and clean-up operations. The vast majority of the press gladly preferred to await major developments in the comfort of Madrid's hotels.[18]

(S) On April 7, 1966, the naval task force retrieved the missing bomb. The Embassy notified the Spanish Foreign Office and Information Ministry while JUSMG reported the succesful recovery to the High General Staff, Air Ministry and JEN. Ambassador Duke proceeded to the recovery site together with representatives of the Spanish Government.[19] On April 8, the Spanish officials boarded a U.S. Navy recovery vessel and viewed the weapon. A small number of press representatives were brought alongside the recovery ship for a glimpse of the bomb and the U.S. military provided a briefing on the recovery operation for the the entire press corps. At the request of the Government of Spain, relayed through the Embassy, the recovery ship with its atomic cargo immediately departed for the United States without docking at any Spanish port. A majority of the press departed soon after the weapon recovery was completed.[20]

(S) Palomares remained a public relations problem for the Embassy for nearly a decade afterwards. The annual anniversaries of the accident were marked by television and press retrospectives focusing on the effects of the crash on the people of Palomares. The Embassy was frequently requested to provide technical assistance for these inquiries and to explain the U.S. position. The population of the village declined rapidly as the soil became increasingly alkaline and incapable of supporting the area's primary cash crop, tomatoes. In addition, many villagers departed out of fear of radiation effects. Internal opponents of the Franco regime, initially spearheaded by the Duchess of Medinia-Sidonia, attacked the Spanish Government, claiming it had failed to safeguard the interests of its own citizens, particularly their rights to claim damages from the United States. The Embassy originated a plan to show U.S appreciation to the people of Palomares for the assistance they rendered to the downed aviators and their patience during the subsequent clean up by building a water desalination plant to assist in irrigation projects. The idea, which Washington approved with some reservations, ran into a series of bureaucratic impasses in Spain.[21]

Conditional Reinstatement of Permission for Overflights

~~(S)~~Once the Spanish Government suspended overflight permission for SAC nuclear armed bombers, the Embassy, through the JUSMG, was the primary channel through which the United States sought a reinstatement of its former privilege. Initially, the Embassy counseled Washington to avoid bringing up the overflight issue until the fourth atomic device was recovered. Negotiations for basing rights for three U.S. fighter squadrons assigned to NATO (from which Spain was excluded) and the approach of the renegotiation of the U.S.-Spanish Defense Cooperation Agreement further complicated the U.S. position.[22]

~~(S)~~Shortly after the recovery of the missing bomb, the Embassy advised the Department of State that it believed the Spanish Government would agree to permit flights of nuclear equipped-aircraft over the Straits of Gibraltar, but that this concession would increase Spanish resistance to allowing nuclear armed aircraft to overfly its territory,adding that it could not judge "when, if indeed ever, . . . GOS would be willing again . . . expose itself to . . . possibility, however remote, of another Palomares."[23]

~~(S)~~Nevertheless, acting on instructions from the Departments of State and Defense, the chief of JUSMG met with Munoz Grandes on May 3, 1966 to begin a long and ultimately unsuccessful effort to resume SAC flights over Spanish territory. While Munoz Grandes appeared willing to consider permitting U.S. aircraft to cross southern Spain via the base at Rota, strong opposition to any rescinding of the ban on overflights, led by the Spanish Foreign Office, delayed any final action on the U.S. request. Finally, at the end of December 1966, Munoz-Grandes informed the chief of JUSMG that the resumption of overflights by nuclear armed aircraft was "out of the question" for the forseeable future. Munoz Grandes did leave open, subject to further study by the Spanish Government, the possible use of Rota airfield "as (a) stopover."[24]

Settlement of Claims

(S) Although the Embassy showed no desire to interfere with the on-site operations of the Air Force and Navy it was slowly dragged into a more active role in the Palomares area by the complaints of local residents (magnified through the reporting of the Spanish and international press) that claims settlements were progressing too slowly. Ambassador Duke urged that the process be sped up. On February 12, 1966, at a meeting of the chief of JUSMG and the High General Staff, Spanish officers requested that the claims agreements forms used by the United States be reworded to permit filing later or supplementary claims for 10 to 20 years after the accident. They pointed out that the effects of the crash on the citizens and land of Palomares might not be fully revealed for many years after the accident. The Embassy contacted the Department of State and urged speedy consideration and action on the position of the Spanish Government.[25] Meanwhile, claims processing was suspended at Spanish request. After consideration of the legal aspects of the Spanish request, the Department of State forwarded a letter for delivery to the Spanish Government which explained the procedures outlined in the Foreign Claims Act and provided assurances that claims could be filed for an extended period of time following the accident. Negotiations on the claims settlements issue took place on February 19 and 21, 1966 between the chief of JUSMG and a representative of the Spanish High General Staff. The negotiators reached agreement that the assurances contained in the U.S. letter satisfied Spanish concerns.[26]

(C) Claims settlements continued for years after the accident. Francisco Simo Orts, the Spanish fisherman who saw the fourth bomb land at sea and assisted in rescuing downed US airmen, filed a series of claims against the United States which embarrassed both U.S. and Spanish officials and kept the issue of U.S. fairness in the press. The Embassy also inherited responsibility for handling claims after the military clean-up teams left Palomares, serving as a clearing house for the inquiries and complaints of the Spanish Government. The satisfaction of claims of Spanish citizens remained an irritant in U.S.-Spanish relations for nearly a decade. In 1976, the Embassy braced for major demonstrations which would mark the tenth anniversary of the Palomares crash. None took place. Internal political matters connected with the transition from dictatorship to democracy in Spain had evidently lessened public interest in the 1966 crash.[27]

Clean-Up Operations

(U)As was the case with claims issues, the Embassy initially left the clean-up operations to the representatives of the Department of Defense at Palomares. However, the requirements of an effective public relations effort and of effective communication with the Spanish Government inevitably led to an increased Embassy role in these matters.

~~(S)~~Initially, Ambassador Duke's major requirement was accurate information on the on-site operations. Teams of nuclear experts from the Department of Defense and the Atomic Energy Commission had arrived at the crash site within days of the accidents and were directing the clean-up and bomb land portion of the search for the missing nuclear bomb. The Embassy lacked a specialist in nuclear matters Duke relied upon his military attaches to provide the Embassy with full information on the recovery and decontamination operations. Utilizing their contacts with the 16th Air Force, the attaches were able to provide the Ambassador with a frequent (initially daily) written report on operations at Palomares which was then summarized and passed on to the State Department.[28]

~~(C)~~In early February the first concern of U.S. officials in Spain was rapid completion of a safe clean-up operation. The thoroughness of the operations carried out to insure the safety of the local population had the paradoxical effect of increasing public concern with the effects of radiation and of keeping the Palomares story in the forefront of news for the Spanish and international press. In addition, the tourist season was approaching. Tourism was a principal element in the rapid expansion of the Spanish economy in the 1960's and a critical factor in the modernization of Spanish politics and society. Both the United States and Spanish Governments were eager to eliminate the memories of Palomares in order to assure the continued growth of this key element in Spain's development. However, accelerating the pace of the decontamination effort proved difficult. On February 2, 1966, General Delmar Wilson, the on-site commander of the clean-up operation signed an agreement with the Spanish on-site representative, General Arturo Montel, which committed the United States to build a disposal pit near Palomares in which all contaminated soil registering 7,000 counts per minute (cpm) on a geiger counter would be stored. U.S. military officials quickly discovered that these ground rules for removal of contaminated soil could not be met by the deadline established by the tourist season. They also concluded that these figures were excessive from the safety standpoint and would seriously

~~B1, B3~~

B1, B3

complicate efforts to remove contaminated materials. Finally, the Embassy and JUSMG opposed the creation of a nuclear dump in Spain since this would only become a monument which anti-nuclear and anti-American forces could utilize for the political purposes. DOD officials argued that a reading of 50,000 cpm was perfectly safe and requested the Embassy to secure Spanish approval for using this level as the benchmark for soil removal. The Department of Defense proposed to remove all soil with readings above this level and to plow under and water down soil with lesser readings.[29]

(S) Based on advice provided by the U.S Atomic Energy Commission, the Department of State believed that a reading level of 100,000 cpm was perfectly satisfactory to protect public health and instructed the Embassy to seek an accord on soil removal based on that level as the benchmark. In order to assist Embassy and Department of Defense representatives in Spain, the Atomic Energy Commission sent two American nuclear energy specialists to Madrid in early February. Dr. John Hall was the Assistant Director for International Relations for the AEC. Dr. Wright Langham was the AEC's expert on plutonium contamination. He had previously worked at the Palomares site. Langham would remain in Madrid until mid-March to serve both as the Embassy contact with the JEN and as a special advisor to Ambassador Duke on nuclear matters. In addition to providing advice for Ambassador Duke, both men were instructed to provide technical explanations to buttress the U.S. positions in negotiations with the Spanish Goverment over soil clean-up operations. The State Department also provided the Embassy with a Washington interagency-approved position paper on detcontamination for use in dealing with the Spanish Government. This paper reiterated U.S. concern that the Spanish cpm level guideline for soil removal was much too low and would needlessly delay decontamenation operations to the detriment of both Spanish tourism and public relations aspects of the Palomares recovery while feeding local fears regarding the effects of radiation.[30]

(S) Armed with this technical aid, the Embassy arranged a meeting between U.S. and Spanish atomic energy experts on February 15. American scientists argued that the 100,000 cpm benchmark for soil removal was adequate for public health and safety. The Spanish scientists did not contest this position on technical grounds but would not accept it as the basis for continuing decontamination operations. U.S. officials were aware that clearance of their proposal would require action at a higher and political level of the Spanish Government. On February 17, the U.S. scientists and the chief of JUSMG met with representatives of the High General Staff. The Spaniards continued to press for soil removal to the 7000 cpm level. The

~~B1, B3~~

U.S. representatives repeated their arguments for utilization of a 100,000 cpm benchmark. Finally, the two sides reached a compromise. The United States would plow up two plots of ground registering a 60,000 cpm reading. In one plot the plowing would reach a depth of 8 inches. This land would be watered and broken up in the internationally-accepted manner proscribed for decontamination. The second plot would be plowed to the depth of 4 inches--the depth normally plowed by Spanish farmers. If readings taken on these two plots were at a normal level, the Spanish Government would abandon its demands for soil removal to the 7,000 cpm level. A copy of the Washington interagency paper and a copy of the telegram outlining the verbal agreement are attached as appendices C and D respectively.[31]

(~~S~~) The Department of State approved the compromise but expressed reservations about utilizing a 60,000 cpm benchmark for soil removal, arguing that this might set a precedent for future decontamination operations which would needlessly complicate U.S. efforts. It provided suggested wording for an agreement with the Spanish Government which would permit the United States to hold to a 100,000 cpm level as the benchmark for future clean-up operations.[32]

(~~S~~) The soil testing was completed on February 21, 1966. U.S. and Spanish scientists agreed that the cpm levels registered after the experiment were at "reasonable levels" for public heath and safety. Based on these conclusions, the Spanish Government abandoned its 7,000 cpm benchmark. Contaminated soil already collected was shipped to the United States for final disposal. The remaining areas were plowed under and watered down. The benchmark of 60,000 cpm became the practical measure for soil removal.[33]

THULE, GREENLAND, JANUARY 1968

(U)At approximately 3:40 pm, January 21, 1968, a SAC B-52 bomber carrying nuclear weapons crashed on the 7-foot-thick ice of North Star Bay approximately 7 miles from the runway at Thule AFB. The aircraft had been attempting an emergency landing after a fire broke out in its heating system. Six crewmen bailed out successfully and were subsequently rescued. A seventh died during the bailout procedure. The four nuclear devices remained within the aircraft and broke up upon impact. Alpha radiation was released in the crash site area. In addition, small fragments from the aircraft passed through the ice pack and settled at the bottom of North Star Bay.

(U)The B-52 crash occurred at a particularly sensitive time for the government of Danish Prime Minister Jens Otto Krag, since anational election campaign was in its final days. The Danish Government, upon receipt of information of the crash (apparently through military channels), released a statement (January 22, 1968) which claimed that Denmark did not permit flights by nuclear armed aircraft over any part of its national territory, including Greenland, and stressed that the plane had been attempting an emergency landing after encountering inflight problems. The text of this statement was not cleared with the U.S. Government prior to its release. The United States had operated its nuclear armed aircraft over Greenland since the conclusion of a 1957 agreement with the Government of Denmark.[34]

(U)Because the wreckage was located in a remote and lightly populated area, claims did not play a major role in the Thule incident. The distance between the crash site and Denmark reinforced the clear division of responsibility between the military and U.S. Embassy already evident after the Palomares accident. The Department of Defense took charge of the recovery and clean-up operations at the crash site, and assumed responsibility for the payment of claims arising from the accident. In addition, the Defense Department public relations teams took charge of the press covering the recovery operation in Greenland and were the primary source of information for reporters in Washington. However, Denmark's democratic politics put an even greater premium on the skillful handling of public relations by Ambassador Katherine White and the Embassy staff in Copenhagen.

Initial Public Relations Efforts

(~~S~~)Within hours of the first news of the crash, the Embassy faced a mounting volume of requests from Danish journalists to travel to Thule. These requests were referred through the Air Attache to the USAF Foreign Liaison Office. The Embassy cautioned both the Departments of State and of Defense that U.S. failure to grant permission to travel to Thule AFB and to facilitate the work of the press in this frigid area would create serious political problems since it would be interpreted as an affront to Danish territorial sovereignty.[35]

(~~S~~)The lessons of Palomares concerning the need for a good public relations program were in the forefront of U.S. Government concern in Washington. On January 23, the Assistant Secretary of State for European Affairs, John Leddy, met with Danish Ambassador Torben Ronne. Leddy opened the discussion by stressing the need for providing the press with as much information as possible, consonant with security requirements, on both the crash and the clean-up operation. He pointedly cited the bad precedents created by press censorship at Palomares. Leddy secured Ambassador Ronne's approval for a Department of Defense press release describing the findings of a ground survey team at the crash site. Ronne urged the quickest possible release of the document. The United States repeatedly cleared its press releases with the Danish Government during the first stages of the Thule operation. This action may have been designed to establish reciprocity with the Danes on public relations issues. If so, the effort failed. The Danish Government repeatedly issued statements without prior U.S. approval.[36]

(U)The immediate problem for both governments was insuring the availability of proper support and transportation for Danish and American reporters desiring to visit Greenland. In addition to troublesome climatic conditions, the arrival of reporters threatened to overwhelm the limited facilities of Thule AFB already straining under the requirements of supporting recovery operations in sub-zero temperatures. In spite of protests by local commanders, the U.S. Government insisted that facilities be provided for the press. Fortunately, the forbidding conditions in Greenland and other major stories (in particular the capture of the U.S.S. Pueblo and the Tet offensive) quickly diverted international press attention. By early February the press corps had left Thule but the story remained a major item of interest in Denmark.[37]

Reaction in Denmark

(U)The need to provide accurate and credible information on the Thule accident was underlined by the response of the Danish press. Anti-American feeling, fueled by the war in Vietnam, reached its peak in Europe during the late 1960's. Even normally pro-American parts of that press publicly called into question the honesty of the U.S. Government and reported that U.S. aircraft had frequently overflown Greenland, fueling suspicion that the United States had violated its agreements with the Danish Government. Danish participation in the study of the nuclear effects of the crash, however, strengthened the credibility of U.S. public statements.[38]

(U)Due to the distances and time problems involved in coordinating information between Washington, Thule, and Copenhagen, Embassy press officers played a limited role in the U.S. public relations effort which was the primary responsibility of Air Force public relations teams at Thule AFB and in Washington. The Embassy information officer, in cooperation with the Air Attache and Embassy press office, arranged transportation for 21 Danish and European journalists to Thule and accompanied them on the visit. The press office also managed to coordinate a nearly simultaneous release of information with Washington by taking down the texts of Department of Defense press bulletins over the phone, copying them, and then providing them to Danish journalists. Department of Defense films on nuclear safety were flown from Washington to Copenhagen for screening by the Danish press. The European Command of the U.S. Army provided the Embassy with a specialist in nuclear matters who assisted press office personnel in preparing and delivering press briefings on such potentially sensitive subjects as safe levels of radioactivity and decontamination procedures. The Embassy also reported that it found a Department of Defense guidance on nuclear matters, prepared after the Palomares accident, of value in its dealings with the press.[39]

(U)On February 5, 1968, the U.S. command at Thule began sending a daily report to Washington and the Embassy on the clean-up operations, designed for briefing the press. The daily information summary was replaced on March 16, 1968 by a system of infrequent releases marking new stages in the progress of the clean-up operation. In the meantime, Danish press interest in the Thule crash began to recede. U.S. cooperation with the Government of Denmark on health and environmental safety overcame the effects of initially hostile press reporting and reestablished credibility with the Danish public. As early as February 8 Danish scientists returning from Thule reported that no evidence existed of immediate danger to the population of Greenland from the crash.[40] To further strengthen the sense of U.S. concern, Ambassador White made a personal visit to the Thule area on February 24-28. White initially proposed a personal visit to the site on February 2. The Ambassador was accompanied by her Deputy Chief of Mission and by a delegation of Danish Government officials and press. Both White and Danish officials stressed the speed and efficiency of the clean-up operations at a press conference.[41] The program of combining the quick release of accurate information, facilitating the travel and accommodations of Danish and foreign journalists, and cooperation with the Government of Denmark paid major dividends for the United States by improving the tone of Danish press coverage and increasing public confidence in the ability and determination of the United States to handle the clean-up operations safely.

Clean-Up Operations

(~~S~~)The inhabitants of the Thule area, an estimated 650 Greenlanders, were never in any danger of direct contamination from the crash. The area around the crash site was immediately sealed off By Thule AFB personnel to prevent any chance of contamination of the population. Local concern about the effects of radiation centered on indirect contamination through the entry of plutonium into the food chain. Of particular concern was the possibility that radioactive wreckage might have passed through the ice flow and contaminated the sea floor. Statements issued by scientists from the Danish Atomic Energy Commission who participated in the clean-up operations and by thesubsequent follow-up examination of the ocean floor conducted during the summer of 1968 by the Department of Defense greatly allayed these fears.[42]

(U)During the winter, Department of Defense directed clean-up operations centered on recovery of aircraft wreckage, including pieces of the four nuclear weapons, and the collection of contaminated ice and snow. The major problems facing the military were delays caused by bad weather and the assembling of adequate equipment. Core samples were taken from the ice to ascertain the depth to which radioactivity had penetrated. The clean-up proceeded from the edges of the crash site to the center so the burned-out crash impact area was the last to be cleaned up. Recovered debris together with contaminated water were then packed and shipped to the United States for final disposal.

~~(S)~~The clean-up operations produced only minimal economic disruption for the inhabitants of Thule. Most of the restricted area was reopened for use in April and the SAC clean-up operation was finished by mid-April. Tests run by Danish scientists on the plant and marine life in the area during the spring indicated that the crash had had no effect on the local ecology. In August 1968, U.S. submarine vehicles scanned the ocean floor for missing debris, [redacted] A few small pieces of debris which did not pose a threat of contamination were discovered.[43] Most of the discussions relating to nuclear clean-up and monitoring of the crash site were carried out by scientific teams representing the two governments. The U.S. team was organized and led by the Department of Defense. The Embassy played no significant role in clean-up operations.

~~B1, B3~~
B1, B3

Nuclear Overflight and Storage

(U)In matters relating to nuclear policy the Embassy in Denmark played a much more restricted role than did the Embassy in Spain after the Palomares accident. The Danish Government chose to utilize its Embassy in Washington to convey its views and carry on most of the substantive negotiations on nuclear policy questions with the United States.

~~(S)~~The major objective of the Government of Denmark in its discussions with the United States was to secure a joint statement that no atomic weapons were stored in Greenland and that the frequently-observed B-52 flights into Thule and over Greenland were by aircraft that did not carry nuclear armament. (The Danish press was full of stories quoting Greenlanders who claimed that B-52 aircraft regularly flew over the island and landed at Thule AFB.) The United States, as a matter of policy, wished to avoid any statements regarding the storage or transporation of its nuclear armaments. On January 26, 1968, U.S. Assistant Secretary of State Leddy submitted to the Danes a draft statement which avoided any mention of the nuclear issue. Leddy noted that [redacted] the United States and Denmark had agreed in 1957 that their 1951 defense accord granted the United States the right both to store weapons at Thule AFB and to overfly Greenland with nuclear armed aircraft. Leddy also underlined U.S. irritation over the Danish Govenment's failure to consult with it prior to making public statements on nuclear policy.[44]

B1, B3

~~(S)~~On February 7, shortly after the formation of a new Danish Government, Ambassador White met with Foreign Minister Poul Hartling at the Dane's request. Hartling presented White with the text of a statement which he planned to read to the Danish parliamentary committee on foreign affairs. This statement assured parliament that no nuclear weapons were stored in Greenland and that the new ministry was entering into negotiations with the United States to insure that none would in the future. White replied that U.S. policy was neither to confirm nor deny matters relating to nuclear arms. Hartling assured the Ambassador that this statement did not imply that his government intended to seek to renegotiate the 1951 defense cooperation agreement. These assurances were repeated to White by Ambassador Ronne, who had returned to Copenhagen for consultations following the formation of a new ministry. Ronne stressed the need for U.S. comprehension of Denmark's position. The Danish Government apparently hoped to win Embassy endorsement for its action in making a public statement on nuclear storage and overflights.[45]

B1, B3

(U)The following day the Danish parliament passed a motion instructing its government to seek "absolute guarantees" from the United States that Denmark would remain a nuclear-free zone.

~~(S)~~During the negotiations which followed, the Embassy played a secondary role: providing information on public opinion, the attitudes of Danish civilian and military officials, and the negotiating positions of the Danish Government and suggesting U.S. negotiation strategy based on this information. Talks between the United States and Denmark took place in Washington.[46]

~~(S)~~The United States sought to preserve its rights to nuclear storage and overflights as outlined in the 1957 agreement. Negotiations conducted by Assistant Secretary of State Leddy and Ambassador Ronne resulted in a May 31, 1968 exchange of notes between the two governments which supplemented the 1951 defense agreement. The United States agreed that it would neither store atomic weapons in Greenland nor initiate overflights of Danish territory without prior consultations with the Government of Denmark. However, in a separate oral statement to Ronne (May 10), Leddy noted that conditions of extreme and sudden peril to the Atlantic Alliance which did not permit sufficient time for consultations with the Danish Government might lead the United States unilaterally to resume overflights of Greenland. The Danish Government dropped its request for a U.S. statement endorsing its position on nuclear weapons (May 16) and subsequently issued a unilateral declaration which reaffirmed its earlier statements. In keeping with its standing policy, the United States made no comment.[47]

B1, B3

Coordination Between the Embassy and the Recovery Operation

(U)Distance and the isolation of the crash site warrented the Embassy policy of non-interference in recovery operations. In addition, the Embassy had no contingency plans for coping with a nuclear accident and the Embassy officers had no training in this field. Moreover, the Mission in Denmark lacked specialists in nuclear affairs and in the days following the crash urgently sought the loan of a qualified specialist in nuclear affairs from the Embassy in Stockholm. As earlier noted, the Department of Defense came to the rescue when it authorized the loan of an officer from the European Command with the necessary technical expertise and the ability to deal with the press.

(C)Nevertheless, the Embassy played an important though limited role in facilitating contact between U.S. and Danish scientists. Ambassador White insisted on acting as the go-between for Defense Department scientists and their Danish counterparts. The Embassy did the groundwork for a joint meeting at Copenhagen between a team of U.S. scientists led by Dr. Carl Walske, Assistant Secretary of Defense for Nuclear Energy, and representatives of the Danish Atomic Energy Agency. All messages between the U.S. scientific team and the Danish Government were sent through the Embassy in order to maintain . . . excellent coordination among all American agencies which has characterized . . . B-52 crash."[48] The Embassy also provided communications facilities between the Department of Defense Science Team and Washington. Initially, communications between the DOD and Danish representatives travelled through a number of channels. However, once the Embassy became aware of this, it insisted that all future contacts must go through it, permitting the State Department to stay up to date with the scientific and technical aspects of the negotiations over the clean-up operation.[49]

(S)The Embassy also played an important role in the coordination of the texts of joint U.S.-Danish statements on scientific and technical aspects of the clean-up and recovery operations. Finally, during the summertime U.S. and Danish ecological surveys of North Star Bay and environs, Embassy officials worked with the representatives of the Danish Government on the public information program.[50]

(U)Overall cooperation between the Embassy and Department of Defense representatives was extremely close and appears to have been unmarred by any serious policy or personality disputes.

Claims

(U)The Danish Government declined to press any claims against the United States arising from the accident. The Department of Defense handled the payment of local claims arising from the accident. These claims were minimal and the Embassy does not appear to have taken any role in the settlement procedures.[51]

CONCLUSIONS

(U)While the documentation available for this study was not sufficient to trace the daily activities of either the Ambassador or the Embassy staffs during the crises which followed the crash of B-52's at Palomares and Thule, it does permit certain conclusions concerning the role of the Ambassador, the tasks performed by the Embassy, and the relationship of the Embassy to the U.S. military during the recovery and clean-up operations.

(U)Both Ambassadors confined themselves to traditional diplomatic functions, seeking to establish cooperation with the host government and to provide information which would put U.S. actions in the most favorable light before the publics of Spain, Denmark, and Greenland. Still, a good deal of flexibility existed for the definition of the ambassadorial role during these incidents and the degree to which the Ambassador took a hand in the resolution of events was determined by the circumstances of the accident and the personality of the incumbent. On the whole, Ambassador Duke took a more active role than Ambassador White both in diplomatic exchanges with the host government and in the public diplomacy function of his mission.

(U)Geography was a factor in the role which Ambassadors had in these crises. Although Palomares was situated in a remote part of Spain, it was on the European mainland and close enough to the centers of Spain's booming tourism trade to endanger part of Spain's economy as well as heighten concern about the possibility of an accidental nuclear explosion throughout the western Mediterranean area and northern Europe. The B-52 crash near Thule occured in a virtually uninhabited area, offshore, and close to a U.S. military facility. These factors in the Thule incident led to greater Department of Defense control and less Embassy involvement.

(U)The differing experiences and managerial styles of the two Ambassadors also interacted with the particular circumstances of the two incidents. Both Ambassadors were political appointees, but Duke had previously served as Chief of Protocol at the Department of State and, possessing a more complete knowledge of the foreign policy-making apparatus in Washington, was potentially in a better position to gain acceptance of his views. More importantly, Duke's particular situation required a more aggressive representation of U.S. interests. The United States was seeking to preserve its nuclear rights and to widen the scope of the information made issues related to the clean up and to claims arising from the accident. This made the Embassy in Spain and the Ambassador a key figure in the complex negotiations which finally resolved the Palomares incident.

(~~S~~)On the other hand, within hours of the crash at Thule, the Danish Government began aggressively seeking concessions from the United States through their Ambassador in Washington. Thus the Embassy in Denmark was largely bypassed on matters of policy and handled more routine matters. Moreover, the documentation indicates that Ambassador White handed responsibility for these matters to her deputy chief of mission who, while very active, probably lacked the weight with both the highest levels of the Danish Government and senior U.S. officials which an Ambassador often enjoys.

(U)The Embassy role in both episodes was almost exclusively non-technical in character. Inadequately staffed to handle the scientific and technical problems arising from the accidents, both Embassies relied upon the Department of Defense, the Atomic Energy Commission, and the Department of State for technical advice. This essential technical support was quickly available in Spain but was not immediately available in the Danish case. Coordination on technical matters, such as clean-up, decontamination, and weapons recovery, was performed primarily by the Defense attaches who utilized their familiarity with the agencies and commands of the Defense Department and with the military establishment of the host nation to provide the Embassy with accurate information and advice. In addition, in Spain, the Chief of JUSMG was able to utilize a close relationship with Munoz Grandes to improve inter-governmental cooperation on the recovery and clean-up operations and to assist the Embassy's ultimately unsuccessful efforts to regain Spanish permission for overflights by nuclear armed aircraft

(U)Throughout both incidents the overriding concerns of the Embassy were the impact of the accident on the U.S. public image and the retention of special rights and privileges relating to the movement and storage of nuclear weapons. The Embassy in Spain faced almost unsurmountable public relations problems due to the authoritarian nature of the Spanish regime which sought to impose a heavy-handed censorship on the press and thus increased public concerns and suspicions. Profiting from the lessons of the Palomares incident and from the requirements of Danish democracy, the Embassy in Denmark was able to create a more successful public relations effort after the Thule accident.

~~(S)~~Neither Embassy was able to influence significantly the host government on the matter of U.S. nuclear weapons rights.In the case of Denmark, the decision was made to revoke those rights within hours of the Thule crash. In the case of Spain, the Embassy's efforts were undercut by the inability of U.S. recovery teams to find the missing nuclear device and a resultant public outcry which drove the Franco regime toward a cancellation of permission for U.S overflights.

(U)Cooperation between the agencies of the Defense Department and the Embassies was good. In Spain, the Embassy felt compelled to prod the military over the speed of its claims repayment operation, but also provided the Department of Defense with badly-needed assistance in negotiations over both claims settlements procedures and standards for contamination clean-up.[52]

(U)Finally, both missions inherited responsibility for final settlement of legal problems arising from the crash. In the case of the Embassy in Denmark, these responsibilities were very limited due to the site of the crash and the disinclination of the Danish Government to press any claims. The Palomares crash, however, produced a long lasting series of headaches for the Embassy in Spain, arising primarily from legal claims but also involving the actions of opponents of the Franco regime. The Embassy in Spain continues to take action on problems related to the 1966 crash at Palomares.

PA/HO:JEMiller
4/12/85
0011r
632-9702

NOTE ON SOURCES

(U)This study was based on the files of the Department of State. In preparing it, primary reliance was placed on the Madrid and Copenhagen Post files and upon the files of the Danish Desk. The Central files of the Department of State were also consulted but they yielded little useful information. Other sources included press accounts, books published in the aftermath of the Palomares accident and information supplied by officers of the Department of State.

NOTES

1. Madrid tel. 839, Jan. 17, 1966, Confid-Nofor. Def 18 Madrid Post Files (Hereinafter cited MPF). On the release of information to the press, cf. Madrid tel. 846, Jan. 17, 1966, Confid., Def 17, MPF. Detailed accounts of the initial actions of the embassy staff are in Tad Szulc, The Bombs of Palomares (NY, 1967), pp. 54-62 and Flora Lewis, One of Our H-Bombs Is Missing (NY, 1967), pp. 63-68. Both are based on interviews conducted shortly after the acident.

2. Tel. 839 from Madrid, Jan. 17, 1966, Confid. op. cit.

3. Deptel. 851 to Madrid, Jan. 22, 1966, Secret, Def 18.1, MPF. Unnumbered Department of Defense tel. to the Embassy in Madrid, Jan. 22, 1966, ibid. Cf. Madrid tel. 838, Jan. 21, 1966, Def. 17, ibid.

4. Madrid tels. 855 and 857, Jan. 19, 1966, both Secret. Madrid 859, Jan. 20, 1966, Secret, all Def 17, MPF. DOD officials at Palomares initially attempted to place a veil of secrecy around all aspects of the accident to avoid exposure of the nuclear weapons on board the B-52. Szulc, whose presentation of the activities of the Embassy is consistently favorable, is highly critical of U.S. military efforts at press control and later DOD public affairs programs. He enjoyed a good relationship with Embassy personnel and his criticisms of the military public relations effort, in addition to reflecting a reporter's pique with the efforts at a news blackout, apparently magnified Embassy frustrations with the DoD handling of its on-site press briefings. Bombs of Palomares, pp. 114-15, 123, 168-69, 214-15. Lewis, while critical of the DOD public relations effort more accurately places most of the blame for the lack of information on the Spanish Government and notes U.S. Embassy irritation with Spain's efforts at censorship. One of Our H-Bombs, pp. 101-02, 176.

5. Madrid tel. 871, Jan. 22, 1966, Secret, Def 17, MPF.

6. Ibid.

7. Madrid tel. 869, Jan. 21, 1966, Confid. Cf. Madrid tel. 873, Jan. 23, 1966, Confid. Tel. JUSMG to CINCEUR, Jan. 22, 1966, Secret, all Def 17, MPF. See, Szulc, The Bombs of Palomares, p. 117 on trend of press reporting.

8. Madrid tel. 896, Jan. 26, 1966, Secret. Madrid tel. 914, Jan. 29, 1966, Confid., all Def 17, MPF. The extra-legal opposition capitalized on the crash to mount a small and peaceful demonstration outside the U.S. Embassy on Feb. 2, 1966. Franco's police eventually broke this march up.

9. Madrid tel. 951, Feb. 5, 1966, Secret, Def 17, MPF. Notes of a conversation with Ambassador Duke, Feb. 2, 1966, Secret, Def 18.1 MPF. Madrid tel. 966, Feb. 9, 1966, Confid, Def 17,MPF. The proposal for a Palomares press conference was turned down in Deptel. 941, Feb. 12, 1966, Secret, Def 18.1, MPF. No rationale for this decision was outlined in the telegram When Duke's proposal failed to win the agreement of the Spanish Government, the Embassy suggested a joint TV appearance by U.S. and Spanish scientists. Madrid tel. 974, Feb. 11, 1966, Confid., Def 17, MPF. Cf. Szulc, Bombs of Palomares, pp. 168-69.

10. Madrid tel. 942, Feb. 4, 1966, Confid., Def 17, MPF. A somewhat garbled version of this incident is in Szulc, Bombs of Palomares, p. 175.

11. Madrid tel. 1020, Feb. 18, 1966, Secret. Madrid tel. 1066, Feb. 25, 1966, Confid., both Def 17, MPF.

12. Madrid tel. 1099, Mar. 2, 1966, Secret, Def 17, MPF.

13. Ortiz to Duke, Jan. 20, 1966, Confid., Def. 18.1, MPF. Szulc, Bombs of Palomares, pp. 219-227 for further details.

14. Madrid tel. 1239, Mar. 22, 1966, Confid., Def 17, MPF.

15. On the problems of the recovery operation and its efect on press relations, see Sculz, Bombs of Palomares, pp. 234-45; Lewis, One of Our H-Bombs, p. 213.

16. Madrid tel. 1276, Mar. 26, 1966, Secret, Def 17, MPF.

17. Unnumbered telegram from Madrid to the Secretary of Defense, Mar 24, 1966, Confid. Madrid tel. 1269, Mar. 25, 1966, Secret, both Def 17, MPF. Sculz, Bombs of Palomares, pp. 215-16, reprints part of one of the press conferences which vividly present the press relations problems created by efforts to avoid admitting that a nuclear weapon was missing:
Reporter: "Tell me, any sign of the bomb?"
USAF Spokesman: "What bomb?"
Reporter: "Well, you know, the thing you're looking for..."
USAF Spokesman: "You know perfectly well we're not looking for any bomb. Just for debris."

Reporter: "All right, any signs of the thing which you say is not the bomb?"
USAF Spokesman: "If you put it that way, I can tell you that there is no sign of the thing that is not the bomb."
Sculz adds: "And so it went for days, for weeks." The New York Times (March 4, 1966.) greeted the March admission that a bomb was in fact missing with the caustic comment that it took the United States only 40 days to acknowledge the truth. On Embassy officials complaints to the press about being treated as nuisances, Szulc, Bombs of Palomares, p. 171. On growing Embassy disstaisfaction with the public relations operation and stains between Embassy officials and DOD representatives, cf., Notes, "Action," Jan. 24, 1966, Unclass., Def 18.1, MPF. "Ambassador's Comments on Return from Almeria," Feb. 3, 1966, ibid.

18. Cf, Szulc, Bombs of Palomares, pp. 226-27.

19. Madrid tel. 1359, April 7, 1966, Confid., Def 17, MPF.

20. Munoz Grandes request was reported in Madrid tel. 1264, March 25, 1966, Confid., Def 17, MPF.

21. Cf. Deptel. 118041, Jan. 14, 1967, LOU, Def 17-Palomares, MPF. On the problem with the duchess, Madrid tel. 1800, Jan. 13, 1967, LOU, Def 17, MPF. On the problems with the desalination plant, cf. Madrid 1557, Jan. 12, 1966, Confid., Def 17, MPF. See also the post morta in Time, Jan. 24, 1969, pp. 41-42., Washington Post, Feb. 9, 1969, and Atlas, Dec. 1971, pp. 78-79.

22. Madrid tel. 1316, April 1, 1966, Secret, Def 12, MPF.

23. Madrid tel. 1444, April 22, 1966, Secret, Def 17, MPF.

24. Madrid tel. 1531, May 6, 1966, Secret, Def 17-1, MPF. Madrid tel. 1836, June 23, 1966, Secret, Def 12, MPF. Madrid tel. 1555, December 16, 1966, Secret, Def 17-1, MPF.

25. Madrid tel. 997, Feb. 12, 1966, Secret, Def 17, MPF.

26. Madrid tel. 1025, Feb. 19, 1966, Secret. Madrid tel. 1031, Feb. 21, 1966, Secret. Madrid tel. 1038, Feb. 21, 1966, LOU, all Def 17, MPF. On the claims settlement procedures, see Defense Nuclear Agency, "Palomares Summary Report," Jan. 15, 1975 (U), pp. 149-81. A copy of the agreement on claims procedures is attached as appendix A to this paper.

27. Memorandum of a conversation between Duke and Aguirre de Carcer, Director General of North American Affairs, Spanish

Foreign Office, Madrid, Jan. 5, 1967, Confid, Def 17, MPF. Notes of discussion with Harvey Ferguson, INR/WEA, Nov. 1, 1984. Ferguson was Economics Officer in Madrid in 1976.

28. Madrid tel. 888, Jan. 25, 1966, Confid-Limdis. Madrid tel. 887, Jan. 25, 1966, Confid. Memorandum from Wilson to Duke, Jan 26, 1966, Secret, all Def 17, MPF.

29. Defense Nuclear Agency, "Palomares Summary Report," pp. 44-73 for details. A copy of the Wilson-Montel agreement is included as appendix B to this paper. For objections to the notion of a nuclear waste site in Spain, see tel. from Chief of JUSMG to the Chief of Staff of the Air Force, Feb. 3, 1966, Secret, Def 18.1, MPF.

30. State tel. 941 to Madrid, Feb. 12, 1966, Secret. State tel. 942 to Madrid, Feb. 12, 1966, Secret, both Def 18.1, MPF. A copy of the interagency paper is included as appendix C to this paper.

31. Madrid tel. 995, Feb. 15, 1966, Secret. Madrid tel. 1019, Feb. 18, 1966, Secret, both Def 17, MPF. A copy of the telegram outlining this verbal agreement is attached as appendix D to this paper.

32. State tel. 993 to Madrid, Feb. 19, 1966, Secret, Def 17, MPF.

33. Madrid tel. 1031, Feb. 21, 1966, Secret. Madrid tel. 1054, Feb. 25, 1966, Confid., Def. 17, MPF.

34. The text of this statement and the text of a telegram reporting Danish agreement are attached as appendix E to this paper.

35. Copenhagen tel. 2837, Jan. 22, 1968, Secret, Def 17, Copenhagen Post Files. Hereinafter cited CPF.

36. Memorandum of a conversation between Leddy and Ronne, Washington, Jan. 23, 1968, Secret.

37. Copenhagen tel. 2863, Jan. 23, 1968, Unclass., Def 17, CPF.

38. Copenhagen tel. 2949, Jan. 28, 1968, Unclass., Def 17 B-52, CPF.

39. Copenhagen tel. 1340, Feb. 2, 1968, LOU. PAO Monthly report for January 1968, Feb. 21, 1968, Unclass., both Def 17 B-52, CPF. The "information guidance" referred to was no. 5329 sent to Madrid on March 3, 1966. No copy of this guidance was found in the Madrid Post files.

40. Copenhagen tel. 1552, Mar. 3, 1968, Unclass., Def 17 B-52, CPF.

41. Copenhagen tel. 1341, Feb. 2, 1968, LOU. Tel. from 4683 AB Group Thule to the Department of Defense, Feb. 29, 1968, Unclass., Def 17, B-52, CPF.

42. Tel. from the SAC Disaster Control Team, Thule, to the Embassy in Denmark, Jan. 28, 1968, Confid. Tel. from Thule AFB to the Department of Defense, Jan. 28, 1968, Unclass. Tel. from the Department of Defense to the Embassy in Denmark, Jan. 30, 1968, Secret. Copenhagen tel. 1358, Feb. 8, 1968, Def 17 Greenland Crash, CPF.

43. Memorandum from Leddy (EUR) to Rusk (S), Feb. 23, 1968, Confid., Lot 73D170, "Thule Crash-Internal Memos." Memorandum on the Thule Operation, April 10, 1968, Unclass., Lot 73D170, Thule Crash--Information, General." Memorandum from George Springsteen (EUR) to Rusk (S), July 22, 1968, Secret, "Lot 73D170, "Thule Crash-Clean-Up Operation." State tel. 231303 to Copenhagen, Aug. 31, 1968, LOU, Def 17 B-52, CPF.

44. Memorandum of a conversation between Leddy and Ronne, Jan. 26, 1968, Secret, Def 17 B-52, CPF.

45. Copenhagen tel. 1352, Feb. 7, 1968, Confid. Copenhagen tel. 1360, Feb. 8, 1968, Confid., both Def 17 B-52, CPF.

46. Copenhagen tel. 1389, Feb. 14, 1968, Confid., Def 17 B-52, CPF. Copenhagen tel. 1395, Feb. 15, 1968, Secret, Def 15, CPF. Copenhagen tel. 1401, Feb 16, 1968, Secret. Letter from Byron Blankinship (DCM, Copenhagen) to David McKillop (Director, EUR/SCAN), Copenhagen, Feb. 23, 1968, Confid., both Def 17 B-52, CPF.

47. President's Evening Reading, May 9 and 31, 1968. Letter from Leddy to Paul Warnke, Assistant Secretary of Defense, April 17, 1968, Secret, both Lot 73D170, "Thule Crash-Internal Memos." The memoranda outlining this agreement are attached as appendix F to this paper.

48. Copenhagen tel. 3210, Feb. 10, 1968, Unclass. Letter from White to Goulding, Assistant Secretary of Defense, Feb. 12, 1968, Unclass., Def 17, CPF.

49. Copenhagen tel. 3346, Feb. 16, 1968, Confid., Def 17 B-52, CPF.

50. Copenhagen tel. 1431, Feb. 27, 1968, LOU. Copenhagen tel. 5684, July 18, 1968, Secret, both Def 17 B-52, CPF.

51. Copenhagen tel. 4315, April 22, 1968, Unclass., Def 17 B-52, CPF. Letter from White to Goulding, op cit.

52. In spite of disagreements over public relations matters and other irritants, the level of cooperation between Embassy and on-site DOD teams was so satisfactory that Ambassador Duke wrote a three page letter to Secretary of the Air Force Harold Brown, praising the performance of General Wilson, the commander of the clean-up operation. Duke to Brown, May 10, 1966, Def. 18.1, MPF.

 P1A

TELEGRAM

Foreign Service of the United States of America

OUTGOING American Embassy MADRID DEF 17

LIMITED OFFICIAL USE

LIMITED OFFICIAL USE
Classification

Charge:
ACTION: Secstate WASHDC 1038

Control:

INFO: LONDON 72

PARIS 108

Date: Feb 21, 1966

DISTR
AMB
DCM
FILES
POL (2)
ECOUN
ADMIN
USIS
JUSMG

London for NAVEUR

Paris for EUCON

Joint Embassy-JUSMG Message

AIRCRAFT ACCIDENT

Ref Embtel 1025

London 72
Paris 108

Following is operative portion of letter dated Feb 18 on claims procedure delivered same day by Chief JUSMG to Gen Prado, Dep Chief High General Staff (unnecessary words omitted):

QUOTE. With reference our conversations 12 February concerning claims for damages arising from aircraft accident which occurred Palomares 17 January 1966, I have been authorized to assure you officially that:

a. Claims forms now in use meet requirements prescribed by Foreign Claims Act, which is legislation authorizing expeditious payment of claims;

b. Notwithstanding wording of these forms, payment of a claim is considered by USG as settlement only for claimed damages or injuries known at time

LIMITED OFFICIAL USE
Classification

LIMITED OFFICIAL USE

TELEGRAM

Foreign Service of the United States of America

OUTGOING American Embassy MADRID

LIMITED OFFICIAL USE
Classification

Charge: Control:

Date:

of filing:

c. Damages or injuries, even though arising from same incident, which subsequently accrue and were unknown at time of filing of first claim may be made the basis of a new claim, which, if found meritorious and otherwise meets requirement of Foreign Claims Act, will be paid;

d. Previously signed release would not be a bar to such claims and two year statute of limitations under Foreign Claims Act would not begin to run until date the damages or injuries became known, and

e. In event any future meritorious claims should arise as result of this accident which cannot be paid legally under Foreign Claims Act, they will be handled through diplomatic channels in accordance with existing agreements between our two Governments which give recognition to Spanish Nuclear Energy Law 25/1964 of 29 April 1964, Article 67 of which in turn provides for a statute of limitations of 10 and 20 years, in the case of immediate and deferred damage, respectively.

LIMITED OFFICIAL USE
Classification

TELEGRAM

Foreign Service of the United States of America

OUTGOING American Embassy MADRID

LIMITED OFFICIAL USE
Classification

Charge: Control:

Date:

I take this opportunity to emphasize that funds have been made available to USAF Foreign Claims Commission at Palomares to enable it pay claims promptly.

I trust foregoing assurances will satisfy fully any doubts or uncertainties which may have arisen with regard to our claims procedures and that restrictions heretefore placed on filing of claims may now be removed. In order to dispell any possible misunderstandings, it may be useful to have assurances contained in this letter disseminated to all interested parties.

Finally, I want to assure you that it is intention of USG to settle all claims arising from this unfortunate accident in an equitable and prompt manner. You can count on full support of US Mission in Spain in carrying out this intention. UNQUOTE.

DUKE

IBAskew:mct 2/21/66 WWWalker

LIMITED OFFICIAL USE
Classification

A-572

TELEGRAM — Foreign Service of the United States of America

CTION OL 3 — INCOMING — AmEmbassy MADRID — DEF 17

NFO ILES MB CM DMIN COUN SIS USMG .IRA .RMA IAVA .IA IES

UNCLASSIFIED

~~S-E-C-R-E-T~~

Classification SECRET

Control: T1C

Recd: 13 FEBRUARY 66

FROM: SECSTATE WASHDC

This document consists of 3 page Copy 2 of 15 Copies. Series A.

NO: PRIORITY 942, FEBRUARY 12

ACTION MADRID PRIORITY 942 INFO DOD

REF: DEF 3281; DEPTEL 925

~~RELEASED IN PART~~
~~B1, 1.4(A), 1.4(D), B3, ATOMIC~~

DEPTEL 942

DOD FOR HOWARD, ATSD/AE

FOLLOWING AGREED INTERAGENCY PAPER SETS OUT US POSITION ON PALOMARES SOIL CLEAN-UP OPERATION AND SUBSEQUENT POSSIBLE ECONOMIC RESTITUTION MEASURES. IT IS DESIGNED TO BE USED AS BACKGROUND FOR SECURING APPROVAL BY SPANISH AUTHORITIES OF COURSES OF ACTION PROPOSED BY US. WOULD APPRECIATE EMBASSY COMMENTS SOONEST, AS WELL AS YOUR VIEWS ON BEST MEHTOD DEALING WITH SPANISH AUTHORITIES. SUGGEST YOU DISCUSS WITH HALL AND LANGHAM MONDAY. MECHANICS OF DEALING WITH POSSIBLE FUTURE RESTITUTION OFFER OUTLINED NUMBERED PARA 4 BELOW ARE STILL UNDER URGENT STUDY HERE AND WE WILL SEND FOLLOW-UP AUTHORIZING MESSAGE WITH FISCAL AND OTHER NECESSARY INFO. IN MEANWHILE NO RPT NO COMMITMENT FUTURE PAYMENTS THIS SORT SHOULD BE MADE.

BEGIN TEXT, GENERAL:

1. US INTENDS CONDUCT CLEAN-UP OPERATIONS TO LEVEL WHICH IS MORE THAN ADEQUATE BY US SAFETY STANDARDS. WE ARE CONCERNED, HOWEVER, BY APPARENT DESIRE OF SPANISH AUTHORITIES TO EXTEND CLEAN-UP FAR BEYOND SAFETY REQUIREMENTS IN INTEREST OF COMBATTING PSYCHOLOGICAL CONSEQUENCES.

2. WE DO NOT SEE THIS AS BEST WAY COPE WITH POSSIBLE FUTURE EMOTIONAL CONCERN AT MARKET PLACE. WOULD SEEM TO US PREFERABLE GO BACK TO NORMALITY SOON AS POSSIBLE, AND THUS HASTEN DEPARTURE THIS SUBJECT FROM PUBLIC MIND. COMPLEX, LONG-TERM CLEAN-UP GESTURES COULD SERVE AS REMINDER, AND THEREFORE INFLATE IMPORTANCE WHOLE MATTER. OUR GENERAL RATIONALE SHOULD BE THAT IT IS NEITHER IN OUR OWN OR SPANISH INTEREST TO ERECT A MONUMENT IN SPAIN TO THIS CRASH. PHYSICALLY, WE WOULD TAKE CARE OF THIS BY REMOVING FROM COUNTRY ALL MATERIAL CONTAMINATED ABOVE CERTAIN LEVEL. IT IS POSSIBLE HAVE PSYCHOLOGICAL AS WELL AS PHYSICAL MONUMENTS, HOWEVER, AND TO AVOID THIS IS ALSO PROBLEM OF MUTUAL CONCERN.

3. TO ASSURE RESUMPTION NORMALCY IN ECONOMY OF AREA, WE INTEND IF AT ALL POSSIBLE TO AVOID "INFLATION OF ATTENTION" WHICH MIGHT RE SULT FROM TAKING EXCESSIVE MEASURES.

FORM FS-501

sjr ~~SECRET~~ Classification SECRET

A-573

UNCLASSIFIED

~~S-E-C-R-E-T~~

Classification

Control:

PAGE TWO DEPTEL 942

Recd:

4. WE ARE AWARE THAT US MAY BE REQUIRED ASSURE PART OF AREA'S ECONOMY BY OUTRIGHT PURCHASE, FOR CONSUMPTION, OF PART OR ALL OF NEXT TOMATO CROP. SUCH MEASURES NEED NOT BE SPECIFICALLY COMMITTED AT THIS TIME, BUT WE SHOULD MAKE CLEAR THAT WHILE WE DO NOT SUPPORT SOIL REMOVAL AS AN ECONOMIC PALLIATIVE, WE ARE OPEN TO CONSIDERATIONS OF SOME FORM OF RESTITUTION. US BELIEVES IT WOULD BE MISTAKE, FOR INSTANCE, TO ANNOUNCE PUBLICLY NOW THAT WE ARE PREPARED BUY TOMATO CROP FOR NEXT YEAR AND/OR SUCCEEDING YEARS. WOULD BE PREFERABLE LET AREA ECONOMY PROCEED NORMALLY, BUT WITH UNDERSTANDING AND COMMITMENT MADE AT THIS TIME TO GOS THAT IN EVENT REAL OR IMAGINED FEARS OF RADIATION IMPERIL FUTURE PRODUCE SALES, US FULLY PREPARED PURCHASE CROPS OR MAKE SUCH OTHER ECONOMIC RESTITUTION AS MAY BE JOINTLY AGREED TO BE WARRANTED.

SPECIFIC:

5. UNITED STATES AEC-DOD SAFETY CRITERIA STIPULATE THAT (A) AREAS WITH CONTAIMINATION INITIALLY GREATER THAN 1000 MICROGRAMS PER SQUARE METER SHALL BE CONTAMINATED AND (B) AREAS WITH LESSER AMOUNTS OF CONTAMINATION THAN 1000 MICROGRAMS PER SQUARE METER SHOULD BE DECONTAMINATED TO AS LOW A VALUE AS POSSIBLE CONSISTENT WITH RESONABLE EFFORTS AND COSTS. THESE CRITERIA ARE BASED ON EXTENSIVE DATA FROM FIELD TESTS CONDUCTED UNDER CONDITIONS NOT TOO DISSIMILAR TO THOSE IN SPAIN. RELEVANT DATA FROM THESE FIELD TESTS CAN BE MADE AVAILABLE TO SPANISH. ADHERENCE TO THESE SAFETY CRITERIA WILL LIMIT POTENTIAL RADIATION DOSES TO LUNGS TO VALUES FAR BELOW HAZARDOUS AMOUNTS.

6. FOR THIS SPECIFIC INCIDENT POLITICAL CONSIDERATIONS ARE OVERRIDING. THUS, THE PROCEDURES FOR DECONTAMINATION RECOMMENDED BELOW WILL REDUCE TOEVEN LOWER VALUES ANY POTENTIAL RADIATION EXPOSURES. PART (B) OF THE US SAFETY CRITERIA IS AN EXPRESSION OF A DESIRABLE BUT NOT MANDATORY ACT. WE CONDIER WETTING AND PLOWING OF AREAS CONTAIMINATED WITH LESS THAN 1000 MICROGRAMS PER SQUARE METER TO BE AN APPROPRIATE AND ADEQUATE PROCEDURE CONSISTENT WITH INTENT OF THIS CRITERION. WE UNDERSTAND THAT 130,000 COUNTS PER MINUTE REGISTERED BY INSTRUMENTS CURRENTLY IN USE ON SITE CORRESPONDS TO 1000 MICROGRAMS PER SQUARE METER AND THAT TENTATIVE NEGOTIATIONS WITH SPANISH HAVE BEEN BASED UPON 100,000 COUNTS PER MINUTE AS ONE CATEGORY. FOUR OUR PRESENT PURPOSES, YOU MAY CONSIDER 100,000 COUNTS PER MINUTE AS EQUIVALENT TO 1000 MICROGRAMS PER SQUARE METER. ~~B1, B3~~ B1, B3

PAGE THREE DEPTEL 942

7. CURRENTLY US-PROPOSED CRITERIA CONTEMPLATE WETTING AND PLOWING OF AREAS INITIALLY BOUNDED BY CONTAIMINATION OF 100,000 COUNTS PER MINUTE AND 7000 COUNTS PER MINUTE. OOWEVER, WE INTERPOSE NO OBJECTION IF IT SHOULD PROVE OPERATIONALLY FEASIBLE AND DESIRABLE TO WET AND PLOW DOWN TO LOWER VALUES THAN 7000 COUNTS PER MINUTE. IN ANY EVENT, WE ARE IN AGREEMENT TO WET DOWN AREAS INITIALLY BOUNDED BY CONTAIMINATION OF 7000 AND 500 COUNTS PER MINUTE. WE UNDERSTAND THAT 200 CUBIC YARDS OF TOP-SOIL HAVE ALREADY BEEN REMOVED FROM AREA 3 RPT 3. THIS QUANTITY OF SOIL AND A COMPARABLE QUANTITY FROM AREA 2 RPT 2 CAN RASONABLY BE RETURNED TO CONUS, AND IN LONG RUN THAT IS OUR REAL CRITERION FOR SOIL REMOVAL. IF 200 CUBIC YARDS FROM AREA 3 DID NOT COME UP TO THE 100,000 CPM SPECIFICATION, WE CAN POSSIBLY PROTECT OUR POSITION BY ADMITTING THIS WAS COMPROMISE ACCEPTABLE TO US BECAUSE AREA 3 IS INHABITED AND CULTIVATED. SINCE AREA 2 IS NOT GENERALLY SO EMPLOYED, WE DO NOT INTEND USE COMPROMISE CRITERION THERE.

B1, B3
B1, B3
B1, B3
B1, B3
B1, B3
B1, B3

8. CRITERIA DETAILED ABOVE ARE BASSD ON POSSIBLE SUSPENSION OF PLUTONIUM INTO AIR WITH SUBSEQUENT INHALUTION. THE OTHER POTENTIAL HEALTH PROBLEM IS INTAKE OF PLUTONIUM BY INGESTION. HOWEVER, THIS IS ALMOST ENTIRELY SIMPLE PROBLEM OF SOURFACE CONTAMINATION OF VEGETATION EXISTING AT TIME OF INCIDENT. SINCE WE UNDERSTAND THIS VEGETATION HAS BEEN HARVESTED THIS PROBLEM NO LONGER EXISTS. ANY PLANT UPTAKE IN FUTURE OF PLUTONIUM FROM SOIL WOULD BE EXCEEDINGLY SMALL AND WOULD CONSTITUTE NO HEALTH HAZARD. END TEXT
RUSK

UNCLASSIFIED

2/18/66 18.1 P1D

~~RELEASED IN PART~~
~~B1, 1.4(A), 1.4(D), B3, ATOMIC~~

JOINT MESSAGEFORM

SECURITY CLASSIFICATION ~~SECRET~~

TYPE MSG	BOOK	MULTI	SINGLE
		X	

PRECEDENCE
ACTION ~~IMMEDIATE~~
INFO PRIORITY

DTG 180915Z

SPECIAL INSTRUCTIONS

FROM: CHIEF JUSMG-MAAG MADRID SPAIN

TO: 16TH ADVON

INFO: 16AF TORREJON AB SPAIN
US EMBASSY MADRID SPAIN (COURIER)

~~S E C R E T~~ ~~RESTRICTED DATA~~ NOFORN FROM CH 00092 FEB 66. FOR WILSON FROM DONOVAN. Confirming telecon 2200 hours 17 February, at meeting with High General Staff, representatives of JEN and US AEC, agreement was reached to conduct tests at Palomares along following lines: ACCOMPLISH TEST ASAP Select small agricultural land area with readings approximately [60,000 cpm,] water and plow to depth of eight (8) inches; break up soil in same manner that has been accomplished on land ready to be returned to owners; take reading; then plow to a depth of four (4) inches; take reading. If readings at this time are at a quote reasonable unquote level the Spanish have agreed that this process will be used on areas of [60,000 cpm] and under. I am sure you realize the importance of this test, therefore it is requested that you have this test observed closely and insure that original plowing is down

~~B1, B3~~

~~B1, B3~~

COPY FOR US EMBASSY (COURIER)

DEPARTMENT OF ENERGY DECLASSIFICATION REVIEW
1st REVIEW-DATE: 11/9/07 AUTHORITY: DC NAME:
2nd REVIEW-DATE: 1/9/07 AUTHORITY: DD NAME:
DETERMINATION (CIRCLE NUMBER(S)) 1. CLASSIFICATION RETAINED 2. CLASSIFICATION CHANGED TO: 3. CONTAINS NO DOE CLASSIFIED INFO 4. COORDINATE WITH: 5. CLASSIFICATION CANCELED 6. CLASSIFIED INFO BRACKETED 7. OTHER (SPECIFY):

DATE 18	TIME
MO FEB	YR 1966
PAGE NO. 1	NO. OF PAGES 2

DRAFTER: TYPED NAME AND TITLE: S. J. DONOVAN, MGen — PHONE: X 316

~~RESTRICTED DATA~~
ATOMIC ENERGY ACT - 1954

RELEASER: SIGNATURE

TYPED (or stamped) NAME AND TITLE: S. J. DONOVAN, Maj General, USAF Chief

SECURITY CLASSIFICATION ~~SECRET~~

REGRADING INSTRUCTIONS
Copy # 2 of copies 4

DD FORM 1 NOV 63 173 REPLACES EDITION OF 1 MAY 58 WHICH WILL BE USED.

UNITED STATES DEPARTMENT OF STATE
REVIEW AUTHORITY: FRANK H PEREZ
CLASSIFICATION: SECRET REASON: 25X2, 25X4, 25X6
DECLASSIFY AFTER: 17 FEB 2033
DATE/CASE ID: 04 SEP 2008 200504115

UNCLASSIFIED

UNITED STATES DEPARTMENT OF STATE
REVIEW AUTHORITY: APPEALS REVIEW PANEL
APPEAL ACTION: RELEASED IN FULL
DATE/CASE ID: 04 NOV 2010 200504115

FROM:

CHIEF JUSMG-MAAG MADRID SPAIN

to a depth of 8 inches, that a thorough work job is accomplished and that the second plowing does not exceed 4 inches in depth. Request this headquarters be advised immediately upon completion of this test. GP-1

SYMBOL	PAGE NR	NR OF PAGES	SECURITY CLASSIFICATION	INITIALS
CH	2	2	~~SECRET~~	

UNCLASSIFIED

Department of State

~~RELEASED IN PART~~ ~~TOP SECRET~~
~~B1, 1.4(A), 1.4(B), 1.4(D)~~

P1F

Control: 9764
Rec'd: November 18, 1957
8:02 a.m.

SAE FROM: Copenhagen

TO: Secretary of State

RMR NO: 419, November 18, 1 p.m.

SS
G
EUR PRIORITY

LIMIT DISTRIBUTION

FOR S/AE

Dept. of State, RPS/IPS, Margaret P. Grafeld, Dir.
( ) Classify as ( ) Extend as ( ) Downgrade to S
Date 8/15/07 Declassify on ______ Reason ______

EMBTEL 406.

Prime Minister has given me informal written statement as his personal answer to my inquiry November 13. It notes that United States Government considers no problem under 1951 agreement of possibly storing in Greenland "supplies of munition of a special kind" and that in conversation I did "not submit any concrete plan as to such possible storing" or "ask questions as to attitude of Danish Government", and concludes that Prime Minister does not think my remarks give rise to any comments from his side.

B1

B1

In my opinion we have now fulfilled our obligation to Prime Minister.

He said he had only one copy of statement which he would keep in his personal file and requested me, to consider my copy purely personal. He was adamant that there should be no publicity of any kind now or later and I particularly urge that every effort be made to avoid leak, which could be highly damaging here both to Danish Government and to our whole defense relationship with Denmark.

PETERSON

BB:RB/9

UNITED STATES DEPARTMENT OF STATE
REVIEW AUTHORITY: APPEALS REVIEW PANEL
APPEAL ACTION: RELEASED IN FULL
DATE/CASE ID: 04 NOV 2010 200504115

UNITED STATES DEPARTMENT OF STATE
REVIEW AUTHORITY: FRANK H PEREZ
CLASSIFICATION: SECRET REASON: 25X5, 25X6
DECLASSIFY AFTER: 18 DEC 2033
DATE/CASE ID: 04 SEP 2008 200504115

~~TOP SECRET~~

20 1957

A-578

~~UNCLASSIFIED~~

UNCLASSIFIED

TELEGRAM

OUTGOING

Foreign Service of the United States of America

Def 17

Charge:	SECRET Classification	Control: 2837
		Date: Jan. 22, 1968 2339

ACTION: SecState WASHINGTON IMMEDIATE

P1E

INFO: Headquarters US EUCOM Vaihingen, Germany

1/22/68

COPENHAGEN 2837
OSD for OASD/PA
Ref: Copenhagen's 2835

RELEASED IN FULL

Subject: Thule B-52 Crash

1. PM Krag stated today "It is well known that in accordance with the Govt's policy there are no atom weapons within Danish territory. This includes Greenland. Consequently, there can be no overflights over Greenland by aircraft carrying nuclear weapons. On the other hand, you cannot exclude that American aircraft in times of emergency will try to seek landings in Greenland."

2. Danish press correspondents are trying hard to find means to reach Thule. They are being told that in accordance with long standing practice their applications will be forwarded through usual Air Attache channels to Air Force foreign liaison office. The clamor to visit site may grow. Refusal to facilitate travel or an appearance of blocking access to Danish territory by American military could lead to strong criticism

Drafted by: DCM:BEBlankinship/mbe (typed 1/23/68) Approving Officer:

Concurrence:

UNITED STATES DEPARTMENT OF STATE
REVIEW AUTHORITY: FRANK H.PEREZ
DATE/CASE ID: 04 SEP 2008 200504115

SECRET
Classification

FORM FS-413
8-65

UNCLASSIFIED

A-579

SECRET
Classification

Charge:

Control: 2.

Date:

of American base policy in Denmark which purports to cherish freedom of travel. Permitting American correspondents to visit site while denying ~~xx~~ similar privilege to Danish correspondents would be considered intolerable by Danish press. We ~~xxxxxx~~ recommend that immediate consideration be given to providing briefings by experts to Danish Govt. officials and possibly media in Copenhagen. Ideally, officials should be briefed so that they can carry the burden of explanation to public media. Even if this is done, it may become necessary and advisable to sponsor a press tour to accident site.

3. About 120 demonstrated ~~xxxxxxxxxxxx~~ peacefully before Embassy for an hour this evening.

WHITE

B

Drafted by:

Approving Officer:

Concurrence:

SECRET
Classification

PIH

~~SECRET~~

Proposed Response to Confidential Danish Note of February 26

~~B1, B3~~

The United States Government assures the Government of Denmark that, notwithstanding the provisions of the 1951 Agreement on the Defense of Greenland, it will not store nuclear weapons in Greenland or overfly Greenland with aircraft carrying nuclear weapons except as a result of a joint decision by our two Governments.

~~SECRET~~

A-581

~~SECRET~~

For the President's Evening Reading

Subject: Denmark - Agreement on Nuclear Overflights and Storage in Greenland

The United States and Denmark, by means of an exchange of notes on May 31, agreed to supplement the April 27, 1951 Agreement on the Defense of Greenland. The supplement makes U.S. storage of nuclear weapons in Greenland and U.S. overflights of Greenland with nuclear armed aircraft subject to the consent of the Danish Government. The exchange of notes became effective on May 31 and constitutes an integral part of the 1951 Agreement.

On May 10, when discussing the texts of the proposed notes, Assistant Secretary Leddy made an oral statement pointing out the possible need for U.S. nuclear overflights under circumstances of a grave and sudden threat that did not allow time to obtain the consent of the Danish Government. On May 16, the Danish Ambassador reported that his Foreign Ministry had noted Mr. Leddy's oral statement.

On May 16 the Danish Ambassador also reported that his Government had dropped its request for U.S.G. participation in or endorsement of a Danish Government public statement concerning nuclear weapons policy for Greenland. The Danish Government plans to make a unilateral statement on this question. In line with the standing US.G. policy of neither confirming nor denying statements on the movement or deployment of the nuclear deterrent, we do not plan to comment on the Danish statement.

Clearance:
EUR/SCAN - Mr. Ingram

EUR/SCAN:EKlebenov:mbw
5/31/68

SECRET

Exhibit 15

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON DC

6 December 2013

HQ USAF/SG MEMORANDUM FOR THE HOUSE ARMED SERVICES COMMITTEE

FROM: HQ USAF/SG
1780 Air Force Pentagon
Washington, DC 20330-1780

SUBJECT: Report On Implementation of the Recommendations of the Palomares Nuclear Weapons Accident Revised Dose Evaluation Report (FY14 NDAA SEC. 1080A)

Thank you for the opportunity to discuss the Air Force views on the Fiscal year 2014 National Defense Authorization Act. The attachment addresses the Air Force response to the recommendations of the 2001 Labat-Anderson Inc. revised dose evaluation report for the Palomares nuclear weapons accident. Following a comprehensive review of all data generated from 1966, my staff revised our response methodology for ionizing radiation dose inquiries involving Palomares incident participants.

Biomonitoring today, though technically feasible, is not expected to confirm a correlation between health outcome and exposure due to the low exposure levels. The Air Force is able to establish an upper bound on possible exposures for response personnel, based on the "High 26" cohort (considered the highest exposed 26 individuals), using actual bio-monitoring results from a time close to the actual exposures and will apply this conservative approach in addressing requests from Veterans Affairs for exposure assessments. This revised conservative approach will afford the veteran with the benefit of the doubt as to level of exposure. Hence, we do not recommend additional, broad-scale, follow-up biomonitoring.

I appreciate your interest in this matter and trust this information is helpful.

THOMAS W. TRAVIS
Lieutenant General, USAF, MC, CFS
Surgeon General

Attachment:
Implementation Report; Palomares Nuclear Accident Revised Dose Report (2001)

REPORT ON IMPLEMENTATION OF THE RECOMMENDATIONS OF THE PALOMARES NUCLEAR WEAPONS ACCIDENT REVISED DOSE EVALUATION REPORT (FY14 NDAA. "SEC. 1080A)

Introduction:

A nuclear weapons accident occurred on January 17, 1966, over Palomares, Spain, when a United States Air Force (USAF) B-52 bomber and KC-135 tanker aircraft collided. The accident led to the release of four thermonuclear weapons. Two of the weapons were damaged when they impacted the ground, causing a release of radioactive plutonium. This release resulted in a three-month response effort to identify, characterize, remove, and remediate the accident site. During the response effort, some personnel were exposed to airborne dust and debris contaminated with plutonium.

The response effort began on the evening of January 17. A base of operations (Camp Wilson) was established, and measurements for released plutonium began on January 18. The response force peaked at about 680 U.S. personnel on January 31, and then gradually fell until the effort ceased on April 11. Approximately 1,600 personnel participated during the operation. Urine samples were collected from 1,586 response personnel and nasal swab samples from 120 personnel while on site to assess possible intakes of plutonium and the potential effects on health. The sample results were evaluated in terms of a maximum permissible level used at the time.

The Air Force Medical Service (AFMS) established the Plutonium Deposition Registry Board in 1966 to oversee exposure assessment and biological monitoring. The assessment program concluded that of the nearly 1,600 participants, 26 personnel represent the highest exposure cohort. Those 26 (referred to as the “High 26”) were followed up for a period of 18 to 24 months following the accident. The Board monitored and evaluated exposure assessment activities, but suspended efforts in 1968. The AFMS determined little additional information could be gained from continuing the effort as collected samples from the highest exposed personnel showed no detectable radioactivity from urine bioassay analysis.

Discussion:

The AFMS contracted out a “re-look” of exposure and biological monitoring data using the most up-to-date methods for estimation of plutonium intake and committed dose (total dose integrated over a fifty-year period following intake). That effort, completed in 2001, essentially confirmed the overall conclusions from 1968 that adverse health effects would not be expected for responders to the accident, but offered three recommendations on actions that might be taken to improve the estimates of plutonium intake and committed doses, and provide further explanation of the discrepancy between the initial high bioassay (urinalysis) results and exposure estimates from environmental sampling.

Recommendation 1. Consider reconciling the estimated intakes and doses derived from the urinary bioassay data with the estimates from environmental measurements. A targeted effort that includes participant activities, participant interviews, urine and other appropriate plutonium analyses using current techniques, medical records review, and modeling should be considered.

Response: In 2001, the Air Force Medical Service determined additional bio-monitoring to reconcile the difference between the estimated intakes and doses derived from the urinary bioassay data with the environmental measurements was not necessary. Further, additional bio-monitoring was not expected to produce higher dose estimates than those calculated in the 2001 report. As part of our most recent reassessment, we considered improved detection sensitivity/selectivity for further bio-monitoring that became available in 2011. While there is some scientific "value" in studying why the air sampling results predict exposures less than those predicted from the biomonitoring, we believe existing biomonitoring information is sufficient to reconstruct doses and establish an acceptable upper bound on possible exposures. This information can and should be used to provide the conservative (worst case) estimate of exposure for responders.

Recommendation 2. Consider communicating the results of this effort to responders, veterans organizations, and other interested parties using appropriate information that clearly confirms the conclusions of the original medical evaluation program, recognizes the difficulties in preparing updated intake and dose estimates, and outlines the options for strengthening the estimates.

Response: In May 2002, the AFMS created a public web site and posted the 2001 report along with a summary of the report to communicate the results to the general public. The 2001 report did not change the conclusions reached from the initial assessment concluded in 1967.

Recommendation 3. Consider further contacts with the Department of Energy (DOE). Comparison with evaluations of their personnel who responded to this accident could provide useful data. The effort should be summarized in a companion document that conveys the details of the project and its potential effects on health in an easily understood manner. That document should be made available to any of the responders who desire a copy.

Response: Few Department of Energy (DOE) personnel directly participated in the clean-up and monitoring efforts. DOE (Atomic Energy Commission at the time) did not collect monitoring data; therefore a direct comparison is not possible. The DOE also, for a time, maintained a webpage on the Palomares incident for the general public.

Conclusion:

The follow-up biomonitoring results obtained in 1967 provide a reasonable, yet conservative (worst case) exposure estimate for response personnel. Modeling methods currently available to perform dose reconstructions would not change the fundamental conclusions reached in 1968 that adverse acute health effects were neither expected nor observed, and long-term risks for increased incidence of cancer to the bone, liver and lung were low. Biomonitoring today, though technically feasible, is not expected to confirm a correlation between health outcome and exposure due to the low exposure levels. The Air Force is able to establish an upper bound on possible exposures for response personnel, based on the “High 26” cohort (considered the highest exposed 26 individuals), using actual bio-monitoring results from a time close to the actual exposures and will apply this conservative approach in addressing requests from Veterans Affairs for exposure assessments. This revised conservative approach will afford the veteran with the benefit of the doubt as to level of exposure. Hence, we do not recommend additional, broad-scale, follow-up biomonitoring.

References:

Labat-Anderson, Inc. “Palomares Nuclear Weapons Accident: Revised Dose Evaluation Report, Vol I-III.” Report for USAF, April 2001.

Odland, Lawrence T., Lt Col, USAF, MC, Robert L. Farr, Kenneth E. Blackburn, and Amon J. Clay, “Industrial Medical Experience Associated with the Palomares Nuclear Incident,” *Journal of Occupational Medicine*, Vol 10 No 7 (July 1968): 356-362.

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON DC

27 Jan 14

MEMORANDUM FOR DEPARTMENT OF VETERANS AFFAIRS JACKSON MS

FROM: AFMSA/SG3PB

SUBJECT: Revised Response for Radiation Dose Information on Veteran [redacted]

1. The Air Force Office of the Surgeon General recently re-evaluated internal processes for completing ionizing radiation dose assessments for veterans involved in the 1966 U.S. Air Force nuclear weapons incident response at Palomares, Spain. Congress initiated this review to ensure a comprehensive and consistent approach is applied to all dose assessments previously completed for this incident and to those assessments which will be conducted in the future.

2. The health risk for U.S. Air Force veterans exposed to plutonium at Palomares remains low, overall, as supported by the fact that we have not seen, nor do we expect to see, many incidents of illness directly attributable to plutonium exposure from this event. Even so, in the best interest of veterans who responded to this accident, our office will now provide a broad range of possible dose values using worst case estimates from both environmental sampling data and biomonitoring results. This veteran's estimated maximum dose value actually increased as a result of this effort.

3. Previously, we addressed Palomares-related claims using data from the 1960s along with descriptions of duties performed. Upon review of available 1960s bioassay data for those determined to be the highest exposed (and most studied) 26 individuals, it is possible that a fraction of the remaining U.S. responders (~1600 individuals) received a committed effective dose (CED) greater than the 0.31 rem maximum estimated using contemporary dose models and the 1960s environmental sampling data. These responders would not receive doses greater than the highest exposed 26 individuals.

4. Despite the better sampling techniques and dose models of today, the Air Force cannot accurately and efficiently determine specific doses outside the highest exposed (and most studied) 26 individuals. Therefore, those responders outside that group of 26 will now be assigned a CED range of 0.31 rem to 10.5 rem based on the application of contemporary models to both environmental and bioassay data from the 1960s. The corresponding upper bounds for critical organ doses will now be 103 rem for the bone surface, 40.6 rem for the lungs, and 4.9 rem for the liver.

5. This office acknowledges that the Department of Veterans Affairs (VA) retains the authority to determine whether or not an individual veteran's specific health condition may be attributed to plutonium exposure.

6. The AF/SG POC is Major AJ Cagle, (703) 681-6988 or EMAIL anthony.j.cagle.mil@mail.mil.

ANTHONY J. CAGLE, Maj, USAF, BSC
Chief, Contingency Radiation Operations
Air Force Medical Support Agency
Office of the Surgeon General

2 Attachments:
1. AFSEC/SEWN tables—Estimated Equivalent Organ Doses from Single Intake Plutonium (Dr. Rademacher, 9 Jan 14)
2. AFMSA/SG3PB memo to VA—Exposure Estimates for AF Nuclear Accident Responders—Palomares (Colonel Ashworth, 6 Dec 13)

Equivalent Organ Doses from Single Intake of $^{239+240}$Pu,
Based on ICRP 26/30/48 and ICRP 71.

					Intake (nCi) =	34
Class Y	ICRP 26/30/48 Inhalation Exposure Pathway		Type S	ICRP 71 Inhalation Exposure Pathway	
	Organ	Dose (rem)		Organ	Dose (rem)
	Gonads	1.51		Adrenals	0.040
	Breast	0.00005		Bladder Wall	0.040
	Lung	40.6		Bone Surface	21.4
	Red Marrow	8.3		Brain	0.040
	Bone Surface	103		Breast	0.040
	Thyroid	0.00005	GI-Tract	Oesophagus	0.040
	Liver	3.80	GI-Tract	St Wall	0.040
	Effective	10.5	GI-Tract	SI Wall	0.040
			GI-Tract	ULI Wall	0.040
			GI-Tract	LLI Wall	0.042
			GI-Tract	Colon	0.042
				Kidneys	0.10
				Liver	4.9
				Muscle	0.040
				Ovaries	0.30
				Pancreas	0.040
				Red Marrow	1.14
			Respiratory Tract	ET Airways	4.8
			Respiratory Tract	Lungs	10.9
				Skin	0.040
				Spleen	0.040
				Testes	0.31
				Thymus	0.040
				Thyroid	0.040
				Uterus	0.040
				Remainder	0.043
				Effective Dose	2.0

Exhibit 16

6 December 2013

MEMORANDUM FOR DEPARTMENT OF VETERANS AFFAIRS, JACKSON, MS
ATTN: Ms. Gail Berry

FROM: Air Force Medical Support Agency/SG3PB

SUBJECT: Radiation Exposure Estimates for USAF Nuclear Weapon Accident Responders – Palomares, Spain

The Air Force Office of the Surgeon General recently evaluated internal processes for completing ionizing radiation dose assessments for veterans involved in the 1966 USAF incident response at Palomares, Spain. A review was initiated to ensure a conservative and consistent approach was applied to all dose reconstructions for this incident. This office continues to strive toward timely, scientifically-based responses for all health-related veteran claims.

Our review found that approximately 1,600 personnel, including Army, Navy, Air Force, and other US federal employees, were involved at various stages of the response with 1,586 individuals submitting at least one sample for analysis. We have records for 19 USAF veterans who submitted claims since 2001 in association with the Palomares response, with three individual appeals for re-assessment for a total of 22 claims. For several of these claims, dose estimates and subsequent responses involved assistance from the Air Force Safety Center.

A review of these 22 cases indicates inconsistencies in dose assignment over the past 12 years. In some cases, the assigned dose was based on the maximum expected dose as derived from average ambient air monitoring results (311 mrem). A dose value of this magnitude likely applies to the average response participant, but appears to underestimate doses to some individuals. In more recent claims, a detailed dose reconstruction was performed using plutonium (Pu) intake values based on initial and follow-up urine samples. The committed dose to specific organs and/or tissues was then assessed using various modeling protocols based on publications of the International Commission on Radiological Protection (ICRP). Previous assessments from this office varied due to data availability and interpretation, updates to ICRP models, and differences in professional opinion on the appropriate use of multiple data sets (ambient air monitoring vs. urine excretion biomonitoring).

Following a comprehensive review of all data generated from 1966, this office has decided to formally standardize our response methodology for radiation dose inquiries involving Palomares participants. In doing so, we will use a common approach to provide a conservative, i.e. worst case, dose estimate for the veteran to afford him or her the benefit of the doubt. This office will use the following methodology to respond to VA/veteran dose inquiries for Palomares responders:

a. Establish the veteran's presence at the incident site.

b. Perform a review of duties based on historical records and statements provided by the veteran.

c. Review available bioassay data for the veteran and assign an intake value.

(1) If the veteran is a member of the cohort with the highest exposure potential (designated as the "High 26"), use their established intake estimates. The established intakes range from 34,000 to 570,000 picocuries (pCi).

(2) For the remaining responders, define intake as "does not exceed the intake calculated for the least exposed member of the High 26 group." The intake range for this group will be conservatively set at 1,100 to 34,000 pCi.

d. Estimate committed doses for the organ(s) of concern. The primary organs of concern from plutonium exposure are the lung, liver, and bone surface, based on International Commission on Radiological Protection (ICRP) Publication 30 (used by the Nuclear Regulatory Commission and Environmental Protection Agency) and ICRP Publication 68 (used by the Department of Energy and the Defense Threat Reduction Agency). We will provide both ICRP-model results in responses to the VA.

e. If the member does not have a valid urine sample, reconstruct the dose based on similar exposures using their specific duties, if possible. If that is not possible, consider having the member provide a urine sample for analysis using the latest analytical procedures that claim to eliminate or greatly reduce confounding factors such as radioactivity from natural or background sources.

This office, with assistance from the Air Force Safety Center, will reevaluate the 19 claims previously addressed and apply the above methodology to rectify inconsistencies in dose determination. We may request your assistance in identifying claims adjudicated prior to the year 2000 and for which we may not have records on hand.

The AF/SG point of contact is Major Dan Shaw, 703-681-7855 or e-mail at daniel.shaw@pentagon.af.mil.

RICHARD A. ASHWORTH, Col, USAF, BSC
Chief, Bioenvironmental Engineering Branch
Office of the Air Force Surgeon General

cc:
AFSEC/SEWN (Dr. Steven Rademacher)

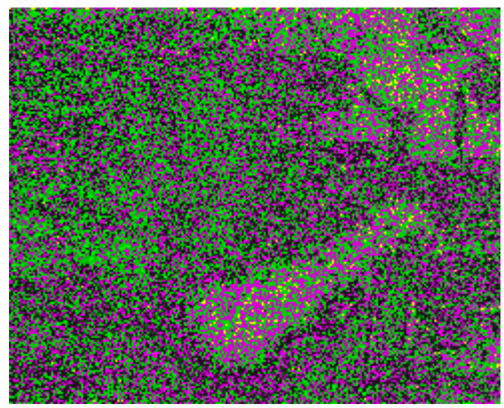
Exhibit 17

Public Health

Aircraft Collision Cleanup at Palomares, Spain

A United States Air Force B-52 bomber and a KC-135 tanker aircraft collided over Palomares, Spain, while attempting inflight refueling on January 17, 1966. The collision caused four thermonuclear weapons to be released. Two of the weapons were damaged when they hit the ground, releasing plutonium, a radioactive material. There was no nuclear detonation.

Approximately 1,600 military and civilian personnel worked to decontaminate the accident site for three months following the accident. During cleanup, personnel wore protective clothing and radiation dose measuring devices, and had regular radiation checks. There have been concerns that those involved in the clean-up mission may have been exposed to airborne dust and debris contaminated with plutonium.



General Wilson and ADM Guest with Recovered Bomb
Department of Defense

Possible health risks

The Air Force states that "adverse acute health effects were neither expected nor observed, and long-term risks for increased incidence of cancer to the bone, liver and lungs [the target organs for plutonium] were low." The Air Force Medical Service reconstructed the possible radiation doses for Veterans who participated in cleanup of the Palomares accident in 2013, using the highest measured doses obtained from biological monitoring at the time of the accident.

The local Spanish population from Palomares has not reported health problems related to the accident.

Health concerns?

If you are concerned about possible health issues related to participating in the cleanup effort at the Palomares accident site, talk to your health care provider.

Compensation for health problems

Exhibit 18

DECLARATION OF VICTOR SKAAR

1. My name is Victor B. Skaar, Chief Master Sergeant, U.S. Air Force (ret.). I was born on November 12, 1936. R. 2112.

Air Force Service

2. I joined the Air Force on my 18th birthday, November 12, 1954, as a healthy young man from the farm. R. 2112, 2455. I served in the Air Force for nearly twenty-seven years. I retired from service honorably on July 31, 1981. R. 2112.

3. During my years in the Air Force I worked in a variety of specialties and roles, including Veterinary Medicine, Preventive Medicine, Military Public Health/Occupational Medicine, Medical Disaster Control, Environmental Health Technician, Air Force Recruiter, Armed Forces Courier, and Aircraft Loadmaster. R. 2112.

Palomares Disaster Involvement

4. On January 17, 1966, a B-52G Bomber on a routine "Chrome Dome" mission, with a crew of seven, carrying four thermonuclear weapons, collided with a KC-135 tanker, with a crew of four, during a refueling attempt at thirty thousand feet over Palomares, Spain. R. 2457. Three of the bombs fell on land in and near Palomares, a small remote fishing village, while the fourth fell into the Mediterranean Sea, about three quarters of a mile offshore, causing a historically unique and challenging underwater search and recovery operation by the U.S. Navy. R. 2489.

5. Two of the bombs that landed on land near Palomares detonated on impact, releasing semi-critical plutonium mass into the air. R. 2489, 2457. Because of the high winds, the plutonium dioxide particles contaminated a wide area. R. 2457. The bombs were spread out across a distance exceeding one mile. R. 2457.

6. While stationed at Moron Air Base (AB), I was the second most senior enlisted Medical Disaster Control Technician in the 16th Air Force Command in Spain. I was immediately dispatched on short notice to Palomares a few hours after the terrible aircraft accident on January 17, 1966. R. at 2489, 2457.

7. I remained at the site for approximately sixty consecutive days where I worked in heavily contaminated areas. R. 2489.

8. My duties at the site varied extensively and involved daily, intimate contact with the various hazardous weapons' radioactive components. My duties included:

    a. Securing and managing the operational availability of the five alpha radiation detectors available in Spain. Those delicate PAC-1S instruments were designed for use on concrete or similar surfaces, not in the hostile environment and landscape where we found ourselves. The on-scene commander, Major General

Delmar Wilson, ordered the immediate establishment of an appropriate Precision Measurement Equipment Laboratory on-site. A technician with field equipment arrived and was ready in the provided "clean environment" tent within 8 hours. I was relieved on Day 2 to attend to other critical "Broken Arrow" duties. (Broken Arrow is the Strategic Air Command code for any and all accidents or incidents involving damage to an actual nuclear warhead.)

b. Mapping and sketching the village of Palomares for the purpose of monitoring radioactivity, designating discrete structures, garden plots, fields, and other general topography features, in order to develop a final decontamination and remediation plan.

c. Coordinating with local and national Spanish officials, including the Junta de Energia Nuclear (JEN - Nuclear Energy Agency). Being proficient in Spanish and technically competent, I was assigned as the liaison Team Chief with six trained monitors for the village and inhabitants, planning and coordinating all activities with my JEN partners. We monitored village residents, their houses, barns and sheds, the water supply, agricultural products, and local livestock. Our priority was to regain the villagers' trust and confidence to the extent that they would return to their normal lives. The Operations Staff had divided our area of concern into six discrete zones. The total area included some 250 contiguous contaminated acres, plus an unknown size of nearby downwind hills, caves, and old abandoned mine shafts that had to be searched and monitored on-foot with great difficulty. Our Spain-based medical Broken Arrow staff were augmented by five sergeants from Air Force bases in Europe.

d. Cleaning and decontaminating structures, areas, and animals. We cleaned, and decontaminated insides of houses and attached animal and chicken barns. We monitored individual animals and bathed them in the presence of their owners. Once decontaminated and re-monitored, the trusting and happy owners departed with a more positive outlook for their future.

e. Conducting ground surface monitoring and recording results on a grid that was updated nightly during the command staff meeting for future planning purposes.

f. Collecting urine samples from servicemembers at the site. I collected samples, prepared containers for shipment the best we could with the local materials on-hand, and delivered them to the helicopter crew-chief /courier with appropriate handling instructions. Those samples were handed-off to a KC-135 crewmember/courier en route directly to Wright-Patterson Air Force Base (AFB) and the U.S. Air Force Radiological Health Laboratory, the DOD designated laboratory that ultimately received and processed all future Palomares-related urine specimens. R. 2108, 2489, 1926.

9. My greatest exposure to plutonium occurred during ground surface monitoring. We would walk, teamed with a Spanish JEN Technician, in a grid-line, halt every two steps

(about five feet), squat to the ground, and place our PAC-1S Alpha particle monitoring device within an inch of the surface being monitored while being careful not to actually touch the surface. For a significant portion of my time at the site, I spent my working hours in those fields performing close encounter activities. My comrades and I were breathing whatever particles were out there. R. 1926-27.

10. I did not use personal protective equipment while conducting these activities, as the staff had decided that the only respiratory protective devices available – paper or cloth surgeons' masks – provided little or no actual protection in our environment and that individuals may wear them if they felt more secure.

11. Plutonium particles became airborne in the wind as did dust. We had a job to do and did not need to be encumbered with unnecessary surgeons' face masks which were not meant for outdoor work. Likewise, our goal in the village was to restore the confidence of our wonderful, unfortunate Spanish friends rather than to frighten them further. Such senior decisions were made only after considerable consultation and advice from staff. This was in fact and foremost a critical military operation with presidential interest during the peak of the Cold War.

12. As the process of detection, decontamination, remediation and ultimate restoration continued, the wind blew radiation particles around the site despite our best efforts to keep critical areas, dirt roads, piles of dirt and vegetation moist. Our various teams monitored and remediated as best possible considering the great demand for and the availability of a limited amount of water and specialized trucks to haul it from about thirty miles away. This entire area was normally ninety percent dependent on irrigated water for daily use. After our departure, agencies of the USA donated the construction of a hydroelectric dam, creating electricity and a stable water supply for the village and agriculture. I witnessed this fantastic improvement during my visit to Palomares in 1999. R. 1927.

13. Veterans at Palomares first harvested crops of top-grade tomatoes, beans, and similar vegetables that were almost ready for market within the Northern European community. That terrible financial loss for farmers was rapidly settled by the on-site staff finance officer and his Spanish attorney partner, who daily settled claims for loss. He was known in the village as the "man with the suitcase." I specifically witnessed an incident in the village as one of our water trucks ran over a loose piglet. The distraught owner verbally blamed the unfortunate young airman driver, and the claim was very rapidly adjudicated, without consideration of how and why the piglet happened to be in the pathway of that vehicle. The cash settlement included consideration of and for the number and value of any number of off-spring the owner would have enjoyed in the future. I repeat that our stated goal was to get the job done while earning the trust and respect of villagers that only knew Americans from watching the daily refueling symphony high in the clear blue sky above.

14. From my personal perspective of daily contact, understanding their culture, their language and sharing their pain, I will take to my grave the knowledge and pride of our

Palomares veterans, from our young Airmen to our commander General Wilson, the knowledge that we each did our utmost best and our countrymen should have been proud. Instead, our Palomares Broken Arrow records became secured within the various government agencies far beyond the Cold War requirements. 0. R. 2457.

15. Recorded plutonium levels were so intense that occasionally our PAC-1S instruments were unable to measure the radiation. At times it exceeded one million counts-per-minute of alpha energy. As far I am aware, plutonium exposure had never been encountered at those levels before. R. 2457, 2461.

16. Toward the end of our combined hard work, airmen with shovels had placed heavily-contaminated materials, including vegetation, soil, clothing, and rocks, into thousands of fifty-five gallon steel drums. Each full drum was sealed, cross banded with three-quarters inch wide industrial-strength steel, covers welded to the steel bands, blown free of dust, and finally monitored with a PAC-1S prior to being loaded onto the flat-bed trailer for delivery to the beach, about one half of a mile away. Ultimately, as the final drum was processed and departed the loading site, my direct boss, Captain Dave Trimberger, the Bioenvironmental Engineer, released me to return to Moron AB and prepare my family for a rapid reassignment to Air Force Recruiting Service, reporting on May 3, 1966.

17. As a result of my contributions at Palomares, I was awarded the Air Force Commendation Medal, with my First Oak Leaf Cluster. on-site by Major General Delmar Wilson, Commander 16th Air Force and On-Scene Commander, Palomares Broken Arrow. R. 2107.

18. While at Palomares, I provided two urine specimens which were sent to the Radiological Health Lab at Wright-Patterson AFB in Ohio. My first specimen indicated an extremely high level of plutonium contamination. R. 2489. R. 2430. R. 2427

Post-Palomares Activities

19. Subsequently, I submitted four additional urine specimens for urinalysis as part of a long-term follow-up effort. R. 2427-29. One of my samples, submitted in October 1966, reported plutonium at a concentration representative of eleven percent of systemic body burden. Because of this high level, I was selected as one of twenty-six individuals at Palomares for long-term follow up, the “high 26” list. R. 2427.

20. On December 7, 1967, LtCol Lawrence T. Odland (Dr. Odland) sent me a letter indicating that the Air Force was discontinuing their Long-Term Medical Follow-Up Program for participants in Palomares because, as he said, “my health is in no jeopardy from retention of radioactive materials.” R. 2430.

21. Dr. Odland apparently knew then that “plutonium lodged in the lungs could not always be detected in veterans’ urine, and men with clean samples might still be contaminated.” Exhibit 16. I discovered this only in 2016. Dr. Odland was actually the Air Force official who persuaded the Air Force to set up a permanent “Plutonium Deposition Registry

Board" to monitor myself and other Palomares veterans for life. He was also the Senior U.S. Air Force Medical Doctor on-site at Palomares. Exhibit 16.

22. Organizers at an early meeting of the Plutonium Deposition Registry Board proposed keeping information about exposure analyses for individual veterans outside of their medical records and not notifying individuals of their exposure. Exhibit 16.

23. In his 1968 report, Doctor Odland recommended that long-term follow-up would no longer be of value. Subsequently, an order was given to halt the follow-up program and the Air Force adopted a "sleeping-dog policy." Exhibit 13; Exhibit 16. Dr. Odland has spoken publicly that he did not agree with the decision to cease the follow-up program.

Application for Benefits Related to Radiation Exposure

24. As explained below, at first the VA denied that I had even been exposed to ionizing radiation. The VA had neither prior technical expertise nor experience nor data comparable with our exposure for their reference. For years, I personally met with individuals from the VA, the Air Force, and Department of Health & Human Services to secure my follow-up medical records and urinalyses related to Palomares, and for all other Palomares comrades as well. The VA should accept these facts – we were there, we were exposed, and we were injured.

25. On July 8, 1981, I submitted an application for benefits related to my exposure to extremely high levels of plutonium radiation, among other conditions. R. 2491. Little did I know that I was setting out on a decades-long task to receive recognition from the VA for my exposure to radiation and the adverse health implications thereof.

26. During my hearing before the Rating Board at the VA Regional Office in Little Rock, Arkansas in February 1982, the Chairman of the hearing admitted that records of my exposure to alpha radiation were not available in my record and said that the VA would try to locate them. R. 2462.

27. On July 16, 1982, the VA denied my claim related to radiation exposure because my "exposure to plutonium [was] not established" and "not of record." R. 2450. On August 13, 1982, I appealed that decision to the Board of Veterans Appeals (BVA) because I knew without a doubt that the Air Force collected data on my exposure. I submitted urine specimens and had correspondence to prove that. R. 2445.

28. On January 28, 1983, the Air Force sent data on my radiation exposure to the VA. R. 2427-29.

29. On December 13, 1983 the BVA remanded my claim to determine if a condition I had, osteopenia, could be caused by my exposure to plutonium radiation. R. 2382-84.

30. In early 1984, during a compensation and pension examination, a VA doctor gave me a provisional diagnosis of osteopenia due to plutonium exposure. R. 2317.

31. On March 15, 1984, the VA issued a Supplementary Statement of the Case denying my claim for exposure to plutonium because “current medical testing does not show osteopenia and even if so, it would be speculative to relate them to the plutonium exposure.” R. 2311.

32. On July 20, 1984, the VA issued another Supplementary Statement of the Case that stated I do not have osteopenia. The VA also stated that “it has not been demonstrated that Mr. Skaar has, in reasonable medical probability, a chronic disease or disorder as a residual of his plutonium exposure.” R. 2297-2299.

33. In 1984, I submitted a Freedom of Information Act (FOIA) request to the Department of the Air Force, Strategic Air Command Chief of Administration and Records/Archives for my radiation records. The response told me to contact the Radiological Health Laboratory at Brooks AFB Texas to obtain information. R. 792.

34. After that advice, I decided to take a break from further search as I had just relocated to a challenging position in public health/environmental health management with the Clark County Health District, Las Vegas, Nevada, and had little free time to deal with the VA.

35. While working at the Clark County Health District, I met Dr. Otto Ravenholt, MD MPH, Chief Health Officer of the Clark County Health District. He soon became interested in my chronic blood disorders as a result of my plutonium exposure. Dr. Ravenholt was a Korean War veteran and understood the VA system. His personal and professional interest in the Palomares Broken Arrow of 1966 reignited my search for truth and justice for us veterans.

36. In 1990, I became familiar with works released by the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) as a function of my significant county-wide professional hazardous materials knowledge, skills, and abilities. The official ATSDR Toxicological Profile pertaining to the medical aspects of human exposure to radioactive materials included a small segment about our Palomares exposure. I identified an error of serious significance contained within their official document and reached out to the ATSDR, but never received a formal reply. R. at 797.

37. In 1992, I again began seeking a complete set of my own records related to plutonium exposure. I sent several FOIA requests to different federal agencies for my Palomares records. The Air Force Radiological Health Laboratory insultingly responded that the records did not exist.

38. I knew better and telephoned the senior director. When the director, a US Air Force Colonel, told me that the records did not exist, I reminded him that he knew that not to be true, and that I would go to the top to gain my records. Other Palomares veterans received similar negative responses or no response to their personal attempts to obtain their records.

39. Shortly thereafter, I initiated my final FOIA request directly to the Secretary of the United States Air Force and included copies of all related prior rejections and false denials. This apparently caused a door to be unlocked after some 27 years.

40. On January 4, 1993, I received a copy of four urinalysis lab reports from four of the six urine samples I submitted in the 1960s. R. at 2128. I also learned that I was number 24 of 26 on the alpha list of those 26 identified as the "high 26."

41. During 1995, I developed a professional relationship with a concerned public health professional, Joseph L. Hughart, Lt.Cmd, MPH, U.S. Public Health Service. He visited Dr. Ravenholt and me, and arranged for me to present on the Palomares experience at a formal meeting of national public health and other first responders in Tampa, Florida.

42. I remained in contact with Mr. Hughart. In early 1997, he told me that the U.S. Public Health Service would develop new toxicological profiles based on information I provided them, it would consider whether there should be follow-up health exams for the Palomares "high 26," and it also planned to develop Palomares into a case study for responding to the release of plutonium into the environment. R. 793-94.

43. Separately, on August 15, 1983, a doctor at Lovelace Medical Center wrote me a letter regarding an abnormal blood count which showed low white and red counts and low hematocrit. R. 2146. The doctor noted that in light of my exposure to radioactivity, I should pursue further follow up.

44. At that time I did not follow up on my yet-to-be-diagnosed abnormal blood count because I was busy relocating from Arkansas to New Mexico.

45. After taking an early retirement from Honeywell, I accepted a third relocation to Las Vegas, Nevada with the Clark County Health District as an Environmental Health Supervisor in 1991. Duties included HazMat and solid waste management, involving annual physicals. Dr. Ravenholt, the Chief Health Officer, became aware of my chronic abnormal "anemic–like" blood conditions and took a personal interest in my Palomares exposure.

46. On July 21, 1998, I was formally diagnosed with leukopenia, low white blood count, by Dr. M. Nafees Nagy at the Nevada Cancer Center. R. 2104.

47. I sought to reopen my claim for residuals from exposure to plutonium on August 20, 1998. R. 2150. I submitted my formal arguments for reopening the claim on December 10, 1998. R. 2119.

48. Around the same time period, I continued seeking further information about my radiation exposure dose along with the doses of other veterans. My wife and I drove from Missouri to Bolling AFB in Washington, D.C. to seek answers about my exposure from the U.S. Air Force Surgeon General Chief Health Physicist, Lt. Col. Kristen N. Swenson. R. 780. She was somewhat embarrassed to admit that neither she nor her staff had knowledge or

records of "Palomares" or "Broken Arrow." However, she committed to initiating an initial risk assessment.

49. Subsequently, the Air Force selected Labat-Anderson, Inc. to prepare new dose estimates for Palomares veterans. I was interviewed by the assigned expert, who admitted to lacking any prior knowledge or experience in the subject and task at hand. From what I've seen, this lack of expertise was endemic across Labat-Anderson and its products.

50. In June 1999, I discussed Labat-Anderson's preparation of new dose assessments for Palomares veterans with the Deputy Director of the Environmental Sciences Division of Labat-Anderson, Inc. R. 799.

51. On February 18, 2000, the Department of Veterans Affairs (VA) issued a rating decision on my leukopenia claim, denying service connection of my radiation exposure and my leukopenia. R. 2095-2099.

52. Further blood tests conducted on December 16, 2008 showed low red blood cell count, low hemoglobin, and low hematocrit. The VA doctor confirmed that I've been diagnosed with leukopenia since at least 1998. R. 2059-61.

53. On September 25, 2009, Dr. Kristin L. Griffin at St. John's O'Reilly Cancer Center in Springfield, Missouri, concluded that the etiology of my pancytopenia is likely related to my exposure to heavy radioactive material. R. 1939. Abnormal platelets/pancytopenia is a further extension of my chronic abnormal leukopenia.

54. On October 17, 2010, my long-term family doctor confirmed my leukopenia diagnosis. R. 2047.

55. In March 2011, I began to pursue service connection for my leukopenia, chronic low blood counts, and thrombocytopenia based on exposure to radiation again. R. 2077.

56. In August 2011, my doctor reiterated the conclusion that my pancytopenia is most likely related to my exposure to heavy doses of radioactive material. R. 2046. I sent this information to the VA to continue my claim for leukopenia and to add my diagnosis of pancytopenia to my radiation residuals claim. R. 2034. I sent additional information to the VA on September 22, 2011. R. 1926-28.

57. On June 1, 2012, the VA denied my claim for leukopenia, confirming the previous denial of this claim. R. 1862. In their explanation, the VA said that their decision is based on an opinion provided by the Director of the Post 9-11 Era Environmental Health Program, on behalf of the Undersecretary of Health. R. 1864.

58. The Director of the Post 9-11 Era Environmental Health Program, on behalf of the Undersecretary of Health, concluded that my leukopenia, thrombocytopenia, and pancytopenia could not be attributed to my exposure to ionizing radiation in service because my maximum total effective dose equivalent was 4.2 rem and health risks are

minimal from exposures of under 5 rem per year and 10 rem in a lifetime. R. 1875, 1877. This data was not assessed by any independent outside agencies or entities.

59. The VA issued a Statement of the Case (SOC) on September 25, 2013 confirming the denial of a service connection based on the opinion of the Director of the Post 9-11 Era Environmental Health Program, on behalf of the Undersecretary of Health, and acknowledging receipt of my private medical records linking my leukopenia to my radiation exposure. The SOC did not weigh the differing opinions. R. 1691.

60. On November 22, 2013, I appealed my denial to the BVA. R. 1582. I wrote to the BVA that I was appealing a variety of issues and complained that the VA had relied on evidence I had never reviewed and that I had requested but never received. R. 1582-86.

61. On December 6, 2013, the Air Force Medical Support Agency sent a memorandum signed by Lt. Col. Cagle in response to a request by a congressional committee to the VA, noting "inconsistencies in dose assignment" for Palomares veterans and establishing new radiation intake estimates for all Palomares veterans. R. 1580-81. Upon receipt of that letter reporting Lt. Col. Cagle's new and revised dose estimate for myself and others, I telephoned the officer to discuss the process. He was professionally responsive but admitted that he had not personally examined the entire medical after-action report of the Palomares operation.

62. I later met in D.C. with Lt. Col. Cagle, his staff Director, Air Force Col. Phillips, two of their Chief Master Sergeants, and one civilian consultant, who as a first lieutenant had signed one of the original "Denial of Records" letters on behalf of the Air Force that I had received during the 1980s. I realized that these airmen disappointingly had little knowledge and less interest in our history. Col. Phillips explained that our level of exposure would not likely be the direct cause of any of our stated cancers, or blood disorders, in their opinion.

63. On September 30, 2014, after receiving the evidence I had requested earlier, I was appalled at what I found. The VA relied on an exposure estimate, 4.2 rem, without explaining how they came to that number.

64. I informed the BVA of my prostate cancer diagnosis and treatment on October 21, 2014. R. 824. My later claim to the VA was denied, because they stated in an expert medical opinion that the diagnosis of my recognized radiogenic disease occurred after the time that a relationship between exposure and disease would have developed.

65. On October 30, 2014, I informed the VA that my dose exposure is "arbitrary and capricious and was formed without sufficient consideration of the facts." R. 780, 824.

66. On May 29, 2015, without addressing my arguments about my dose, the BVA remanded my case to the VA Regional Office. The BVA held that new and material evidence had been presented to reopen my February 2000 rating decision denying entitlement to service connection for radiation residuals. R. 703-707.

67. On August 4, 2016, the Director of the Post 9-11 Era Environmental Health Program, on behalf of the Undersecretary of Health, again concluded that leukopenia is not likely caused by exposure to radiation. The Director relied on a new dose estimate, showing a committed effective dose of 17.9 rem and a red marrow dose of 14.2 rem. R. 132-35.

68. On August 19, 2016, the VA Regional Office again denied my claim for service connection for leukopenia as a result of radiation exposure. R. 122-27. The RO did not explain the scientific basis for the dose it relied on, nor did the RO address my earlier complaints about the arbitrariness of the dose selected.

69. On September 14, 2016, I filed a VA Form 9 to appeal my claim to the BVA. R. 103. I also contacted the great Missouri Congressional staffs for assistance and encouragement with my claim.

70. On April 14, 2017, the BVA denied me entitlement to service connection for leukopenia as a result of radiation exposure. R. 1-12.

Skin Cancer

71. Following a biopsy in October 2012, doctors diagnosed me with basal cell carcinoma and melanoma. R. 1719-20, 763-65.

72. Later in November of the same year, my skin cancers were removed. The melanoma cancer was deep into the flesh but successfully removed. Six-month follow-ups were scheduled. R. 163, 1503-1505.

73. The VA learned of my skin cancer during a compensation and pension medical examination in January 2013. R. 1645.

74. In September 2013, I sought review from the VA of the connection between my skin cancer and my exposure to ionizing radiation. R. 27.

75. The VA evaluated my melanoma skin cancer based on my first dose estimate of 4.2 rem. R. 1491. The VA found that there was a 35.13 percent probability of causation at the 99th percentile using the Interactive RadioEpidemiological Program (IREP), its system for calculating the likelihood of causation due to radiation. R. 1530-35.

76. The VA then denied my basal cell carcinoma and melanoma claim in March 2014. R. 1372.

77. On May 16, 2014, I submitted a statement to the VA asking them to address claims for exposure to ionizing radiation and melanoma and basil cell skin cancer. R. 1305.

78. On June 23, 2014, I again wrote a letter to the VA complaining about the doses relied on by the VA and asking the extent to which my melanoma skin cancer is included in the

category of radiogenic diseases listed in 38 C.F.R. § 3.311 titled "other" cancers. R. 1252-53.

79. Instead of issuing me an SOC, the VA reconsidered my basal carcinoma and melanoma claims based on the revised dose estimates provided by the Air Force—the same revised dose estimates they applied to my leukopenia claim. R. 1229-34.

80. Even though my effective dose increased significantly pursuant to the new dose methodology, the VA's new causation analysis inputted a lower dose into IREP and the probability of causation between radiation and my skin cancer fell from 35.13 percent to 0.96 percent R. 1229-34.

81. Further, in conducting their new IREP assessment the VA changed their inputs into IREP. First, the VA used my total effective dose in 2013, but then used my skin-specific dose in 2014. Second, the VA switched from an acute exposure rate to a chronic exposure rate. Third, the VA changed from an alpha radiation type to a photon radiation type. Compare R. at 1532 and 1534 with R. at 1231 and 1233. The VA did not explain why it made these changes.

82. On September 4, 2014, the VA continued its denial of my skin cancer claim, referring to their previous decision on skin cancer as a "deferred rating." R. 1187-93.

83. In February 2015, I wrote to the BVA, regarding my melanoma and basal cell carcinoma skin cancer. No response was received. R. 163.

84. In the BVA April 14, 2017 decision regarding my skin cancers claim, the BVA mentioned that "it was noted . . . there was a reasonable possibility that the skin cancer was the result of exposure to ionizing radiation." R. 9.

85. Pursuant to 28 U.S.C. § 1746, I declare under penalty of perjury that the foregoing is true and correct.

Executed this 27 day of February 2019.

[signature]
VICTOR B. SKAAR

Exhibit 19

DECLARATION OF NONA ARP WATSON

1. My name is Nona Arp Watson, and I am the widow of a deceased U.S. Air Force veteran, Nolan Watson. I am submitting this declaration to support Victor Skaar's legal challenges related to the events that took place in the vicinity of Palomares, Spain in 1966 in connection with the "Broken Arrow" nuclear disaster. I also wish to describe my deceased husband's medical conditions that were caused by his participation in the Palomares nuclear clean-up effort and the Department of Veteran Affairs' treatment of his radiogenic disability claims.

2. The facts set forth herein are based on conversations with my late husband Nolan Watson and his first-hand account, repeated to me over many years, of his experience at Palomares. My knowledge regarding his activities derives from conversations I had directly with Nolan and from personally viewing documentation and evidence supporting his statements.

3. I was born on November, 4, 1944.

4. I graduated from Berry College in Rome, Georgia with a degree in education in 1966. In approximately 1979, I obtained a Master's degree in education from West Georgia College in Carrollton, Georgia. I am a retired teacher with experience teaching middle school science and math. I retired after teaching for over 28 years.

5. Nolan Watson was born on February 5, 1943 and died on May 20, 2017.

6. Nolan Watson and I were married in 2002.

7. Attached to this Declaration as Exhibit A is a true and correct copy of a statement, handwritten by Nolan Watson regarding the accident at Palomares, Spain that Nolan Watson submitted in support of his claim for disability benefits to the Department of Veterans Affairs, along with a typewritten transcription of his statement.

Nolan Watson's Service in the Air Force and the Accident at Palomares

8. After graduating from high school in 1961, Nolan Watson joined the United States Air Force. When he was completed his tour with the U.S. Air Force in 1967, his rank was Airman First Class (E-5).

9. In approximately 1963 or 1964, Nolan was transferred to an Air Force Base in Morón, Spain. While at Morón Air Force Base, he served in the 3973 combat defense squadron. He was a K9 dog handler working security.

10. On January 17, 1966, two United States military planes, a B-52 Bomber and refueling plane, collided near Palomares, Spain. When the two United States military planes collided, four nuclear bombs fell on the Spanish coast.

11. Nolan was on the first bus that was sent to Palomares to search for the lost nuclear bombs. The bus met a one and one half ton truck at a dry riverbed where the tail of the B-52 bomber was found.

12. After my husband reached the riverbed, the servicemen ate a meal together. Then, my husband was put on a team with five servicemen from the Air Force Base at Torrejón,

Spain. The search team initially assembled by the Air Force was very unorganized. No one had maps of the area to assist the servicemen in their search for the bombs.

13. Before beginning their search for the nuclear bombs, the Air Force did not give Nolan or any of the other servicemen with him any equipment or protective gear to use or wear.

14. Nolan and the other servicemen with him searched for the bombs during the day on January 17, 1966. Sometime after dark, they feel asleep on the ground, with no tents, equipment, sleeping gear, protective clothing or gear, or flashlights.

15. When the sun rose on the morning of January 18, 1966, my husband and the other servicemen with him noticed they were sleeping near a huge crater where one of the four bombs had crashed.

16. At that time, my husband noticed that the bomb in the crater was damaged. He later learned that plutonium from the bomb escaped into the atmosphere. Thus, that first night after the accident, my husband and the servicemen with him slept very near the exposed plutonium without any protective gear or clothing.

17. After finding the damaged nuclear bomb, Nolan Watson and other servicemen waited several hours for a team from the Air Force decontamination group to arrive at the location. When the decontamination group arrived, the group made my husband and the other servicemen in his group change clothes, though my husband kept on his shoes and underwear. Someone in the group had a Geiger counter and waved the counter over Nolan's and the other serviceman's clothing. Nolan remembered the Geiger counter giving off high readings. However, the decontamination group never took down the names or identity of my husband or the other servicemen.

18. During the search and clean-up efforts in which my husband took part, my husband and other servicemen wore regular clothes, without coveralls or gas masks. During this time period, some servicemen received surgical masks, but not my husband.

19. Nolan Watson was told by the Air Force at the time of the accident that there was no danger of radiation at the recovery and clean-up site. In fact, he was asked by the Air Force to eat the local tomatoes so that the Spanish residents would not be afraid of side effects due to radiation.

20. During the remaining time Nolan Watson worked around the recovery efforts, no one ever checked him again for radiation exposure or any other health concern.

21. The Air Force never asked my husband to provide a urine sample while he was in Palomares in January 1966.

22. Nolan remained at the recovery and clean-up site from January 18, 1966 through January 30, 1966.

23. At no time after my husband left Palomares did the Air Force or any other governmental entity request that my husband provide a urine sample or take any other test that would measure his exposure to radiation during the recovery and clean up at Palomares.

Nolan Watson's Health Problems and Conditions

24. After my husband was exposed to the radiation at Palomares in January 1966, for the remainder of his life, he experienced significant health problems and conditions.

25. During his lifetime, my husband suffered from numerous health maladies, including headaches, stiff hips, painful joints, kidney stones, kidney cancer, and localized skin cancer.

26. In 2003, six months after we were married, Nolan was diagnosed with cancer in his left kidney. His treating physicians said the cancerous tumor in his left kidney could have been there for ten or more years, depending on how long the cancerous tumor had been growing. At that time, his physicians removed his left kidney.

27. About the same time, his treating physicians told Nolan that his remaining kidney was not fully functional. His physicians recommended that he closely monitor his diet so that he would not have to go on dialysis. This effort helped him to avoid dialysis for about four to five years. I helped Nolan carefully monitor his diet and lifestyle during this time period.

28. In or around the 2009, despite his efforts to monitor his diet, Nolan had to start dialysis services. Until he died in 2017, Nolan had to go to a dialysis center three days per week.

29. Due to Nolan's dialysis schedule, he and I were significantly limited in traveling and engaging in any activity that was far from the dialysis center.

30. In fact, each time that he had to go to the dialysis center, it would consume approximately five hours of his day. And, on each of those days, he felt poorly for the rest of the day and evening. He was unable to participate in activities he enjoyed on dialysis days, including taking care of our farm and tending his garden.

31. In 2010, Nolan's physicians discovered that he had cancer in his other kidney. His physicians told him that the cancer was inoperable. Still, he continued dialysis.

32. Also during this time period, Nolan and I were required to pay co-pays on everything at the Veterans Hospital in Augusta, Georgia or at the dialysis centers. Some of these years, we drove 10,000 miles going to and from the Veterans Hospital and the dialysis center. Because of my retirement benefits from my tenure as a teacher, Nolan did not qualify to receive any financial assistance for his medical bills and related expenses.

33. In early 2017, Nolan's treating physicians had informed him that the cancerous tumors in his right kidney had grown. The physicians also told him that they expected the cancer to spread beyond his right kidney and as they had told him in 2010, they could not operate to remove the kidney.

34. In May 2017, Nolan fell in our yard at home when he was trying to turn off the water hose he was using to water his garden. The fall caused internal bleeding and my husband died several days later in the hospital.

My Investigation into Palomares and the Air Force's Actions

35. Sometime in or about 2008 or 2009, Nolan and I, and another couple that Nolan knew through his service at Morón Air Force Base talked about planning a reunion for the 3973d

defense squadron that had served at Morón at or about the same time as Nolan. We planned an initial reunion for the veterans.

36. Thereafter, each year, other veterans and their families planned other reunions for the 3973d defense squadron. It was at these reunions that I first heard the veterans discussing the Palomares accident. The veterans discussed how the Air Force had told them that no harm could come to them from radiation exposure unless they touched the radioactive material. The veterans also discussed how they had no protective clothing or gear during the recovery or clean-up.

37. From my tenure as a science teacher, I knew that the veterans' discussion about exposure to radiation (based upon representations made to them by the Air Force) were inaccurate. I was surprised and disturbed to hear about the lack of effort made by the Air Force to protect the servicemen during the recovery and clean-up and to follow up with the veterans to monitor their health. At this time, I decided to look more into the Palomares accident and the Air Force's response to the accident as it related to the veterans.

38. Initially, I had conversations with Otto Kosa, another Air Force veteran who served during the Palomares accident, about the accident. He decided to place something on the defense squadron's website asking the veterans to contact him if they had participated in the recovery and clean up in January 1966. Mr. Kosa would then forward me these veterans' names, and I had conversations with several of them.

39. These initial conversations prompted me to conduct some research. I found the Air Force's initial report on the accident in 1975. Mr. Kosa found a copy of the 2001 Labat-Anderson Report on the internet around the same time and he forwarded it to me. The Labat-Anderson Report referred to several appendices, but they were not attached to the copy that Mr. Kosa found.

40. I studied the Labat-Anderson Report, and shortly thereafter found a summary of the Report that the Air Force published in 2002 on the internet. On that webpage, I found a link to the Appendices (except for Appendix C) to the Labat-Anderson Report. Appendix C contained information relating to urine samples that were taken and evaluated by the Air Force during the recovery and clean-up at the Palomares accident.

41. A review of the Appendices, along with the Labat-Anderson Report's analysis, caused me to seriously question its conclusions regarding the veterans' exposure to radiation that the Air Force accepted that were set forth in the Report. To fully analyze the Report, I needed to review Appendix C.

42. It was at that time that I contacted the office of my congressperson, Representative Paul Broun. I hoped that his office could help me locate a copy of the Appendix C and help with correspondence to the Air Force regarding the Labat-Anderson Report.

43. On March 21, 2011, I opened a Congressional inquiry with Representative Paul Broun. A staffer with Representative Broun's office was able to find a copy of Appendix C and provided a copy to me.

44. After reviewing the 1975 Report and the Labat-Anderson Report and its Appendices, I concluded that the Report relied upon many factual inaccuracies, and performed scientifically deficient analyses, resulting in flawed conclusions. For example:

- The Labat-Anderson Report neglects to mention that many responders never gave a urine sample on site or never had a urine sample taken.
- Of the 680 responders present in January 1966, only 127 urine samples were taken that month, when the risk of contamination would have been highest. My husband – who arrived the first day and slept next to a cracked-open hydrogen bomb leaking radioactive plutonium, meaning he may have been one of the most-exposed servicemen at Palomares – was never even asked to provide a sample.
- Of the 127 samples taken in January 1966, only 44 of those 127 samples provided a result. Thus, of the 680 responders present in January, the time period right after the accident, the Air Force had only 44 samples – the initial sampling therefore covered less than 7% of those present.
- Of the samples they actually did have, Labat-Anderson excluded those with the highest measurements.
- There were problems with processing the urine samples, too. For example, I was told by the some of the veterans with whom I spoke that some of the urine samples were sent to the labs in coke bottles. Appendix C shows there were large time gaps in the labeling of the samples at the lab. Many of the ones taken in January took a month or more to get to the lab, while others took only a few days to get to the lab.
- Appendix C of the Report indicates that approximately 1,600 original urine samples were taken from the responders in Palomares. A review of the data in Appendix C shows that over 500 of these samples did not even have a result. Thus, almost one-third of the urine samples taken provided no data to the Air Force whatsoever.
- Only half of the Palomares veterans with urinalysis results in Appendix C had samples collected on site, and only half had their samples retested, as protocol required.

45. Labat-Anderson stated in their Report that their results were preliminary, and recommended that new bioassay testing be conducted in order to properly analyze Palomares veterans' exposure. To my knowledge, no follow-up urinalysis or other testing was ever conducted.

46. The Report also recommended that the Air Force communicate with all responders about efforts to determine exposure levels. To this day, the Air Force has never informed the responding servicemen of their potential radiation exposure. The Air Force made no effort to contact the responders.

47. Amazingly, in 2012, shortly after I inquired about the discrepancies and inconsistencies in the Labat-Anderson Report through my Representative as discussed below, the Air Force *removed the Report from the internet so that others could not review it*.

Representative Broun's Inquiry and Legislative Action

48. In early 2012, as a result of the congressional inquiry that I opened, Rep. Paul Broun sent a letter to the Air Force asking why new urine testing had not been ordered as recommended by the Labat-Anderson Report. A true and correct copy of this letter is attached hereto as Exhibit B.

49. On May 21, 2012, Air Force Major General Lori Robinson responded; however, she just restated the conclusions of the Labat-Anderson Report. A true and correct copy of the Major General's response is attached hereto as Exhibit C.

50. Rep. Broun responded to Major General Lori Robinson's letter challenging her information about the nasal swabs, and the urine, air, soil, vegetation, and water samples. A true and correct copy of Rep. Broun's response is attached hereto as Exhibit D.

51. The Air Force responded to Rep. Broun's letter in July 2012. A true and correct copy of that letter is attached hereto as Exhibit E.

52. In June 2013, Rep. Broun introduced and the House of Representatives passed H.R. 1960, an amendment to the FY14 NDAA, requiring the Air Force to answer Congress about its efforts after the Labat-Anderson Report. A true and correct copy of a letter from Rep. Broun to Nolan Watson concerning HR 1960 (along with a copy of HR 1960) is attached hereto as Exhibit F.

53. HR 1960 stated: "Not later than 180 days after the date of the enactment of this Act, the Secretary of the Air Force shall submit to the Committees on Armed Services of the Senate and the House of Representatives a report on the implementation of the recommendations of the Palomares Nuclear Weapons Accident Revised Dose Evaluation Report related in April by the Air Force in 2001."

54. In December 2013, in response to HR 1960, the Air Force provided a "Methodology Report" to Congress. The Air Force's response was to simply state that conducting new urinalysis could lead to an even lower radiation exposure estimate, without explaining why. A true and correct copy of the Air Force's response is attached hereto as Exhibit G.

55. On March 23, 2014, I sent eleven questions to Rep. Paul Broun to ask the Air Force regarding its 2013 Methodology Report. A true and correct copy of the memorandum containing the eleven questions (without exhibits) is attached hereto as Exhibit H.

56. On May 9, 2014, the Air Force answered my eleven questions by restating, in more words, its 2013 Methodology Report. A true and correct copy of the Air Force's response is attached hereto as Exhibit I.

57. To this day, the U.S. Government maintains that Palomares veterans were not exposed to dangerous levels of radiation. Yet this conclusion from the Labat-Anderson Report is based on completely unreliable data obtained from urine samples taken from some – not all – of the responding servicemen.

Nolan Watson's Disability Claim

58. In 2011, Nolan Watson filed a disability claim with the Department of Veterans Affairs, asking for service connection for his kidney cancer, caused by radiation exposure during the recovery and clean-up at Palomares in January 1966.

59. In support of his claim, Nolan filed a statement from his treating physician at the Charlie Norwood VA Medical Center in Augusta, Georgia. The statement explained that he had no family history of cancer, and that kidney cancer is one of the types of cancer that may be caused by exposure to radiation. His doctor wrote: "We discussed that there was no way to prove or disprove his cancer was due to radiation, but that renal cell carcinoma has been associated with radiation in other studies and he has no family history or other risk factors so it is as likely as not that his renal cell carcinoma was caused by his active duty radiation exposure." A true and correct copy of his physician statement is attached hereto as Exhibit J.

60. While in the process of assisting Nolan with the filing of his disability claim in 2011, I was told by a representative of the Georgia Veterans Affairs Services office in Conyers, Georgia that the Department of Veterans Affairs automatically turn down disability claims relating to radiation exposure twice before the Department would take the claim seriously.

61. My husband's claim for disability benefits was initially denied in July 2012. In September 2012, Nolan appealed this initial decision.

62. In May 2016, the VA denied Nolan's initial appeal. On August 13, 2016, Nolan filed an appeal to the Board of Veterans Appeals and requested a hearing in Washington, D.C.

63. After Nolan Watson passed away in May 2017, I filed a substitution form in the pending appeal, substituting myself as his representative.

64. The Board has taken no action in Nolan's appeal since 2016.

65. From the time Nolan filed his disability claim in 2011 until he passed away in 2017, he would tell me that if his claim was approved, he wanted to be able to leave a little money to his grandchildren.

66. Nolan Watson had formed many bonds with other servicemen in the Air Force, and he was proud of his service to his country. However, during the years that his disability claim was pending until his death, he felt betrayed by Air Force officials, the Department of Veterans Affairs, and his elected representatives.

Communications with Other Palomares Responders

67. During the course of my investigation into the Palomares accident and the Air Force's response, I was able to discuss the accident with other Air Force servicemen. These servicemen sent me copies of their statements regarding the events around the Palomares accident.

68. Attached hereto as Exhibit K is a true and correct copy of a statement made by Peter Ricard that he emailed to me on August 22, 2012. Mr. Ricard was stationed at the Morón Air Force Base. Regarding his operation of a radioactivity detector after the accident, he states: "My duty consisted of 'operating' a PAC 1S radioactivity detector. I was instructed not to

turn on the PAC 1S when we would encounter the local inhabitants; we were not to excite the locals. We took 'readings' in the valley as well as on the local farms. We would also 'fake' taking reading of their animals. I honestly do not recall anyone recording any readings. It seemed our task was to placate the local natives. I should state that I had no training with the PAC 1S. All I did was turn it on and off. I had no knowledge of the significance of the readings and the affect on the humans in contact with radioactivity. I can honestly say that I don't even know if the equipment worked property."

69. Attached hereto as Exhibit L is a true and correct copy of a statement made by Ron McCutchen that he emailed to me on October 25, 2010. Mr. McCutchen was stationed at the Morón Air Force Base. Regarding his help with recovery efforts after the Palomares accident, he stated: "We were told that we did'nt [sic] need any safety equipment. We were never issued protective suits, respiration equipment, gloves, nothing, yet day after day we removed tons and tons of radioactive dirt and were told that there was no danger. We were never given a physical. No urine test. No lung x-ray. Nothing."

70. Pursuant to 28 U.S.C. § 1746, I declare under penalty of perjury that the foregoing is true and correct. Executed this 26th day of February, 2019.

Nona Arp Watson

Nona Arp Watson

Exhibit 19-a

I was stationed at Moron AFB. on Jan. 17, 1966 when the U.S. lost 4 nuclear bombs over Palomares, Spain. I was given orders to leave early morning of the 18th. There was a bus, a 1½ ton truck and 28 AP's that left first. I have a copy of my orders and a list of the men that were with me. I can't remember the exact time we got there but we were the first of the responders. There were only high level officers and heads of government agencies there when we arrived. I think a group from Torrejon AB got there not too long after our group. Things were very unorganized, mainly the first week. I guess because somthing like this had never happened before.

We were quickly separated and assigned to many different places. None of us, I don't think, stayed together. I was put on a search team. We were told to stay at arm's length and we did this for hours and hours. By the end of the day, I was with about 5 men from Torrejon AB. At least I thought they were. We didn't talk much. We were too busy. No one kept up with who we were. We just followed orders and did what we were told.

That night we were very tired and we had to slep on the ground where we were because there was no tents until the third night. When we ~~sta~~ started searching again, we ralized we were seting right above a crater where the bomb had crashed open. We reported what we found. I remember what it looked like and I have always told this story to my family. We waited a pretty long time before anyone could get to us because of how rough the ground was.

Thay took us back, put us in a tent, went over us with a Geiger counter and took our clothes except for our underware and shoes. I remember that the clothes had no name, rank or branch of service on them.

To this day, this is the ~~the~~ only time I was ever checked in any way for radiation. I was never asked to give a urine sample or given any onther kind of test. We were told there was no danger of radiation. We were even asked to eat the tomatoes so the Spanish people would would not be afraid of them.

I was at the crash site from Jan 18th Jan. 30th When the radition was the highest.

In 2003 I was diagnosed with kidney cancer and I lost my left kidney. In 2010 I was told I had cancer in my right kidney I soon had to go on dialysis three time a week. Because of many health problems I was told that surgery would be too dangerous. There is very little that can be done now. I can only pray that it grows very slowly.

I truly believe my exposure to radition in Spain caused my cancer.

Since then I was very shocked to find out that much of what was said was not what really happened.

A1C Nolan Ford Watson Jr

Exhibit 19-b

PAUL C. BROUN, M.D.
10TH DISTRICT, GEORGIA

COMMITTEE ON
HOMELAND SECURITY

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
CHAIRMAN, INVESTIGATIONS AND
OVERSIGHT SUBCOMMITTEE

COMMITTEE ON
NATURAL RESOURCES

Congress of the United States
House of Representatives
Washington, DC 20515–1010

WASHINGTON OFFICE:
325 CANNON HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
PHONE: (202) 225-4101
FAX: (202) 226-0776

WEB: BROUN.HOUSE.GOV

The Honorable Buck McKeon - Chairman
The House Committee on Armed Services
2120 Rayburn House Office Building
Washington, D.C. 20515

Dear Chairman McKeon:

I am writing to you to share my concern about an issue that was brought to my attention by my constituent, Mrs. Nona Watson in regards to her husband's service in the United States Air Force.

As you are likely aware, on January 17,1966, a United States Air Force B-52G carrying four Mk28 Hydrogen Bombs collided in mid-air with the KC-135 tanker that was refueling the aircraft. The B-52G broke apart, scattering three of the United States' Mk28 Hydrogen Bombs over the landscape of the small fishing village of Palomares, Spain. The other Hydrogen Bomb fell into the ocean. However, due to the impact of the three other bombs into the landscape, the non-nuclear explosives were detonated, causing approximately two square miles of radiation contamination.

Mrs. Watson came to our office on March 21, 2011 to open a congressional inquiry in regards to her husband, Nolan Watson, and his ongoing claim with the Department of Veterans Affairs. Through documents received from Mr. and Mrs. Watson, it has come to my attention that there were possibly up to one-thousand members of the United States Military that were exposed to radiation and placed in harm's way due to this fact. However, the United States Air Force has not recognized that these soldiers were possibly exposed to dangerously high levels of radiation. While the Air Force has claimed that all precautions necessary were taken, multiple documents and personal statements presented to my office show that there were many contradictory statements and orders issued in regards to the Palomares Incident.

It has also become extremely hard for the Veterans from this incident to have their claims for radiation exposure approved by the Department of Veterans Affairs. While Mrs. Watson has informed us that one of the men who responded to the crash (the surviving Veterans have a reunion where they meet and discuss these issues yearly) has had his claim approved, most are like Mr. Watson's which lingers in the system most likely awaiting denial due to the fact that this incident is not recognized as possibly exposing our service-men to dangerously high levels of radiation.

My office stands prepared to offer any assistance that you request in regards to this letter. My staff also stands ready to provide the documentation that has been provided to us in regards to the Palomares Nuclear Incident by my constituents.

PAUL C. BROUN, M.D.
10TH DISTRICT, GEORGIA

COMMITTEE ON
HOMELAND SECURITY

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
CHAIRMAN, INVESTIGATIONS AND
OVERSIGHT SUBCOMMITTEE

COMMITTEE ON
NATURAL RESOURCES

Congress of the United States
House of Representatives
Washington, DC 20515–1010

WASHINGTON OFFICE:
325 CANNON HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
PHONE: (202) 225–4101
FAX: (202) 226–0776

WEB: BROUN.HOUSE.GOV

I am respectfully requesting your review of this incident and that you would direct any correspondence to my Athens District Office in regards to this matter which is located at the following address:

The Office of Congressman Paul C. Broun
3706 Atlanta Highway, Suite 3B
Athens, Georgia 30606

Thank you for looking into this important matter and I look forward to your response.

Respectfully Yours,

Paul C Broun

Paul C. Broun, M.D.
Member of Congress

CC:
The Honorable Jeff Miller, Chairman – The House Committee on Veterans Affairs
The Honorable Michael B. Donley, Secretary of the United States Air Force
The Honorable Eric Shinseki, Secretary – U.S. Department of Veterans Affairs
General Norton A. Schwartz, Chief of Staff- The United States Air Force

Exhibit 19-c

DEPARTMENT OF THE AIR FORCE
WASHINGTON DC 20330-1000

OFFICE OF THE SECRETARY

MAY 21 2012

SAF/LL
1160 Air Force Pentagon
Washington, DC 20330

The Honorable Paul Broun
United States Representative
3706 Atlanta Highway, Suite 3B
Athens, GA 30606

Dear Representative Broun:

Thank you for your letter to the Chief of Staff of the Air Force regarding Mr. and Mrs. Nolan Watson's concerns about radiation exposure as a result of a mid-air collision that occurred on January 17, 1966 over Palomares, Spain.

The Air Force Surgeon General's office investigated this incident in 2001, the report from which addresses concerns noted in Mrs. Watson's inquiry. The report concluded that the responders were not expected to experience any health effects from their participation in the response to the Palomares accident. The Air Force Medical Support Agency (AFMSA) has not received a Veterans Affairs radiogenic disease claim for Mr. Nolan Watson; therefore, the Air Force has not specifically evaluated his potential exposure.

In general, radiological health concerns from personnel responding to this incident are primarily due to inhalation of air-suspended radioactive materials dispersed as a result of the accident. During the initial response and subsequent recovery operations, personnel involved were provided protective clothing. Air sampling was conducted and assessed on-site to monitor and limit the inhalation of radioactive plutonium, especially during activities such as plowing fields, curing and bundling crops, filling barrels with contaminated soil, and removal of contaminated debris from the sites of aircraft wreckage and damaged bombs. In addition, swabs of the nasal passages of responders were taken and assessed as a means of providing on-site indications of possible plutonium inhalation. These samples were subsequently sent to the USAF Radiological Health Laboratory (RHL), Wright-Patterson AFB, OH for confirmatory analysis.

Throughout the response effort and subsequent follow up, 1,586 urine samples, 439 air samples, and numerous soil, vegetation, and water samples were collected and analyzed either on-site or at the USAF RHL. Of the 1,586 urine samples, twenty were found to exceed the body burden. At the time of the accident, body burden was the term applied to the amount of a radioactive material in the body that could result in a radiation dose at the allowable occupational limit.

A urine re-sampling program started soon after operations ceased on April 11, 1966 evaluated 422 urine samples and identified six individuals who exceeded ten percent of a body burden. Twenty-six individuals (twenty from the original sampling, and six from the re-sampling) were followed for eighteen to twenty-four months, after which it was concluded that little additional information could be gained by further sampling. Air Force officials have reviewed applicable records and determined Mr. Watson is not among the group of twenty-six individuals and would not, therefore, have exceeded annual occupational exposure limits as specified in Title 10, Code of Federal Regulations, Part 20.1201.

Since November 2011, AFMSA has spoken with Mrs. Watson regarding the Air Force's response to this incident. In an effort to address her concerns, they have contracted an individual to review and address aspects of her concerns. AFMSA is in the process of finalizing the response and will provide this directly to Mrs. Watson upon its completion.

We trust this information is helpful.

Very respectfully,

LORI J. ROBINSON
Major General, USAF
Director, Legislative Liaison

Exhibit 19-d

PAUL C. BROUN, M.D.
10TH DISTRICT, GEORGIA

COMMITTEE ON
HOMELAND SECURITY

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
CHAIRMAN, INVESTIGATIONS AND
OVERSIGHT SUBCOMMITTEE

COMMITTEE ON
NATURAL RESOURCES

Congress of the United States
House of Representatives
Washington, DC 20515–1010

WASHINGTON OFFICE:
325 CANNON HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
PHONE: (202) 225-4101
FAX: (202) 226-0776

WEB: BROUN.HOUSE.GOV

Major General Lori J. Robinson, USAF
Director, Legislative Liaison
SAF/LL
1160 Air Force Pentagon
Washington, D.C. 20330

Major General Robinson:

Thank you for your response dated May 21, 2012 in regards to my constituents Nolan and Nona Watson. I appreciate the prompt response and professionalism displayed by the men and women of the United States Air Force Office of the Legislative Liaison. However, I am writing you to discuss a number of discrepancies that have come to my attention in your letter.

In the second paragraph of your letter, you reference the following:

> *The Air Force Medical Support Agency (AFMSA) has not received a Veterans Affairs radiogenic disease claim for Mr. Nolan Watson; therefore the Air Force has not specifically evaluated his potential exposure.*

However, upon discussion with Ms. Gail Berry, the Supervisor of the Radiation Ratings Division of the Veterans Affairs Regional Office in Jackson, Mississippi, this information was requested via e-mail on April 27, 2012, almost one month before your letter was written. Also, according to Ms. Junie St. Jacques-Culmer of the Veterans Affairs Regional Office in Atlanta, Georgia, this information was also most likely requested by the Atlanta Regional Office at a previous date. Why does the AFMSA not have a record of these requests?

There are also discrepancies in other paragraphs of the letter. In my original letter to you, I stated that my office stood ready to provide additional documentation to the United States Air Force in regards to this issue, however this information was not requested. I refer to the following statements in your correspondence:

> ¶3. *During the initial response and subsequent recovery operations, personnel involved were provided protective clothing [...] In addition, swabs of the nasal passages of responders were taken and assessed as a means of providing on-site indications of possible plutonium inhalation. These samples were subsequently sent to the USAF Radiological Health Laboratory (RHL), Wright-Patterson AFB, OH for confirmatory analysis.*

¶4. *Throughout the response effort and subsequent follow up, 1,586 urine samples, 439 air samples, and numerous soil, vegetation, and water samples were collected and analyzed either on-site or at the USAF-RHL.*

¶6. *Since November 2011, ADMSA has spoken with Mrs. Watson regarding the Air Force's response to this incident. In an effort to address her concerns, they have contracted an individual to review and address aspects of her concerns. AFMSA is in the process of finalizing the response and will provide this directly to Mrs. Watson upon its competition.*

The information and evidence given to my office from Veterans who served in Operation Broken Arrow in the clean-up of the Palomares Nuclear Accident directly contradicts the information provided to my office in paragraphs two, three, and four of your letter. For your convenience, I have enclosed these statements and a copy of your original correspondence. In reference to the ADMSA report, I would like to know what the expected completion date is and when this report is completed, I respectfully request that you furnish my office with a copy of this report.

Please direct all correspondence to Jared Peden in my Athens District Office. The address is:

The Office of Congressman Paul C. Broun, M.D.
3706 Atlanta Highway
Suite 3B
Athens, Georgia 30606

Mr. Peden can also be contacted at Jared.Peden@Mail.House.Gov or at (706)-549-9588. I look forward to your prompt response and request that you respond to my office no later than July 2, 2012.

Sincerely,

Paul C Broun MD

Paul C. Broun, M.D.
Member of Congress

Exhibit 19-e

DEPARTMENT OF THE AIR FORCE
WASHINGTON, DC

Office of the Secretary

July 12, 2012

SAF/LL
1160 Air Force Pentagon
Washington, DC 20330

The Honorable Paul Broun
United States Representative
3706 Atlanta Highway, Suite 3B
Athens, GA 30606

Dear Representative Broun:

This is in reply to your recent inquiry on behalf of Mr. and Mrs. Nolan Watson.

Due to the Air Force's obligation to protect personally identifiable information (PII) and differences in e-mail encryption, the Air Force Medical Support Agency (AFMSA) does not receive radiogenic disease claims from the Department of Veterans Affairs' (DVA) Jackson Regional office by e-mail. It does receive facsimiles, mail, and commercial deliveries. AFMSA received Mr. Watson's claim by fax on April 26, 2012, with the claim dated April 27, 2012. The DVA claim was evaluated and a dose reconstruction was performed and AFMSA provided the attached response to the Jackson Regional office on June 8, 2012.

Mr. and Mrs. Watson previously mailed documentation to AFMSA directly. The 12 pages of testimonials included with the subject letter do not change the previous cited findings in the 2001 report. Again, responders were not expected to experience any health effects from their participation in the response to the Palomares accident. The testimonials were forwarded to the Air Force Safety Center's Weapon Safety Division for retention.

AFMSA provided a copy of the attached response (Palomares Nuclear Accident Information) to Mrs. Watson by e-mail on June 25, 2012.

We trust this information is helpful.

Sincerely,

KELLY L. GOGGIN, Colonel, USAF
Chief, Congressional Inquiry Division
Office of Legislative Liaison

Attachments:
1. Response to the DVA for Mr Watson, 8 Jun 12
2. Palomares Nuclear Accident Information, 25 Jun 12

Exhibit 19-f

PAUL C. BROUN, M.D.
10TH DISTRICT, GEORGIA

COMMITTEE ON
HOMELAND SECURITY

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
CHAIRMAN, INVESTIGATIONS AND
OVERSIGHT SUBCOMMITTEE

COMMITTEE ON
NATURAL RESOURCES

Congress of the United States
House of Representatives
Washington, DC 20515–1010

WASHINGTON OFFICE:
2437 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
PHONE: (202) 225–4101
FAX: (202) 226–0776

WEB: BROUN.HOUSE.GOV

June 13, 2013

Mr. Nolan F. Watson
1850 Barrows Grove Rd
Buckhead, GA 30625-1604

Dear Mr. Watson,

In response to your request for assistance, I am happy to report that I have successfully introduced an amendment to House Resolution 1960, the National Defense Authorization Act of 2014.

This Amendment requires that the Secretary of the Air Force submit a report to the Committees on Armed Services of the Senate and the House of Representatives a report on the implementation of the recommendations of the Palomares Nuclear Weapons Accident Revised Dose Evaluation Report that was released in April of 2001 by the United States Air Force. This report is due within 180 days of House Resolution 1960 becoming law.

We will take final votes on H.R. 1960 this Friday. Once the United States Senate passes its version of the National Defense Authorization Act, the bill will go to conference. This is the latest information available. I am here to serve you and I am making every effort to resolve your case to your satisfaction. I will contact you as soon as more information is available.

If you have any questions or concerns, please contact Jared Peden in my Athens District Office located at 3706 Atlanta Highway, Suite 2, Athens, Georgia 30606. You may also contact your caseworker by calling (706) 549-9588.

Thank you for your patience in this matter.

Respectfully Yours,

Paul C Broun

Paul C. Broun, M.D.
Member of Congress

PB/jp
Enclosure: Broun NDAA Amendment

ATHENS
3706 ATLANTA HIGHWAY
SUITE 2
ATHENS, GA 30606
PHONE: (706) 549–9588
FAX: (706) 549–9590

AMENDMENT TO THE RULES COMMITTEE PRINT OF H.R. 1960

OFFERED BY MR. BROUN OF GEORGIA

At the end of subtitle H of title X, add the following new section:

SEC. 1080. REPORT ON IMPLEMENTATION OF THE RECOMMENDATIONS OF THE PALOMARES NUCLEAR WEAPONS ACCIDENT REVISED DOSE EVALUATION REPORT.

Not later than 180 days after the date of the enactment of this Act, the Secretary of the Air Force shall submit to the Committees on Armed Services of the Senate and the House of Representatives a report on the implementation of the recommendations of the Palomares Nuclear Weapons Accident Revised Dose Evaluation Report released in April by the Air Force in 2001.

Exhibit 19-g

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON, DC

6 December 2013

MEMORANDUM FOR DEPARTMENT OF VETERANS AFFAIRS, JACKSON, MS
ATTN: Ms. Gail Berry

FROM: Air Force Medical Support Agency/SG3PB

SUBJECT: Radiation Exposure Estimates for USAF Nuclear Weapon Accident Responders – Palomares, Spain

The Air Force Office of the Surgeon General recently evaluated internal processes for completing ionizing radiation dose assessments for veterans involved in the 1966 USAF incident response at Palomares, Spain. A review was initiated to ensure a conservative and consistent approach was applied to all dose reconstructions for this incident. This office continues to strive toward timely, scientifically-based responses for all health-related veteran claims.

Our review found that approximately 1,600 personnel, including Army, Navy, Air Force, and other US federal employees, were involved at various stages of the response with 1,586 individuals submitting at least one sample for analysis. We have records for 19 USAF veterans who submitted claims since 2001 in association with the Palomares response, with three individual appeals for re-assessment for a total of 22 claims. For several of these claims, dose estimates and subsequent responses involved assistance from the Air Force Safety Center.

A review of these 22 cases indicates inconsistencies in dose assignment over the past 12 years. In some cases, the assigned dose was based on the maximum expected dose as derived from average ambient air monitoring results (311 mrem). A dose value of this magnitude likely applies to the average response participant, but appears to underestimate doses to some individuals. In more recent claims, a detailed dose reconstruction was performed using plutonium (Pu) intake values based on initial and follow-up urine samples. The committed dose to specific organs and/or tissues was then assessed using various modeling protocols based on publications of the International Commission on Radiological Protection (ICRP). Previous assessments from this office varied due to data availability and interpretation, updates to ICRP models, and differences in professional opinion on the appropriate use of multiple data sets (ambient air monitoring vs. urine excretion biomonitoring).

Following a comprehensive review of all data generated from 1966, this office has decided to formally standardize our response methodology for radiation dose inquiries involving Palomares participants. In doing so, we will use a common approach to provide a conservative, i.e. worst case, dose estimate for the veteran to afford him or her the benefit of the doubt. This office will use the following methodology to respond to VA/veteran dose inquiries for Palomares responders:

a. Establish the veteran's presence at the incident site.

b. Perform a review of duties based on historical records and statements provided by the veteran.

c. Review available bioassay data for the veteran and assign an intake value.

(1) If the veteran is a member of the cohort with the highest exposure potential (designated as the "High 26"), use their established intake estimates. The established intakes range from 34,000 to 570,000 picocuries (pCi).

(2) For the remaining responders, define intake as "does not exceed the intake calculated for the least exposed member of the High 26 group." The intake range for this group will be conservatively set at 1,100 to 34,000 pCi.

d. Estimate committed doses for the organ(s) of concern. The primary organs of concern from plutonium exposure are the lung, liver, and bone surface, based on International Commission on Radiological Protection (ICRP) Publication 30 (used by the Nuclear Regulatory Commission and Environmental Protection Agency) and ICRP Publication 68 (used by the Department of Energy and the Defense Threat Reduction Agency). We will provide both ICRP-model results in responses to the VA.

e. If the member does not have a valid urine sample, reconstruct the dose based on similar exposures using their specific duties, if possible. If that is not possible, consider having the member provide a urine sample for analysis using the latest analytical procedures that claim to eliminate or greatly reduce confounding factors such as radioactivity from natural or background sources.

This office, with assistance from the Air Force Safety Center, will reevaluate the 19 claims previously addressed and apply the above methodology to rectify inconsistencies in dose determination. We may request your assistance in identifying claims adjudicated prior to the year 2000 and for which we may not have records on hand.

The AF/SG point of contact is Major Dan Shaw, 703-681-7855 or e-mail at daniel.shaw@pentagon.af.mil.

Rich a. Ash

RICHARD A. ASHWORTH, Col, USAF, BSC
Chief, Bioenvironmental Engineering Branch
Office of the Air Force Surgeon General

cc:
AFSEC/SEWN (Dr. Steven Rademacher)

Exhibit 19-h

MEMORANDUM

TO: The Honorable Paul C. Broun, M.D.

FROM: Mrs. Nona Arp Watson

CC: The Honorable Buck McKeon, Chairman
The House Committee on Armed Services

DATE: March 21, 2014

RE: Questions to Air Force regarding Report on Implementation of the Recommendations of the Palomares Nuclear Weapons Accident Revised Dose Evaluation Report

BACKGROUND INFORMATION

In April 2001, the Palomares Nuclear Weapons Accident Revised Dose Evaluation Report (the "2001 Report") was released by the Air Force. The 2001 Report recommended further actions that the Air Force should take regarding possible radiation exposure to the responders who assisted after the Palomares nuclear accident in 1966. A copy of the 2001 Report (without appendices) is attached as Exhibit 1. Such recommendations included:

> (1) Additional effort is needed to reconcile the estimated intakes and doses derived from the urinary bioassay data with the estimates from environmental measurements. A targeted effort that includes participant activities, participant interviews, urine and other appropriate plutonium analyses using current techniques, medical records review, and modeling should be considered.
>
> (2) The results of this effort should be communicated to responders, veterans organizations, and other interested parties using appropriate information that clearly confirms the conclusions of the original medical evaluation program, recognizes the difficulties in preparing updated intake and dose estimates, and outlines the options for strengthening the estimates.
>
> (3) Further contacts with the Department of Energy . . .

2001 Report, pp. 32-33.

On May 22, 2002, the Air Force Medical Service issued a release (the "May 2002 Release"). A copy of the 2002 Release is attached as Exhibit 2. In the May 2002 Release, the Air Force acknowledged that the "ability to reconstruct doses [of radiation exposure] from urinalysis was confounded by poor data quality." The May 2002 Release also acknowledged that the 2001 Report made "several recommendations, to include further research in some areas, communications with the veterans involved in the clean-ups, and continued interaction with the Department of Energy." In the May 2002 Release, the Air Force Medical Service also stated that "*[e]fforts to implement these recommendations are underway*." (emphasis added).

After May 2002, the Air Force failed to make any efforts whatsoever to implement these recommendations despite representing to the public in its 2002 Release such implementation was underway. No further testing or studies were conducted to determine radiation exposure levels of the responders, no direct communications with veterans or veteran organizations were made, and information available to the public indicates that there was no continued interaction with the Department of Energy.

Given the Air Force's complete failure to implement the recommendations of the 2002 Report for over ten years, in June 2013, The Honorable Paul C. Broun, M.D. of Georgia introduced the Amendment to the Rules Committee Print of H.R. 1960 (the "2013 Amendment"). A copy of the 2013 Amendment is attached as Exhibit 3. The 2013 Amendment required that the Air Force submit a report on its implementation of the recommendations of the 2001 Report.

On December 6, 2013, the Air Force submitted its Report On Implementation of the Recommendation of the Palomares Nuclear Weapons Accident Revised Dose Evaluation Report (FY14 NDAA SEC. 1080A) (the "2013 Report"). A copy of the 2013 Report is attached as Exhibit 4. In the 2013 Report, the Air Force (after initially misstating the conclusion of the 2001 Report) stated that it was not necessary to implement the first recommendation contained in the 2001 Report relating to the further interviewing and testing of those responders to the Palomares accident. The Air Force reasoned that the initial urine samples obtained in 1966 and limited testing thereafter of only selected responders was sufficient to determine compensable exposure levels for all responders even though it had previously (in the May 2002 Release) concluded that the initial urine sample data was of "poor quality" as a result of "sample contamination and limited analytical sensitivity." Thus, the Air Force acknowledged that it did not implement the recommendation and failed to perform any additional interviews or tests of any of responders. It simply relied on admitted "poor" data to support its conclusion that no further action was needed.

As for the second recommendation regarding communications with responders with the results from the further interviews and testing that the Air Force was supposed to conduct, in the 2013 Report, the Air Force stated that it had implemented such recommendation simply by creating a public web site and posting the 2001 Report and a summary of such Report thereon. The Air Force made no effort to contact the responders, though the Air Force has a record of all the responders who were present after the Palomares accident. The Air Force simply concluded that posting the 2001 Report on the Internet was sufficient communication with the responders. *Notably, the 2001 Report is no longer available on the Internet. Sometime in 2012, access to the 2001 Report was taken off the Internet.* As such, no responder could presently review or obtain a copy of the Report.

As requested by your staff, I have listed below several questions to be addressed to the Air Force concerning its 2013 Report. After each question, to provide background and context, certain information pertaining to the question is discussed.

<u>QUESTION 1</u>: THE 2001 REPORT RECOMMENDED THAT FURTHER ACTIONS "SHOULD" BE TAKEN TO DETERMINE RESPONDERS' EXPOSURE LEVELS. IN THE 2013 REPORT, THE AIR FORCE STATES THAT THE 2001 REPORT ONLY RECOMMENDED THAT FURTHER ACTION "MIGHT" BE TAKEN. WHY DID THE AIR FORCE CHANGE THE MANDATE OF THE 2001 REPORT FROM "SHOULD" TO "MIGHT?"

- The 2001 Report recommended that the Air Force *should* take further actions because of the unreliability of the initial urine samples. *See* 2001 Report at p. 32 ("Several future actions *should* be considered to further refine these initial estimates.") (emphasis added); <u>id</u>. Executive Summary at p. ES 2 ([T]he urine results are inconsistent with plutonium's know behavior and *are inadequate by themselves to support meaningful intake and dose evaluations without confirmatory studies,* such as analysis of urine samples now using very sensitive instrumentation, detailed review of participant medical records, participant interviews, and comprehensive assessments based on sound environmental measurements.") (emphasis added).

- In the 2013 Report, the Air Force misrepresents the conclusion of the 2001 Report and states the 2001 Report "offered three recommendations that *might* be taken to improve the estimates of plutonium intake and committed doses." 2013 Report (emphasis added).

- The 2001 Report did not use the permissive, weak suggestion of "might." It clearly stated that the Air Force "should" take further actions, implying by its choice of the word – should – an obligation or duty to take further action.

<u>QUESTION 2</u>: PLEASE EXPLAIN HOW, IN THE 2013 REPORT, THE AIR FORCE CAN BLATENTLY MISREPRESENT THE CONCLUSION OF THE 2001 REPORT?

- The 2013 Report states in pertinent part: "[The 2001 Report] essentially confirmed the overall conclusions from 1968 that adverse health effects would not be expected for responders to the accident." 2013 Report at p. 1.

- *The 2001 Report never made this conclusion.* In fact, in the Conclusion and Recommendation and Executive Summary sections quoted below, the 2001 Report concluded that additional information was needed and recommended that the Air Force take future action to make determinations about actual exposure.

  - Conclusion and Recommendation Section: "Additional efforts are needed to reconcile the results from the urine data with the levels that can be reasonably supported by the environmental data and experience with other exposed people." 2001 Report at p. 32.

  - Executive Summary Conclusion: "[T]he urine results are inconsistent with plutonium's know behavior and are inadequate by themselves to support meaningful intake and dose evaluations without confirmatory studies, such as analysis of urine samples now using very sensitive instrumentation, detailed review of participant medical records, participant interviews, and comprehensive assessments based on sound environmental measurements." *See* 2001 Report at Executive Summary at pp. ES 2-3.

<u>QUESTION 3</u>: THE UNRELIABILITY OF THE INITIAL URINALYSIS DATA WAS THE REASON THAT THE 2001 REPORT RECOMMENDED FURTHER ACTION, INCLUDING FURTHER TESTING, BE TAKEN TO DETERMINE RESPONDERS' EXPOSURE LEVELS. IN THE 2013 REPORT, HOW CAN THE AIR FORCE NOW RELY UPON THE VERY SAME UNRELIABLE URINALYSIS DATA TO REJECT THE RECOMMENDATION IN THE 2001 REPORT FOR FURTHER TESTING?

- In the 2013 Report, the Air Force rejected the recommendations in the 2001 Report to perform additional testing or studying because it "believe[d] existing bio-monitoring information [was] sufficient to reconstruct doses and establish an acceptable upper bound on possible exposures."

- The "existing bio-monitoring information" to which the Air Force refers is the unreliable initial urine samples and further sampling based on such initial urine samples. Thus, the Air Force is stating that further testing is not needed because the prior urinalysis testing was "sufficient." This directly contradicts the Air Force's prior stance on the reliability of such testing.

- The 2001 Report recommends that the Air Force should conduct further testing and studies because of the unreliability of the urine samples. In the 2013 Report, the Air Force rejects such recommendation based upon its assessment of the very same unreliable urine samples.

<u>QUESTION 4</u>: IN 2002, THE AIR FORCE ACKNOWLEDGED THAT THE INITIAL URINE SAMPLES TAKEN AFTER THE PALOMARES INCIDENT WERE OF POOR QUALITY, "MOSTLY AS A RESULT OF SAMPLE CONTAMINATION AND LIMITED ANALYTICAL SENSITIVITY." IN THE 2013 REPORT, HOW CAN THE AIR FORCE RELY SOLELY UPON SAMPLES IT HAS ACKNOWLEDGE ARE OF "POOR QUALITY" TO DETERMINE WHICH RESPONDERS WERE EXPOSED TO THE HIGHEST AMOUNTS OF RADIATION?

- On May 22, 2002, shortly after the 2001 Report was issued, the Air Force Medical Service published the May 2002 Release.

- In the May 2002 Release, the Air Force Medical Service stated: "The Palomares report [the 2001 Report] found that the ability to reconstruct doses from urinalysis was confounded by *poor data quality*, mostly as a result of sample contamination and limited analytical sensitivity." May 2002 Release at p. 1 (emphasis added).

- In the 2013 Report, the Air Force relies upon these same initial urine samples to determine which responders received the highest exposure based on the testing results of the "High 26." *See* 2013 Report ("The Air Force is able to establish an upper bound on possible exposures for response personnel, based on the 'High 26' cohort (considered the highest exposed 26 individuals) using actual bio-monitoring results from a time close to the actual exposures . . .").

- This reliance is misplaced and flawed.

- It is important to understand how these "High 26" were identified. In 1966, the Air Force made a decision to follow up with 422 responders based solely upon the results from the unreliable initial urine samples. It was from the retesting of those responders that the Air Force identified the "High 26."

  - Notably, the Air Force did not resample all the responders who gave initial samples, including the responders whose samples had not provided a test result. For example, 507 out of the total *1,635* initial urine samples did not provide any test result (or 31% of the total samples). None of these responders ever had any test result from their urine samples so it is impossible for the Air Force to know if any of these responders' level of radiation would have equaled or exceeded that of the "High 26" if those responders had been retested.

  - In fact, 65% (83/127) of the initial urine samples taken in January 1966 (the same month of the accident) did not have test results and none of these responders whose urine samples did not have a test result were ever retested to determine if they were in the High 26.

Simple logic would expect those responders present during the initial recovery of the bombs would be more likely to have a higher exposure to radiation, especially those responders who were near the bombs before recovery occurred. However, 83 of these responders who provided an initial urine sample never had any test result and were never retested. Again, based only on the initial urine samples that provided NO RESULT, it is impossible for the Air Force to know if the radiation level of any of these responders who were present during the first couple of weeks after the accident would have equaled or exceeded that of the "High 26."

- o Moreover, not all responders gave an initial urine sample.

- ➢ Despite the complete unreliability of the test results from the initial urine samples, the Air Force solely relied upon such samples to determine which responders to retest in 1967-1968. Only from those retested did the Air Force designate the "High 26." Such process is completely unreliable and completely ignores all responders who were not tested at all and a substantial percentage of responders who were tested but whose urine sample never provided any test results.

- ➢ How can the Air Force say that these 26 had the highest exposure when it did not even have results from almost a third of the responders and it admitted in 2002 that the initial urine samples (from which the Air Force chose certain responders for follow up testing) were of poor data quality?

- ➢ Additional discussions about flaws in the initial urine sampling are discussed below and further support the fallacy of the Air Force's reliance on the "High 26" to make any determinations about any responders' claims with the Veterans Affairs.

<u>QUESTION 5</u>: EVEN PUTTING ASIDE THAT THE AIR FORCE PREVIOUSLY ACKNOWLEDGED IN 2002 THAT THE INITIAL URINE SAMPLING WAS UNRELIABLE, HOW CAN THE AIR FORCE NOW RELY UPON SUCH SAMPLES FOR ITS CONCLUSIONS GIVEN THE APPARENT FLAWS AND UNRELIABILITY OF SUCH SAMPLING?

- The Air Force acknowledges that the data collection cards are the only permanent record of the actual data relating to the initial urine samples generated at the time of the incident. *See* 2001 Report, Appendix E at p. E-3 (relevant portions of Appendix E are attached as <u>Exhibit 5</u>). The information on the data cards was transcribed into a spreadsheet. An example page of the spreadsheet was included in the 2001 Report. See 2001 Report, Appendix B at p. B-12 (relevant portions of Appendix B are attached as <u>Exhibit 6</u>). However, the entire spreadsheet was reproduced in Appendix C to the 2001 Report. Appendix C was not made available to the public; however, a copy of the full spreadsheet contained at Appendix C was obtained through Congressmen Broun's office. A copy of the spreadsheet contained at Appendix C is attached as <u>Exhibit 7</u>. This spreadsheet collects all the data relating to the initial urine samples from the data cards.

- Appendix C listed 1,758 entries indicating 1,635 initial urine samples and 123 nasal swabs. *Nowhere in the 2001 Report or the 2013 Report does the Air Force acknowledge that 507 of the 1,635 initial urine samples did not have a result.*

- Before determining the High 26, the Air Force did not follow up and retest any of the responders whose 507 urine samples did not provide a test result. This represents approximately 31% of all initial urine samples about which the Air Force had no information. *No one knows what the level of radiation of those responders was at that time.*

- Notably, of the 127 initial urine samples taken in January 1966 (the month of the incident), 83 did not have a result. Thus, 65% of the initial urine samples of those present immediately after the incident occurred did not have a result. *See* Summary of January 1966 initial urine samples ("January 1966 Summary") attached as <u>Exhibit 8</u>. Again, before determining the High 26, the Air Force did not follow up and retest any of the responders whose 83 urine samples in January did not provide a test result. *No one knows what the level of radiation of those responders was at that time.*

- Of the 52 first initial urine samples taken in January 1966 (sample numbers in the "200s" that arrived at the lab on January 25, 1966), only TWO (or 4%) had a test result. *See* January 1966 Summary. Notably, the two for which a result was recorded had identical data suggesting that a single data sample was double counted. Moreover, none of these 52 urine samples from January

1966 had a sample date listed on the spreadsheet. *No one knows what the level of radiation of those other 50 responders was at that time.*

- A review of the January 1966 Summary shows that the entries for many of the urine samples taken during that month were missing pertinent information or had obvious errors. For example, 55 of the 127 urine samples taken in January 1966 were missing sample dates. And, one sample date was listed before the accident even occurred. *See* Sample # 1125 on January 1966 Summary (listing sample date as January 12, 1966, five days before the accident occurred).

- Further review of the January 1966 Summary shows that 69 out of 127 of the transit times for the initial samples were over thirty days. Three samples took over 60 days to arrive at the lab. *See* Samples #s 1935, 1943, and 1991 on January 1966 Summary. This delay in testing the urine samples from January 1966 supports the statement in the May 2002 Release that the "urinalysis was confounded by poor data quality, mostly *as a result of sample contamination* and limited analytical sensitivity." May 2002 Release at p. 1 (emphasis added). This is especially true if the relatively short transit times of the urine samples from other months are compared to those of January.

- The relatively low number of samples taken from responders in January also is of grave concern. On January 31, a total number of 680 United States personnel were at the response site. *See* 2001 Report at p. 3. Only 127 samples were taken from those 680 responders. *See* Appendix C; *see also* January 1966 Summary. And, of those 127 samples, only 44 had results. Thus, only about 7% of the responders present in January 1966, the time immediately after the accident, had given urine samples.

- And, the responders from Moron, one of two Air Force bases that sent responders to the site, were even less represented in test results than the entire population. For example, on January 18, 1966, 126 personnel from Moron were sent to the site. *See* 2001 Report at p. 3. Testimony from responders sent from Moron indicates that many more responders were sent from that base in January. However, only six urine samples were collected in January from all the responders sent from the Moron base. *See* January 1966 Summary.

- Moreover, at the time the initial urine samples were obtained, the collector(s) did not obtain any information about the responder's job duties, proximity to the bombs, or the number of days the responder had been at the accident site. If a responder gave a sample on the first day he arrived at the accident site, there was no retesting of that responder if he worked at the site for 2 months. Thus, the initial urine samples provide absolutely no information about where responder was working, how long responder had been present at site when he was tested or how long the responder stayed at site after he was tested.

- In addition to 507 of the urine samples not having test results, it is notable than several of the samples lacked virtually any information whatsoever. *See* Appendix C at p. 19. These samples lacked date received, sample date, test results, base of responder, etc. The only data collected was the amount of urine collected. Despite the complete lack of information, the Air Force relies upon these samples to increase the number of samples taken.

- The initial urine samples lack any indicia of reliability and simply should not form the *entire* basis for the Air Force to decide in 2013 what the compensable level of exposure for the responders should be. The Air Force's reliance on such flawed data is entirely misplaced.

<u>QUESTION 6</u>: IN THE MAY 2002 RELEASE, THE AIR FORCE STATES: "EFFORTS TO IMPLEMENT THESE RECOMMEDATIONS [FROM THE 2001 REPORT] ARE UNDERWAY." PLEASE IDENTIFY ALL EFFORTS MADE BY THE AIR FORCE TO IMPLEMENT THE RECOMMENDATIONS FROM THE 2001 REPORT FOR THE TIME PERIOD BEGINNING IN 2001 UNTIL 2013 WHEN THE 2013 REPORT WAS RELEASED.

- May 2002 Release states: "The reports make several recommendations, to include further research in some areas, communication with veterans involved in the clean-ups, and continued interaction with the Department of Energy. Efforts to implement these recommendations are underway." May 2002 Release at p. 2.

- The Air Force has not revealed any efforts it was making in 2002 or thereafter to implement these recommendations.

- Was this a misstatement? Was the Air Force actually not making any efforts to implement these recommendations?

<u>QUESTION 7</u>: WHY DOES COMPARING A RESPONDER'S LEVEL OF EXPOSURE BASED ON 1966 URINE TEST RESULTS TO THE EXPOSURE LEVELS OF THE "HIGH 26" IN ANY WAY SUPPORT THE CONCLUSION THAT FURTHER BIO-MONITORING IS NOT NECESSARY?

- The Air Force is still relying upon unreliable data to make its decisions on which responders should or should not receive any compensation for injuries possibly caused by radiation exposure.

- If the 1966 data is unreliable, the Air Force should not *solely* rely upon such data to make its decision in 2013 of what level is compensable and that NO FURTHER TESTING IS NEEDED.

- Only further testing will show the actual level of exposure of the responders. This is likely why the 2001 Report recommended that further testing be conducted. The Air Force's conclusion in 2013 that further testing is not needed, which is entirely based upon the unreliable data collected in 1966, is illogical and wrong.

<u>QUESTION 8</u>: GIVEN THAT THE AIR FORCE HAS ADMITTED AND ACKNOWLEDGED THAT PRESENT DAY BIO-MONITORING OF THE SURVIVING RESPONDERS IS FEASIBLE, WHY WILL THE AIR FORCE NOT AGREE TO RETEST ALL THE SURVIVING RESPONDERS TO DETERMINE WHICH ONES WERE EXPOSED TO COMPENSABLE LEVELS OF RADIATION?

- The Air Force admits in the 2013 Report that current bio-monitoring is feasible. *See* 2013 Report ("As part of our most recent reassessment, we considered improved detection sensitivity/selectivity for further bio-monitoring that became available in 2011."). Thus, the Air Force COULD test every surviving responder and get a test result which would indicate that responder's level of radiation exposure in 1966.

- About one third of the responders who gave initial urine samples in 1966 never had a test result from such sampling. Moreover, some responders never gave a urine sample. It is impossible to look at the 1966 data and come to any conclusion regarding these surviving responders. These responders would have to be tested now to determine what their level of exposure was.

- Moreover, those surviving responders who did provide a urine sample in 1966 and whose test result from that time shows a level of radiation below that of the "High 26" should also be retested. As discussed above, a responder could have given a sample on his first day at the site and then remained at the site for days, weeks, or even months. Even if such responder's 1966 sample was uncontaminated, that responder's 1966 test likely would not be an accurate gauge of radiation exposure. These surviving responders should also be retested to obtain accurate, reliable results.

- The number of surviving responders to retest is finite and would not require the testing of thousands of veterans. Most likely, the number of surviving responders is less than 1,000. The Air Force has records identifying all service personnel who responded to the Palomares accident.

- The Air Force never indicates further bio-monitoring would be cost-prohibitive. Given the danger to which the veterans were exposed during their service at the Palomares accident and the possibility of significant health issues relating to such service, the limited costs associated with the testing should not be a consideration in refusing to conduct such tests.

<u>QUESTION 9</u>: THE 2001 REPORT RECOMMENDED THAT THE AIR FORCE COMMUNICATE WITH ALL RESPONDERS, VETERANS ORGANIZATIONS AND OTHER INTERESTED PARTIES ABOUT EFFORTS TO DETERMINE EXPOSURE LEVELS. IN THE 2013 REPORT, THE AIR FORCE STATES THAT IT FOLLOWED THIS RECOMMENDATION BY SETTING UP A WEB SITE POSTING THE 2001 REPORT. PLEASE EXPLAIN HOW SETTING UP A WEBSITE AND MERELY MAKING THE REPORT AVAILABLE WITHOUT ANY DIRECT COMMUNICATIONS WITH VETERANS OR VETERANS ORGANZIATIONS FOLLOWS THE LETTER AND SPIRIT OF THE RECOMMENDATION MADE IN 2001?

- In the 2001 Report, the recommendation was to communicate to "responders, veterans organizations, and other interested parties" the "results of the [further testing/studies] efforts" "using appropriate information that clearly confirms the conclusions of the original medical evaluation program, recognizes the difficulties in preparing updated intake and dose estimates, and outlines the options for strengthening the estimates."

- There is no record that the Air Force ever made any attempt to reach out to ANY responder or veterans organization.

- Posting the 2001 on the Internet is lip service to this recommendation. If the 2001 Report merely wanted the 2001 Report to be made public, perhaps the posting of the Report on the Internet would have complied with such recommendation. But, merely posting the 2001 Report on the Internet is not communicating with the veterans or veterans organizations about potential exposure levels.

- There is no record that any responder has ever received any direct communications from the Air Force about possible health effects due to radiation exposure at the Palomares accident. The Air Force's refusal to communicate to all of the responders indicates that the Air Force DOES NOT WANT these responders to know of the possible adverse health conditions radiation exposure could have caused.

- The Air Force should send a notification to every single Palomares responder that he/she might have been exposed to compensable levels of radiation during his/her response to the Palomares accident.

<u>QUESTION 10</u>: WHY DID THE AIR FORCE TAKE THE 2001 REPORT OFF THE INTERNET (AND THUS MAKE IT INACCESSABLE TO VETERANS AND VETERAN ORGANIZATIONS) SOMETIME IN 2012?

- The second recommendation of the 2001 Report was to communicate with veterans about exposure levels. The Air Force represented that it fulfilled this recommendation by posting the 2001 Report on the Internet.

- However, the Air Force removed the 2001 Report (and the May 2002 Release) from the Internet sometime in 2012. A search for the word "Palomares" on the Air Force (<u>www.af.mil</u>) and Air Force Medical Service (<u>www.afms.af.mil</u>) brings up NO results. Moreover, a Google search for "Palomares Nuclear Accident Revised Dose Report (2001)" does not bring up the 2001 Report. Further Google searches using a combination of relevant words (dose, report, Palomares, etc.) also does not lead a searcher to the 2001 Report. Prior to 2012, these searches found the 2001 Report without any problem.

- It is somewhat unbelievable that the Air Force now can stand by its statement that it made the 2001 Report available to veterans and veterans organizations by making it available electronically on the Internet. Such Report is not available and its absence now indicates that the Air Force is trying to keep the 2001 Report (and the May 2002 Release) from the very veterans and veterans organizations with which it was supposed to communicate.

<u>QUESTION 11</u>: HOW CAN THE AIR FORCE CITE TO THE FACT THAT 120 NASAL SWABS SAMPLES WERE TAKEN IN 1966 TO ASSESS RADIATION LEVELS OF RESPONDERS WHEN THERE WERE ONLY RESULTS FROM 5 OF THOSE SAMPLES?

- In the 2013 Report, the Air Force briefly describes what testing was conducted in 1966 after the Palomares accident. In that regard, the Air Force states that it collected "nasal swab samples from 120 personnel while on site to assess possible intakes of plutonium and the potential effects on health." 2013 Report.

- However, a review of those nasal swaps samples and test results shows that of 123 nasal swabs (not 120) only FIVE had test results. *See* Appendix C. That means that the Air Force had five nasal swap test results from the other 1,600 responders.

- The sampling from the nasal swabs further supports the Air Force's conclusion in 2001 and 2002 that the data collected in 1966 was of poor quality.

Exhibit 19-i

PAUL C. BROUN, M.D.
10TH DISTRICT, GEORGIA

COMMITTEE ON
HOMELAND SECURITY

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
CHAIRMAN, INVESTIGATIONS AND
OVERSIGHT SUBCOMMITTEE

COMMITTEE ON
NATURAL RESOURCES

Congress of the United States
House of Representatives
Washington, DC 20515–1010

WASHINGTON OFFICE:
2437 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
PHONE: (202) 225-4101
FAX: (202) 226-0776

WEB: BROUN.HOUSE.GOV

May 14, 2014

Mrs. Nona Watson
1850 Barrows Grove Rd
Buckhead, GA 30625-1604

Dear Mrs. Watson,

As you are aware my office has been in contact with the Department of the Air Force to assist you with your case. My office has received a response regarding the inquiry made on your behalf.

According to the congressional liaison, the enclosed document is in response to the Palomares inquiry for Mrs. Nona Watson.

I hope the information provided will clarify any questions or concerns you may have. However, in the event you have any further questions about this case or any other federal matter, please do not hesitate to contact me or Beth Blalock at 706-969-1461 or beth.blalock@mail.house.gov.

I appreciate the opportunity to be of assistance.

Sincerely,

Paul C Broun MD

Paul C. Broun, M.D.
Member of Congress

Enclosure
PB/bb

ATHENS
3706 ATLANTA HIGHWAY
SUITE 2
ATHENS, GA 30606
PHONE: (706) 549-0588
TOLLFREE: (855) 549-9500
FAX: (706) 549-0500

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON, DC

MAY 0 9 2014

MEMORANDUM FOR THE HONORABLE PAUL C. BROUN, MD.

FROM: HQ USAF/SG3
7700 Arlington Blvd
Falls Church, VA 22042-5158

SUBJECT: Response to Palomares Inquiry for Constituent, Mrs. Nona Arp Watson

Thank you for the opportunity to respond to this inquiry. Please see the attachment, which addresses the 11 questions raised by your constituent, Mrs. Nona Arp Watson, regarding the December 6, 2013, *Report on Implementation of the Recommendations of the Palomares Nuclear Weapons Accident Revised Dose Evaluation Report (FY14 NDAA SEC 1080A)*. Our intent is to demonstrate that our revised and conservative approach to dose measurement affords the applicable veterans the benefit of the doubt as it pertains to their level of exposure.

I appreciate your interest in this matter and trust this information is helpful.

CHARLES E. POTTER
Brigadier General, USAF, MSC
Assistant Surgeon General,
Healthcare Operations

Attachment:
Response to Questions Submitted by Mrs. Nona Watson

Constituent Questions

Question 1: The 2001 report recommended that further actions "should" be taken to determine responders' exposure levels. In the 2013, the Air Force states that the 2001 report only recommended that further action "might" be taken. Why did the Air Force change the mandate of the 2001 report from "should" to "might"?

Answer: The Air Force Medical Service (AFMS) contracted with Labat-Anderson Inc. to perform a "re-look" of exposure and biological monitoring, which resulted in the Palomares Nuclear Accident Revised Dose Report (2001). While the report was not a mandate on the AFMS, the AF considered every recommendation. Additional information is provided below in Question #6.

Question 2: Please explain how, in the 2013 report, the Air Force can blatantly (sic) misrepresent the conclusion of the 2001 report?

Answer: The following is directly from the Executive Summary of the 2001 report.

> Results
> "The CEDEs estimated from urinary bioassay were judged unrealistically high when compared with estimates prepared for other plutonium exposure cases – persons residing in the Palomares vicinity and Manhattan Project workers. The estimates of plutonium intake and CEDE from inhalation using environmental data measured in Palomares ranged up to no more than about 0.2 rem. Consequently, the estimates from urine analyses are not useful as representative intakes and doses. The detailed evaluations performed for the High 26, Repeat Analysis and Contamination Cutoff Cases represent preliminary estimates that cannot be considered as definitive. Follow-up studies are required to develop credible estimates of dose that are compatible with those calculated from environmental data."
>
> Conclusions
> "Preliminary results calculated for all 26 individuals in the High 26 Cases Group, the 54 individuals in the Repeat Analysis Cases Group, and the 313 individuals in the Contamination Cutoff Cases Group proved unrealistically high. They are inconsistent with those calculated from environmental data and when compared with the experience from exposed workers. Furthermore, the urine results are inconsistent with plutonium's known behavior and are inadequate by themselves to support meaningful intake and dose evaluations without confirmatory studies, such as analysis of urine samples now using very sensitive instrumentation, detailed review of participant medical records, participant interviews, and comprehensive assessments based on sound environmental measurements."

The AFMS interprets the author's intent in these paragraphs as: doses estimated from urinalysis are unrealistically high and inconsistent with expected doses based on environmental data. The author's statement, "*Furthermore, the urine results are inconsistent with plutonium's known* *behavior*..." is provided because plutonium has a long biological half-life and should be retained in the body for numerous years. Extensive studies on the High 26, exhibited non-detectable plutonium in less than two years. The observed excretion pattern did not follow anticipated model for the isotope.

In addition, from 2001 report, Section 5 – Estimates from Environmental Data:

> 5.2 - Results
> "Calculations of intake and dose were performed for three exposure scenarios. The first assumed that response force workers were on site for two weeks, and worked 6 days per week for 12 hours a day. This would represent many of the responders who rotated at two-week intervals. The second scenario used 4 weeks on site under the same work conditions to represent those who stayed somewhat longer. Finally, the last scenario assumed that responders could have been exposed for 11 weeks, which essentially represents the entire response effort; i.e. from just after the accident until March 31, 1966. Those estimates are shown in Table 5 and indicate that even the highest scenario produces much less than 1 rem whole body committed effective dose equivalent."
>
> "The resuspension factors described in Section 3.1 were used to calculate air concentrations, intakes, and doses (CEDE) for the same scenarios described above. The results listed in Table 6 indicate that even the highest dose (0.312 rem) is well below a significant amount. Furthermore, these estimates differ significantly from the intakes and dose estimates derived from urine analysis, and demonstrate the need to refine the analysis with follow-up studies."

Despite the better sampling techniques and dose models of today, the Air Force cannot accurately and efficiently determine specific doses outside the highest exposed (and the most studied) 26 individuals. The AFMS, in considering the above conclusions from the 2001 report, provided a highly conservative (i.e., very high-sided) dose assessment range of 0.31 rem to 10.5 rem based on the application of contemporary models to both environmental and bioassay data from the 1960s. The upper bound of this estimate is a factor of 33 times higher than 0.312 rem, the maximum estimated dose from air sampling data and presence on the site during the duration of the accident recovery. The corresponding upper bounds for critical organ doses will now be 103 rem for the bone surface, 40.6 rem for the lungs, and 4.9 rem for the liver. These are the three primary target organs for plutonium deposition and retention in individuals, based on extensive physiological studies and autopsies performed during animal exposure research and on workers exposed to plutonium. As such, these organs will have the greatest potential for diseases directly attributable to plutonium deposition and retention. This has been borne out in the animal research studies and in human epidemiological studies of workers exposed to plutonium.

Question 3: The unreliability of the initial urinalysis data was the reason that the 2001 report recommended further action, including further testing, be taken to determine responders' exposure levels. In the 2013 report, how can the Air Force now rely upon the

very same unreliable urinalysis data to reject the recommendation in the 2001 report for further testing?

Answer: In 2001, the AFMS determined that additional biomonitoring with a purpose of reconciling the difference between the estimated intakes and doses derived from the urinary bioassay data with the environmental measurements was not necessary. Furthermore, additional biomonitoring was not expected to produce higher dose estimates than those calculated in the 2001 report. As part of our most recent reassessment, we considered improved detection sensitivity/selectivity for further biomonitoring that became available in 2011. While there is some scientific "value" in studying why the air sampling results predict exposures substantially lower than those predicted from the biomonitoring, we believe existing biomonitoring information is sufficient to reconstruct doses and establish an acceptable upper bound on possible exposures. This information can and should be used to provide highly conservative estimate of exposure to responders.

In response to the 2001 contractor report, the USAF originally rejected biomonitoring data as "unrealistically high" and "inconsistent with plutonium's known behavior." Additionally, the prospect of implementing additional biomonitoring in 2001 remained technically unfeasible, so the USAF adopted the environmental sampling data estimates from the 2001 report as the most realistic data for estimating personnel exposures. In spite of this data to the contrary, our revised position today actually includes the "unrealistically high" (and the most studied) biomonitoring data for the High 26 as upper bounds for the USAF responders to the Palomares accident.

Biomonitoring today, though technically feasible, is not expected to confirm a correlation between health outcome and exposure due to low exposure levels. The Air Force is able to establish an upper bound on possible exposures for response personnel, based on the High 26 cohort (considered the highest exposed 26 individuals), using actual biomonitoring results from a time close to the actual exposures and will apply this conservative approach in addressing requests from Veterans Affairs for exposure assessments. This revised conservative approach will afford the veteran with the benefit of the doubt as to the level of exposure.

Question 4: In 2002, the Air Force acknowledged that the initial urine samples taken after the Palomares incident were of poor quality, "mostly as a result of sample contamination and limited analytical sensitivity". In the 2013 report, how can the Air Force rely solely upon samples it has acknowledge (sic) are of "poor quality" to determine which responders were exposed to the highest amounts of radiation?

Answer: The phrase "poor data quality" in context of the 2002 Air Force webpage refers to cross-contamination in many of the early biomonitoring samples. Even in the 1960s reports, cross-contamination is cited numerous times as a direct contributor to "unrealistically high" results. In other words, cross-contamination would only make an individual's biomonitoring results indicate a higher (and not a lower) estimated exposure than actually experienced. The USAF has determined today that even though biomonitoring results seem "unrealistically high" across the board, biomonitoring data should nonetheless be factored into exposure estimates as the best source of data for a highly conservative dose estimate. Based on all the evidence, the High 26 was truly considered the highest exposed group (this was determined through direct comparison of urine sample results). This group also presents, by far, the best data for analysis—they submitted off-site samples through a very controlled process in an uncontaminated environment several months after the exposure, and their samples were analyzed by alpha spectroscopy. It is doubtful anyone outside the High 26 received a dose greater than the least exposed member of this group.

Question 5: Even putting aside that the Air Force previously acknowledged in 2002 that the initial urine sampling was unreliable, how can the Air Force now rely upon such samples for its conclusions given the apparent flaws and unreliability of such sampling?

Answer: Please refer to Question #4 above.

Question 6: In the May 2002 release, the Air Force states: "Efforts to implement these recommendations (from the 2001 report) are underway". Please identify all efforts made by the Air Force to implement the recommendations from the 2001 report for the time period beginning in 2001 until 2013 when the 2013 report was released.

Answer: To address questions as to actions taken on the 2001 report recommendations, AFMSA/SG3PB staff performed an extensive review of all available files and contacted other offices (e.g., Air Force Safety Center, Air Force Technical Applications Center) that were associated with the Palomares incident to include contacting the individual who served as the SG's Health Physics consultant at the time of the 2001 report. AFMS actions taken to address each specific report recommendation are summarized below.

> Recommendation # 1: Consider reconciling the estimated intakes and doses derived from the urinary bioassay data with the estimates from environmental measurements. A targeted effort that includes participant activities, participant interviews, urine and other appropriate plutonium analyses using current techniques, medical records review, and modeling should be considered."

Response: Bids from nationally accredited laboratories for additional biomonitoring were solicited, as well as visits to laboratory experts at Los Alamos National Laboratory. However, the decision was made not to conduct additional testing. The decision to not follow-up with this recommendation was made for two reasons: 1) Limited, if any, further refinement was expected from additional sampling due to detection limits of the technology and the intervening time since exposure, and 2) confounding factors could still exist. For example, the trace presence of uranium in the urine will interfere with the alpha radiation spectrometry, despite the fact these trace amounts of uranium present a negligible health risk for the exposure levels being considered.

> Recommendation # 2: Consider communicating the results of this effort to responders, veterans organizations, and other interested parties using appropriate information that

clearly confirms the conclusions of the original medical evaluation program, recognizes the difficulties in preparing updated intake and dose estimates, and outlines the options for strengthening the estimates.

Response: In May 2002, the AFMS created a public web site and posted the 2001 report along with a summary of the report to widely communicate the results to the general public. The 2001 report did not change the conclusions reached from the initial assessment concluded in 1967. The 2001 report was posted to the afore-mentioned webpage for public access and forwarded to the VA for consideration and distribution as deemed necessary.

Recommendation # 3: Consider further contacts with the Department of Energy (DOE). Comparison with evaluations of their personnel who responded to this accident could provide useful data. The effort should be summarized in a companion document that conveys the details of the project and its potential effects on health in an easily understood manner. The document should be made available to any of the responders who desire a copy.

Response: Few Department of Energy (DOE) personnel directly participated in the cleanup and monitoring efforts. DOE (the Atomic Energy Commission in 1966) did not collect monitoring data; therefore a direct comparison is not possible. The DOE also, for a time, maintained a webpage on the Palomares incident for the general public.

Question 7: Why does comparing a responder's level of exposure based on 1966 urine test results to the exposure levels of the "High 26" in any way support the conclusion that further bio-monitoring is not necessary?

Answer: The Air Force has recently decided to adopt the biomonitoring results for the High 26, although considered "unrealistically high" in the 2001 contractor-prepared report, as highly conservative, upper bounds for all responders.

The AFMS established the Plutonium Deposition Registry Board in 1966 to oversee exposure assessment and biological monitoring. The Board monitored and evaluated exposure assessment activities but suspended efforts in 1968. The AFMS determined little additional information could be gained from continuing the effort as they collected samples from the highest exposed personnel until there was no detectable radioactivity in their urine. The conclusions from the extensive monitoring were summarized by the overseeing physician (and Commander of the Radiological Health Laboratory), Lt Col (Dr.) Lawrence Odland, in an article published in the Journal of Occupational Medicine (July 1968, Volume 10, No. 7) where he stated "*Extensive follow-up studies on the 26 people (portion of the 1,586 personnel monitored with the highest urine readings) over a period of nearly one year supported the conclusion that, based on available methods for estimations of systemic body burden of plutonium following inhalation exposure, not one individual who participated in the Palomares operation demonstrated a systemic long-term retention in amounts exceeding the maximum permissible.*"

Question 8: Given that the Air Force has admitted and acknowledged that present day bio-monitoring of the surviving responders is feasible, why will the Air Force not agree to retest all the surviving responders to determine which ones were exposed to compensable levels of radiation?

Answer: The AFMS does acknowledge that it is now technically feasible to test for plutonium deposition at very low levels in urine without uranium spectrum interference as published by Savannah River National Laboratory in Health Physics Journal, Aug 2011, Vol. 101, No. 2. Despite this relatively new capability, the AFMS remains confident that our revised dose assessment as reported to the HASC (2013 memo) provides a highly conservative dose estimate for responders.

The USAF does not make compensatory determinations. The AFMS provides dose assessments in response to Veteran's Administration (VA) radiation exposure inquiries. The VA makes compensatory determinations based on several factors, including the specific disease, affected organ or tissue, estimated dose to the affected organ or tissue, and the probability the disease was caused by the exposure

Question 9: The 2001 report recommended that the Air Force communicate with all responders, veteran's organizations and other interested parties about efforts to determine exposure levels. In the 2013 report, the Air Force states that it followed up this recommendation by setting up a web site posting the 2001 report. Please explain how setting a website and merely making the report available without any direct communications (sic) with veterans or veterans organizations follows the letter and spirit of the recommendation made in 2001?

Answer: The 2001 report was posted to the afore-mentioned webpage for public access and forwarded to the VA for consideration and distribution as deemed necessary.

Question 10: Why did the Air Force take the 2001 report off the internet (and thus make it inaccessible to veterans and veteran organizations) sometime in 2012?

Answer: The AFMS created a public web site and posted the 2001 report along with a summary of the report that included the following statements, "*The reevaluations, using modern modeling methods, confirmed original conclusions that the exposures were not significant.*" The summary went on to say "*The reports make several recommendations, to include further research in some areas, communication with the veterans involved in the clean-ups, and continued interaction with the Department of Energy. Efforts to implement these recommendations are underway.*"

The USAF determined in 2002 that providing a publicly-accessible webpage would be the best way to openly communicate information on Palomares and to provide introductory comments for the 2001 report for the benefit of interested veterans and citizens. The USAF determined in 2012 that the webpage created more confusion than clarity, as it presented technical information from the 2001 contractor report to the masses without sufficient expert interpretation. Moreover, it brought about the unintended effect of conveying a single contractor report, the 2001 report, as a complete and official Air Force position.

Question 11: How can the Air Force cite to the fact that 120 nasal swabs samples were taken in 1966 to assess radiation levels of responders when there were only results from 5 of those samples?

Answer: From the proceedings of the Plutonium Deposition Registry Board meeting that took place from 26-28 Oct 1966, records indicate that 120 nasal swipes were completed. Of those counted, no detectable activity was noted in 70 samples. The remaining 50 samples were shown to have a range from 1.0 to 337 dpm, mean of 24.4 dpm, standard deviation of 48 dpm and median of 13 dpm. The document was prepared by Dr. L. T. Odland.

In Dr. Odland's paper titled *Bio-Assay Experiences in Support of Field Operations Associated with Widespread Dispersion of Plutonium* (1968), he stated the following:

> "Nasal wipes were not utilized to any significant degree, and over half of those submitted had no detectable activity. In theory, a wipe sample from external nares, having radioactivity on subsequent analyses, provides excellent presumptive evidence of exposure to airborne nuclides. Depending on the amount of activity detected, applicable individuals could be promptly removed from hazardous area. Urine samples from these individuals could then be obtained in a contamination-free environment. However, in practice, a nasal wipe is not always reliable. The procedure must be done properly to be of value. Often the cotton tip is not inserted into the nares sufficiently to contact all mucous surface. Many individuals are very sensitive to nasal probing, and if the corpsman is of lesser rank than the patient, and timid, the entire procedure is likely to be little more than a sham. A further complication is the natural tendency for individuals to insure a clean nose just prior to the wipe. Such blowing action may remove a significant amount of radioactivity."

Nasal wipes were completed as a screening tool simply to determine the possibility of plutonium intake. Analysis of nasal swipes does not produce reliable exposure estimates; urinalysis remains a more useful tool for estimating personnel exposure levels.

Exhibit 19-j

PLAN
  Continue Current Dosage or as directed per Coumadin Clinic Provider.
  Comments: RESULTS AND RTC TO MRS. WATSON.
  Labs:
    PT Profile
    Others:

  Follow-up as directed.
  Return to clinic: 3 WEEKS

/es/ KATHRYN L KOVEN
Clinical Pharmacist
Signed: 11/29/2010 14:13

11/29/2010 ADDENDUM   STATUS: COMPLETED
RESULTS BY OUTSIDE LAB.

/es/ KATHRYN L KOVEN
Clinical Pharmacist
Signed: 11/29/2010 14:13

 LOCAL TITLE: GU-UROLOGY ATTENDING NOTE
STANDARD TITLE: UROLOGY ATTENDING NOTE
DATE OF NOTE: NOV 29, 2010@09:20:19 ENTRY DATE: NOV 29, 2010@09:20:19
      AUTHOR: TERRIS,MARTHA K   EXP COSIGNER:
     URGENCY: STATUS: COMPLETED

67 year old s/p L radical nephrectomy 5/20/2003 for stage T1B renal cell carcinoma. Of note, his nephrectomy was very complicated due to his alkalosing spondylitis. He was noted at that time to have a small contralateral renal mass of indeterminate nature. We have followed it with serial imaging and it has grown consistent with a contralateral renal cell carcinoma. Due to his worsening renal insufficiency and danger of re-exploration, we continued to follow this conservatively. He is now on dialysis and has expressed interest in treatment. We have advised he and his wife that it is unlikely that he would survive surgery and that he could not be positioned for RFA or biopsy safely. They return today with the same questions.

I explained in great detail that since his rib cage was essentially sitting on his pelvic bones in a fixed manner, that we would have to remove several ribs, collapse one of his lungs, and go through his pleural cavity and diaphragm to get to his kidney because of his skeletal deformity. He may not be able to come off of the ventilator postoperatively from such a surgery. We also reviewed the fact that the last time we did a CT scan, the additional fluid hydration pushed him into CHF and this was just a fraction of the fluid shifts to be expected during a major trans-thoracic surgical procedure. I emphasized yet again that he has a very high chance of dying intraoperatively or immediately post-operatively and that I am not willing to risk his life for a tumor that we have been monitoring for 8 years and may take another 8-10 to spread and be a threat to his life. Even if it metastasized within the year, that would provide him a greater life expectency that surgery. The options of embolization of the renal tumors and/or TKIs were discussed again. I believe he and his wife have a grasp of the situation now but I have had this conversation with them before and will probably have to have it again. They would like another CT scan after the holidays and will talk to Heme-Onc about timing of TKI (I suggested waiting until..if ever...he develops evidence of metastatic disease).

They ventilated at length about the fact that he suffered significant radiation exposure during his stay in the military cleaning up the aftermath of a B-52 carrying nuclear warheads in Spain. We discussed that there was no way to prove or disprove his cancer was due to radiation but that renal cell carcinoma has been associated with radiation in other studies and he has no family history or other risk factors so it is as likely as not that his renal cell carcinoma was caused by his active duty radiation exposure.

Entire visit lasted 110 minutes.

Plan: Renal protocol CT morning of Monday Weds or Friday (since he has dialysis those afternoons) in 2-3 months
Follow-up with Heme-Onc to discuss timing of TKI
RTC 3 months

/es/ MARTHA K TERRIS, MD
Physician, Chief of Urology Section
Signed: 11/29/2010 11:22

Receipt Acknowledged By:

11/29/2010 11:32 /es/ WILLIAM M. KITTLE, MD
PRIMARY CARE PHYSICIAN

11/29/2010 12:04 /es/ TERESA A COLEMAN
ATTENDING

* AWAITING SIGNATURE * KOTA,VAMSI

11/29/2010 18:38 /es/ SUSAN NOE, MD
CARDIOLOGY ATTENDING

11/29/2010 14:44 /es/ MAHENDRA K MANDAWAT, MD
CARDIOLOGY ATTENDING

LOCAL TITLE: PRIMARY CARE TELEPHONE NOTE
STANDARD TITLE: PRIMARY CARE TELEPHONE ENCOUNTER NOTE
DATE OF NOTE: NOV 18, 2010@09:39:59 ENTRY DATE: NOV 18, 2010@09:42:05
AUTHOR: PETTY,SATONYA T EXP COSIGNER:

Exhibit 19-k

From: Peter Ricard (pmr1@rittermail.com)
To: nonawatson@bellsouth.net;
Date: Wed, August 22, 2012 1:09:54 PM
Cc:
Subject: Peter Ricard--Palomares Statement

August 21, 2012

To Whom It May Concern:

I am Peter Michael Ricard and I make this statement voluntarily. I was stationed at Moron AB, Spain from July 1964 to December 1967. My highest grade held at that time was Sergeant (E-4). While assigned to the 3973 Headquarters Squadron, Moron AB, I served as a cook at the Moron and San Pablo dining halls.

I was not in the initial cadre ordered to Palomares. I either went in the second or third group. We were flown from Moron AB to Vera, Spain and back in a C-124 aircraft. I was there for a three week TDY. I was quartered in an Army tent. At the time of the Broken Arrow, I had been in the Air Force 34 months and my grade was Airman 1st Class (E-3)

While at Palomares, I was assigned two separate tasks. My initial tasking was to search for the one missing nuclear weapon. This task was performed with several hundred airmen. We would stretch out in long lines and walk and climb the valley where the "experts" thought the fourth weapon might be. We would walk several miles in one direction till noon, at which time a helicopter would bring us bag lunches. After lunch, we would stretch the line out from where end of the line was and moving the line out from that point and return to the point where we began. We covered the entire valley and the foothills in this fashion many times. No weapon was found.

My second assignment was with the U.S. Atomic Energy Commission and their Spanish counterparts. My duty consisted of "operating" a PAC 1S alpha radioactivity detector. I was instructed not to turn on the PAC 1S when we would encounter the local inhabitants; we were not to excite the locals. We took "readings" in the valley as well as on the local farms. We would also "fake" taking reading of their animals. I honestly do not recall anyone recording any readings. It seemed our task was to placate the local natives.

I should state that I had no training with the PAC 1S. All I did was turn it on and off. I had no knowledge of the significance of the readings and the affect on the humans in contact with radioactivity. I can honestly state that I don't even know if the equipment worked properly.

We were not issued any protective clothing during my time at Palomares. All assigned tasks while walking and searching for the weapon and while operating the PAC 1S alpha radioactivity detector were done wearing Air Force fatigues without any protective clothing or respirators or caps of any sort.

During my last night at Camp Wilson I was required to stay in the quarantine tent. I was never required to give a urine sample. I was never examined. I have no idea how much radioactivity I was exposed to during my three weeks at Camp Wilson.

After my return to Moron I never again heard about my service at Camp Wilson. I was never contacted to inquire about my health or any concerns I might have about my tour of duty at Camp Wilson.

I was discharged from the Air Force in December 1967. I later in July 1968 re-entered the Air Force. The Personnel Office was never able to find my personnel file, nor my medical and dental files. I am wondering all these years later if that is just coincidental.

I submit this statement voluntarily. This statement is an honest attempt to state the conditions under which I served while assigned to Camp Wilson, Palomares, Spain.

I have to state that I don't believe we were ever told the truth about the existing threat to our health that existed. They told us there was no danger. I have several conditions today such as diabetes and coronary disease which could possibly be attributed to exposure to plutonium.

I firmly believe that the senior Air Force leadership was ill prepared to deal with the conditions at Palomares and they were not prepared to provide adequate detection and monitoring of nuclear agents.

Respectfully,

PETER MICHAEL RICARD, Major, USAF (Retired) (SSAN: 015-34-6734) (AFSN: 11423350)

Exhibit 19-l

From: "ron mccutchen" <mccutchenron@gmail.com>
To: <nonawatson@bellsouth.net>
Sent: Monday, October 25, 2010 8:07 PM
Subject: Palomares, Spain

To Whom It May Concern:

In Feb 1966 I was ordered to go to Palomares Spain from where I was assigned at Moron AB, Spain to assist in Operation Recovery.

From the time we arrived there until we departed several weeks later we were lied to by our superiors.

We were told there was no danger from radiation (plutonium). We were told there was nothing to worry about, there was no danger.

We were told that we did'nt need any safety equipment. We were never issued protective suits, respiration equipment, gloves, nothing, yet day after day we removed tons and tons of radioactive dirt and

were told that there was no danger.

We were never given a physical. No urine test. No lung x-ray. Nothing.

They did destroy our clothing though, I guess for safety reasons. Or was it to get rid of the evidence?

We were lied to the entire time we were there. They are still lying about it. But we know the truth, all of us, all 1600 of us, we know the truth.

Ronald E. McCutchen
10319 Timbercrest La.
Austin TX 78750
512-627-3767
AF Ser# 18686357

my copIES

OMB Approved No. 2900-0075
Respondent Burden: 15 minutes

Department of Veterans Affairs

STATEMENT IN SUPPORT OF CLAIM

FIRST NAME - MIDDLE NAME - LAST NAME OF VETERAN *(Type or print)*	SOCIAL SECURITY NO.	VA FILE NO.
Ronald R. Howell	[redacted]	C/CSS- 24 798 507

The following statement is made in connection with a claim for benefits in the case of the above-named veteran:

Duties and activities while in radiation risk activity.
When I first arrived I was retrieving parts of the two bombs that broke open and I was exposed to the radiation dust. At the end of each day I was checked for contamination before I went into the contamination showers. After the showers I was rechecked and sometimes had to shower a second or third time until I reached an acceptable reading on the counter.
After the bombs were retrieved and moved off site I then searched for and removed plane parts in the valley and mountains. When that phase was complete the tomato fields had to be cleared. The fields were sprayed with defoliant and we cut down the plants with machetes. The plants were put in shredding machines and then transferred into 55 gallon blue barrels. The barrels were stacked by the beach and then transported to a US Navy ship and sent to the USA.
The tomatoes were frequently served by the field mess to military personnel working in the fields.
I served at this site in Palomares for three months from January - April 1966. I have enclosed additional documentation concerning John S. Chipouras, a fellow veteran who was in Palomares for three weeks during the period I was there. He too has health problems caused by the ionizing radiation exposure that we were subject to.

I have also enclosed additional information regarding the "Broken Arrow".

Copies of many MRI's I have documenting the brain tumor have already been submitted to you. I have been told that this is a very slow growing tumor and it quite likely that I have had it for many years. It was only diagnosed when it significantly affected my hearing.

Additional testimonials:
A1C Nolan F. Watson
A1C Larry L. Slone
A2C Travis E. Quinn
A1C Wayne L. Hughart
Ronald E. McCutchen
A1C Adolph Vasquez

I CERTIFY THAT the statements on this form are true and correct to the best of my knowledge and belief.

SIGNATURE	DATE SIGNED
Ronald R. Howell	2-2-2012

ADDRESS	TELEPHONE NUMBERS *(Include Area Code)* DAYTIME	EVENING
6079 46th Ave. N. St. Petersburg, FL 33709	(727) 403-0770	(727) 547-6987

PENALTY: The law provides severe penalties which include fine or imprisonment, or both, for the willful submission of any statement or evidence of a material fact, knowing it to be false.

NONA - THIS is me. ~~[illegible]~~

~~[illegible]~~

Could send
in this picture with statement

Ronald R Howell

THis is mE
PROTEctive Suits
(white coveRALLS)

Ronald Howell

Protective MAsks/Gloves
(on Top of his head)
cotton gloves

His friend
Willy (doesn't
remember
last name

Exhibit 20

DECLARATION OF JOHN H. GARMAN

1. I am TSgt. John H. Garman (ret.). I was born April 30, 1942.

2. I am submitting this affidavit in support of Victor Skaar's application for disability benefits due to radiation exposure in the vicinity of Palomares, Spain in 1966, in connection with the "Broken Arrow" nuclear disaster. I also wish to describe briefly the history of my claims at the VA and the VA's treatment of my radiogenic disability claims that I have as a veteran of the Palomares nuclear clean-up effort.

3. On September 16, 1960, I enlisted on active duty in the United States Air Force. The report from my general physical upon enlistment was negative for any abnormalities of multiple body systems. My uncorrected distance vision was 20/20, bilaterally.

4. I have no history of cancer in my family.

5. VA records show that, in January 1961, I experienced a sudden onset of tinnitus followed by a single major convulsive episode. The VA's Statement of the Case from August 21, 1981 asserts no other complaints of tinnitus were shown during my service or thereafter.

6. During April and May 1963, I was treated for infectious hepatitis with jaundice.

7. In June 1965, I complained of my eyes tiring easily.

8. In January 1966, I was a 23-year-old Air Policeman in the U.S. Air Force. At the time of the "Broken Arrow" incident in which two planes collided over Palomares, Spain and dropped nuclear bombs onto the Spanish countryside, I was stationed at Morón Air Base in southern Spain.

9. I was sent to the crash site in Palomares by the Air Force and arrived within five hours of the disaster.

10. I received no protective clothing or respiratory equipment during my time at Palomares.

11. At first I was a language interpreter, but then like most, I was assigned to assist other U.S. Air Force personnel in locating and recovering pieces of aircraft wreckage.

12. I was one of the original first responders to discover one of the nuclear weapons that had impacted in a local villager's backyard along with the second weapon which was discovered just outside the village of Palomares. Both of these nuclear weapons were emitting Plutonium radiation from cracks in them. During the remainder of my time at the crash site, I was exposed to high levels of Plutonium radiation.

13. After helping locate the weapons, on the third or fourth day, I began to work as an interpreter for Lt Colonel Hirsch. I would translate what locals said to gather information from eye witnesses.

14. We identified a local fisherman who had seen one of the bombs enter the water and knew where it was located. We went to a local bar around 0500 one morning to speak with him – we had to meet him before he went out fishing for the day – and he offered to guide us directly to it. When we got back and told the General, he did not believe us. Later, it was confirmed that the fisherman had been correct.

15. Throughout this time, we slept on an encampment on the beach at Palomares within yards of one of the bomb craters.

16. After about a week at Palomares, someone scanned me with an Alpha Particle Detector in a tent with showers. I don't remember exactly who the man was, or whether he was military or an Atomic Energy Commission Employee.

17. After the man scanned me, he told me to remove my clothes because my uniform was contaminated and they had to confiscate it. He gave me some sort of coveralls to wear until they could get me another uniform, and told me to scrub myself thoroughly in the showers – which I did.

18. I never received a number reflecting my Alpha Particle Detector reading.

19. I was in Palomares from the morning of January 17, 1966 to the afternoon of January 29, 1966. My Temporary Duty (TDY) voucher confirms this.

20. Since my Air Force exposure to ionizing radiation, I have experienced a series of debilitating health crises, which I believe were caused by my radiation exposure while serving in Palomares in 1966.

21. I was not exposed to ionizing radiation at another time before or after my service at the Palomares crash site in 1966.

22. In 1967, I gave two urine samples that were tested for plutonium content. I gave these a month or two after returning from the crash site, when I was back at Morón AFB. I was not asked for, and did not give, urine samples while at the Palomares site.

23. When I returned from Spain, to the now-decommissioned Chanute AFB in Illinois, I was directed to go to the hospital. While there, I was given a one-gallon plastic bottle to collect urine samples. I was told to return the bottle when I had filled it, which I did. This was in early 1967.

24. I continued to experience neck, chest, and back pain, as well as constant headaches, during my time in the service.

25. In October 1971, I had surgery to remove a lump from my shoulder and, in 1975, another surgery to remove a lump from my lower lip. In 1979, I was evaluated for lumps, again – this time, in my armpits.

26. At the young age of 37, on December 18, 1979, I was diagnosed with bladder cancer -- Stage A, Grade I, transitional cell carcinoma of the bladder.

27. I had surgery to remove my bladder cancer.

28. On September 30, 1980, I retired from active duty with a 100% disability rating for bladder cancer. My general physical for separation from the active service, dated July 1980, was negative for any abnormalities of the chest, neck, liver, ears, or eyes and failed to reference to any lumps, including those removed from my shoulder and lower lip and those detected in my armpits.

29. On October 6, 1980, the VA received my claim for service-connection of multiple conditions, including bladder cancer, skin rash, neck pain, recurrent lumps, chest pains, tinnitus, radiation exposure residuals, and infectious hepatitis.

30. On November 26, 1980, the VA denied my claim on the stated ground that I did not appear in person for my examination, even though I never received notification to appear for an examination. After receiving this notification, I contacted the VA to reopen my claim and schedule a VA examination.

31. On March 2, 1981, I received a VA medical exam where the examiner noted that, after giving a specimen that morning, I passed blood, and left blood stains on my pants. The examiner also noted lymphadenopathy – enlarged lymph nodes – of the left axilla and inguinal areas.

32. On June 15, 1981, a VA rating action reduced service connection for my bladder cancer from 100% from October 1, 1980 to 20% from December 19, 1980.

33. In response, I filed a Notice of Disagreement, which the VA received on July 23, 1981.

34. In August 21, 1981, the VA claimed it reduced my service connected benefits for bladder cancer because of a lack of major residuals in my VA examination. It also denied service-connection for my radiation exposure residuals, skin rash, neck pain, recurrent lump, chest pains, tinnitus, and infectious hepatitis.

35. I filed a substantive appeal, which the VA received October 19, 1981.

36. On January 22, 1982, a VA rating action continued the evaluation of my bladder cancer claim at 20% disability.

37. Concurrently, in February, 19, 1982, I submitted disability benefits claims for tinnitus, momentary loss of eye control, and frequent headaches. Later that year, the VA examined me.

38. On August 19, 1982 the VA acknowledged my headaches were service-connected, as service medical records clearly show the headaches to be chronic in nature and present at my initial VA exam, as well as my separation from service exam. They also granted service-connection for my skin rash, but denied it for my eye issues.

39. A month later, on September 15, 1982, the VA issued a Supplemental Statement of the Case, denying an increase in the 20% evaluation for residuals from my bladder cancer. It also denied my disability benefit claims for: radiation exposure residuals, recurrent lumps, neck pain, chest pain, tinnitus, infectious hepatitis, and an eye disability.

40. In 1983, the Department of the Air Force advised the VA that there was no record of my radiation exposure in their records.

41. On April 14, 1983, the Board remanded my appeal for the collection of further clinical evidence regarding my bladder cancer claim, and ordered that I should receive a special exam to assess my bladder cancer residuals.

42. In an April 26, 1983 letter, Colonel R. B. Graham, Chief of the Radiation Services Division, described the urinalysis results from my 1967 testing as "uncharacteristic of an actual exposure in which case plutonium would persist for many years."

43. In August 19, 1983, I received a VA special urology examination, which found no significant abnormalities. The examiner said, "frankly" malignant-appearing cells were not seen, and diagnosis showed the urine was negative for tumor cells. However, the examiner noted the tendency of the epithelium to binucleoate, a cell mutation often occurring in cancer.

44. On October 17, 1983, the VA issued a Supplemental Statement of the Case upholding its denial to increase my benefits in excess of 20% for bladder cancer residuals.

45. On March 26, 1984, the BVA denied my appeal for disability benefits in excess of 20% for my bladder cancer residuals.

46. On December 3, 2015, I received 100% disability benefits rating for my COPD.

47. On February 24, 2016, the VA received my claim for service connection for radiation exposure residuals and other conditions.

48. In its June 2, 2016 rating decision, the VA refused to increase benefits for my service-connected claims (COPD, bladder cancer, chronic headaches, hemorrhoids, hiatal hernia, lower lip post-operative scar, post-operative back scar, and cheek rash), and denied as not service connected and not subject to compensation my remaining claims (radiation exposure residuals, left elbow bursitis, left wrist condition, lumbosacral strain in my back, cervical spine condition, neck pain, eye disability, tinnitus, bilateral hearing loss, chronic sinusitis, chronic pharyngitis, chest pains, recurrent lumps, infectious hepatitis, sciatica, left arm radiculopathy, right arm ulnar pesthesia).

49. On December 26, 2016, I submitted another application for disability compensation and related benefits for my radiation exposure at Palomares.

50. On December 27, 2016, the VA received my claim of radiation exposure. On December 29, 2016, the VA issued a letter requesting clarification of my claim.

51. On March 18, 2017, the VA considered my claim based on all evidence of record.

52. On March 20, 2017, the VA notified me of its decision to deny my claim for radiation exposure and residuals. Incredibly, it stated "SERVICE CONNECTION FOR RADIATION EXPOSURE RESIDUALS IS DENIED SINCE THIS CONDITION NEITHER OCCURRED IN NOR WAS CAUSED BY SERVICE."

53. Civilian Department of Energy personnel who buried the drums of Palomares dirt in Aiken, South Carolina months after the nuclear disaster are covered by law and eligible for disability benefits, but U.S. military veterans who collected the dirt at the crash site itself, immediately after the release of plutonium, are not.

54. On October 10, 2017 I filed a timely Notice of Disagreement electing de novo review noting that I have experienced bladder cancer, major respiratory problems, and lumps – not only the lumps removed prior to my 1983 denial, but also a major new lump currently in the center of my chest. To the best of my knowledge, I do not recall that the lumps were ever biopsied for evidence of potential radiation exposure.

55. In my October 2017 Notice of Disagreement, I specifically disagreed with service connection for radiation exposure residuals.

56. On November 9, 2018, I spoke with the DRO for clarification.

57. On November 13, 2018, the VA conducted a De Novo Review of my case.

58. On November 13, 2018, the VA issued a Statement of the Case denying service connection for radiation residuals. The VA stated I was seeking re-adjudication of the service connection basis for my service connected disabilities – COPD and residuals of bladder cancer – to have them be due to radiation exposure.

59. In the same November 13, 2018 letter, the VA denied service connection for my recurring lumps due to radiation exposure because the lumps were neither chronic nor incurred in service. It also denied service connection for my bladder cancer due to radiation exposure, because bladder cancer was not listed on C.F.R. § 3.09's presumptive list of conditions.

60. On December 12, 2018, I filed a VA-9 form appealing my November 14, 2018 denial of service connection for lumps resulting from radiation exposure at Palomares.

61. Like so many of my fellow Palomares veterans, my primary concern is that the VA fully recognize the extent to which we were exposed to dangerous ionizing radiation fifty-three years ago, and treat us as our dignity and the law require.

62. In summary, I wish to emphasize that the entire time I was present at the crash site from January 17 to January 29, 1966, I was exposed to high levels of Plutonium which has resulted in numerous medical conditions that continue to impact my quality of life today. I WAS THERE, I WAS EXPOSED, AND I SUFFERED INJURY!

63. Pursuant to 28 U.S.C. § 1746, I declare under penalty of perjury that the foregoing is true and correct. Executed this XX day of February, 2019.

John H. Garman — Feb 15, 2019

JOHN H. GARMAN DATE

Exhibit 21

DECLARATION OF VIRGIL MCDANIEL

1. My name is Virgil McDaniel. I was born on June 11, 1945. I am submitting this declaration to support Victor Skaar's account of the events that took place in the vicinity of Palomares, Spain in 1966, in connection with the "Broken Arrow" nuclear disaster. I also wish to describe medical conditions that were caused by my participation in the Palomares nuclear clean-up effort and the VA's treatment of my radiogenic disability claims.

2. I served in the United States Air Force from October 1963 to September 1967.

3. I was stationed at Torrejon Air Force Base, Spain from July 1965 to September 1967.

4. I was sent to Palomares, Spain driving a truck in a convoy as one of the first responders. I was at Palomares for about 81 days.

5. I was a transportation vehicle operator. I had to drive the troops to the fields, the hills, and the mountains to pick up the fragments and make sure every nut and bolt and tin off the planes was picked up.

6. Though I was not a hazardous materials driver, I also had to drive one of the bombs to a Spanish Air Force Base, San Javier. I drove a two and a half ton truck with the caution lights on, behind a leading truck and in front of a vehicle following in the rear. The bomb was tied down without any kind of radiation protection.

7. We also had to cut the tomato plants and eat the tomatoes. We were in the dark and did not know what was going on – not even the sergeants knew what has happening.

8. I was not tested for anything and I do not remember giving any urine samples. The only time I saw the doctor was after the clean-up in Torrejon to check out a back injury I had suffered while driving in heavy terrain.

9. I did not receive any protective gear. The regular troops were just out there in the open, doing whatever we were told. I wore the same fatigues for days.

10. For the first week, we slept in trucks, buses, or on the ground -- anywhere we could find. After the first week tents were brought in to what we called tent city. We took baths in the sea for a week before we could bathe properly in the shower tents set up later.

11. Some of the guys were sleeping and running around in the craters. There was a big hole where the bomb had fallen. It was right next to where we sleeping.

12. I was healthy and had no health conditions before joining the Air Force.

13. I applied for VA disability benefits in 1986 but was denied. I have a rash that started around 1967 when I got out of the Air Force. The doctors don't know what the cause is. I didn't have the rash when I first came in. I wrote the VA a letter and told them about the incident at Palomares. The VA did not mention Palomares when they denied my claim.

14. I filed an appeal in 2003 and was denied again because my rash was not listed in the discharge examination when I left the Air Force. I have appealed it three times and given up on any further appeals.

15. I have hypertension, heart trouble, heart blockage, diabetes, and knee problems. The VA doctor said both of my knees are bad because I don't stand up straight due to my bad back.

16. I also filed for PTSD relating to my experience at Palomares.

17. Pursuant to 28 U.S.C. §1746, I declare under penalty of perjury that the foregoing is true and correct. Executed this 21 day of February, 2019.

[signature]

Exhibit 22

DECLARATION OF TRAVIS QUINN

1. My name is Travis Quinn. I was born on March 18, 1946. I currently live in Clute, Texas. I am submitting this declaration to describe what I experienced in order to support Victor Skaar's account of the events that took place in the vicinity of Palomares, Spain in 1966, in connection with the "Broken Arrow" nuclear disaster.

2. I served in the United States Air Force from 1963 to 1967.

3. I was stationed at Morón Air Force Base, Spain, from 1965 to 1967.

4. I was sent to Palomares, Spain, on January 17, 1966.

5. I remained at the site for about approximately two months, where I worked in heavily contaminated areas.

6. Our first written orders were issued for approximately 32 days, but our stay was extended when the Spanish government wanted all contaminated produce pulled up and removed from their country.

7. My duties at the site varied extensively. They included guarding the bombs that fell from the B-52, guarding any aircraft wreckage, and removing crops that were contaminated. As this incident unfolded and some sort of order was established, my assignments were to guard where needed and to search for airplane parts throughout the countryside. After that was completed, I was put in the group of airmen removing the tomato crops, putting them into 55-gallon drums and sending them to the United States to be buried.

8. My greatest exposure to plutonium occurred during the guarding of the bombs. We spent 12 hours on each shift. I was told that the radiation coming from the bombs would not penetrate a tissue paper. I had no reason not to believe them; I was an airman and they were my bosses. We were doing as we were ordered, and we didn't have much time or the rank to question what we were assigned to do. We were also concerned about our fellow airmen that had lost their lives because of the crash.

9. When we came back to our tents, we were never checked for any radiation. If there were any machines that could test for radiation, they were never turned on.

10. I never received any type of personal protective equipment while conducting these activities at Palomares.

11. It is hard for me to grasp that the United States government admitted it made a mistake in contaminating the village and the surrounding area of Palomares, continued to test the soil and people of Spain to reassure them that they were safe, and paid them for the loss of their crops, but we American airmen were not treated as well as the people of Palomares.

12. Although I have been lucky compared to some of my fellow airmen, the past 50-plus years of my buddies dying of various cancers has affected me greatly. Just the idea of waiting to be next has put a tremendous strain on my life. Just writing this brings back memories that should have stayed buried.

13. I have not applied for VA benefits related to my exposure at Palomares, because I have been waiting for a ruling on this matter before filing.

14. Pursuant to 28 U.S.C. §1746, I declare under penalty of perjury that the foregoing is true and correct. Executed this 25 day of February, 2019.

Travis Quinn

Exhibit 23

DECLARATION OF ANTHONY D. MALONI

1. My name is Anthony D. Maloni. I was born on October 10, 1944. I am submitting this declaration to support Victor Skaar's account of the events that took place in the vicinity of Palomares, Spain in 1966, in connection with the "Broken Arrow" nuclear disaster. I also wish to describe my medical conditions, which I believe were caused by my participation in the Palomares nuclear clean-up effort, and the VA's refusal to recognize my service connection claim.

2. I joined the United States Air Force on May 18, 1964, and received an honorable discharge on May 12, 1968.

3. On January 20, 1966, I was 21 years old, and was sent to Torrejón Air Force Base, Spain to serve as a teletype operator.

4. Within a day or two of arrival at Torrejón, I was ordered onto a bus bound for Palomares, along with dozens of my fellow airmen. We were one of the first waves of troops who arrived at the crash site.

5. Our superior officers told us that they were going to the crash site and that bombs had been lost, but no one warned us of the potential health consequences of exposure to radioactive plutonium and uranium at the site.

6. My first task was to join crews that were destroying crops in the agricultural fields that were near the village. We walked the fields pulling up stakes, uprooting cabbages, and cutting through tomato fields twice the size of football fields with machetes and loading the plutonium-contaminated vegetables in the backs of trucks.

7. Large pits or holes were dug at various areas in which all the contaminated fruits and vegetables were dumped in and then covered up with lime.

8. The Air Force did not issue us protective clothing or equipment while we worked in the dirt surrounding the crash site, with the exception of a thin surgical mask that we were not required to wear. I wore the mask only briefly because it was uncomfortable and was clear even to us airmen that the only protection it might offer was psychological.

9. My next task was to look for debris from the B-52 bomber and the KC-135 plane that collided in mid-air and were blown apart.

10. Our superior officers required me and the other airmen to stand shoulder-to-shoulder and slowly walk the fields surrounding the crash site to identify irradiated debris from the wreckage. If the debris was small enough, we picked it up with our bare hands.

11. A couple of days later, a shipment of handheld Geiger counters arrived, to our delight. However, when we turned them on, they all went crazy. The officer in charge said that the Geiger counters were useless because the radiation levels were much higher than the

Geiger counters could handle. We were then ordered to put them back in their boxes to be sent back home.

12. About five days later, another shipment of Geiger counters arrived with the ability to detect larger amounts of radiation. These were similar to the ones that people use today to look for coins in the ground. When we turned these Geiger counters on the same thing happened to these as the hand held – readings jumped all over the place. We were told to do the best we can.

13. When we scanned the homes of local Palomares residents, we were instructed to turn off the Geiger counters and only pretend to use them to give the residents peace of mind.

14. When we turned the counters back on, however, they recorded very high levels of radiation.

15. One day on detail looking for debris, we encountered thick smoke and horrible odors. As we continued to work it got much worse. I had never encountered that odor but one of the airmen near me said the smell was diesel fuel.

16. Our group continued to move forward over a large embankment and what we came upon was a burning field that was sprayed with diesel fuel. We were told that the soil was highly contaminated because large parts of the wreckage were previously there.

17. The smoke from the burning field was so thick and acrid, it made me vomit. I have no doubt that what I breathed in that day damaged my lungs and other parts of my body.

18. While at Palomares, like most of the responders I lived in a tent on the beach within sight of one of the impact craters from the dropped bombs, and bathed in the Mediterranean Sea.

19. It took several days for supplies to be delivered to Palomares, and we drank the local water.

20. The Air Force dining mess fed us the tomatoes that had been growing in the irradiated fields, which the Spanish government had demanded that the U.S. Government purchase.

21. While at Palomares, I provided a urine sample. The Air Force did not tell us precisely what the sample was for.

22. I remained at Palomares for approximately a month assisting with the cleanup until I was eventually sent back to Torrejón.

23. At Torrejón I gave urine samples on a monthly basis. At one point, as the doctor collected my urine sample, I asked him if exposure to the radiation would render me sterile. This was one of the rumors that had been circulating among the other responders. I didn't have kids yet, and was terrified of the possible health effects of our exposure.

24. The doctor told me that I should not worry about sterility, but told me that I had a good chance of developing bone cancer or something similar.

25. When I returned to Torrejón, I went back to my position as a teletype operator. One of my assignments involved typing up airmen's results from urine sampling. I saw my own results, and remember being worried, because they appeared to be very high.

26. The Air Force did not provide me with the results from my urine sampling during my service.

27. When I left the Air Force in 1968, I made sure to check that I had been exposed to radiation on my medical discharge exam. This is the only reference to my exposure anywhere in my military medical records.

28. I believe that the Air Force would never have provided me with the results of my urinalysis if I had not submitted a Freedom of Information Act (FOIA) request in March 2017 and then joined a federal FOIA lawsuit brought by Vietnam Veterans of America (VVA). *See VVA, Connecticut State Council of VVA, and Antony Maloni v. Dept. of Defense*, No. 3:17-cv-1660-AWT (D.Conn. filed Oct. 3, 2017).

29. The Air Force did not send me my results until April 2018 – over a year after I submitted my FOIA request and six months after I joined the VVA lawsuit.

30. The government never followed up with me regarding my exposure at Palomares.

31. When I entered the Air Force at 19 years old in 1964, I was a healthy young man from a remarkably healthy family. I am one of ten children, and none of my siblings have faced the health challenges that I describe below.

32. Shortly after returning from Palomares to Torrejón Air Force base, I went to the hospital because I had pain in my back and I was weak, nauseated, and exhausted. I don't remember what exactly it was or if the doctors could even diagnose it.

33. I began developing severe migraine headaches after Palomares and these headaches have never gone away. Some of them last for days and can be truly debilitating. There were times when I had to leave work and stay in my bedroom for a couple of days.

34. In my early 30s, I began to develop autoimmune-related skin conditions like psoriasis and partial alopecia, as well as hay fever and chronic bronchitis, which persist today.

35. I have had high blood pressure since my early 30s, and in my early 60s, I suffered a heart attack, despite trying to remain fit because of my immune system.

36. In 2015, I was diagnosed with arthritis in my neck.

37. In 2018 I caught pneumonia twice, the flu, and I was diagnosed with arthritis in my legs, which has made walking and exercise more difficult.

38. Over a number of years, I have made repeated trips to the dermatologists with rashes so severe that the dermatologist have been giving me internal medicine because I have been in so much pain. I have been taking prescribed medicine for years, but my skin continues to cause me extreme problems and pain.

39. In February 2014, I applied for service-connected disability benefits related to exposure to radioactive plutonium at Palomares.

40. On September 9, 2014, the Boston Regional Office denied my claim, writing that "a review of service records fails to show exposure to ionizing radiation during service."

41. I filed a Notice of Disagreement on August 25, 2015, explaining that I was exposed at Palomares, and had checked the box for radiation exposure on my medical forms when I was discharged from the Air Force.

42. I elected to have a hearing with a Decision Review Officer. The hearing did not take place until January 6, 2017.

43. After the hearing, the VA denied my claim again. I filed an appeal to the Board of Veterans Appeals in September 2017. My appeal is currently pending before the Board.

44. I have done everything in my power to live a healthy life for my wife, my children, and myself. I try to stay in shape. April 1st this year will be 50 years since I gave up smoking. I do not drink, and I have never taken an illegal drug in my life.

45. I am the only one of my ten siblings to suffer from the medical conditions that I described above. I believe that the month that I spent at Palomares breathing in the plutonium-laced air, with absolutely no protection while performing my duties as a member of the United States Air Force has not only permanently compromised my entire immune system, but has caused me extreme pain and suffering over many years, and continues to add on more with each passing year.

46. In concluding, I would like to describe how I feel about Palomares. Over the last 10 years or so I have read a number of articles and watched videos about Palomares and the many different people who have been there, as well as of others who have not been to Palomares, but who are experienced in the science of plutonium and in how the government has handled my and other Palomares veterans' cases.

47. I have learned that each hydrogen bomb that was on the B-52 was on the order of 100 times more powerful than the ones that were dropped on Japan, and that comparisons are unfair because the level of plutonium in the Palomares bombs was so much higher.

48. Further, nuclear experts have reached conclusions that the urine testing done at Palomares and Torrejón was flawed, and the level of plutonium that we breathed was off the charts compared to what the government tests showed.

49. As far as the government's handling the claims is concerned, in my opinion, it would be hard to find someone who could do a worse job. The government threw out a number of urine samples and didn't properly conduct the urine sampling, and now wants to argue that the samples are contaminated and useless. The VA has told veterans like me that they weren't even at Palomares. The worst thing the government has done, though, is not take any measures to properly protect the servicemen at Palomares in the first place, knowing the risks of radiation.

50. Even though what happened at Palomares, which is the biggest non-war nuclear accident in U.S. history, the government continues to reject claims that have been filed without any legitimate reason, with the hope that everybody that was at Palomares will soon be dead.

51. In 2015, U.S. Secretary of State John Kerry signed an agreement with the Spanish foreign minister to clean up the latest contaminated area that was recently found at Palomares. The Spanish government recently found that the shellfish are still dying in the area. This is not surprising, as plutonium is extremely toxic, and takes approximately 24,000 years before it decays.

52. With all that being said and with what you know about Palomares, I would like to pose a question to the court: if your son or daughter was in the military, and the military was looking for volunteers to go to the cleanup site, and the military was going to provide the same surgical mask that they gave us and nothing else, what would you tell them?

53. I am hoping that the VA does the right thing for all the families of the veterans that were there at Palomares.

54. Pursuant to 28 U.S.C. §1746, I declare under penalty of perjury that the foregoing is true and correct. Executed this 26 day of February, 2019.

Anthony D. Maloni