Needs Assessment for Medical Surveillance of Former Hanford Workers

Phase I - October 1, 1997 Report

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Executive Summary

The Defense Reauthorization Act of 1993, Public Law 102-484, Section 3162 mandates, "The Secretary shall establish and carry out a program for the identification and ongoing medical evaluation of current and former Department of Energy employees who are subject to significant health risks as a result of exposure of such employees to hazardous or radioactive substances during such employment." This needs assessment responds to the cooperative agreement from the Department of Energy (DOE) Request for Application (RFA) soliciting applications for cooperative agreements to Support Medical Surveillance for Former Department of Energy Workers. The RFA calls for a two-phase approach. Phase I is directed at conducting a needs assessment, and Phase II is directed at providing medical surveillance for former DOE workers.

Existing databases were used in this needs assessment to identify the population of workers and to characterize exposures for these workers on the Hanford Site. Review of records, building location and a job-exposure matrix were used to estimate the number of workers exposed to specific hazards. A review of the occupational health literature was used to identify exposures representing an important health hazard resulting in illnesses or health risks and where a medical intervention (specific intervention or notification) would be of benefit to the workers. Analysis of available health outcome data suggests that respiratory hazards (asbestos, welding fumes etc.) and noise are important concerns. In addition, experience among beryllium exposed workers elsewhere supports the need for provision of medical surveillance.

The needs assessment identified 104,770 individuals who worked at the Hanford site during the period of 1943 to 1997. Of these an estimated 91,525 are alive in 1997. Of this population an estimated 27,988 have potential asbestos exposure, up to 15,972 have potential beryllium exposure based on job title with 682 working at jobs and in buildings with potential beryllium exposure, and 35,440 have potential noise exposure. This represents an underestimate because not all subcontractors are believed to be included. Among the limited proportion of the cohort with available health outcome data there are important decrements in lung function and hearing. Spirometry data shows 647 (5.4%) with reduced Forced Vital Capacity (FVC) and 970 (8.1%) with reduced Forced Expiratory Volume in one second (FEV_1). Comparing rates of abnormal FVC among those with possible and probable asbestos exposure VS those unlikely to have asbestos exposure the odds ratio for abnormal FVC were 1.15 and 0.89 respectively. Regarding hearing loss, there are 3,501 with standard threshold shifts, and 2,127 with impairment in the compensable range for hearing loss. These health outcome findings further support the need for provision of medical surveillance for workers exposed to these hazards.

There are many limitations to this approach. The populations are not well characterized with respect to types of exposure, occupational and non-occupational (e.g. smoking), or health outcomes. Approximately 40% of those identified in the databases have no recorded job titles. This results in a likely underestimation of those exposed. In addition, not all of those workers whose job titles suggest possible or probable exposure would have actually been exposed, adding further uncertainty to the estimates. Unfortunately, not all of the databases, most importantly REX (Radiological Exposure System) are yet available for analysis. Despite these limitations, the finding of a substantial number of individuals in the population with respiratory abnormalities and impairment in hearing considered along with the widely recognized hazards of asbestos, beryllium, and noise exposure make the provision of surveillance to this population defensible.

The extent of limitations and uncertainties require that these estimates be viewed cautiously and argue for an iterative process to improve the needs assessment. Such revisions will be based on the availability of additional data and review by the Department of Energy, the medical contractor, Hanford Environmental Health Foundation, Oil, Chemical, and Atomic Workers (OCAW) and others. Additional studies are planned to continue the characterization of the population to exposure hazards such as ionizing radiation, solvents, heavy metals, welding fumes, other respiratory irritants, and metal working fluids. The results of this additional data collection, analyses and of medical surveillance exams will permit us to appropriately target those receiving medical surveillance for asbestos exposure, noise induced hearing loss, and beryllium exposure as well as other hazards identified by our investigations in the near future.

Final estimates of those who should be provided with surveillance (estimated by the number exposed, adjusted for proportion dead (13%), proportion who were solely construction workers (10%), inability to locate (10%), and declining to participate (50%) results in an expected 10,075 asbestos exposed, 12,758 noise exposed and 4,638 beryllium exposed workers who will be eligible and likely to accept medical surveillance. Finally, an approach to medical surveillance is proposed. This approach incorporates risk communication to as many workers as feasible, an annual review of the findings (positive identification of adverse effects) as a means of further justifying the need for surveillance, refining the population of eligible workers, and providing former workers and the Department of Energy a framework for evaluating the program's effectiveness.

I. Introduction

The Defense Reauthorization Act of 1993, Public Law 102-484, Section 3162 mandates, "The Secretary shall establish and carry out a program for the identification and ongoing medical evaluation of current and former Department of Energy employees who are subject to significant health risks as a result of exposure of such employees to hazardous or radioactive substances during such employment." This needs assessment responds to the cooperative agreement from the Department of Energy (DOE) Request for Applications (RFA) soliciting applications for cooperative agreements to Support Medical Surveillance for Former Department of Energy Workers. The RFA calls for a two-phase approach. Phase I is directed at conducting a needs assessment, and Phase II is directed at providing medical surveillance for former DOE workers. The goals of the two phases specified in the RFA are to:

- Identify groups of workers at significant risk for occupational diseases;
- Notify members of these risk groups; and
- Offer these workers medical screening that can lead to medical interventions.

The Department of Energy's Hanford Site has evolved over the last 53 years from a sparsely populated agricultural area into an enormous and complex industrial facility (1). In 1944, construction began in an effort to build the nation's first plutonium production facility. Construction continued into the 1950s as the site became more and more complex. A total of nine nuclear reactors and five nuclear materials reprocessing canyons were built and operated at Hanford. As a result of over 40 years of nuclear materials processing, an enormous amount of high level radioactive and chemical waste has been generated and is now stored at the site. The hazards associated with the site have included heavy metals, solvents, asbestos, beryllium, ionizing radiation, noise, and other safety hazards associated with construction and heavy industry (1-21). The extent of exposure to these hazards has not been adequately measured or recorded in a consistent manner, but it is likely that many workers were sufficiently exposed to warrant medical surveillance for the health effects associated with these hazards.

The purpose of this Phase I project was to evaluate the need for medical surveillance of former Hanford workers, to identify those at significant risk for occupational disease, and to demonstrate the ability to contact former workers in order to provide appropriate notification and/or medical surveillance. These results form the basis for a plan (Phase II) to offer medical surveillance to workers at the Hanford site who are at increased risk for occupationally-related diseases and for whom identification of those exposures or illnesses would be of benefit.

This needs assessment seeks to address four questions posed in a letter dated May 30, 1997 by Dr. Paul Seligman, Deputy Assistant Secretary for Health Studies of DOE. These questions are:

1) Does the report clearly document the need for establishing a medical evaluation and/notification program for the targeted former workers?

2) Is the size of the former worker's target population defined?

3) Are the specific hazards (chemical, physical, radiological) and degree of potential exposure (duration, degree) adequately documented?

4) Are the nature and extent of the health impacts that are anticipated well understood and appropriately characterized?

To address these questions we have organized our methods section and the report to:

1) identify the population of non-construction trade workers at Hanford;
2) identify occupational hazards to which they were exposed;
3) justify the need for medical surveillance based on the exposures; identified or anticipated health impacts;
4) demonstrate the feasibility of contacting former workers; and
5) propose an approach to providing medical surveillance.

II. Methods

A. Human Subjects

All aspects of this needs assessment involving human subjects were reviewed and approved by the institutional review boards at the University of Washington and the site-specific board at Hanford (Pacific Northwest National Laboratory).

B. Available Databases

Identification of the population has required stitching together multiple databases. Since award of the contract we have been working closely with the Department of Energy Headquarters, the local Richland DOE Office, Pacific Northwest National Laboratories, Flour-Daniel Hanford Company, Oil Chemical and Atomic Workers (OCAW) and the Hanford Environmental Health Foundation to identify and gain access to key databases. These databases are characterized, when available, for the following information:

A. Name
B. Purpose
C. Location / owner
D. Number of individuals
E. Years covered
F. Types of data included (personal identifiers, job title, duration, exposures, health outcomes, etc.)
G. Comment on data quality (validity, completeness, reliability etc.)

Each of the databases used or anticipated being used pending access is described below.

Databases Available for Analysis:

Flow Gemini is the Hanford Environmental Health Foundation medical examination and scheduling system. It contains 47,557 workers who have been scheduled for examinations since 1985. Flow Gemini contains exam data for Chemistry, Urinalysis, Hematology, Audiometry, Pulmonary Function, X-ray, ECG, Physical Exams, Immunology, Toxicology, Medical Monitoring Programs, and more. It also contains limited information from the Hanford PeopleCore and HSS systems. Diagnoses were not entered into Flow, and no lab normal values are available to compare test values. Information is not necessarily updated. Addresses and vital status are suspect. Documentation for Flow Gemini is limited. Many of the fields are empty or so sparsely populated as to be of limited value.

REMS is the central repository for Radiation Exposure Monitoring (REMS) at DOE-HQ. It contains 42,874 Hanford workers who have been gathered from the REX Radiological Exposure System. The records cover the years 1985 to 1996, but exposure records for 1985 and 1986 do not correspond to individuals. REMS contains very limited demographic information (i.e., birth year rather than birth date, first initial often instead of first name) and annual dose records. The dose records also have a job code associated with them, but not every exposure corresponds to a person, and not every person has an exposure. Building or job location is not recorded in REMS. Internal dose records were calculated using Annual Effective Dose Equivalent prior to 1993, and Committed Effective Dose Equivalent after.

OHH88 is the source file for the employment history data used to create the cohort for Ethel Gilbert's 1989 mortality study of workers who began working between 1945 and 1986. OHH88 includes 9758 workers who were excluded from the mortality study, bringing the total number of operators to 53,105 and construction workers to 13,740. Because 2,280 workers are included in both the operator and the construction worker files, the total number of individual workers from these files is 64,565. Some of these may be current workers, but the exact number has not yet been determined. Data include personal identifiers, date and place of birth, death year, gender, race, work history dates, job title text, and 1971 Bureau of Census job code. Data is fairly complete with 99.6%, 93.1%, and 94.1% of birth, ethnicity, and gender information available respectively. Work history data includes 531,012 records of which 422,587 contain beginning job date and 88,437 contain end work date. All workers have at least one job code and only 0.1% of the workers have no beginning date for their work history while 14.3% have no ending date.

C. Pending Database Access

Access to databases related to the Hanford site is difficult for many reasons including national security concerns, privacy considerations, protection of human subjects and the costs of access. We have received excellent cooperation from the Department of Energy's Richland Office, Hanford Environmental Health Foundation, Pacific Northwest National Laboratories and Fluor-Daniel Hanford at the site to systematically address these issues. As a result, we have gained access to a sufficient number of databases to provide this initial needs assessment. As discussed elsewhere, the conduct of a needs assessment is an iterative process. We propose to continue these activities during Phase II in order to provide optimal identification of workers who will benefit from surveillance.

Access to three crucial databases has been delayed due to one or more of the following reasons: 1) need for joint University of Washington and local IRB approval; 2) need to secure letters from each of the prime contractors granting access; 3) need to assure compliance with the privacy act; 4) need to negotiate costs of access; and 5) securing approval and execution of a work order to provide the database. As a result access to three key databases for final population enumeration is still pending. These databases are:

The REX Radiological Exposure System maintains and reports individual Hanford worker, subcontractor and visitor radiological records since 1944 (except for some early Westinghouse employees). It is held by Pacific Northwest National Laboratories. REX contains internal dosimetry records, radiation badge readings, and limited demographic information. Access to REX has been approved and we are awaiting execution of the work order to provide access.

PSCR+ (Personal Security Clearance Record) is the Hanford security badging system, held by B & W Protec, Inc. Complete records only go back to 1985 (since the inception of the Central Badging Office). Prior to 1985, each company maintained their own internal badging systems, and the quality and quantity of data dumped into PSCR+ is unknown. There are approximately 100,000 workers, subcontractors and visitors in the system. Perhaps some small number never worked at Hanford.

Hanford PeopleCore is the central repository of human resources data supplied by all the contractor HR systems, held by Lockheed Martin. Demographic information is supplemented by location, company and employment data for prime-contractor employees, subcontractors, vendors and agency personnel.

D. Assembly of Master Database

The OHH88 database was compiled from the OHH88_OP operators data set and OHH88_CO construction workers data set, received from Jeff Buchanan from Pacific Northwest National Laboratories. This data was originally from the REX Radiological Exposure System, and they were the source files for Ethel Gilbert's cohort. This database was combined with the REMS database from DOE-HQ. REMS has social security numbers (SSNs) for 41,614 of the 42,874 records. REMS was then matched with OHH88 and there were 10,342 matches on SSN. This resulted in a database with 97,097 records (64,565 + 42,874 = 107,439 total less the 10,342 matches). The Flow Gemini database from the Hanford Environmental Health Foundation contained 47,557 workers who were former workers, current workers, or had too little job data to address employment status. Of the 14,253 Flow Gemini workers without employment information, 7,836 had no match in OHH or REMS. An additional 7,673 records not found in

OHH or REMS were added for a total of 104,770. An estimate of the number of current workers was made by querying the August 1997 Hanford Employment Directory. This eliminated 13,816 leaving 90,954.

E. Estimation of number of workers currently alive

Gilbert's study of the mortality of Hanford workers (1945-1986) suggests the mortality experience was similar to or even less than that of the general population in the United States (SMR 0.83) (22-26). Based on these results age specific survival rates were calculated for the population used in Gilbert's study (OHH88 database). These survival rates were then applied to the entire cohort in order to estimate the proportion of workers surviving in 1997.

F. Estimation of Exposures

Retrospective estimation of exposures for individual workers has been difficult. To estimate exposures we have:

- Reviewed documents describing hazards on site
- Created a job exposure matrix
- Used building location as a proxy for possible exposure to beryllium.

Pending resources for exposure estimation:

- Employee Job Task Analysis
- Individual Worker Exposure Questionnaire

Occupational History and Exposure Questionnaire

Once workers have been contacted and have signed a consent form to participate in our study, they are sent a follow-up questionnaire eliciting the details of their work history at Hanford, specific information about the hazards to which they were exposed, and what personal protective equipment was used for each job held at the facility. The questionnaire is composed of two parts: Part 1 is the Job History and General Health Form; Part 2 is the Job Specific Information Form. Workers will receive five copies of Part 2 and may request additional copies as needed to complete their job history. As of this report, we are currently piloting the questionnaire. A copy of the questionnaire, cover letter, and reminder postcard is included in Appendices A and B. The results of this questionnaire will be subject to some problems of recall by the study participants. Nonetheless, they will be extremely useful in refining the estimates in the job-exposure matrix and in obtaining building information. The information gained from this questionnaire will be particularly useful in understanding exposure potential in the early years of Hanford operations as none of our industrial

hygienists were on the site prior to the 1980s. Information gathered from questionnaire responses will also be used to assign individual workers to specific medical surveillance programs as will be defined in Phase II.

Employee Job Task Analysis (EJTA) Data

The Hanford Occupational Health Process (HOHP) is developing a systematic hazard-based surveillance program. The identification of hazards is through the employee job task analysis (EJTA). This program will assess hazards for each worker on the site. In a separate project we are validating EJTAs being performed by facility supervisors and industrial hygienists. Although the EJTAs are being done only on current workers, they will provide valuable information regarding exposures by job and building for the more recent decades during which clean-up work has become the primary focus.

Review of documents

Documents cataloguing exposures on the site were reviewed. The documents reviewed include:

- Office of Technology Assessment. Complex Cleanup: The Environmental Legacy of Nuclear Weapons Production. US Congress OTA-O-484. US Govt Printing Office, Washington, DC, 1991.
- Epidemiologic Surveillance Data Center and Office of Epidemiology and Health Surveillance, US Dept of Energy. Epidemiologic Surveillance 1992: Annual Summary for Hanford Site.
- National Research Council. Building Consensus through Risk Assessment and Management of the Department of Energy's Environmental Remediation Program Commission to Review Risk Management in the DOE's Environmental Remediation Program. National Academy Press, Washington, DC, 1994a.
- BEMR. Volume I. Estimating the Cold War Mortgage. DOE, March 1995. DOE/EM-0232.
- BEMR. Volume II. Site Summaries. DOE, March 1995. DOE/EM-0232.
- The Blush Report. Blush SM, Heitman TH. March 1995. Train Wreck along the River of Money: An Evaluation of the Hanford Cleanup. A report for the US Senate Committee on Energy and Natural Resources.
- Building Consensus through Risk Assessment and Management. National Resource Council (NCR), 1994.

- CERE Report. Health and Ecological Risks at the US Department of Energy's Nuclear Weapons Complex: A Qualitative Evaluation. March 1995.
- CERE (Xavier). Inventory of Public Concerns. Xavier University. Draft, 1995.
- Chemical Safety Vulnerability Working Group Report. DOE, September 1994. DOE/EH-0396P. Volume 1 of 3.
- Closing the Circle on the Splitting of the Atom. DOE, January 1995.
- Committed to Results. DOE, April 1994. DOE/EM-0152P.
- Confederated Tribes Reports. Scoping Report. Nuclear Risks in Tribal Communities. Confederated Tribes, 1995.
- Environmental Management 1995. DOE, February 1995. DOE/EM-0228.
- Plutonium Vulnerability Management Plan. DOE, March 1995. DOE/EM-0199.
- Hanford Environmental Dose Reconstruction (HEDR), Technical Steering Panel. Summary: radiation dose estimates from Hanford radioactive materials releases to the air and Columbia River. Richland, WA: HEDR PNNL, 1994
- Hanford Thyroid Disease Study (HTDS), Pilot Study Final Report. Seattle, WA: Fred Hutchinson Cancer Research Center, 1995.
- Archived Industrial Hygiene Records. Richland DOE Office. Reviewed by Kathy Ertell.
- Archived Exposure Records Collected by Field Industrial Hygienists. Richland DOE Office. Reviewed by Kathy Ertell.
- U.S. Department of Energy, Office of Environmental Management. Linking Legacies: connecting the Cold War nuclear weapons production processes to their environmental consequences.

Job-Exposure Matrix

The 73 existing Common Occupational Classification System (COCS) Codes developed by the DOE were examined by our industrial hygienists and grouped within the more broad COCS categories resulting in the development of 42 distinct occupational exposure categories. Each of the occupational exposure categories represents a group of job categories likely to have been exposed to the same hazards at Hanford. A list of the COCS codes included in each category are listed in Appendix B. A job-exposure matrix was then constructed such that an estimate of exposure could be assigned for each of the 42 hazards to each occupational category for each of five decades (1943-1990)

of Hanford operations.

Because the OHH88 database uses census codes rather than COCS Codes for job classifications, the census codes were re-coded by two of our industrial hygienists (KD and KE) so that COCS codes and the occupational exposure groups could be used in all of our analyses. The re-coding scheme is provided in Appendix B.

Due to the lack of quantitative data available, it would be impossible to make quantitative estimates of the intensity of exposure for the matrix at this time. It is possible, however, to make qualitative estimates of the likelihood of exposures in each occupational category for each time period. This was deemed sufficient for the purpose of estimating the number of exposed individuals in an effort to assess the need for medical surveillance. The estimates are based on the training and experience of the industrial hygienists and review of the referenced materials.

A group of four certified industrial hygienists was assembled to develop estimates for the completion of the matrix. (see Appendix D for a list of industrial hygiene staff) Two of these industrial hygienists had had extensive experience at the Hanford site (KE and EB). One had some knowledge of Hanford operations, and some experience doing retrospective exposure assessments of this type, but no experience at the site (KD). The other had extensive experience in the area of epidemiologic exposure assessment, but little familiarity with operations specific to Hanford (NS). Each of the four hygienists were given an opportunity to independently assign qualitative exposure estimates for each hazard to each of the occupational categories for each decade of Hanford operations. Exposure categories were: "probably not exposed" (0), "possibly exposed depending on location and specific tasks" (1), and "probably exposed" (2).

All four industrial hygienists then convened to develop one job-exposure matrix with exposure estimates assigned by group consensus. It should be stressed that the numbers in the matrix are qualitative in nature and are *not* an indication of exposure intensity

Using the job exposure matrix and work history data, the number of workers with possible or probable exposures to each hazard was estimated. The denominator for this estimation was the 78,427 (75%) of the 104,770 with one or more job titles. This permits an estimation of the likely exposures for each worker. Workers were considered exposed for each job title to which they are linked.

Building Information

For some of the hazards, job category will be less predictive of exposure than will building assignment. This is why many of the job categories were assigned a "1" for "possibly exposed" in the job matrix. Workers with the same job title who worked in different buildings might have very different exposures. Thus, we must also consider estimating numbers of exposed individuals by location rather than by job.

Unfortunately, the only database that we have obtained to date that contains any information about building assignment is Flow Gemini. We have used Flow Gemini to identify workers in specific buildings in order to construct populations of workers exposed to targeted substances. Due to the limitations of Flow Gemini, it is difficult to reach conclusions regarding total numbers of people exposed as a result of building assignment based on this database alone. We plan to use REX, which we expect to contain a more complete work history information, including building assignment, to more accurately identify those who have worked in buildings of concern. Another source for this information will be an individual exposure questionnaire (Appendix B).

G. Estimates of Need for Medical Surveillance

The Federal Register notice put forth the goals as:

1. Identify groups of workers at significant risk for occupational diseases;
2. Notify members of these risk groups; and
3. Offer these workers medical screening that can lead to medical interventions.

Based on these goals the hazards on the site were reviewed to identify which ones met both the criteria of having the potential to cause occupational illness and lead to beneficial medical interventions. For hazards for which we have adequate data, medical literature on occupational hazards and potential surveillance programs was reviewed to provide a justification for medical surveillance for former workers exposed to noise, asbestos, and beryllium. As additional exposures are characterized, it is likely that medical surveillance will be justified for some of those exposures.

The term medical surveillance is used in the context of this report to include identification of workers at an increased risk, provision of medical screening, provision of recommendations to the worker for further testing, treatment, workers compensation when appropriate, preventive measures, and a summary of findings and recommendations to DOE to assist them with future hazard

reduction. In many cases (e.g. beryllium and asbestosis), periodic monitoring for latent diseases is anticipated, but not included in the proposed estimates at this time.

Analysis of Health Outcome Data

The Flow Gemini database contained health outcome data. These data were reviewed to identify outcomes which may point to adverse effects which are related to past occupational exposures. The data reviewed include pulmonary function and audiometry results. Future analyses will also include blood screening tests (lead, mercury, liver function tests, and renal function).

Pulmonary Function

Pulmonary function (spirometry) results were evaluated with descriptive statistics. Using the percent predicted for FVC and FEV1, and absolute ratio of FVC and FEV1, the percent abnormal (< 80%) was calculated as was the distribution by pattern of abnormality (normal, obstructive, restrictive,) (27). Data on the reliability of measures acceptability of tracings as per the American Thoracic Society's standards were not available. Abnormal spirometry results were identified using the prediction equations of Knudson, and the following definitions: normal was defined as FVC $\geq$ 80%, $FEV_1/FVC \geq 0.7$; restrictive ventilatory defect was defined as $FEV_1/FVC \geq 0.7$, and FVC < 80%; obstructive ventilatory defect was defined as $FEV_1/FVC < 0.7$ and FVC $\geq$ 80%; mixed obstructive/restrictive defect was defined as $FEV_1/FVC < 0.7$ and FVC < 80% (27).

To assess the potential for the abnormalities to be associated with job titles with asbestos exposure, the proportionate ratio of percentage abnormal by trade to expected percent abnormal for the entire cohort (based on the average percentage of those less than 80% predicted for FVC and FEV_1) was calculated for those jobs in the job–exposure matrix with no, known or suspected asbestos exposure.

Audiometry Data

Audiometry data was analyzed to calculate the number of workers with a standard threshold shift (STS) and age-adjusted STS and the number with compensable impairment as defined by the Washington State Department of Labor and Industries which manages workers compensation for the Hanford Site. In addition, to assess whether the pattern of loss was similar to that seen in noise-induced hearing loss (high frequency) the mean loss for those with greater

than two tests and whole body impairment or STS was calculated for frequencies 500 through 4000 HZ (28).

Whole Person Impairment is calculated using the Washington State Department of Labor and Industries guidelines based on American Medical Association guidelines as follows. Hearing levels for 500, 1000, 2000, 3000 Hz over 100 or below 0 dB were recoded to 100 and 0 respectively. Percent monaural hearing impairment is then computed by summing of 500 through 3000 Hz hearing levels with any sum over 368 recoded to 368 dB, divided by 4 and multiplied by 1.5%. Binaural hearing impairment is 5 times the monaural impairment for the worse ear plus the monaural impairment of the better ear divided by 6. Whole Person Impairment is then determined according to a table which converts from binaural hearing impairment.

STS was computed by subtracting the mean hearing level for 2000, 3000, 4000 Hz for the first test from the mean of the last test for each. A mean loss of 10 dB in either ear is considered as a STS. Age adjustment was performed as allowed, but not required, by the Occupational Safety and Health Administration (28).

Based on the number of workers identified and alive, their job titles, and (for beryllium) their job location, an estimate of the number of workers who should be eligible for medical monitoring was made. Based on the data obtained from the pilot mailings, estimated survival rates, interest in participating and ability to locate, these estimates are adjusted to reflect the likelihood that a worker will request an evaluation.

H. Locating Former Workers

Determining the location of former workers is a crucial step in delivering medical surveillance. If workers cannot be located, they cannot be contacted for notification of potential exposures and medical surveillance cannot be delivered. In our pilot project, we have learned about the locating process from other researchers who have been successful in this activity, especially the Fred Hutchinson Cancer Research Center in Seattle, Washington, which offers a tracking resource service for researchers attempting to locate "lost" study subjects. We have evaluated and tested some of the Center's methods to see which work best for locating former DOE workers.

Locating former Hanford workers on the lists generated from the Flow Gemini database has been done using a variety of methods. Special care was taken to ensure that current workers were not included in the former worker rosters; names were screened against a roster of current workers. The roster of current workers was provided by Lockheed Martin Hanford Company and is updated on a monthly basis.

Our Phase I location of workers used readily available resources: regional phone directories on compact disc, the Social Security Death Index, reverse directories, postal change of address, county records, and historical records. Our goal was to determine the feasibility and utility of these inexpensive, easily accessible resources for location of former DOE workers.

Our first step in locating former Hanford workers was to check the names and last known addresses through current phone directories for the Pacific Northwest region. In our pilot projects we have found that approximately 35% of located workers were found through this initial screening step. Many Hanford workers appear to have stayed in the area after retirement or termination from Hanford. In fact, approximately 75% of located former Hanford workers in our Phase I projects were found in the local TriCity area, comprised of the towns of Kennewick, Pasco, Richland, and outlying rural communities within a twenty mile radius such as Benton City, Prosser, and Grandview.

Phone directory searches were used to locate subjects who have moved outside the local area as well. Although this is more difficult because no identifiers are included in phone directories, it can sometimes produce good results. We have found the most success with this method when the person's birthplace is known, as people often relocate to their home state or town at some point in their lives. We have also had some success in searching states where other DOE sites are located, as many DOE workers leave one site and go to another.

If potential matches were found in the phone directory searches, a confirmation phone call was made to ensure that the person located was indeed the former worker for whom we were looking. Confirmation was made by asking the person to confirm their date of birth and that they were Hanford workers. The confirmation step could also be done by letter. In any case, confirmation of correct identity is absolutely essential since there are often several potential matches for any name and address.

If initial phone directory searches were not successful, the Social Security Death Index (SSDI) was the next resource used. If the former worker's Social Security number is known, this resource can be used to determine whether workers are deceased. The Fred Hutchinson Cancer Research Center currently uses the SSDI as one method of tracing study subjects. In their recent experience, approximately 3% of "lost" study subjects were found to be deceased. Since a relatively high proportion of former Hanford workers are of retirement age, as compared to the general population from whom the Center's population was drawn, we considered that our rate of deceased former workers may also be higher. In one of our Phase I pilot projects, we found that out of 262 former workers selected from a database as being potential beryllium workers,

35 workers (13%) were deceased. This pilot project list was composed of people who had worked in processes during the 1950s-1980s, so older age groups were well represented.

We feel it is best to determine vital status fairly early in the locating process, since contacting the families of deceased workers may cause discomfort and suffering for them. However, because people who have died within the last year will not be found in the Social Security Death Index, and names and Social Security numbers derived from databases may be inaccurate, some contact with the families of deceased workers is inevitable, and must be handled with tact and discretion.

If initial phone directory searches and SSDI searches were not successful, local reverse directories, such as the Polk Directory, were used to locate neighbors, employers, or spouses. Contact was then made with these individuals to determine if they knew where the former worker is currently living.

If no success was obtained after these steps, local obituaries were searched. Obituaries are maintained alphabetically at local historical societies. Similar obituary records are also maintained in most communities. Obituaries can confirm deaths which have occurred in the past year. Since many obituaries contain the names and current locations of the relatives of the deceased, in some cases it is sometimes useful to review obituaries for deceased with the same last name as the former worker. Doing this provided us with an additional contact.

In some instances, county assessor's records were also checked to determine the current owner of the property at the former worker's last known address. The current property owners are then contacted for possible clues about the location of former property owner.

If no positive leads were determined after these steps, a postal change of address inquiry was filed. This involves asking the Post Office for current forwarding addresses. However, forwarding addresses are only available for the past year. Therefore, this method was used last because we believed it was the least likely to produce positive results for our pilot population.

Of the list of 262 potential beryllium workers, 162 (62%) were located and their identities confirmed. Thirty-five (13%) were found and confirmed to be deceased. The remaining 65 (25%) have not been located by the methods above so other locating methods will be used for these workers.

I. Pilot Mailing

To assess the feasibility of contacting workers, four pilot mailings of study packets were sent to a total of 3,898 former workers. The first mailing was sent to a list of 128 workers whose names were provided by the OCAW as retired union members receiving union pensions. The second and third mailings included two lists of 126 workers generated from the Flow Gemini database, one addition OCAW worker and 14 additional workers who had requested packets as a result of outreach efforts. The fourth mailing went to 3502 workers on a list generated from the Flow Gemini database and one more worker who requested a study packet.

Former workers included in the second and third pilot were contacted by phone to verify addresses. The fourth pilot mailing was sent without first locating workers to verify their addresses. The different methods were used to determine the value of spending the time and money to accurately locate individuals prior to mailing out the packet.

The study packet (Appendix A) included a cover letter, an instruction sheet, an initial contact form, two copies of the consent form, a brochure about our study, and a postage paid return envelope. Additionally, for each pilot mailing a reminder postcard was sent within two weeks of the former worker receiving a study packet.

An Exposure Questionnaire (Appendix B) will be mailed out to each worker who agrees to participate. At this time, a pilot of 43 have been sent out in order to assess the questionaire.

Analysis of Pilot Mailings

The mailings were analyzed for response rates indicating a willingness to participate and location of workers.

III. Identification of the Population of Former Hanford Workers

A. Estimated Size of the Entire Hanford Former Worker Population

Previous estimates of the number of former Hanford workers have been based on a number of different sources. One source was the PeopleCORE database, which lists all of Hanford prime contractor employees as of 1988. Another source was the list of 52,522 operators and 2,285 construction workers derived from employment records extracted by Ethel Gilbert and placed in CEDR for her 1989 mortality study of workers who began employment between 1945 and 1983 (22-26). Other sources included various union lists. All of these lists are considered to be an underestimation of the entire former Hanford worker population either because of restrictions on the time period included, or because of the omission of the potentially large number of employees of subcontractors and sub-subcontractors.

By obtaining other databases from the DOE and its contractors, we have been able to construct a more comprehensive database of former Hanford workers than has been available to date. We have obtained the original employment history files (OHH88) from which CEDR was derived. This database includes an additional 9758 workers who were excluded from the mortality study (because they were not known to be exposed to radiation, bringing the total number of operators to 53,105 and construction workers to 13,740. Because 2,280 workers are included in both the operator and the construction worker files leaving 11, 460 workers who were solely construction workers. The total number of individual workers from these files is 64,565. Some of these may be current workers, but the exact number has not yet been determined.

In addition, from the DOE headquarters, we have obtained the REMS database which contains all radiation monitoring data between 1987 and 1996. The REMS database contains 42,874 Hanford workers.

We have also obtained the Flow Gemini database maintained by the Hanford Environmental Health Foundation (HEHF), which includes workers who were seen by the medical contractor between 1985 and the present. This database containing a total of 47,542 workers is, in many ways, the least reliable of all the databases we have obtained to date. It contains 14,253 records that lack work history information. These workers may or may not have worked at Hanford. The total number of definite former workers in Flow Gemini is 19,494.

Table 1 outlines the numbers of workers in each of the three databases. There is significant overlap between the three databases as shown in Figure 1. When this overlap is accounted for, there are a total of 104,770 Hanford workers in the three databases. The site currently has approximately 13,816 workers

employed in the DOE Richland Office and by the prime contractors. There is no easy method to determine the number of employees of subcontractors working on the site but this may represent up to another 9,000. These are not included in the calculations of eligible workers. In addition, some workers may have been construction workers only. Gilbert estimated that 11,460 workers had been construction workers only and they were excluded from her cohort (22 - 26). For these reasons the estimated total number of former workers (excludes current and construction only) is reduced by 25,276. An estimated 87.4% (11,460) are alive in 1997. Excluding workers who were only in construction and adjusting for survival and excluding those deceased the final estimate of eligible, living former workers is 68,034. In the final estimates of those who might request medical surveillance, it is likely that not all workers are included. Therefore, this is an underestimate due to lack of ascertainment of subcontractor employees. However, this represents the best available estimate.

B. Demographics

Table 2 displays the mean age of this workforce in 1997 as 56 years old, 70% male, 24% female, and 6% "gender missing". The ethnic distribution is 94% Caucasian, 2% African-American, .1% Asian or Latino, and 3.5% "race missing". Because these data are frequently not complete, the number of workers with information for each variable is presented.

C. Mortality Estimates

Table 3 shows the estimated number of workers alive in 1997 by age group. Of the 104,770 in the master database, the estimated total number of workers alive in 1997 is 91,525.

TABLE 1. ESTIMATION OF THE SIZE OF THE POPULATION

Database	Number of Workers
OHH88	**64,565**
Operator file	53,105
Construction worker file	13,740
Workers included in both files	2,280
Solely a construction worker	11,460
REMS	**42,874**
FLOW GEMINI	47,557
Former workers	19,494
Current workers	13,795
Workers without employment information	14,253
Probable Hanford workers	6,432
Probably not Hanford workers	(7,821)
Flow Gemini Hanford Workers	**39,721**
OHH88 and REMS overlap	10,342
OHH88 and FLOW GEMINI overlap	20,320
REMS and FLOW GEMINI overlap	21,968
Total in OHH88, REMS, and FLOW GEMINI Combined	**104,770**
Exclude Estimated Current Workers	-(13,816)
Total Former Workers	**90,954**
Estimated Solely a Construction Worker (13,740 - 2,280)	(11,460)
Total Estimated Deceased Workers (12.6% X 90,954)	(11,460)
Total Estimated Eligible & Living Former Workers	**68,034**[1]

[1] Underestimate likely due to lack of information about subcontractor employees.

Figure 1. Overlap Between Populations in OHH88, Flow Gemini, and REMS Databases

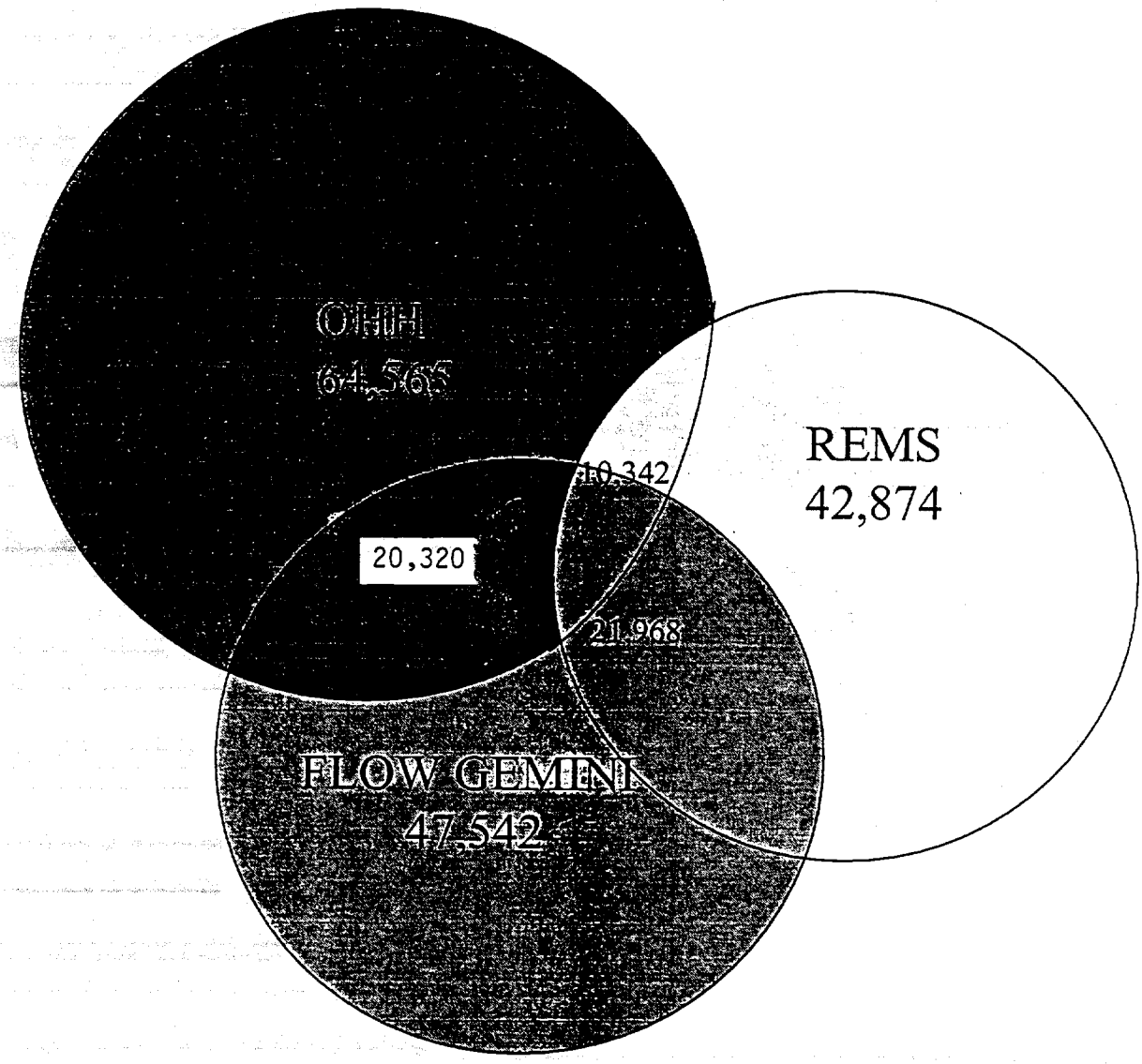


TABLE 2. Demographics of Hanford Workers (combined OHH88, Flow Gemini, and REMS Populations

Combined OHH88, Flow Gemini, and REMS Population			112,606
Flow Gemini Workers with No Employment Information and No OHH or REMS Matches			7821
Valid Population			104,770
AGE IN 1997	Mean		56
	Standard Deviation		21
	Valid N		100,487
	Missing Age		4298
SEX	Female	Count	26,066
		Percent	24.9%
	Male	Count	73,979
		Percent	70.6%
	Unknown / Missing	Count	4740
		Percent	4.5%
RACE OHH88 population only	White	Count	60,741
		Percent	94.1%
	Black	Count	1457
		Percent	2.3%
	Asian, Latino, and Native American	Count	103
		Percent	.1%
	Other and Unknown	Count	2264
		Percent	3.5%

TABLE 3. Estimated Survival of Workers by Age Group

Age	Number of Workers in Master Data Set	Percentage Alive in OHH88 Data Set	Percentage Assumed Alive in Master Data Set	Number of Workers Assumed Alive
< 20	321	100.0	100.0	321
20-29	7943	99.9	99.9	7936
30-39	15188	99.7	99.7	15141
40-49	20710	99.4	99.5	20605
50-59	15874	97.7	97.5	15477
60-69	12246	92.9	93.0	11393
70-79	12244	79.9	81.0	9917
80-89	8774	56.9	57.2	5018
90-99	4538	30.1	30.9	1404
100 +	2685	22.1	21.3	571
missing/ unknown age	4247	95.4	88.1	3742
Total	**104,770**	**88.9**	**87.4**	**91,525**

Note: Percentage Alive in OHH88 Data Set and Percentage Assumed Alive in Master Data Set differ due to the changed gender composition of the Hanford work force from 1988 to 1997.

IV. Exposure Estimation

Exposures are characterized in several ways including review of the literature and documentation of exposures at Hanford. Table 4 shows the major exposures which have been present at some time on the site.

To estimate the number of workers exposed to individual hazards a job-exposure matrix was constructed. The 73 existing Common Occupational Classification System (COCS) Codes developed by the DOE were examined by our industrial hygienists and grouped within the more broad COCS categories resulting in the development of 42 distinct occupational exposure categories. Each of the occupational exposure categories represents a group of job categories likely to have been exposed to the same hazards at Hanford. A list of the COCS codes in each category are listed in Appendix C. A job-exposure matrix was constructed such that an estimate of exposure could be assigned for each of the 42 hazards in Table 4 to each occupational category for each of five time periods of Hanford operations.

Figure 2 shows a summary of the job-exposure matrix. This figure demonstrates the exposures for major categories of jobs. A more complete version is shown in Appendix D.

Table 5 provides the number of workers exposed to each hazard based on the job-exposure matrix. These estimates provide the basis of estimating the number of workers who may have been exposed to a hazard and may benefit from medical surveillance.

The types, intensity and duration of exposures likely changed with the changing work processes at Hanford over the past 5 decades. An analysis of the relative proportions of job categories was conducted to examine these changes. Table 6 and Figures 3 - 8 display the relative proportions of major job categories. This table and these figures show the number and proportion of job titles assigned by decade. Because workers might be assigned to multiple jobs these numbers are only an indirect approach to assessing changes in jobs and exposures.

Table 4. List of Hazards of Interest

Beryllium
Cadmium
Lead
Mercury
Chromium
Nickel
Zirconium/Zircalloy
Other Metals

Chlorinated solvents
Aconitrile
Toulene and Ketones
Glycol Ethers
Paints/Thinners
Other Solvents

Plutonium
Uranium
Other isotopes
Gamma Radiation

Stack Gas
Irritant Gas
Other Acids/Caustics

Uranyl Nitrate Hexahydrate
Uranium Tetrafluroide
Tributyl Phosphate
NPH (kerosene)

Noise
Vibration
Laser Light
RF or Microwave Radiation

Nitrates
Hydrazine
Sodium Dichromate
Lithium Hydroxide
Asbestos
Welding Fumes
Formaldehyde
Herbicides
Pesticides
PCBs
Metal Working Fluids
Fuels, Greases, Oils
Silica

Figure 2. Job-Exposure Matrix

	Metals													Solvents							Radioactive Material						Acids/Caustics			
	Beryllium	Cadmium	Lead	Mercury	Chromium	Nickel	Zirconium/Zircalloy	Other/Unknown						Chlorinated Solvents	Acetonitrile	Toluene and Ketones	Glycol ethers	Paints/Thinners	Other solvents		Plutonium	Uranium	Other isotopes	Gamma radiation			Stack gas	Irritant gases	Other	
First Line Supervisors	*		*				*	*						*	*	*	*	*	*		*	*	*	*			*	*	*	
Managers																					*	*	*	*			*			
Chem,Env,Nuc Engineers	*		*																					*						
Civil, Mining, Constr Engineers																														
Other Engineers																														
Plant Engineers			*	*													*		*					*						
Chemists																														
Life Scientists																														
Materials Scientists	*	*	*		*	*	*	*						*	*	*		*	*					*						
Physicists																														
Other Scientists																														
Compliance Inspectors																														
Health Physicists			*																											
Industrial Hygienists																														
Administrative Office Staff																														
Other Professionals																														
Environmental Science Techs																														
Health Physics Techs	*		*	*										*		*		*	*					*			*	*	*	
Ind Safety and Health Techs				*										*										*			*	*		
Instr and Control Techs	*			*																				*						
Lab Techs			*											*	*	*			*											
Other Technicians																														
Carpenters			*															*	*											
Electricians	*		*				*							*																
HVAC Mechanics	*						*							*																
Machinists	*	*	*		*	*	*	*						*				*	*											
Masons								*																						
Millwrights	*	*	*	*	*	*	*	*						*																
Painters		*	*	*	*			*						*			*													
Plumbers & Pipefitters	*		*		*	*	*							*			*	*												
Structural & Metalworkers			*		*	*								*			*	*												
Vehicle Mechanics			*											*			*	*												
Welders	*		*		*	*	*							*																
Insulators	*																													
Nuclear Proc & Waste Ops			*	*										*	*	*														
Drillers														*																
Material Moving Equip Ops														*	*	*			*											
Reactor Operators			*																											
Utilities Operators								*																						
Firefighters																														
Food Service Workers																														
Janitors and Cleaners																		*												
Laundry Workers	*	*	*		*		*																							
Laborers			*																											
Light Vehicle Drivers																														
Security Guards			*																											

	Process Chemicals				Physical Agents				Miscellaneous												
	Uranyl nitrate hexahydrat	Uranium tetrafluoride	Tributyl phosphate	NPH (kerosene)	Noise	Vibration	Laser Light	RF or Microwave radiation	Nitrates	Hydrazine	Sodium dichromate	Lithium hydroxide	Asbestos	Welding fumes	Formaldehyde	Herbicide	Pesticide	PCBs	Metal working fluids	Fuels, greases, oils	Silica
First Line Supervisors	*	*	*	*	*				*	*	*	*	*	*	*	*	*	*	*	*	*
Managers	*	*	*	*	*																
Chem,Env,Nuc Engineers	*	*	*	*	*				*				*								
Civil, Mining, Constr Engineers					*																
Other Engineers																					
Plant Engineers	*	*	*	*	*				*	*	*	*	*	*	*			*			
Chemists	*	*	*	*					*						*						
Life Scientists															*						
Materials Scientists					*		*	*						*					*		
Physicists					*		*	*													
Other Scientists																					
Compliance Inspectors					*																
Health Physicists																					
Industrial Hygienists																					
Administrative Office Staff																					
Other Professionals																					
Environmental Science Techs											*					*	*				
Health Physics Techs	*	*	*	*	*								*	*							
Ind Safety and Health Techs					*																
Instr and Control Techs					*																
Lab Techs					*		*	*	*	*	*	*			*	*	*	*			
Other Technicians																					
Carpenters					*	*							*		*		*				
Electricians					*	*							*					*		*	
HVAC Mechanics					*	*							*							*	
Machinists					*	*							*	*					*	*	
Masons					*								*								*
Millwrights					*	*							*	*					*	*	
Painters					*	*							*								*
Plumbers & Pipefitters	*	*	*	*	*	*							*	*				*	*	*	
Structural & Metalworkers					*	*							*	*						*	
Vehicle Mechanics					*	*							*	*						*	
Welders					*	*							*	*							*
Insulators					*								*								
Nuclear Proc & Waste Ops	*	*	*	*	*	*			*	*	*	*	*								
Drillers					*	*														*	
Material Moving Equip Ops	*	*	*	*	*	*														*	*
Reactor Operators					*																
Utilities Operators					*	*			*	*	*		*							*	*
Firefighters					*	*															
Food Service Workers																					
Janitors and Cleaners					*	*							*								
Laundry Workers					*	*							*								
Laborers					*	*							*							*	*
Light Vehicle Drivers					*	*										*	*			*	
Security Guards					*												*				

Table 5. Number of Workers Exposed by Hazard

	Possibly Exposed	Probably Exposed	Total
Noise	11027	24413	35440
Gamma radiation	23860	8946	32806
Asbestos	18695	9293	27988
Lead	18661	8313	26974
Plutonium	23969	2757	26726
Uranium	23969	2757	26726
Other isotopes	23969	2757	26726
Vibration	8416	17925	26341
Chlorinated Solvents	17982	7096	25078
Stack Gas	25021		25021
Toluene and Ketones	13762	8447	22209
Fuels, greases, oils	10971	10773	21744
Sodium dichromate	21467		21467
Pesticide	20402		20402
Paints/Thinners	15830	981	16811
Herbicide	15964		15964
Silica	15963		15963
Irritant Gases	12485	3473	15958
Other	12822	2467	15289
Other solvents	11750	3367	15117
Welding fumes	8577	4982	13559
Uranyl nitrate hexahydrat	12646	880	13526
Uranium tetrafluoride	12646	880	13526
Tributyl phosphate	12646	880	13526
NPH (kerosene)	12646	880	13526
Nitrates	12911		12911
Beryllium	12886		12886
Acetonitrile	8590	2994	11584
Nickel	4739	6173	10912
Zirconium/Zircalloy	10879		10879
Chromium	5568	4868	10436
Hydrazine	10417		10417
PCBs	8641	1508	10149
Mercury	9736	403	10139
Other/Unknown	8057	1507	9564
Metal working fluids	6405	2755	9160
Formaldehyde	8258	511	8769
Lithium hydroxide	7778		7778
Glycol ethers	2675	3961	6636
Cadmium	4007		4007
RF or Microwave radiation	989		989
Laser Light	980		980

Table 6. COCS Categories by Decade

	Beginning Decade						
	40	50	60	70	80	90	Total
COCS							
Crafts	4756	8430	8660	17133	15438	1719	56136
Engineer	1735	4745	6367	20401	29394	4770	67412
Gen Admin	8158	14379	10067	26561	24640	4565	88370
Laborer, Servics	10318	6345	3344	9582	9844	1647	41080
Gen Manager Exec	2845	4560	3765	11276	14360	1917	38723
Prof Admin	1592	3207	2645	9707	14732	5218	37101
Operators	6656	9849	7468	12282	15319	1306	52880
Scientist	709	2252	4184	7945	6235	1952	23277
Technicians	3683	10140	11730	28660	30945	3357	88515
	40452	63907	58230	143547	160907	26451	493494

COCS Catagory by Job Begin Year Decade for 78,427 workers with begin job date and COCS code

Figure 3. COCS Category by Decade - 1940's

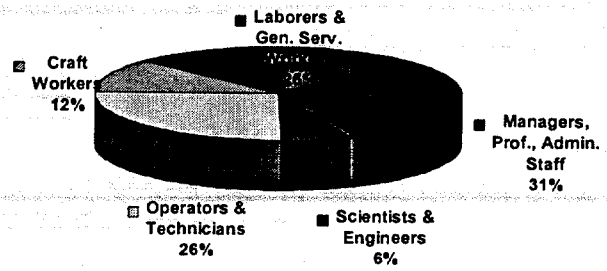


Figure 4. COCS Category by Decade - 1950's

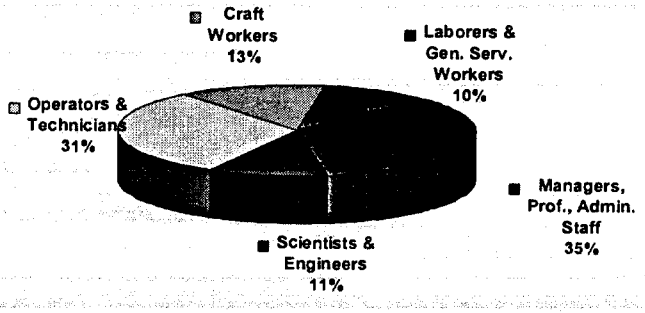


Figure 5. COCS Category by Decade - 1960's

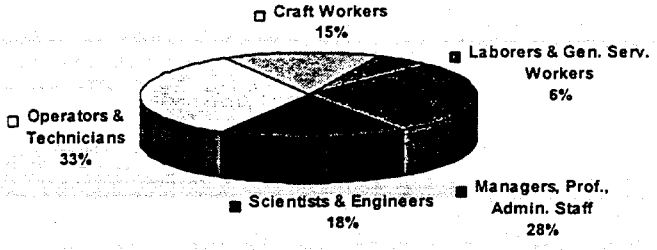


Figure 6. COCS Category by Decade - 1970's

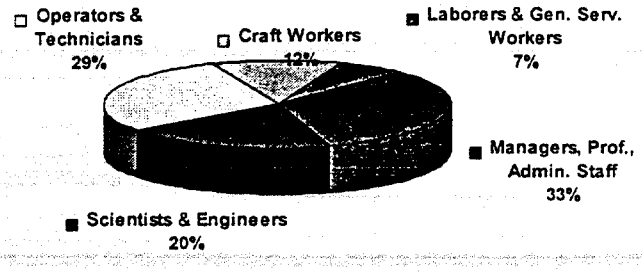


Figure 7. COCS Category by Decade - 1980's

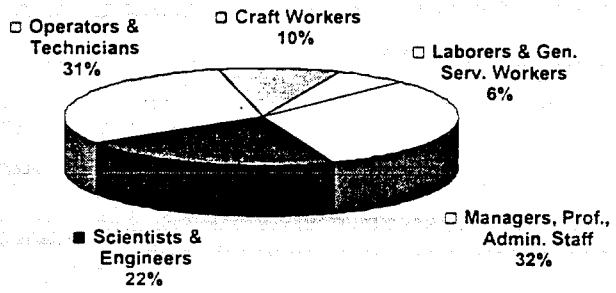
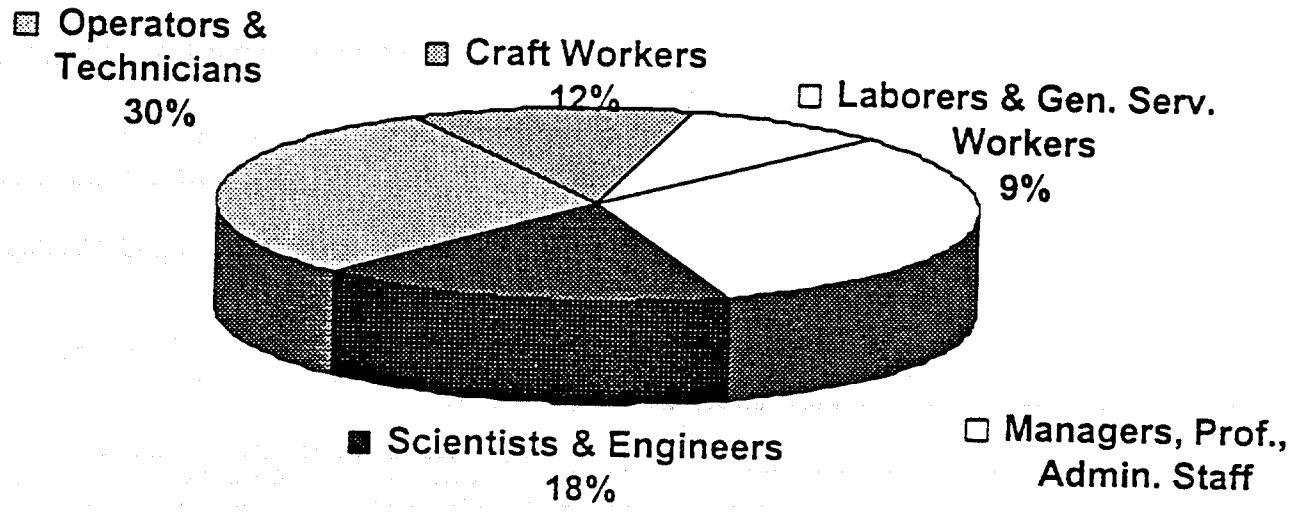


FIGURE 8. TOTAL 1940-1980 by COCS Category



IV. Justification of the Need for Medical Surveillance

A. Estimating Need for Medical Surveillance

The need for medical surveillance was estimated by identifying those workers with specific exposures and identifying those exposures where medical surveillance would lead to medical interventions. For this needs assessment medical interventions was broadly defined. Specifically, surveillance was considered for exposures which would lead to:

- interventions to alter the course of a disease; and/or
- interventions which could identify substantial impairment, and/or health risks and reasonably require worker notification.

B. Rationale: Interventions to alter the course of disease

The rationale for screening examinations which would identify disease at a point where interventions could affect its course is well documented and needs little justification (29-33,43). For selected exposures we have provided specific justification for surveillance below.

C. Rationale: Interventions which could lead to worker Notification

The rationale for screening evaluations to identify disease which could lead to worker notification is based on an ethical duty to notify workers of increased risk (33). Notification may be important in modifying diagnostic or treatment interventions (e.g. notification of asbestos exposure might void the necessity of an open lung biopsy in a case of pulmonary interstitial fibrosis) and, in some cases, these workers may be eligible for workers compensation. For many workers this may be limited to risk communication.

In reviewing exposures, three exposures were identified for which medical surveillance can be well justified at this time. These are:

- asbestos;
- noise
- beryllium

In addition, we expect that as we continue our Phase I activities, additional exposures will become sufficiently characterized to justify surveillance. At this time, however, there is too little information to warrant their inclusion in a surveillance program. Exposures of specific concern include: ionizing radiation, welding fumes, other respiratory irritants, metal working fluids, solvents, heavy metals, and other carcinogens. Acquisition of the REX database in conjunction with analyses of medical outcome data and the results of additional exposure

assessments based on worker surveys will be completed over the next 4-6 months and an updated Phase I needs assessment will be provided.

Justification of medical surveillance for exposed workers is based on identifying evidence of significant exposures and also identifying interventions which will be of benefit.

D. Justification of Medical Surveillance Asbestos

Health Hazards

The hazards of asbestos exposure are well recognized (34-41). These include pleural effusions and fibrosis, parenchymal fibrosis, bronchogenic carcinoma, mesothelioma, and elevated rates of malignancy in the upper respiratory and gastrointestinal tracts . The interaction of asbestos exposure and cigarette smoking in increasing the risk of lung cancer also deserves special attention. Asbestos exposure and smoking appear to have a multiplicative effect (40). Among those with the highest exposures, asbestos insulators, the risk of lung cancer among smoking asbestos exposed workers appears to be increased up to 50 fold (30,40). Lesser exposures appear to have less risk.

Asbestos use, in the United States, began at the turn of the century and rapidly increased at the time of World War II. Asbestos exposure was greatest among construction and maintenance workers. Because asbestos fibers n the respirable range remain suspended in the air, there is substantial potential for secondary exposure to those who work nearby.

Asbestos Use at Hanford

Asbestos was widely used at the Hanford Site. This is based on the nature of the work and the need for extensive use of thermal insulation. There is already an extensive asbestos monitoring program in place. This program is reflected in the Flow Gemini database which includes a total of 1,392 workers from the period 1985 to 1997. While some chest radiographs have been read clinically and, according to the International Labour Organization's system for classifying pneumoconioses, by certified B readers, the results are not available in the Flow Gemini system. Given these limitations asbestos exposure was estimated through the job exposure matrix. An estimated 27,988 workers who worked in jobs where asbestos exposure was possible or probable. An estimated 21,555 workers are alive who worked in jobs were asbestos exposure was likely, Of these 67 percent are known to have worked at Hanford for one year or more.

In order to assess the potential effects of respiratory toxins such as

asbestos, an analysis of the lung function data in the Flow Gemini database was conducted. While this database began to assimilate data in the 1980s the findings likely represent, for some workers, the cumulative effects of exposure from earlier years. Table 7 displays the demographic and baseline lung function of those in the Flow Gemini system. Table 8 displays the proportion of abnormal and lung function patterns in the cohort. The average percent of workers with less than 80% of predicted lung function for Forced Vital Capacity (FVC) and Forced Expiration Flow in one second (FEV_1), based upon 100% predicted values an odds ratio was calculated for each trade. Table 9 displays the expected percentage of abnormal, the rate of abnormality, and odds ratio for each trade for FVC and FEV_1. As shown in Table 9, 647 (5.4%) of workers have FVC < 80% predicted and 970 (8.1%) have an FEV_1 < 80% predicted. Looking at large trades with likely exposure to asbestos, plumbers and pipefitters had an odds ratio (OR) for an abnormal FVC (<80%) of 1.79 (N=363). Plant engineers (N=673), and Electricians (N=394) have OR for abnormal FVC of 1.41 and 1.32 respectively. The ratio of abnormal FEV_1 for plumbers and pipefitters, plant engineers, and electricians was 1.84, 1.45, 1.16 respectively. As a whole, the ratio for abnormal FVC for those with probable/possible asbestos exposure is 1.15 compared to .89 among those unlikely to have asbestos exposure. In addition, asbestos exposed trades, as identified by the job exposure matrix had higher rates of obstructive, restrictive, and mixed pattern disease. (Table 8).

There are several limitations to these analyses. There are likely many reasons why spirometry was obtained on these workers. The potential for respondent bias and limitation in exposure assessment limit the conclusions which can be drawn from these data. The lack of data on smoking status and exposure to other respiratory toxins (e.g. silica, beryllium, welding fumes) raises the potential for misclassifying or attributing abnormalities from smoking to asbestos exposure.

Despite these limitations, there appears to be a substantial cohort of asbestos exposed workers (Table 5). Analysis of available lung function data demonstrate higher than expected rates of abnormality (Tables 7-9). For these reasons, it is reasonable to be concerned that sufficient asbestos exposure may have occurred to result in increased risks of lung cancer and pleural and parenchymal fibrosis.

Benefits of Medical Surveillance

Medical surveillance for asbestos related malignant and non-malignant respiratory disease can be justified on several grounds. First and foremost, for those with asbestos exposure who smoke, identification and patient education concerning the risk and importance of smoking cessation will have the benefit of reducing risk over time (40). While there is limited efficacy in smoking cessation programs, there is evidence that quit rates of 5 to 20% can be achieved.

Second, many with asbestosis are at risk for misdiagnosis. Appropriate diagnosis can result in avoiding non-beneficial and potentially invasive and expensive evaluations of dyspnea and respiratory disease. In addition, while there is general concensus that screening for lung cancer with chest radiographs (or other measures such as sputum cytology) is not beneficial. This is not uniformly accepted. There are data that screening chest radoigraphs may identify cancers at an earlier stage permitting resection. For these reasons a screening examination which focuses on smoking status, respiratory symptoms, chest radiograph and spirometry is warranted.

Table 7: Demographics and Baseline Lung Function from Flow Gemini

Total records				47,557
Total individuals with one or more spirometries				19,051
Gender Distribution		Male	16,428	86.2%
		Female	2617	13.7%
		Unknown	6	0.0%
		Total	19,051	
Mean Age				46.3
Baseline Lung Function	**Actual Mean**	**Actual SD**	**% Predicted Mean**	**% Predicted SD**
FVC	4.89	1.04	102.54	14.89
FEV1	3.90	0.87	101.11	16.44
FEV1/FVC	0.80	0.07	96.76	8.63
Number of workers with spirometries and Flow Gemini job history information				12,026

Table 8. Pattern of Lung Function Abnormalities

Among the 12,026 Flow Gemini Workers with a spirometry exam and job history information.

	Lung Function								
	Mixed Obstructed/ Restricted		Restricted		Obstructed		Normal		Total
COCS Codes	N	Row %	N	Row %	N	Row %	N	Row %	
Possible Asbestos Exposure									
Masons	1	14.3%	0	0.0%	1	14.3%	5	71.4%	7
Laundry Workers	1	4.8%	2	9.5%	3	14.3%	15	71.4%	21
Painters	3	2.8%	8	7.5%	12	11.3%	83	78.3%	106
Welders	1	3.3%	1	3.3%	4	13.3%	24	80.0%	30
Janitors/Cleaners	2	2.7%	8	10.7%	5	6.7%	60	80.0%	75
Millwrights	5	4.1%	8	6.5%	11	8.9%	99	80.5%	123
Plumbers/Pipefitters	10	2.8%	25	6.9%	32	8.8%	296	81.5%	363
Utilities Operators	2	0.8%	14	5.6%	27	10.9%	205	82.7%	248
Structural/Metal Workers	4	2.1%	8	4.2%	20	10.5%	159	83.2%	191
Vehicle Mechanics/Mobile Equipment	2	3.0%	2	3.0%	6	9.1%	56	84.8%	66
Electricians	9	2.3%	19	4.8%	31	7.9%	335	85.0%	394
Plant Engineers	7	1.0%	44	6.5%	44	6.5%	578	85.9%	673
Helper Labor Gen	0	0.0%	11	5.4%	17	8.4%	174	86.1%	202
Helper Labor Specialized	0	0.0%	3	3.6%	8	9.6%	72	86.7%	83
Nuclear Waste Process Operators	5	0.8%	33	5.2%	41	6.4%	559	87.6%	638
Carpenters	0	0.0%	4	4.1%	8	8.2%	85	87.6%	97
Chemical Engineers	2	0.7%	6	2.1%	24	8.3%	258	89.0%	290
Nuclear Engineers	2	1.9%	4	3.8%	5	4.7%	95	89.6%	106
Health Physics Tech	2	0.3%	25	4.3%	27	4.6%	529	90.7%	583
First Line Supervis	0	0.0%	1	0.5%	16	7.8%	188	91.7%	205
Environ Engineers	1	0.6%	5	3.0%	8	4.7%	155	91.7%	169
Machinists	0	0.0%	1	4.3%	0	0.0%	22	95.7%	23
Exposure Possible Total	**59**	**1.3%**	**232**	**4.9%**	**350**	**7.5%**	**4052**	**86.3%**	**4693**

COCS Codes	Mixed Obstructed/ Restricted N	Row %	Restricted N	Row %	Obstructed N	Row %	Normal N	Row %	Total
Unlikely Asbestos Exposure									
Mathematicians	0	0.0%	1	25.0%	0	0.0%	3	75.0%	4
Media Tech	0	0.0%	3	9.7%	4	12.9%	24	77.4%	31
Drafters	5	2.7%	14	7.7%	18	9.9%	145	79.7%	182
Tech Writers/Editors	2	5.7%	2	5.7%	3	8.6%	28	80.0%	35
Equipment Operators, Material Moving	4	4.3%	4	4.3%	9	9.7%	76	81.7%	93
Architects	0	0.0%	0	0.0%	2	18.2%	9	81.8%	11
Physicists	0	0.0%	1	3.4%	4	13.8%	24	82.8%	29
Health Physicists	0	0.0%	13	8.7%	12	8.1%	124	83.2%	149
Communication Specialists	0	0.0%	1	16.7%	0	0.0%	5	83.3%	6
Q/A /Control Engineers	2	1.4%	8	5.7%	13	9.3%	117	83.6%	140
Office Clerks Specialized	6	5.0%	7	5.9%	5	4.2%	101	84.9%	119
Office Clerks Gen	1	1.1%	6	6.5%	6	6.5%	79	85.9%	92
Computer System Analysts	0	0.0%	1	2.3%	5	11.4%	38	86.4%	44
Cost Est/ Planners/Schedulers	5	2.3%	11	5.2%	13	6.1%	184	86.4%	213
Light Vehicle Drivers	6	2.2%	14	5.2%	16	5.9%	234	86.7%	270
Other Engineers	5	0.8%	30	4.8%	43	6.9%	549	87.6%	627
Compliance Inspectors	2	4.9%	0	0.0%	3	7.3%	36	87.8%	41
Instrumt/Control Tech	0	0.0%	15	6.6%	11	4.9%	200	88.5%	226
Construction Engineers	1	1.4%	2	2.9%	5	7.1%	62	88.6%	70
Petroleum/Mining Engineers	0	0.0%	0	0.0%	1	11.1%	8	88.9%	9
Engineering Tech	3	1.0%	9	2.9%	23	7.3%	280	88.9%	315
Industrial Engineers	0	0.0%	1	3.6%	2	7.1%	25	89.3%	28
Phys Assist, Nurses	1	3.6%	0	0.0%	2	7.1%	25	89.3%	28
Electrical Engineers	4	2.0%	8	4.0%	9	4.5%	179	89.5%	200
Project/Prog Mangr	0	0.0%	5	4.0%	8	6.5%	111	89.5%	124
Laboratory Tech	1	0.4%	10	3.7%	17	6.3%	241	89.6%	269
Guards Security Specialists	0	0.0%	7	4.0%	11	6.3%	156	89.7%	174
Prof Administrative	3	0.7%	12	2.8%	30	6.9%	390	89.7%	435
Other Scientists	1	0.9%	4	3.4%	7	6.0%	104	89.7%	116

COCS Codes	Mixed Obstructed/ Restricted N	Row %	Restricted N	Row %	Obstructed N	Row %	Normal N	Row %	Total
Security Guards	0	0.0%	12	5.5%	10	4.5%	198	90.0%	220
Environ Scientists	0	0.0%	5	3.3%	10	6.7%	135	90.0%	150
Gen Mangr/Executives	4	0.6%	23	3.3%	40	5.8%	622	90.3%	689
Safety Engineers	0	0.0%	3	2.2%	10	7.5%	121	90.3%	134
Computer Scientists	0	0.0%	2	4.8%	2	4.8%	38	90.5%	42
Nuclear Plant Operators	2	2.1%	2	2.1%	5	5.3%	86	90.5%	95
Other Tech	0	0.0%	2	6.3%	1	3.1%	29	90.6%	32
Mechanical Engineers	2	0.5%	4	1.0%	30	7.7%	356	90.8%	392
Personnel/Labor Relations Specialists	1	9.1%	0	0.0%	0	0.0%	10	90.9%	11
Materials Scientists	1	3.0%	0	0.0%	2	6.1%	30	90.9%	33
Life Scientists	1	1.5%	2	3.0%	3	4.5%	61	91.0%	67
Admin Assistants	0	0.0%	1	2.9%	2	5.9%	31	91.2%	34
Accountants/Auditors	1	1.0%	3	2.9%	5	4.8%	95	91.3%	104
Civil Engineers	0	0.0%	5	2.4%	12	5.8%	190	91.8%	207
Computer Operat/Coders	0	0.0%	2	5.4%	1	2.7%	34	91.9%	37
Environ Science Tech	0	0.0%	1	2.7%	2	5.4%	34	91.9%	37
Trainers	1	0.5%	6	2.7%	10	4.6%	202	92.2%	219
Chemists	0	0.0%	7	3.3%	9	4.2%	197	92.5%	213
Firefighters	0	0.0%	4	3.7%	4	3.7%	101	92.7%	109
Other	1	1.2%	3	3.5%	2	2.4%	79	92.9%	85
Indust Safety/Health Tech	0	0.0%	1	2.3%	2	4.7%	40	93.0%	43
Industrial Hygienists	0	0.0%	1	2.0%	2	4.0%	47	94.0%	50
Secretaries	0	0.0%	2	5.6%	0	0.0%	34	94.4%	36
Buyer/ Contracting Specialists	0	0.0%	0	0.0%	1	4.5%	21	95.5%	22
Geologists	0	0.0%	0	0.0%	2	2.8%	69	97.2%	71
Typists/Word Processors	0	0.0%	0	0.0%	0	0.0%	1	100.0%	1
Gen Admin, Secretarial	0	0.0%	0	0.0%	0	0.0%	3	100.0%	3
Lawyers	0	0.0%	0	0.0%	0	0.0%	4	100.0%	4
Physicians	0	0.0%	0	0.0%	0	0.0%	8	100.0%	8
Social Scientists	0	0.0%	0	0.0%	0	0.0%	5	100.0%	5
Survey/Mapping Tech	0	0.0%	0	0.0%	0	0.0%	8	100.0%	8
Exposure Unlikely Total	**66**	**0.9%**	**280**	**3.9%**	**449**	**6.2%**	**6446**	**89.0%**	**7241**
Overall Total	**125**	**1.0%**	**512**	**4.3%**	**799**	**6.7%**	**10498**	**88.0%**	**11934**

Note: The 92 individuals with COCS codes that did not allow for exposure evaluation are not included.

Table 9. Odds Ratio of Abnormal FVC and FEV1 by COCS Code Stratified by Possible / Probable VS Unlikely Asbestos Exposure

Sorted by Estimated Exposure and Odds Ratio

Among the 12,026 Flow Gemini Workers with a spirometry exam and job history information.

COCS Codes	Total N	N with FVC < 80	Expected N with FVC < 80	% with FVC < 80	Actual/ Expected Ratio
Possible/Prob. Asbestos Exposure					
Masons	7	1	0.4	14.3%	2.66
Laundry Workers	21	3	1.1	14.3%	2.66
Janitors/Cleaners	75	10	4.0	13.3%	2.48
Millwrights	123	13	6.6	10.6%	1.96
Painters	106	11	5.7	10.4%	1.93
Plumbers/Pipefitters	363	35	19.5	9.6%	1.79
Plant Engineers	673	51	36.2	7.6%	1.41
Electricians	394	28	21.2	7.1%	1.32
Welders	30	2	1.6	6.7%	1.24
Utilities Operators	248	16	13.3	6.5%	1.20
Structural/Metal Workers	191	12	10.3	6.3%	1.17
Vehicle Mechanics/Mobile Equipment	66	4	3.6	6.1%	1.13
Nuclear Waste Process Operators	638	38	34.3	6.0%	1.11
Nuclear Engineers	106	6	5.7	5.7%	1.05
Helper Labor Gen	202	11	10.9	5.4%	1.01
Health Physics Tech	583	27	31.4	4.6%	0.86
Machinists	23	1	1.2	4.3%	0.81
Carpenters	97	4	5.2	4.1%	0.77
Helper Labor Specialized	83	3	4.5	3.6%	0.67
Environ Engineers	169	6	9.1	3.6%	0.66
Chemical Engineers	290	8	15.6	2.8%	0.51
First Line Supervis	205	1	11.0	0.5%	0.09
Possible/Prob. Exposure Totals	**4693**	**291**	**252.5**	**6.2%**	**1.15**

Table 9 Continued

COCS Codes	Total N	N with FVC < 80	Expected N with FVC < 80	% with FVC < 80	Actual/ Expected Ratio
Unlikely Asbestos Exposure					
Communication Specialists	6	1	0.3	16.7%	3.10
Tech Writers/Editors	35	4	1.9	11.4%	2.12
Office Clerks Specialized	119	13	6.4	10.9%	2.03
Drafters	182	19	9.8	10.4%	1.94
Media Tech	31	3	1.7	9.7%	1.80
Personnel/Labor Relations Specialists	11	1	0.6	9.1%	1.69
Health Physicists	149	13	8.0	8.7%	1.62
Equipment Operators, Material Moving	93	8	5.0	8.6%	1.60
Office Clerks Gen	92	7	4.9	7.6%	1.41
Cost Est/ Planners/Schedulers	213	16	11.5	7.5%	1.40
Light Vehicle Drivers	270	20	14.5	7.4%	1.38
Q/A /Control Engineers	140	10	7.5	7.1%	1.33
Instrumt/Control Tech	226	15	12.2	6.6%	1.23
Other Tech	32	2	1.7	6.3%	1.16
Electrical Engineers	200	12	10.8	6.0%	1.12
Other Engineers	627	35	33.7	5.6%	1.04
Secretaries	36	2	1.9	5.6%	1.03
Security Guards	220	12	11.8	5.5%	1.01
Computer Operat/Coders	37	2	2.0	5.4%	1.00
Compliance Inspectors	41	2	2.2	4.9%	0.91
Computer Scientists	42	2	2.3	4.8%	0.89
Other	85	4	4.6	4.7%	0.87
Life Scientists	67	3	3.6	4.5%	0.83
Other Scientists	116	5	6.2	4.3%	0.80
Construction Engineers	70	3	3.8	4.3%	0.80
Nuclear Plant Operators	95	4	5.1	4.2%	0.78
Laboratory Tech	269	11	14.5	4.1%	0.76
Project/Prog Mangr	124	5	6.7	4.0%	0.75
Guards Security Specialists	174	7	9.4	4.0%	0.75
Gen Mangr/Executives	689	27	37.1	3.9%	0.73
Accountants/Auditors	104	4	5.6	3.8%	0.71
Engineering Tech	315	12	16.9	3.8%	0.71
Firefighters	109	4	5.9	3.7%	0.68
Industrial Engineers	28	1	1.5	3.6%	0.66
Phys Assist, Nurses	28	1	1.5	3.6%	0.66
Prof Administrative	435	15	23.4	3.4%	0.64
Physicists	29	1	1.6	3.4%	0.64
Environ Scientists	150	5	8.1	3.3%	0.62
Chemists	213	7	11.5	3.3%	0.61
Trainers	219	7	11.8	3.2%	0.59
Materials Scientists	33	1	1.8	3.0%	0.56
Admin Assistants	34	1	1.8	2.9%	0.55

Environ Science Tech	37	1	2.0	2.7%	0.50
Civil Engineers	207	5	11.1	2.4%	0.45

Table 9. Continued

COCS Codes	Total N	N with FVC < 80	Expected N with FVC < 80	% with FVC < 80	Actual/ Expected Ratio
Indust Safety/Health Tech	43	1	2.3	2.3%	0.43
Computer System Analysts	44	1	2.4	2.3%	0.42
Safety Engineers	134	3	7.2	2.2%	0.42
Industrial Hygienists	50	1	2.7	2.0%	0.37
Mechanical Engineers	392	6	21.1	1.5%	0.28
Petroleum/Mining Engineers	9	0	0.5	0.0%	0.00
Typists/Word Processors	1	0	0.1	0.0%	0.00
Gen Admin, Secretarial	3	0	0.2	0.0%	0.00
Architects	11	0	0.6	0.0%	0.00
Buyer/ Contracting Specialists	22	0	1.2	0.0%	0.00
Lawyers	4	0	0.2	0.0%	0.00
Physicians	8	0	0.4	0.0%	0.00
Geologists	71	0	3.8	0.0%	0.00
Social Scientists	5	0	0.3	0.0%	0.00
Survey/Mapping Tech	8	0	0.4	0.0%	0.00
Unlikely Exposure Totals	**7237**	**345**	**389.4**	**4.8%**	**0.89**
Asbestos Exposure Not Estimated					
Other Crafts	71	9	3.8	12.7%	2.36
Other Operators	15	1	0.8	6.7%	1.24
Other Laborers	6	0	0.3	0.0%	0.00
Exposure Not Estimated Totals	**92**	**10**	**4.9**	**10.9%**	**2.02**
Overall Totals	**12026**	**647**	**647.0**	**5.4%**	**1.00**

Table 9. Continued

FEV1 by COCS Job Code

Sorted by Estimated Exposure and Odds Ratio

Among the 12,026 Flow Gemini Workers with a spirometry exam and job history information.

COCS Code	Total N	N with FEV1<80	Expected N with FEV1< 80	% with FEV1< 80	Actual/ Expected Ratio
Possible/Prob. Asbestos Exposure					
Painters	106	19	8.5	17.9%	2.22
Millwrights	123	19	9.9	15.4%	1.92
Plumbers/Pipefitters	363	54	29.3	14.9%	1.84
Masons	7	1	0.6	14.3%	1.77
Structural/Metal Workers	191	25	15.4	13.1%	1.62
Utilities Operators	248	32	20.0	12.9%	1.60
Janitors/Cleaners	75	9	6.0	12.0%	1.49
Electricians	394	46	31.8	11.7%	1.45
Welders	30	3	2.4	10.0%	1.24
Helper Labor Specialized	83	8	6.7	9.6%	1.19
Laundry Workers	21	2	1.7	9.5%	1.18
Plant Engineers	673	63	54.3	9.4%	1.16
Nuclear Waste Process Operators	638	57	51.5	8.9%	1.11
Helper Labor Gen	202	16	16.3	7.9%	0.98
Vehicle Mechanics/Mobile Equipment	66	5	5.3	7.6%	0.94
Nuclear Engineers	106	8	8.5	7.5%	0.94
Health Physics Tech	583	38	47.0	6.5%	0.81
Carpenters	97	6	7.8	6.2%	0.77
Chemical Engineers	290	16	23.4	5.5%	0.68
Environ Engineers	169	8	13.6	4.7%	0.59
First Line Supervis	205	9	16.5	4.4%	0.54
Machinists	23	1	1.9	4.3%	0.54
Possible/Probable Exposure Totals	**4693**	**445**	**378.5**	**9.5%**	**1.18**

Table 9. Continued

COCS Codes	Total N	N with FEV1 < 80	Expected N with FEV1 < 80	% with FEV1 < 80	Actual/ Expected Ratio
Unlikely Asbestos Exposure					
Mathematicians	4	1	0.3	25.0%	3.10
Equipment Operators, Material Moving	93	15	7.5	16.1%	2.00
Tech Writers/Editors	35	5	2.8	14.3%	1.77
Physicists	29	4	2.3	13.8%	1.71
Media Tech	31	4	2.5	12.9%	1.60
Drafters	182	22	14.7	12.1%	1.50
Light Vehicle Drivers	270	32	21.8	11.9%	1.47
Office Clerks Specialized	119	14	9.6	11.8%	1.46
Cost Est/ Planners/Schedulers	213	22	17.2	10.3%	1.28
Q/A /Control Engineers	140	14	11.3	10.0%	1.24
Office Clerks Gen	92	9	7.4	9.8%	1.21
Compliance Inspectors	41	4	3.3	9.8%	1.21
Health Physicists	149	14	12.0	9.4%	1.16
Instrumt/Control Tech	226	21	18.2	9.3%	1.15
Personnel/Labor Relations Specialists	11	1	0.9	9.1%	1.13
Other Engineers	627	54	50.6	8.6%	1.07
Construction Engineers	70	6	5.6	8.6%	1.06
Computer Operat/Coders	37	3	3.0	8.1%	1.01
Accountants/Auditors	104	8	8.4	7.7%	0.95
Prof Administrative	435	32	35.1	7.4%	0.91
Industrial Engineers	28	2	2.3	7.1%	0.89
Phys Assist, Nurses	28	2	2.3	7.1%	0.89
Computer Scientists	42	3	3.4	7.1%	0.89
Other	85	6	6.9	7.1%	0.88
Computer System Analysts	44	3	3.5	6.8%	0.85
Nuclear Plant Operators	95	6	7.7	6.3%	0.78
Other Tech	32	2	2.6	6.3%	0.77
Gen Mangr/Executives	689	43	55.6	6.2%	0.77
Engineering Tech	315	19	25.4	6.0%	0.75
Safety Engineers	134	8	10.8	6.0%	0.74
Life Scientists	67	4	5.4	6.0%	0.74
Trainers	219	13	17.7	5.9%	0.74
Geologists	71	4	5.7	5.6%	0.70
Electrical Engineers	200	11	16.1	5.5%	0.68
Security Guards	220	12	17.7	5.5%	0.68
Environ Scientists	150	8	12.1	5.3%	0.66
Laboratory Tech	269	14	21.7	5.2%	0.65
Guards Security Specialists	174	9	14.0	5.2%	0.64
Mechanical Engineers	392	19	31.6	4.8%	0.60
Civil Engineers	207	10	16.7	4.8%	0.60
Chemists	213	10	17.2	4.7%	0.58
Indust Safety/Health Tech	43	2	3.5	4.7%	0.58

Project/Prog Mangr	124	5	10.0	4.0%	0.50
Firefighters	109	4	8.8	3.7%	0.45

COCS Codes	Total N	N with FEV1 < 80	Expected N with FEV1 < 80	% with FEV1 < 80	Actual/ Expected Ratio
Materials Scientists	33	1	2.7	3.0%	0.38
Admin Assistants	34	1	2.7	2.9%	0.36
Secretaries	36	1	2.9	2.8%	0.34
Other Scientists	116	3	9.4	2.6%	0.32
Industrial Hygienists	50	1	4.0	2.0%	0.25
Petroleum/Mining Engineers	9	0	0.7	0.0%	0.00
Typists/Word Processors	1	0	0.1	0.0%	0.00
Gen Admin, Secretarial	3	0	0.2	0.0%	0.00
Architects	11	0	0.9	0.0%	0.00
Buyer/ Contracting Specialists	22	0	1.8	0.0%	0.00
Communication Specialists	6	0	0.5	0.0%	0.00
Lawyers	4	0	0.3	0.0%	0.00
Physicians	8	0	0.6	0.0%	0.00
Social Scientists	5	0	0.4	0.0%	0.00
Environ Science Tech	37	0	3.0	0.0%	0.00
Survey/Mapping Tech	8	0	0.6	0.0%	0.00
Unlikely Exposure Totals	**7241**	**511**	**584.0**	**7.1%**	**0.87**
Asbestos Exposure Not Estimated					
Other Crafts	71	13	5.7	18.3%	2.27
Other Laborers	6	1	0.5	16.7%	2.07
Other Operators	15	0	1.2	0.0%	0.00
Exposure Not Estimated Totals	**92**	**14**	**7.4**	**15.2%**	**1.89**
Overall Total	**12026**	**970**	**970.0**	**8.1%**	**1.00**

E. Justification for Surveillance: Noise-Induced Hearing Loss

An estimated 14% of workers in the United States are exposed to noise at hazardous levels (exceeding 90dB) (28, 42-53). Some workers may be at risk at even lower levels of noise exposure. Noise induced hearing loss is characterized by loss of air conduction (AC) and bone conduction (BC). Noise appears to adversely affect the cochlea but abnormalities of AC and BC may represent defects in the sensory–neural pathways or auditory nervous system (28, 42-53). Noise induced hearing loss is characterized by disproportionate loss in the higher frequencies (28,42-53). The range of impairment due to noise exposure can range from impairment which is minimally symptomatic to levels where the patient is deaf. The association between noise exposure and hearing loss is extremely well documented (28,42-53). In addition, there are well characterized approaches to screening patients (49,50,51).

Benefits of Surveillance

Identification of noise induced hearing loss is of substantial benefit to the workers. Early identification can lead to recommendations for hearing protection and noise abatement. More advanced disease can be mitigated by use of hearing aids. For these reasons medical surveillance which leads to interventions is clearly justified. In addition, noise induced hearing loss is compensable under the regulations of the Washington State Department of Labor and Industries. Workers sustaining work-related hearing loss are eligible for compensation for existing permanent partial disability and costs of medical evaluation and treatment.

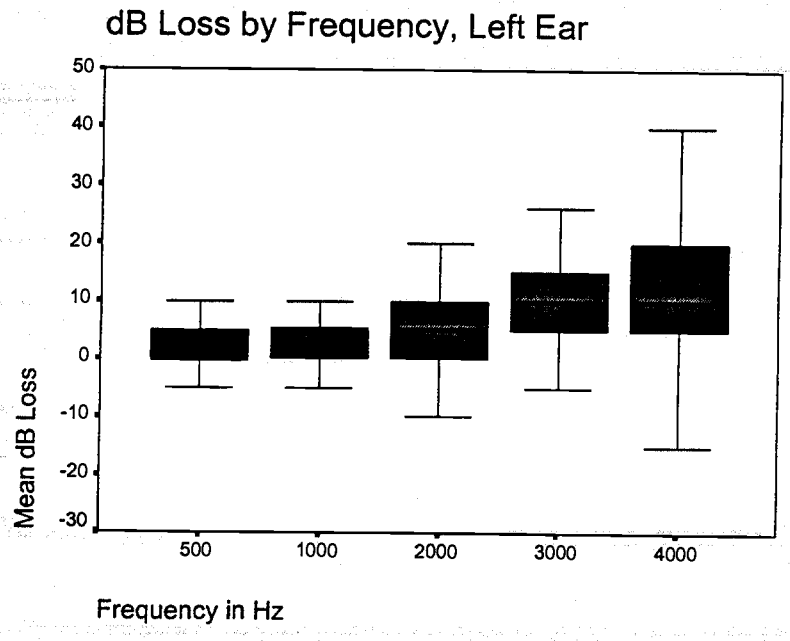
Analysis of audiometric records from the Flow Gemini database for evidence of patterns of loss suggesting noise induced hearing loss (high frequency), standard threshold shifts, and percent impairment suggest that noise induced hearing loss is of important concern. As shown in Table 10, of the 37,656 workers with one or more audiometry tests, 2,127 qualify for Whole Person Impairment. Of the 25,226 workers with two or more audiometry tests 3,501 have Standard Threshold Shift (STS). There are 5,062 workers with either Whole Person Impairment or STS. Any tests with incomplete results were dropped from the analysis. Fourteen percent of those with 2 audiograms demonstrate a STS. These findings are limited by the absence which ties the individual losses to specific exposures or non-occupational causes. Nonetheless the pattern and numbers strongly support provision of a surveillance program. This concern holds even after taking a conservative approach and applying an age adjustment to calculation of the STS.

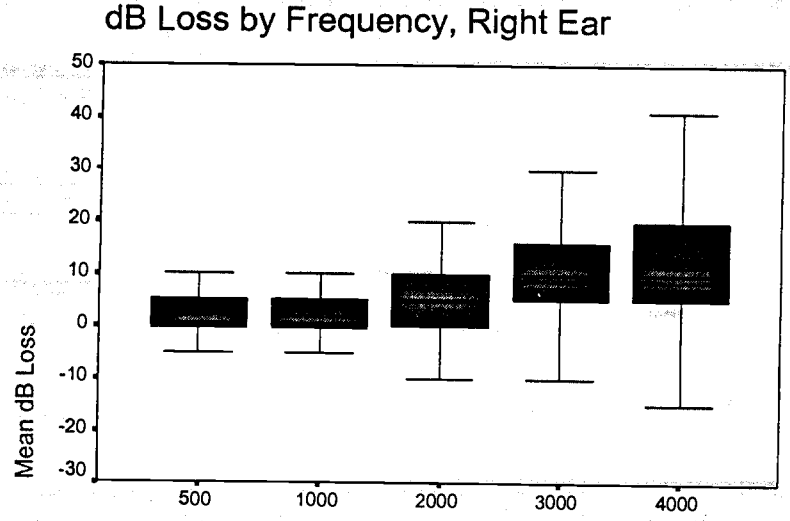
To assess whether the loss was consistent with a pattern which is work-related we analyzed the mean loss in each year by frequency. Figure 9 displays the pattern of mean loss among those with a STS. This pattern demonstrates greater loss at the higher frequencies as is consistent with noise-induced hearing loss. To examine which job titles have higher rates of STS , the rate of STS by COCS was compared to the rate of STS among all workers in the cohort with 2 or more audiograms (Table 11). Those with an odds ratio of 1.3 or greater were all in jobs identified with noise exposure in the job exposure matrix (Table 11). These findings strongly support the inclusion of noise-exposed workers in the surveillance program.

Table 10. Hearing Loss: Demographic Characteristics, Standard Threshold Shifts, and Impairment

number in flow	37,656
number and % male	26,667 (71%)
female	10,925 (29%)
mean age (years)	46.4
number with 1 audiogram	12,430
number with 2 audiogram	25,226
number with STS	3,501
number with age-adjusted STS	1,405
number with compensible impairment	2,127
mean Percent of Whole person impairment(dB)	6

Figure 9. Pattern of Mean Hearing Loss Among Those With STS.





n = 3,501 workers with STS

TABLE 11. Hearing Loss: Odds Ratio of STS for Workers With and Without Noise Exposed COCS Codes Compared to Average Ratio for All Workers

COCS	N for COCS	Expected Count	Expected Percent	Not Exposed COCS		Exposed COCS		Ratio for Total Cohort
				STS	Ratio	STS	Ratio	
C050 Masons	6	0.9	14.82			3	3.37	3.37
C110 Welders	33	4.9	14.82			12	2.45	2.45
C100 Vehicle Mechanics/Mobile Equip	100	14.8	14.82			36	2.43	2.43
C060 Millwrights	139	20.6	14.82			49	2.38	2.38
C070 Painters	108	16.0	14.82			36	2.25	2.25
C010 Carpenters	97	14.4	14.82			32	2.23	2.23
C090 Structural/Metal Workers	186	27.6	14.82			54	1.96	1.96
C080 Plumbers/Pipefitters	363	53.8	14.82			99	1.84	1.84
C040 Machinists	67	9.9	14.82			18	1.81	1.81
L080 Security Guards	231	34.2	14.82			62	1.81	1.81
R030 Equip Operators, Material Moving	103	15.3	14.82			27	1.77	1.77
L070 Light Vehicle Drivers	370	54.8	14.82			85	1.55	1.55
C020 Electricians	403	59.7	14.82			92	1.54	1.54
E100 Plant Engineers	779	115.5	14.82			177	1.53	1.53
L050 Helper Labor Gen	192	28.5	14.82			42	1.48	1.48
R070 Utilities Operators	269	39.9	14.82			58	1.45	1.45
E140 Construction Engineers	96	14.2	14.82			19	1.34	1.34
T070 Instrumt/Control Tech	275	40.8	14.82			53	1.30	1.30
E110 Q/A /Control Engineers	191	28.3	14.82	36	1.27			1.27
P120 Physicians	11	1.6	14.82	2	1.23			1.23
E120 Safety Engineers	122	18.1	14.82	22	1.22			1.22
E050 Environ Engineers	202	29.9	14.82			34	1.14	1.14
E070 Mechanical Engineers	473	70.1	14.82	79	1.13			1.13
T100 Survey/Mapping Tech	12	1.8	14.82	2	1.12			1.12
S050 Materials Scientists	60	8.9	14.82			10	1.12	1.12
S030 Geologists	76	11.3	14.82	12	1.07			1.07
P170 Prof Administrative	952	141.1	14.82	146	1.03			1.03
P050 Compliance Inspectors	33	4.9	14.82			5	1.02	1.02
T110 Other Tech	60	8.9	14.82	9	1.01			1.01
E080 Nuclear Engineers	181	26.8	14.82			27	1.01	1.01
M030 Project/Prog Mangr	295	43.7	14.82			44	1.01	1.01
S060 Mathematicians	27	4.0	14.82	4	1.00			1.00
T020 Drafters	185	27.4	14.82	27	0.98			0.98
L010 Firefighters	117	17.3	14.82			17	0.98	0.98
S070 Physicists	78	11.6	14.82			11	0.95	0.95
M010 First Line Supervis	302	44.8	14.82	42	0.94			0.94
R050 Nuclear Waste Process Operators	652	96.6	14.82			91	0.94	0.94
R040 Nuclear Plant Operators	109	16.2	14.82			14	0.87	0.87
T050 Health Physics Tech	613	90.9	14.82			79	0.87	0.87
P070 Cost Est/ Planners/Schedulers	454	67.3	14.82	57	0.85			0.85

E040 Electrical Engineers	257	38.1	14.82	32	0.84			0.84
M020 Gen Mangr/Executives	1358	201.3	14.82			169	0.84	0.84
E010 Chemical Engineers	347	51.4	14.82			41	0.80	0.80
T080 Laboratory Tech	261	38.7	14.82			31	0.80	0.80
S100 Computer Scientists	197	29.2	14.82	23	0.79			0.79
S040 Life Scientists	77	11.4	14.82	9	0.79			0.79
E020 Civil Engineers	187	27.7	14.82			22	0.79	0.79
P080 Health Physicists	173	25.6	14.82	20	0.78			0.78
P140 Guards Security Specialists	155	23.0	14.82	17	0.74			0.74
E130 Other Engineers	1044	154.7	14.82	108	0.70			0.70
S020 Environ Scientists	259	38.4	14.82	27	0.70			0.70
P150 Trainers	346	51.3	14.82	35	0.68			0.68
L040 Laundry Workers	31	4.6	14.82			3	0.65	0.65
T060 Indust Safety/Health Tech	53	7.9	14.82			5	0.64	0.64
T090 Media Tech	87	12.9	14.82	8	0.62			0.62
S010 Chemists	312	46.2	14.82	26	0.56			0.56
S090 Other Scientists	189	28.0	14.82	15	0.54			0.54
P040 Communication Specialists	88	13.0	14.82	7	0.54			0.54
E090 Petroleum/Mining Engineers	13	1.9	14.82			1	0.52	0.52
L030 Janitors/Cleaners	227	33.6	14.82			17	0.51	0.51
G030 Office Clerks Specialized	619	91.7	14.82	46	0.50			0.50
P010 Accountants/Auditors	491	72.8	14.82	34	0.47			0.47
P030 Buyer/ Contracting Specialists	234	34.7	14.82	16	0.46			0.46
E060 Industrial Engineers	76	11.3	14.82	5	0.44			0.44
P130 Phys Assist, Nurses	33	4.9	14.82	2	0.41			0.41
T030 Engineering Tech	625	92.6	14.82	38	0.41			0.41
P100 Lawyers	17	2.5	14.82	1	0.40			0.40
P060 Computer System Analysts	406	60.2	14.82	24	0.40			0.40
G010 Admin Assistants	278	41.2	14.82	16	0.39			0.39
L060 Helper Labor Specialized	121	17.9	14.82			7	0.39	0.39
P110 Personnel/Labor Relations Special	147	21.8	14.82	8	0.37			0.37
P090 Industrial Hygienists	74	11.0	14.82	4	0.36			0.36
P160 Tech Writers/Editors	136	20.2	14.82	7	0.35			0.35
G020 Office Clerks Gen	1168	173.1	14.82	48	0.28			0.28
G060 Gen Admin, Secretarial	50	7.4	14.82	2	0.27			0.27
G040 Secretaries	966	143.2	14.82	37	0.26			0.26
T010 Computer Operat/Coders	97	14.4	14.82	3	0.21			0.21
T040 Environ Science Tech	45	6.7	14.82	1	0.15			0.15
G050 Typists/Word Processors	49	7.3	14.82	1	0.14			0.14
S080 Social Scientists	48	7.1	14.82	1	0.14			0.14
P000 Prof Admin	1	0.1	14.82					
P020 Architects	12	1.8	14.82					

* COCS codes L090, C120, R060, R080 are not included in this table because information about these workers jobs was not available.
* For 3501 workers with STS.

F. Justification for Beryllium – Beryllium Sensitization and Chronic Beryllium Disease

Beryllium is a strong light metal used in a variety of industries ranging from electronics to the nuclear industry. Beryllium has been widely used at the Hanford site but relatively little is know about the intensity of those exposures. Beryllium exposure can cause an acute pneumonitis increased risk of lung cancer or a chronic granulomatous illness similar to sarcoidosis (54-60). The disorder can be progressive and even fatal. Clinically chronic beryllium disease is characterized by cough and shortness of breath. Chest radiographs may show hilar adenopathy with or without parencymal fibrosis. Pulmonary function may show restrictive or obstructive defects. Pathologically, non-caseating granulomas are seen. The disorder appears to be a form of delayed hypersensitivity to beryllium and is characterized by increased lymphocyte proliferation in response to exposure to beryllium salts. For this reason the lymphocyte transformation test (LDT) (also know as the lymphocyte transformation test (LPT)) provides a relatively sensitive (80%+ on peripheral blood) test to identify beryllium sensitization. Once sensitivity has been identified a more detailed evaluation of the respiratory tract including pulmonary function tests and bronchoscopy with transbronchial biopsy is warranted. In general, determinization of sensitization requires positives on two or more consecutive LDTs before embarking upon additional workup.

Beryllium-Exposed Workers

Workers at Hanford have been exposed to unknown concentrations of beryllium as a result of fuel fabrication, research and development, and clean up processes. Preliminary identification of workers potentially exposed to beryllium was originally done by searching the Flow Gemini database by building assignment. Because beryllium has the ability to sensitize on minimal exposure, the potential for bystanders to be exposed and sensitized must be considered. Two lists of buildings are being used to identify workers who may have been exposed to beryllium. The first is a list generated by a University of Washington Research Industrial Hygienist. This list was compiled using information about historical process locations and air sampling reports. The second list was compiled by personnel at DOE/RL in response to the Draft Interim Worker Protection Program Notice for Review and Comment. These lists are provided in Appendix F along with the numbers of workers from the Flow Gemini database assigned to each building. A total of 3749 workers have been identified in Flow Gemini as having worked in these buildings. It is likely that this number includes many workers who were not exposed, but it is also missing many workers who worked with beryllium prior to 1985. This number is probably significant because fuel fabrication occurred during the period 1960 - 1989.

Flow Gemini also contains information about which individuals were assigned to various medical monitoring programs within HEHF. There are 117 workers in Flow Gemini who have been assigned to a beryllium medical surveillance program, of which 38 are former workers. When these workers are added to the list of workers in buildings with potential for beryllium exposure, the total number of workers in Flow Gemini with potential exposure becomes 3785. Given that Flow Gemini only contains about 25% of our entire population of former workers, this estimate is consistent with the number (11,859) derived from the job-exposure matrix for beryllium-exposed individuals. Because approximately 10% of these workers are currently employed at Hanford, this data suggests that the current monitoring program does not cover all workers who may be at risk for berylliosis.

Beryllium is the only targeted hazard for which we have any quantitative exposure information. This information was obtained by searching HEHF maintained storage boxes which contain industrial hygiene sampling reports and records of presentations and training programs. Although the documentation of sampling and analysis methods are not always sufficient enough to draw conclusions from the results, the records do provide information about where, when, and why HEHF was doing sampling for beryllium. In addition, the boxes of records contained some lists of potentially exposed workers. These lists will be used to supplement our lists as described in Table 12.

Under a pilot project funded by the Consortium for Risk Evaluation with Stakeholder Participation (CRESP), additional information about exposure to beryllium will be obtained utilizing an exposure questionnaire and LPT screening. A questionnaire specifically designed for beryllium workers is being sent to all workers from the major fuel fabrication buildings (313 and 333) and to those workers who are enrolled in a beryllium surveillance program. This survey includes 262 former workers. All workers responding to the questionnaire will be offered lymphocyte transformation testing to estimate the prevalence of beryllium sensitization in this population. More workers will be included in this survey as more beryllium-exposed workers are identified, and if funded, folded into Phase II of this application.

Benefits of Surveillance

Because chronic beryllium disease is a progressive disorder which may benefit from treatment with corticosteroids and other pulmonary medications, it is important to identify these patients. It is also important to obtain an accurate diagnosis and distinguish berylliosis from other pulmonary disease. Medical surveillance is justified on these grounds as well as for the purpose of providing worker's compensation. Because beryllium sensitization among Hanford is not well documented it is reasonable to first focus efforts on determining the prevalence of beryllium sensitivity based on the LPT. If this screening test is

negative for an adequate sample of workers at highest risk it may not be fully justifiable to continue a large scale surveillance effort. The rate of beryllium sensitization ranges up to almost 5% of some low to moderately exposed cohorts (55,56). For this reason a fairly large sample of worker will need to be evaluated first to identify if they have a reasonable likelihood of being exposed and then have the LPT performed.

Table 12. Beryllium Exposed Workers

Number of exposed workers based on job exposure matrix	12,886[2]
Number of workers in buildings where beryllium was used	3,749[3]
Number of workers in beryllium medical surveillance program	117[4]
Total number possibly exposed from all three of the above lists	15,972[5]
Number of workers both in beryllium buildings and exposed based on job exposure matrix	682[6]

[2] Source: OHH88 and workers from Flow Gemini with work history information (n=97,854)
[3] Source: Flow Gemini database (n=47,557)
[4] Very few current workers are exposed to beryllium, though many have a history of exposure as reflected in total below (15,972). 34 of the 117 are former workers.
[5] This is an overestimate of the actual number exposed since many people in potentially exposed job titles and many people in which beryllium was used will not have been exposed (see next footnote).
[6] This is an underestimate of exposed workers. The number of workers in beryllium buildings comes only from Flow Gemini, which only includes workers who were still working in 1985 or later. It also misses many of the clerical workers who may have been incidentally exposed base on location alone. The fact that only 55 of 117 workers in the beryllium medical surveillance program are included in the list of 682 further demonstrates that this is an underestimate.

G. Summary of Number of Workers Eligible and Likely to Participate in a Surveillance Program

The potential for substantial uncertainties to exist in these projections is acknowledged. The factors contributing to the uncertainties include: 1) difficulties in ascertaining all who worked on the site; especially subcontractors; 2) difficulties in identifying the jobs and job titles for workers (over 40% missing in some databases); 3) limitations in exposure assessment; 4) uncertainties with respect to who is still a current worker (10%) or was solely a construction worker (10%); 5) survival (90%); 6) ability to locate (90%); and 7) likely participation (50%). Based on our analyses we have used the factors above to be applied to the number exposed to get an estimate of the number of exams offered. These factors estimate the number likely to participate by the following equation:

Likely to participate =
{current worker (.9) x (Alive (.9)} x {able to locate (.9)} x {likely to participate (.5)}

Likely to participate = .36 x total number exposed

The numbers likely to participate in each of the three medical surveillance programs have been calculated and are presented in Table 13. The number exposed is likely conservative given the extensive proportion missing job titles and the likely undercounting of subcontractors. For this reason the numbers proposed are felt to be very conservative with a caveat that the exposure assessment used in the job-exposure matrix is likely to over-estimate the total number exposed. This is balanced, however, by the lack of job titles for 25% of workers. As discussed later an iterative process where the needs assessment is updated annually based on new information including the incidence of positive screening examination is strongly favored.

Table 13. Estimated Need for Medical Surveillance

Asbestos

Number exposed:		27,988
Alive, former worker, not solely construction, and likely to participate:	(36%)	10,075

Noise

Number exposed:		35,440
Alive, former worker, not solely construction, and likely to participate:	(36%)	12,758

Beryllium

Number Exposed (Job exposure matrix only):		12,886
Alive, former worker, not solely construction, and likely to participate	(36%)	4,638
Number exposed – job-exposure matrix and worked in a beryllium Containing building:		682
Alive, former worker, not solely construction, and likely to participate	(36%)	244

VII. Feasibility of Contacting Former Workers

A. Location Resources

There are other resources for tracking the location of former workers which were not used in our Phase I project, primarily due to cost, resource use restrictions, and the relatively small scale of our pilot projects. Due to higher initial and continuing cost, these resources are best used for locating larger numbers of subjects. Even with these resources, the data provided cannot be assumed to be correct. The results of searches with information brokers often turn up lists of possible names, even when Social Security numbers are used. In such cases, confirmation calls or letters must be made to each individual in order to determine that the correct person has been located. These resources would likely need to be used during Phase II activities when larger number of workers would be located.

Locator Resources:

1) Washington State Department of Licensing records
These are data tapes of motor vehicle licenses. Computer linkages are made based on name and date of birth. Information which is provided by this data set includes name, date of birth, address, and date of most recent driver's license. The Fred Hutchinson Cancer Research Center reports that in their tracking activities, approximately 35% of study subjects who have lived in Washington state can be located using these records. If a former workers is no longer driving due to advanced age, these records would still provide the last address known to the Department of Licensing.

2) National Change of Address
These are private databases which contain postal address forwarding information for the last 3 years. Names and last known addresses are submitted, and a report is received which gives postal change of address records for the past three years. The Fred Hutchinson Cancer Research Center reports that approximately 20% of their study subjects not found in the Department of Licensing records can be located using National Change of Address.

3) Credit Bureau Searches
The major credit bureaus (TRW, Equifax) provide access to the demographic portions of their databases to users with a legitimate need for the information. Searches are based on name, address, and social security number. The information provided includes a list of possible matches for name, address, and social security number. The Fred Hutchinson Cancer Research Center reports that approximately 17% of

study subjects not located by the Department of Licensing and National Change of Address can be located by use of data from credit bureaus.

4) Information Brokers

These are national services which assist with finding lost people. These information brokers compile databases from many different sources. Their services are quite expensive by comparison to the other services but can be helpful in finding workers who cannot be located by other means. The Fred Hutchinson Cancer Research Center reports that in their tracing studies, it is necessary to use information brokers to find approximately 7% of study subjects.

It should be noted that the population of former workers may differ substantially from other populations which have been traced by the Fred Hutchinson Cancer Research Center. For this reason, the percent of subjects located by each method could vary for the former worker population.

In summary, our methods of locating former workers have been relatively successful. We have succeeded in locating approximately 75% of our most complete pilot population, including confirmed deaths. Unfortunately, the work involved in locating former workers is tedious and time-consuming. To minimize the cost and time involved, the most accurate and current lists must be obtained from DOE contractors. Based on our Phase I work with DOE-RL and Hanford contractors over the last year, we believe we are well positioned to obtain much of this data in Phase II. Overall, we expect to locate 90% of former workers and have used a location rate of 90% in our final estimates.

B. Pilot Mailings

To date, four pilot mailings have been sent out to a total of 3,898 former workers. The first mailing was sent to a list of 128 workers whose names were provided by the OCAW as retired union members receiving union pensions. The second and third mailings included two lists of 126 workers generated from the Flow Gemini database, one additional OCAW workers and 14 additional workers who had requested packets as a result of outreach efforts. The fourth mailing went to 3502 workers on a list generated from the Flow Gemini database and also to one additional worker who requested a packet.

The study packet (Appendix A) includes a cover letter, an instruction sheet, an initial contact form, two copies of a consent form, a brochure about our study, and a postage paid return envelope. Additionally, a reminder postcard was sent two weeks after reception of the study packet. Table 14 provides information on the success of our mailings in contacting these workers and recruiting them to

participate in our study. Mailings # 1, 2, 3 made some attempt to locate and verify workers. Mailing # 4 is currently in progress and did not attempt to locate workers (thus a lower response rate). Participation rates, at this early stage are at 40%. With a more defined program we estimate 50% of former workers who are located will choose to participate. Given the increased rate of return from the Post Office for bad addresses on the fourth mailing and the difference in the response rate between the first three mailings and the fourth mailing, it appears worthwhile to locate workers before sending them an information packet.

Table 14. Pilot Mailing Response Rates

Pilot #	Packets Mailed	Returned by Post Office		Agrees to Participate*	
		Number	(Percent)	Number	(Percent)
Underwent Intensive Location Effort					
1	128	4	(3)	47	(37)
2	136	1	(1)	55	(40)
3	131	0	(0)	52	(40)
Total 1,2,&3	395	5	(<1)	154	(39)
Without Intensive Location Effort					
4	3503	741	(21)	423	(12)

*Based on their responses, 15 workers will be followed by the Building Trade Project
Additional note: 26 study packets were returned due to the former workers being deceased; 2 forms were completed by family member's of deceased workers; 2 workers returned forms with comments that as DOE employees they did not perform duties at the Hanford site; and 8 former workers did not wish to participate.

VII. Description of Phase II: Approach to Medical Surveillance

Proposed Approach to Medical Surveillance

As noted above there are substantial limitations to characterizing the past exposures of individual former workers. As a result characterizing health risks is also limited. Given the potentially large number of workers who will be eligible and the limited resources a strategy which focuses on targeted examinations as opposed to a general physical examination and health evaluations is proposed. Based on the results of the targeted examinations those with a reasonable probability of an occupational illness will have a claim filed for additional evaluation as needed. In this manner, the program will rely on initial examinations which will have a high sensitivity for identifying potential occupational disease and leave the more comprehensive examination for those cases where the presence of an occupational illness is more likely. For workers at the Hanford Site the State of Washington Department of Labor and Industries Manages the claims and their procedures will be followed with respect to applying for workers compensation and follow-up care. A coordinating center for surveillance will be established (Seattle Clinical Coordinating Center). In order to better target the surveillance examinations a five step process is proposed.

Step 1. Targeted Mailings to Identify Workers Wishing to Participate- Mailings prioritized by risk and decade of work.

Step 2. For workers wishing to participate – individual exposure assessment / health status questionnaire

Step 3. Determination of Eligibility

Step 4. Surveillance Examination

Step 5. Annual Revised Needs Assessment based on exposures and health outcomes

Each of these steps is describe in greater detail below.

Step 1. Targeted Mailings to Identify Workers Wishing to Participate- Mailings stratified by risk

A series of pilot mailing have been completed. These pilot mailing provided basic information about the project, solicited information about prior union affiliations and asked whether the participant wished to participate further. The materials provided in this mailing are provided in Appendix B.

Based on the current needs assessment and subsequent revisions, targeted mailings will be sent to workers with potential asbestos, beryllium, and noise exposure. These mailings will be stratified by an estimate of risk and by decade of work and for asbestos a minimum of 10 years of latency from first exposure.

Step 2. For workers wishing to participate – individual exposure assessment / health status questionnaire

Workers who return the preliminary mailing (including informed consent) will be asked to fill out a more detailed questionnaire on work place exposures, specific concerns, and general health status. This questionnaire is included in Appendix C.

Step 3. Determination of Eligibilty

The exposure questionnaires will be analyzed to determine eligibility. Because the information is qualitative, eligibility will be determined based on whether or not there is an indication of exposure based on specific reports of exposure, building, or job title. As additional data are gathered this may be modified to include other factors such as duration. Because resources for examinations are not unlimited those at highest risk will be identified based on exposure and building history. These risk estimates will be revised based on the workers reports of exposure and health outcomes (e.g. rates of asbestos-related radiographic abnormalities, beryllium sensitization, noise-induced hearing loss). A complete data based job exposure is proposed for Phase II to support assignment of risk.

Step 4. Surveillance Examinations

Surveillance examinations will be provided initially for three areas; asbestos, beryllium and noise. While the findings of abnormal lung function and hearing loss are particularly disturbing the results (especially lung function) are not highly specific for occupationally-related disease. Surveillance examinations will be used to determine if there is a reasonable probability of an occupationally-related illness or risk to be present. For those with a reasonable probability of an occupational disease being present a claim for workers compensation will be filed to cover the costs. In Washington State physicians have a duty to inform workers of the presence of work-related illness or injury and assist in filing claims for workers compensation. Claims can also be filed for diagnostic purposes which permits medical coverage for costs related to evaluating whether a condition is work-related. As Phase I is completed, additional monitoring programs are likely to be proposed.

A. Asbestos Surveillance

The asbestos surveillance examination will consist of the following components:

1. Self administered occupational and health history.
2. Directed physicial examination (blood pressure, pulse, respiratory rate, heart, lungs, abdomen, extremities.
3. Spirometery (pre and post bronchodilator) according to ATS Standards.
4. Chest radiograph according to ILO guidelines.
5. Risk communication regarding:
   A. smoking
   B. further asbestos exposure
   C. follow-up of medical problems.

6. Forwarding of material to the Seattle Clinical Coordinating Center for:
   A. Review of chest radiograph at Seattle Coordinating Center for ILO reading
   B. Review of medical data (questionnaire, physical examination, spirometry) to determine if:
      1. patient has an asbestos-related illness
      2. filing claim for workers compensation as appropriate
      3. referral for additional medical evaluation and treatment as appropriate
      4. risk communication (e.g. avoidance of further exposure, smoking cessation etc.).

B. Noise-Induced Hearing Loss

1. Self administered questionnaire – occupational and health history
2. Directed physical examination (head, ears, nose, throat).
3. Audiometry (follow standard procedures)
4. Risk communication regarding findings on history, physical examination, and audiogram.
5. Forward all material to the Seattle Clinical Coordinating Center for review.
   A. Review in Seattle to assess likelihood of work-related hearing loss to:
      1) determine if patient likely has noise-induced hearing loss;
      2) file claim for workers compensation as appropriate;
      3) refer for additional medical evaluation and treatment (otolaryngologist and audiologist); and
      4) provide risk communication.

C. Beryllium Sensitization

1. Self administered questionnaire – occupational and health history (by mail).
2. Lymphocyte transformation test drawn at a local laboratory and shipped to National Jewish Hospital.
3. Review of questionnaire and laboratory results at the Seattle Clinical Coordinating Center. If positive, LPT will be repeated and if a second consecutive LPT is positive, referral to occupational – pulmonary physicians with expertise in chronic beryllium disease. If negative, letter explaining findings with available telephone consultation with a health care provider as needed.

Step 5. Annual Revised Needs Assessment based on exposures and health outcomes

There are substantial uncertainties in the risk estimates provided. The initiation of the surveillance program will provide crucial additional information on the prevalence of abnormalities among those participating in the surveillance program. In addition, the questionnaires will provide greater information on individual exposures and duration of exposure. Finally, several crucial databases will become available including REX and the employee job task analyses. These will all permit a revision of the current needs assessment. The subsequent iterations of the needs assessment will permit;

A. Reassessment of the need and priority of surveillance examinations;
B. Provide the site with important information on the presence and effects of past occupational hazards.

D. Limitations

Before concluding it is important to acknowledge the limitations of the current report to prevent misinterpretation of the data. The ascertainment of workers and the characterization of jobs and exposures to hazards is based on several databases. It is not possible to fully assess the quality of those data. With respect to characterization of hazards there are no good data presented on dose, duration, or intensity of exposure. Furthermore, the health outcome data which has been analyzed suggest adverse occupational effects. The extent to which these adverse effects are related to work at Hanford, at other occupational sites, or to non-occupational causes is not clear. The finding of higher rates of abnormalities for lung function and hearing loss in the setting of crude and uncertain measures of exposure raises substantial concern for the existence of an association between workplace exposures and occupational illness. For these reasons the results should be viewed cautiously and an iterative approach including incorporation of DOE's and other's reviews is proposed. Nonetheless, there are 35,440 workers who may have had noise exposure, 27,998 who may have had asbestos exposure, and 15,972 who may have had beryllium exposure. Analysis of health outcomes does suggest higher than expected rates

of abnormalities supporting the need for a surveillance program.

E. Summary and Recommendations

This report has documented substantial numbers of workers with potential exposure to a wide spectrum of hazards. Three of these hazards have been sufficiently characterized to warrant surveillance. These are asbestos, noise, and beryllium. The development of a surveillance program for former workers exposed to asbestos, noise, and beryllium is recommended. This surveillance program should provide medical care and appropriate risk communication to the workers. When appropriate, referral for additional evaluation and treatment should be made and claims for workers compensation should be filed. Finally, the annual report on the needs assessment should be provided to the site contractors and Department of Energy to insure that the hazards identified are mitigated. We look forward to subsequent submissions on additional hazards identified as additional databases (e.g. REX) and exposure questionnaire data is analyzed and comments are received.

Acknowledgement

This Phase I Needs Assessment could not have been done without the advice and support of many organizations and, importantly, the many employees and members of organizations related to the Hanford site. The assistance and counsel of those at the Oil, Chemical, and Atomic Workers Union, the Department of Energy, Richland Office, the Department of Energy Office of Health Studies, The Hanford Environmental Health Foundation, Fluor-Daniel Hanford, and Pacific Northwest National Laboratory.

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Appendix A.
Initial Contact Mailing Packet

UNIVERSITY OF WASHINGTON
Occupational and Environmental Medicine Program

HANFORD WORKER HEALTH STUDIES

Metropolitan Park West
1100 Olive Way - Suite 1150
Seattle, Washington 98101
(206)625-1169 Fax (206)625-1285

Richland Office
1201 Jadwin Avenue - Suite 101
Richland, Washington 99352
(509)946-4716 Fax (509)946-4311

Scott Barnhart, MD, MPH, Principal Investigator
Tim Takaro, MD, MPH, Co-Principal Investigator

Dear Former Hanford Worker,

You are invited to participate in a U.S. Department of Energy (DOE) funded project. This two-phase project has been designed to identify and evaluate the potential need for medical monitoring of former Hanford production, construction, and other workers. We are currently in Phase I of the project which is the 'Needs Assessment' phase. Phase II, if authorized, would be the 'Medical Monitoring' phase of the project.

We, at the University of Washington, will carry out this project for former production and non-construction Hanford workers. A second team is responsible for former Hanford building trades workers. If you agree to participate in the 'Needs Assessment' phase of this project, the enclosed Initial Contact Form will determine which team will follow up on assessing your potential occupational exposure.

Depending on the job tasks performed as a DOE-employee, you may have been exposed to radioactive or toxic substances which may put you at risk for disease. That disease may not show up for many years. By agreeing to participate in this project you have an opportunity not only to better protect your own health but also, you will be making an important contribution to furthering our knowledge and understanding of health risks associated with workplace exposures. These results may help identify areas on DOE sites where changes could be made to protect the health of current and future workers.

The enclosed Information Pamphlet will help you understand the 'Needs Assessment' phase of our project and expands on the information in the Consent Form. If you have any questions after reading through this information, please contact us at the telephone number listed on the last page of the Information Pamphlet. Thank you for your interest in this project.

Scott Barnhart, M.D.
Principal Investigator
Director, Occupational and Environmental Medicine Program
University of Washington

Tim Takaro, M.D.
Co-Principal Investigator
Occupational and Environmental Medicine Program
University of Washington

HANFORD FORMER WORKERS PROJECT

Production and Non-Construction Workers

MEDICAL MONITORING PROGRAM
Phase I - Needs Assessment

conducted by

University of Washington
Occupational and Environmental Medicine Program

Information Pamphlet

Occupational and Environmental Medicine Program
University of Washington

July 1997

The Following Organizations Have Provided Letters in Support of the Hanford Former Workers Project:

Washington State Health Department-Division of Radiation Protection

Center to Protect Workers' Rights

Washington State Department of Labor and Industries

Benton-Franklin District Health Department

Association of Occupational & Environmental Clinics

Sheet Metal Workers International Association

Hanford Atomic Metal Trades Council

Hanford Environmental Health Foundation

University of Washington-School of Public Health and Community Medicine

IS DOE LOOKING AT OTHER SITES BESIDES HANFORD?

Yes. In October, 1996 the DOE also chose other teams of health and labor specialists to look at selected groups of former DOE workers at the following locations:

Paducah, Kentucky	Nevada Test Site	Oak Ridge, Tennessee
Rocky Flats, Colorado	Portsmouth, Ohio	

HOW DID YOU FIND ME?

You may have found us by way of newsletter announcements, internet web sites or word of mouth. If we found you, it was through the DOE records that we were provided with in order to accomplish this project.

WHAT IS THE COST TO PARTICIPATE IN THIS PROJECT?

There will not be any financial cost to you.

WHAT DO I HAVE TO DO TO PARTICIPATE IN THIS PROJECT?

If you are a former production or non-construction worker, by signing the consent form, completing the Initial Contact Form and returning both to us, you become a participant. After analysis of the information we receive, a representative sample of former workers will be contacted by us and asked to provide a more detailed history on health and work experiences. This group will be selected on the basis of job type and potential hazardous work exposures. You are free to refuse to participate in this project and may withdraw at any time without penalty or jeopardy of any benefits to which you are otherwise entitled.

ISN'T THERE A SECOND HANFORD PROJECT FOR FORMER BUILDING TRADES WORKERS?

Yes, the DOE has divided former Hanford employees into two work categories: Building and construction trades workers and production workers. The Hanford Building and Construction Trades Former Worker Project (BCT) is currently being proposed and would collect information from the building and construction trades workers. We, here at the University of Washington, will collect information from production and other non-construction workers. The enclosed Former Worker Initial Contact Form will determine which category you will be placed in.

IF I PARTICIPATE IN THIS PROJECT WILL I BE VIOLATING ANY AGREEMENTS OF SECRECY?

By answering only those questions which appear on the USDOE approved questionnaires used in this project, you will not violate the "Classified Information Nondisclosure Agreement" signed during your employment. Personnel who were involved in the production of nuclear weapon components or in work related to an intelligence activity must use caution if the questionnaire format is not used, because the information in these areas remains extremely sensitive. For further information regarding this, please contact the Richland Operations Office Classification Officer:
R.L. Stutheit at (509)372-4510 or e-mail: ricky_l_stutheit@rl.gov

WHY DO YOU WANT MY SOCIAL SECURITY NUMBER?

Your social security number is a means of linking the information you provide to us with information obtained from other sources which use social security numbers as the only unique identifier. We will keep personal identification information like your name and social security number in a separate location from all other information obtained. When necessary, we will use a study code to link your personal identification information to other information. All information provided to our project will be kept in the strictest confidence, and used only as authorized for this project which adheres to the Privacy Act of 1974. Providing us with your social security number is voluntary.

WON'T IT BE DIFFICULT TO DETERMINE WHAT I WAS EXPOSED TO IN THE PAST?

Yes! The information you provide will significantly contribute to this effort. The amount of information available to us from other sources about past worker exposures will vary. Since no one source has all the information we need, it will be a difficult process to determine what you were exposed to and evaluate potential links to adverse health effects resulting from workplace exposure. However, by combining and cross-checking various data sources we can begin to construct exposure profiles for former workers.

WILL I BE NOTIFIED ABOUT THE RESULTS OF THE PROJECT?

We will notify you of Phase I results if you indicate so on the Initial Contact Form. You may also be contacted in the future with advice concerning medical monitoring or if excessive health risks are noted during the project.

WHO TO CALL FOR ADDITIONAL INFORMATION?

If you have any questions about this project and your participation in it, please feel free to contact:

University of Washington Occupational & Environmental Medicine Program

Contact: Richland Office
Kathy Ertell or Kathy Koons
Telephone: 509-946-4716
800-350-0896 (leave message)

Address: University of Washington - Richland Office
1201 Jadwin Avenue
Suite 101
Richland, Washington 99352

e-mail address: fworker@u.washington.edu
Web site address: http://weber.u.washington.edu./~fworker/fworker.html

Thank you for your time and contribution to this project.

WHAT ARE THE GOALS OF THIS PROJECT?

The initial focus during the "Needs Assessment" phase of our project will be to identify former Hanford workers who may be at significant risk for disease based on workplace exposure to radioactive or other hazardous substances, and establish contact with these workers. Based on the information collected, the teams will then make recommendations to the DOE concerning the need for future follow-up programs, including plans for the development of medical monitoring for former workers which would be funded by Congress. Phase II, if authorized, would be the implementation of medical monitoring programs for targeted groups of former workers. These programs would seek to benefit workers by helping to prevent or minimize illnesses related to DOE exposures in years past, and improve the health of the former worker.

HOW WILL THIS PROJECT BENEFIT ME?

The information you supply will aid us in establishing individual exposure profiles and designing medical monitoring programs which may help you know whether you were put at significant risk for disease while working at Hanford. As we collect the information from you and from site records we can characterize job categories and identify job tasks with a high risk for workplace exposure to hazardous substances. This information will help you decide if there is cause for concern and what steps you may want to take to better protect your health.

WHY IS THE DOE FUNDING THIS PROJECT?

The U.S. Congress passed Section 3162 of the Defense Authorization Act of 1993. This law directed the DOE to initiate a program which will evaluate the health of former DOE defense nuclear facility workers and look for potential links between occupational exposures to hazardous substances and significant adverse health effects.

WHO IS CONDUCTING THIS PROJECT?

We are a group of medical doctors and scientists at the University of Washington. We are one of two teams who were selected by the DOE to look at selected groups of former workers at the Hanford Site.

UNIVERSITY OF WASHINGTON CONSENT FORM

Medical Monitoring for Former Hanford Workers

Phase I - Needs Assessment

Investigators:
Tim K. Takaro, MD, , Faculty, Department of Medicine, (206)616-7458
Scott Barnhart, MD, Professor, Department of Medicine, (206)731-3744

Investigators' Statement

PURPOSE AND BENEFITS

Thousands of individuals have worked at Department of Energy (DOE) sites over the past 50 years. Many jobs involved potentially hazardous exposures during the operation of nuclear reactors, processing, handling and storage of nuclear materials, construction of large industrial facilities, building maintenance, and cleanup after spills, fires and other accidents. Depending on the jobs they performed, workers may have been exposed to radioactive substances or toxic substances, such as asbestos, solvents or beryllium. Sometimes the exposures can put workers at risk for diseases which may not show up for many years. This project is designed to provide information which will help you decide whether there is cause for concern and what steps you may want to take to protect your health. Recommendations to the Department of Energy (DOE) on the advisability and need for further follow-up, including plans for medical monitoring will be developed. Follow-up monitoring programs, if authorized, will seek to benefit targeted groups of former workers found to be at risk for adverse health effects by helping to prevent or minimize illnesses related to DOE exposures in years past, and improve workers' health.

PROCEDURES

We will attempt to contact all former workers for a brief survey including their current address, work history and exposures. This form will take about 10 minutes to complete. A representative sample of about 30% will be asked to provide more detailed information about their work experience, exposures, smoking, and health status. An example of the type of questions asked are; 'During the past four weeks have you been limited in the kind of work or other activities as a result of your physical health?', and 'Indicate the frequency of exposure to asbestos and if you think the exposure is a health risk to you'. You are free not to answer any questions you do not wish to answer. It will take about 40 minutes to complete this form. This sample will be selected on the basis of job type and potential work exposures. Results from this sample will help formulate recommendations for medical monitoring for former workers.

We are requesting your permission to review your employment and medical records to determine the nature and extent of health hazards that you may have encountered. Information concerning time in a job, type of work performed, type of exposures, and health events will be evaluated and compiled into electronic data sets to establish an exposure profile. By signing this form your are granting us this permission. Exposure and medical information from employers records, state, and federal data sets will be linked to the information you provide. We will turn all information over to the DOE and destroy our records of the data by 9/30/1998 unless we are granted continuation awards by the DOE. If we are granted continuation awards we will turn all information over to the DOE and destroy our records by 9/30/2002.

RISKS, STRESS, AND DISCOMFORT

It may be inconvenient for you to complete the survey forms we provide to you. Your information will be available to others for health or environmental studies. All information provided to our project will be kept in the strictest confidence, and used only as authorized for this project which adheres to the Privacy Act of 1974.

OTHER INFORMATION

We were provided your name and address from data bases controlled by the DOE. We will provide the information you give to us, including personal identification, to the DOE. The information you provide to us and all information we obtain is controlled by the DOE Privacy Act of 1974.

UNIVERSITY OF WASHINGTON CONSENT FORM

We are requesting your social security number to provide a means of linking the information you provide with information from other sources which use social security number as the only unique identifier. Providing us with your social security number is voluntary. Personal identification information like name and social security number will be kept in a separate location from all other information. A code will be used to link identification information to other information when necessary.

Personal identification information will not be included in public reports nor will it be available to the public. You will not be violating any agreements of secrecy you have made with an agency of the United States Government by providing this information.

You may refuse to participate and you are free to withdraw from this project at any time without penalty or loss of benefits to which you are otherwise entitled. There will not be any financial cost to you nor will there be any fees paid to you for your participation.

_____

Signature of investigator Date

Subjects Statement

The project described above has been explained to me. I voluntarily consent to take part in this activity. I have had an opportunity to ask questions. I understand that any future questions I may have about the research or about my rights as a subject will be answered by one of the investigators listed above.

_____

Signature of subject Printed Name Date

You have been provided with two identical Consent Forms. Retain one copy for your personal records. Please sign the second copy and return it, with the completed Initial Contact Form, in the enclosed self-addressed stamped envelope.

Tim K. Takaro, M.D. MPH.
University of Washington
Metropolitan Park West
Suite 1150
1100 Olive Way
Seattle, WA 98101

Hanford Former Worker Project

Production and Non-Construction Workers

FORMER WORKER INITIAL CONTACT FORM

MEDICAL MONITORING PROGRAM
Phase I - Needs Assessment

conducted by

University of Washington
Occupational and Environmental Medicine Program

This questionnaire will ask you general questions about your work history. The information you provide will help us understand more about the health risks associated with workplace exposures and will help determine the need for follow-up programs, including plans for the development of medical monitoring programs for targeted groups of former workers.

The '*Worker Category Section*' has been designed to determine which of the two Hanford teams will assess your health risk:

If you shade '**Production**', '**Maintenance**', and/or '**Other**': The University of Washington will evaluate your exposures and health risks.

If you shade '**Construction**' only: The Hanford Building and Construction Trades Former Worker Project (BCT) is currently proposed to conduct similar evaluations for former Hanford building and construction trades workers. This second team would be responsible for any further contact with you. We will forward this form to DOE who will then supply this information to the Hanford BCT Project.

Please return this questionnaire within 7 days of receiving the study packet.

Your **SIGNED CONSENT FORM** must be returned to us for your inclusion in the first phase of this project with the University of Washington.

Directions for Entering Information

1. Please read each question carefully, **print** each answer according to the directions using **black** ink.

2. When boxes are provided for an entry, enter one character per box and do not touch the edges.

   Given 2 boxes, if you worked 9 years, the value 9 would be entered as: 9

3. When options are provided, shade in the bubble to the left of the appropriate response.

   Given 3 bubble options, the response 'No' would be entered as: ○ Yes ● No ○ Uncertain

4. Please see reverse side for *State Code abbreviations* and *Union Affiliation Definitions*.

We thank you for your time and contribution to this important health risk assessment

State Codes

AL	Alabama	IA	Iowa	NJ	New Jersey	VT	Vermont
AK	Alaska	KS	Kansas	NM	New Mexico	VA	Virginia
AZ	Arizona	KY	Kentucky	NY	New York	WA	Washington
AR	Arkansas	LA	Louisiana	NC	North Carolina	WV	West Virginia
CA	California	ME	Maine	ND	North Dakota	WI	Wisconsin
CO	Colorado	MD	Maryland	OH	Ohio	WY	Wyoming
CT	Connecticut	MA	Massachusetts	OK	Oklahoma	PR	Puerto Rico
DE	Delaware	MI	Michigan	OR	Oregon	VI	Virgin Islands
DC	District of Columbia	MN	Minnesota	PA	Pennsylvania	GU	Guam
FL	Florida	MS	Mississippi	RI	Rhode Island		
GA	Georgia	MO	Missouri	SC	South Carolina		
HI	Hawaii	MT	Montana	SD	South Dakota		
ID	Idaho	NE	Nebraska	TN	Tennessee		
IL	Illinois	NV	Nevada	TX	Texas		
IN	Indiana	NH	New Hampshire	UT	Utah		

Acronyms	Union Affiliation Definitions
AWIU	International Association of Heat and Frost Insulators and Asbestos Workers
IBB	International Brotherhood of Boilermakers, Iron Ship Builders, Blacksmiths, Forgers and Helpers
BAC	International Union of Bricklayers and Allied Craftworkers
UBC	United Brotherhood of Carpenters and Joiners of America
GCIU	Graphic Communications International Union
I B E W	International Brotherhood of Electrical Workers
I U E C	International Union of Elevator Constructors
IUOE	International Union of Operating Engineers
IRON WORKERS	International Association of Bridge, Structural and Ornamental Iron Workers
LIUNA	Laborers' International Union of North America
IBPAT	International Brotherhood of Painters & Allied Trades of the United States & Canada
OP&CMIA	Operative Plasterers' and Cement Masons' International Association of the United States and Canada
UA	United Association of Journeymen and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada
ROOFERS	United Union of Roofers, Waterproofers and Allied Workers
SMWIA	Sheet Metal Workers International Association
IBT	International Brotherhood of Teamsters
HAMTC	Hanford Atomic Metal Trades
OCAW	Oil, Chemical & Atomic Workers
IAM	International Association of Machinists

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Hanford Former Worker Project

FORMER WORKER INITIAL CONTACT FORM

Today's Date: / / Social Security Number: - -

Date of Birth: / /

Where were you born? State: Town:

Specify country, if not U.S.

Name:

First M.I. Last

Please list any other names you have used:

Current Mailing Address:

Street Number Apt. Number

City State Zip Code

Permanent Mailing Address:

Street Number Apt. Number

City State Zip Code

Home Telephone: ( ) -

Office Telephone: ( ) -

1. Are you or were you a member of a union at Hanford? ○ Yes ○ No, Unaffiliated

   a. If yes, what union(s) have you been affiliated with: (shade all that apply)

○ OCAW	○ LIUNA	○ IUOE	○ IBEW
○ IAM	○ UBC	○ IBT	○ ROOFERS
○ AWIU	○ IBB	○ BAC	○ IRONWORKERS
○ IUEC	○ SMWIA	○ IBPAT	○ Other Specify:
○ OP & CMIA	○ GCIU	○ UA	○ Other Specify:

   b. What category best describes the type of work performed: (shade all that apply)

○ Production ○ Maintenance ○ Construction ○ Other Specify:

2. Who is the person, living in your household, who will know your whereabouts?

Next of Kin:

First M.I. Last

If you shaded **'Production', Maintenance'** and/or **'Other','** please complete the rest of the form.

If you shaded **'construction'** only **stop here** and return this form to the University of Washington without the Consent Form.

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This is a unique form, the original must be returned.
You may retain a copy. Please do not copy for others.

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Hanford Former Worker Project

3. Who is the person, *not* living in your household, who is most likely to know your whereabouts if you move?

Contact Person Name: _____
First M.I. Last

Address: _____
Street Number Apt. Number

_____
City State Zip Code

Phone Number: ( ) -

The following questions apply 'only' to your employment at DOE Weapons Production Facilities

4. What is the total number of <u>years</u> you were employed at **'any'** U.S .weapons production facility? ☐☐

5. Besides Hanford, what other DOE sites have you worked at? (shade all that apply)

○ Portsmouth	○ Paducah	○ Other1 Specify:_____
○ Oak Ridge	○ Nevada Test Site	○ Other2 Specify:_____
○ Rocky Flats	○ Savannah River Site	○ Other3 Specify:_____

The following questions apply 'only' to your employment at the Hanford Weapons Facility Site

6. What is the total number of <u>years</u> you were employed at Hanford? ☐☐

7. What was your first date of employment at Hanford? ☐☐ / ☐☐
Month Year

8. Are you currently employed at Hanford? ○ Yes ○ No

9. Are there medical monitoring programs you would like to see offered? ○ Yes ○ No

a. If yes, please describe (for additional comments, use back of form):

_____

10. Is someone other than the former worker completing this form? ○ Yes ○ No

a. If yes, what is your name?_____
First Last

b. Why are you are completing this form?_____

11. Do you wish to be notified of the results from this project? ○ Yes ○ No

12. In the future, may we contact you by phone for a detailed work history? ○ Yes ○ No

a. If yes, please indicate the most convenient time? ○ Morning ○ Afternoon ○ Evening

Please take a few minutes to review this questionnaire and fill in any questions you may have skipped over. Remember to return your signed Consent Form with this questionnaire.

***Thank you** for your time and contribution to this health risk assessment.*

6562 58470

This is a unique form, the original must be returned. You may retain a copy. Please do not copy for others.

Dear Former Hanford Worker:

A short while ago a packet of material explaining a former Hanford worker project was mailed to you. This project is being conducted by the University of Washington and is sponsored by the Department of Energy. The overall goal of this initiative is to identify and evaluate the potential need for medical monitoring of former Hanford workers.

If you have already returned the Initial Contact Form with a signed copy of the Consent Form, we would like to thank you for your time and interest in this project. If you have misplaced your study packet or have additional questions regarding your participation, please contact us at 509-946-4716 or 800-350-0896 and we will gladly answer your questions or mail a new study packet to you.

Your participation will greatly enhance the quality of any medical monitoring programs for you and your fellow workers.

Tim Takaro, MD, MPH
University of Washington

Metropolitan Park West
1100 Olive Way - Suite 1150
Seattle, Washington 98101

SCRIPT FOR IDENTIFICATION OF PARTICIPANTS
Hanford Former Workers Project

Hello, this is (*locator's name*). I am with the University of Washington's Occupational and Environmental Medicine Program. I am attempting to locate former Hanford workers. May I speak with (*participant's name*)?

We are working with the Department of Energy to identify and evaluate the health of former DOE defense nuclear facility workers. We obtained your name through the DOE records that were provided to us to carry out this project.

Have you ever worked on the Hanford Site?

If no: I'm sorry to have taken your time. You are not the person we are looking for.

If yes: Is this a good time to talk? If not, when is a more convenient time for me to call you back?

I would like to ask you your address and date of birth. By providing us with this information we are able to make certain you are the person we are trying to contact and if you wish to receive our study packet, we need to ensure we have your current mailing address.

Is your address ( )?

If no, what is your correct address?

Is your date of birth ( )?

If no, what is your correct date of birth?

If you agree to learn more about the study, within the next 3 months you will be receiving an information pamphlet and questionnaire from the University of Washington on Phase I of the Former Hanford Worker's Project. To participate in Phase I of this two phase project you will be asked to review the information pamphlet, sign the consent form, and complete the brief questionnaire. Participation is voluntary and there will be no financial cost to you. All information provided to us will be kept in the strictest confidence and used only as authorized for this project.

I will be happy to answer any questions you might have but ask that you please read the information first. If you have any additional questions prior to receiving this material, please feel free to contact Kathy Ertell at 509-946-4716 or leave a voice mail message on our toll-free line at (800)350-0896.

Thank you very much for your time. Your cooperation is greatly appreciated.

Appendix B.
Exposure Questionnaire

UNIVERSITY OF WASHINGTON
Occupational and Environmental Medicine Program

HANFORD WORKER HEALTH STUDIES

Metropolitan Park West
1100 Olive Way · Suite 1150
Seattle, Washington 98101
(206)625-1169 Fax (206)625-1285

Richland Office
1201 Jadwin Avenue - Suite 101
Richland, Washington 99352
(509)946-4716 Fax (509)946-4311

Scott Barnhart, MD, MPH, Principal Investigator
Tim Takaro, MD, MPH, Co-Principal Investigator

Dear Former Hanford Worker;

Earlier this summer, we invited you to participate in a project funded by the U.S. Department of Energy (DOE) to identify and evaluate the need for medical monitoring of workers formerly employed at the Hanford site. You agreed to participate in this project by returning a signed consent form. We are now in the process of gathering information regarding job history, potential exposures, and overall health status in order to evaluate the need for various types of medical monitoring and would like you to fill out the enclosed questionnaire. The information in this questionnaire will be used to determine whether or not there is a need for medical monitoring of former Hanford workers. We may contact you again to invite you to enroll in one or more potential medical monitoring programs, or we may simply notify you of possible health effects associated with your exposures at Hanford.

The questionnaire has two parts. Part 1 asks you to provide a detailed history of all the jobs you held at Hanford as well as information about your general well-being. Part 2 asks about specific chemicals or other hazards to which you may have been exposed and personal protective equipment you may have used. After you fill in the "Job History and General Health Form" (Part 1), please complete a "Job Specific Information Form" (Part 2) for each job you listed under "Job Title" in Part 1. Extra copies of the "Job Specific Information Form" are included for this purpose. Return all completed forms in the enclosed postage paid envelope. We will be sending you a follow-up post card in approximately one week. If you need more copies of the "Job Specific Information Form", if you have any questions at all, or do not wish to be contacted further please call us toll free at 1-800-419-9691. Thank you for your willingness to participate in this project.

Scott Barnhart, MD
Principal Investigator
Director, Occupational and Environmental Medicine Program
University of Washington

Tim Takaro, MD
Co-principal investigator
Occupational and Environmental Medicine Program
University of Washington

Former Worker Occupational History Survey
Part 1: Job History and General Health

Please print in capital letters and avoid contact with the sides of the box.
Do not cross 0's, 7's or Z's.
Please ROUND all answers to WHOLE numbers.

0	1	2	3	4	5	6	7	8	9

Shade circles like this: ●
Not like this: ⊗ ✓

Study ID

1. Today's Date ___ / ___ / ___

2. Sex: ○ Male ○ Female

3. What is your Marital status? ○ Single ○ Married or Married Situation ○ Widowed ○ Divorced

4. Race ○ White ○ Black ○ Asian ○ Hispanic ○ Native American ○ Other _____

5. What is the highest grade you completed in school?
(12 years = completion of high school. Include years of college) ___

Please list your jobs at a United States weapons production facility (e.g. Manhattan project, DOE), which you have held for at least one month. Start with your most recent or current job as Job Title #1.

	Job Title	Start date Month	Start date Year	End date Month	End date Year
#1		/		/	
#2		/		/	
#3		/		/	
#4		/		/	
#5		/		/	
#6		/		/	
#7		/		/	
#8		/		/	
#9		/		/	
#10		/		/	
#11		/		/	
#12		/		/	

Former Worker Occupational History Survey
Part 1: Job History and General Health

Health Status

This section asks for your views about your health. This information will give us an idea of your overa and mental health status.
Please answer every question by marking one box. If you are unsure about how to answer, please give answer you can.

1. In general, would you say your health is: ○ Excellent ○ Very Good ○ Good ○ Fair ○ Poor

The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

	Yes, Limited A Lot	Yes, Limited A Little	No, Not Limited At All
2. Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf.	○	○	○
3. Climbing several flights of stairs.	○	○	○

During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

4. Accomplished less than you would like? ○ Yes ○ No
5. Were limited in the kind of work or other activities? ○ Yes ○ No

During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

6. Accomplished less than you would like? ○ Yes ○ No
7. Didn't do work or other activities as carefully as usual? ○ Yes ○ No

8. During the past 4 weeks, how much did pain interefere with your normal work (including both wor the home and housework)?

○ Not at all ○ A little bit ○ Moderately ○ Quite a bit ○ Extremely

These questions are about how you have felt during the last 4 weeks. For each question, please give the answer that comes closest to the way you have been feeling.

How much time during the last 4 weeks:

	All	Most	A Good bit	Some	A Little	None
9. Have you felt calm and peaceful?	○	○	○	○	○	○
10. Did you have a lot of energy?	○	○	○	○	○	○
11. Have you felt downhearted and blue?	○	○	○	○	○	○

12. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)?

○ All of the time ○ Most of the time ○ Some of the time ○ A little of the time ○ None of the time

Tobacco Smoking

	Yes	No
1. Have you smoked as many as 100 cigarettes in your lifetime?	○	○
2. Do you now smoke cigarettes (as of one month ago)?	○	○

3. When you were smoking, how many cigarettes did you usually smoke on a typical day? (1 pack = 20 cigarettes) Number of cigaretes: _____

4. How many years did you smoke cigarettes before you stopped? Or, if you still smoke, how many years have you smoked? Number of years: _____

Thank you

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Former Worker Occupational History Survey

Part 2: Job Specific Information Form

Study ID

Please complete a seperate Job Specific Information Form for each job.

Job number as listed on page 1. Number of years in this job:

1. Facility where this job was located:
   - ○ Hanford
   - ○ Fernald
   - ○ Idaho National Laboratory
   - ○ Lawrence Livermore Laboratory
   - ○ Los Alamos Laboratory
   - ○ Nevada Test Site
   - ○ Oak Ridge
   - ○ Rocky Flats
   - ○ Sandia Laboratory
   - ○ Savannah River Site
   - ○ Other _____

2. Work area: _____ Location in that area: _____

   Building and Room _____

3. Job Title / Occupation (select title from the enclosed list if possible)

   _____

Code: For office use only.

4. Please indicate whether you used any of the following types of personal protection equipment (PPE) for this job, and indicate the frequency of use.

Type of PPE	Used on this job? Yes	No	Frequency of Use: Daily	1-4 days/ week	Less than once/week	Emergency Only
Disposable Dust Mask	○	○	○	○	○	○
Cartridge Respirator	○	○	○	○	○	○
Supplied Air Respirator	○	○	○	○	○	○
Radiation Protection Suit	○	○	○	○	○	○
Other PPE _____ Please specify	○	○	○	○	○	○

Former Worker Occupational History Survey

Part 2: Job Specific Information Form

5. Please indicate whether or not you worked with or near the following materials during this job. Also, indicate the frequency of exposure and whether you had enough exposure for you to be concerned about the possible health risks.

Material	Worked with or near?		Frequency of Exposure				Exposure high enough to cause concern?		Years Exposed in this job.		
	Yes	No	Daily	Weekly	Monthly	Yearly	Yes	No	<1	1-5	>5
Metals											
Beryllium	○	○	○	○	○	○	○	○	○	○	○
Cadmium	○	○	○	○	○	○	○	○	○	○	○
Lead	○	○	○	○	○	○	○	○	○	○	○
Mercury	○	○	○	○	○	○	○	○	○	○	○
Chromium	○	○	○	○	○	○	○	○	○	○	○
Nickel	○	○	○	○	○	○	○	○	○	○	○
Zirconium/ Zircalloy	○	○	○	○	○	○	○	○	○	○	○
Other/Unknown	○	○	○	○	○	○	○	○	○	○	○
Solvents											
Chlorinated Solvents	○	○	○	○	○	○	○	○	○	○	○
Includes: Carbon tetrachloride, Trichloroethylene, Perchloroethylene (Perc), Methyl chloroform (1,1,1-trichloroethane), methylene chloride											
Acetonitrile	○	○	○	○	○	○	○	○	○	○	○
Toluene and Ketones	○	○	○	○	○	○	○	○	○	○	○
Includes: toluene, methyl ethyl ketone (MEK), hexone, methyl isobutyl ketone (MIBK)											
Glycol ethers	○	○	○	○	○	○	○	○	○	○	○
Includes: Amercoat paint,											
Paints/thinners	○	○	○	○	○	○	○	○	○	○	○
Includes: Amercoat paint, other paints, turpentine, mineral spirits											
Other non-chlorinated solvents or oils	○	○	○	○	○	○	○	○	○	○	○
Includes: methanol, ethanol, ethyl alcohol, ether, kerosene											

Former Worker Occupational History Survey

Part 2: Job Specific Information Form

Material	Worked with or near? Yes	No	Frequency of Exposure: Daily	Weekly	Monthly	Yearly	Exposure high enough to cause concern? Yes	No	Years Exposed in this job. <1	1-5	>5
Radioactive Materia											
Plutonium	○	○	○	○	○	○	○	○	○	○	○
Uranium	○	○	○	○	○	○	○	○	○	○	○
Other radioisotopes	○	○	○	○	○	○	○	○	○	○	○
Gamma radiatio	○	○	○	○	○	○	○	○	○	○	○
Acids/Caustics											
Stack gas	○	○	○	○	○	○	○	○	○	○	○
Irritant gases Includes: chlorine, ammonia, hydrofluoric acid (HF)	○	○	○	○	○	○	○	○	○	○	○
Other Includes: nitric acid, sulfuric acid, hydrochloric acid, sodium hydro	○	○	○	○	○	○	○	○	○	○	○
Process Chemicals											
Uranyl nitrate hexahydrate (UN	○	○	○	○	○	○	○	○	○	○	○
Uranium tetrafluoride (UF4 or green salt	○	○	○	○	○	○	○	○	○	○	○
Tributyl phosphate (TBP	○	○	○	○	○	○	○	○	○	○	○
NPH (Kerosene)	○	○	○	○	○	○	○	○	○	○	○
Physical Agents											
Noise	○	○	○	○	○	○	○	○	○	○	○
Vibration	○	○	○	○	○	○	○	○	○	○	○
Laser light	○	○	○	○	○	○	○	○	○	○	○
Radiofrequency or Microwave radiation	○	○	○	○	○	○	○	○	○	○	○

Former Worker Occupational History Survey

Part 2: Job Specific Information Form

Material	Worked with or near?		Frequency of Exposure				Exposure high enough to cause concern?		Years Exposed in this job.		
	Yes	No	Daily	Weekly	Monthly	Yearly	Yes	No	<1	1-5	>5
Miscellaneous											
Nitrates	○	○	○	○	○	○	○	○	○	○	○
Hydrazine	○	○	○	○	○	○	○	○	○	○	○
Sodium dichromate	○	○	○	○	○	○	○	○	○	○	○
Lithium hydroxide	○	○	○	○	○	○	○	○	○	○	○
Asbestos	○	○	○	○	○	○	○	○	○	○	○
Welding fumes	○	○	○	○	○	○	○	○	○	○	○
Formaldehyde	○	○	○	○	○	○	○	○	○	○	○
Herbicide/ pesticide	○	○	○	○	○	○	○	○	○	○	○
PCBs	○	○	○	○	○	○	○	○	○	○	○
Metal working fluids	○	○	○	○	○	○	○	○	○	○	○
Fuels, greases, oils	○	○	○	○	○	○	○	○	○	○	○
Other/unknown	○	○	○	○	○	○	○	○	○	○	○

6. Have you ever had a work-related injury or illness? ○ Yes ○ No ○ Don't Know

7. Have you ever been diagnosed with a work-related illness by a doctor? ○ Yes ○ No ○ Don'tKnow

8. Have you ever missed more than three days of work because of a work-related illness or injury?
○ Yes ○ No ○ Don'tKnow

9. If there is anything else about your work experience or exposures at Hanford that you think we shoul about, please comment in the space below.

Thank you

Dear Former Hanford Worker:

A short while ago the Former Worker Occupational History Study Packet was mailed to you.

If you have already returned the completed forms, we would like to thank you for your continued time and interest in this project. If you have misplaced your study packet or have additional questions, please contact us at 509-946-4716 or 800-350-0896 and we will gladly answer your questions or mail a new study packet to you.

Your participation will greatly enhance the quality of any medical monitoring programs for you and your fellow workers.

Tim Takaro, MD, MPH
University of Washington

Metropolitan Park West
1100 Olive Way - Suite 1150
Seattle, Washington 98101

Appendix C.
List of Common Occupational Classification Codes

	Occupational Exposure Group	COCS Codes	
M1	First Line Supervisors	M010	
M2	Managers	M020	
E1	Chem,Env,Nuc Engineers	E010, E050, E080	
E2	Civil, Mining, Constr Engineers	E020, E090, E140	
E3	Other Engineers	E040, E060, E070, E080, E110, E120, E130	
E4	Plant Engineers	E100	
S1	Chemists	S010	
S2	Other Scientists	S020, S030, S060, S080, S090, S100	
S3	Life Scientists	S040	
S4	Materials Scientists	S050	
S5	Physicists	S070	
P1	Other Professionals	P010, P020, P030, P040, P060, P070, P100, P110, P120, P130, P140, P150, P160, P170	
P2	Compliance Inspectors	P050	
P3	Health Physicists	P080	
P4	Industrial Hygienists	P090	
G1	Administrative Office Staff	G010, G020, G030, G040, G050, G060	
T1	Other Technicians	T010, T020, T030, T090, T100, T110	
T2	Environmental Science Techs	T040	
T3	Health Physics Techs	T050	
T4	Ind Safety and Health Techs	T060	
T5	Instr and Control Techs	T070	
T6	Lab Techs	T080	
C1	Carpenters	C010	
C2	Electricians	C020	
C3	HVAC Mechanics	C030	
C4	Machinists	C040	
C5	Masons	C050	
C6	Millwrights	C060	
C7	Painters	C070	
C8	Plumbers & Pipefitters	C080	
C9	Structural & Metalworkers	C090	
C10	Vehicle Mechanics	C100	
C11	Welders	C110	
C12	Other Crafts	C120	Not included in matrix
C13	Insulators	C130	Added to original COCS
R1	Nuclear Proc & Waste Ops	R010, R050	
R2	Drillers	R020	
R3	Material Moving Equip Ops	R030	
R4	Reactor Operators	R040	
R5	Utilities Operators	R070	
R6	Other Operators	R060, R080	Not included in matrix
L1	Firefighters	L010	
L2	Food Service Workers	L020	
L3	Janitors and Cleaners	L030	
L4	Laundry Workers	L040	
L5	Laborers	L050, L060	
L6	Light Vehicle Drivers	L070	
L7	Security Guards	L080	
L8	Other General Service Workers	L090	Not included in matrix

If Census Code =	Then COCS Code =
223, 441,573 and job title = SUPV D/D, 590, 966, 993	M010
221, 222	M020
216, 241, 242, 243, 243.33, 244	M030
202, 233, 236, 245	M040
010	E010
011	E020
012	E040
013	E060
014	E070
020	E090
023 and job title = Environmental Engineer	E050
023 and job title = Nuclear Engineer	E080
023 and job title = Plant Engineer	E100
023 and job title = QA/QC Engineer	E110
023 and job title = Safety Engineer	E120
023 and job title = Construction Engineer	E140
023 and job title not equal to any of above	E130
045	S010
054 and job title = Environmental Scientist	S020
054 and job title = Industrial Hygienist	P090
054 and job title = Health Physicist	P080
054 and none of the above	S090
051	S030
044	S040
015	S050
035	S060
053	S070
091, 093	S080
036, 043, 052, 053, 055, 195	S090
003	S100
001	P010
002, 183	P020
225	P030
171	P040
213, 215, 610	P050
004	P060
321	P070
031	P100
056	P110
065	P120
062, 064, 065, 072, 075, 076, 921, 922, 923, 925, 074	P130
964	P140
113 and job title = Industrial Hygienist	P090
113 and job title = Health Physicist	P080
113 and not IH or HP, 134, 141	P150
181, 184, 189, 192, 194	P160
032, 033, 101, 163, 164, 174, 180, 182, 190, 191, 212, 326, 323	P170

312	G010
333, 364, 394	G020
305, 310, 315, 325, 342, 344, 345, 350, 355, 360, 362, 374, 375, 376, 381, 385, 390, 392	G030
370, 372	G040
391	G050
220, 265, 280, 330, 332, 395	G060
005, 343	T010
152	T020
154, 155, 162	T030
162	T040
085 and job title = Health Physics Technician, 691	T050
085 and job title = Industrial Safety and Health Technician or Industrial Safety Technician or Industrial Hygiene Technician	T060
153, 492, 485	T070
080, 085 and job title = Laboratory Technician, 151, 848	T080
505, 173 and job title = Media Technician	T090
161	T100
082, 083, 150, 156, 157, 173 and job title is not Media Technician, 426, 484, 492, 495, 515, 574, 994, 085 and job title is not Lab Tech	T110
415, 416, 662	C010
430, 431	C020
535, 536	C030
461, 462	C040
410, 421, 411, 560	C050
502	C060
510, 511, 521, 543, 520	C070
522, 523	C080
550	C090
373, 471, 472, 473, 481, 486, 491	C100
680	C110
403, 404, 420, 422, 445, 530, 534, 552, 554, 561, 562, 563, 571 572, 575, 613, 621	C120
601	C130
622, 692	R010
614	R020
412, 424, 436, 455, 715, 550	R030
693	R040
(690 or 692 or 694 or 695 or 696) and job title = Nuclear Waste Process Operator	R050
602, 645, 652, 663	R060
525, 694, 695, 433	R070
452, 545, 640, (690 or 696) and job title is not Nuclear Waste Process Operator	R080
666, 961	L010
912, 913, 914, 916	L020
940, 950, 903	L030
630	L040

643, 750, 751, 753, 755, 761, 770, 780, 785	L050
605, 623, 642, 740, 754, 573 and job title = D/D	L060
703, 714, 706	L070
962	L080
701, 712, 932, 933, 743	L090
995	not defined

Appendix D: Job-Exposure Matrix

Industrial Hygiene Staff for Job-Exposure Matrix

Noah Seixas, PhD, CIH	Assistant Professor, University of Washington, Department of Environmental Health
Kathy Ertell, MS, CIH	Research Consultant, University of Washington, Occupational and Environmental Medicine Program
Kate Durand, MHS, CIH	Research Scientist, University of Washington, Occupational and Environmental Medicine Program
Edward Beck, CIH	Industrial Hygienist, Hanford Environmental Health Foundation Consultant to University of Washington

Exposures by COCS by Decade

	M010					M020-M030					E010, E050 E080					E020, E090 E140					E040 E060-E070 E110-E130					E100					S010				
	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s
Metals																																		
Beryllium	1	1	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cadmium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lead	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0
Mercury	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0
Chromium	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nickel	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zirconium/Zircalloy	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other/Unknown	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solvents																																		
Chlorinated Solvents	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2	2	2
Acetonitrile	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2	2	2
Toluene and Ketones	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2	2	2
Glycol ethers	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0
Paints/Thinners	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0
Other solvents	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0
RadioactiveMaterial																																		
Plutonium	1	1	1	1	0	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	2	1	1	1	1
Uranium	1	1	1	1	0	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	2	1	1	1	1
Other isotopes	1	1	1	1	0	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	2	1	1	1	1
Gamma radiation	2	1	1	1	1	2	0	0	0	0	2	1	1	0	0	1	0	0	0	0	0	0	0	0	0	2	1	1	1	1	2	1	1	1	1
Acids/Caustics																																		
Stack gas	1	1	1	1	0	1	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0
Irritant gases	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1

Exposures by COCS by Decade

	M010					M020-M030					E010, E050 E080					E020, E090 E140					E040 E060-E070 E110-E130					E100					S010				
	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s
Process Chemicals																																		
Uranyl nitrate hexahydrate	1	1	1	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1	0
Uranium tetrafluoride	1	1	1	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1	0
Tributyl phosphate	1	1	1	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1	0
NPH (kerosene)	1	1	1	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1	0
Physical Agents																																		
Noise	1	1	1	1	1	1	0	0	0	0	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0
Vibration	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laser Light	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RF or Microwave radiation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miscellaneous																																		
Nitrates	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
Hydrazine	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0
Sodium dichromate	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0
Lithium hydroxide	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0
Asbestos	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0
Welding fumes	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0
Formaldehyde	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0
Herbicide	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pesticide	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PCBs	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0
Metal working fluids	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuels, greases, oils	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silica	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exposures by COCS by Decade

	S020-030 S060 S080-S100					S040					S050					S070					P010-P040 P060-P070 P100-P170					P050					P080				
	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s
Metals																																		
Beryllium	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cadmium	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lead	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2
Mercury	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chromium	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nickel	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zirconium/Zircalloy	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other/Unknown	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solvents																																		
Chlorinated Solvents	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acetonitrile	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Toluene and Ketones	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glycol ethers	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paints/Thinners	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other solvents	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RadioactiveMaterial																																		
Plutonium	0	0	0	0	0	1	1	1	1	1	2	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Uranium	0	0	0	0	0	1	1	1	1	1	2	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Other isotopes	0	0	0	0	0	1	1	1	1	1	2	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Gamma radiation	0	0	0	0	0	1	1	1	1	1	2	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Acids/Caustics																																		
Stack gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Irritant gases	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exposures by COCS by Decade

	S020-030 S060 S080-S100					S040					S050					S070					P010-P040 P060-P070 P100-P170					P050					P080				
	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s
Process Chemicals																																		
Uranyl nitrate hexahydrate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uranium tetrafluoride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tributyl phosphate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NPH (kerosene)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Physical Agents																																		
Noise	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0
Vibration	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laser Light	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RF or Microwave radiation	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miscellaneous																																		
Nitrates	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrazine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sodium dichromate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithium hydroxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Asbestos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Welding fumes	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Formaldehyde	0	0	0	0	0	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Herbicide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pesticide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PCBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metal working fluids	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuels, greases, oils	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exposures by COCS by Decade

	P090					G010-G060					T010-T030 T090-T110					T040					T050					T060					T070				
	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s
Metals																																			
Beryllium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	1	1	1	0
Cadmium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0
Mercury	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
Chromium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nickel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zirconium/Zircalloy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other/Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solvents																																			
Chlorinated Solvents	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
Acetonitrile	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Toluene and Ketones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Glycol ethers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paints/Thinners	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Other solvents	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
RadioactiveMaterial																																			
Plutonium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	0	0	0	0	0	0	0	0	0
Uranium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	0	0	0	0	0	0	0	0	0
Other isotopes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	0	0	0	0	0	0	0	0	0
Gamma radiation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	0	0	0	0	2	0	0	0	0
Acids/Caustics																																			
Stack gas	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	1	1	1	0	1	1	1	1	0
Irritant gases	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0

Exposures by COCS by Decade

	P090					G010-G060					T010-T030 T090-T110					T040					T050					T060					T070				
	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s
Process Chemicals																																			
Uranyl nitrate hexahydrate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Uranium tetrafluoride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Tributyl phosphate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
NPH (kerosene)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Physical Agents																																			
Noise	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Vibration	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laser Light	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RF or Microwave radiation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miscellaneous																																			
Nitrates	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrazine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sodium dichromate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithium hydroxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Asbestos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Welding fumes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Formaldehyde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Herbicide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pesticide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PCBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metal working fluids	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuels, greases, oils	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Exposures by COCS by Decade

	T080					C010					C020					C030					C040					C050					C060				
	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s
Metals																																		
Beryllium	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	1	1	1	1
Cadmium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1
Lead	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1
Mercury	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Chromium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Nickel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	0	0	0	0	0	1	1	1	1	1
Zirconium/Zircalloy	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1	0	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1
Other/Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1
Solvents																																		
Chlorinated Solvents	2	2	2	2	2	0	0	0	0	0	1	1	1	1	0	2	2	2	2	2	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1
Acetonitrile	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Toluene and Ketones	2	2	2	2	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Glycol ethers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Paints/Thinners	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1
Other solvents	2	2	2	2	2	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1
RadioactiveMaterial																																		
Plutonium	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Uranium	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Other isotopes	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gamma radiation	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Acids/Caustics																																		
Stack gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Irritant gases	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0

Exposures by COCS by Decade

	T080					C010					C020					C030					C040					C050					C060				
	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s
Process Chemicals																																		
Uranyl nitrate hexahydrate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uranium tetrafluoride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tributyl phosphate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NPH (kerosene)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Physical Agents																																		
Noise	1	1	1	1	1	2	2	2	2	2	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	2	2	2	2	2
Vibration	0	0	0	0	0	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1
Laser Light	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RF or Microwave radiation	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miscellaneous																																		
Nitrates	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrazine	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sodium dichromate	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithium hydroxide	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Asbestos	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Welding fumes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1
Formaldehyde	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Herbicide	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pesticide	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PCBs	1	1	1	1	1	0	0	0	0	0	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metal working fluids	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	0	0	0	0	0	2	2	2	2	2
Fuels, greases, oils	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	2	2	2	2	2
Silica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0

Exposures by COCS by Decade

	C070					C080					C090					C100					C110					C120					C130				
	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s
Metals																																		
Beryllium	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1						0	1	1	1	0
Cadmium	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
Lead	2	2	2	2	2	1	1	1	1	1	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1						0	0	0	0	0
Mercury	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
Chromium	1	1	1	1	1	2	2	2	2	2	1	1	1	1	1	0	0	0	0	0	2	2	2	2	2						0	0	0	0	0
Nickel	0	0	0	0	0	2	2	2	2	2	1	1	1	1	1	0	0	0	0	0	2	2	2	2	2						0	0	0	0	0
Zirconium/Zircalloy	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1						0	0	0	0	0
Other/Unknown	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
Solvents																																		
Chlorinated Solvents	2	2	2	2	2	1	1	1	1	0	1	1	1	1	1	2	2	2	2	2	1	1	1	1	1						0	0	0	0	0
Acetonitrile	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
Toluene and Ketones	2	2	2	2	2	1	1	1	1	1	0	0	0	0	0	2	2	2	2	2	0	0	0	0	0						0	0	0	0	0
Glycol ethers	0	2	2	2	2	0	0	0	1	1	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0						0	0	0	0	0
Paints/Thinners	2	2	2	2	2	0	0	0	1	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0						0	0	0	0	0
Other solvents	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	0	0	0	0	0						0	0	0	0	0
RadioactiveMaterial																																		
Plutonium	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1						1	1	1	1	1
Uranium	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1						1	1	1	1	1
Other isotopes	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1						1	1	1	1	1
Gamma radiation	1	1	1	1	1	2	2	2	2	2	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1						1	1	1	1	1
Acids/Caustics																																		
Stack Gas	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	0						1	1	1	1	0
Irritant Gases	0	0	0	0	0	2	2	2	2	2	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1						0	0	0	0	0
Other	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
Process Chemicals																																		

Exposures by COCS by Decade

	C070					C080					C090					C100					C110					C120					C130				
	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s
Uranyl nitrate hexahydrate	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
Uranium tetrafluoride	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
Tributyl phosphate	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
NPH (kerosene)	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
Physical Agents																																				
Noise	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2						1	1	1	1	1
Vibration	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2						0	0	0	0	0
Laser Light	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
RF or Microwave radiation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
Miscellaneous																																				
Nitrates	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
Hydrazine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
Sodium dichromate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
Lithium hydroxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
Asbestos	1	1	1	1	1	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2						0	0	0	0	0
Welding fumes	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	2	2	2	2	2						0	0	0	0	0
Formaldehyde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
Herbicide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
Pesticide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
PCBs	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
Metal working fluids	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0
Fuels, greases, oils	0	0	0	0	0	2	2	2	2	2	1	1	1	1	1	2	2	2	2	2	0	0	0	0	0						0	0	0	0	0
Silica	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1						0	0	0	0	0

Exposures by COCS by Decade

	R010, R050					R020					R030					R040					R060					R070					R080				
	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s
Metals																																		
Beryllium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
Cadmium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
Lead	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2						0	0	0	0	0					
Mercury	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
Chromium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
Nickel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
Zirconium/Zircalloy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
Other/Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						1	1	1	1	1					
Solvents																																		
Chlorinated Solvents	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0						0	0	0	0	0					
Acetonitrile	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0						0	0	0	0	0					
Toluene and Ketones	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0						0	0	0	0	0					
Glycol ethers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
Paints/Thinners	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
Other solvents	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0						0	0	0	0	0					
RadioactiveMaterial																																		
Plutonium	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0						0	0	0	0	0					
Uranium	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0						0	0	0	0	0					
Other isotopes	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0						0	0	0	0	0					
Gamma radiation	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2						0	0	0	0	0					
Acids/Caustics																																		
Stack Gas	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						1	1	1	1	1					
Irritant Gases	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
Other	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
Process Chemicals																																		

Exposures by COCS by Decade

	R010, R050					R020					R030					R040					R060					R070					R080				
	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s
Uranyl nitrate hexahydrate	2	1	1	1	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0						0	0	0	0	0					
Uranium tetrafluoride	2	1	1	1	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0						0	0	0	0	0					
Tributyl phosphate	2	1	1	1	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0						0	0	0	0	0					
NPH (kerosene)	2	1	1	1	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0						0	0	0	0	0					
Physical Agents																																			
Noise	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1						2	2	2	2	2					
Vibration	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0						2	2	2	2	2					
Laser Light	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
RF or Microwave radiation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
Miscellaneous																																			
Nitrates	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						1	1	1	1	1					
Hydrazine	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						1	1	1	1	0					
Sodium dichromate	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						1	1	1	1	1					
Lithium hydroxide	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
Asbestos	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						2	2	2	2	2					
Welding fumes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
Formaldehyde	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
Herbicide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
Pesticide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
PCBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
Metal working fluids	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						0	0	0	0	0					
Fuels, greases, oils	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0						1	1	1	1	1					
Silica	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0						1	1	1	1	1					

Exposures by COCS by Decade

	L010					L020					L030					L040					L050, L060					L070					L080				
	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s
Metals																																		
Beryllium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cadmium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	2	2	2	2	2
Mercury	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chromium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nickel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zirconium/Zircalloy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other/Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solvents																																		
Chlorinated Solvents	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acetonitrile	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Toluene and Ketones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glycol ethers	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paints/Thinners	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other solvents	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
RadioactiveMaterial																																		
Plutonium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Uranium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Other isotopes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Gamma radiation	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1
Acids/Caustics																																		
Stack Gas	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Irritant Gases	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Process Chemicals																																		

Exposures by COCS by Decade

	L010					L020					L030					L040					L050, L060					L070					L080				
	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s	40s & 50s	60s	70s	80s	90s
Uranyl nitrate hexahydrate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uranium tetrafluoride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tributyl phosphate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NPH (kerosene)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Physical Agents																																				
Noise	2	2	2	2	2	0	0	0	0	0	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Vibration	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0
Laser Light	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RF or Microwave radiation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miscellaneous																																				
Nitrates	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrazine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sodium dichromate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithium hydroxide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Asbestos	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Welding fumes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Formaldehyde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Herbicide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pesticide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0
PCBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
Metal working fluids	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuels, greases, oils	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2	2	2	0	0	0	0	0	0
																					1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0

	L090
	40s & 50s / 60s / 70s / 80s / 90s
Metals	
Beryllium	
Cadmium	
Lead	
Mercury	
Chromium	
Nickel	
Zirconium/Zircalloy	
Other/Unknown	
Solvents	
Chlorinated Solvents	
Acetonitrile	
Toluene and Ketones	
Glycol ethers	
Paints/Thinners	
Other solvents	
RadioactiveMaterial	
Plutonium	
Uranium	
Other isotopes	
Gamma radiation	
Acids/Caustics	
Stack Gas	
Irritant Gases	
Other	
Process Chemicals	

	L090				
	40s & 50s	60s	70s	80s	90s
Uranyl nitrate hexahydrate					
Uranium tetrafluoride					
Tributyl phosphate					
NPH (kerosene)					
Physical Agents					
Noise					
Vibration					
Laser Light					
RF or Microwave radiation					
Miscellaneous					
Nitrates					
Hydrazine					
Sodium dichromate					
Lithium hydroxide					
Asbestos					
Welding fumes					
Formaldehyde					
Herbicide					
Pesticide					
PCBs					
Metal working fluids					
Fuels, greases, oils					
Silica					

Appendix E
Beryllium Building Lists

UW IH List	DOE/RL List	UW IH Dates & Info	DOE/RL Dates	Building Use or Project (DOE/RL)	# of Workers
100DR		1957 Be spill			0
	1100			JA Jones Warehouse	49
1154	1154	1980s		Radio Maintenance Shop	69
	1706			?	2
	1713F			Small animal quarters	0
202S		1960 research			5
	222T			Office Administration Bldg. Rm 6	11
231Z	231Z	1962-1980	1957, 1962-1980	Materials Engin Lab/Nuc weapons prod	194
	241A				0
271B		polishing end caps			272
272W	272W	machining Be electrical		Machine shop	64
303F	303F		1960-1988	Hazardous waste storage	0
303K	303K		1960-1988	Hazardous waste storage	0
304	304		1960-1988	Hazardous waste storage	0
	304U			Hazardous waste storage	0
306		1956-1987			18
	306E		1960-1988	Fuels development	134
306W	306W	1960s	1960	Fuels development	101
308		1960-1968			62
	308A			Fuels development	0
	309			Office and Shop	193
	311		1960-1988	Hazardous waste storage/Tank farms	0
311TF					0
313	313	1960-1987	1960-1988	Fuel Production	49
	314			Fuel Development	74
	324			Chemical Engineering	449
	325			Radio Chemical Building	337
326	326	1953-1986		Physics and Metal Building	285
	327		1960-1988	Radio Metallurgy Building/R&D	45
	328			Plant Operations	328
	329			Chemical Science Lab	0
331	331	Animal studies		Life Science Building	0
333	333	1960-1987	1960-1970	Fuel Production	231

Beryllium Building Lists

IH Data List	Musen List	IH Dates & Info	Musen Dates	Building Use or Project (Musen)	# of Workers
	3000			Warehouse	54
	3706		1960-1970	IS Development Metallurgical Lab	225
	3708			Radio Analytical Lab	13
3712	3712		1960-1988	Special Fuels Development	0
3720	3720	early 1970s	1970s	Research and Machining/Matrls & Env Sci	113
3731A	3731A	1980 ??		Graphite Machine Shop	1
	3745B			Posatron Ion Accelerator	2
	3751A		1980s	Craft Services	0
	MSL5			Uplands Office Lab	99
RTL	RTL Rm 520	1983-1988	1983-present	DOD Research	255