Needs Assessment for Medical Surveillance of Former Hanford Workers

Phase I - October 18, 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.

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.

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 = 107,349 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.

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.

D. 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 Appendix 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 C. 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 C.

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.

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).

E. 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% predicted, $FEV_1/FVC \geq 0.7$; restrictive ventilatory defect was defined as $FEV_1/FVC \geq 0.7$, and FVC < 80% predicted; obstructive ventilatory defect was defined as $FEV_1/FVC < 0.7$ and FVC $\geq$ 80% predicted; mixed obstructive/restrictive defect was defined as $FEV_1/FVC < 0.7$ and FVC < 80% predicted(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, subtract 25 and multiplied by 1.5%. Binaural hearing impairment is 5 times the monaural impairment for the better ear plus the monaural impairment of the worse 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 baseline 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.

Location of 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.

F. 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 B) 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 C) 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 11,460. An estimated 87.4% 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 67,736. 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

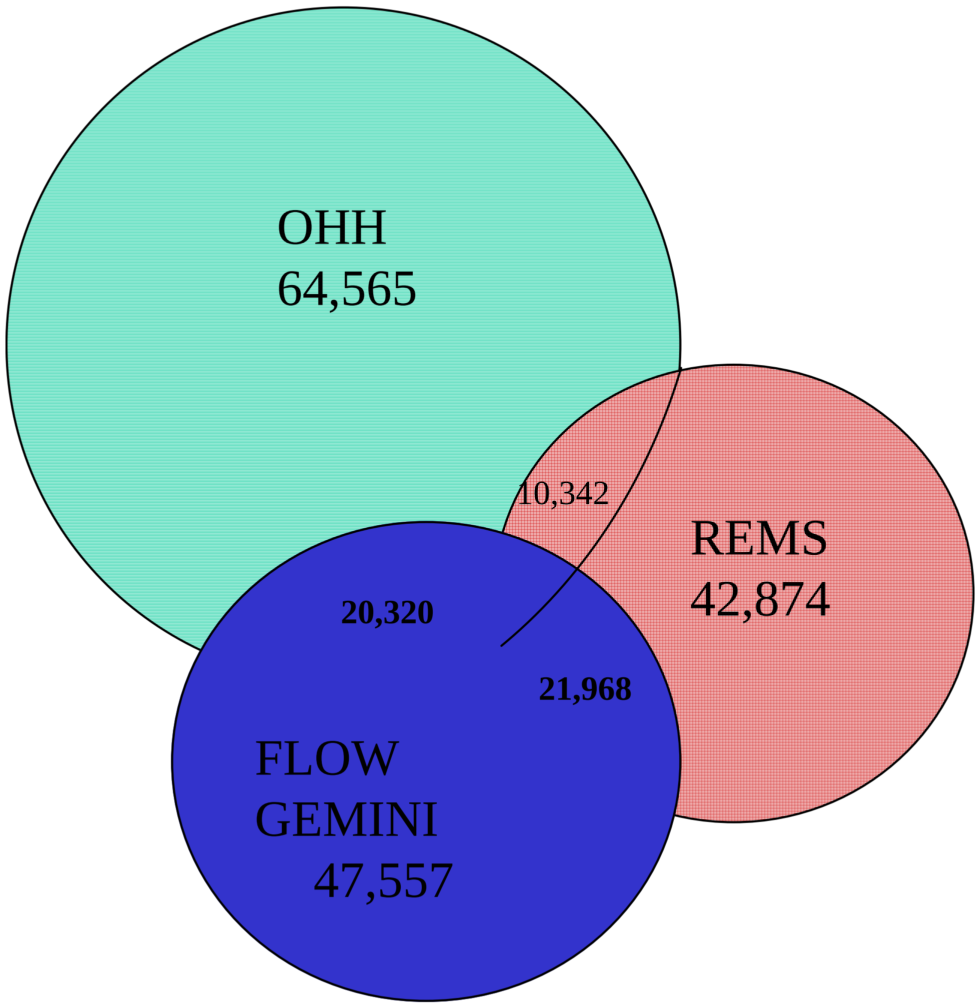


TABLE 2. Demographics of Hanford Workers (combined OHH88, Flow Gemini, and REMS Populations

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 Percent	26,066 24.9%
	Male	Count Percent	73,979 70.6%
	Unknown / Missing	Count Percent	4740 4.5%
RACE OHH88 population only	White	Count Percent	60,741 94.1%
	Black	Count Percent	1457 2.3%
	Asian, Latino, and Native American	Count Percent	103 .1%
	Other and Unknown	Count Percent	2264 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
Acetonitrile
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

	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
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	*						*		*									*			*				*	*			*						*							*				

	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																																														
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	*																									*		*				*				*		*						*		

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

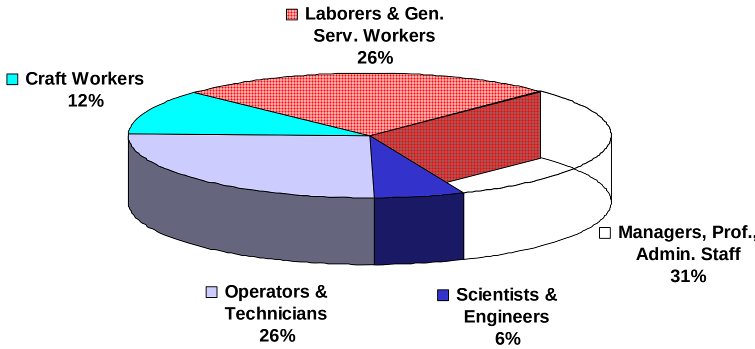


Figure 4. COCS Category by Decade - 1950's

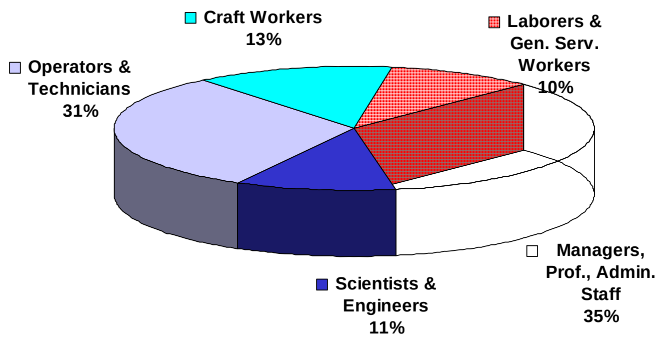


Figure 5. COCS Category by Decade - 1960's

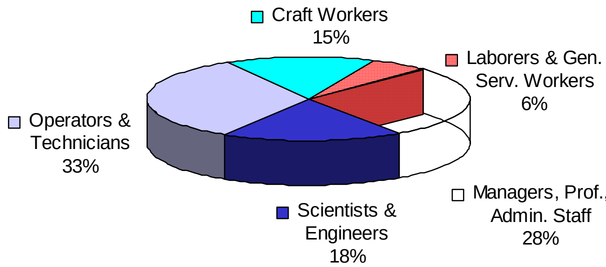


Figure 6. COCS Category by Decade - 1970's

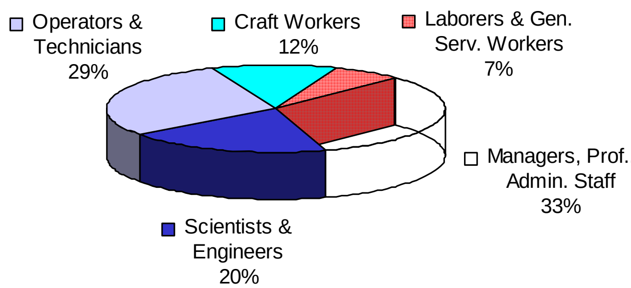


Figure 7. COCS Category by Decade - 1980's

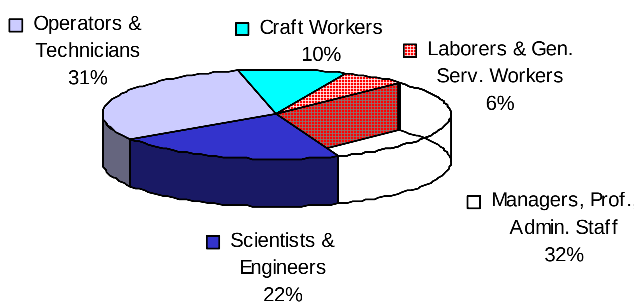
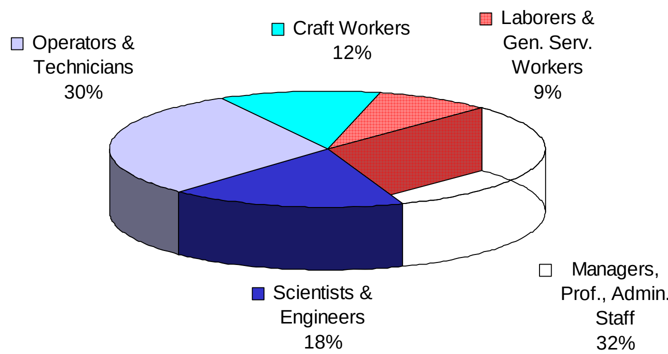


Figure 8. Total 1940-1980 by COCS Category



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.

C. 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.

D. 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 13,092 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. Demographics of these workers are described in Table 7.

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 demographics and baseline lung function of workers in the Flow Gemini system who have had spirometry. Table 8 displays the proportion of workers in each COCS code with various patterns of abnormality. Normal lung function was defined as FVC ≥ 80% predicted, FEV_1/FVC ≥ 0.7; restrictive ventilatory defect was defined as FEV_1/FVC ≥ 0.7, and FVC < 80% predicted; obstructive ventilatory defect was defined as FEV_1/FVC < 0.7 and FVC ≥ 80% predicted; mixed obstructive/restrictive defect was defined as FEV_1/FVC < 0.7 and FVC < 80% predicted(27).

In addition, the number of workers with less than 80% of predicted lung function for Forced Vital Capacity (FVC) and Forced Expiration Flow in one second (FEV_1) was determined for each COCS code. Expected numbers with less than 80% predicted values of FVC and FEV_1 were calculated from the percentage with less than 80% predicted among all COCS codes. Table 9 displays the observed number of abnormal individuals (defined as < 80% predicted), the number of expected abnormal individuals, and the odds ratio (observed/expected) for each COCS code for FVC and FEV_1. COCS codes are grouped by exposure according to the job exposure matrix. 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 OR for abnormal FEV_1 for plumbers and pipefitters, plant engineers, and electricians was 1.84, 1.45, 1.16 respectively. Also of note was the OR of 2.00 for Material Moving Equipment Operators, which is probably due to significant dust exposures in this job. 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 6 - 8). 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		
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
COCS Codes	**Mixed Obstructed/ Restricted N**	**Row %**	**Restricted N**	**Row %**	**Obstructed N**	**Row %**	**Normal N**	**Row %**	**Total**
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 FVC < 80	Expected N with FVC < 80	% with FVC < 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 FVC < 80**	**Expected N with FVC < 80**	**% with FVC < 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.

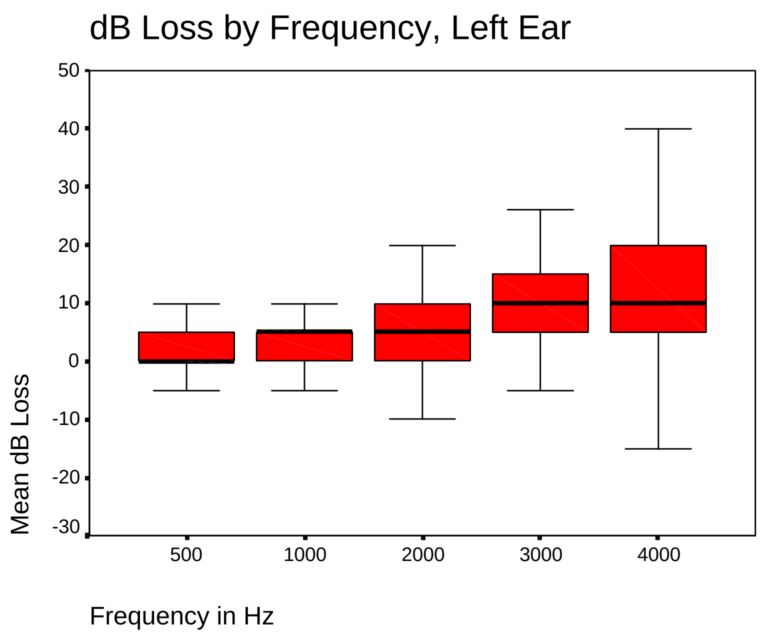
Analysis of audiometric records from the Flow Gemini database for evidence of patterns of loss suggesting noise induced hearing loss (high frequency), standard threshold shifts, and percent impairment suggest that noise induced hearing loss is of important concern. As shown in Table 10, of the 37,656 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.

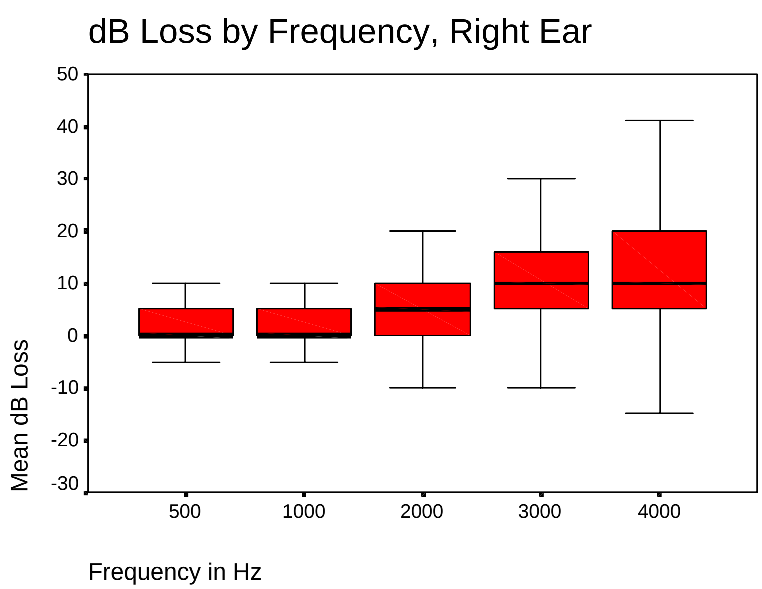
To assess whether the loss was consistent with a pattern which is work-related we analyzed the mean loss in each year by frequency. Figure 10 displays the pattern of mean loss among those with a STS. This pattern demonstrates greater loss at the higher frequencies as is consistent with noise-induced 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 compensible impairment	2,127
mean Percent of Whole person impairment	6

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





n = 3,501 workers with STS

TABLE 10. 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 parenchymal 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 E 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 11. 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 in one sense since many people in potentially exposed job titles and many people who worked in buildings in which beryllium was used will not have been exposed. It is an underestimate in another sense since it does not include people who worked in beryllium buildings before 1985, nor does it include people without building assignments.
[6] This is likely 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.

D. 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 12. 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 12. 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 E) 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 13 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 13. 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 A.

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 B.

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.

<u>A. Asbestos Surveillance</u>

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 based on job or building assignment. 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. As previously noted, 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. The iterative needs assessment process is, therefore, extremely important. 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.

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Appendix A: Initial Contact Mailing Packet

Appendix B. Exposure Questionnaire

Appendix C. List of Common Occupational Classification Codes

Appendix D: Job-Exposure Matrix

Appendix E: Beryllium Building Lists