

Evaluation of the Rutenber Database for Impact on Rocky Flats Special Exposure Cohort Eligibility

**Brant Ulsh, Ph.D., CHP, and Jim Neton, Ph.D., CHP
National Institute for Occupational Safety and Health
Office of Compensation Analysis and Support
July 2009**

Summary

In August 2007, the Secretary of the Department of Health and Human Services designated two classes of employees from the Rocky Flats Plant (RFP) for inclusion in the Special Exposure Cohort (SEC). Since that time, there has been a great deal of inquiry as to whether the use of data in epidemiological studies authored by A. James Rutenber, Margaret Rutenber, and their colleagues, as opposed to data from the Neutron Dose Reconstruction Project (NDRP), would result in the inclusion of a great number of workers from RFP in the SEC. Much of the speculation and attention surrounding the Rutenber data has been driven by the print media. *The Rocky Mountain News (RMN)* has published numerous articles that question the validity of relying on the Department of Energy's NDRP data (versus the Rutenber data) to determine eligibility for the RFP SEC [1-6]. This report summarizes the NIOSH evaluation and findings of the comparison of these two data sets (Rutenber and NDRP). Copies of this report have been distributed to the ABRWH, the SEC Petitioners, and publicly displayed on the NIOSH website.

Although media reports have alleged that the data NIOSH uses for dose reconstruction of Rocky Flats Plant (RFP) workers (*i.e.*, the dosimetry records provided by the Department of Energy (DOE), including the (NDRP) are distinct, this is inaccurate. James Rutenber served on the board advising the NDRP at the same time as he was conducting epidemiological studies with Margaret Rutenber. Not surprisingly, there is considerable overlap between the two projects. In fact, the source dosimetry data used by both the NDRP and the Rutenber studies were provided by the Rocky Flats site.

The methods used by the Rutenber team and the NDRP in the estimation of unmonitored neutron dose do differ somewhat. The Rutenber team recognized that it would have been preferable to use the NDRP results in their work; however, the NDRP was not completed until several years after the Rutenber studies. Since NDRP results were not available to the Rutenber team, they had to devise methods to impute neutron doses from combined (neutron plus gamma) penetrating doses. It is here that differences in calculated neutron doses and to whom these doses were assigned arise, inconsequential as they are.

In order to determine whether these differences would result in changes to any individuals' SEC status, NIOSH assessed whether any RFP claimants had positive neutron dose recorded in the Rutenber database that was not indicated in the NDRP. NIOSH has access to the dosimetry files for RFP claimants; therefore we queried the Rutenber and NDRP databases to identify any individuals with positive neutron dose in the former, but not the latter, during the SEC period. We then determined whether or not the individuals had already been included in the SEC and, for those who had not, we applied the criteria for inclusion in the SEC employed by the Department of Labor (DOL) (*e.g.*, at least 250 days of employment in the SEC period, having a qualifying cancer, and having at least 100 mrem of neutron exposure in any given year prior to 1967). This allowed NIOSH to establish how large an impact use of the Rutenber data (in addition to the NDRP data) would have on determining SEC eligibility. DOL is responsible for determining SEC eligibility. However, it is NIOSH's belief that the use of the Rutenber database in addition to the information already used by DOL might result in one additional member to the SEC. NIOSH is confident that this general pattern observed among RFP claimants

would be reflected in the worker population at large. Thus, NIOSH feels comfortable concluding that media claims that use of the Rutenber data would result in upwards of 3,000 workers being added to the SEC are inaccurate.

I. Background

This section provides an overview of (1) the NDRP; (2) the timeline that culminated in the issuance of the NDRP; and (3) the epidemiological studies conducted by the Rutenber team at the Colorado Department of Public Health and the Environment (CDPHE). Articles appearing in the *Rocky Mountain News (RMN)* presented the data used by NIOSH for RFP dose reconstructions (*i.e.*, DOE dosimetry records, including the NDRP) and the data used in the Rutenbers' studies as distinct [1-6]. This is inaccurate. In fact, Jim Rutenber served on the advisory board for the NDRP and used the same source dosimetry data for his studies as were used by the NDRP. Not surprisingly, there is considerable interaction and overlap between the two projects.

An informal medical monitoring program was established for former RFP workers in 1980; this program was formalized as the Medical Monitoring of Former Employees program, and funded by DOE's Office of Occupational Medicine and Medical Surveillance in 1992 [7]. It was recognized early in the history of the medical monitoring program that cooperation among ongoing epidemiological, beryllium, and radiological health programs would be beneficial [8].

The CDPHE submitted a grant application to NIOSH for support of an epidemiologic evaluation of RFP workers, with James Rutenber as lead investigator, on August 9, 1993. The grant application was approved by NIOSH for a five-year contract period beginning September 30, 1993 and ending September 29, 1998. The application acknowledged the MMFE program, described the collaboration between this program and the CDPHE, and proposed, "By working closely with this Rocky Flats program, the research team plans to promote the development of similar dosimetric techniques". The application also recognized issues with past neutron dose estimates, however, and noted that addressing these issues would be "time-consuming and expensive". Therefore, depending in part on DOE's plans for historical dose reconstructions for the RFP workforce, it was proposed that, "the team will explore alternate approaches for making semi-quantitative estimates of radiation exposures and doses. The team will also explore the utility of job exposure matrices for exposure estimates that can be applied to the entire cohort".

The MMFE program was advised by the MMFE Advisory Committee (hereafter referred to as "the Committee"). The Committee included experts in health physics, radiation biology, medicine, epidemiology (including James Rutenber, discussed later in this report), and neutron dosimetry [7]. Although the program originally focused on internal doses received primarily as a result of intakes of plutonium, DOE requested that external dose, and specifically neutron dose, be considered [8]. A former RFP Health Physicist, Roger Falk, identified the neutron dose estimates from the 1950s and 1960s as the weakest part of the external dosimetry estimates for former workers. In 1994, the Committee agreed with Mr. Falk's recommendations that the neutron doses from the 1950s-60s should be re-evaluated, and the NDRP was launched as a subproject of the overall MMFE program [9]. The Committee explicitly endorsed collaboration

between the NDRP and the ongoing epidemiological studies being conducted by Jim Rutenber and his colleagues at the CDPHE [10;11]. A sub-committee devoted to oversight of the NDRP was established in 1995 [11]. In late 1995, the Committee decided that the NDRP should re-evaluate neutron doses that had originally been improperly measured (*i.e.*, re-read neutron films) and develop methodologies to determine unmonitored neutron doses. It was also in late 1995 that concerns about resources available for the NDRP and the rest of the MMFE program began to be expressed [12]. These concerns continued into 1996 [13], and at the beginning of 1997, the Committee decided to discontinue advising the NDRP due to limited resources [14;15]. The Committee apparently reconsidered this decision, as the NDRP was again taken up in 1998 [16]; however, there was continuing concern over competition for resources [17;18]. By mid-2000, re-reading of films was well underway, and the Committee began to consider how to translate the neutron track data into neutron dose estimates [19]; however, there were continuing resource concerns and doubts about whether the NDRP could be completed [20].

It was at this point in 2001, well prior to completion of the NDRP in 2005, that Dr. Rutenber published two papers on his Rocky Flats research [21;22]. He reported to NIOSH on the CDPHE's epidemiologic studies of Rocky Flats workers in 2003 [23]. It is important to note that since the NDRP was not yet complete, the CDPHE team had to devise strategies to estimate neutron doses (as discussed more completely later in this report).

The NDRP apparently turned a corner in 2001, as the Committee recognized the excellent progress that was being made [24]. Around this time, the significant milestones of matching 90,000 films to historical personnel records and re-reading approximately 2/3 of the films were completed [25]. It was also at this time that the Committee concluded that the NDRP "will clearly serve as a model for other DOE facilities and provide reliable dose estimates for workers under the Energy Employees Occupational Illness Compensation Act". The NDRP was nearing completion by the end of November, 2003 [26], and the Committee issued its final recommendations in November, 2004 [27]. The Committee concluded that "The implementation of the dose reconstruction protocol and the statistical interpretation of results were developed using sound scientific methodology". The Committee further recommended that "the neutron doses estimated by the NDRP be included in the final dose of record for affected workers at the Rocky Flats Plant". The NDRP protocol was officially issued in 2005 [28], and the re-evaluated doses were released to NIOSH for use in dose reconstructions under EEOICPA at that time.

On April 4, 2006, Brant Ulsh met with Jim Rutenber to discuss the data that the latter had in his possession from his epidemiological studies at RFP. Dr. Rutenber summarized the format of the data and the architecture of the database, and informed Dr. Ulsh of the sources of his data. According to Dr. Rutenber, the dosimetry data was provided to him by the staff working on the NDRP. Dr. Ulsh determined that his data might be marginally useful to NIOSH as it provided job exposure histories, but NIOSH had a more complete dosimetry data set than did Dr. Rutenber because NIOSH had access to the complete NDRP. NIOSH also later obtained the job history cards for individual workers from DOE that were captured and used in the NDRP. Access to this data diminished the usefulness of the Rutenber job exposure history data, although the worker interviews might still be of marginal value to NIOSH, if they provided information not otherwise captured in NIOSH interviews.

During the evaluation of the RFP SEC petition, the Advisory Board on Radiation and Worker Health (ABRWH) engaged in considerable debate regarding what data sets were appropriate for use. Ultimately, the ABRWH did not accept the results of the NDRP as sufficient for use in dose-reconstruction prior to 1967, and recommended SEC classes as a result. The Secretary of Health and Human Services (HHS) received the Board's recommendation regarding the RFP SEC petition and made the determination to add the following two classes of workers to the SEC:

Employees of the Department of Energy (DOE), its predecessor agencies, or DOE contractors or subcontractors who were monitored or should have been monitored for neutron exposures while working at the Rocky Flats Plant in Golden, Colorado, for a number of work days aggregating at least 250 work days from April 1, 1952, through December 31, 1958, or in combination with work days within the parameters established for one or more other classes of employees in the Special Exposure Cohort.

Employees of the Department of Energy (DOE), its predecessor agencies, or DOE contractors or subcontractors who were monitored or should have been monitored for neutron exposures while working at the Rocky Flats Plant in Golden, Colorado, for a number of work days aggregating at least 250 work days from January 1, 1959, through December 31, 1966, or in combination with work days within the parameters established for one or more other classes of employees in the Special Exposure Cohort.

Because of the way in which these classes were defined, the identification of those workers with the potential for neutron exposure became a critical factor in establishing eligibility for compensation. Both NIOSH and the ABRWH continued to want to compare data from NDRP with that in the Rutenber data sets to ensure that the data used by NIOSH for dose reconstructions and by DOL for determining membership in the SEC was complete. On April 19, 2008, Brant Ulsh of NIOSH met with Margaret Rutenber (Jim Rutenber had passed away by this time) to discuss obtaining the Rutenber data in their entirety, and to discuss ways to compare lists of workers with neutron exposure in her database against the NDRP. They discussed strategies to query her database, but agreed that a follow-up visit to collaboratively generate the appropriate lists of workers and to take possession of the Rutenber data would be required. They also discussed the possibility that workers received neutron exposures in buildings other than those included in the SEC, as had been suggested by reports in the RMN [1-6]. Both Dr. Ulsh and Ms. Rutenber agreed that this was a misinterpretation of the data. While workers may have been officially stationed in other buildings, their duties took them to buildings (included in the SEC) where they received neutron exposure. Dr. Ulsh stated, and still believes, that if workers had recorded neutron exposures, they were included in the NDRP, and therefore in the SEC. Ms. Rutenber again confirmed that the neutron dosimetry data in the Rutenber database came from the records maintained by the Rocky Flats site via the staff of the NDRP. Dr. Ulsh therefore again concluded that since the data for the Rutenber database and the NDRP

came from the same source, there should be minimal discrepancies between the two, but they agreed to test this.

On June 20, 2008, Margaret Rutenber provided NIOSH a list of workers from the Rutenber database whom she believed had positive neutron exposure, but were stationed in buildings other than those included in the RFP SEC petition. NIOSH discovered some problems with this list (it included individuals who did not appear to meet the agreed criteria) that reinforced the need to collaborate to generate the lists, so that everyone involved could agree that the query had captured the group of workers of interest.

On July 8, 2008, Margaret Rutenber provided a second list of workers from the Rutenber database whom she believed had positive neutron exposure, but were stationed in buildings other than those included in the RFP SEC petition. This second list contained several columns of data for which no definition was provided, and it was unclear how the numbers were calculated, therefore NIOSH again requested an interpretation of the data included in this list.

On July 29, 2008, Margaret Rutenber provided an interpretation of the data in her second list via email. She again indicated her agreement that it would be beneficial for NIOSH to come back to visit. The purpose of this trip would be to compare the NDRP with the Rutenber data, and to take possession of the Rutenber data.

Following resolution of legal issues surrounding transfer of the Rutenber data to NIOSH, on February 9, 2009, Dr. Ulsh, along with ABRWH member Mark Griffon and Mutty Sharfi of the ORAU Team, visited Margaret Rutenber. Ms. Rutenber made a presentation on the data and studies, and gave NIOSH a copy of the database containing measured and imputed neutron dosimetry, and some attendant documentation. In discussions during this visit, it was once again confirmed that the actual dosimetry data used in the Rutenber studies were provided by the Rocky Flats site, and were the same dosimetry data used by the NDRP. It was further discussed that the interviews conducted by the Rutenbers with former Rocky Flats workers consisted of discussions with a limited number of individuals with experience in plant operations on the topic of job titles and their potential exposures to radiation and numerous toxic chemicals of interest.

II. Data Sources

Throughout the deliberative process related to the RFP SEC petition, and especially after the SEC classes were established, it has been repeatedly claimed that the Rutenber studies provide a separate source of data, distinct from the NDRP. It has been further suggested that the Rutenber studies should be used as a basis for including workers in the SEC class.

As discussed below, this idea that the Rutenber studies and the NDRP are separate and distinct sources of data is inaccurate. Both the NDRP and the Rutenber studies relied on the same source data – namely, the dosimetry records provided by the Rocky Flats radiation protection department.

NDRP

The NDRP Protocol [28] describes the first source of the dosimetry data used in the study as the neutron dosimetry records:

“There were two primary information sources that were used to identify workers affected by the NDRP. The most directly related source was the neutron dosimetry worksheets. These sheets specifically identified those workers who were assigned neutron-sensitive elements (i.e., neutron films or glass plates).”

In addition to those workers directly monitored for neutrons, a broader net was cast for workers who should be included in the NDRP. These workers were identified through records of the beta-gamma worksheets filled out upon reading beta-gamma films workers wore in plutonium buildings:

“The second source of names was the beta-gamma worksheets for plutonium-related buildings. Only the beta-gamma worksheets from the plutonium production buildings (any building with a number starting with 7) and Buildings 91 and 86, and the combined worksheets for Buildings 21, 22, and 23, were entered into the beta-gamma database. The rosters on the beta-gamma worksheets for these buildings were used to identify workers who would be assigned a notional neutron dose if they were not monitored for neutrons. Beta-gamma worksheets for other buildings were not entered into the database.” [28]

Concern has been expressed especially about whether “roving” workers were adequately accounted for in the NDRP. “Roving” workers were those officially stationed in a non-neutron building, but whose work occasionally took them into neutron buildings; therefore they had the potential to be exposed to neutrons. As described in the NDRP protocol, and as explained by NIOSH, these workers are explicitly included in the NDRP, and therefore the SEC classes:

“A small portion of the total number of neutron worksheets represent[s] the issuance of neutron dosimeters to a few personnel whose home building assignment was a nonplutonium production building, such as Buildings 21, 22, 23, 34, 44, 81, and 86. These individuals primarily worked in non-neutron buildings but were routinely issued neutron dosimeters because they occasionally performed work activities in plutonium production buildings. Some examples of these job descriptions are guards, radiation monitors, technical researchers, and uranium process operators.” [28]

It should be noted that the data used by the NDRP are primary dosimetry records created upon reading the films. This contrasts with the derivative data contained in electronic databases upon transcription of the primary records. In general, there is nothing inherently deficient about derivative databases if the data are entered reliably and correctly. Indeed, this is the type of data most typically available to NIOSH for dose reconstruction. However, when primary data are available and usable, they generally take precedence over derivative data, and certainly are considered more reliable than estimated or imputed dosimetry data. Since the Rutenber studies relied upon imputed neutron dose estimates, it would be difficult to make the case that the

estimates calculated for the Rutenber studies should take precedence over the actual dosimetry results (including the re-reading of over 90,000 original neutron films) used by the NDRP.

Rutenber studies

The CDPHE team constructed their study cohort using Rocky Flats records retrieved from a number of sources, including Los Alamos National Laboratory:

“A database was acquired from LANL that had been maintained for 9,539 production workers who were ever employed at Rocky Flats between 1951 and 1979. This database was originally constructed for the epidemiologic studies of Wilkinson et al. (1987). LANL had updated the vital status for this group through 1993, and had retrieved and coded death certificates for the deceased. This database contained name, maiden name, employee identification number (EID), dates of birth, hire, termination, and death, the date a person was last known to be alive, state of birth, and underlying cause of death coded according to the International Classification of diseases, 9th Revision (ICD-9). This database was reported to be relatively accurate and all fields except the date of death were used in construction of the cohort database.” [23]

For its report [23], the CDPHE obtained employment records directly from the Rocky Flats Personnel Offices. This report provides the following:

“Records for 14,327 former or current workers were obtained from the RFETS Personnel Offices. This file contained name, EID, social security number (SSN), dates of birth, hire, termination and death, last job title, and last-known home address. These data were reported to be of reasonable quality and all fields, except date of death (which was not reliable according to RFETS personnel), were used in construction of the production-era cohort database.

The nine databases that compose the Radiological Health Records System (RHRS) were obtained from the RFETS Radiation Protection Division. These databases were used both to identify workers for inclusion in the production era database and to link dosimetry data to individual workers. Three of these databases contained personnel information, including name, person-ID, SSN, date of birth, sex, last known address, telephone number, dates of hire and termination. Person-ID is a unique personal identification code that was reportedly assigned only once to each employee. This identification code was useful because other personal identifiers such as SSN and EID were sometimes shared by married couples, were assigned to more than one worker, or were inaccurately recorded. Person-ID was the unique identifier used to link personnel data to the radiation databases. The RHRS databases were considered to be of good quality and all fields were used in construction of the production era database.” (page 11)

“In 2000, we matched the cohort database with the radiation dosimetry database maintained by the Radiation Protection Division at RFETS and identified a group of 2,448 production-era workers who were not in the cohort database. These workers had been monitored for radiation exposure, but were not listed in any of the other databases developed for our study.

The group is composed of contractors and Department of Energy employees who performed tasks that placed them at risk for internal and external radiation exposures; for this reason they were added to the production era database.” (page 12)

“Although no historical data exist regarding the specific job tasks performed by contractors, both internal and external radiation dose data exist for most of the contractors.” (page 12)

It was recommended to the CDPHE team that their dose estimates rely on existing dosimetry data, as described in their study protocol:

“The DWG [Dosimetry Working Group] also supported the use of existing external dose data for epidemiologic studies, because they are the best available estimates of doses from external exposures. They suggested, however, that the records for cumulative external doses be corrected for possible errors in neutron dose estimates.” [29]

The CDPHE team acted on this recommendation, and proceeded to obtain dosimetry records from Rocky Flats. The report states as follows [23]:

“Data for external radiation doses came from film and thermoluminescent dosimetry (TLD) badges that measured total body doses from external gamma and neutron exposures. Six separate radiation databases were obtained from the Radiation Protection Division at Rocky Flats. Two databases recorded the external doses measured by personal dosimeters. The first contained quarterly doses recorded from 1991 to 1996 and the second, combined annual doses recorded for individual workers for all exposures occurring before December 31, 1976 and doses for individual workers recorded for variable time periods from January 1, 1977 through December 31, 1990.” (page 12)

“Data for annual external radiation doses were also obtained from LANL for the cohort of 9,539 workers that was established by Wilkinson et al. (1987). These data were compared with data from other sources for quality assurance, and used when external doses were missing from other sources.” (page 13)

A challenge the CDPHE team faced was that for some time periods, doses from both neutrons and gamma were combined into one total penetrating dose number.

“The electronic databases recorded separate doses from gamma photons and neutrons for 1959-1963 and for all years after 1975. For 1952-1958 and 1964-1975, only total penetrating dose—the sum of equivalent doses from gamma photons and neutrons—was recorded electronically.” [23]

Since there were questions about the reliability of the original neutron dose estimates, the CDPHE team had to develop methodologies to split this total penetrating number back into the gamma and neutron components. As noted earlier, the CDPHE team would have preferred to rely on the results from the NDRP; however the NDRP was not at a point where revised neutron dosimetry estimates were available. On consultation with Roger Falk (who was also conducting

the NDRP), the CDPHE team devised a strategy to split the total penetrating dose into gamma and neutron components based on job category and work location; this strategy is described in the next section.

III. Neutron dose estimate methodologies

While the source dosimetry data used by both the Rutenber studies and the NDRP are the same, there are some differences in how these data are used to calculate neutron doses. The Rutenber team recognized that it would have been preferable to use the results of the NDRP; however these were unavailable. The following section describes how the Rutenber team calculated neutron doses, and how the NDRP later calculated neutron doses.

Neutron dose reconstruction project

There are multiple components to the doses calculated in the NDRP. The first component was the re-evaluated neutron films worn by the individual workers. The NDRP re-evaluated over 90,000 films. The second component was notional doses, which the NDRP defined as follows:

“Notional neutron doses are neutron doses that were assigned for periods of time identified as gaps in the worker’s neutron dose timeline.” [28]

The term “gap” was also defined in the NDRP Protocol:

“A gap is defined as a period of time when the worker was not monitored for neutrons or has no recorded dose of neutrons but was monitored for gamma doses in a plutonium related building for that period.” [28]

Buildings with significant neutron potential included: 707, 771, 776, 777, 778, 779, 886, and 991. Some workers from a few other buildings (21, 22, 23, 34, 44, 81, and 86) were included if they were monitored for either neutrons or for beta-gamma exposures in a neutron building.

“The period of the gap was determined from the neutron work-sheet timeline. If more than one building was involved in the period of the gap, determined from the header information on the gamma worksheets for the period of the gap, the gap was divided into segments based on the dates on the gamma worksheets.” [28]

The NDRP methodology made maximum use of an individual’s own dosimetry data to calculate notional doses to cover gaps. The more dosimetry data a worker had (and hence the smaller the gap period), the more heavily his own data weighed in the notional dose calculation. This is the most reliable method for calculating notional doses, as it minimizes the application of population properties to individuals.

Rutenber studies

It was recognized that there were problems with the neutron dose calculations originally performed by the site in the 1950s and 1960s; this was the motivation for conducting the NDRP in the first place [29]:

“Neutron doses have not been accurately measured for workers during the early years of RF operations. Although the Health Effects Department has initiated a program to reconstruct neutron doses for all current employees, these data may not be available for a number of years. Therefore, we will determine the feasibility of using data from the JEM to identify those Job titles, years of employment, and buildings that would be indicative of possible neutron exposure and use these to develop a dichotomous variable (exposed not exposed) for exposure status to assign to subjects in the cohort mortality study and then make detailed neutron dose reconstructions for the subjects in the case cohort studies.”

It should be noted that in the absence of individual neutron dosimetry records, the use of a job exposure matrix (JEM) by the Ruttenber team led to the assignment of neutron dose to *all* members of a job class if *any* member of that job class could have been exposed to neutrons. From an epidemiological standpoint, this is most likely of little consequence since it only affects how the total recorded penetrating dose is subdivided into neutron and gamma components. However, it can have dramatic consequences for constructing a list of individuals who might have been exposed to neutrons.

In the 1990s, there was considerable overlap in the NDRP and the Ruttenbers’ epidemiological studies [29]:

“The RF Health Effects Department has already begun a program to recalculate neutron doses for all workers who are still employed at RF. We will work with them to develop a plan to re-estimate neutron doses for subjects in our studies by counting neutron tracks on old neutron films. This effort may not be completed in time for the epidemiologic studies. If this is the case, we will use the JEM to help identify subjects who had neutron exposures and to develop a simple categorical scale based on any vs. no exposure, for instance.

We will use the JEM to identify the processes and locations that exposed individuals to high neutron doses (such as working around fluorinators), and then job titles will be classified according to whether work was performed near those processes and locations. To do this, floor plans of the buildings will be obtained and the sites of process lines and equipment identified, Floor plans with process lines and measurements for gamma and neutron doses are available in records of Radiation Protection Division gamma and neutron surveys for some years. Also, we will identify the job duties associated with each job title, and determine whether workers tended to work in one place or if they rotated through different locations.”

The Ruttenber team recognized that the best option for calculating neutron doses would be to use the NDRP results; however these were unavailable [29]:

“Although it would be preferable to re-evaluate external and internal radiation doses for all RF workers, this effort would take a number of years to complete and would be costly.

Instead, we will take the following steps in estimating radiation doses for the cohort mortality study...”

Given that completion of the NDRP was still a number of years away in the mid- to late 1990s, the Rutenber team had to devise a method for splitting combined penetrating doses into the neutron and gamma components. Upon consultation with the NDRP staff, the Rutenber team applied rules of thumb based on building and job title to make this split. The split was accomplished by applying ratios and using a job-exposure matrix. It is important to note that this method is superior to many other epidemiological studies, in that it does make use of the individual’s own penetrating dose measurements. However, properties of a group (*i.e.*, job category) are applied to split this number into neutron and gamma components [23].

“Because computer databases for dosimetry have recorded total penetrating doses (the sum of equivalent doses from gamma photons and neutrons) for most workers between 1952 and 1975, it is not possible to directly extract the erroneous neutron doses from the electronic data for these workers. There are electronic records with separate gamma and neutron doses for some workers from 1952 to 1970. Analyses of ratios for accurate gamma and neutron doses between 1968 and 1971 indicate that neutron doses for Building 771 (the site of plutonium fluorination processes) were about two times as high as gamma doses for the years between 1952 and 1966, and one-half as high as gamma doses for the other buildings where neutron exposures occurred during this time period. We used these ratios and data on administrative building assignments and job titles to adjust neutron doses for workers with separate neutron and gamma doses.

We used these adjusted neutron doses and presumably correct neutron doses from 1977 to 1989 to estimate “correction ratios” for total penetrating doses—the ratios of neutron-adjusted total penetrating dose to total penetrating dose for all workers with recorded neutron doses for building 771 (mean of ratios = 1.99, standard deviation [SD] = 0.92), and for other buildings (mean of ratios = 1.13, SD = 0.82). We then used the neutron dose data and the JEM to identify all buildings that had neutron exposures, and computed corrected total penetrating doses by applying the correction ratios to total penetrating dose for the workers in these buildings who did not have separate neutron doses recorded for the years 1952 to 1966.” (page 13-14)

While the source dosimetry data used by both the NDRP and by the Rutenbers’ epidemiological studies were the same, the methods used to calculate neutron doses in the absence of direct neutron dosimetry differed. This was a result of the NDRP not being finished in time for the Rutenber team to use. When compared to the dose estimate methods used in a typical epidemiological study, the method used by the Rutenber team is quite preferable in that it is at least based on each individual’s total penetrating dose data. However, since some degree of imputation based on population properties is necessary to split the penetrating dose into gamma and neutron doses, it was recognized, even by the Rutenber team, that the method employed by the NDRP (direct re-reading of original neutron films) was preferable. It is not scientifically justifiable to give precedence to imputed results over direct neutron dosimetry, regardless of the sophistication of the methodology used to calculate the imputed numbers.

IV. Comparison of Rutenber database and NDRP

There are several fields in the Rutenber database that contain what appear to be neutron doses. These include: RECORD_NEU, NEU_REC PEN, NEU_NEW_ADJPEN2, and NEU_ADJPEN3. NIOSH has made multiple attempts to determine the final neutron dose assigned in the Rutenber database through communications with Margaret Rutenber. In an email dated May 20, 2009, Ms. Rutenber stated:

“Based on Roger Falk's protocol for building 771 we used the ratio as follows:

BLDG = 771,

ADJ_PEN = 2.0* IMP_PEN,

ADJ_NEUT=(2/3)*ADJ_PEN

ADJ_GAMP=(1/3)*ADJ_PEN

For all other BLDG's,

ADJ_PEN = 1.1* IMP_PEN,

ADJ_NEUT=(1/3)*ADJ_PEN

ADJ_GAMP=(2/3)*ADJ_PEN

So based on those ratios the Recorded Pen dose pre 1966 would be multiplied by .666 or .333 depending on the building.”

In a follow-up email dated May 20, 2009, NIOSH requested clarification of the definitions of the NEU_NEW_ADJPEN2, NEU_ADJPEN3, and IMP_PEN fields, but received no reply. Follow-up telephone messages were also unreturned. Since we were unable to determine exactly which field contains the neutron dose applied by the CDPHE team, we took the most expansive view and treated any individual with a nonzero value in RECORD_NEU, NEU_REC PEN, NEU_NEW_ADJPEN2, and NEU_ADJPEN3 as neutron-exposed according to the CDPHE studies. Using these most-inclusive criteria results in a total of 4,163 RFP workers with positive values in these fields prior to 1967 that have no pre-1967 measured or notional neutron dose in the NDRP. Interestingly, there are also 486 individuals listed in the NDRP who are not included in the Rutenber database; NIOSH has no explanation for this. The assignment of neutron dose to 4,163 additional workers is a direct result of the CDPHE team not having access to the original neutron dosimetry records, and the consequent decision to apply neutron dose based on job classes. If any member of a particular job class could have been neutron exposed, then all workers in that job class were assigned neutron dose.

Press reports have suggested that use of the Rutenber data would result in the addition of several thousand people to the SEC class. However, the simple fact that the workers were assigned neutron dose in the Rutenber database would not be sufficient to merit addition to the SEC because there are multiple criteria required by law for membership in the SEC (*e.g.*, at least 250 days of employment in an SEC period, having a presumptive cancer). As well as criteria applied by DOL to determine whether or not individuals meet the SEC class definition (*e.g.*, having a neutron dose equal to or greater than 100 mrem per year, thereby meeting the requirement that an

individual was or should have been monitored for neutrons by current standards). In addition, numerous claimants with no evidence of neutron exposure have already been added to the SEC based on their work in Building 81.

To determine the true impact of the use of the Rutenber data to determine SEC eligibility, NIOSH performed a more detailed analysis of the data using claimant data as comparison. For those claimants who are not already in the SEC class but assigned neutron dose by the CDPHE team, we also examined whether there was any indication of neutron exposure potential in workers' radiation records. These indications could include neutron dosimetry results, records of work in plutonium buildings, reports of incidents which occurred in plutonium buildings, plutonium bioassay results, or lung counts indicating actual or suspected plutonium exposures. There are a total of 100 current claims for RFP workers who are not included in the NDRP prior to 1967, but for whom the Rutenber team imputed pre-1967 neutron doses. Of these 100 claims, 50 individuals are already included in the SEC class, 22 had non-SEC cancers, nine had less than 250 days of employment in the SEC period, four had dose reconstructions with a POC>50%, three individuals' claims were closed because either the employee died with no survivors or the survivors died, and one had a non-SEC cancer but was compensated for beryllium exposure. Thus, for a total of 89 of the 100 claimants with the imputed neutron doses in the Rutenber database, this data can have no impact on the compensation decision. In addition, the imputed annual neutron doses in the Rutenber database are less than 100 mrem for each year in the SEC period for 10 of the remaining 11 individuals. A detailed review of these claimants' dosimetry files was conducted and there is nothing that suggests neutron exposure prior to 1967. That is, there were no neutron dosimetry results, incident reports from a Pu building, Pu bioassay results, or any other evidence indicative of neutron exposure potential. There is one claimant with an annual neutron dose greater than 100 mrem in the Rutenber database, but not in the NDRP. There is no evidence of neutron exposure potential for this individual in his dosimetry files. DOL is responsible for determining whether such evidence is sufficient to add individuals to the SEC. Therefore, with the possible exception of the aforementioned claimant, the use of the Rutenber database in addition to the information already used by DOL would result in no additional members to the SEC. There is every reason to believe that this general pattern observed among RFP claimants based on the Rutenber data would be reflected in the RFP worker population at large. This demonstrates that press suggestions that upwards of 3,000 RFP workers would be added to the SEC by use of the Rutenber database are unsubstantiated.

V. Conclusion

This paper analyzed and compared the methodologies used by two studies, the Rutenber epidemiological studies and the Neutron Dose Reconstruction Project (NDRP), to estimate neutron doses to Rocky Flats workers during the time period of the two established SEC classes (April 1, 1952 to December 31, 1966). The results of this analysis are:

- The idea presented in the press that these studies rely on different records is a misconception. Both the Rutenber and NDRP studies started from the dosimetry records provided by the radiation protection staff at the Rocky Flats site.
- While the CDPHE team clearly expressed their preference to use the NDRP results, these results were not available to the CDPHE team when they were performing their

epidemiological studies. In the absence of the NDRP results, the CDPHE team had to devise a strategy for splitting total penetrating doses into gamma and neutron dose components.

- The method devised by the CDPHE team involved determining which buildings contained neutron source terms that could lead to neutron exposures, and determining which job types could have been exposed in those buildings. There is no disagreement between the Rutenber studies and the NDRP regarding which buildings were “neutron” buildings.
- The CDPHE team assigned neutron doses to all members of a job type if any member of that job type could have been exposed to neutrons. The NDRP relied on primary dosimetry records, constructed detailed individual worker history timelines, and assigned neutron doses to workers if there was evidence of neutron exposure potential in the form of either neutron or beta/gamma monitoring in a neutron building. This difference in methodology led the Rutenber studies to assign neutron doses to 4,163 more RFP workers than did the NDRP. There are also 486 individuals listed in the NDRP who are not included in the Rutenber database; NIOSH has no explanation for this.
- NIOSH determined the impact of using the Rutenber database in addition to the NDRP for determining eligibility for inclusion in the SEC, should a decision be made to do so by DOL. This determination involved a detailed review of the 100 current claims for which the Rutenber studies, but not the NDRP, assigned neutron dose prior to 1967. There was no evidence in any of the dosimetry records associated with these claims to suggest that any of these workers was exposed to neutrons.
- Out of the 100 current claims examined in detail, with the exception of one possible claimant, no additional workers would meet the SEC criteria if the Rutenber database was used to determine SEC eligibility. Claims in the press that thousands of additional workers would be compensated are unsubstantiated.

A copy of this report has been provided to the Department of Labor to inform its decision whether or not to use the Rutenber data for determining SEC eligibility.

VI. Reference List

- [1] L.Frank. Dropping the nuclear ball. Rocky Mountain News . 11-9-2007.
- [2] L.Frank. Feds won't accept exposure data that could help ailing Rocky Flats workers. Rocky Mountain News . 11-24-2008.
- [3] L.Frank. Years after he died, Flats worker a problem for feds. Rocky Mountain News . 12-13-2008.
- [4] L.Frank. Rocky Flats widow still waiting; agency says it's still 'working'. Rocky Mountain News . 12-20-2008.
- [5] L.Frank. Former Flats workers again denied aid. Rocky Mountain News . 1-24-2009.
- [6] L.Frank. Feds to review new Rocky Flats data. Rocky Mountain News . 2-14-2009.
- [7] N.M.Daugherty, R.B.Falk, F.J.Furman, J.M.Aldrich, D.E.Hilmas. Former radiation worker Medical Surveillance Program at Rocky Flats, Health Phys., 80, (2001) 544-551.
- [8] H.B.Spitz, J.Ruttenber, B.D.Breitenstein, E.L.Gillette. Minutes for the September 14, 1993 Medical Monitoring of Former Employees Advisory Committee Meeting. 5-18-1994.
- [9] H.B.Spitz, J.Ruttenber, B.D.Breitenstein, E.L.Gillette. Minutes for the May 18, 1994 Medical Monitoring of Former Employees Advisory Committee Meeting. 8-25-1994.
- [10] H.B.Spitz, J.Ruttenber, B.D.Breitenstein, E.L.Gillette. Minutes for the August 25, 1994 Medical Monitoring of Former Employees Advisory Committee Meeting. 1-18-1995.
- [11] H.B.Spitz, J.Ruttenber, B.D.Breitenstein, E.L.Gillette, T.Borak, D.Hankins. Minutes for the January 18, 1995 Medical Monitoring of Former Employees Advisory Committee Meeting. 12-7-1995.
- [12] H.B.Spitz, J.Ruttenber, B.D.Breitenstein, E.L.Gillette, T.Borak, D.Hankins. Minutes for the December 7, 1995 Medical Monitoring of Former Employees Advisory Committee Meeting. 5-9-1996.
- [13] E.L.Gillette. Executive summary health effects advisory committee meeting May 9, 1996. 5-24-1996.
- [14] T.B.Borak, B.D.Breitenstein, E.L.Gillette, D.E.Hankins, A.J.Ruttenber, H.B.Spitz. Executive summary health effects advisory committee meeting on medical monitoring of former radiation workers at Rocky Flats, September 17, 1997. 10-6-1997.

- [15] T.B.Borak, B.D.Breitenstein, E.L.Gillette, D.E.Hankins, A.J.Ruttenber, H.B.Spitz. Executive summary health effects advisory committee meeting on medical monitoring of former radiation workers at Rocky Flats, January 30, 1997. 3-18-1997.
- [16] T.B.Borak, B.D.Breitenstein, E.L.Gillette, D.E.Hankins, A.J.Ruttenber, H.B.Spitz. Executive summary health effects advisory committee meeting on medical monitoring of former radiation workers at Rocky Flats, March 25, 1998. 4-28-1998.
- [17] T.B.Borak, B.D.Breitenstein, E.L.Gillette, D.E.Hankins, A.J.Ruttenber, H.B.Spitz. Executive summary ORAU/ORISE advisory committee meeting on former radiation worker medical surveillance program at Rocky Flats, April 14, 1999. 4-14-1999.
- [18] T.B.Borak, B.D.Breitenstein, E.L.Gillette, D.E.Hankins, A.J.Ruttenber, H.B.Spitz. Executive summary ORAU/ORISE advisory committee meeting on former radiation worker medical surveillance program at Rocky Flats, November 3, 1999. 4-14-1999.
- [19] T.B.Borak, B.D.Breitenstein, E.L.Gillette, D.E.Hankins, A.J.Ruttenber, H.B.Spitz. Executive summary ORAU/ORISE advisory committee meeting on former radiation worker medical surveillance program at Rocky Flats, April 26, 2000. 4-26-2000.
- [20] T.B.Borak, B.D.Breitenstein, E.L.Gillette, H.B.Spitz, T.Thomas, J.Weaver. Executive summary ORAU/ORISE advisory committee meeting on former radiation worker medical surveillance program at Rocky Flats, January 11, 2001. 1-11-2001.
- [21] A.J.Ruttenber, M.Schonbeck, J.McCrea, D.McClure, J.Martyny. Improving estimates of exposures for epidemiologic studies of plutonium workers, *Occup.Med.*, 16, (2001) 239-258.
- [22] A.J.Ruttenber, J.S.McCrea, T.D.Wade, M.F.Schonbeck, A.D.LaMontagne, M.V.Van Dyke, J.W.Martyny. Integrating workplace exposure databases for occupational medicine services and epidemiologic studies at a former nuclear weapons facility, *Appl.Occup.Environ.Hyg.*, 16, (2001) 192-200.
- [23] A.J.Ruttenber, M.Schonbeck, S.Brown, T.Wells, D.McClure, J.McCrea, D.Popken, J.Martyny. Report of epidemiologic analyses performed for Rocky Flats production workers employed between 1952-1989. 3-3-2003.
- [24] T.B.Borak, B.D.Breitenstein, T.Thomas, J.Weaver. Executive summary ORAU/ORISE advisory committee meeting on former radiation worker medical surveillance program at Rocky Flats, October 31, 2001. 10-31-2001.
- [25] T.B.Borak, B.D.Breitenstein, W.Galke, K.Skrable, J.Weaver. Executive summary ORAU/ORISE advisory committee meeting on former radiation worker medical surveillance program at Rocky Flats, November 13, 2002. 11-12-2003.

- [26] T.B.Borak, B.D.Breitenstein, W.Galke, K.Skrable, J.Weaver. Executive summary ORAU/ORISE advisory committee meeting on former radiation worker medical surveillance program at Rocky Flats, November 12, 2003. 11-12-2003.
- [27] T.B.Borak, W.Galke, K.Skrable, J.Weaver. Advisory committee review of the Neutron Dose Reconstruction Project (NDRP) for Rocky Flats Workers. 11-17-2004.
- [28] R.B.Falk, J.M.Aldrich, J.Follmer, N.M.Daugherty, D.E.Hilmas. Neutron dose reconstruction protocol. ORISE 05-0199. 2-7-2005.
- [29] Colorado Department of Public Health and the Environment. Protocol for the epidemiologic evaluation of cancer and occupational exposures at the Rocky Flats Environmental Technology Site. 6-27-1995.