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Former Worker Medical Surveillance Program at Department of Energy Gaseous Diffusion Plants

Phase I: Needs Assessment

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EXECUTIVE SUMMARY

Purpose We report the results and analysis of a one year needs assessment study evaluating whether a medical monitoring and risk communication program is justified for former workers at three Department of Energy gaseous diffusion plants.

Methods To complete this study, we used available exposure assessment data from paper records and electronic databases and reviewed epidemiologic studies that had been completed at the plants. We interviewed investigators who have completed or are currently engaged in studies at the three plants of concern. We also gathered "expert" former and current workers to conduct risk mapping sessions and focus groups to obtain in-depth information about the plants. We obtained employee rosters and related basic occupational histories, to the extent available, from the contractors and other institutions.

Findings Gaseous plant diffusion workers have had significant exposure to pulmonary toxins (nickel, fluorine compounds, uranium, asbestos, silica, beryllium, and acids/bases) bladder carcinogens (epoxy resin compounds), renal toxins (chlorinated solvents, uranium), neurotoxins (mercury, solvents), hepatotoxins (carbon tetrachloride, PCB's), noise, and heat. Epidemiologic and other studies are conflicting, mostly based on location of study. They demonstrate excess risk for bladder cancer at K-25; excess chronic respiratory disease; asbestosis at all three plants; excess lung cancer; chronic nephritis; and cancer of the bone.

Interviews with groups of workers demonstrate the following perceptions among former workers: a strong feeling of personal vulnerability to disease as a result of DOE employment; a sense of shared risk with co-workers, an overwhelming feeling of uncertainty and ignorance about significance of exposures; a deep sense of distrust about communications from and actions of DOE and contractors; and a lack of faith in the ability of current health providers to evaluate presence of occupational diseases. The focus groups were also extremely useful in providing concrete guidance about how to establish effective risk communication and medical surveillance programs.

The target population for a bladder cancer screening program at K-25 would include an estimated 500 to 600 workers. If a preventive pulmonary health program is established, it should be offered to former workers with significant exposures to pulmonary toxins at all three sites. The estimated population was calculated two ways. Ranges of estimates of 2,850 to 4,230 workers and 10,000 to 14,000 workers were obtained by these two methods.

Conclusion The findings of this needs assessment study support a targeted medical surveillance program. This conclusion is based on the evidence that large numbers of workers had significant exposures to detrimental agents; the epidemiologic evidence, best developed at Oak Ridge, that gaseous diffusion workers suffer excess rates of selected diseases; and the strong need expressed by former workers for a credible targeted program of medical surveillance and education. A health protection and risk communication program should center on workers at risk for 1) bladder cancer, 2) chronic respiratory disease, including chronic obstructive lung disease and the pneumoconioses, and 3) lung cancer. These conditions are amenable to early intervention (bladder cancer); amelioration (chronic respiratory diseases), and primary prevention (lung cancer via smoking cessation) A risk communication delivered by a credible source will reduce uncertainty and distrust. After participation in the proposed screening program, former DOE workers will have increased real knowledge about their personal health status, what is known about their risks, and how they can promote their own health. We believe that mounting such a program in Phase II will make a tangible improvement in people's lives.

PART I: OVERVIEW

I. Introduction

In October, 1996, a consortium led by the Oil Chemical Atomic Workers (OCAW) International Union initiated a needs assessment study to evaluate whether former Department of Energy (DOE) workers at gaseous diffusion plants would benefit from the establishment of a program of medical surveillance. This assessment was conducted with a grant and guidance provided by the Department of Energy. The OCAW consortium was constituted by the Mount Sinai School of Medicine, the University of Massachusetts Lowell (UMass Lowell), the Alice Hamilton College, and the OCAW International Union. The three sites targeted for study were the Oak Ridge Gaseous Diffusion Plant (K-25), the Portsmouth Gaseous Diffusion Plant, and the Paducah Gaseous Diffusion Plant.

To conduct this needs assessment, the OCAW/Mount Sinai/UMass Lowell consortium identified the need for four domains of information. These include:

- Exposure characterization for workforce at gaseous diffusion plants
- Occupational morbidity and mortality patterns identified through epidemiologic and other health studies
- Educational needs and organizational context for delivery of medical surveillance and risk communication programs
- Demographic profile of target population

These domains correspond to the criteria established by the DOE in its document, *Guidance for Submittal of Phase I Reports and Phase II Continuation Applications for Former DOE Workers Medical Surveillance Program.*

Through a vigorous and focussed 12 month effort organized in these domains, we have addressed the specific issues raised by the Department of Energy in determining whether a medical surveillance program is needed and would benefit the targeted populations. These specific issues include characterizing the type and degree of relevant detrimental exposures; defining essential health impacts; defining the size of the target populations, and finally, clearly documenting the need for establishing a program that will combine medical monitoring with risk communication.

To provide answers to these questions in one year was a tall task. Unlike many of the other grantees in this program, the OCAW consortium had not been funded previously to conduct systematic investigations at DOE facilities. On the other hand, we had the great advantage of having excellent access to and high credibility with most members of the workforces that operated DOE's gaseous diffusion plants. Our challenge during the past 12 months has been to harness the enormous knowledge possessed by the DOE workforce in combination with mining readily available industrial hygiene records, health physics data, and epidemiological analyses. To the extent possible, we rely heavily upon the relevant work conducted by other institutions such as NIOSH, ORAU (the Oak Ridge Associated Universities) and others. Some of the work of these institutions remains in progress, and, therefore, is not yet available for use in examining the rationale for a medical surveillance program. For instance, NIOSH has ongoing studies at the Oak Ridge facility and is extending its epidemiologic analyses at Portsmouth. These studies will produce additional information that will be very useful for planning and conducting a medical surveillance program. If DOE supports Phase II of the program, these additional studies will be utilized to provide much needed information, especially to characterize exposures in the target groups and the degree of occupational risks present.

Throughout the needs assessment process, the OCAW consortium has abided by a central principal of the project: to maximize involvement of rank and file workers from the gaseous diffusion plants in all aspects of the conduct of the needs assessment process and the planning of the medical surveillance and risk communication program. We have used this method for several essential reasons. The most obvious is the view that rank and file workers are excellent sources of information for identifying the hazards that has existed at the plants over the past 40 to 50 years. This is especially true at the gaseous diffusion plants where quantitative assessments of exposures have been limited. Second, the study consortium understands that any program planning process will be effective only to the extent to which the so-called recipients of the program are involved. Finally, health protection, the ultimate goal of the DOE Former Worker Medical Surveillance Program, requires workers acting on their own behalf. Beginning to overcome the many years of distrust, uncertainty and ignorance required an open process from the very beginning of a medical surveillance program.

This report does not contain an exhaustive list of all of the medical needs that workers at the three DOE gaseous diffusion plants might have as a result of their occupational exposures. Creating such an exhaustive inventory of all health risks that gaseous diffusion workers have or might have was beyond the scope, the mandate and the resources available to the OCAW consortium in the last 12 months. We recognize that the DOE former worker medical surveillance program is pilot in nature and will be limited in funds over the next several years.

Hence, we concentrated on exposures and health outcomes that best meet the criteria that DOE has established for this program as reflected in Section 3162 that created the program. Specifically, we have attempted to identify significant exposures, as supported by available qualitative and quantitative data, that have or are likely to produce health impacts that might be alleviated by early detection and/or by communication with the potentially affected workers. There are undoubtedly other exposure-disease relationships expressed in gaseous diffusion workers that deserve the attention of the Department of Energy. This would include possible health impacts that have not yet been fully investigated in the work force; exposures for which data are insufficient to allow judgment about the likelihood of their significance; health impacts that had been demonstrated to exist but may or may not be occupational in etiology; and health outcomes that are not amenable to screening or for which early detection does not lead to fruitful intervention. Pursuing these possibilities, however important, was not part of the mandate that we received from the Department of Energy. Nor could we take responsibility for following up these potential or actual occupational risks, given the limited time and resources available to us during this 12 months needs assessment.

This report is organized into two parts to satisfy the competing goals of being succinct and of being substantive. Part I (Introduction, Methods, and Principal Findings) is intended as an overview in order to communicate the principal methods used and the results thereby obtained. This overview distills the more detailed collections and summaries of data which are presented in Part II. (Sections 4 through 6). Section 4 provides details about the type and levels of exposures experienced by gaseous diffusion workers at the DOE facilities. Section 5 presents the results of focus groups of former and current DOE workers in assessing health concerns, evaluating the level of knowledge and perceived risks, and eliciting opinions about how to conduct a medical surveillance program. Section 6 summarizes and critiques the available epidemiological and other health studies from the gaseous diffusion plants. Readers are encouraged to read Part II in detail to gain a full understanding of study methodology and the types of information that underlie the summaries presented in Part I.

II. Methodology

We employed a number of methods of study during this 12 month needs assessment. These methods were chosen based on the ability to obtain reliable data within a limited time period, the desire to include rank and file workers in the data gathering process, and the need to acquire information that would allow us to plan the risk communication and health service component of a medical surveillance program.

A. Review of Existing Exposure Records

The primary focus of this component of the exposure assessment was to determine the nature and intensity of major exposures as a function of building, area, department, and/or job classification. Another primary need was to establish an approach for linking the building, department and exposure data to individuals within the former worker cohort.

The primary documents and data files which were used for this preliminary exposure assessment are listed below. A full listing of the major sources of health physics and industrial hygiene data that we used from the gaseous diffusion sites is provided in Appendix A. Additional useful industrial hygiene data are currently being analyzed by NIOSH investigators. Some industrial hygiene data that has been requested by NOSH from DOE has yet to be declassified (e.g. - K-25 Air sampling data from the 1960's).

Principal Sources of Data for Exposure Assessment

1. "Mortality Patterns among Uranium Enrichment Workers at the Portsmouth Gaseous Diffusion Plant" Robert Rinsky, NIOSH, 1996.
2. Building / Department Matrices developed by NIOSH for the Portsmouth site.
3. INDUSTRIAL HYGIENE exposure database (for Uranium, Fluorides, and Nickel) for the Portsmouth site developed by NIOSH (requested but not yet received)
4. K-25 Quarterly Health and Safety reports (1948-1989)
5. K-25 Urinalysis working data files (ORAU:available through CEDR, 1948 – 1985)
6. K-25 External Radiation Exposure working data files (ORAU:available through CEDR)
7. Oak Ridge Phase I Health study reports, ChemRisk, Inc. (Off-site dose reconstruction project)
8. Paducah Gaseous Diffusion Process class conducted by Mr. Carl Walter

For the Portsmouth site, the available industrial hygiene data that were used by Rinsky were limited to three agents: nickel, uranium, and fluoride compounds. Rinsky identified eleven buildings where the majority of the air samples had been taken over the history of the site for these three agents. For nickel, there were sufficient data to assess exposure in only one building. Given these limitations, we employed specific risk mapping sessions with former workers (see section below) to gain a fuller understanding of the range and levels of exposures encountered at the Portsmouth site. Since even less quantitative monitoring data are available at the Paducah site, risk mapping also became the primary source of exposure information at Paducah.

K-25 has been the subject of more study than the other two gaseous diffusion plants. Indeed, at K-25, more exposure assessment data have been collected, allowing a greater quantitative assessment of building and department exposure levels. Furthermore, NIOSH is currently assembling an INDUSTRIAL HYGIENE database that will add to the body of information regarding exposure levels at the K-25 facility at Oak Ridge.

For this preliminary assessment, information regarding levels of exposure by building and department over time were extracted from two primary sources: the K-25 Health and Safety Quarterly reports (1948 – 1989) and the K-25 Urinalysis working data file (ORAU). Additionally, information regarding department name, department number, building name, building number, and job classification were obtained from NIOSH. Information regarding job classification, job number, and frequency was also assembled from an ORAU working data file (ORAU personnel data, CEDR). This last task was performed in order to identify the approximate number of workers in a given job category of interest.

The K-25 Urinalysis working data file was found to be a very useful source of quantitative exposure levels as a function of building and department. The specific steps that we took to analyze this file are described in Part II of this report. While our analysis did not identify every building or department where high exposure may have occurred, it did allow for a preliminary understanding of the buildings and departments at highest risk. The obvious limitations of this file are detailed in Part II.

The K-25 Quarterly Health and Safety Reports from 1948 to 1989 were a second main source of information about levels of exposure of various agents within various buildings over time. The types of information in these reports included: buildings prioritized for radiation measurement surveys; building-specific radiation contamination levels; urinalysis summary tables; air sampling summary tables; illness and injury summaries; major construction activities; and personnel protective measures implemented. While report detail and format varied over the years, the information that they contained was valuable when used in concert with data from other sources.

To a fair extent, the information learned from the K-25 site can be used to assist in the exposure assessments at the other two gaseous diffusion plants. Much of the technology for the gaseous diffusion process and, to a large extent, the actual process equipment were developed at Oak Ridge and used throughout the three sites. In addition, each site had specific operations (e.g. - centrifuge and barrier manufacture at K-25) that were unique to their site. The cross-site commonalities within certain operations and job titles at certain time periods allow some generalization across sites. This becomes especially important for Portsmouth and Paducah, where less exposure assessment study has been performed.

B. Risk mapping

Risk Mapping is an approach that has been used extensively at industrial facilities as a tool to assist workers and/or joint health and safety committees in determining high risk areas within their facilities. Traditionally, the technique is used to identify current problem areas within a facility and to assist in developing an intervention strategy for resolving the problem areas. For this project, the risk mapping approach was used to map past exposure conditions at the three gaseous diffusion facilities.

In addition to using the mapping process for locating past exposure conditions within the buildings of interest, the method was modified to allow the field researchers to collect semi-quantitative exposure data for each identified exposure of concern. Field researchers also collected data regarding other building and process characteristics (i.e., description of major processes, number of workers in the building of interest, and years of operation).

Several steps were necessary to develop the risk mapping activity at the three sites. We customized the risk mapping method for use in retrospective exposure assessment. We developed the following tools for field use:

- *Job Exposure Information Sheet* to collect job/process/exposure information for each chemical agent identified on the risk map

- *Building Characteristics Report Form* to allow field researchers to collect descriptive information on the buildings of interest over time (i.e., description of major processes, number of workers, and years of operation).

- *Risk Mapping Training Guidebook* to train the field researchers in the risk-mapping technique.

The study consortium, led by UMass Lowell and the Alice Hamilton College, conducted a two day train the trainer session for the field researchers. The field researchers included OCAW local union worker trainers, local union health and safety representatives, and retirees. Each facility had at least three field researchers assigned to the risk mapping activity.

"Experts" were then selected for the initial risk mapping session at each of the three sites. The UMass Lowell, the OCAW International, and OCAW Local Union worked together to identify and to assemble an "expert" team of former workers for the initial risk mapping sessions at each site. The "experts" selected for the initial sessions consisted primarily of hourly workers with extensive experience at the site. Several line supervisors were also included in these sessions. "Experts" were not selected at random, but based on their vast amount of site experience and the broad array of job classifications and process buildings where they worked. .

The initial risk mapping sessions focused on the entire facility (Portsmouth, Paducah, and K-25) and were conducted to assist in determining priority areas for future, more specific, risk mapping sessions. As a product from each of theses sessions, the expert group produced a listing (10-15) of buildings of most concern regarding retrospective exposures. This list, along with information obtained through review of previous research studies, was used to identify areas for subsequent risk mapping sessions.

The second round of risk-mapping sessions were specifically conducted to learn more about the priority buildings at each of the facilities that were identified in the initial session. Information was systematically collected utilizing the tools list above: the Job Exposure Information Sheet and the Building Characteristics Report Form

All of the information obtained for risk-mapping sessions was compiled into a database to allow for assessment of the data.

C. Focus groups

Focus groups of former workers were conducted in order obtain in-depth information about a variety of issues, including exposures, perceptions of risk, health concerns, health care, and receptivity to a health screening program. The overall design, recruitment strategy, training, and analysis was led by Elizabeth Samaras of the Alice Hamilton College. The actual implementation of the focus groups was led by former or current workers from the three gaseous diffusions plants.

Established OCAW Occupational Safety and Health Education Coordinators (OSHECs) at each site were recruited to serve as moderators for the focus group sessions. They were trained using a *Moderator Guide* specifically developed for this project (see Part II for details). To prepare, moderators participated in a day long training seminar and role-play. Another OCAW member was recruited and trained to serve as the scribe for each focus group session.

Two Focus Groups were held at each of the three sites under study: Portsmouth, Paducah and Oak Ridge. A range of 8 to 17 individuals participated in each session. Sessions were held in the respective OCAW union hall at each site. All participants received a participant information sheet and signed informed consent forms that had been read aloud to the group before the session. The sessions were audio taped with the full knowledge and consent of participants.

The initial focus group at each site was comprised of "experts" selected by the local union officers and OCAW field staff due to their knowledge of the plant and familiarity with plant operations. A second focus group at each site included retired and terminated workers who were randomly selected from employee rosters obtained in the curse of the needs assessment.

In a preliminary analysis of the transcripts of focus group sessions, an initial coding scheme of important themes was developed. Ms. Samaras has undertaken a basic coding and sorting of themes and have provided illustrative quotes from the transcriptions. These are presented in detail in Part II of this report.

D. Community Inventories

As part of the needs assessment process, we have embarked on developing community profiles, identifying health care, educational, and community service facilities that will be useful in conducting Phase II of the program. This information has been collected by former and current workers who were trained to construct systematic inventories of institutional resources in the communities where former workers reside. Three specific instruments were developed with the assistance of former and current workers: 1) *Health Care Facility Inventory*, 2) *Health Care Provider Inventory*, and 3) *Community Services/Resources Inventory*. Copies of these are provide in Part II of this report.

These inventories contain essential information to develop strategies for referral of screened individuals for diagnosis and treatment, for provision of workers' compensation assistance, and for designing an effective educational and risk communication program. They also contain useful information for assembling program advisory groups in Phase II of the program. At the three study sites, 600 inventory forms were completed and have been compiled to date. Additional information will be collected according to the specific needs of the implementation phase of the medical surveillance program.

E. Review of Epidemiologic Studies

We reviewed all available published and unpublished studies describing the morbidity or mortality experience of gaseous plant diffusion workers for the three study sites. These studies have been performed by NIOSH and by investigators for the Oak Ridge Institute for Science and Education (ORISE), part of the Oak Ridge Associated Universities (ORAU). We also obtained the results of surveys of the prevalence of non-malignant asbestos-related disease among maintenance workers at the three gaseous diffusion plants that was undertaken in conjunction with a law firm from Texas. These written publications are reviewed in detail in Part II, and telephone discussions have been held with the lead investigator of each study.

F. Demographic Profile of Target Population

Employee rosters have been obtained for each of the three sites with the sole exception with terminated workers at the Paducah Gaseous Diffusion Plant. While the list of retirees has been received from Paducah, the names, addresses, and other essential information of the terminated workers does not exist in electronic form. We have identified the location of this information on the terminated workers at Paducah, and communicated with the individuals responsible for this information. We have obtained a monetary estimate of the cost for committing this information to computer disc if performed by contractor. This estimate is very high. If this task is needed, we will assure its completion during Phase II of the project.

Available data on employees at Oak Ridge and Portsmouth include names, social security numbers, dates of hire and termination, department (s), job title(s), and gender. For Oak Ridge, we also have date and cause of death, and will obtain similar data from NIOSH during Phase II. We also have the last known addresses for all retirees and terminated workers from all three sites (excluding the terminated workers at Paducah as noted above).

To obtain the estimated size of the population targeted for medical screening, we identified priority departments for screening based on exposure data and risk mapping, and identified workers who were employed in those departments, excluding current workers (still actively employed) and workers who were known to have died. For the centrifuge workers at risk for bladder cancer, we limited our analysis to workers who were hired in the affected departments prior to 1985 and to workers who retired or terminated only after 1963. This was done in attempt to capture workers who were employed in the centrifuge operation, which was open between 1963 and 1985.

The vital status of a large percentage at the Oak Ridge Plant, is not known, especially among workers who were employed during the first few years when the plant was opened in the 1940's. Many such workers have undoubtedly died, but the percentage of deaths among those with unknown vital status is not known. The group that was lost to follow-up prior to January 1, 1979 was approximately 10,500 people, according to Dupree and colleagues at ORISE in their 1994 mortality update of the K-25 cohort. This group, to the extent alive, will likely not be found. There were an additional 10,000 workers in Dupree's study who were lost to follow-up after 1979.

Given the incompleteness of information from at least two of the cohorts (Oak Ridge K-25 and Paducah), the estimates of the sizes of the population at risk must be regarded as approximate. They are, however, sufficient for planning purposes.

Section 3. <u>Principal Findings</u>

A. Hazards and Exposure Levels of Former Gaseous Diffusion Workers

For the purposes of planning a medical surveillance program, it is most useful to organize the large numbers of diverse exposures encountered in gaseous diffusion facilities by principal human organ or organ systems affected. In cases where a health effect has been identified by job operation (e.g. - welding) or location (e.g. - centrifuge) rather than by single exposure, then job title or location becomes the tool used to organize health effects. Employing this means of considering hazardous exposures yields Table I-1.

Table I-1
<u>Important Classes of Exposures at Gaseous Diffusion Plants by Target Organ</u>

Target Organ/Disease	Exposure Class	Important examples	Selected Locations
<u>Lung</u>			
Chronic obstructive lung disease	Irritants	Fluorine compounds	Cascade bldgs.
		• Hydrofluoric acid	Feed operations
		• Uranium hexafluoride	
		Welding	Cascade bldgs.
		Fiberglass	Pilot plant
		Freon	Plating shop
		Acids/bases	Plating shop, Decontamination
			Converter shop
		Cadmium	Maintenance shop
Pneumoconioses	Fibrogenic dusts	Asbestos	Maintenance shop
		Silica	Decontamination
		Beryllium	Maintenance shop
Lung cancer	Carcinogens	Asbestos	Maintenance shop
		Nickel	Barrier manufacture
		Uranium	Cascade bldgs.
		Welding	Barrier manufacture
<u>Genitourinary system</u>			
Bladder cancer	Bladder carcinogens	Centrifuge operation (resins)	Centrifuge bldgs.
Renal toxicity	Renal toxins	Uranium	
		Chlorinated solvents	Instrument shop
<u>Nervous System</u>			
Cognitive dysfunction	CNS toxins	Mercury	Barrier manufacture
			Instrument shop
		Chlorinated solvents e.g. - trichloroethylene	Decontamination
		Lead	Instrument shop
<u>Gastrointestinal system</u>			
Hepatitis	Hepatoxicity	Chlorinated solvents e.g- carbon tetrachloride	Decontamination
		PCB's	Maintenance shop
			Incinerator
<u>Hearing</u>	Noise		Cascade bldgs.
			Product withdrawal
<u>Cardiovascular system</u>	Heat		Cascade bldgs.

Our knowledge about the magnitude of the exposures cited above derives from several sources: urine monitoring results, external radiation monitoring, industrial hygiene samples, risk mapping sessions, and focus groups. All of these methods have limitations, as detailed in Part II of this report. A brief summary of data for the most important exposures is provided in this section: the reader is urged to see the additional description in Part II.

Nickel / Nickel Carbonyl (Ni(CO)4

Nickel exposures were prevalent at all gaseous diffusion plants, especially at the barrier manufacturing operations at Oak Ridge (Buildings K-1100, K-1037, K-1004L, K-1401, and K-1420). The K-25 urine data indicate that four most important departments in terms of nickel exposure are Department 1726, 1340, 1603 and 1606 (See Appendix B-5).

At K-25, Union Carbide industrial hygiene records collected between 1948 and 1973 show that the average potential exposure to nickel was 1.5 to 2.0 mg/m3 in the barrier manufacturing building (K-1037), based on an average of 3000 samples. The company health and safety quarterly reports from the 1950s report that approximately 50% of the measurements taken for nickel exceeded the established maximum allowable concentration of 0.5 mg/m3. Union Carbide reported average nickel exposures during welding and cutting operations to be approximately 0.2 to 0.3 mg/m3. A NIOSH health hazard evaluation conducted in 1972 reported breathing zone air concentrations of 3.8 mg/m3 during welding operations with high (10%) Nickel steel. These findings are corroborated by the K-25_urine data showing high average urinary concentrations in selected buildings (e.g - K-1037, K-1004L, and K-1401), extending into the 1970's. Note that the current NIOSH REL for nickel is 0.015 mg/m3, which is one hundred times lower than the levels found at parts of Oak Ridge over the past several decades.

Fluoride compounds

Exposure to hydrofluoric acid, uranium hexafluoride, and other fluorine compounds was widely reported throughout the three sites. These exposures were often episodic - "puffs of smoke"- throughout the process buildings, feed buildings, and withdrawal buildings especially pre-1975. Several workers involved in the risk mapping sessions at all three sites reported throat irritation that they believed was caused by the exposure to HF.

Risk mapping indicated that exposure to fluorides existed in several areas or processes common to all three gaseous diffusion plants: feed vaporization, product withdrawal, fluorine plants, process buildings, oxide conversion plants, and decontamination and maintenance buildings. The reports of over-exposure are supported by the K-25 urine data showing averages exceeding 500 to 1,000 ug/L in numerous departments and building well into the 1980's (Appendix B). Priority buildings and departments have been identified.

Asbestos

Asbestos was identified in many buildings within all three gaseous diffusion facilities. It is widely present in traditional thermal insulation uses. It was also extensively used as transite board from which the walls of some very large buildings were constructed. Although no industrial hygiene data (air sampling or bulk sampling) or location inventory are available, the worker-experts in the focus groups expressed a high level of concern about asbestos and described uncontrolled use of asbestos-containing materials over the past decades that are likely to lead to a high risk of disease.

Mercury

During the risk-mapping sessions at K-25, former workers reported that "mercury was everywhere: You could dig a hole in a process building and a puddle of mercury would be at the bottom." These assertions were supported by the urine mercury monitoring program at Oak Ridge. Individual and mean urine mercury results in the 1950's and 1960's routinely exceeded 20, 30, and even 50 ug Hg/L urine (Appendix B). (Urinary mercury values in the general population are a maximum of 5 to 10 micrograms/liter.) It was reported that during these early years (through the mid- 60s) mercury recovery was an extensive program since they were "cleaning" mercury for the Y-12 site. Priority departments (1002, 1075, 1262, 1264, 1340, 1726, 1272, and 1325) and buildings (K-1024, 1420, 1301,2,3) have been identified at Oak Ridge. The risk mapping sessions highlighted the instrument mechanics as a job classification with significant mercury exposure.

Solvents

Solvent exposures of primary significance are chlorinated solvents used for degreasing, primarily carbon tetrachloride and trichloroethylene. The cascade process required strict cleanliness of parts, necessitating use of large quantities of these solvents. Former workers report such practices as "mopping the floor with carbon tetrachloride on a daily basis." Monitoring for a urinary metabolite (e.g. - trichloroacetic acid) was performed, but too infrequently to be useful.

Radiation

External radiation exposure levels based on individual records from Oak Ridge and Portsmouth are generally low when compared to the many other DOE facilities. At Portsmouth the median dose equivalent was 0.06 rem (60 mrem); 75% of the workers in the Portsmouth database are reported to have less than 240 mrem. Similar external levels were observed at Oak Ridge K-25. Quarterly reports between 1952 through 1958 report averages for monitored workers between 10 and 50 mrem per quarter with maximum recorded doses of approximately 300 mrem per quarter. Median cumulative dose of external penetrating radiation was 140 mrem. 638 workers had workers with cumulative doses greater than 5 rem.

Another potentially significant source of external exposure that went unmonitored at the three gaseous diffusion sites until very recently are neutron exposures. A recent NIOSH Health Hazard Evaluation report (September 1997) reviewed the concern of neutron exposures at the Portsmouth site. It is unclear whether there is any means of reconstructing past neutron exposures Areas where this may have been of particular concern include the high assay process areas and the product withdrawal, sampling and storage areas.

Internal Radiation Exposures

Estimating a lifetime internal dose is difficult given the limited number of workers in urinalysis programs for limited periods of time. A more plausible use of such data, as performed by Rinsky, is to use such data to identify departments and buildings where higher internal exposures were more likely.

Heat and Noise

Heat and noise were universally reported in risk mapping sessions, especially in the cascade process buildings.

Beryllium

The main source of Beryllium at the K-25 site was associated with the liquid thermal diffusion process within the S-50 complex (1944 – 1950). Workers subsequently involved in the decontamination of the facility in the late 50s also presumably had exposure. Contractor reports discuss "grossly contaminated ventilation systems" in some of the S-50 support buildings and classified those buildings as unsuitable for use as a storage facility.

A second source of exposure to beryllium at K-25 was in Building 1401 (maintenance, especially department 1752) where machining of beryllium parts for Y-12 was performed, reportedly from the late 1960s to early 1970s.

B. Nature and Extent of Health Impacts Experienced by Gaseous Diffusion Plant Workers

The epidemiologic literature describing the occupational morbidity and mortality of gaseous diffusion workers is characterized by severe deficiencies. The most important limitations include:

- Incompleteness In the K-25 mortality study that was completed by Dupree and colleagues in 1994, over one-half of the study cohort had unknown vital status. At Paducah, no mortality study has been completed.

- Failure to evaluate exposure-specific patterns of disease With the exception of welding and nickel exposure, no exposure-specific mortality analyses have been completed at the Oak Ridge K-25 plant. The mortality analysis at Portsmouth has evaluated disease patterns associated with potential exposure to uranium, nickel and fluoride, though measurement of exposure to these agents is crude. Any exposure-specific mortality could easily be missed through dilution when reporting on the overall mortality patterns of the entire cohorts at Portsmouth and K-25.

- Mortality is an insensitive indicator for selected morbid conditions. Selected serious medical conditions may allow long term survival and would be missed by studies that only measure mortality. The bladder cancer excess observed among centrifuge workers was only observed, through the study of bladder cancer incidence, not mortality.

- Incomplete follow-up/short latency. The length of follow-up for selected operations at the gaseous diffuison plants have been relatively short. Of note is that the centrifuge operation began in 1963 so that only the earliest workers will have reached 25 years of latency by the mid-1990's. Only 3% of the centrifuge workers had died at the time of the cross-sectional study undertaken by ORISE in 1988-1989. In Rinsky's study at the Portsmouth plant, less than a third of the person-years at risk occurred after 20 years of latency.

- Inadequate statistical power. The combination of limited numbers of deaths in some of the cohorts and the rarity of selected medical conditions collude to produce a limited ability for epidemiologic method to detect excess occurrence of these diseases with adequate statistical power. This is especially true when subgroup analyses by exposure are performed.

Despite these limitations, the epidemiologic studies of the gaseous diffusion plants provide some important leads that can be used fruitfully by a medical surveillance program. These are summarized below. A more full description and critique of these studies is provided in Part II of the report.

Bladder cancer An excess bladder cancer incidence was observed (SIR = 7.8, 95% CI: 1.1-68) among the workers who *a priori* had the highest estimated exposure to epoxy resins and solvents in the centrifuge operation at K-25. A larger group of centrifuge workers was subsequently studied and showed no excess risk. The latter group included workers who had no estimated exposure to the suspect agents. The plausibility of a cause-effect relationship is enhanced by the presence of a documented bladder carcinogen, 4,4-methylenedianiline, in the centrifuge operation.

Chronic Respiratory Disease (CRD) In 1997, Frome and colleagues published the results of a comparative mortality at the various facilities at Oak Ridge and found a SMR = 107 for CRD mortality at K-25, which had the highest CRD SMR of any of the Oak Ridge facilities. Furthermore, the rate of disease is increasing over time at a rate of 1.1% per year. Dupree and ORISE colleagues reported a more detailed analysis of the K-25 cohort in 1994. The SMR = 119 for non-malignant respiratory mortality among white males with a 95% C.I.: 111-127. An analysis by decade showed a stable excess over time. Wells et al from ORISE examined mortality among K-25 and other welders at Oak Ridge. The SMR for CRD was 136 (95% C.I.: 89-200). There was a similar finding among the welders at the other Oak Ridge facilities. Among the full welder cohort, the CRD SMR = 132, with borderline statistical significance. These results are credible as excesses due to occupation given the large numbers of irritants to which workers throughout K-25 were exposed.

Pneumoconioses The cross-sectional studies of asbestos-related disease among maintenance workers at all three gaseous diffusion facilities, even if taken with a grain of salt, showed a significant prevalence of pleural and parenchymal fibrosis due to asbestos. For the 759 workers examined at the three sites, 241 (32%) showed fibrosis compatible with asbestos-related exposure. This is hardly surprising given the extensive presence and conditions of use of asbestos reported by the former workers in the focus groups and risk mapping. It is also well-known from other similar facilities such as chemical plants and refineries that asbestos-related disease is commonplace among the maintenance workers. Of particular concern at Oak Ridge is the extensive use of asbestos-containing transite as a building material.

No studies of silica-exposed or beryllium-exposed workers at the gaseous diffusion plants have, to our knowledge, been undertaken.

Lung cancer An excess of lung cancer mortality among K-25 workers was reported by Frome et al in 1997, by Dupree and colleagues in 1994, and in the welders study by Well and others, also in 1994. The observed SMR's were 110 (Frome), 119 (Dupree), and 143 (Wells). The SMR elevation found by Dupree was statistically significant and was almost so in the Wells study. While cigarette smoking may play a role, an occupational contribution may also be present, given the presence of recognized lung carcinogens: asbestos, nickel, uranium, and probably welding fumes.

Bone cancer An excess of bone cancer was seen among K-25 workers in Dupree's study (SMR = 182 (95% CI:104-296), especially after 1980. Frome et al also obtained an excess of bone cancer in their analysis: SMR = 158. Indeed, the SMR for bone cancer at K-25 was higher that that at Y-12 or X-10, where higher radiation exposures were believe to have occurred. The finding of excess bone cancer is of particular interest, because uranium is an alpha-emitting radionuclide that is bone-seeking.

Chronic nephritis This is another disease of *a priori* interest, given the presence of nephrotoxins, especially uranium and the solvents, in the gaseous diffusion plants. Dupree found an overall SMR = 99 for deaths due to chronic nephritis among white males. However, in the last decade studied, 1980-1989, the SMR jumped to 641, which was statistically significant. There were 12 deaths due to chronic nephritis in the 1980's.

All of the studies cited above, with the exception of the asbestos surveys, occurred in Oak Ridge. The mortality findings at Portsmouth, as well demonstrated by Rinsky, quite clearly show no excess of disease. Indeed, it shows quite the opposite. While a strong healthy worker effect probably explains the low SMRs observed by Rinsky in the Portsmouth study, there is little evidence from comparisons internal to the study that suggest that there is any pattern of excess mortality that can be attributed to occupational exposure. Why the Portsmouth mortality analysis should be significantly different from that at Oak Ridge is unclear.

Part of the difference is undoubtedly due to earlier initiation of the K-25 plant, that is, some 10 years prior to the opening of the Portsmouth plant and the accompanying large cohort of workers with very short term exposure at K-25. The selection pressures that yielded such healthy workers at Portsmouth may not have been as strong at Oak Ridge.

However, there are significant differences in exposures and operations at the three sites. At Oak Ridge, barrier manufacture, centrifuge development and testing, and related decontamination work occurred. An additional difference between Oak Ridge and Portsmouth is the relative youth of the cohort at Portsmouth. Less than one-third of the person-years at risk at Portsmouth occur after 20 years of latency.

C. Educational Needs and Health Concerns of Former Workers

The focus groups were invaluable in providing insight about how former workers viewed the "significance" of their prior exposures, and their current state of knowledge, health concerns, and health care. Inclusion of 69 workers, most of whom had more than 30 years of employment at one of the three sites, provided a broad spectrum of opinion.

The following themes arose during the six focus group sessions:

- Strong feeling of **personal vulnerability** to disease as a result of DOE employment
- Sense of **shared risk** with co-workers, such that co-workers' ill-health reinforces one's own risk
- Overwhelming feeling of **uncertainty and ignorance** about significance of exposures; results of studies completed to date; whether personal illness was caused by occupational agents; and what actions might be taken to protect one's health
- Deep sense of **distrust** about communications from and actions of DOE and contractors
- **Lack of faith** in the ability of current health providers to evaluate presence of occupational diseases

The focus groups were also extremely useful in providing concrete guidance about how to establish effective risk communication and medical surveillance programs. Medical issues that were highlighted for address in planning Phase II of this program include: accessibility, cost, important of personal physician, need for trustworthy information, cost, and periodic nature of examination. Preferences about credible medical facilities were also provided. Helpful ideas about how and where to perform outreach and education were obtained.

As part of Phase I, we have also constructed community inventories of 600 health and community organizations that can be used in planning and implementing Phase II.

Additional detail regarding these issues is provided the complete analysis by Elizabeth Averill Samaras RN, MSN in Part II of this report.

D. Size of the Target Population

Estimating the size of the target population naturally requires defining what the target population is. In the following section, we provide the rationale for a targeted medical surveillance program that meets the criteria established by the Department of Energy. If requested, we will submit a full plan for Phase II, which will describe in detail the rationale and design of a medical surveillance and risk communication program.

To fulfill the mandate for medical surveillance established by the DOE, we will propose a medical monitoring program designed to detect and to reduce the burden of bladder cancer, chronic lung disease, and lung cancer.

Bladder cancer Workers at occupational risk for bladder cancer worked at K-25 in the centrifuge operations. In their incidence study, Cragle et al included 281 workers, for whom the SIR = 7.8. As defined by the investigators, these workers worked for a minimum of 500 days in Departments 1016,1332,1336,1337, and 1785. The employee roster database shows that there were approximately 1,600 workers who worked at least 1 year in one of these departments between 1963 and 1985. As of 1990, 126 of these workers were known to be dead. Approximately 300 of these workers were still employed at the plant as of 1995. Hence, there were approximately 1,180 workers who meet the above criteria and who no longer work at the plant. Given additional deaths from 1990 to 1997 and the sizable numbers of workers who terminated from the plant prior to 1980 (and therefore will not be able to be found), we estimate that there will be about 500 to 600 former workers who will be eligible for a bladder screening program.

Preventive Pulmonary Health Workers in gaseous diffusion facilities, especially those at K-25, have a documented risk of a variety of lung diseases, including chronic obstructive lung disease, pneumoconioses, and lung cancer. It is justified to include all workers with significant exposures to lung irritants, asbestos, silica, beryllium, and lung carcinogens in a medical screening and risk communication program. Since many of these agents are ubiquitous at gaseous diffusion facilities, large numbers of workers at K-25, Portsmouth and Paducah have experienced these exposures.

In order to differentiate levels of risk within the large group of gaseous diffusion workers exposed to pulmonary toxins, we have identified two levels of priority based largely on the degree of certainty of exposure to pulmonary toxins.

- **Priority group I** consists of all workers at K-25 who worked at least 1 year in departments where urinary testing results show levels of nickel, fluorides, or uranium above certain thresholds. (Details about these thresholds and use of urinary results are in Section 4 in Part II of this report). In addition, all workers with the primary job titles in the maintenance building (K-1401 at K-25) were included. These were welders, insulators, pipefitters, electricians, sheet metal workers, laborers, janitors, carpenters, machinists, converter maintenance workers, lubricators, and maintenance mechanics. Excluding the approximate 2,500 deaths (until 1990) and the 1,100 currently active workers in this group leaves 5,061 terminated workers in this group at Oak Ridge. Approximately 2,711 of these workers terminated prior to 1979 and are unlikely to be traced. The final estimated size for the target group is 2,350 at Oak Ridge.

  There is an alternative way to identify the target population at K-25. By this method, exposed workers consist of all workers who worked at least 1 year in the 64 departments at K-25 where at least 1% of the urine samples for uranium, fluoride, and nickel were taken during the years that urine monitoring was conducted. A complete listing of these departments is provided in Appendix C-2 in Part II of this report. Of the 11,506 workers ever employed for at least 1 year in these departments, 2,889 were known to be dead as of 1990. Another 1,551 workers were still active at the employed in 1995. Of the remaining 7,066 workers (terminated but alive), it is estimated that one-half terminated prior to 1980 and are unlikely to be found, or are dead. This leaves an estimated target population of 3,530 at Oak Ridge This estimate is conservative, since not all maintenance workers are included in these departments.

  At Portsmouth, the sub-cohort with uranium exposure was based on urinalysis results for gross alpha measurements, as described in Rinsky's report. Rinsky also identified sub-cohorts with likely exposure to fluoride and nickel, but we have not yet been provided with these data from NIOSH and couldn't include it in our analysis. Using the uranium sub-cohort, we identified departments where exposure to uranium was likely and added other workers who were more accurately identified by job title rather than department. These job titles include scientists, laboratory assistants, and the maintenance job titles listed above. The total number of workers was 1,927, of whom 468 still work. Of the 1,459 terminated workers, 20% are estimated to have died. This is higher than the 12% death rate that Rinsky obtained for the entire cohort, but his follow-up period ended in 1991. In addition, our percentage applies only to terminated workers. Two-thirds of the terminated workers terminated prior to 1980. The final estimated target population at Portsmouth is 300 to 400 workers. This is surely an underestimate, since the nickel- and fluoride-exposed workers are not specifically included. They will be added after the needed files are obtained.

For Paducah, there are approximately 3,000 workers who formerly worked at the plant. If we use the mortality percentage that Rinsky found at Portsmouth (12%), then about 360 workers will have died. Given the total number of workers who ever worked at the plant, about 4,000, the plant had about 45% of the workers that were employed at Portsmouth. We estimate that a minimum of 200 to 300 former workers at Paducah would be eligible and able to be located for participation in the pulmonary screening program. More accurate estimates will be made after additional data such as department and job title information are available for individual workers.

- **Priority group II** includes all buildings where exposure to at least one pulmonary toxin that was identified from the preliminary results of the risk mapping process was judged to be high. This included all buildings at K-25 except K-1220, K-1423, K-1024, K-131, K-1004-R and S, and K-1023. Therefore, most of the buildings at K-25, especially those that include the largest numbers of workers, would be included in Priority Group II. Since the employee roster database obtained from ORISE does not list building, it is not possible to estimate the numbers of workers eligible for screening based on building data. However, most former employees would be included in screening and would number in the range of 5,000 to 7,000 range.

  Using the same criteria at Portsmouth, the only buildings excluded would be X-326, X330, X-333, and X-343. The anticipated number of eligible workers would be 3,000 to 5,000. At Paducah, the only building excluded would be C-310. The estimated target population at Paducah would number about 2,000.

Section 4. Need for Medical Surveillance and Risk Communication

The results of the 12 month needs assessment study support the need for a medical monitoring and risk communication program. This conclusion is based on the evidence that large numbers of workers had significant exposures to detrimental agents; the epidemiologic evidence, best developed at Oak Ridge, that gaseous diffusion workers suffer excess rates of selected diseases; and the strong need expressed by former workers for a credible targeted program of medical surveillance and education.

In Phase II, we propose to develop and implement a health protection and risk communication program for gaseous diffusion workers centered on the workers at risk for 1) bladder cancer, 2) chronic respiratory disease, including chronic obstructive lung disease (COPD) and the pneumoconioses, and 3) lung cancer. We select these conditions, because they meet the criteria established by the DOE for medical monitoring and risk communication. Our logic is three-fold. First, these diseases are caused by exposures that have occurred at the gaseous diffusion plants. Second, morbidity and mortality studies demonstrate that gaseous diffusion workers are at excess risk for these diseases. Third, a medical monitoring program framed around these conditions can provide tangible benefits. It can lead to early detection of bladder cancer, which can increase survival and quality of life. A well-designed program can identify COPD and the pneumoconioses, for which advice about proper treatment (COPD), vaccinations, and prompt treatment of superimposed infections will be highly beneficial. Lung cancer is not yet amenable to early detection through rational screening, but smokers can be enrolled in smoking cessation programs, thereby reducing both occupational and non-occupational risks.

The risk communication will be a centerpiece of a health protection/medical monitoring program. While there remains considerable uncertainty about the health risks experienced as a result of working at gaseous diffusion plants, this uncertainty must be openly communicated by credible sources. In combination with a medical surveillance program designed to protect health, accurate information about risks will be itself be health promoting. We propose the hard outcomes noted above for medical monitoring, in part, because they can be identified with certainty. The health outcomes that we seek to include in a monitoring program are highly amenable to screening on a population basis. After participation in the screening program, former DOE workers will have increased real knowledge about their personal health status, what is known about their risks, and how they can promote their own health. In conclusion, mounting such a program in Phase II will make a tangible improvement in people's lives.

PART II: METHODOLOGY AND RESULTS

EXPOSURE ASSESSMENT

Preliminary Exposure Assessment for the Former Workers at the DOE Gaseous Diffusion Facilities

(Oak Ridge K-25, Portsmouth, and Paducah)

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1.0 Introduction

The purpose of this one year study was to identify primary worker exposures which occurred over time at the three Gaseous Diffussion Facilities (Oak Ridge K-25 site, Portsmouth, and Paducah). These exposures were characterized, to the extent possible, to allow for a means of determination of worker populations at greatest risk. A similar approach was taken at each of the three sites. A central part of the exposure assessment included the use of building specific risk mapping. This approach allowed for input directly from those involved historically at each particular building of interest. This risk mapping process also allowed the researchers to gain a great deal of insight on day to day operations and exposures which took place at these sites through time.

This paper discusses the primary exposures identified at each of the three gaseous diffusion sites, the buildings where exposures were likely, and the departments and/or job classifications most involved in areas and processes likely to be at greater risk. The results of this effort are based on the risk mapping data along with past study information reviewed and to a lesser extent, pilot questionnaire data.

2.0 Description of Gaseous Diffusion Facilities

The Paducah Gaseous Diffusion Plant (PaGDP) is located on a 3,423 acre reservation in McCraken County, Kentucky approximately 15 miles west of Paducah. The site was acquired by the Atomic Energy Commission in 1950. The PaGDP was built in the 1951-1954 period and has been in continuous operation since startup. It consists of four main process buildings and is the largest of the three DOE gaseous diffusion plants, having the capability of using 3,040 MW. The four major process buildings contain 1,760 process stages, along with common feed and product withdrawal facilities. As intended, the plant operated mainly as a stripper plant for the Portsmouth and Oak Ridge Gaseous Diffusion Plants (ORGDP), whereby PaGDP would ship product to Portsmouth or ORGDP for further enrichment. The plant was designed to operate at an enrichment level of 2% U-235. However, in the early 1990's, the plant was modified to operate at up to 5% enrichment, which allowed PaGDP to ship product directly to customers. Prior to this recent process modification, two major process renovations took place at the site, one around 1970 and the other in 1982. PaGDP was initially managed and operated by Union Carbide. Currently plant management at the PaGDP is divided between Lockheed Martin Energy Systems and the US Enrichment Corporation.

The Portsmouth Gaseous Diffusion Plant (PoGDP) is located in Pike County, Ohio on a 4,000 acre reservation. The plant has been in continuous operation since 1954, when it was managed and operated by Goodyear Atomic Company. PoGDP was designed to enrich uranium from 0.7% U-235 up to 98% U-235. The plant consists of three large process buildings (X-326, X-330 and X-333). In addition, other major support functions include: maintenance (X-720), Decontamination (X-705), Chemical Cleaning (X-700), Converter Assembly (X-700), UF6 Feed Vaporization (X-342), and Product Withdrawal (X-344). Currently plant management at the PoGDP is split between Lockheed Martin Energy Systems and the US Enrichment Corporation.

Located west of the city of Oak Ridge, Tennessee, the K-25 site began operations in 1945 as the Oak Ridge Gaseous Diffusion Plant (ORGDP). The ORGDP was built as part of the Manhattan Project during World War II to supply enriched uranium for nuclear weapons production. Construction of the K-25 building, the primary productin building, also known as the "U", started in 1943 and was fully operational in 1945. The K-25 facility, which was capable of enriching uranium to 95% U-235, was operable from 1945-1964. Additional buildings involved in the enrichment process at Oak Ridge included: K-27 (operable between 1945-1964 and capable of 20% enrichment), K-29 (operable between 1951-1985 and capable of 10% enrichment), K-31 (operable between 1951-1985 and capable of 5% enrichment), and K-33 (operable between 1945-1985 and capable of 2% enrichment). K-31 and K-33 were used through 1985 for the production of enriched uranium that was supplied to nuclear reactors used to generate electric power.

The K-25 site differs in several important ways from the two other gaseous diffusion plants (Paducah and Portsmouth). The K-25 site initially housed three production-scale enrichment processes (gaseous diffusion, gas centrifuge and thermal diffusion). Eventually, gaseous diffusion was selected as the most favorable method of enrichment. The gas centrifuge program (K-1200 complex) initiated in 1960 was cancelled in 1985 and the thermal diffusion program (S-50 Complex including K-725) was cancelled in 1946. In addition, the K-25 site was the only site which produced the "barriers" used within the gaseous diffusion cascade system (Barrier Manufacturing Building K-1100, K-1037).

While there are numerous differences at the three gaseous diffusion facilities, the primary production buildings and primary support buildings (i.e., Feed and Withdrawal buildings, Decontamination building, Maintenance Buildig) are very similar in design and in the materials which were handled therefore making comparisons of exposure between facilities possible.

The gaseous diffusion process is based on Grahams' law, which states that "the relative rates of diffusion of gases under the same conditions are inversely proportional to the square roots of the densitites of those gases". Using this principle, the Uranium Hexafluoride (UF6) gas is enriched by using a multi-stage series of separations (using a porous membrane – "barrier"). The degree of enrichment is dependent on how many process stages or cascades the feed stock is passed through. The feed gas, UF6, is extremely corrosive to most metals and highly reactive with water and grease. Due to these characteristics of UF6, the structural metals used in the process consist primarily of nickel-plated steel, Monel (a copper-nickel alloy), and aluminum. Assuring process parts were grease free and "conditioned" prior to being reintroduced into the cascade were essential steps after decontamination or maintenance work which resulted in increased exposures to chlorinated solvents (degreasing) and fluorine (conditioning).

3.0 Methodology

To best summarize exposures at each of the three sites three basic approaches were initiated: 1) Risk Mapping of Priority Buildings, 2) Exposure Records Review and Assessment, and 3) Development and Dessimination of a Questionnaire to former workers. The approach to each of these items is detailed within this section.

3.1 Risk Mapping

Risk Mapping is an approach which has been used extensively at industrial facilities as a tool to assist workers and/or joint health and safety committees in determining high risk areas within their facilities. Traditionally the technique is used to identify current problem areas within a facility and to assist in developing an intervention strategy for resolving the problem areas. (1,2) For this project the risk mapping approach was used to map past exposure conditions at the three gaseous diffusion facilities.

In addition to using the mapping process for mapping past exposure conditions within the buildings of interset, the method was also modified to allow the field researchers to collect semi-quantitative exposure data for each identified exposure of concern. In addition, the field researchers were also tasked with collecting data regarding building / process characteristics (i.e., description of major processes, number of workers in the building of interest, years of opreation, etc.).

Several steps were necessary in developing and running the risk mapping sessions at the three sites. The steps were as follows:

1) The University of Massachusetts Lowell customized the risk mapping method for use in restrospective exposure assessment. Part of customizing the risk mapping tool included the development of a "job exposure information sheet" which was used to collect job/process/exposure information for each

chemical / agent identified on the risk map. (see Attachment 1) In addition, a "Building Characteristics Report Form" was developed to allow the field researchers to collect descriptive information on the building of interest (i.e., description of major processes, number of workers, years of operation, etc.). (see Attachment 2)

2) The University of Massachusetts Lowell in conjunction with the OCAW International staff developed a training guidebook for use in training the field researchers in the technique. The guidebook was constructed to include baseline information regarding the project as well as basic information regarding medical surveillance.

3) The University of Massachusetts Lowell in conjunction with the OCAW International and the Alice Hamilton College conducted a train the trainer for the field researchers. The field reserchers for this project included OCAW Local Union worker trainers, Local Union Health and Safety representatives, and Local Union retirees (each facility had at least three field researchers working on the project). The train the trainer session was a two day session to familiarize the field research teams with the risk mapping methodology.

4) Selection of "experts" for initial risk mapping session at each of the three sites. The University of Massachusetts Lowell coordinated with the OCAW Internatinal along with the OCAW Local Union research teams to assemble an "expert" team of former workers for the initial risk mapping sessions at each site. The "experts" selected for the initial sessions consisted primarily of hourly workers with extensive experience at the site. Several line supervisors were also available for the "expert" sessions. While the groups did not consist of a typcial expert panel which might be assembled by researchers in order to characterize past exposures at an industrial site, the groups had a vast amount of site experience and were selected to encompase a broad array of job classifications and process buildings of interest.

5) The initial risk mapping sessions focused on the entire facility (Portsmouth, Paducah, and K-25) and were conducted to assist in determining priority areas for future, more specific, risk mapping sessions. As a product from each of theses sessions, the expert group produced a listing (10-15) of buildings of most concern regarding retrospective exposures. This list, along with information obtained through review of previous research studies, was used to identify areas for future risk mapping sessions.

6) Building specific risk mapping sessions were conducted for priority buildings at each of the facilities. These risk mapping sessions allowed for the collection of the aforementioned data sheets: Job Exposure Information Sheet and the Building Characteristics Report.

7) The Job Exposure Information Sheet data along with information from the Building Characteristics Reports were compiled into a database to allow for assessment of the data.

3.1 Exposure Records Review and Assessment

The primary focus of this preliminary exposure assessment was to determine major exposures as a function of building /area, department, or job classification. Another primary need is to establish an approach for linking the building / exposure data to an individual within the former worker roster. In addition to reviewing available information on exposures, buildings and departments, the history of job classifications at each site was reviewed.

Appendix A contains a summary of major sources of data regarding health physics and IH records at the gaseous diffusion sites. It should be noted that some of the potentially most useful IH data is currently under final development by NIOSH and some IH data requested by NIOSH from DOE has yet to be declassified (K-25 Air sampling data 1960s).

The primary documents / data files which were used for this preliminary exposure assessment included:

1. "Mortality Patterns among Uranium Enrichment Workers at the Portsmouth Gaseous Diffusion Plant" Robert Rinsky.
2. Building / Department Matrices developed by NIOSH for the Portsmouth site.
3. IH exposure database (for Uranium, Fluorides, and Nickel) for the Portsmouth site developed by NIOSH (requested but not yet received)
4. K-25 Quarterly Health and Safety reports (1948-1989)
5. K-25 Urinalysis working data files (ORAU – available through CEDR – 1948 – 1985)
6. K-25 External Radiation Exposure working data files (ORAU – available through CEDR)
7. Oak Ridge Phase I Health study reports, ChemRisk, Inc. (Off-site dose reconstruction project)
8. Paducah Gaseous Diffusion Process class conducted by Mr. Carl Walter

For the Portsmouth site the review of the data was primarily used to assist in targeting buildings for risk mapping. The Rinsky study identified eleven buildings where the majority of the air samples had been taken over the history of the site (air samples for U, Ni, and Fluorides). While it can not be assumed that working in other buildings at Portsmoputh equates to a zero exposure this information provided one method for identifying at risk groups.

One limitation of the data available from this Mortality study was that it was focused on three agents. And further, one of the agents (Nickel) had a limited amount of air sampling data available through the years which forced their study to focus on exposures to Nickel within one building (Welding operations /X-720. The NIOSH researchers concluded that due to the size of the cohort (the overall cohort of 8877 workers was reduced to 465 workers in areas where airborne Nickel was measured) "only the most extreme type of occupationally-induced epidemic would be seen". (3)

For these reasons we felt that the best way to gain an understanding of the range of exposures and relative levels of exposure encountered at the Portsmouth site was through the use of data generated in building specific risk mapping sessions. The risk mapping would also be the primary source of exposure information for the Paducah site.

It is important to point out that information gained regarding type, level and exposure location for the more extensively studied site (K-25 Oak Ridge) is to a certain extent transferable to the exposure assessment work performed at the Portsmouth and Paducah site. Since the technology for the gaseous diffusion process and to some extent the actual process equipment (i.e., barrier tubes) were developed at Oak Ridge it is our belief that exposures for certain buildings and job functions at certain time periods would be comparable at the three sites. To the extent that data was not available for Portsmouth and Paducah this information regarding the process can be used in conjunction with the Risk Mapping data to assist in identifying buildings/departments and or groups of workers at increased risk.

For the K-25 site additional data was available which allowed for a more quantitative assessment of building / exposure levels and department / exposure levels. NIOSH is currently assembling an IH database that will add to the body of information regarding exposure levels at the K-25 facility at Oak Ridge.

For this preliminary assessment, information regarding levels of exposure by building/department over time were extracted from two primary sources: the K-25 Health and Safety Quarterly reports (1948 – 1989) and the K-25 Urinalysis working data file (ORAU). Additionally, information regarding department name, department number, building name, building number, and job classification were obtained from NIOSH. Information regarding job classification, job number, and frequency was also assembled from ORAU working data file (ORAU personnel data, CEDR). This last task was performed in order to identify approximate number of workers in a given job category of interest (for example; those identified in past research – Barrier Operators, component assemblers (Centrifuge workers), etc.).

The K-25 Urinalysis working data file was found to be a very useful source of quantitative exposure levels as a function of building and department. The assessment of the K-25 Urinalysis working file included the following steps:

1. The K-25 data was divided into approximate 5 year increments ('48-'54, '54-'59,'60-'64,'65-''69, '70-'74, '75-'79, and '80-'85.
2. The data was reviewed to determine building number vs. frequency of urine sample by type of sample analysis (the primary type of sample analysis were Uranium, Fluorides, Gross Alpha, Mercury, and Nickel). Through this process it was realized that only certain portions of the database contained information on Building Number ('55-'59 and '60-'64). Other subsets of the database included information regarding department only.
3. The protion of the database with Building Number information was segregated. The buildings which contributed greater than 5% of the total number of urine samples were identified.
4. These data were assessed to determine averages of all uraine sample by type for each building. As a conservative measure all data recorded as less than an MDA value were assigned a value of zero. This data is included in this report within Appendix B. It should be noted that these averages were not used for purposes of assigning individual exposures but rather they were used as a preliminary screening step to identify priority buildings and departments.
5. The data was then assessed to determine each identified building and the departments which were associated with that building. For each building , departments contributing more than 5% of the total number of samples were identified. A summary of this analysis is included within Appendix C-1.
6. A listing of all departments identified from any building during either time period ('55-'59 or '60-'64) was developed. There was a great deal of overlap (i.e., one department in several buildings) and therefore the composite list is not that extensive. This Composite Department List is included within Appendix C-2.
7. An assessment of urinalysis data as a function of department (for the priority departments as determined in step 6 above) over the entire database (1948 – 1985) was performed. The results of this assessment are shown in Appendix B1-B4.
8. A more in-depth analysis of Fluorine, Nickel, and Mercury urinalysis data was performed within the five year time periods. All departments contributing greater than 1% of the total number of samples for that time period were included in the analysis. Results were reviewed and compared against threshold values to determine frequency of elevated samples. These results are included within Appendix B-5.

While this analysis is not expected to identify every building or department where high exposure may have occurred it did allow for a preliminary understanding of the buildings and departments at highest risk.

Several obvious limitations should be mentioned:

1. The urinalysis program at Oak Ridge only covered a small percentage of the work force believed to be at highest risk along with a random sampling of the rest fo the site population.
2. The building data was only available from 1955 – 1964 and therefore some key operations have been excluded by this analysis. For example, the years of interest for the centrifuge workers was between 1964 and 1985 and therefore these buildings / departments may not have been identified in the above assessment.
3. In many cases the department number is not linked to the building where an individual worked complicating the assessment of potentially at risk groups of workers.

The second main source of information which was useful in terms of establishing levels of exposure within various buildings at the K-25 site was the Quarterly Health and Safety Reports (1948 – 1989). While these reports varied in terms of level of detail and report format over the years, there was a great deal of useful summary exposure information within these reports. The information of most use included:

1. Listings of buildings prioritized for radiation measurement surveys
2. Radioactive contamination levels as a funciton of building over times
3. Urinalysis summary tables (Total # and # in excess of the Plant Action Guideline)
4. Air Sampling Summary Tables (Total # and # in excess of the Plant Action Guideline)
5. Summary illness and injury information
6. Summary of major construction activities during each quarter
7. Summary of personnel protective measures implemented (i.e., respirators, ventillation, etc.)

During this preliminary exposure assessment, the information found in these reports was used only to support/confirm exposure levels identified through Risk Mapping Assessment and/or urinalysis data analysis.

3.2 Questionnaire for Former Workers

A questionnaire was developed in conjunction with the Mount Sinai School of Medicine to survey retirees regarding health status, health care needs, work history, and exposure information. A pilot questionnnaire was mailed to determine the adequacy of he survey and the mailing address roster. Results were not available for this report.

4.0 Results

The primary objective of this investigation was to identify the primary exposures which took place over the years at the three gaseous diffusion facilities and to the extent possible quantify those exposures. The general approach taken at all three sites was to identify the major buildings where exposures took place, to determine what those exposures were, to determine who worked in the areas where exposures were likely (job title/ classification or department), and to determine (qualitative or semi-quantitative) the level of exposure.

To have the ability to assign an exposure to an individual it would be necessary to determine not only the exposure level in the building, but also you must have the ability to link the exposure building information to each individual.

The employee rosters for the three gaseous diffusion sites do not include information regarding building where the employee worked over time. The rosters do have information regarding department (department code). To assign an exposure level therefore requires the ability to link the department worked with the building exposure information.

The health physics data for the three sites may not be best suited to the above method of analysis. The health physics data (both badge data and urinalysis data) are coded by department and HP badge number. Therefore, it is possible to assign dose on an individual basis. If data is not available (i.e., personnel not monitored) than exposures may be extrapolated based on department designations rather than relying on building specific information (4)

4.1 K-25 Site

At the K-25 site three primary data sources were analyzed to assist in identifying primary exposures and assigning qualitative exposure levels to buildings of interest. The three data sources were: 1) K-25 quarterly reports, 2) ORAU working data files (specifically the K-25 Urine file), and 3) data collected during targeted risk mapping sessions.

This preliminary analysis was successful in identifying primary chemicals/agents of concern and linking those chemicals/agents to specific buildings/operations within the K-25 facility. Some attempts were made to determine departments of concern however, continued work would be necessary to assign exposure levels to individuals.

A building department matrix over the years of operation at the K-25 site is being developed by NIOSH as part of the K-25 Multiple Myeloma case control study currently underway. Many of the subtasks completed by the NIOSH researchers were useful for this investigation (K-25 Department listing, K-25 Building Listing over time, and K-25 Job Classification Listing).

In order to make some determination of the departments of concern as well as the buildings of concern an existing ORAU working data file (K-25 URINE) was reviewed. The data in the working file was divided into time periods (i.e., '48 – '54, '55-'60, '60 – '65, etc.) and various runs of the data were conducted. It was determined that building data was available for the time periods between 1955 and 1965. It was also determined that most of the data included information regarding department.

For the years where building data was available (1955-1965) we generated a summary table showing the number of urine samples by type. Based on these two subsets of data a preliminary assessment of the departments of interest could be obtained. The basis for this conclusion is simple: the buildings where a great deal of urine samples were collected were likely the buildings where the greatest exposures were taking place and therefore by selecting those buildings which together represent a large percentage of the total number of urine samples taken (i.e., cumulatively greater than 95%) and determining which departments are associated with those buildings a determination could be made of the departments of greatest interest regarding internal exposures (chemical and radiation).

The approach described above is limited for several reasons: 1) the building data only exists over a 10 year period and any buildings of interest from the early years or the years after 1965 are not included within this model; therefore departments associated with those buildings/operations may be overlooked, and 2) the analysis was conducted without a complete understanding of the relationship of department number over time.

The Health Physics working data files (K-25_EXT, K-25_WB, and K-25_URINE) also had limitations. The Health Physics exposure data has several limitations which have been identified by past researchers (5). Galloway's research concluded that the "Oak Ridge Gaseous Diffusion Plant dosimetry data at the present time are unsuitable for epidemiologic purposes". The limitations cited include: Incomplete dosimetry data, Small fraction of workforce monitored, Mostly zeros in exposure data, and Frequency of collection of bioassay samples leading toward large probabilities of missed doses.

All of the above factors make it difficult to quantify and assign individual workers a dose and currently this analysis has not been completed. NIOSH intends to assign dose for cases and controls in their K-25 Multiple Myeloma study however, this effort is expected to involve review of individual hard copy records for each individual in the study along with possible measurement of archived film badges (which were collected in the past but not measured). This level of effort is not realistic for an entire cohort.

For this investigation attempts were made to identify relative levels of external radiation dose and internal dose for the buildings of concern through the risk mapping sessions. The results of the risk mapping can be compared against summary radiation exposure information identified in K-25 quarterly health and safety reports as well as the K-25 Urine working data files (for 1955-1965 where building information is available). The K-25 quarterly health and safety reports give very good summary information regarding external radiation exposure averages, summary statistics on uptakes, and summary information regarding levels of contamination throughout the site. In fact, several of the quarterly reports (between 1955- 1962) provided summary facility maps which mapped the exposure/contamination levels around the site for certain major hazards of interest (i.e., uranium, fluorides, UF6). These maps were also very useful as a comparison against information reported during the risk mapping sessions.

Finally, for the K-25 site a preliminary assessment of exposures vs. "priority" departments was completed.

4.1.1 Major Buildings of Interest at the K-25 Site

4.1.1.1 Gaseous Diffusion Process Buildings K-25, K-27, K-29, K-31, and K-33

Description of Process

The first gaseous diffusion processes in the K-25 building became operational in January 1945. The K-27 building became operational in late 1945. The other three cascade buildings (K-29, K-31 and K-33) became operational by 1954. In 1964 K-25 and K-27 were shut down. In 1985 the remaining process buildings were shut down.

In this process uranium, in the form of Uranium Hexafluoride (UF6 or Process Gas – PG), is forced to flow through the inside of a porous nickel membrane (barrier). The pressures are controlled so that about half the gas diffuses through the barrier and is subsequently introduced to the next higher stage,, while the remaining undiffused portion flows to the next lower stage. Axial flow compressors driven by electric motors compress the UF6 to maintain interstage flow (6).

A gas cooler is provided for each stage because gas compression generates heat that must be removed. The diffuser, or converter, is a large cylindrical vessel that contains the barrier material. The entire process was an enclosed system which operated below atmospheric pressures.

A number of stages were connected together to form cells. The diffusion cascade was made up of a number of cells. With all process buildings operational the ORGDP had a total of 5100 stages.

Because the diffusion cascade operated below atmospheric pressure light gases accumulated at the top of the cascade. If these light gases were not vented to the atmosphere they would accumulate at the top of the cascade and block the flow of the enriched uranium hexafluoride. Purge facilities are operated just above the top of the product withdrawal point. These light gases come from several sources: Inleaking of air resulting in Nitrogen, Oxygen, Argon, and HF in the system, Conditioning of cells resulting in ClF3 and Fluorine in the system, and in-leaking of coolant resulting in chlorofluorocarbons in the system. (7)

The purge cascade consisted of equipment similar to that used in the rest of the cascade, but converted to handle the lighter gases. The cascade was designed with a top purge (light gases Nitrogen, air) and side purge (Chlorine and Chlorine fluorides). Sodium Fluoride and alumina traps were placed in line to trap residual process gas (Uranium, Tc-99). Over the 40 years this purge facility was in several locations (K-311-1, K-310-3, K-402-8, K-402-9).

Primary Exposures

The primary exposures for the cascade process buildings (based primarily on the risk mapping of the K-25 process building) include: Uranium, UF6, Uranyl Fluoride (UO2F2), Fluorine (C-216), HF, Perfluorodimethylcyclohexane (C-816 Coolant), Perfluorotrichlorobutane (B-437 Coolant), Chlorine Trifluoride (conditioning gas), Asbestos, Nickel (welding/cutting), Cadmium (Cold Traps), and Mercury. These exposures are summarized in Table 4.2

Description of Workforce

The primary job classifications which were associated with daily operations within the K-25 building included: Operators (2-15/building/shift – 12 buildings, 4 shifts), Maintenance Mechanics (30-40/day (from K-1024)), instrument mechanics (2-5), electricians (2-5), and lab technicians (2-5). The total number of workers within the building during an average day would be anywhere from 150 – 500. Post 1960, the number is believed to have been around 200 (8). A table summarizing this information for all of the process buildings is included as Table 4.1

The Departments associated with this building are included within Appendix C.

4.1.1.2 Centrifuge Complex

Description of Process

From 1960 through the early 1980s the gas centrifuge program at the K-25 site pursued the development of an alternative technology for the enrichment of uranium. Much like the diffusion process, the centrifuge process handled uranium as gaseous UF6, and through the cascading of a few centrifuges, the desired enrichment could be achieved. The greatest potential advantage of the centrifuge process was that it only required 4% of the power required for gaseous diffusion.

The primary buildings within the centrifuge complex included: The Equipment Test Facility (1971 – 1985), the Component Preparation Laboratory (1974 – 1985), the Component Test Facility (1975 – 1985), Advanced Machine Development Laboratory (1960 – 1985), the Advanced Equipment Test (1960 – 1985), and the Centrifuge Plant Demonstration Facility (K-1220) (1960 – 1985). The gas centrifuge operations were shut down in 1985.

For the purposes of this paper, the Centrifuge complex includes:K-1200, K-1210, K-1220, and K-1052. Other related operations were found in the "J" Lab (K-1004-J).

Primary Exposures

The primary exposures identified within these buildings (reported during risk mapping sessions) included: Epoxy Resins (and dust from the resins), 4,4-Methylenedianiline (MDA), m-Phenylenediamine (mPDA), bis (2,3-Epoxycyclopentyl) ether (BECPE), Diglycidyl Ether of Bisphenol A (DGEBA) , fibers (type of fiber is classified), alcohol, TCE, Freon, UF6, radiation, and noise. The levels of radiation and UF6 were reported as low to medium which would be consistent with the fact that the experimental project worked with low assay materials. Table 4.3 summarizes the exposures identified within the centrifuge complex.

Description of Workforce

The workforce for these buildings was reported to include: Maintenance Mechanics, Research Assciates, Research Assistants, Instrument Mechanics, Operators, Component Assemblers, Janitors, laborers, electricians, welders, and laboratory technicians. The Component Assemblers and the Laboratory Technicians were most directly involved in the construction, assembly and testing of the centrifuge cascade system.

The departments associated with this complex are identified within Appendix C. These departments were identified based on the ORAU Centrifuge Worker Study (Phase I and II).

4.1.1.3 K-1037 Barrier Manufacturing Building

Building Description

K-1037 was the primary Barrier Manufacturing Building. Several other buildings were involved in the complete assembly of the barrier tubes including K-1004 L, K-1100, K-1401 (Converter Retubing and Assembly Area), and K-1420 (Barrier tube recycling area).

This facility is a unique in that it is the only facility in the United States which manufacturers barrier. The Portsmouth and Paducah facilities both obtained barrier tubes from Oak Ridge. The initial barrier material used within the K-25 cascade was reportedly developed at Columbia University.

The process by which the barrier is manufactured remains classified. With the exception of nickel, the materials used in the manufacture of the barrier are also classified. This building was not investigated since members of the research team have not yet obtained clearance.

Primary Exposures

Nickel Powder and Nickel Carbonyl are the primary exposures identified. Other materials used in the manufacture of the barrier material remain classified. The levels of nickel dust were reportedly very high in Health and Safety Quarterly reports (1952-1965) (9) and by retiree interviews. On the average, between 1952 and 1957 approximately 30% of reported air samples analyzed for Nickel concentrations exceeded the established plant action level of 0.5 mg/m^3 The average Nickel concentrations reported by Union Carbide (average of approximately 3000 samples) between 1948 and 1973 was between 1.5-2 mg/m^3. (10). The K-25 Urine data supports the apparent elevated exposures to Nickel within this building (Appendix B: Department Urine Analysis and Building Urine Analysis). Exposure information is summarized in Table 4.4.

Description of Workforce

The workforce consisted of the following: Barrier Operators, Maintenance Mechanics, and Laboratory Technicians. There were approximately 300 – 400 workers per day in this building. This information is summarized within Table 4.1.

The departments associated with this building are included within Appendix C.

4.1.1.4 K-1004 L Enrichment Technology Facility

Building Description

One of the primary functions of the K-1004 L Lab was the development and testing of the cascade barrier material. The facility had three primary areas: Barrier Preparation, Barrier Science and the Cascade Pilot Plant. The Cascade Pilot Plant was a small cascade system used to test the quality of the barrier.

Primary Exposures

Fluorine, chlorine trifluoride, hydrogen fluoride (drying and conditioning testing), Nickel, and Nickel Carbonyl . The exposures are summarized within Table 4.5.

Description of Workforce

The workforce consisted of the following: Lab Technicians, Engineers, Maintenance Mechanics, Operators, and Electricians. This information is summarized within Table 4.1.

The departments associated with this building are includeed within Appendix C.

4.1.1.5 K-1420 Decontamination Facility

Building Description

K-1420 was the primary Decontamination Facility at the K-25 site. The Facility was in operation between 1953 through 1985. The facility was used to deconaminate parts prior to being sent to the Maintenance Building (K-1401) for repair work. Prior to 1953 decontamination work was performed in Buildings K-1303 and K-1410.

The primary method for cleaning the parts included mechanical cleaning in combination within aqueous cleaning using nitric acid, sulfuric acid and sodium carbonate solutions. The large parts were cleaned within large spray booths. The liquid waste generated during the decontamination process was collected and sent to the Uranium Recovery Area (K-1420 "B" Area). The uranium was recovered for reuse and the byproduct was discharged to the K-1407B Holding Pond. The acid solution from the decontamination process was sent to the Uranium Recovery Building.

The K-1420 Building had several other important operational areas including: Cylinder Cleaning Area, Mercury Recovery Room (approx. 1960 – 1985), Barrier recycle area, and Nickel Plating operation.

Primary Exposures

This building was reportedly an area with great exposure potential. The primary exposures included: Uranium, radiation, UF6, Uranyl Fluoride (UO2F2), HF, Nickel (welding, fabricating, plating, and barrier recycle), Nitric Acid, Sulfuric Acid, TCE, and Mercury. This exposure information is summarized within Table 4.6.

Description of Workforce

The workforce consisted of the following: Chemical Operators, Welders, Maintenance Mechanics, Painters, Electricians, Instrument Mechanics, and Laborers. This information is summarized within Table 4.1.

The departments associated with this building are includeed within Appendix C.

4.1.1.6 K-1410 Plating Facility

Building Description

The K-1410 Building was the primary plating building from approximately 1951 to 1979. The building was used for electrolytic nickel plating operations. The building contained acid and plating solutions for large parts plating.

From 1942 to 1953 the K-1410 Building was used for decontamination of parts with high assay contamination.

Primary Exposures

The primary exposures were as follows: Acetic Acid, Asbestos, Carbon Tetrachloride, TCE, Acids, Bases, Nickel, uranium and radiation. The exposure information is summarized within Table 4.7.

Description of Workforce

The workforce consisted of the following: Maintenance Mechanics, Operators, Welders, Electricians, and Instrument Mechanics. This information is summarized within Table 4.1.

The departments associated with this building are includeed within Appendix C.

4.1.1.7 K-1410 Decontamination Facility

Building Description

From 1942 to 1953 the K-1410 Building was used for decontamination of parts with high assay contamination. During this period of time the building was reported to have been grossly contaminated with Uranium. This statement is supported by maps contained within quarterly health and safety reports dating back to 1949. It is clear that until 1953 the building contained a high level of radioactive contamination. In addition, the quarterly reports from the time period indicate that the K-1410 building was one of five buildings on routine monitoring for external radiation levels due to high levels likely in the buildings (the other four buildings are K-1004 J lab, K-1004 D Radon Plant, K-1131, and K-1231).

Primary Exposures

The primary exposures consisted of the following: Uranium, radiation, fluorides, chlorinated solvents, acids and bases. The exposures are summarized within Table 4.8.

Description of Workforce

The workforce conssited of the following: Maintenance Mechanics, Operators, Welders, Electricians, and Instrument Mechanics. This information is summarized within Table 4.1.

The departments associated with this building are includeed within Appendix C.

4.1.1.8 K-1401 Maintenance Building

Building Description

The K-1401 Building was the primary Maintenance Building for the K-25 site from 1944 through 1985. Various cleaning, conditioning, and assembly operations were conducted in this building. There was great emphasis in this building on degreasing operations due to the fact that the parts which were to go into the gaseous diffusion process could not be contaminated with hydrocarbons since the hydrocarbons could react violently with UF6. Therefore, strict attention was given to the removal of any oil and grease from parts.

Part of the Maintenance Building was a Metals Cleaning and Conditioning operation that was used to prepare various metals for fabrication and assembly operations. The cleaning operations involved the use of large cleaning baths with various cleaning agents including: HCl, NaOH, trichloroethane, TCE, carbon tetrachloride, freon, aromatics and acetone.

Another part of the Maintenance Building was the metal conditioning area. After metal parts were worked on and prior to assembly the metals were conditioned for corrosion resistance. This was an essential step since the process metals would be in contact with the highly corrosive process gas (UF6). The conditioning of the metals was performed with fluorine gas.

Other operational areas within the K-1401 building included fabrication and assembly operations area (machining, etc), weld shop, paint shop, Lead Melting Facility, Compressor shop, Valve Shop, Pump Shop, Furnace Conditioning Stands (used to condition "plugged" barrier – in the early years), and carpentry shop.

Primary Exposures

The primary exposures in this building consisted of the following: Acids, Bases, Chlorinated solvents, freon, troxide, Uranium, UF4, UF6, UO2F2, HF, phosgene, Beryllium, Nickel, Mercury, and Cadmium. The exposures are summarized within Table 4.9.

Description of Workforce

The workforce associated with this building consisted of the following: Retubers, Electricians, Maintenance Mechanics, Welders, Janitors, ET&I staff, carpenters, laborers, machinists, sheet metal workers, welders, converter maintenance, inspectors, oilers (lubricators), instrument mechanics, and stores. This information is summarized within Table 4.1.

4.1.1.9 K-1423 Toll Enrichment and Sampling Facility

Building Description

The Toll Enrichment Facility, K-1423, operated between 1969 and 1985 (??). It was the shipping and receiving point for UF6 cylinders (2.5, 10, and 14 ton cylinders). The operations that may have resulted in exposures to employees were the cylinder sampling operation, routine purging of cylinders after sampling and transfer, and cylinder venting operations. The feed material that was received in K-1423 would be shipped to the K-1131 Feed Facility after sampling was performed and determined to be adequate.

Primary Exposures

The primary exposures in this building included: UF6, HF, Uranium and radiation. The exposure information is summarized in Table 4.10.

Description of Workforce

The workforce consisted of the following: Operators and Maintenance Mechanics. Appoximately 20 people worked there per day. This information is summarized within Table 4.1.

The departments associated with this building are includeed within Appendix C

4.1.1.10 K-1131 Feed Vaporization and Tails Withdrawal Facility

Building Description

The K-1131 building was the Feed Vaporization and Tails Withdrawal facility. The purpose of the Feed Vaporization side of the building was to heat cylinders containing solidified Uranium Hexafluoride to convert the material to a pressurized vapor for feeding into the cascade. Conversely the Tails Withdrawal operation served the function of removing the depleted uranium hexafluoride from the enrichment cascade.

The K-1131 Building also housed the Fluorine Plant. The K-25 facility produced their own Fluorine gas (used primarily for conditioning parts). The production of fluroine involved electrolytic processing of aqueous fluoride solutions resulting in two gaseous products – hydrogen and fluorine. The fluorine stream would contain some HF which was condensed out. The hydrogen was vented to atmosphere.

The K-1131 building also was used to produce UF6 from 1950 – 1968. In this process the uranium dioxide (from outside vendors) was converted to UF6.

Primary Exposures

High External Radiation levels, UF6, UO2F2, Uranium Oxides (UO2 and UO3), Uranium (high), Fluorine, HF, Asbestos, Heat and Noise. This Building was often associated with a large percentage of the external radiation exposures and internal radiation exposures exceeding the plant action levels (H&S Quarterly reports from 1949 – 1965) (9) The exposures in this building are summarized in Table 4.11.

Description of Workforce

The workforce consisted of the following: Maintenance Mechanics, Operators, and Electricians. This information is summarized within Table 4.1.

The departments associated with this building are includeed within Appendix C.

4.1.1.11 K-413 Product Withrawal Facility

Building Description

The function of the K-413 Product Withdrawal Facility was to remove enriched uranium hexafluoride from the cascade. This facility operated between 1947 through 1965. The product withdrawal process was done in the same way as the tails withdrawal through the use of compression-liquefaction or in earlier years through the use of cold traps. Exposures in the facility were primarily related to releases of UF6.

Primary Exposures

The primary exposures in this building consisted of the following: UF6, HF, and radiation. The exposure information is summarized in Table 4.12

Description of Workforce

The workforce consisted of the following: Maintenance Mechanics and Operators. This information is summarized within Table 4.1.

The departments associated with this building are includeed within Appendix C

4.1.1.12 K-1301,2,3:Decontamination and Recovery and Oxide Conversion

Building Description

The K-1303 facility had a variety of operations over the years of operation. The operations which took place in this building over the years included: fluorine production, decontamination and recovery of fluorinated lubricating oils, vacuum distillation and recovery of mercury, decontamination of cascade process equipment, a research compressor unit, and, at one time, a 55-gallon drum under a hood which served as an incinerator.

The Mercury recovery process within this building operated from before 1948 to 1956. Workers accounts recall a "pencil thin stream of mercury" going from the K-1303 building to Poplar Creek.

The K-1301,2 building was used as part of the oxide conversion process.

Primary Exposures

The primary exposures in this building included: Mercury, Uranium, Uranium Oxides, Acids, Solvents. This exposure information is summarized in Table 4.13.

Description of Workforce

The workforce in this building consisted of the following: Chemcial Operators and Maintenance Mechanics. A total of approximately 30- 40 people per day worked in the building. This information is summarized within Table 4.1.

The departments associated with this building are includeed within Appendix C.

4.1.1.13 K-1413 Research and Development Facility

Building Description

The K-1413 facility was a research and development facility which operated from the early 50s through 1985. The research conducted in the facility included: methods for conversion of uranium chips to UF6, methods of conversion of UO2 to UF4 using HF, tower fluorination of UO2 or UF4 to UF6, calcination of uranyl nitrate to U3O8, etc. The waste disposal pits around the K-1413 facility were also used for disposal of waste streams from the Y-12 facility.

Primary Exposures

The primary exposures in this building included: Perchloroethylene, Uranium, Uranium Oxides, radiation, HF, and Mercury (from Y-12 waste handling). The exposure information is summarized in Table 4.14.

Description of Workforce

The workforce in this building consisted of the following: Laboratory Technicians, Operators and Maintenance Mechanics. A total of approximately 50 people per day worked in the building. This information is summarized within Table 4.1.

The departments associated with this building are includeed within Appendix C.

4.1.1.14 K-1231 Powder Mill

Building Description

K-1231 was a support building for K-1037 Barrier Manufacturing Building and K-1131 oxide conversion building. Involved in the production of UF6 from oxides. One major process involved the pulverizer area in which tails from K-1131 were pulverized for reprocessing in K-1131.

Primary Exposures

The primary exposures in this building were as follows: Uranium oxides, HF, Fluorine, and classified materials associated with the Barrier operation. These exposures are summarized in Table 4.15.

Description of Workforce

The workforce in this building consisted of the following: Instrument Mechanics, Electricians, Welders, Operators and Maintenance Mechanics. This information is summarized within Table 4.1.

The departments associated with this building are includeed within Appendix C.

4.1.1.15 K-1004 A,B,C, and D (Radon Lab) Labs

Building Description

All four of these buildings were analytical laboratories which primarily supported gaseous diffusion operations research and development.

Primary Exposures

The exposures were similar in all four laboratories and include the following: Acids, Bases, Mercury, Radiation, Uranium, Solvents, Freon, Asbestos and PCBs. The exposure information is summarized in Table 4.16.

Description of Workforce

The workforce for all of the labs was similar and consisted of the following: Lab Technicians, Research Associates, Operators, Maintenance Mechanics, and Electricians. The average number working in each of the labs per day was approximately 30 – 40. This information is summarized within Table 4.1.

The departments associated with this building are includeed within Appendix C.

4.1.1.16 K-1024 Instrument Shop and Mercury Recovery Area

Building Description

K-1024 was the primary Instrument Shop from 1944 through approximately 1964.

Primary Exposures

The primary exposures reported within this building included: Solvents and Mercury. The exposure information is summarized within Table 4.17.

Description of Workforce

The workforce for this building consisted of the following: Instrument Mechanics and Maintenance Mechanics. The total number of workers was approximately 50 – 100. These workers would be dispatched to jobs within the process buildings (K-25 and K-27). This information is summarized within Table 4.1.

The departments associated with this building are includeed within Appendix C.

4.1.1.17 K-131 Feed Building

Building Description

K-131 was the original process feed building. It was in operation from 1944 through approximately 1958.

Primary Exposures

The primary exposures in this building included: UF6, radiation, and HF. The exposue information is included within Table 4.18.

Description of Workforce

The workforce consisted of the following: Operators and Maintenance Mechanics. Approximately 20 workers per day were in the building. This information is summarized within Table 4.1.

The departments associated with this building are includeed within Appendix C.

4.1.1.18 K-1004-J ("J" Labs)

Building Description

The "J" labs were the labs which supported the Centrifuge development operations. For the purposes of this report the "J" Labs include the following: K-1004-R, K-1004-S, K-1004-T, K-1004-U, K-1010, and K-1023.

Primary Exposures

The primary exposures reported included: Epoxy Resins, Radiation, UF6, solvents, freon, and noise. The exposures are summarized within Table 4.19.

Description of Workforce

The workforce consisted of the following: Lab Technicians, Research Associates, Research Assistants, Maintenance Mechanics, Instrument Mechanics, Electricians, Welders, and Engineers. This information is summarized within Table 4.1.

The departments associated with this building are includeed within Appendix C.

4.1.1.19 K-1435

Building Description

The incineration facility, K-1435, includes facilities for receiving, sorting, preparing, and burning PCB materials, uranium-contaminated PCBs, and other hazardous wastes in a rotary kiln incinerator. Operational testing began in 1988 and operations continue today. The radioactive isotopes incinerated in the K-1435 incinerator include: Uranium, Technetium, Cesium-137, Neptunium-237, Protactinium-234m, Plutonium-238,239, and Thorium-228,230, 232, 234. The incinerator has also burned classified materials.

Primary Exposures

The primary exposures reported include the following: Mixed waste, PCBs, Uranium, and Radiation. The exposure information is summarized within Table 4.20.

Description of Workforce

The workforce included the following: TSCA Operators, Maintenance Mechanics, Electricians, and Welders. The total number of workers was approximately 40 per day. This information is summarized within Table 4.1.

The departments associated with this building are includeed within Appendix C.

4.1.1.20 S-50 Area

Building Description

The Liquid Thermal Diffusion Plant was constructed in 1944 as a means to slightly enrich Uranium for feed to the Electromagnetic Enrichment Process (located at the Y-12 plant). This process was discontinued once gaseous diffusion was successfully accomplished. There is very little information on the tear down of the initial process building.

In 1945, the S-50 site became the R&D area for the Nuclear Energy for Propulsion of Aircraft (NEPA) project.

At least one of the buildings, the K-725 Beryllium Building, is documented as being heavily contaminated with beryllium, uranium, and mercury (9).

Primary Exposures

The primary exposures in this area are unknown however, the K-725 Building along with some of the other process buildings may have been a source of exposure to Mercury, Beryllium and Uranium. Those exposed could have included the original workforce, the clean-up work crews, or those housed in the facilities after the primary production and R&D activities were concluded.

Description of Workforce

The workers involved in production activities and/or clean-up activities are unknown.

4.1.2 Preliminary Assessment of Urinalysis Data by Department (Fluorides, Mercury, and Nickel)

The Urinalysis files were reviewed in a more in-depth fashion based on department number. This analysis was necessary since significant building information was only available for approximately 10 years of the data set (1955-1964). This preliminary analysis focused on three agents of great interest: Mercury, Nickel, and Fluorides.

In five year intervals the data was reviewed to determine the number of samples as a function of department. Any department with greater than one percent of the total number of urinalysis samples for the given time period was included within the analysis. The data within each priority department was than reviewed and compared against threshold values to determine the frequency of elevated samples. For fluorides and Mercury the thresholds were based on the reported PAGs within the health and safety quarterly reports however, a PAG was not established for Nickel and therefore arbitrary cutoffs were established to allow for intercomparison. These results are detailed within appendix B-5.

In reviewing the data several departments stand out as priority departments for each given agent. These are as follows:

Fluorides: Dept. 1751, 1269, 1273 (1948-1964) and 1730, 1785, and 1606 (1965-1985)
Mercury: Dept. 1002, 1075, 1262, 1264, 1340, 1726, 1272, and 1325.
Nickel: Dept. 1726 and 1340 (1955-1969) and Dept. 1603 and 1606 (1970-1985)

4.2 Portsmouth

4.2.1 Major Buildings of Interest at the Portsmouth Site

4.2.1.1 X-326, X-330, X-333 Cascade Process Buildings

Building Description

The Cascade at Portsmouth contains 4020 isotopic stages. Five basic separative equipment sizes (compressors and converters) are used, with motors ranging from 15 horsepower to 4200 horsepower. As the assay of the product increases the size of the equipment becomes smaller, this is primarily for nuclear criticiality safety reasons.

Building X-333 houses the largest equipment and is where the lower UF6 enrichment takes place. X-333 has a low assay withdrawal point (for withdrawaling product in the 2%-5% enriched range). X-330 houses the next largest equipment and includes the tails (depleted material) withdrawal point of the process. X-326 contains the smallest equipment and involves the high end enrichment stages. Within the

X-326 highly enriched uranium (97.65% U-235) is produced. X-326 contains a high assay wihdrawal point (1st floor) and several extend range product (ERP) withdrawal stations (1st and 2nd floors).(11).

As in Oak Ridge and Paducah the separative equipment (converters, compressors, etc,.) are located on the 2nd floor, or cell floor. The first floor, operating floor, contains system instrumentation and components of the cold trap recovery system.

Primary Exposures

The primary exposures for the cascade process buildings (based primarily on the risk mapping of the X-326 process building) include: Uranium, Radiation, UF6, Uranyl Fluoride (UO2F2), UF4, PCBs, Fluorine, HF, Freon, Chlorine Trifluoride (conditioning gas), Nickel (welding/cutting), Magnewium Fluoride (Cold Traps), Mercury, Heat, Noise, Asbestos, Tc-99, and Arsenic. It is worth mentioning that the external radiation and internal radiation exposures would be different for the three process buildings. X-326 (with the higher assay material including greater amounts of U-235 and U-234) has been reported to have higher external exposure rates and internal exposures than the X-330 building which is higher than the X-333 (low assay bnuilding). (11)

These exposures are summarized in Table 4.2.2.

Description of Workforce

The workforce within the process buildings would consist of the following: Process (or Cascade) operators, Maintenance Mechanics, Instrument Mechanics, and Electriicans. This information is summarized within Table 4.2.1.

Priority departments for the process buildings based on Uranium and gross alpha urinalysis data (Bloom 1987 and Rinsky 1997) include: 731 Cascade Maintenance, 732 Cascade Instrument Mechanics, 810 Cascade Operations, 811 Process I (X-333), 812 Process II/III (X-330), 814 Process IV/V (X-326), 816 Process V (X-326), and 815.

4.2.1.2 X-342 Feed Vaporization Building

Building Description

X-342 was where the old Steam Bays used for vaporization of UF6 stock material as feed to the process occurred. The steam bays were used for this procedure from 1954 to approximately 1982. This proess greatly contributed to the current problem of corroding cylinders since the cylinders were directly exposed to steam in order to vaporize the UF6 within the cylinders.

This building also houses the Fluorine Generators where fluorine is produced and has a large area where empty (possibly with "heels") cylinders are stored.

Primary Exposures

The primary exposures reported in the risk mapping sessions included: UF6, fluorine, HF , Uranium, and Radiation. These exposures are summarized in Table 4.2.3.

Description of Workforce

The workforce consisted of the following: Uranium Material Handlers and Chemical Operators. This information is summarized within Table 4.2.1.

Priority departments for this building based on Uranium and gross alpha urinalysis data (Bloom 1987 and Rinsky 1997) include: 821 Fluorine Generation and 822 Feed Vaporization.

4.2.1.3 X-343 Feed Vaporization Building

Building Description

This building contains the new AutoClave feed vaporizers. The autoclaves were put on line as the feed vaporizer system in approximately 1982.

The building also has a storage area for cylinders (both empty and received stock material).

Primary Exposures

The primary exposures reported in the risk mapping sessions included: UF6, radiation, and HF. These exposures are summarized in Table 4.2.4.

Description of Workforce

The workforce consists of the following: Chemical Operators and Uranium Material Handlers. This information is summarized within Table 4.2.1.

Priority departments for this building based on Uranium and gross alpha urinalysis data (Bloom 1987 and Rinsky 1997) include: 821 Fluorine Generation and 822 Feed Vaporization.

4.2.1.4 X-344 Product Withdrawal Building

Building Description

X-344 is the Product withdrawal Area. Product is recovered in large cylinders and transferred to smaller cylinders for shipment. The building also houses fluroine generator cells. Other activities occurring in this building include cylinder storage and product sampling.

In the early days (1958 – 1964) in addition to the activities listed above, the X-344 building housed a Flame Tower Reactor process which was used to produce UF6 from UF4 (green salt) by reaction with Fluorine gas.

Primary Exposures

Primary exposures reported during risk mapping sessions included: Fluorine, HF, Noise, Radiation, UF4, UF6, and Uranium. In a survey conducted by NIOSH (Bloom, 1987) the X-344 building was determined to have the highest ambient levels of external radiation of the buildings surveyed. The average level was reported as 0.08 mrem/hr. In addition, based on analysis of urine data, NIOSH ranked X-344 as Medium to High with regard to internal exposure potential. One should also keep in mind that this survey was conducted long after any green salt processing was done in this building (1958 – 1964).

These exposures are summarized in Table 4.2.5.

Description of Workforce

The workforce for this building consists of the following: Chemical Operators, Maintenance Mechanics, and Uranium Material Handlers. This information is summarized within Table 4.2.1.

Priority departments for this building based on Uranium and gross alpha urinalysis data (Bloom 1987 and Rinsky 1997) include: 821 Fluorine Generation and 822 Feed Vaporization.

4.2.1.5 X-700 Converter Shop

Building Description

The operations which took place within this building included: Converter Maintenance, converter cleaning, converter conditioning, and welding.

Primary Exposures

The primary exposures reported during the risk mapping sessions included: Chromic Acid, Nitric Acid, Sulfuric Acid, Ammonium Hydroxide, Fluorine, Freon, TCE, Silica (Sand blasting operations), Welding fumes, Uranium, , and Phosgene (reaction of TCE with welding operations). These exposures are summarized in Table 4.2.6.

Description of Workforce

The workforce in this building consisted of the following: Converter Maintenance (40/day), Welders (12/day) and Chemical Operators (xxx/day) . It should be noted that the chemical operators housed within X-700 were service workers for the entire site other than the cascade buildings and would often be called for clean-up activities (mercury, lead, etc). This information is summarized within Table 4.2.1.

Priority departments for this building based on Uranium and gross alpha urinalysis data (Bloom 1987 and Rinsky 1997) include: 826 Chemical Cleaning.

4.2.1.6 X-705 Decontamination

Building Description

The primary function of the X-705 Building was for the Decontamination of both small and large parts. The primary method for cleaning the parts included mechanical cleaning in combination within aqueous cleaning using nitric acid, sulfuric acid and sodium carbonate solutions. The large parts were cleaned within large spray booths. The liquid waste generated during the decontamination process was collected and sent to the Uranium Recovery Area.

The major process areas of concern within the building included: The "Tunnel" where large parts decontamination was conducted, the Uranium Recovery Area, the Spray Tanks, and the Small Parts Decontamination Stands.

Within the Tunnel parts would be taken through a "car wash" style decontamination. The initial step would be dismantling, then a Citric Acid wash, a Nitric Acid Wash, a water rinse and a drying booth. The effluent from the tunnel would go either to Uranium Recovery or directly to a holding pond depending on the likely concentrations of Uranium.

The Uranium Recovery Process ("B" Area) involved a liquid/liquid extraction process for recovering Uranium. The process involved mixing the Uranium with Nitric Acid and extracting with Stoddard solvent mixed with Tri-butyl phosphate and DI water. The final product would be black oxide ($U3O8$).

In the early days (pre 1985) the black oxide was taken to the "E" area and was processed into UF6.

The spray tank area was used to decontaminate equipment and filter media through a leaching process primarily involving the use of TCE.

It was also reported that the X-705 Building used to contain a primative type incinerator for burning waste. A lot of probelmes with smoke filling that area of the building were reported. The incinerator was discontinued in 19xxx.

Primary Exposures

The primary exposures reported during risk mapping sessions included: TCE, Uranium, UF6, UF4, HF, Uranium Oxides, Radiation, Mercury, Nickel, Nitric Acid, Sodium Hydroxide, Ammonium Hydroxide, Chromic Acid, Freon, and Asbestos. The "E" area was reportedly the worst place to work. According to a 1987 radiological survey conducted by NIOSH, X-705 had the highest exposure potentials for internal exposures and the 2nd highest potential for external exposures (after X-344).

These exposures are summarized in Table 4.2.7.

Description of Workforce

The workforce consisted of the following: Chemical Operators, Maintenance Mechanics, Compressor Mechanics, Instrument Mechanics, Lab Technicians, Chemists, Converter Maintenance, and Welders. This information is summarized within Table 4.2.1.

Priority departments for this building based on Uranium and gross alpha urinalysis data (Bloom 1987 and Rinsky 1997) include: 823 Decontamination, 824 Furnace Stand, 825, 827 Uranium Oxide Conversion, 828 Laundry, and 858 Misc. Decontamination.

4.2.1.7 X-710 Technical Services Analytical Lab

Building Description

The X-710 Laboratory were the primary analytical laboratories which supported the gaseous diffusion operations.

Primary Exposures

The primary exposures reported during risk mapping sessions included: Acids, Solvents, UF_6, Uranium, Radiation, HF, Freon, Chromates, PCBs, Asbestos, and Mercury. These exposures are summarized in Table 4.2.8.

Description of Workforce

The workforce for this building consisted of the following: Laboratory Assistants (~150/day), Scientists (20-40), glass blowers, Lab Supervisor, Maintenance Mechanics (2), Sheet Metal Men (2), Electricians (2), Instrument Mechanic (1), Painters (2), and Janitors (3). This information is summarized within Table 4.2.1.

4.2.1.8 X-720 Maintenance

Building Description

X-720 was the main Maintenance Building on the Portsmouth site. This building is an open bay style building which houses most of the maintenance crafts. The operations within this building include the following: Instrument Shop, Dismantling and Cleaning Area, Spray Paint Booth, Burning Booth (where "burned motors"), Electrical Shop, Utility Shop, Sheet Metal Shop, Weld Shop, Machine Shop, Grinding Crib, Compressor Shop, Valve Shop, Seal Shop, Stores Area, and TCE degreasing tanks.

Primary Exposures

The primary exposures reproted during the risk mapping sessions included: Acetone, Alcohol, Aluminum, Arsenic, Asbestos, Benzene, cyanide, freon, HF, HCl, HNO_3, lead, mercury, TCE, Varnish, Welding Fumes, radiation, and Uranium. Although the parts coming into this building were supposed to have been decotaminated there were many reported problems with residual contamination. This was especially the case for parts that were disassembled for maintenance work (the inside may still contain radioactive materials – usually UO_2F_2). These exposures are summarized in Table 4.2.9.

Description of Workforce

The workforce for this building consisted of the following: Instument Mechanics, Welders, Machinists, Maintenance mechanics, Sheet Metal Workers, Painters, Electricians, pipe fitters, insulators, Compressor Maintenance, and Stores Materials men. This information is summarized within Table 4.2.1.

Priority departments for this building based on Uranium and gross alpha urinalysis data (Bloom 1987 and Rinsky 1997) include: 711 Electrical Maintenance, 712 Instrument Maintenance, 714 Utility Maintenance, 724 Sp and Mech Shop.

4.2.1.9 X-744-G Materials Handling

Building Description

Materials Handling and Sampling Building. Operations included: Drum Storage, Cylinder Storage, Oxide Sampling, Aluminum Smelting operation, and Waste Handling operation (transfers to Holding Pond).

Primary Exposures

The primary exposures reported during risk mapping sessions included: Aluminum (from smelting operation), HF, UF6, Radiation, and Uranium Oxides. These exposures are summarized in Table 4.2.9.

Description of Workforce

The workforce within this building consisted of the following: Uranium Material Handlers and Chemical Operators. This information is summarized within Table 4.2.1.

Priority departments for this building based on Uranium and gross alpha urinalysis data (Bloom 1987 and Rinsky 1997) include: 512, 551 Materials Sampling and Testing, and 829 Uranium Materials Handlers.

4.2.1.10 X-746 Materials Receiving Building

Building Description

Materials Receiving Building operations included: Cylinder Storage, Very Highly Enriched (VHE) Cylinder Storage, and Cylinder Sampling.

Primary Exposures

The primary exposures reported during the risk mapping sessions included: HF, radiation, UF6, Uranium, and TCE. These exposures are summarized in Table 4.2.9.

Description of Workforce

The workforce within this building consists of the following: Uranium Material Handlers, Chemical Operators, and Painters. This information is summarized within Table 4.2.1.

Priority departments for this building based on Uranium and gross alpha urinalysis data (Bloom 1987 and Rinsky 1997) include: 512, 551 Materials Sampling and Testing, and 829 Uranium Materials Handlers.

4.3 Paducah

Data assessed to determine the primary exposures at the Paducah Gaseous Diffusion Facility consisted primarily of the data collected during building specific risk mapping sessions conducted with groups of retirees. Additional information regarding the site history was compiled from a draft document under development by the DOE and from information gained during an in-depth course regarding the gaseous diffusion process (conducted by Carl Walter).

Although past study information was not available for the Paducah site certain information identified at the Portsmouth and K-25 site is applicable to the Paducah site. Many of the processes and process equipment are very similar since the design specifications and many of the process equipment (i.e., barriers) was developed at K-25.

One primary difference between the Paducah site and Portsmoth and K-25 is that the Paducah facility was designed to be a feed facility and only enriched uranium to 2% U-235 whereas the Portsmouth and K-25 facilities were capable of enrichment to weapons grade. From an exposure standpoint this would translate into lower external radiation levels as well as lower potential internal exposures.

While the radiation exposures in the process buildings may in fact be lower other process exposures were most likely very comparable and more dependent on the chemical properties of the materials rather than the radioactive properties.

For these reasons we feel that the Paducah risk mapping data used in conjunction with the increased understanding of the exposures at the two other gaseous diffusion sites will allow for a useful assessment of the exposures by building and job classification at the Paducah site.

4.3.1 Major Buildings of Interest at the Paducah Gaseous Diffusion Plant

4.3.1.1 C-331,C-333, C-335, C-337 Cascade Process Building

Building Description

The Paducah Gaseous Diffusion facility consists of four cascade buildings with a total of 200 cells consisting of 1760 stages. The Paducah site was originally refered to as the C-site ("C" standing for Carbide) and therefore all buildings are coded with the letter "C". The Paducah facility was designed for greater capacity (not higher assay).

The cascade buildings are very similar to those found at the Portsmouth facility with some slight differences including: the design of the seal, location of the cooler inside the converter rahter than external to the converter (Ports), and the single top purge rather than a top and side purge system as at the Portsmouth site.

During the late 1970s to early 1980s the Paducah facility went through a Cascade Improvement Program/ Cascade Upgrade Program (CIP/CUP).

Some interesting information regarding standing operating practices in the past at the Paducah facility were obtained during a class conducted by Carl Walter. Some points of interest regarding exposure are as follows (12):

- Today cell conditioning averages approximately 1 treatment / month out of all running cells however, 10 years ago (approx. 1987) averaged approximately 1 treatment per week.
- Common practice of "Crawling the Pipe" where workers would crawl within the process lines to search and recover process debris (Expansion joint sleves, compressor blades, etc.)
- Mentioned that 100,000 – 500,000 lbs of freon lost per year; most losses occuring through condensers
- In the early 1960s Uranium was a premium; this is when reactor tails were obtained as feed stock (resulted in contaminants in system including Pu, Np, and Tc)

- Two major fires took place (C-310 Building in 1956 and C-337 Building in 1963) which Carl Walter stated were a direct result of high pressure on production.
- When process piping is pulled initially it looks clean however gradually you'll see a white coat forming on the piping; this is due to the fact that the piping is porous and has some UF6 remaining in the pours which reacts with the moisture in the air to form UO2F2.

Primary Exposures

The primary exposures for the cascade process buildings (based primarily on the risk mapping of the C-337 process building) include: Uranium, Radiation, UF6, Uranyl Fluoride (UO2F2), UF4(ground floor), PCBs (contamination and storage), Fluorine, HF, Freon, Chlorine Trifluoride (conditioning gas), Nickel (welding/cutting), Magnewium Fluoride (Cold Traps), Mercury, Heat, Noise, and Psychological Stress. These exposures are summarized in Table 4.3.2.

Description of Workforce

The workforce within the process buildings consisted of the following: Operators (9/shift), Maintenance Mechanics (10-15/ shift), Electrical Maintenance (8/shift), Instrument Mechanics (8/shift), Janitor (1/shift), and Foreman (4/shift – one for each craft). This information is summarized within Table 4.3.1.

4.3.1.2 C-400 Decontamination Building

Building Description

The primary function of the C-400 Building was for the Decontamination of both small and large parts. The primary method for cleaning the parts included mechanical cleaning in combination within aqueous cleaning using nitric acid, sulfuric acid and sodium carbonate solutions. The large parts were cleaned within large spray booths. The liquid waste generated during the decontamination process was collected and sent to the Uranium Recovery Area.

Primary Exposures

The primary exposures reported during risk mapping sessions included: TCE, Uranium, UF6, UF4, HF, Uranium Oxides, Radiation, Mercury, Nickel, Nitric Acid, Sodium Hydroxide, Ammonium Hydroxide, Chromic Acid, Freon, and Asbestos. This information is summarized in Table 4.3.3.

Description of Workforce

The workforce within this building consists of the following: Maintenance Mechanics, Chemical Operators, and Electrical Maintenance. This information is summarized within Table 4.3.1.

4.3.1.3 C-720 Maintenance Building

Building Description

Various cleaning, conditioning, and assembly operations were conducted in this building. There was great emphasis in this building on degreasing operations due to the fact that the parts which were to go into the gaseous diffusion process could not be contaminated with hydrocarbons since the hydrocarbons could react violently with UF6. Therefore, strict attention was given to the removal of any oil and grease from parts.

Part of the Maintenance Building was a Metals Cleaning and Conditioning operation that was used to prepare various metals for fabrication and assembly operations. The cleaning operations involved the use of large cleaning baths with various cleaning agents including: HCl, NaOH, trichloroethane, TCE, carbon tetrachloride, freon, aromatics and acetone.

Another part of the Maintenance Building was the metal conditioning area. After metal parts were worked on and prior to assembly the metals were conditioned for corrosion resistance. This was an essential step since the process metals would be in contact with the highly corrosive process gas (UF6). The conditioning of the metals was performed with fluorine gas.

Other operational areas within the K-1401 building included fabrication and assembly operations area (machining, etc), weld shop, paint shop, Lead Melting Facility, Compressor shop, Valve Shop, Pump Shop, Furnace Conditioning Stands (used to condition "plugged" barrier – in the early years), and carpentry shop.

Primary Exposures

The primary exposures reported during the risk mapping sessions included: UF6, radiation, Uranium, TCE, welding fumes, Sulfuric Acid, Acetone, Nitric Acid, Nickel, Lead, and Carbon Tetrachloride. This information is summarized in Table 4.3.4.

Description of Workforce

The workforce in this building consisted of the following: Maintenance Mechanics, Instrument Mechanics, Sheet Metal Workers, Electrical Mechanics, Inspection Workers, Stores Workers, and Janitors. This information is summarized in Table 4.3.1.

4.3.1.4 C-315 Tails Withdrawal

Building Description

This building was used to remove the by-product from the cascade system. The depleted uranium removed from the system is put into cylinders, the light gases removed from the system are released to the atmosphere.

Primary Exposures

The primary exposures reported during the risk mapping sessions included: UF6, fluorine, HF, Uranium, radiation, Ammonia and Noise. This information is summarized in Table 4.3.5.

Description of Workforce

The workforce in this building consisted of the following: Operators (2-3 / shift), Maintenance Mechanics (4 / shift), Electricians (2 / shift), Janitor (1 / shift), and Foreman (4 / shift). This information is summarized in Table 4.3.1.

4.3.1.5 C-310 Product Withdrawal Building

Building Description

C-310 is the product withdrawal building where enriched UF6 product was removed from the process cascade and put into cylinders for transport.

Primary Exposures

The primary exposures reported during the risk mapping sessions included: Noise, UF6, Heat, TCE, Uranium, Tc-99, ClF3, and HF. This information is summarized in Table 4.3.6.

Description of Workforce

The workforce in this building consisted of the following: Operators (3-7 / shift), Maintenance Mechanics (4 / shift), Instrument Mechanics (2 / shift), Electrical Mechanics (2 / shift), and Foreman (4 / shift). This information is summarized in Table 4.3.1.

4.3.1.6 C-410 Feed Plant

Building Description

This building would introduce the feed UF6 into the cascade system.

Primary Exposures

The primary exposures reported during the risk mapping sessions included: Noise, Fluorine, UF6, radiation, HF, UO3, UF4, Ammonia, Acetone and TCE. This information is summarized in Table 4.3.7.

Description of Workforce

The workforce consisted of the following: Operators (2 / shift), Maintenance Mechanics (2 / shift), Instrument Mechanics (1 / shift), and Lab Technician (1 / shift). This information is summarized in Table 4.3.1.

4.3.1.7 C-420 Oxide Conversion Plant

Building Description

In this building the U3O8 was converted to Uranium Oxide than to Green Salt and finally to Uranium Hexafluoride for use as feed stock. This operation was discontinued in 1980. In this operation the U3O8 was reacted with Nitric Acid to produce UO3 (orange cake). The U03 was then reduced with H2 to UO2 which was than reacted with HF to produce UF4 (green salt). In the last step the UF4 was reacted with Fluorine gas (Flame Reactor Tower) to produce UF6.

Primary Exposures

The primary exposures in this building consisted of the following: Uranium Oxides, UF4, UF6, Flourine, HF, Heat, Noise, Asbestos and TCE. This information is summarized in Table 4.3.8.

Description of Workforce

The workforce consisted of the following: Operators (4 / shift), Maintenance Mechanics (4 / shift), Electrical Mechanics (2 / shift), Instrument Mechanics (2 / shift), and Janitors (1 / shift).

4.3.1.8 C-340 Uranium Metals Building

Building Description

This building was used to process depleted uranium from UF6 (byproduct from the process cascade) to Uranium oxide and finally into Uranium derbies.

Primary Exposures

The primary exposures reported during the risk mapping sessions included: Uranium oxide, UF4, UF6, Freon, HF, Magnesium Oxide, Noise, TCE, Ammonium Hydroxide, and Noise. This information is summarized in Table 4.3.9.

Description of Workforce

The workforce consisted of the following: Operators (10-20 / shift), Maintenance Mechanics (3-5 / shift), Instrument Mechanics (3-5 / shift), and Electrical Maintenance (3-5 / shift). This information is summarized in Table 4.3.1.

5.0 Discussion

In order to best discuss the findings of the investigation of the three gaseous diffusion sites the following portion of the report is formated according to chemical/agent rather than by site. This will allow for discussion of the findings for each site as well as for comparison across the three sites where appropriate. It should be noted that the chemicals / agents may not represent the universe of exposures which may have taken place at any one of these sites but rather the findings reported below are based on self-reporting by "expert" former worker groups and to the extent possible supported and/or verified with other data from past research activities.

5.1 Nickel / Nickel Carbonyl (Ni(CO)4

Nickel and Nickel Carbonyl exposures were both prevalent at the Oak Ridge facility with operations associated with the Barrier Manufacturing operations. The buildings which are associated in some way with the Barrier tube manufacturing process include: K-1100, K-1037, K-1004-L, K-1401, and K-1420. One primary job classification associated with the K-1037 building is the Barrier Operator. Based on the preliminary analysis of the K-25 urine data it is apparent that four departments appear to be priority departments with regard to Nickel exposures: Department 1726 and 1340 (1955-1969) and Departments 1603 and 1606 (1970-1985) (See Appendix B-5).

According to a Union Carbide letter dated 10/24/77 the average potential exposure witin the Barrier Manufacturing Building (K-1037) based on an average of 3000 samples taken between 1948 and 1973 was between 1.5 – 2.0 mg/m3. This average is supported by the Health and safety quarterly reports which show that in the early to late 1950s approximately 50% of the measurements taken exceed the established Maximum Allowable Concentration (MAC) of 0.5 mg/m3. It was also stated (1952 2nd quarter report) that "Dangerous concentrations of Nickel and Nickel Carbonyl have been detected in the atmosphere of this (Melter) room". Further, in the early 1950s quarterly reports there were several references to problems with increased incidences of Nickel Dermititis. The elevated exposure levels for the Barrier Manufacturing process building and support buildings is further supported by the K-25_urine data showing average urinary concentrations vs. Building Number (Appendix B). In these tables it shows that K-1037, K-1004L, and K-1401 with relatively elevated averages (when compared against the averages for other buildings).and values well in excess of values expected in an unexposed population (5 micrograms/liter – Caseretts and Doules).

It is clear that the average of 1.5-2.0 mg/m3 is approximately 100 times greater than the current NIOSH REL of 0.015 mg/m3.

Additional exposures to Nickel occur throughout the Gaseous Diffusion Plants during welding and fabrication operations, plating operations, and scrap material handling operations. Union Carbide (10) reports average exposure during welding and cutting operations to be approximately 0.2 to 0.3 mg/m3. A NIOSH health hazard evaluation conducted in 1972 reported breathing zone air concentrations of 3.8 mg/m3 during welding operations with high (10%) Nickel steel (13). This is important since much of the welding which takes place at the gaseous diffusion sites is conducted on Monel, which is composed of 67% Nickel.(12).

Union Carbide reports concentrations up to 100 micrograms/m3 for Nickel Plating. Cohen et al reports an average of 27.1 micrograms/m3 for an automated nickel-chrome plating operation (14).

Union Carbide also reports scrap handling operations with TWAs of approximately 0.1 mg/m3 (10).

This information suggests that personnel other than the employees within the Barrier Manufacturing operations (such as Welders, Maintenance Mechanics, etc.) may have been exposed to elevated levels of Nickel.

5.2 Fluorine/Fluorides/HF

Exposure to fluorine and HF was reported throughout the three sites. The exposures to "puffs of smoke" were very common within the process buildings, feed buildings, and withdrawal buildings especially pre 1975. Several workers involved in the risk mapping sessions at all three sites reported throat irritation that they believed was caused by the exposure to HF.

The potential for exposure to fluorides existed in several areas / processes common to all three facilities including: Feed Vaporization Buildings, Product Withdrawal Buildings, Fluorine plants, Process Buildings, Oxide Conversion Plants, and Decon and Maintenance Buildings (conditioning of parts prior to assembly).. These reported areas of elevated exposures are supported by the K-25_urine data showing averages by building. In these tables elevated fluoride levels are identified in K-1131 (Feed and Fluorine Plant) and K-413 (Product Withdrawal). Further, when comparing the averages to the average for an unexposed population (0.4mg/liter) it is apparent that significant expsures took place in several of the buildings at the K-25 site. A review of the urinalysis data also seems to highlight several primary departments of concern with regard to fluoride exposures: Department 1751, 1269, and 1273 (1948-1964) and Departments 1730, 1785, and 1606 (1965-1985).

The values in the table should also be compared against the TLV level of 3 mg/m3. Several building averages have averages near 1.0 mg/m3 (maximum building average of 1.32 for building K-1131 in 1960-1964). Review of the fluoride averages by Department also shows that the averages seem to increase over time through approximately 1975 after which they seem to drop slightly. The highest average for any department duriing any time period was 1.65 for Department 1273 in the 1955- 1959 time period.

5.3 Mercury

At the K-25 site reitrees reported that "Mercury was everywhere, you could dig a hole in a process building and a puddle of mercury would be at the bottom". Quarterly reports note a "shoe monitoring program" instituted to assure that mercury contaminatin is not spread. (H&S quarterly report 4th quarter 1957). It was reported that during these early years (through the mid 60s) mercury recovery was an extensive program since they were "cleaning" Mercury for the Y-12 site.

Urinalysis data supports the risk mapping data in that elevated concentrations in the urine are identified through 1975 for certain depts. Dept. 1002, 1075, 1262, 1264, 1340, 1726, 1272, and 1325. Buildings involved in mercury processing include: K1024, 1420, 1301,2,3. The risk mapping sessions highlighted the Instrument Mechanics as one job classification which they believed to have had elevated exposures to mercury.

Background population is reported as 5 micrograms/liter (Casarette and Doules) and several building and department averages were found to be in excess of 10 –14 micrograms/liter. The urinalysis data suggests that mercury exposures were only a problem in the late 50s to early 60s however, from 1965 through 1985 the number of samples drops off significantly.

5.4 Solvents

Solvent exposures of primary significance seem to be chlorinated solvents used for degreasing. As would be expected these solvents (primarily Carbon Tetrachloride and Trichloroethylene) were used extensively for cleaning operations. Hovever, a point that was emphasized in the risk mapping sessions was that these facilities had a high standard for quality and efficiency for the cascade process and therefore the demand for "clean" parts was strict. If there was any grease or hydrocarbon left on the parts being repaired or put back into the process equipment there was a potential for a violent reaction with the UF6.

To this end, practices such as "mopping the floor with Carbon Tetrachloride" were reported as daily procedures.

5.5 Radiation

Generally, the external radiation exposure levels based on individual records from Oak Ridge and Portsmouth are low when compared to the overall DOE complex. At Portsmouth the median dose equivalent was 0.06 rem (60 mrem) and 75% of the workers in the Portsmouth database are reported to have less than 240 mrem. (3) Similar external levels seem to be the case for the Oak Ridge site. Quarterly Reports between 1952 through 1958 report averages for monitored workings between 10 – 50 mrem per quarter with maximum recorded doses of approximately 300 mrem per quarter. Median cummulative dose of external penetrating radiation was 140 mrem and 638 workers had workers with cummulative doses greater than 5 rem (Wing Mortality study).

Another source of external exposure which went virtually unmonitored at the three gaseous diffusion sites until very recently are neutron exposures. A recent NIOSH Health Hazard Evaluation report (September 1997) reviewed the concern of neutron exposures at the Portsmouth site. Unmonitored exposures to neutrons may have been a source of significant external exposure however it is unclear whether there is any realistic way to reconstruct neutron exposures over the years at these sites. Areas where this may have been of particular concern include the high assay process areas and the product withdrawal, sampling and storage areas.

5.6 Internal Radiation Exposures

Estimating a lifetime internal dose is a very difficult task since there were a limited number of workers which were involved in the urinalysis programs at certain time periods and the elevated samples are nearly impossible to link to an uptake. However, identifying departments and buildings which were at greater relative risk due to initernal exposures is plausible. The department analysis for K-25 and the analysis for Portsmouth (NIOSH, Bloom and Rinsky) seems to at least identify priority departments and/or buildings of interest with regard to internal radiation exposures.

5.7 Heat amd Noise

Heat and Noise were reported over and over in the risk mapping sessions. Many retirees were concerned that noise exposure and protection from noise exposure be closely reviewed because they don't want others to have the hearing problems they currently experience.

5.9 Asbestos

Asbestos was identified in many buildings within all three facilities and is not limited to the walls of the process buildings. During risk mapping sessions workers reported using asbestos blankets while working on or near hot process equipment.

5.10 Beryllium

The main source of Beryllium at the K-25 site was associated with the liquid thermal diffusion process within the S-50 complex (1944 – 1950). In addition to the people that worked in the S-50 complex the facility underwent a decontamination process in the late 50s. It is unclear who cleaned up the area and who worked in there afterwards. H&S reports discuss "grossly contaminated ventillation systems" in some of the S-50 support buildings which would classify those buildings as unsuitable for the planned storage facility.

Another source of exposure to Beryllium was in building 1401 Maintenance Building where machining of Beryllium parts for Y-12 was conducted ; this was reported to have occurred in the late 1960s to early 1970s. (Bruce Lawson; H&S quarterly report). A department which may have been associated with these operations is Department 1752 Y-12 Tool Grinding.

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Table 4.1: K-25 Site Building Characteristics

Building Number	Building Name	Main Process or Function	Avg. # workers/day	Yr. Start	Yr. Stop
K-25	K-25	Uranium Enrichment	150 - 500	45	64
K-27	K-27	Uranium Enrichment	60 - 80	45	64
K-29	K-29	Uranium Enrichment	60 - 80	54	85
K-31	K-31	Uranium Enrichment	60 - 80	54	85
K-33	K-33	Uranium Enrichment	60 - 80	54	85
K-1004-L	Pilot Plant	Barrier Testing			~'92
K-1423	Toll Enrichment Facility	Ship and Receive; Sampling	15 - 20	67	85
K-1037	Barrier Manufacturing	Produced the Barrier material	300 - 400	~48	~'81
K-1401	Maintenance Bldg.	All Maint. Crafts	400 - 550	44	~85
K-1420	Decontamination	Decon of Large and Small Parts	100		~85
K-1200,1210,1220, 1052	Centrifuge Complex	R&D of Centrifuge Enrichment Process	300 - 400	~'73	83
K-1004-J (r,s,t,u, 1010,1023)	J Lab	R&D of Centrifuge Enrichment Process	120 - 150		83
K-1004 A,B,C,D	Analytical Labs	Analytical Labs for site	120 - 150		
K-1435	TSCA Incinerator	Waste Incineration	40	88	present
K-1301,2,3	Decon and Hg Recovery	Decon, Hg Recovery, and Oxide Conversion	30 - 40	44	58
K-633	Test Loop	Test Cascade	30 - 35	65	84
K-413	Product Withdrawal	Product Withdrawal from Cascade	8	44	65
K-1024	Instrument Shop	Instrument Repair	50 - 100	44	64
K-1410	Plating Shop	Plating operations		53	85
K-1410	Decontamination	Decontamination of parts		42	53
K-1131	Feed Vap. And Tails With.	Feed, Tails, Fluorine Prod. And Oxide Conv.			
K-1231	Powder Mill	Support for Barrier and K-1131			
K-1413	R&D Facility	R&D Lab	20 - 50	52	85+
K-131	Feed Building	Feed to K-25	20	44	58
K-725	Beryllium Building	Liquid Thermal Diff. Support bldg.	unknown	44	50

Table 4.2 K-25/K-27/K-29/K-31/K-33 Building Exposure Averages

Chemical / Agent	Avg. Exp. Level	Reference
Uranium	M	Risk Map Reporting; K-25_urine data (Appendix)(Medium)
UF6	M - H	Risk Map Reporting; K-25_urine data (Appendix)(Medium)
Uranyl Fluoride	M	Risk Map Reporting
Fluorine	M	Risk Map Reporting; K-25_urine data (Appendix)(Medium)
HF	M - H	Risk Map Reporting; K-25_urine data (Appendix)(Medium)
Process Coolant	M	Risk Map Reporting
Chlorine Trifluoride	M	Risk Map Reporting
Asbestos	L	Risk Map Reporting
Nickel	M - H	Risk Map Reporting; K-25_urine data (Appendix)(Medium)
Mercury	M - H	Risk Map Reporting; K-25_urine data (Appendix)(Medium)
Heat	H	Risk Map
Noise	H	Risk Map

Table 4.3: Centrifuge Complex Building Exposure Averages

	K-1200 Building	
Chemical / Agent	**Avg. Exp. Level**	**Reference**
ALCOHOL	M	Risk Map
CUTTING OILS	M	Risk Map
EPOXY RESIN DUST	H	Risk Map
EPOXY RESINS	H	Risk Map
EXPOXY RESIN DUST	H	Risk Map
FREON	M	Risk Map
NOISE	M	Risk Map
RADIATION	M	Risk Map
SOLVENTS	L	Risk Map
UF6	M	Risk Map
VARSOL	M	Risk Map
WELDING FUMES	M	Risk Map
	K-1210	
Chemical / Agent	**Avg. Exp. Level**	**Reference**
ACTIVATED ALUMINA	H	Risk Map
FREON	H	Risk Map
FREON 114	M	Risk Map
NOISE	M	Risk Map
RADIAITON	H	Risk Map
RADIATION	M	Risk Map
SOLVENT	M	Risk Map
SOLVENTS	M	Risk Map
TRICHLOROETHYLENE	H	Risk Map
UF6	M	Risk Map
URANIUM	M	Risk Map
WELDING FUMES	H	Risk Map
	K-1220	
Chemical / Agent	**Avg. Exp. Level**	**Reference**
CUTTING OIL	M	Risk Map
DEGREASERS	M	Risk Map
PUMP OIL	L	Risk Map
SOLVENTS	M	Risk Map
UF6	M	Risk Map
WELDING FUMES	M	Risk Map
	K-1052	
Chemical / Agent	**Avg. Exp. Level**	**Reference**
NOISE	M	Risk Map
RADIATION	M	Risk Map
UF6	M	Risk Map
WEDLING FUMES	H	Risk Map

Table 4.4: K-1037 Building Exposure Averages

Chemical / Agent	Avg. Exp. Level	Reference
Nickel	H	K-25_urine(Appendix); H&S Quarterly rpts ('49 - '59); Urnion Carbide Letter,1977
Nickel Carbonyl	H	H&S Quarterly Rpts (1952 2nd quarter, etc.)
Mercury	H	K-25_urine(Appendix); H&S Quarterly rpts
Uranium	L	K-25_urine(Appendix); H&S Quarterly rpts
Fluroides	L	K-25_urine(Appendix); H&S Quarterly rpts ('49 - '59)

Table 4.5: K-1004-L Building Exposure Averages

Chemical / Agent	Avg. Exp. Level	Reference
ACETONE	M	Risk Map
ARSENIC	L	Risk Map
ASBESTOS	M	Risk Map
CARBON TETRACHLORIDE	M	Risk Map
CLF3	L	Risk Map; K-25_urine (Appendix) (low to medium)
COPPER	L	Risk Map
FIBER FRAX	H	Risk Map
FIBER GLASS	H	Risk Map
FLUORINE	M	Risk Map; K-25_urine (Appendix) (low to medium)
FREON	M	Risk Map
GREEN SALT (UF4)	H	Risk Map; K-25_urine (Appendix) (medium to high)
LEAD	L	Risk Map
MERCURY	M	Risk Map; K-25_urine (Appendix) (medium to high)
NICKEL	M	Risk Map; K-25_urine (Appendix) (medium to high)
NOISE	H	Risk Map
PCB	M	Risk Map
TRICHLOROETHYLENE	M	Risk Map; K-25_urine (Appendix) (medium to high)
UF6	L	Risk Map
UO3	H	Risk Map; K-25_urine (Appendix) (medium to high)
URANIUM	M	Risk Map; K-25_urine (Appendix) (medium to high)
XX powder(Classified substance)	H	Risk Map
XXXXX (Classified substance)	H	Risk Map

Table 4.6: K-1420 Building Exposure Averages

Chemical / Agent	Avg. Exp. Level	Reference
CAUSTICS	H	Risk Map
HCL	M	Risk Map
HF	M	Risk Map; K-25_urine
HNO3	M	Risk Map
MERCURY	H	Risk Map; K-25_urine
METALS	H	Risk Map
MICROWAVES	H	Risk Map
NICKEL	M-H	Risk Map; retiree interview (high - barrier ops);Union Carbide Ltr.
NITRIC ACID	H	Risk Map; H&S quarterly rpts (Nitrous Oxide in Uranium Recovery)
RADIATION	H	Risk Map; H&S quarterly rpts
TRICHLOROETHYLENE	H	Risk Map; H&S quarterly rpts
UF6	M	Risk Map; K-25_urine
UO2F2	H	Risk Map; K-25_urine
URANIUM	H	Risk Map; K-25_urine
WELDING FUMES	H	Risk Map

Table 4.7: K-1410 Plating Building Exposure Averages

Chemical / Agent	Avg. Exp. Level	Reference
ACETIC ACID	H	Risk Map
ASBESTOS	H	Risk Map
CARBON TETRACHLORIDE	H	Risk Map
COLD	H	Risk Map
FREON	H	Risk Map
HEAT	H	Risk Map
NICKEL	H	Risk Map;Carbide Ltr.('77) (plating ops - Ni levels up to 0.1 mg/m^3
NITRIC ACID	H	Risk Map
RADIATINO	M	Risk Map
RADIATION	H	Risk Map
SODA ASH	H	Risk Map
SULFURIC ACID	H	Risk Map
TRICHLOROETHYLENE	H	Risk Map
URANIUM	M	Risk Map

Table 4.8: K-1410 Decontamination Building Exposure Averages

Chemical / Agent	Avg. Exp. Level	Reference
Uranium	H	Risk Map; H&S Quarterly Reports
Radiation	H	Risk Map; H&S Quarterly Reports
Fluorides	H	Risk Map
Chlorinated Solvents	H	Risk Map
Acids	H	Risk Map
Bases	M	Risk Map

K-1401 BUILDING EXPOSURE AVERAGES

Chemical / Agent	Avg. Exp. Level	Reference
ALKALI	H	Risk Map
ASBESTOS	H	Risk Map
CHROMIC ACID	H	Risk Map
FREON	H	Risk Map
GRINDING DUST	H	Risk Map
HYDROCHLORIC ACID	H	Risk Map
NOISE	H	Risk Map
PCB	H	Risk Map
PERCOLENE	H	Risk Map
PHOSGENE	L - M	Risk Map; H&S Quarterly Reports (verify sampling in weld areas)
RADIATION	L - M	Risk Map; H&S Quarterly Reports (Low - Medium)
SULFURIC ACID	H	Risk Map
TRICHLOROETHYLENE	H	Risk Map; k-25_urine; H&S Quarterly Reports (air sampling)
TROXIDE	M	Risk Map
UF4	L-H	Risk Map; k-25_urine (low)
UF6	L-H	Risk Map; k-25_urine (low)
UO2F2	L-H	Risk Map; k-25_urine (low)
URANIUM	L-H	Risk Map; k-25_urine (low)
WELD FUMES	H	Risk Map; k-25_urine (Pb, Ni)
WOOD DUST	H	Risk Map
Beryllium	unknown	H&S Quarterly Report (machining of Beryllium); B. Lawson
Nickel	M-H	Quarterly Reports (Barrier Furnace; grinding); K-25_urine
Cadmium	unknown	Quarterly reports (Silver Solder containing Cadmium)
Mercury	H	Risk Map; K-25_urine

Table 4.10: K-1423 Building Exposure Averages

Chemical / Agent	Avg. Exp. Level	Reference
Uranium	L-M	Retiree Interview (Ben xxx)
UF6	L-M	Retiree Interview (Ben xxx)
HF	L-M	Retiree Interview (Ben xxx)
Radiation	M	Retiree Interview (Ben xxx)

Table 4.11: K-1131 Building Exposure Averages

Chemical / Agent	Avg. Exp. Level	Reference
ASBESTOS	H	Risk Map
FLUORINE	H	Risk Map; K-25_urine
HEAT	H	Risk Map
HF	H	Risk Map; K-25_urine
HYDROGEN	H	Risk map
NOISE	H	Risk Map
RADIATION	H	Risk Map; H&S Quarterly Reports
UF4	H	Risk Map; K-25_urine;
UF6	H	Risk Map; K-25_urine;
UO2	H	Risk Map; K-25_urine;
UO3	H	Risk Map; K-25_urine;

Table 4.12: K-413 Building Exposure Averages

Chemical / Agent	Avg. Exp. Level	Reference
UF6	M-H	retiree interview; K-25 Urine
HF	M-H	retiree interview; K-25 Urine
Radiation	M-H	retiree interview

Table 4.13: K1301,2,3 Building Exposure Averages

Chemical / Agent	Avg. Exp. Level	Reference
Mercury	M-H	retiree interview; k-25 urine
Uranium	M-H	retiree interview
Uranium Oxides	M-H	retiree interview
Radiation	M	retiree interview
Acids	H	retiree interview
Solvents	H	retiree interview

Table 4.14: K-1413 Building Exposure Averages

Chemical / Agent	Avg. Exp. Level	Reference
Radiation	L-M	interview with retirees (D.Stevens, Ben)
Uranium	M-H	interview with retirees (D.Stevens, Ben); K-25_urine
UF6	M-H	interview with retirees (D.Stevens, Ben); K-25_urine
Fluorides	M-H	interview with retirees (D.Stevens, Ben); K-25_urine
Mercury	M-H	interview with retirees (D.Stevens, Ben); K-25_urine
TCE	M-H	interview with retirees (D.Stevens, Ben)

Table 4.15: K-1231 Building Exposure Averages

Chemical / Agent	Avg. Exp. Level	Reference
ASBESTOS	H	Risk Map
FLUORINE	M-H	Risk Map; K-25_urine (medium)
HCL	H	Risk Map
HEAT	H	Risk Map
HF	M-H	Risk Map; K-25_urine (medium)
RADIATION	H	Risk Map; H&S Quarterly Reports; K-25_ext
URANIUM	M-H	Risk Map; K-25_urine (medium)

Table 4.16: K-1004 A,B,C,D Labs Building Exposure Averages

	K-1004-A	
Chemical / Agent	**Avg. Exp. Level**	**Reference**
ACIDS	M	Risk Map
ASBESTOS	H	Risk Map
BASES	M	Risk Map
MERCURY	M	Risk Map
NOISE	H	Risk Map
PCB	M	Risk Map
RADIATION	M	Risk Map
SILICA	M	Risk Map
SOLVENTS	M	Risk Map
URANIUM	M	Risk Map
	K-1004-B	
Chemical / Agent	**Avg. Exp. Level**	**Reference**
ACIDS	M	Risk Map
ASBESTOS	H	Risk Map
BASES	M	Risk Map
FREON	M	Risk Map
MERCURY	M	Risk Map
PCB	H	Risk Map
RADIATION	L	Risk Map
SOLVENTS	M	Risk Map
URANIUM	L	Risk Map
	K-1004-C	
Chemical / Agent	**Avg. Exp. Level**	**Reference**
ACIDS	M	Risk Map
ASBESTOS	H	Risk Map
BASES	M	Risk Map
CYANIDE	M	Risk Map
MERCURY	M	Risk Map
PCB	H	Risk Map
PICRIC ACID	H	Risk Map
RADIATION	L	Risk Map
SOLVENTS	M	Risk Map
URANIUM	L	Risk Map

Table 4.17: K-1024 Building Exposure Averages

Chemical / Agent	Avg. Exp. Level	Reference
Solvents	H	Retiree Interview (Ben)
Mercury	H	Retiree Interview (Ben); K-25_urine
Nickel	M	Retiree Interview (Ben)
Lead	M	Retiree Interview (Ben)

Table 4.18: K-131 Building Exposure Averages

Chemical / Agent	Avg. Exp. Level	Reference
UF6	L-M	Retiree Interview
Radiation	L-M	Retiree Interview
HF	L-M	Retiree Interview
		Retiree Interview

Table 4.19: K-1004-J Lab (K-1004-R,S,T,U and K-1010 and K-1023) Building Exposure Averages

	K-1004-R	
Chemical / Agent	**Avg. Exp. Level**	**Reference**
EPOXY RESINS	M	Risk Map
NOISE	M	Risk Map
RADIATION	M	Risk Map
UF6	M	Risk Map
	K-1004-S	
Chemical / Agent	**Avg. Exp. Level**	**Reference**
EPOXY	M	Risk Map
NOISE	M	Risk Map
RADIATION	M	Risk Map
UF6	M	Risk Map
	K-1004-T	
Chemical / Agent	**Avg. Exp. Level**	**Reference**
EPOXY RESINS	H	Risk Map
SOLVENTS	H	Risk Map
	K-1004-U	
Chemical / Agent	**Avg. Exp. Level**	**Reference**
CUTTING OILS	M	Risk Map
DEGREASERS	M	Risk Map
NOISE	M	Risk Map
WELDING FUMES	H	Risk Map
	K-1010	
Chemical / Agent	**Avg. Exp. Level**	**Reference**
CUTTING FLUIDS	M	Risk Map
DEGREASERS	M	Risk Map
FREON	M	Risk Map
NOISE	L	Risk Map
WELDING FUMES	H	Risk Map
	K-1023	
Chemical / Agent	**Avg. Exp. Level**	**Reference**
LASER	M	Risk Map
NOISE	M	Risk Map
RADIATION	M	Risk Map
UF6	M	Risk Map

Table 4.20: K-1435 Building Exposure Averages

Chemical / Agent	Avg. Exp. Level	Reference
MIXED WASTE	M	Risk Map
PCB	H	Risk Map
HEAT	H	Risk Map
NOISE	H	Risk Map
RADIATION	H	Risk Map
SODIUM HYDROXIDE	L	Risk Map
URANIUM	H	Risk Map

Table 4.2.1: Portsmouth Site Building Characteristics

Building Number	Building Name	Main Process or Function	Avg. # workers/day	Yr. Start	Yr. Stop
X-326	Process Building	Uranium Enrichment	Not reported	1954	present
X-330	Process Building	Uranium Enrichment	Not reported	1954	present
X-333	Process Building	Uranium Enrichment	Not reported	1954	present
X-342	Feed Building	Volatize UF6; Flourine productioin	Not reported	1954	1981
X-343	Feed Building	Volatize UF6; sampling	Not reported	1981	present
X-344	Product Withdrawal	Product Withdrawal and sampling	Not reported	1958	present
X-700	Converter Shop and Cleaning	Process Equip Maint and Fabrication	Not reported	1955	
X-705	Decontamination	Decontamination of process parts	Not reported	1955	present
X-710	Technical Services Bldg	Analytical Laboratories	200-300	1955	present
X-720	Maintenance	Process and Facility Maint (all crafts)	Not reported	1954	present
X-744	Materials Handling	Cylinder and Waste Storage	Not reported		
X-746	Materials Receiving	Cylinder and Waste Storage	Not reported	1954	present

Table 4.2.2: X-326/330/333 Building Exposure Averages

Chemical/Agent	Avg. Exp. Level	Reference
ACIDS	L-M	Risk Mapping
ARSENIC	M	Risk Mapping
ASBESTOS	M	Risk Mapping
CLF3	M	Risk Mapping
FLUORINE	M	Risk Mapping
FREON	M	Risk Mapping
HEAT	H	Risk Mapping
HF	M	Risk Mapping
MOLYBDENUM	M	Risk Mapping
NOISE	H	Risk Mapping
PCB	M	Risk Mapping
RADIATION	M	Risk Mapping
SOLVENTS	L	Risk Mapping
SULFUR DIOXIDE	M	Risk Mapping
TC-99	M-H	Risk Mapping
TRICHLOROETHYLENE	M	Risk Mapping
UF6	M	Risk Mapping
URANIUM	M	Risk Mapping

Table 4.2.3: X-342 Building Exposure Averages

Chemical/Agent	Avg. Exp. Level	Reference
FLUORINE	H	Risk Mapping
HF	H	Risk Mapping
LITHIUM FLUORIDE	H	Risk Mapping
RADIATION	M	Risk Mapping
UF6	M	Risk Mapping
URANIUM	M	Risk Mapping

Table 4.2.4: X-343 Building Exposure Averages

Chemical/Agent	Avg. Exp. Level	Reference
HF	M	Risk Mapping
RADIATION	M	Risk Mapping
UF6	M	Risk Mapping

Table 4.2.5: X-344 Building Exposure Averages

Chemical/Agent	Avg. Exp. Level	Reference
FLUORINE	M	Risk Mapping
HF	M	Risk Mapping
NOISE	H	Risk Mapping
RADIATION	M	Risk Mapping
SODA ASH	M	Risk Mapping
UF4	H	Risk Mapping
UF6	H	Risk Mapping
URANIUM	H	Risk Mapping

Table 4.2.6: X-700 Building Exposure Averages

Chemical/Agent	Avg. Exp. Level	Reference
ACIDS	H	Risk Mapping
AMMONIUM HYDROXIDE	H	Risk Mapping
ASBESTOS	M	Risk Mapping
CAUSTIC	H	Risk Mapping
CHROMIC ACID	H	Risk Mapping
FLUORINE	M	Risk Mapping
FREON	M	Risk Mapping
NITRIC ACID	M	Risk Mapping
PHOSGENE	M	Risk Mapping
SILICA	M	Risk Mapping
SOLVENT	H	Risk Mapping
SULFURIC ACID	H	Risk Mapping
TRICHLOROETHYLENE	H	Risk Mapping
TROXIDE	H	Risk Mapping
URANIUM	M	Risk Mapping
WELDING FUMES	H	Risk Mapping

Table 4.2.7: X-705 Building Exposure Averages

Chemical/Agent	Avg. Exp. Level	Reference
ALUMINUM	H	Risk Mapping
ALUMINUM NITRATE	M	Risk Mapping
ASBESTOS	H	Risk Mapping
BLACK OXIDE	M	Risk Mapping
BORIC ACID	H	Risk Mapping
CAUSTICS	M	Risk Mapping
FLUORINE	M	Risk Mapping
FREON	M	Risk Mapping
HCL	M	Risk Mapping
HF	H	Risk Mapping
LEAD	H	Risk Mapping
MERCURY	M	Risk Mapping
METALS	M	Risk Mapping
NICKEL	H	Risk Mapping
NITRIC ACID	M	Risk Mapping
RADIATION	M	Risk Mapping
SILICA	H	Risk Mapping
SODIUM HYDROXIDE	H	Risk Mapping
SOLVENTS	M	Risk Mapping
STODDARD SOLVENT	M	Risk Mapping
TECHNICIUM	M	Risk Mapping
THORIUM	M	Risk Mapping
TRIBUTYL PHOSPHATE (TBP)	M	Risk Mapping
TRICHLOROETHANE	M	Risk Mapping
TRICHLOROETHYLENE	M	Risk Mapping
U3O8	M	Risk Mapping
UF6	M	Risk Mapping
UO2F2	H	Risk Mapping
URANIUM	M	Risk Mapping
URANYL NITRATE HEXAHYDRATE (UNH)	M	Risk Mapping
WELDING FUMES	M	Risk Mapping

X-710

Table 4.2.8: Building Exposure Averages

Chemical/Agent	Avg. Exp. Level	Reference
ACIDS	H	Risk Mapping
ASBESTOS	H	Risk Mapping
CHROMATES	H	Risk Mapping
FREON	H	Risk Mapping
HF	H	Risk Mapping
MERCURY	H	Risk Mapping
OILS	H	Risk Mapping
PCB	H	Risk Mapping
RADIATION	M	Risk Mapping
SOLVENTS	H	Risk Mapping
UF6	H	Risk Mapping
URANIUM	H	Risk Mapping

Table 4.2.9: X-720 Building Exposure Averages

Chemical/Agent	Avg. Exp. Level	Reference
ACETONE	H	Risk Mapping
ACIDS	M	Risk Mapping
ALCOHOL	H	Risk Mapping
ALUMINUM	M	Risk Mapping
ARSENIC	H	Risk Mapping
ASBESTOS	H	Risk Mapping
BENZENE	H	Risk Mapping
CARBIDE	L	Risk Mapping
CYANIDE COMPOUNDS	H	Risk Mapping
FREON	H	Risk Mapping
HCL	H	Risk Mapping
HF	H	Risk Mapping
IPA	H	Risk Mapping
KEROSENE	H	Risk Mapping
LEAD	M	Risk Mapping
MERCURY	M	Risk Mapping
METALS	M	Risk Mapping
MONEL	M	Risk Mapping
NICKEL	M	Risk Mapping
NITRIC ACID	H	Risk Mapping
PAINT	H	Risk Mapping
PCB	H	Risk Mapping
RADIATION	M	Risk Mapping
SILVER	H	Risk Mapping
SOLVENTS	L	Risk Mapping
SULFURIC ACID	H	Risk Mapping
TECHNICIUM-99	M	Risk Mapping
TOLUENE	H	Risk Mapping
TRICHLOROETHANE	H	Risk Mapping
TRICHLOROETHYLENE	H	Risk Mapping
UF6	H	Risk Mapping
URANIUM	M	Risk Mapping
VARNISH	H	Risk Mapping
WELD FUMES	M	Risk Mapping

Table 4.2.10 Building Exposure Averages

Chemical/Agent	Avg. Exp. Level	Reference
ALUMINUM	M	Risk Mapping
HF	H	Risk Mapping
RADIATION	M	Risk Mapping
UF6	H	Risk Mapping
URANIUM	M	Risk Mapping
URANIUM OXIDE	M	Risk Mapping

Table 4.2.11: X-746 Building Exposure Averages

Chemical/Agent	Avg. Exp. Level	Reference
HF	H	Risk Mapping
RADIATION	M	Risk Mapping
TCE	H	Risk Mapping
UF6	H	Risk Mapping
URANIUM	M	Risk Mapping

Table 4.3.1: Paducah Site Building Characteristics

Building Number	Building Name	Main Process or Function	Avg. # workers/day	Yr. Start	Yr. Stop
C-337	Process Building	Uranium Enrichment	100 - 120	54	present
C-335	Process Building	Uranium Enrichment	100 - 120	54	present
C-333	Process Building	Uranium Enrichment	100 - 120	54	present
C-331	Process Building	Uranium Enrichment	100 - 120	54	present
C-310	Product Withdrawal	Process Product Withdrawal		54	present
C-315	Tails Withdrawal	Process Tails withdrawal			
C-340	Uranium Metals Bldg.	Produced Depleted U derbies	40 -50		
C-400	Decontamination	Decontamination; Uranium Recovery			
C-410	Feed Plant	UF6 feed; fluorine production; Tower (UF4 to UF6)			
C-420	Oxide Conversion	Oxide conversion (UO3 to UF4)			
C-720	Maintenance	Maintenance; all crafts	150 - 250	54	present
746-A	Smelter	Aluminum and Nickel Smelting	~4	60?	?

Table 4.3.2: C-331/333/335/337 Building Exposure Averages

Chemical/Agent	Avg. Exp. Level	Reference
BATTERY ACID (HYDROCHLORIC ACID)	H	Risk Mapping
CLF3	H	Risk Mapping
DUST	H	Risk Mapping
FREON	M	Risk Mapping
HEAT	H	Risk Mapping
HF	L	Risk Mapping
MAGNESIUM FLUORIDE	H	Risk Mapping
MERCURY	L	Risk Mapping
NOISE	H	Risk Mapping
PCB	H	Risk Mapping
PSYCHOLOGICAL STRESS	H	Risk Mapping
RADIATION	L	Risk Mapping
STEAM	M	Risk Mapping
TRICHLOROETHYLENE	M	Risk Mapping
UF4	L	Risk Mapping
UF6	L	Risk Mapping
URANIUM	L	Risk Mapping
WELDING FUMES	H	Risk Mapping
ARSENIC	L	Interview

Table 4.3.3: C-400 Building Exposure Averages

Chemical/Agent	Avg. Exp. Level	Reference
ALUMINUM	H	Risk Mapping
AMMONIUM HYDROXIDE	M	Risk Mapping
ASBESTOS	H	Risk Mapping
BLACK MAGIC	H	Risk Mapping
CAUSTIC	H	Risk Mapping
CHROMIC ACID	H	Risk Mapping
CLF3	H	Risk Mapping
CYANIDE	H	Risk Mapping
FREON	H	Risk Mapping
HF	H	Risk Mapping
MAGNESIUM FLUORIDE	M	Risk Mapping
MERCURY	H	Risk Mapping
NICKEL	H	Risk Mapping
NITRIC ACID	H	Risk Mapping
NOISE	H	Risk Mapping
RADIATION	H	Risk Mapping
SODA ASH	M	Risk Mapping
SODIUM FLUORIDE	H	Risk Mapping
SODIUM HYDROXIDE	H	Risk Mapping
TECHNICIUM - 99	H	Risk Mapping
TRICHLOROETHYLENE	H	Risk Mapping
TROXIDE	M	Risk Mapping
UF4	M	Risk Mapping
UF6	M	Risk Mapping
UO2	M	Risk Mapping
UO3	M	Risk Mapping
URANIUM	H	Risk Mapping

Table 4.3.4: C-720 Building Exposure Averages

Chemical/Agent	Avg. Exp. Level	Reference
ACETONE	M	Risk Mapping
CARBON TETRACHLORIDE	L	Risk Mapping
LEAD	M	Risk Mapping
LIQUID NITROGEN	L	Risk Mapping
MONEL	H	Risk Mapping
NICKEL	H	Risk Mapping
NITRIC ACID	H	Risk Mapping
NOISE	M	Risk Mapping
RADIATION	M	Risk Mapping
SILVER	M	Risk Mapping
SULFURIC ACID	H	Risk Mapping
TRICHLOROETHYLENE	M	Risk Mapping
UF6	H	Risk Mapping
URANIUM	H	Risk Mapping
WELDING FUMES	H	Risk Mapping

Table 4.3.5: C-315 Building Exposure Averages

Chemical/Agent	Avg. Exp. Level	Reference
NOISE	H	Risk Mapping
PHYSICAL HAZARD	H	Risk Mapping
Radiation	H	Risk Mapping
UF6	H	Risk Mapping

Table 4.3.6: C-310 Building Exposure Averages

Chemical/Agent	Avg. Exp. Level	Reference
CHLORINE TRIFLUORIDE (CLF3)	M	Risk Mapping
ELECTRICAL HAZARD	M	Risk Mapping
HEAT	M	Risk Mapping
HF	M	Risk Mapping
LIQUID NITROGEN	M	Risk Mapping
NOISE	H	Risk Mapping
SODA ASH	L	Risk Mapping
TECHNICIUM-99	L	Risk Mapping
TRICHLOROETHYLENE	M	Risk Mapping
UF6	M	Risk Mapping
URANIUM	L	Risk Mapping

Table 4.3.7: C-410 Building Exposure Averages

Chemical/Agent	Avg. Exp. Level	Reference
ACETONE	L	Risk Mapping
AMMONIA	M	Risk Mapping
ASBESTOS	H	Risk Mapping
CO2	M	Risk Mapping
ELECTRIC	M	Risk Mapping
FLUORINE	M	Risk Mapping
HEAT	H	Risk Mapping
HF	M	Risk Mapping
HYDROGEN	H	Risk Mapping
NOISE	M	Risk Mapping
RADIATION	M	Risk Mapping
STEAM	M	Risk Mapping
TRICHLOROETHYLENE	L	Risk Mapping
UF6	M-H	Risk Mapping
URANIUM	M-H	Risk Mapping

Table 4.3.8: C-420 Building Exposure Averages

Chemical/Agent	Avg. Exp. Level	Reference
ASBESTOS	H	Risk Mapping
FLUORINE	H	Risk Mapping
HEAT	H	Risk Mapping
HF	H	Risk Mapping
HYDROGEN	M	Risk Mapping
HYDROGEN SULFIDE	H	Risk Mapping
NOISE	H	Risk Mapping
RADIATION	M	Risk Mapping
UF4	M-H	Risk Mapping
UO3	M-H	Risk Mapping

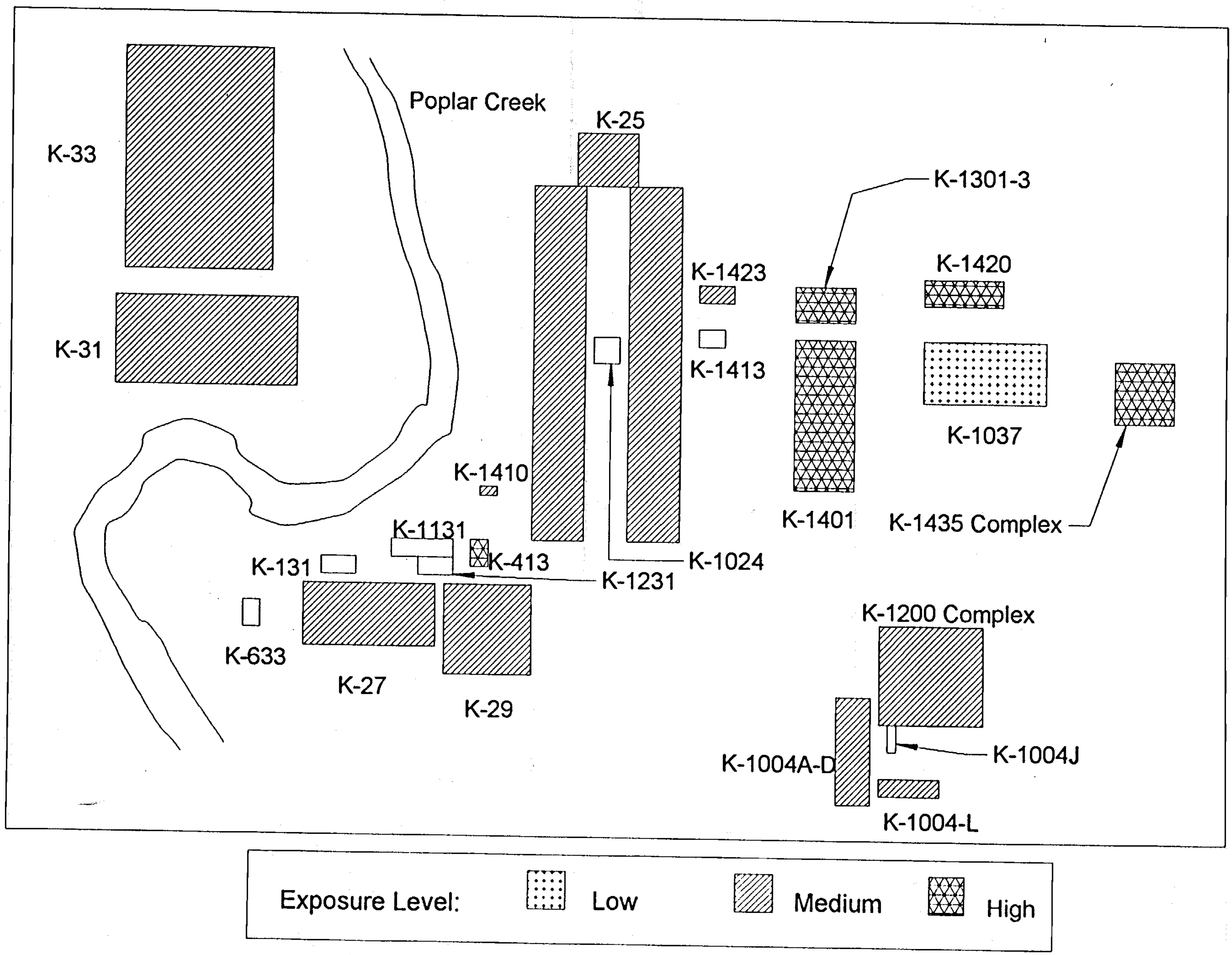
Table 4.3.9: C-340 Building Exposure Averages

Chemical/Agent	Avg. Exp. Level	Reference
AMMONIA	L-M	Risk Mapping
AMMONIUM HYDROXIDE	L	Risk Mapping
ASBESTOS	M	Risk Mapping
BLACK OXIDE	H	Risk Mapping
DUST	L	Risk Mapping
FREON	L	Risk Mapping
HEAT	H	Risk Mapping
HF	M	Risk Mapping
HYDROGEN	L	Risk Mapping
MAGNESIUM	H	Risk Mapping
MAGNESIUM FLUORIDE	H	Risk Mapping
NICKEL	M	Risk Mapping
NITRIC ACID	M	Risk Mapping
NOISE	H	Risk Mapping
OFF GAS	M	Risk Mapping
POTASSIUM HYDROXIDE	L	Risk Mapping
RADIATION	H	Risk Mapping
TRICHLOROETHYLENE	M	Risk Mapping
UF4	H	Risk Mapping
UF6	M	Risk Mapping
URANIUM	M	Risk Mapping

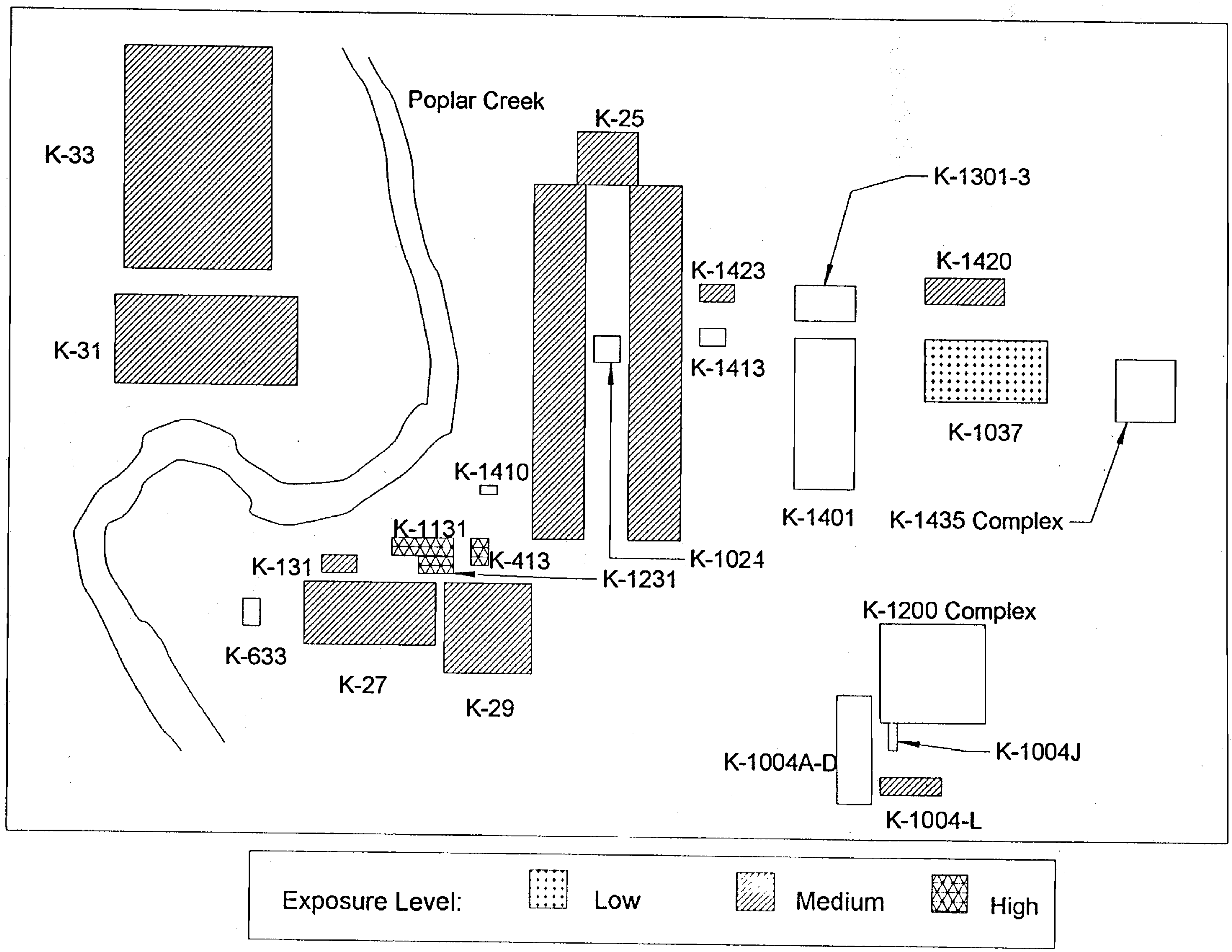
Summary Exposure Maps for the Oak Ridge K-25 Site

Maps Derived from Risk Mapping Data (Tables 4.2 through 4.20)

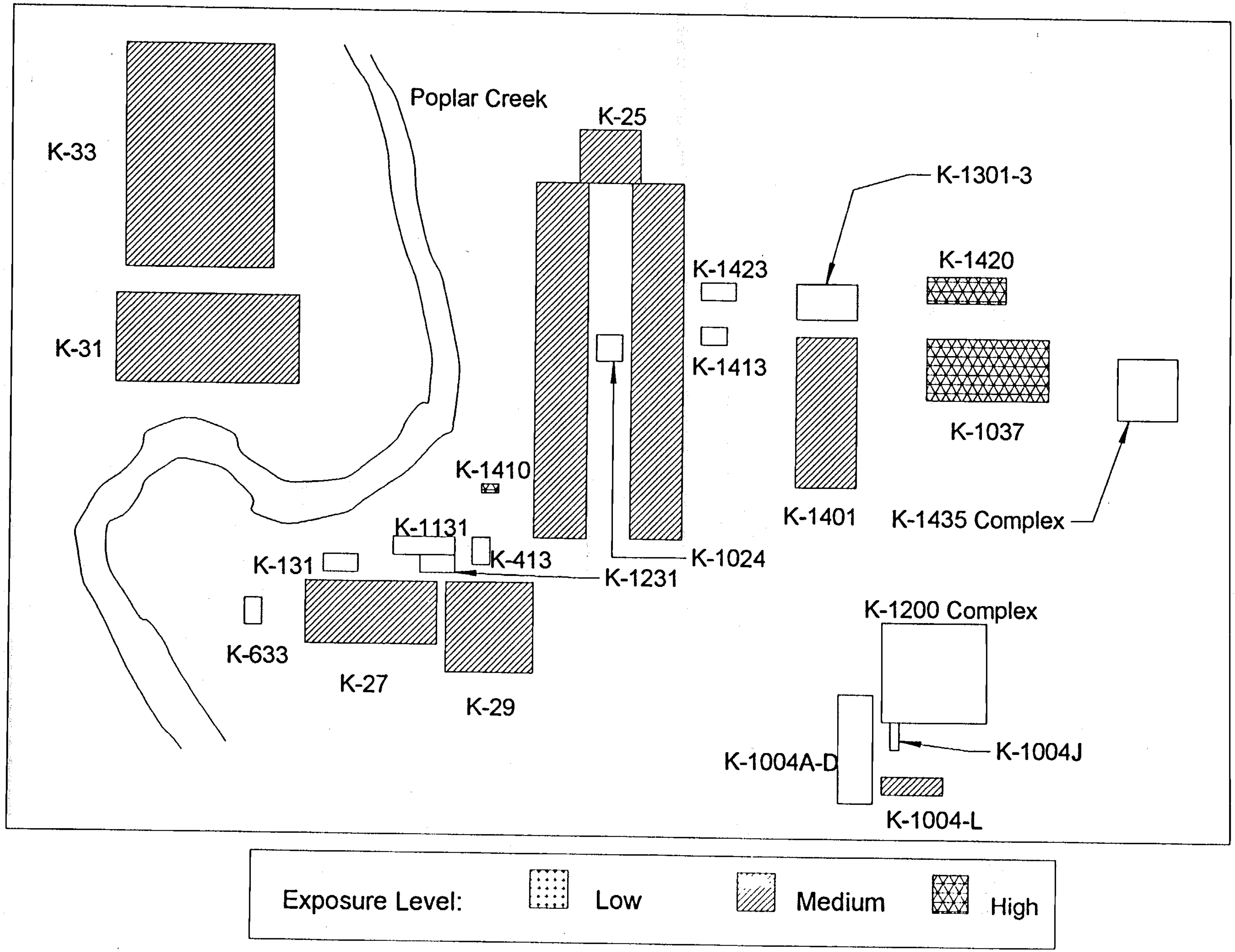
Oak Ridge Gaseous Diffusion Plant
Contaminant: Uranium



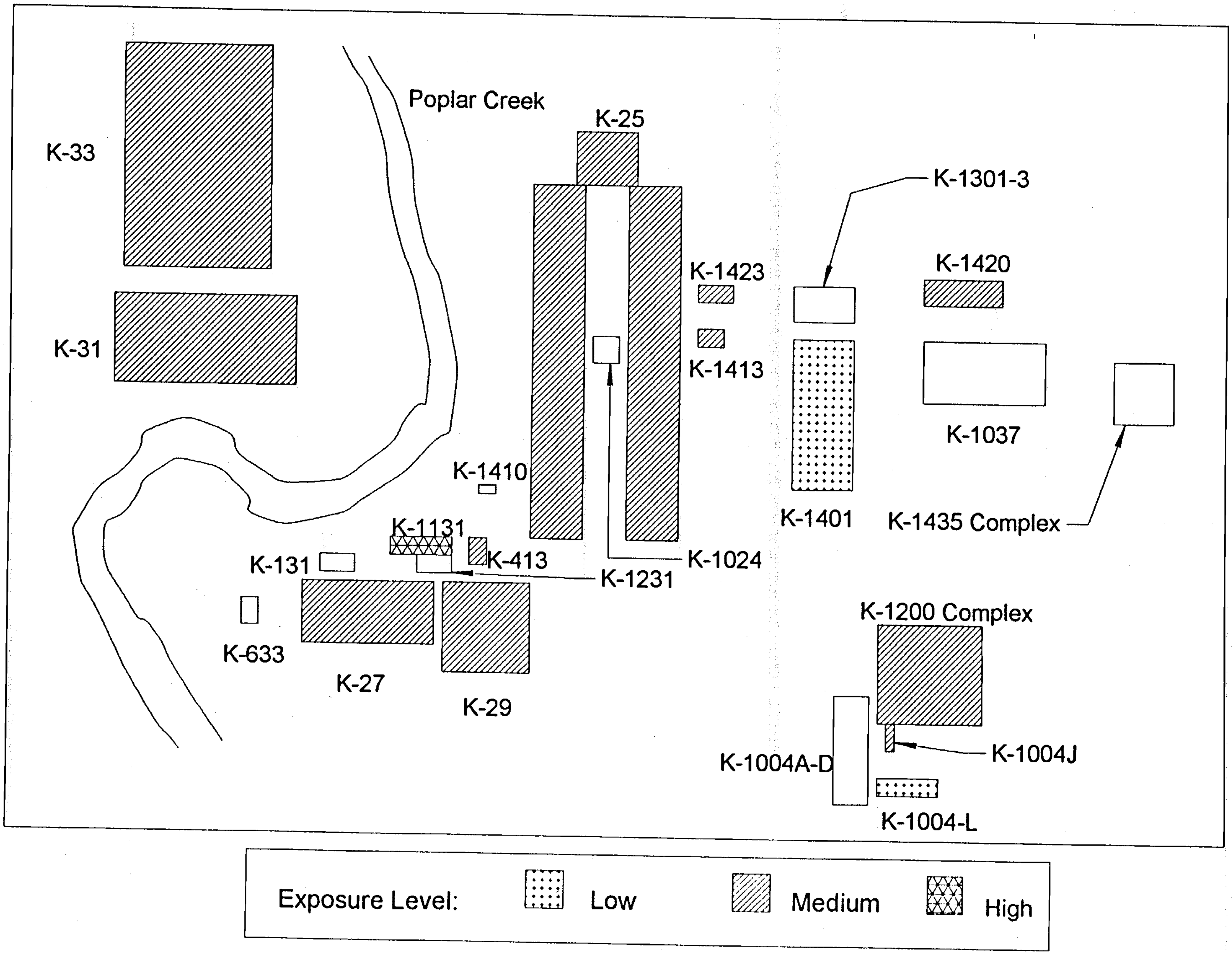
Oak Ridge Gaseous Diffusion Plant
Contaminant: Fluorine & HF



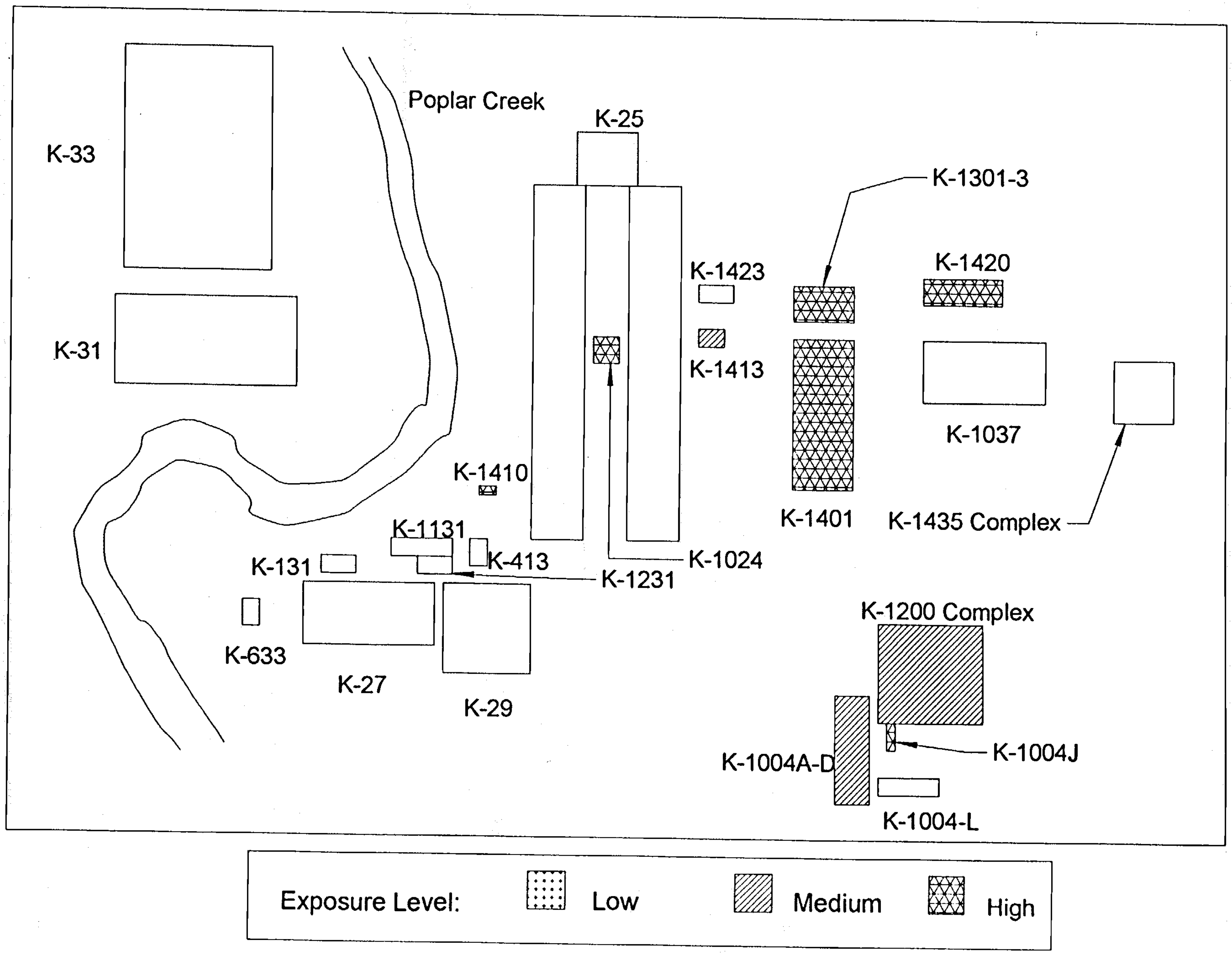
Oak Ridge Gaseous Diffusion Plant
Contaminant: Nickel



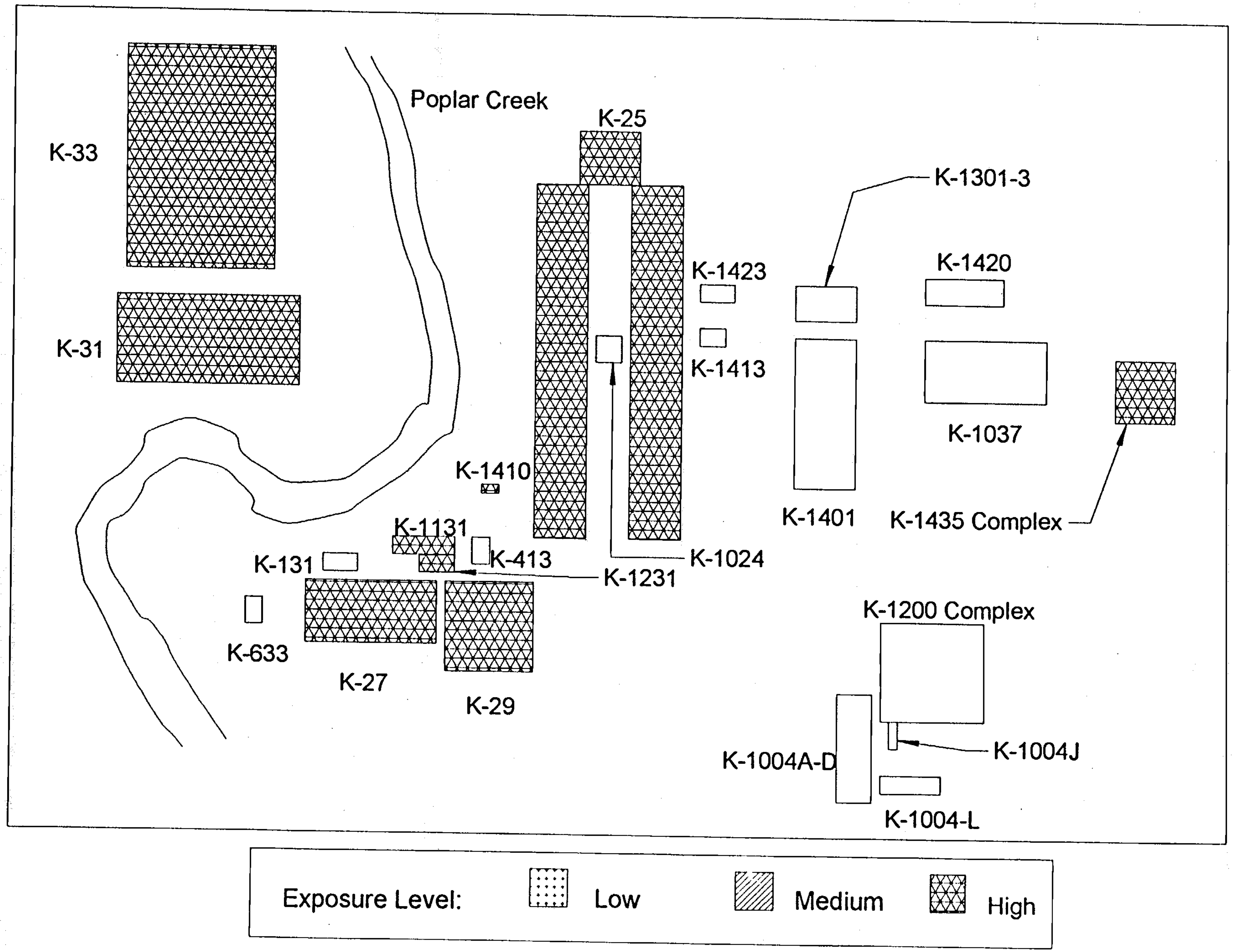
Oak Ridge Gaseous Diffusion Plant
Contaminant: Uranium Hexafluoride



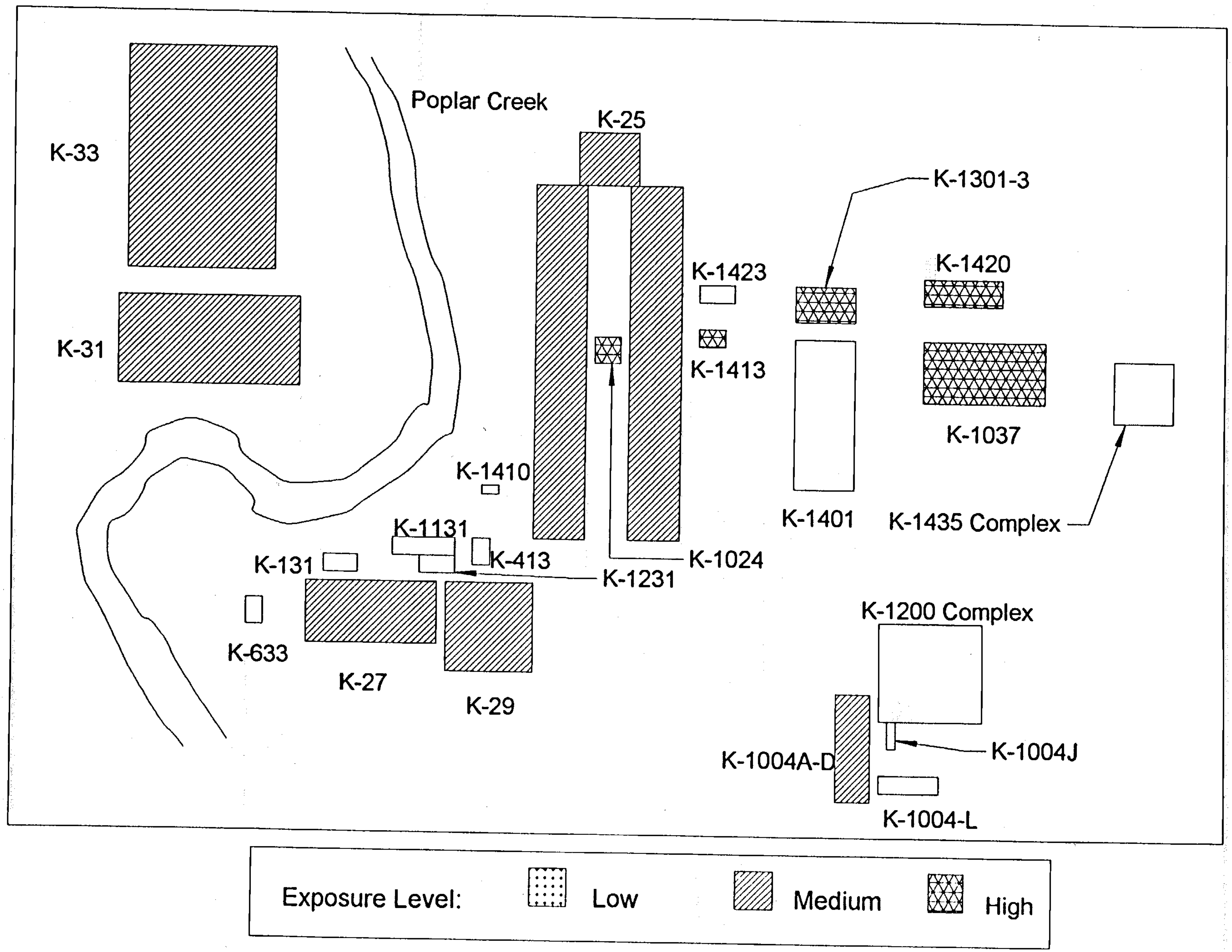
Oak Ridge Gaseous Diffusion Plant
Contaminant: Solvents



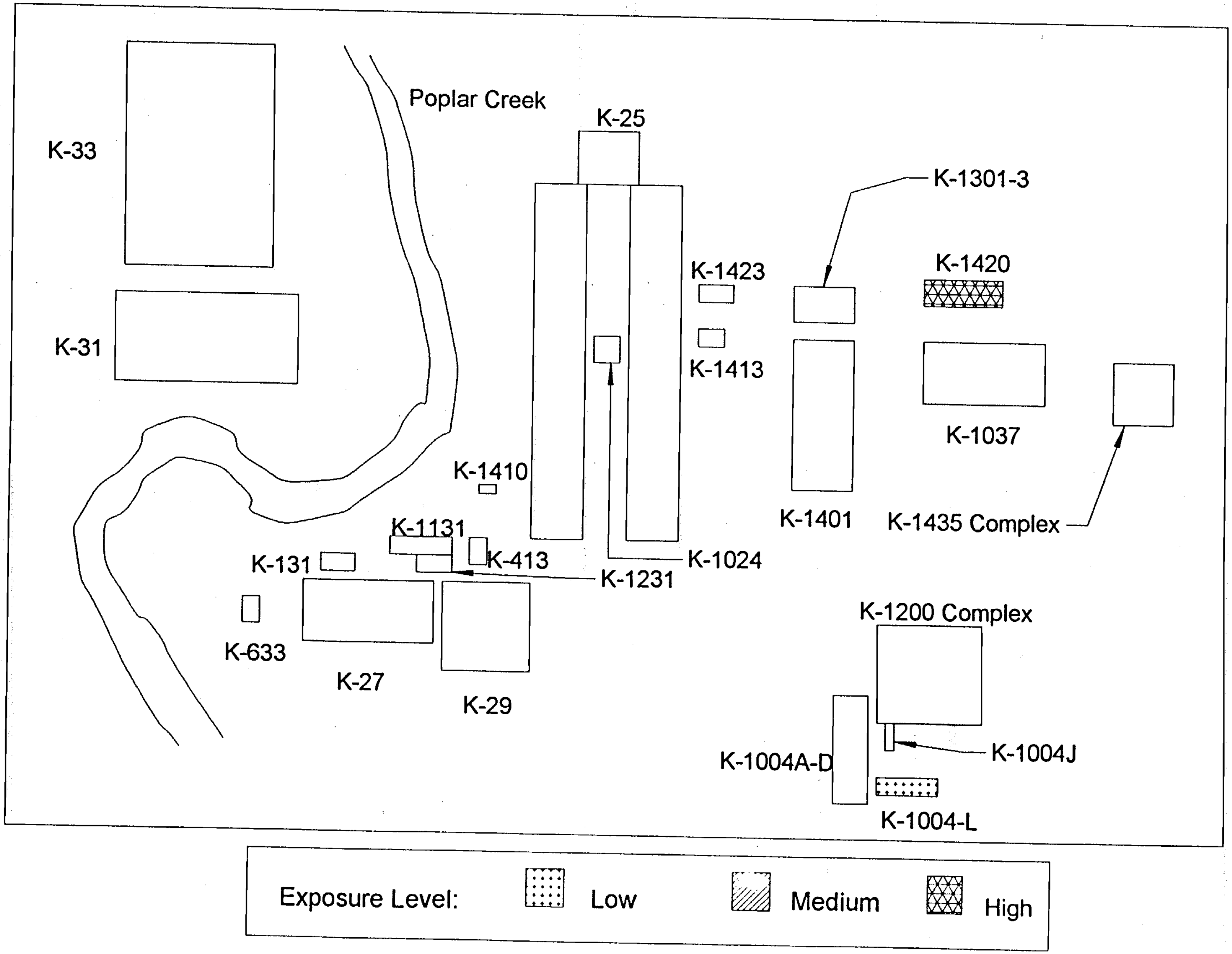
Oak Ridge Gaseous Diffusion Plant
Contaminant: Heat



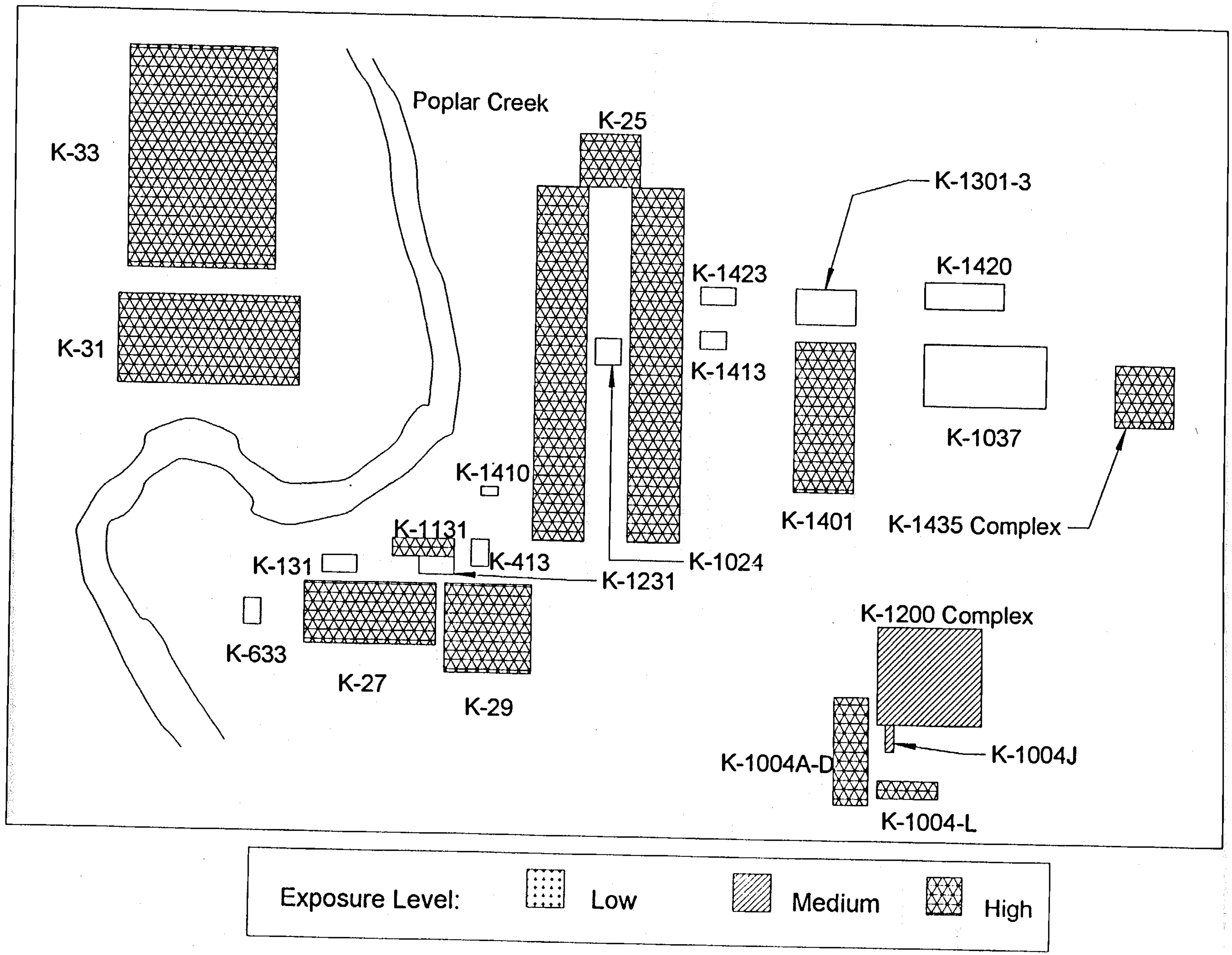
Oak Ridge Gaseous Diffusion Plant
Contaminant: Mercury



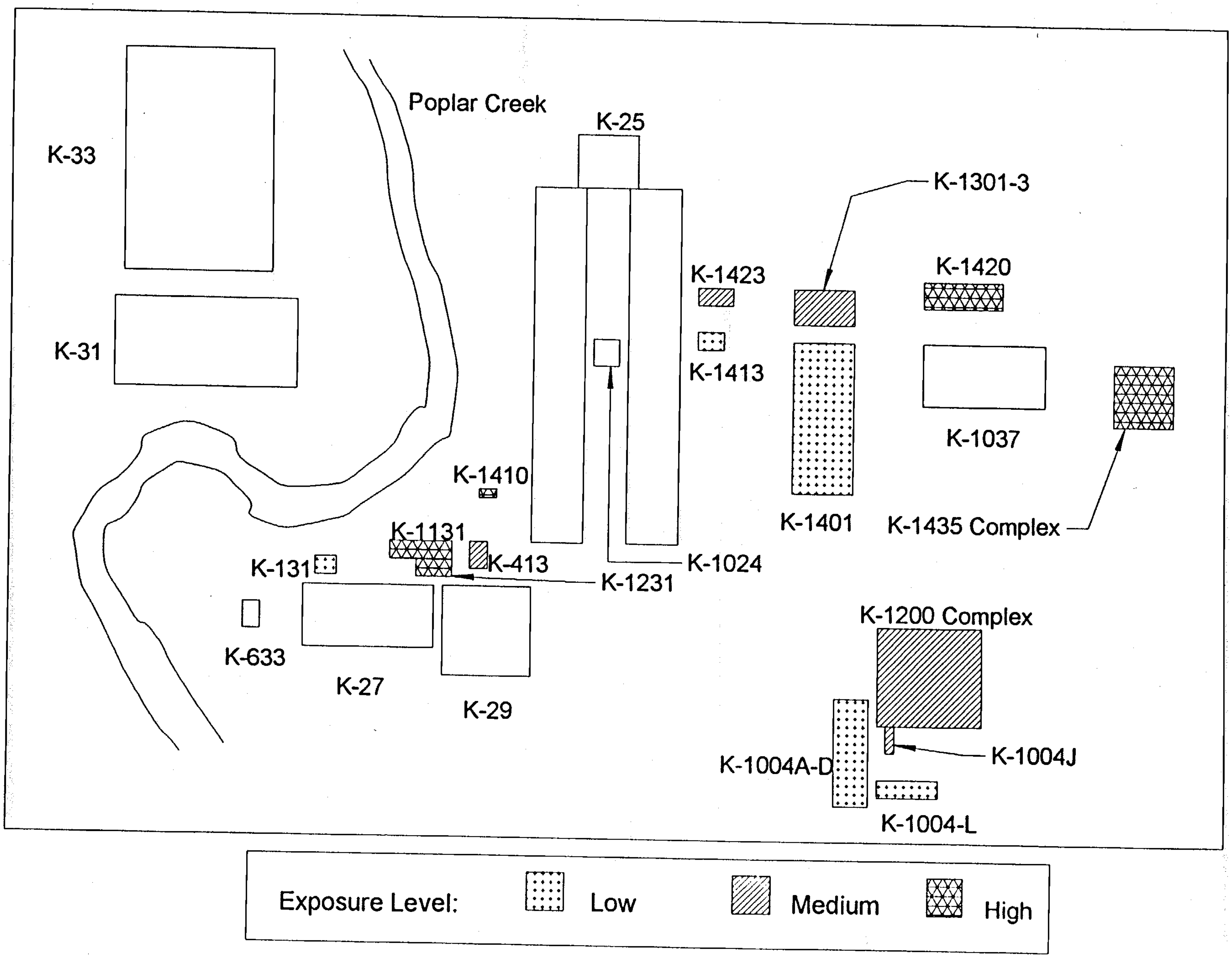
Oak Ridge Gaseous Diffusion Plant
Contaminant: Heavy Metals



Oak Ridge Gaseous Diffusion Plant
Contaminant: Noise



Oak Ridge Gaseous Diffusion Plant
Contaminant: Radiation

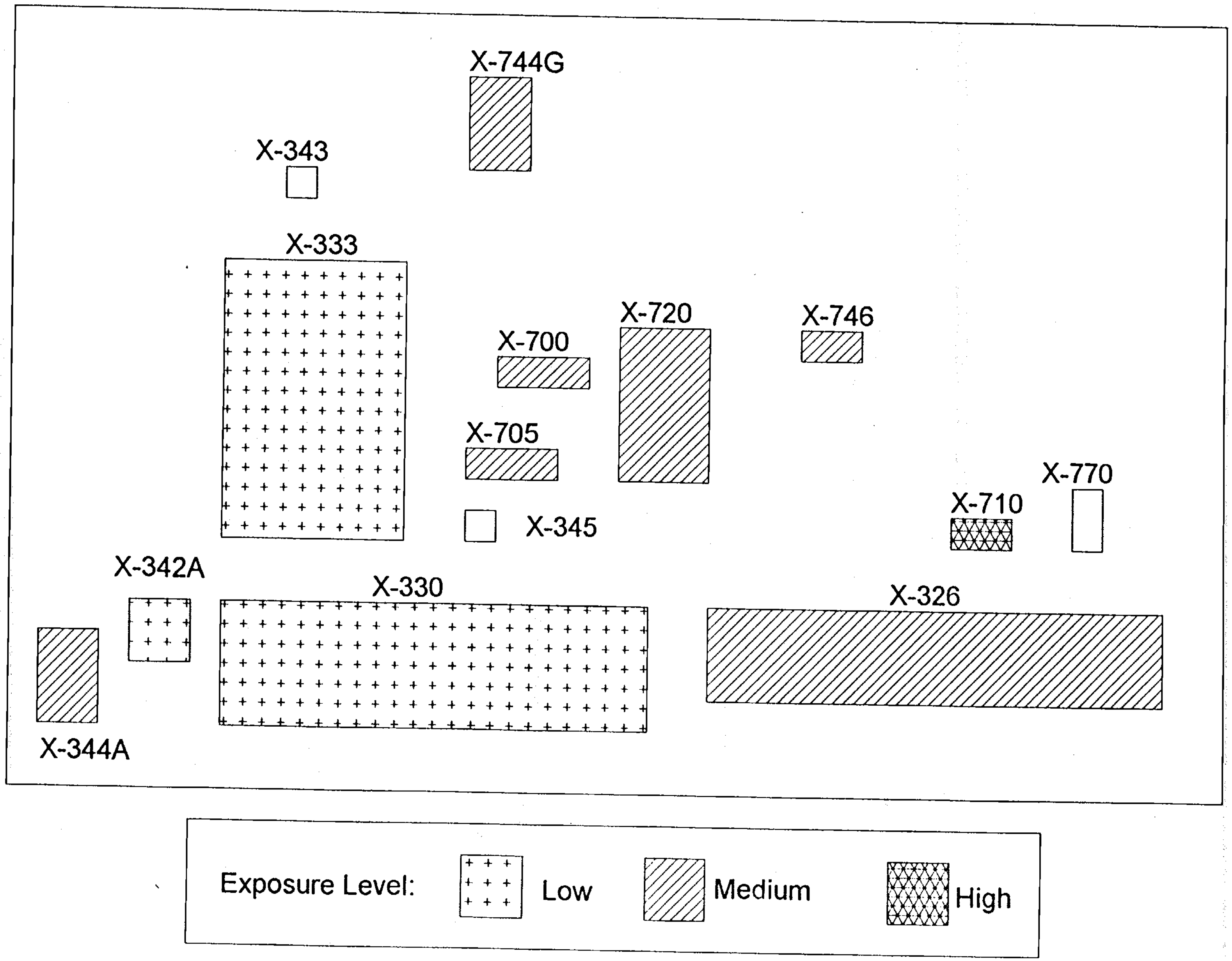


Summary Exposure Maps for the Portsmouth Site

Maps Derived from Risk Mapping Data (Tables 4.2.2 through 4.2.10)

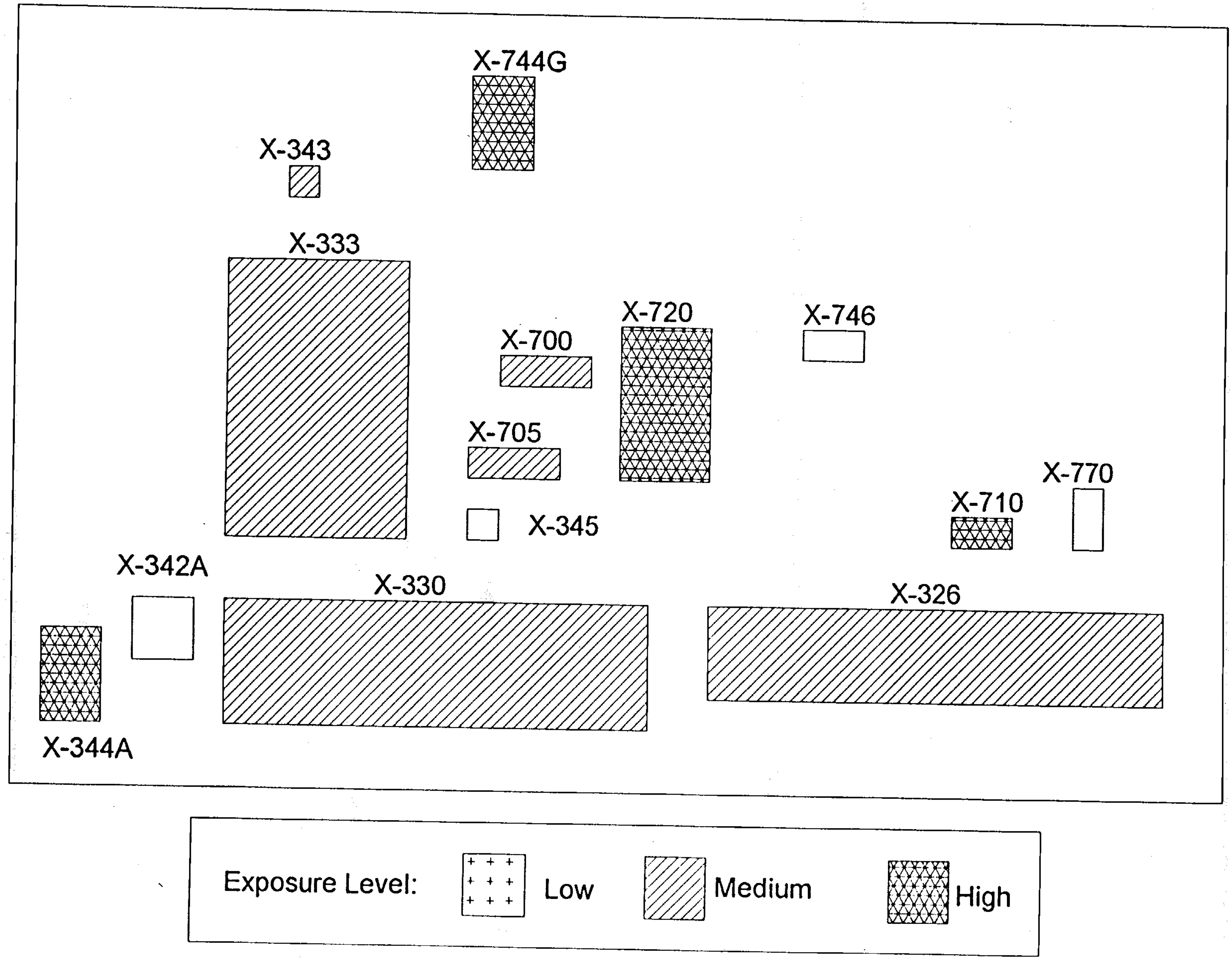
Portsmouth Gaseous Diffusion Plant

Contaminant: Uranium



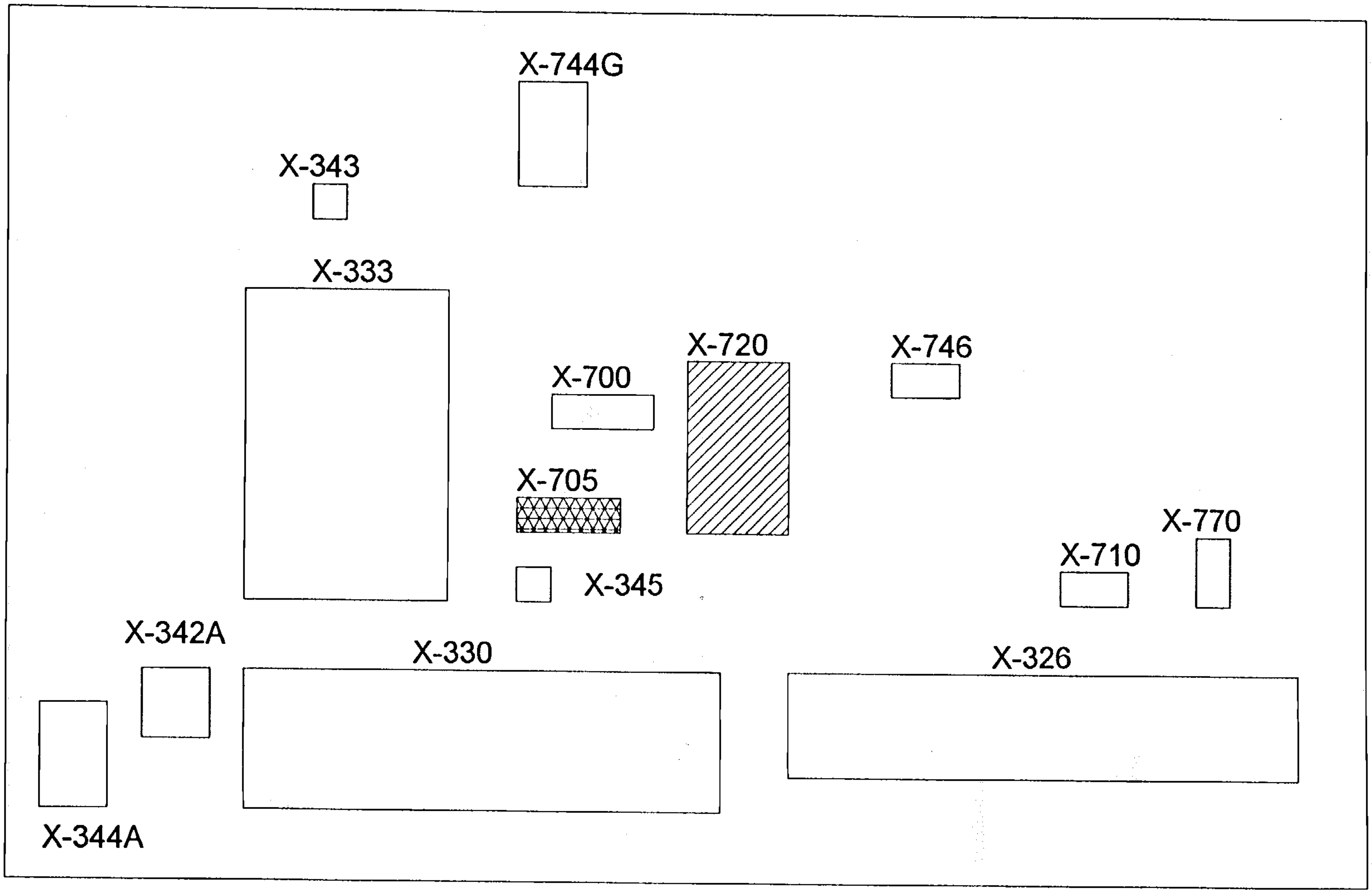
Portsmouth Gaseous Diffusion Plant

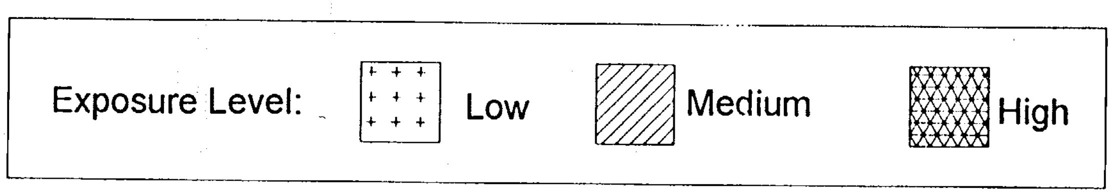
Contaminant: Fluorine & HF



Portsmouth Gaseous Diffusion Plant

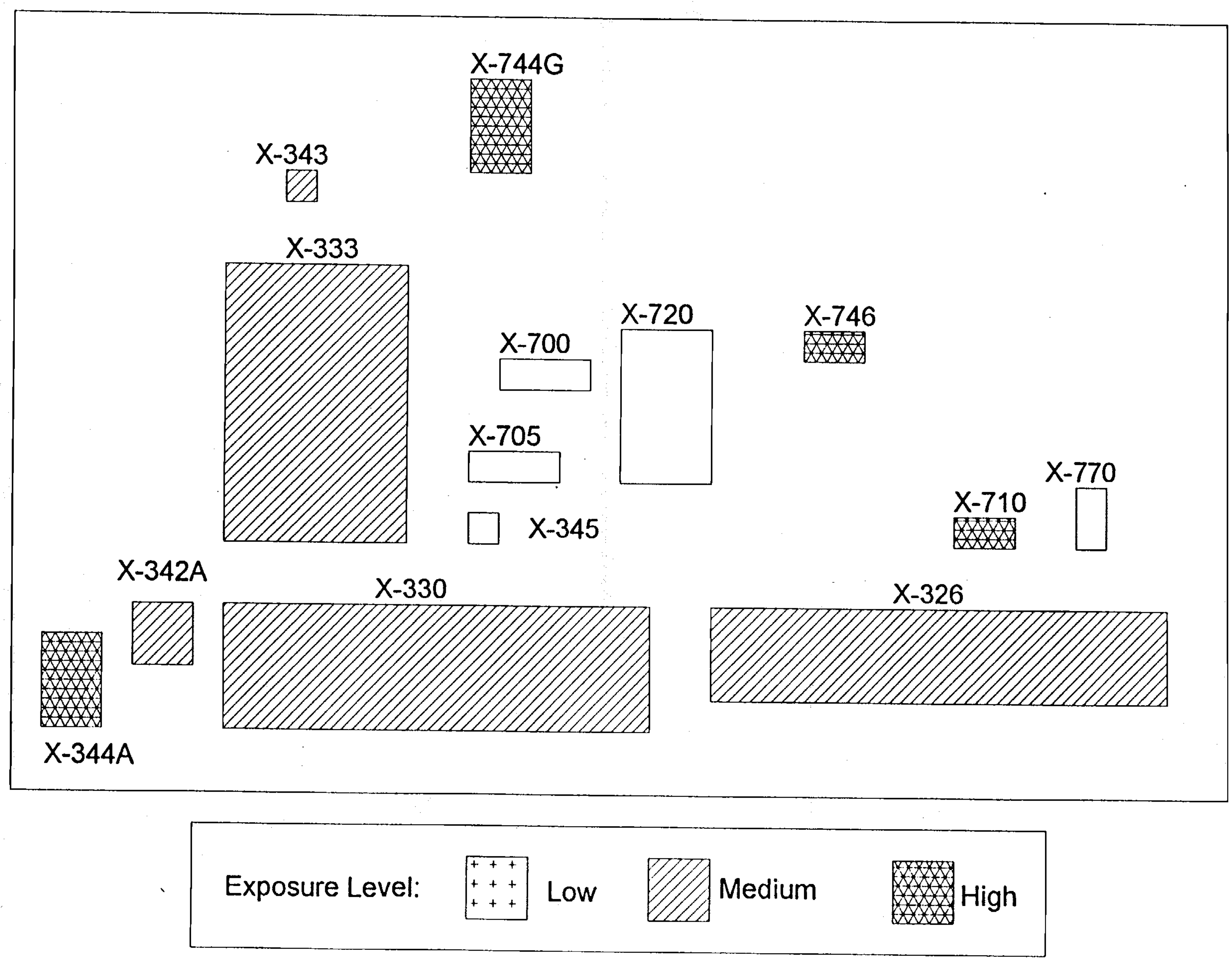
Contaminant: Nickel





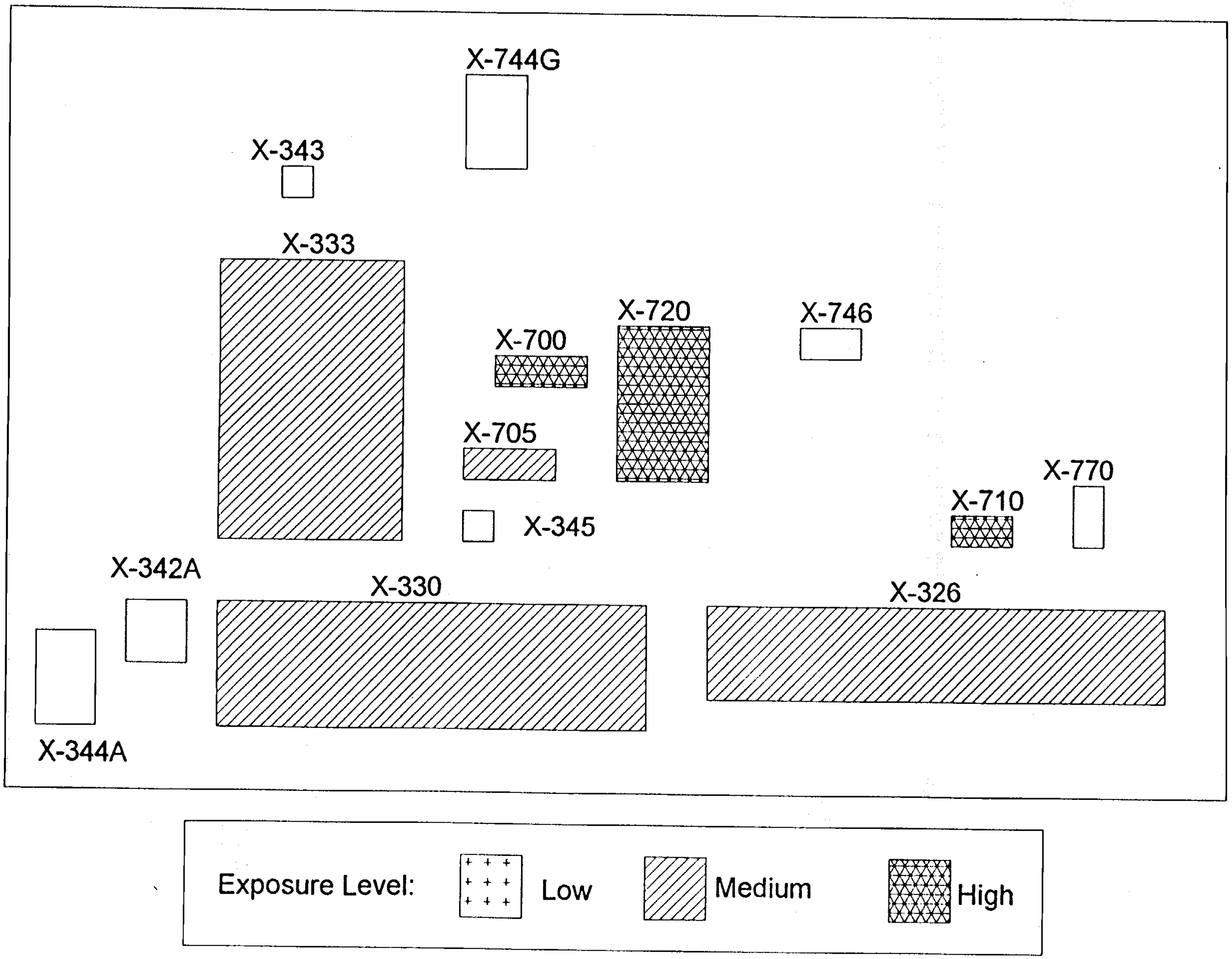
Portsmouth Gaseous Diffusion Plant

Contaminant: Uranium Hexafluoride



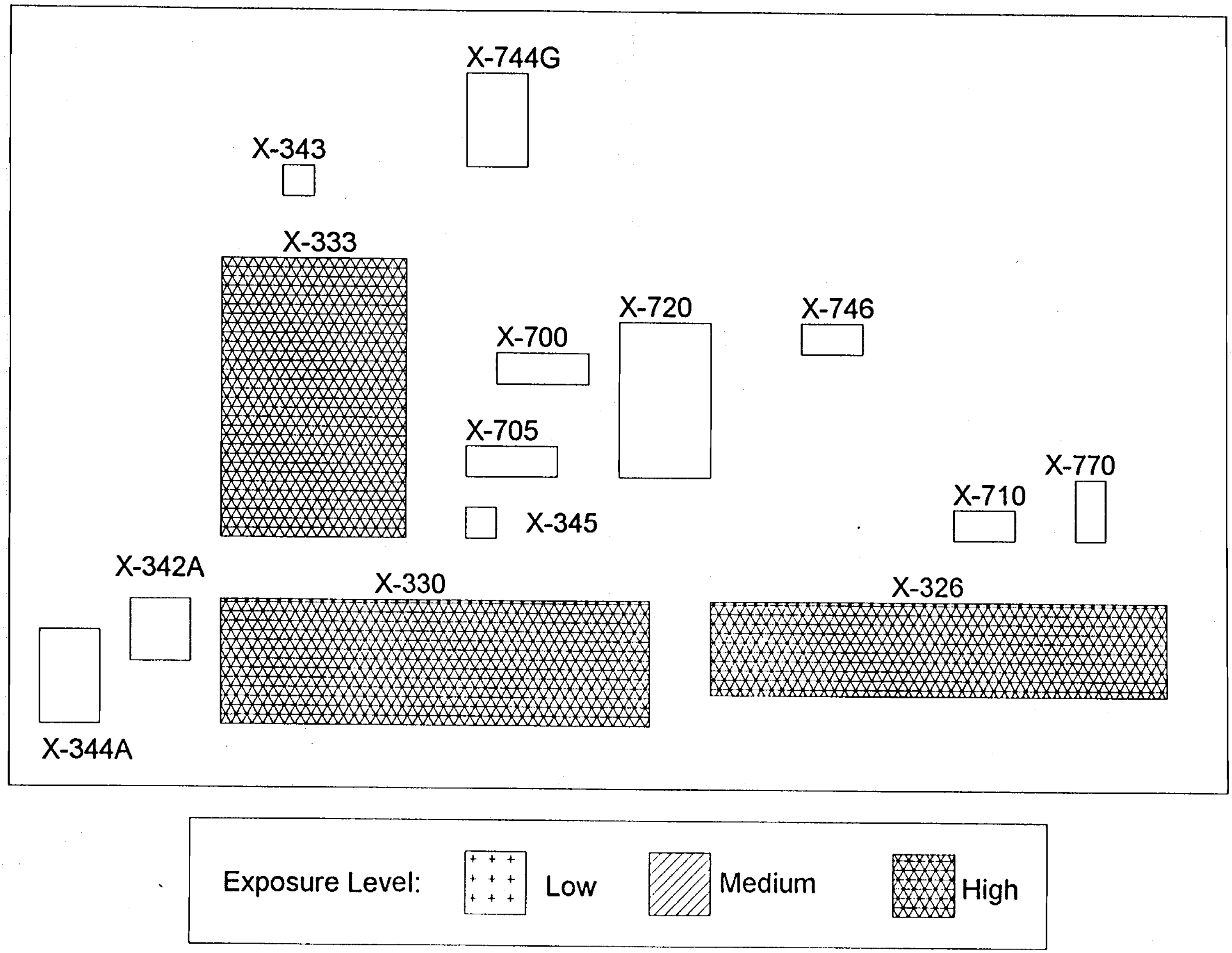
Portsmouth Gaseous Diffusion Plant

Contaminant: Solvents



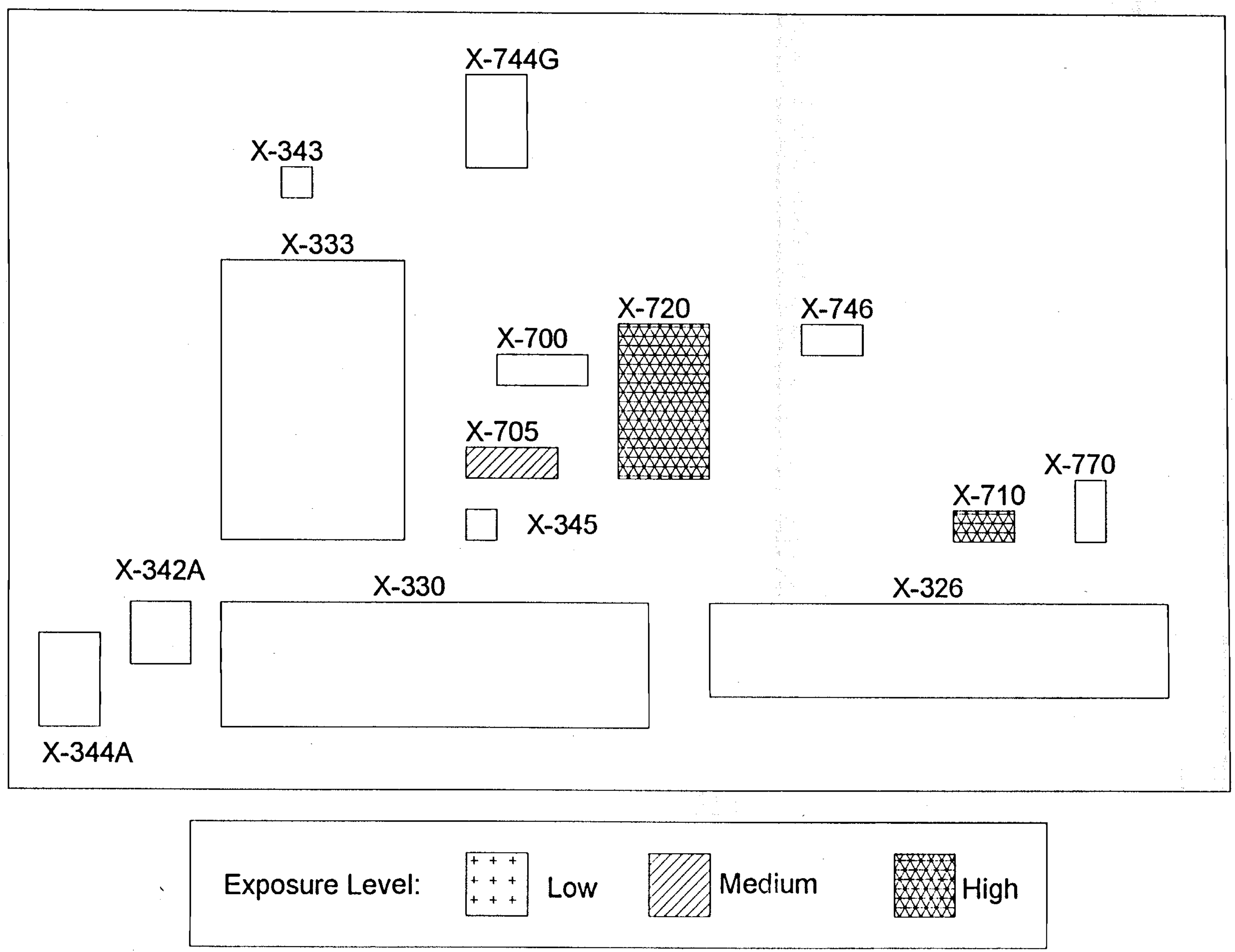
Portsmouth Gaseous Diffusion Plant

Contaminant: Heat



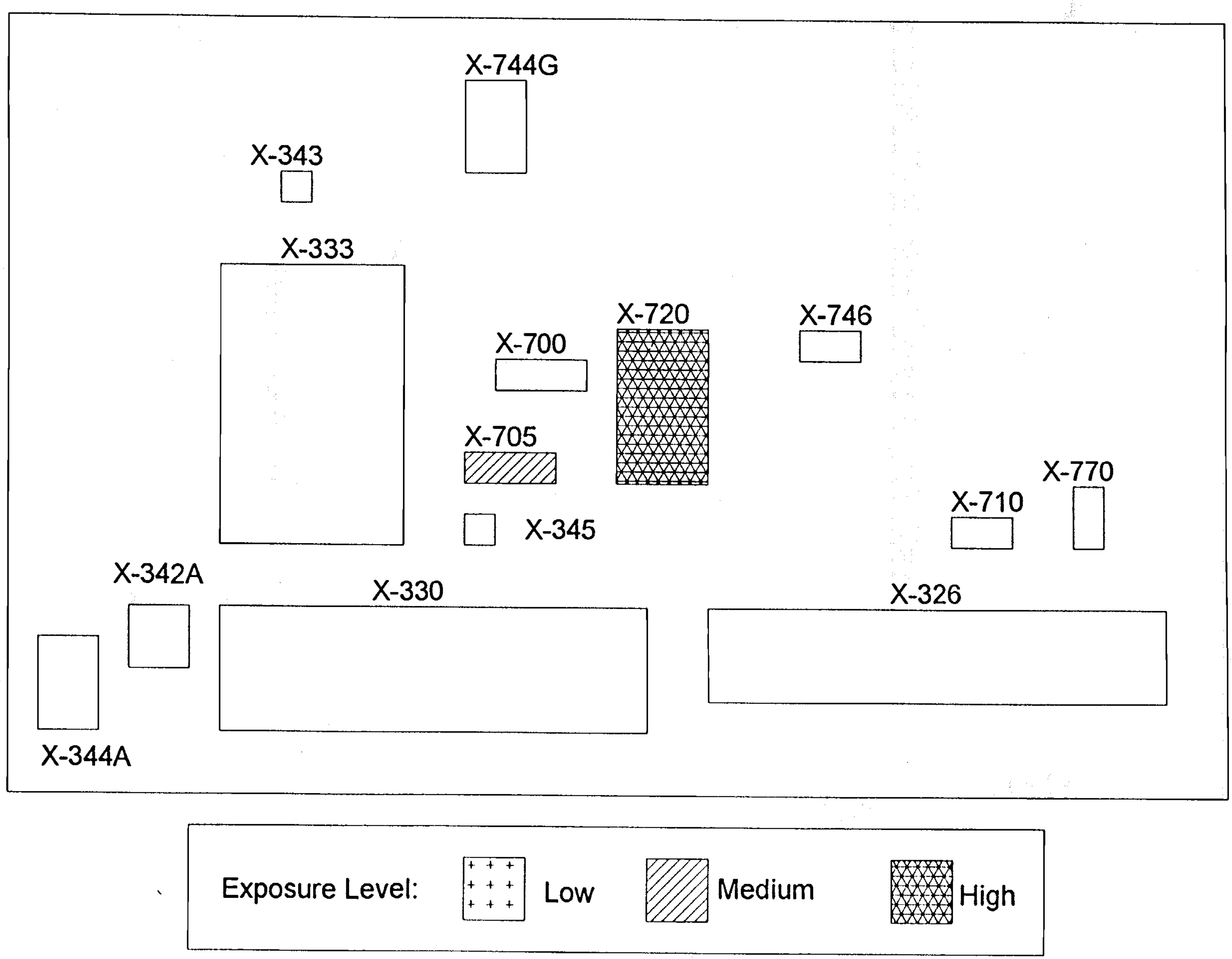
Portsmouth Gaseous Diffusion Plant

Contaminant: Mercury



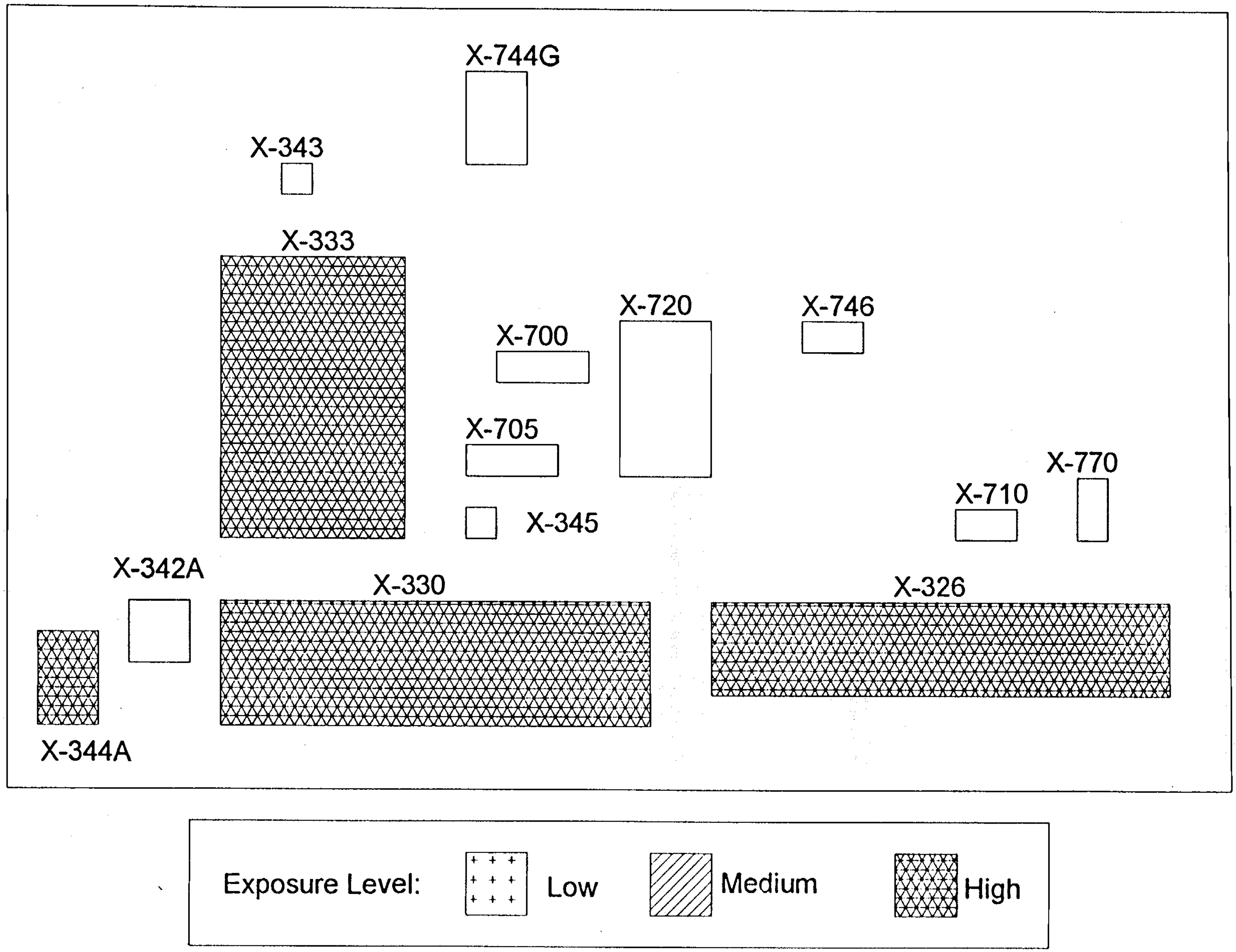
Portsmouth Gaseous Diffusion Plant

Contaminant: Heavy Metals



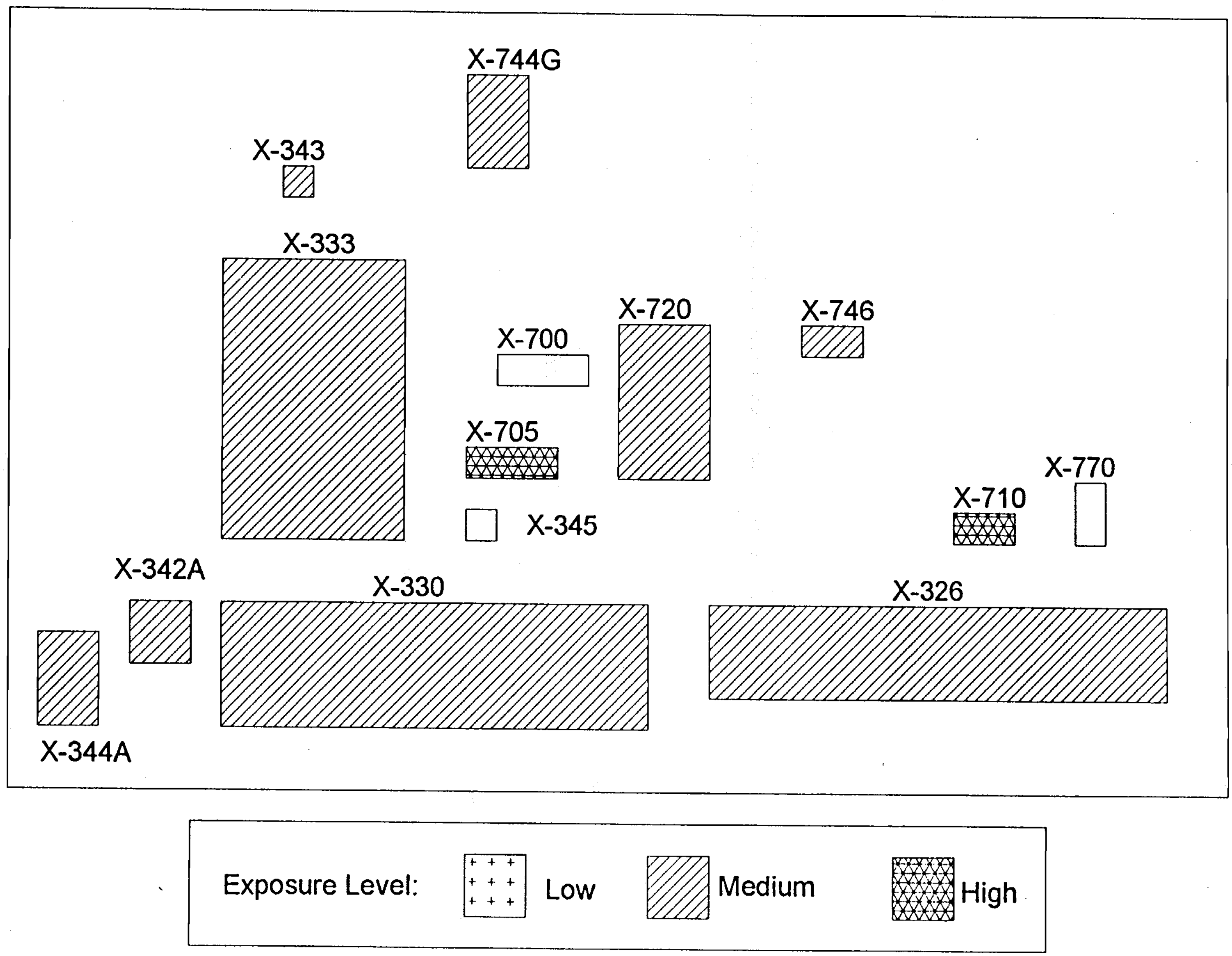
Portsmouth Gaseous Diffusion Plant

Contaminant: Noise



Portsmouth Gaseous Diffusion Plant

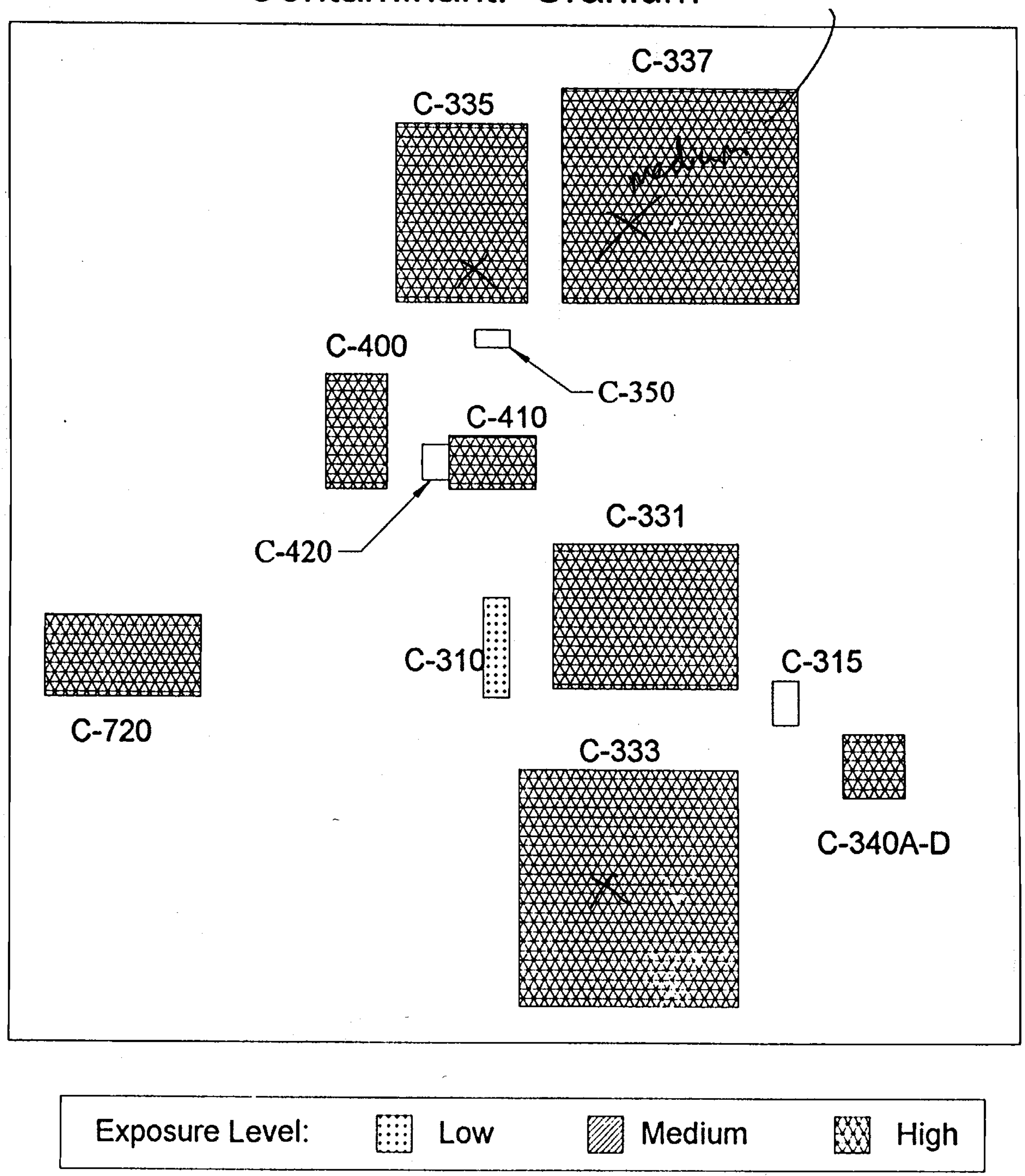
Contaminant: Radiation



Summary Exposure Maps for the Paducah Site

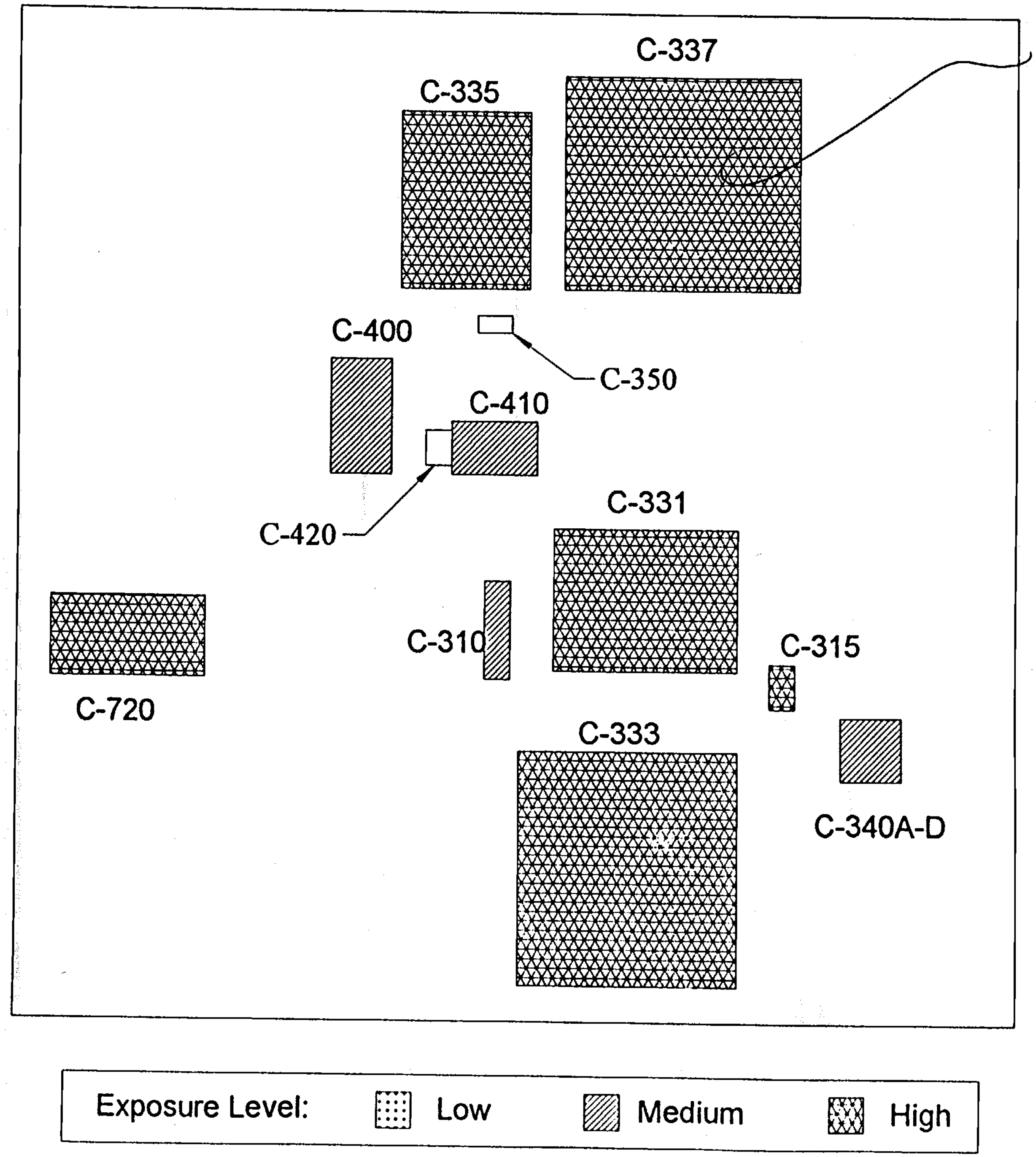
Maps Derived from Risk Mapping Data (Tables 4.3.2 through 4.3.9)

Paducah Gaseous Difusion Plant
Contaminant: Uranium

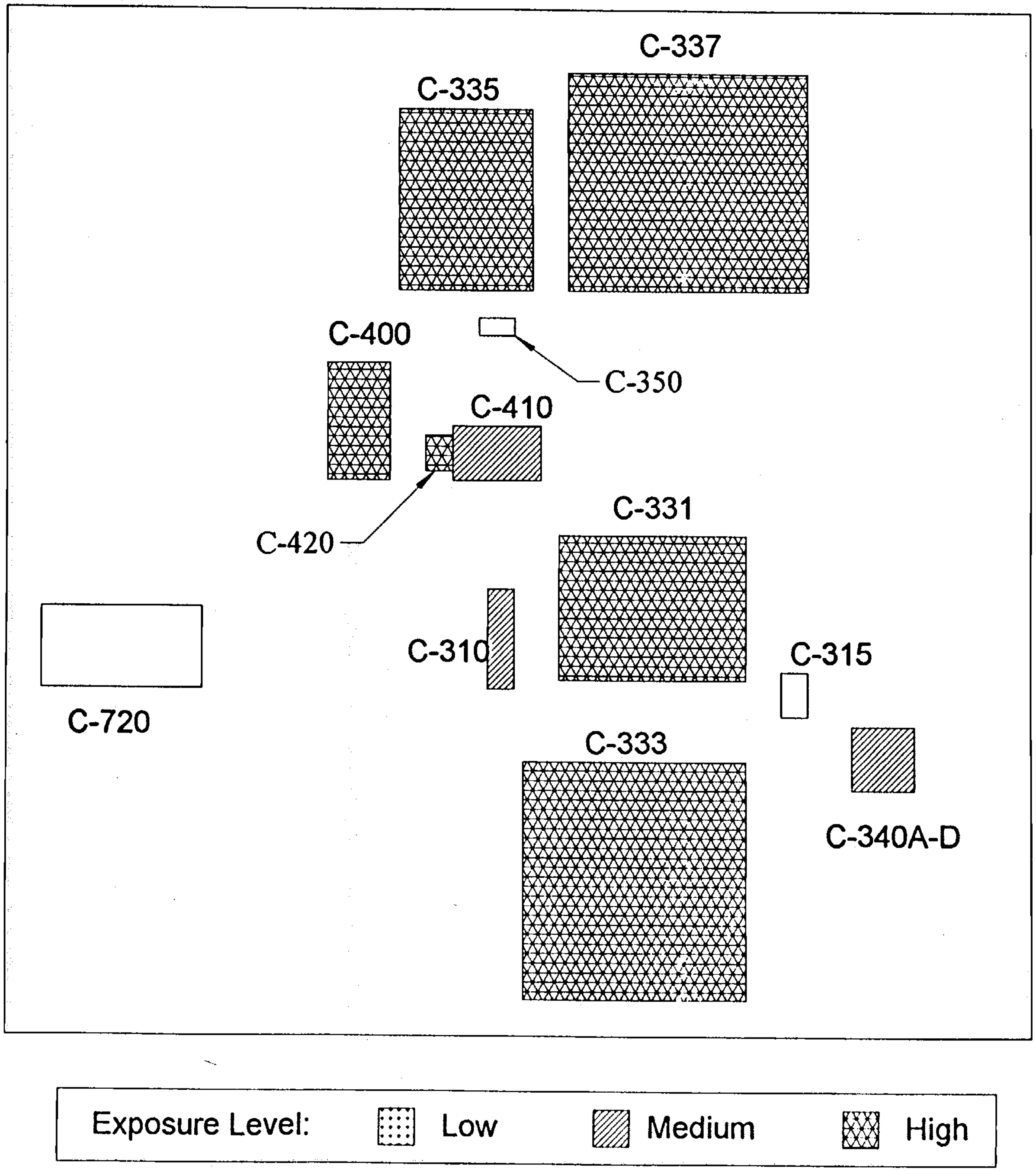


Paducah Gaseous Difusion Plant

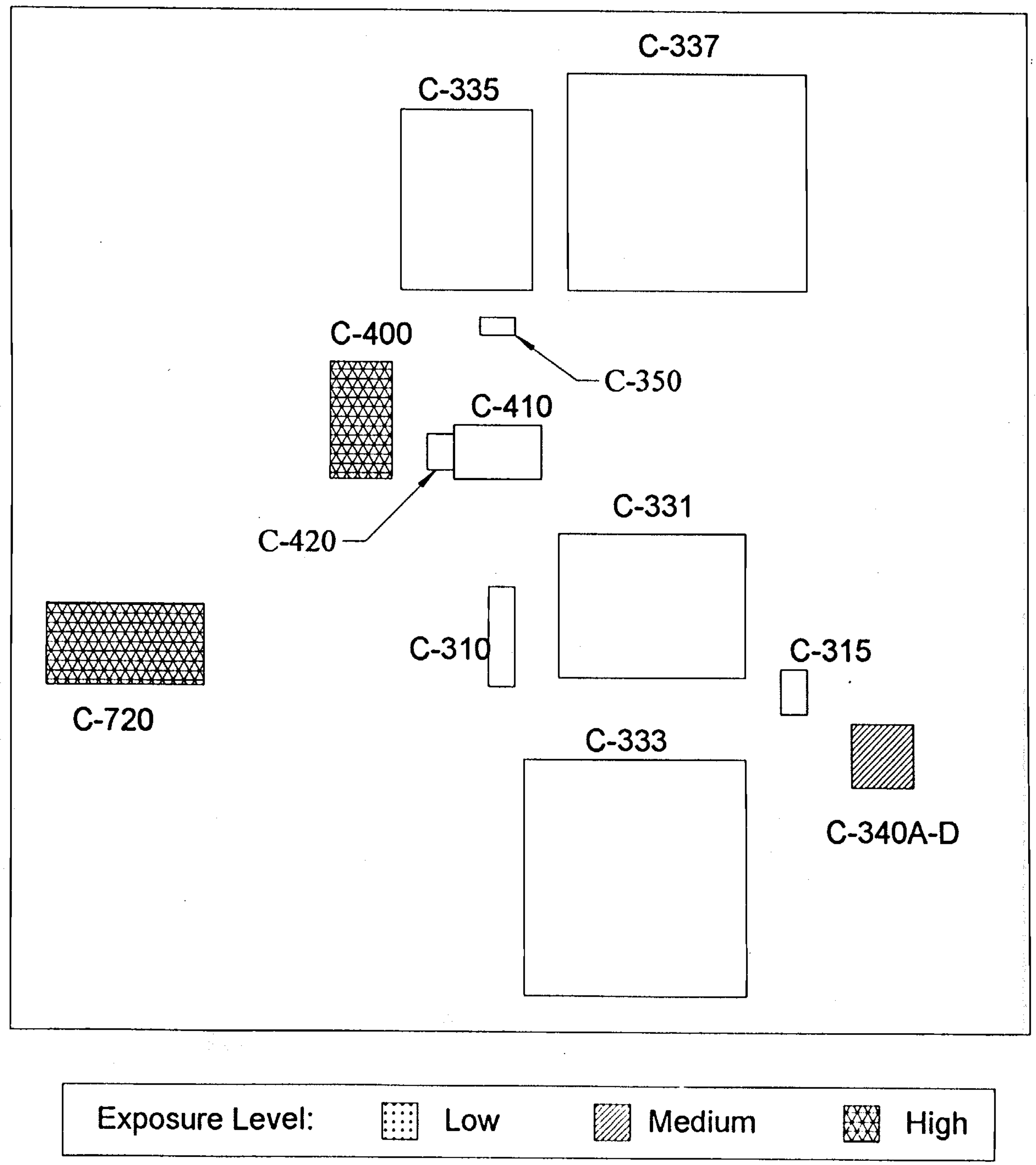
Contaminant: Uranium Hexafluoride



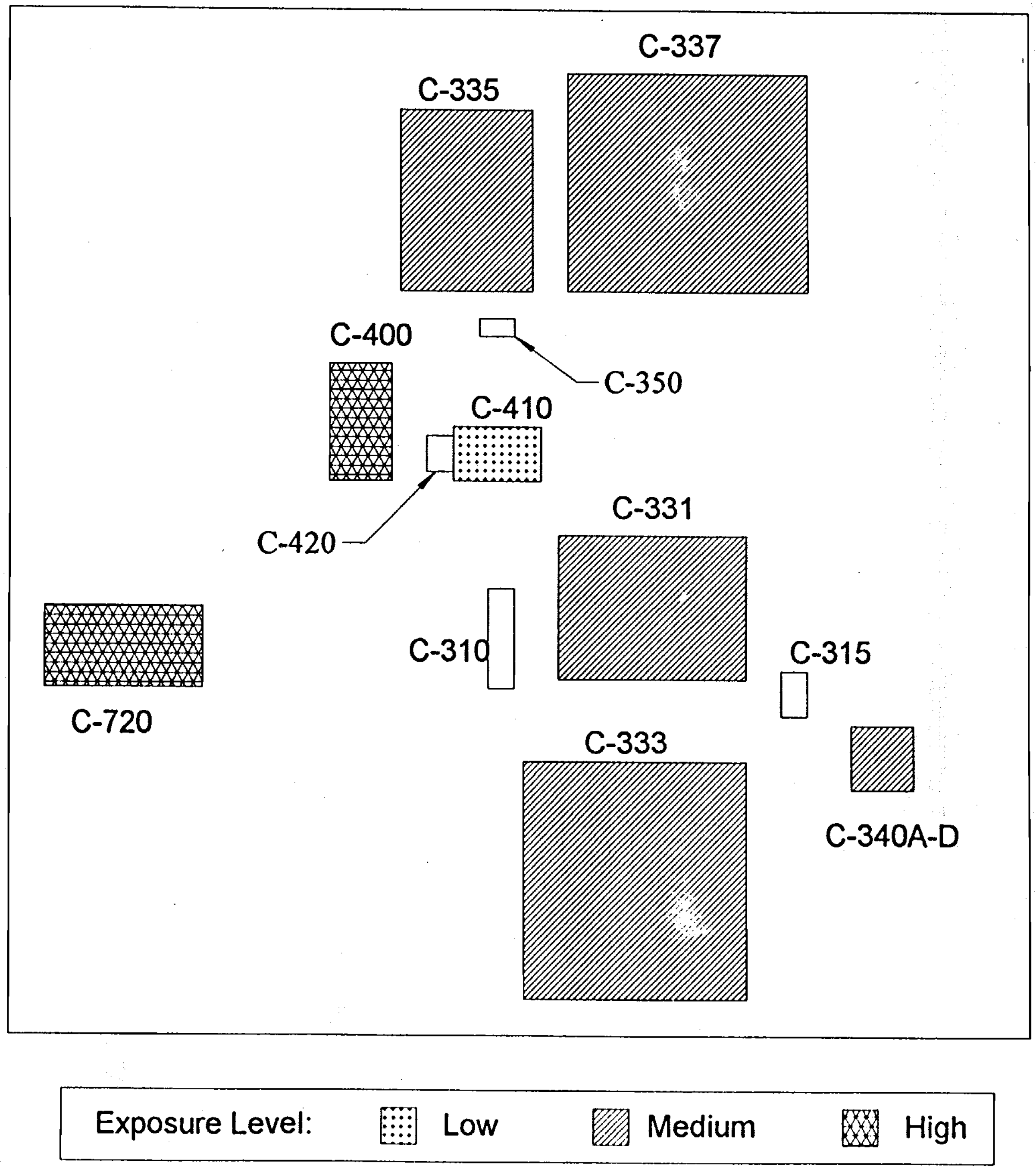
Paducah Gaseous Difusion Plant
Contaminant: Fluorine & HF



Paducah Gaseous Difusion Plant
Contaminant: Nickel

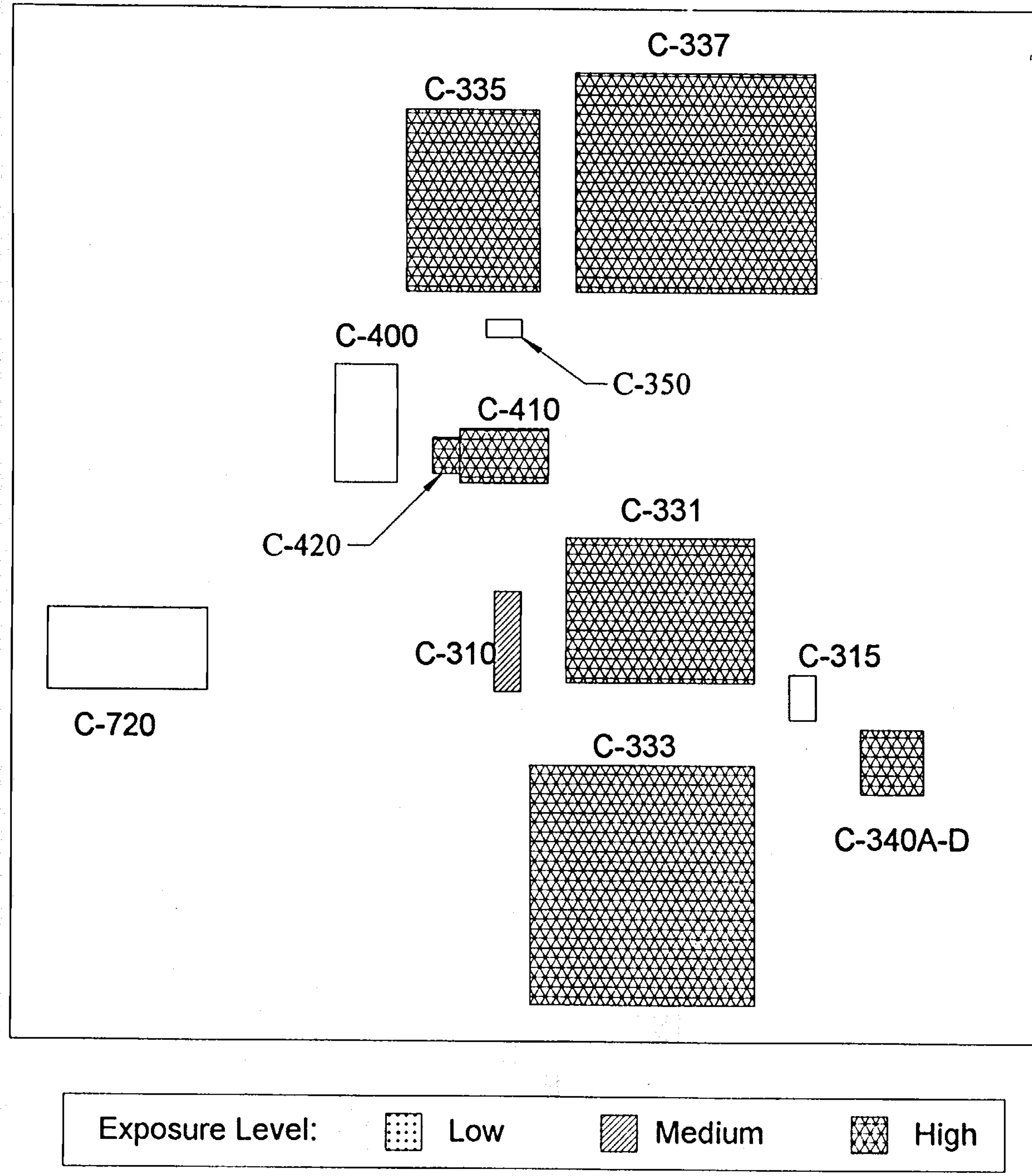


Paducah Gaseous Difusion Plant
Contaminant: Solvents

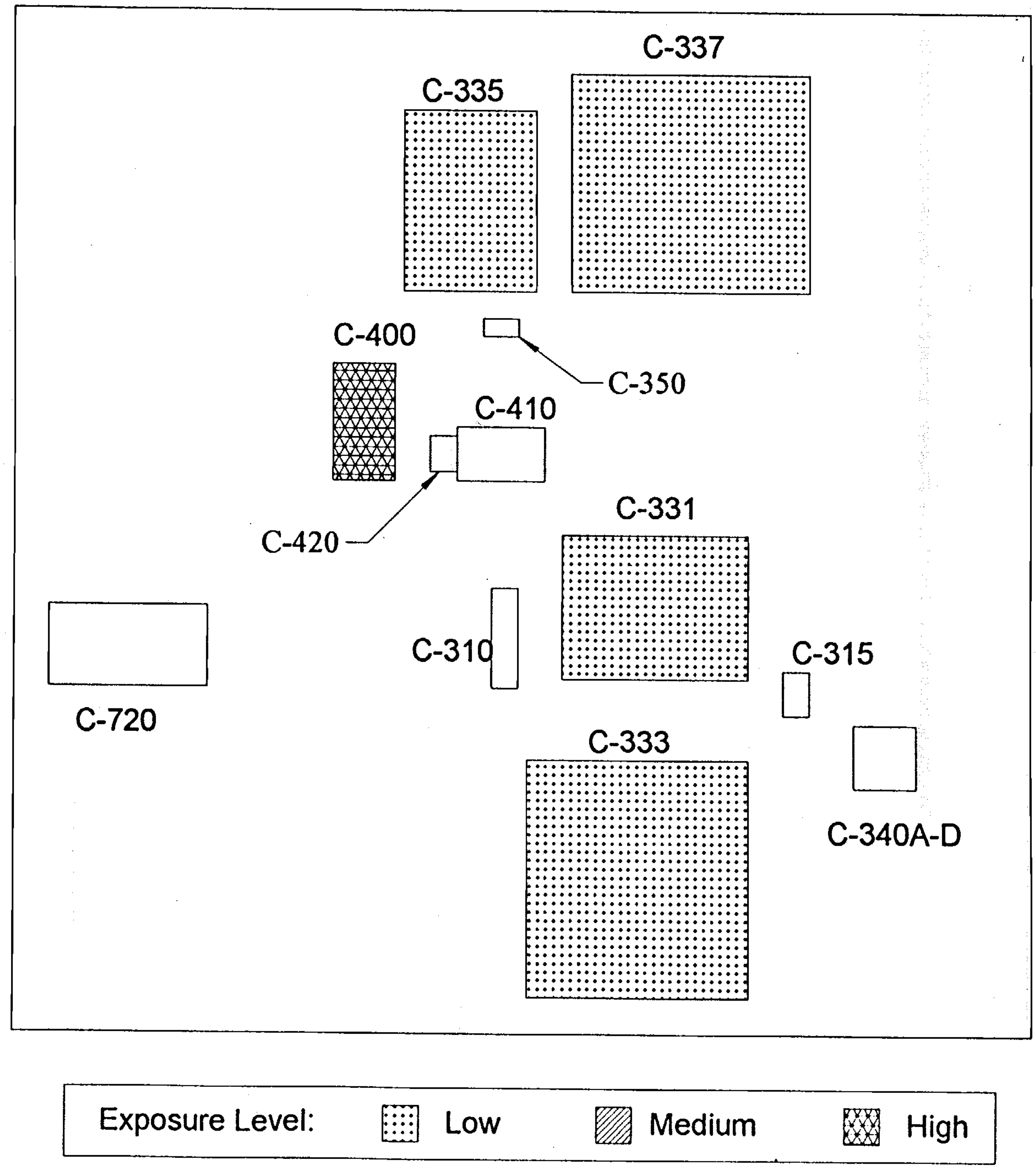


Paducah Gaseous Difusion Plant

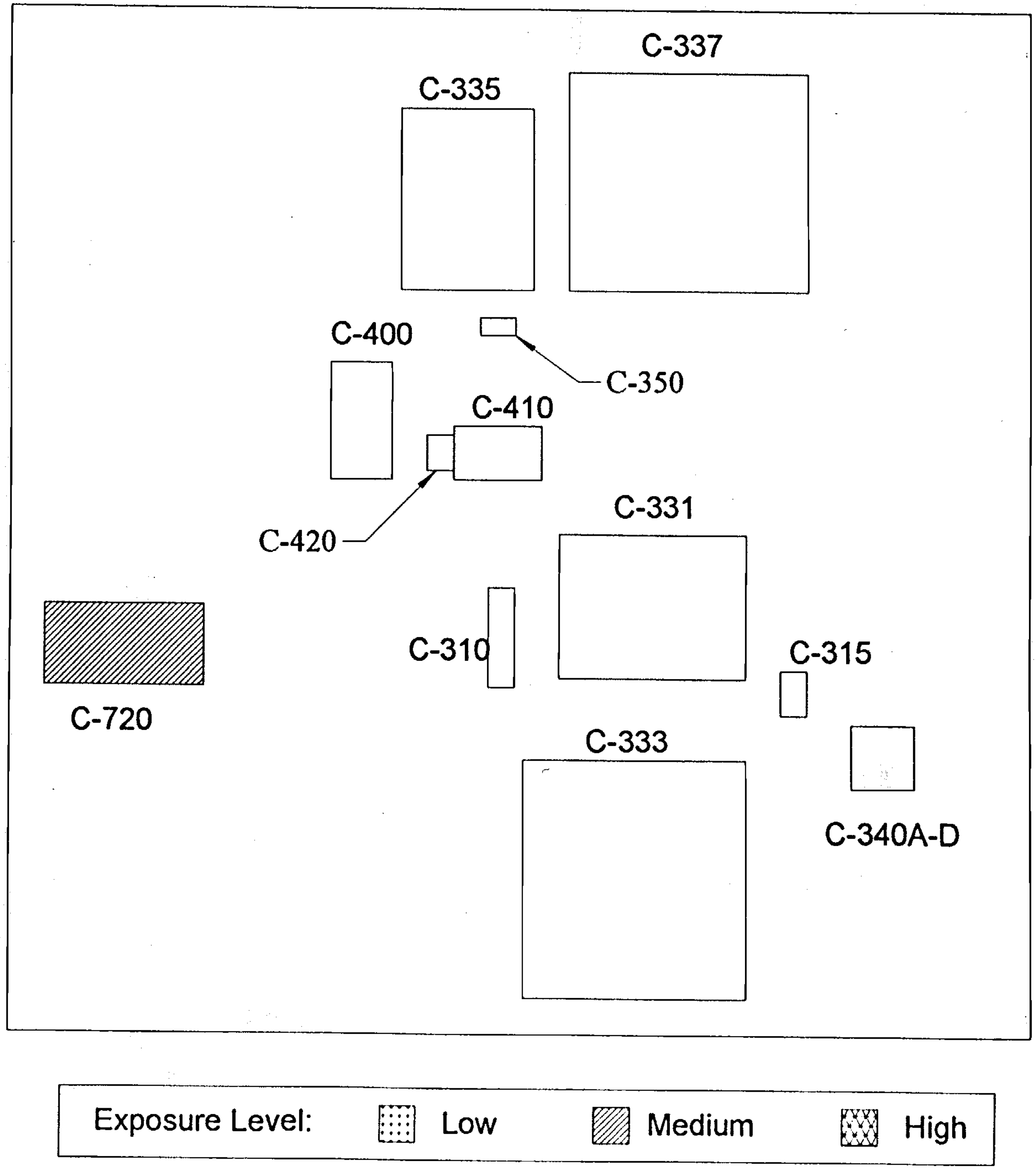
Contaminant: Heat



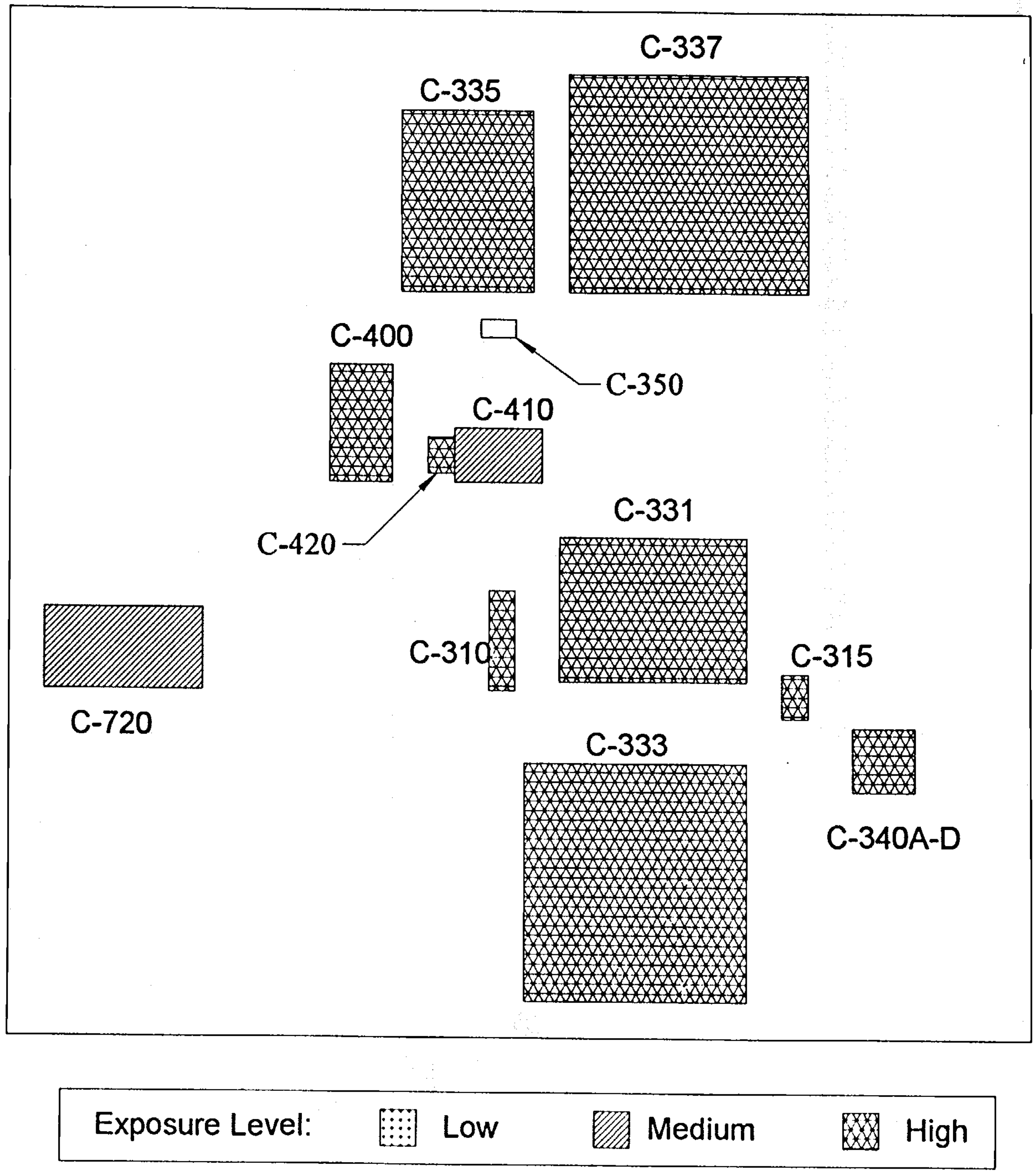
Paducah Gaseous Difusion Plant
Contaminant: Mercury



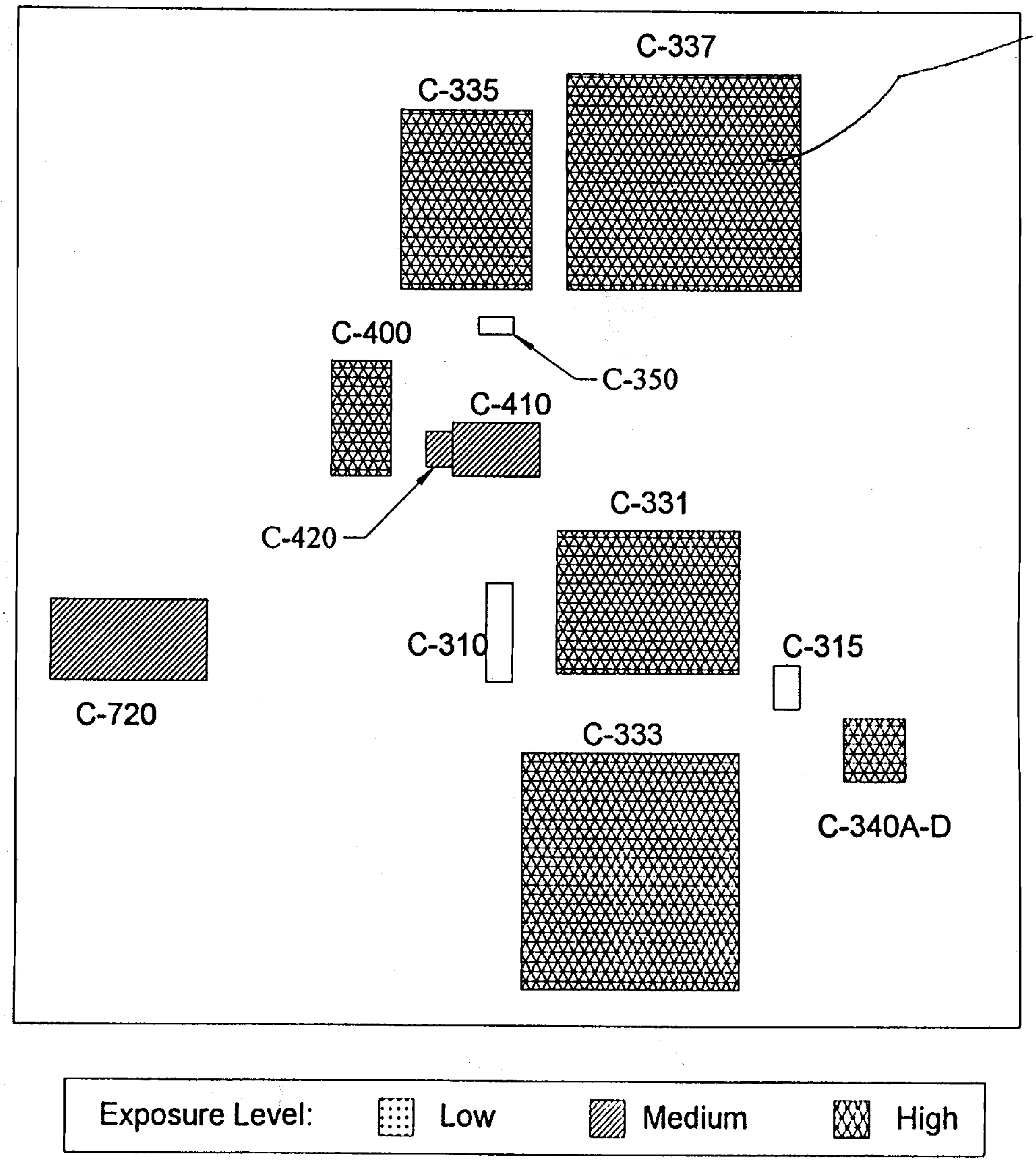
Paducah Gaseous Difusion Plant
Contaminant: Heavy Metals



Paducah Gaseous Difusion Plant
Contaminant: Noise



Paducah Gaseous Difusion Plant
Contaminant: Radiation



Appendix A: Summary of IH/HP Data for each Site

Appendix A: Summary of Available Data

Oak Ridge

1. IH database under development by NIOSH for multiple Myleoma study. This database includes data scanned by NIOSH (1948-1985) along with more recent data obtained from the site in electronic form (1985-present). The data which was declassified has been coded and is currently under-going final QC by NIOSH however, a large set of data from the mid 60s to early 70s remains to be declassified and therefore is not included in the database at this time.
2. ChemRisk Off-site dose reconstruction reports. This study is very useful for identifying major releases and/or accidents and it is also useful for process and building changes over time.
3. Urinalysis working data files available through CEDR (1948 – 1985).
4. External Radiation and Whole Body Count working data files available through CEDR (1948 – 1985)
5. Air Sampling Data held at Oak Ridge (1984-1985) held in K-1001, B-103-V (unclear whether this data was included in NIOSHs database
6. Air Sampling Data (1974-1982) Electronic Tapes held in Y-12, 9103 Vault (unclear whether this data was included in NIOSHs database
7. Centrifuge Worker Study (Phase I and II); conducted by ORAU CER
8. Nickel Worker Study, Analytical files available on CEDR

Portsmouth

1. Mortality Patterns Among Uranium Enrichment Workers at Portsmouth Gaseous Diffusion site, Robert Rinsky.
2. Building / Department Matrix developed for the NIOSH Mortality study.
3. JEM Analytical files and IH working files for Uranium, Fluorides, and Nickel developed by NIOSH (requested by UMass Lowell)
4. Urinalysis working data file (Uranium, gross alpha, fluorides, and other metals) (de-identified computer tape requested by UMass Lowell from NIOSH)
5. Mortality Among Uranium Enrichment Workers, Brown and Bloom, NIOSH, 1987.
6. Health Physics Survey Report of Portsmouth Gaseous Diffusion Plant, NIOSH 1987.

Paducah

1. IH records (1960-1986) however data is reported to be sparce between 1960 and 1970. Records are in paper form.
2. IH records (1986 – present) available in electronic form.
3. Health Physics External Radiation records (more than 500,000 individual records) available on microfiche
4. Health Physics Exposure estimates (1952 – present) available in paper form.
5. Health Physics internal dose estimates (1952 – present) available in paper form.
6. Health Physics internal dose whole body count raw data (1952 – present) available in paper form.
7. Health Physics urinalysis raw data (1952 – present); this includes approximately 107,000 urine sample results on cards through 1977 and from 1978 to present approximately 10,000 records per year on electronic media.

Appendix B: K-25 Urinalysis Data Analysis

K-25 Urinalysis Data Averages by Building (1955-1959)

	U	Fl	Hg	Alpha	Lead	TCA	Nickel
K-25	5.54	611.2	12.3	4933	20*	1800	104
K-413	6.4	998	0*	2721			
K-1004-L	4.43	733	13.8	1162		3182	81.3
K-1024	1.8	554	14.1	526	20*		0*
K-1030	1.64	517	25*	722			
K-1037	2.02	665	13.8	1162	23.3*		165
K-1131	13.8	1220	11.5	1338	40*		47
K-1231	6.9	787	16.6*	916			
K-1301,2,3	1.39	920	14*	3217	26*		
K-1401	1.36	522	11.9	528	23.9	5951*	65.7
K-1410	24.1	858	6.6*	5271			
K-1413	9.06	977	10.5	1253		1400*	150*
K-1420	8.35	668	14.3	1586	15	0*	

K-25 Urinalysis Data Averages by Building (1960 - 1964)

	U	Fl	Hg	Alpha	Lead	TCA	Nickel
K-25	11.06	809	9.4	7900	90*	4429	141
K-131	5.41	745		1048			
K-1004-L	11.01	767	11.5	1020	80*	3730	231
K-1024	3.89	647	8.43	496		1570	1030*
K-1037	4.39	864	11.3	493	0*		274
K-1131	18.74	1320	7.3	1950		0*	109*
K-1231	8.21	1026		801			
K-1301,2,3	4.33	871	8	750			0*
K-1401	4.3	716	13.6	608	27.1	1734	202
K-1413	21.3	957	11.9	1634		1666	171
K-1420	15.6	918	7.5	5671	30*		123*

K-25 Urinalysis Data Averages[1] Reported by Priority Department 1948 – 1954

	U	Fl	Hg	Alpha	Be	Pb	Pu	TCA	Ni	Tc
	(µg/liter)	(µg/liter)	(µg/liter)	1E-3 cpm/100 ml	(µg/liter)	(µg/liter)	1E-3 cpm/24 hr	(µg/liter)	(µg/liter)	
1795										
1794										
1785										
1770	52.4	565	12.3 (2)	1847				2000 (2)		
1751										
1730	29.8	356	26.3	5088	5000 (2)					
1726	8.71	434	34.1	1254						
1606										
1602										
1340										
1273										
1272										
1269										
1262	4.3	237	27.9	1230						
1077	3.98	230	19.2	481		39 (2)				
1075	2.69	252	31.5	733						
1072										
1060	4.94	480	31.0	537						
1035	0.53	372	29 (2)	240						
1027	1.92	346	15 (2)	388						
1025	0.76	622	58	357		50 (2)				
1012	0.59	229	23.3 (2)	359						
1005	4.57	253	14.2 (2)	859	23.3 (2)	88				
1002	7.7	516	11.3 (2)	1297			6.66 (2)			

(1) All values in the table represent averages of all urine samples during the time period. Conservatively, any value reported as less than an MDA was assigned 0.
(2) Total number of samples less than 20.

K-25 Urinalysis Data Averages[1] Reported by Priority Department
1955 – 1959

	U	Fl	Hg	Alpha	Be	Pb	Pu	TCA	Ni	Tc
	(µg/liter)	(µg/liter)	(µg/liter)	1E-3 cpm/100 ml	(µg/liter)	(µg/liter)	1E-3 cpm/24 hr	(µg/liter)	(µg/liter)	
1795										
1794	1.51	565	10	567						
1785										
1770	9.9	1062		1397						
1751	13.6	1303	26 (2)	1288			0 (2)			
1730	17.7	691	20 (2)	3889						
1726	.83	651	15.3	522					169.3	
1606										
1602										
1340	3.2	706	10.4	650			0 (2)	2976	81.3	
1273	13.7	1646	3.3	772						
1272	3.9	821	10.4	229						
1269	10.4	702	16.8	2213						
1262	3.0	592	13.6	943			93.5	4510 (2)		
1077	2.05	597	30 (2)	920		30 (2)				
1075	5.4	644	12.9	1359					73	
1072										
1060	1.61	643	8.3	548						
1035										
1027										
1025	2.08	722	10 (2)	635		34				
1012	3.57	598		721					0 (2)	
1005	4.79	743	13.8 (2)	1178		29.4			164	
1002	10.10	835	8.9 (2)	3431		24 (2)			112	

(1) All values in the table represent averages of all urine samples during the time period. Conservatively, any value reported as less than an MDA was assigned 0.
(2) Total number of samples less than 20.

K-25 Urinalysis Data Averages(1) Reported by Priority Department 1965 - 1969

	U	Fl	Hg	Alpha	Be	Pb	Pu	TCA	Ni	Tc
	(µg/liter)	(µg/liter)	(µg/liter)	1E-3 cpm/100 ml	(µg/liter)	(µg/liter)	1E-3 cpm/24 hr	(µg/liter)	(µg/liter)	
1795										
1794										
1785	4.99	1441	10.3	2797						
1770										
1751										
1730	17.8	1100	0 (2)	2759						
1726	1.28	1224	14 (2)	1334					23.3	
1606										
1602										
1340	4.99	1106	13.7	555					30.7	0 (2)
1273										
1272	1.53	1113	13.8							
1269										
1262										
1077	1.88	1142	0 (2)	525					18.3 (2)	
1075	2.21	1100	12.2 (2)	869					40 (2)	
1072										
1060										
1035										
1027										
1025	4.92	890	13.1	892		25 (2)				
1012										
1005										
1002	3.24	1180	5.55 (2)	685		39 (2)			18.6 (2)	

(1) All values in the table represent averages of all urine samples during the time period. Conservatively, any value reported as less than an MDA was assigned 0.
(2) Total number of samples less than 20.

K-25 Urinalysis Data Averages(1) Reported by Priority Department
1970 – 1974

	U	Fl	Hg	Alpha	Be	Pb	Pu	TCA	Ni	Tc
	(µg/liter)	(µg/liter)	(µg/liter)	1E-3 cpm/100 ml	(µg/liter)	(µg/liter)	1E-3 cpm/24 hr	(µg/liter)	(µg/liter)	
1795										
1794										
1785										
1770										
1751										
1730	25.8	1434		5123						
1726	2.29	1232		213					22 (2)	
1606										
1602										
1340	4.25	1161	6.6	865					7.3	
1273										
1272										
1269										
1262										
1077	2.56			482						
1075	5.87			1455						
1072										
1060										
1035										
1027										
1025	5.27	1216 (2)	8.33 (2)	882						
1012	3.11			2298						
1005										
1002	6.32	1333 (2)		1167						

(1) All values in the table represent averages of all urine samples during the time period. Conservatively, any value reported as less than an MDA was assigned 0.
(2) Total number of samples less than 20.

K-25 Urinalysis Data Averages[1] Reported by Priority Department
1975 – 1979

	U	Fl	Hg	Alpha	Be	Pb	Pu	TCA	Ni	Tc
	(µg/liter)	(µg/liter)	(µg/liter)	1E-3 cpm/100 ml	(µg/liter)	(µg/liter)	1E-3 cpm/24 hr	(µg/liter)	(µg/liter)	
1795										
1794										
1785	10.2	1117	.54	1052					52.5	1089
1770										
1751										
1730	26.6	891		3322					23.8	1045
1726										
1606	32.3	1106	2.9 (2)	2361					90.5	909
1602										
1340										
1273										
1272										
1269										
1262										
1077										
1075										
1072	4.15	756		316					17	713
1060										
1035	6.11	871		590						958
1027										
1025										
1012	5.7	848	0 (2)	832						640
1005										
1002	9.21	804		1129					27	1229

(1) All values in the table represent averages of all urine samples during the time period. Conservatively, any value reported as less than an MDA was assigned 0.
(2) Total number of samples less than 20.

K-25 Urinalysis Data Averages[1] Reported by Priority Department
1980 – 1985

	U	Fl	Hg	Alpha	Be	Pb	Pu	TCA	Ni	Tc
	(µg/liter)	(µg/liter)	(µg/liter)	1E-3 cpm/100 ml	(µg/liter)	(µg/liter)	1E-3 cpm/24 hr	(µg/liter)	(µg/liter)	
1795	1.3	763		514					9.6	308
1794										
1785	4.8	982	.15	770					4.1	1045
1770										
1751										
1730	6.48	1018		1300					4.1	422
1726										
1606	1.1	1071		300					5.1	
1602	0 (2)	1007		0 (2)					15.3	3000 (2)
1340										
1273										
1272										
1269										
1262										
1077	2.0	775		142 (2)		9.3				133 (2)
1075	2.9	694		1856						867
1072	2.6	893	0 (2)	386		0 (2)			3.04	400
1060										
1035	3.5	913		570		7.9				766
1027										
1025	2.1	893		423					6.6	470
1012										
1005										
1002	3.44	912	0 (2)	704					2.5	2580

(1) All values in the table represent averages of all urine samples during the time period. Conservatively, any value reported as less than an MDA was assigned 0.
(2) Total number of samples less than 20.

Analysis of Urinalysis Data (1954-1959) by percentage exceeding threshold values

Bldg #		Flourides						Mercury			
	Total #	#> 1.5mg/l	#>3.0mg/l	%> 1.5mg/l	%>3.0mg/l	Total #	#>5 microg/l	#>20 mircorg/l	#>50 microg/l	%>20 mircorg/l	%>50 microg/l
K-25	2704	277	30	10.2	1.1	279	164	97	9	34.8	3.2
K-413	87	17	3	19.5	3.4	1				0.0	0.0
K-1004-L	554	74	6	13.4	1.1	280	171	97	12	34.6	4.3
K-1024	634	49	4	7.7	0.6	558	347	178	28	31.9	5.0
K-1030	330	19	2	5.8	0.6	2				0.0	0.0
K-1037	1911	232	24	12.1	1.3	242	148	88	10	36.4	4.1
K-1131	2180	685	125	**31.4**	**5.7**	104	63	25	6	24.0	5.8
K-1231	501	89	13	17.8	2.6	9				0.0	0.0
K-1301,2,3	163	30	5	18.4	3.1	10				0.0	0.0
K-1401	4054	309	32	7.6	0.8	329	192	101	12	30.7	3.6
K-1410	76	16	4	21.1	5.3	3				0.0	0.0
K-1413	494	122	18	24.7	3.6	21	8	5	2	23.8	9.5
K-1420	2975	361	47	12.1	1.6	56	31	15	3	26.8	5.4

freq_anall50sbldg

Analysis of Urinalysis Data (1960-1964) by percentage exceeding threshold values

Bldg #		Flourides						Mercury			
	Total #	#> 1.5mg/l	#>3.0mg/l	%> 1.5mg/l	%>3.0mg/l	Total #	#>5 microg/l	#>20 mircorg/l	#>50 microg/l	%>20 mircorg/l	%>50 microg/l
K-25	1039	117	8	11.3	0.8	96	47	97	3	101.0	3.1
K-131	180	19	0	10.6	0.0	0				#DIV/0!	#DIV/0!
K-1004-L	338	33	0	9.8	0.0	228	117	65	11	28.5	4.8
K-1024	135	9	0	6.7	0.0	229	110	54	1	23.6	0.4
K-1037	567	93	2	16.4	0.4	38	17	10	3	26.3	7.9
K-1131	707	220	38	**31.1**	**5.4**	30	16	6	0	20.0	0.0
K-1231	161	34	4	21.1	2.5	0				#DIV/0!	#DIV/0!
K-1301,2,3	103	11	2	10.7	1.9	21	10	6	1	28.6	4.8
K-1401	726	57	4	7.9	0.6	138	81	45	3	32.6	2.2
K-1413	244	48	2	19.7	0.8	16	9	7	0	43.8	0.0
K-1420	1044	123	14	11.8	1.3	64	28	13	2	20.3	3.1

freq_anale60sbldg

Summary of K-25 Urinalysis Data by Dept: 1948 - 1955

Dept #		Fluorides				Mercury				Nickel	
	Total #	# > 1.5mg/l	# > 3mg/l	Total #	# > 5microg/l	# > 20microg/l	# > 50microg/l	Total #	# > 10microg/l	# > 50microg/l	# > 100microg/l
1001	103	1	0								
1002	1935	209	36								
1003	317	3	1	250	220	177	60				
1004	252	7	1								
1005	902	29	4								
1012	58	0	0								
1013	92	1	0								
1015	0	0	0								
1018	0	0	0								
1022	42	1	0								
1025	115	9	4								
1027	5	0	0								
1030	1	0	0								
1031	99	4	0								
1035	13	0	0								
1037	0	0	0								
1060	0	0	0	51	46	37	4				
1072	0	0	0								
1073	1	0	0								
1075	1323	22	2	1227	1025	820	210				
1077	763	19	2								
1078	0	0	0								
1080	14	0	0								
1081	0	0	0								
1088	0	0	0								
1093	12	0	0								
1105	4	0	0								
1261	0	0	0	0	0	0	0				
1262	678	10	0	407	350	275	74				
1264	771	9	1	297	257	201	48				
1265	50	1	0	13	12	10	3				
1269	150	18	1								
1271	21	0	0	30	28	22	1				
1272	13	0	0	6	6	6	0				
1273	5	0	0								
1315	420	10	2								
1322	0	0	0	0	0	0	0				
1324	0	0	0	0	0	0	0				
1325	0	0	0	0	0	0	0				
1327	0	0	0								
1332	0	0	0								
1340	212	3	0	103	100	76	17				
1342	0	0	0								
1344	0	0	0								
1345	0	0	0								
1346	0	0	0								
1602	0	0	0								
1603	0	0	0								
1606	3	0	0								
1726	685	32	4	175	152	131	46				
1728	187	13	6								
1730	581	29	6								
1748	132	8	2								
1751	856	273	75								
1753	48	1	0								
1754	8	0	0								
1760	529	38	10								
1770	479	26	5								
1785	21	2	1	0	0	0	0				
1794	4	0	0								
1795	0	0	0								

tab_deptse50s

Summary of K-25 Urinalysis Data by Dept: 1955 - 1959

Dept #	Fluorides			Mercury				Nickel			
	Total #	# > 1.5mg/l	# > 3mg/l	Total #	# > 5microg/l	# > 20microg/l	# > 50microg/l	Total #	# > 10microg/l	# > 50microg/l	# > 100microg/l
1001	482	22	2					6	1	1	1
1002	4065	647	99					35	24	21	8
1003	45	1	0	1	1	0	0				
1004	409	7	2								
1005	1855	251	39					43	32	29	21
1012	224	23	1								
1013	264	15	3								
1015	0	0	0					0	0	0	0
1018	0	0	0					0	0	0	0
1022	50	1	1								
1025	95	10	1					0	0	0	0
1027	452	23	6								
1030	28	2	1					0	0	0	0
1031	276	10	1								
1035	522	40	4								
1037	268	18	3								
1060				59	28	10	2				
1072	0	0	0					0	0	0	0
1073	0	0	0								
1075	2079	144	19	1790	1126	641	98				
1077	2124	173	17								
1078	382	28	3								
1080	310	21	1								
1081	4	0	0								
1088								0	0	0	0
1093	319	33	2								
1105	0	0	0								
1261	21	2	0	30	19	9	0				
1262	748	65	9	595	372	215	30				
1264	66	3	0	18	18	17	7				
1265	22	2	1	17	7	4	1				
1269	3423	440	55								
1271	25	3	0	1	0	0	0				
1272	19	1	0	24	14	6	1				
1273	137	54	13								
1315	24	3	0								
1322	0	0	0	0	0	0	0	0	0	0	0
1324	0	0	0	0	0	0	0	0	0	0	0
1325	0	0	0	0	0	0	0	0	0	0	0
1327											
1332	0	0	0								
1340	699	85	6	208	112	61	4	67	46	39	21
1342	0	0	0					0	0	0	0
1344	0	0	0					0	0	0	0
1345	0	0	0								
1346	0	0	0								
1602	0	0	0					0	0	0	0
1603								0	0	0	0
1606	0	0	0					0	0	0	0
1726	1342	167	15	203	134	89	11	604	427	369	274
1728	1	0	0								
1730	1031	115	16					0	0	0	0
1748	166	39	5								
1751	1048	374	58								
1753	196	30	2					0	0	0	0
1754	0	0	0								
1760	0	0	0								
1770	411	106	14								
1785	0	0	0	0	0	0	0	0	0	0	0
1794	415	28	1								
1795	0	0	0					0	0	0	0

tab_deptsl50s

Summary of K-25 Urinalysis Data by Dept.: 1960 - 1964

Dept #	Fluorides Total #	Fluorides # > 1.5mg/l	Fluorides # > 3mg/l	Mercury Total #	Mercury # > 5microg/l	Mercury # > 20microg/l	Mercury # > 50microg/l	Nickel Total #	Nickel # > 10microg/l	Nickel # > 50microg/l	Nickel # > 100microg/l
1001	50	5	1					0	0	0	0
1002	1528	287	31					25	16	12	10
1003	0	0	0	0	0	0	0				
1004	0	0	0								
1005	479	48	1					47	30	22	15
1012	181	12	1								
1013	27	0	0								
1015	0	0	0					0	0	0	0
1018	0	0	0					0	0	0	0
1022	3	0	0								
1025	34	1	1					0	0	0	0
1027	29	2	0								
1030	15	2	1					0	0	0	0
1031	0	0	0								
1035	107	12	1								
1037	24	2	1								
1060				73	42	17	0				
1072	0	0	0					0	0	0	0
1073	0	0	0								
1075	413	50	2	426	211	104	4				
1077	308	34	0								
1078	0	0	0								
1080	35	3	0								
1081	2	1	0								
1088								0	0	0	0
1093	106	10	0								
1105	794	73	2								
1261	100	5	0	183	80	42	3				
1262	0	0	0	0	0	0	0				
1264	57	3	0	0	0	0	0				
1265	171	22	0	77	48	32	4				
1269	807	107	14								
1271	199	26	1	27	7	2	0				
1272	167	17	0	204	111	60	7				
1273	507	143	25								
1315	0	0	0								
1322	0	0	0	0	0	0	0	0	0	0	0
1324	0	0	0	0	0	0	0	0	0	0	0
1325	0	0	0	0	0	0	0	0	0	0	0
1327								0	0	0	0
1332	0	0	0								
1340	687	80	5	295	131	70	9	245	164	100	74
1342	0	0	0					0	0	0	0
1344	0	0	0					0	0	0	0
1345	0	0	0								
1346	0	0	0								
1602	0	0	0					0	0	0	0
1603								0	0	0	0
1606	0	0	0					0	0	0	0
1726	338	60	2	33	15	10	2	429	328	243	197
1728	0	0	0								
1730	662	103	4					0	0	0	0
1748	105	12	0								
1751	2	0	0								
1753	219	25	0					0	0	0	0
1754	15	2	0								
1760	0	0	0								
1770	184	44	2								
1785	64	16	2	34	8	4	0	1	0	0	0
1794	0	0	0								
1795	10	1	0					0	0	0	0

tab_deptse60s

Summary of K-25 Urinalysis Data by Dept.: 1965 - 1969

Dept #	Fluorides			Mercury				Nickel			
	Total #	# > 1.5mg/l	# > 3mg/l	Total #	# > 5microg/l	# > 20microg/l	# > 50microg/l	Total #	# > 10microg/l	# > 50microg/l	# > 100microg/l
1001	1	0	0					0	0	0	0
1002	41	12	0					14	6	2	0
1003	0	0	0	0	0	0	0				
1004	0	0	0								
1005	0	0	0					0	0	0	0
1012	0	0	0								
1013	6	1	0								
1015	50	6	0					0	0	0	0
1018	0	0	0					0	0	0	0
1022	2	1	0								
1025	20	2	0					0	0	0	0
1027	0	0	0								
1030	0	0	0					0	0	0	0
1031	0	0	0								
1035	0	0	0								
1037	0	0	0								
1060				0	0	0	0				
1072	0	0	0					0	0	0	0
1073	0	0	0								
1075	7	1	0	9	5	3	0				
1077	12	4	0								
1078	0	0	0								
1080	7	0	0								
1081	20	5	0								
1088								0	0	0	0
1093	0	0	0								
1105	0	0	0								
1261	0	0	0	0	0	0	0				
1262	0	0	0	0	0	0	0				
1264	0	0	0	0	0	0	0				
1265	1	0	0	0	0	0	0				
1269	0	0	0								
1271	13	1	1	51	21	11	1				
1272	85	1	1	✓ 141	94	52	8				
1273	0	0	0								
1315	0	0	0								
1322	0	0	0	0	0	0	0	0	0	0	0
1324	6	0	0	15	11	6	0	0	0	0	0
1325	23	0	0	34	22	12	0	0	0	0	0
1327								0	0	0	0
1332	0	0	0								
✓ 1340	327	79	5	30	21	9	2	✓ 108	66	18	2
1342	0	0	0					0	0	0	0
1344	0	0	0					0	0	0	0
1345	0	0	0								
1346	0	0	0								
1602	0	0	0					0	0	0	0
1603								0	0	0	0
1606	0	0	0					0	0	0	0
✓ 1726	82	24	1	5	2	2	1	✓ 42	28	6	0
1728	0	0	0								
1730	45	11	1					0	0	0	0
1748	0	0	0								
1751	0	0	0								
1753	15	6	0					0	0	0	0
✓ 1754	37	20	1								
1760	0	0	0								
1770	0	0	0								
✓ 1785	125	52	1	33	19	9	0	0	0	0	0
1794	0	0	0								
1795	0	0	0					0	0	0	0

tab_deptsl60s

Summary of K-25 Urinalysis Data by Dept.: 1970 - 1974

Dept #	Fluorides Total #	Fluorides # > 1.5mg/l	Fluorides # > 3mg/l	Mercury Total #	Mercury # > 5microg/l	Mercury # > 20microg/l	Mercury # > 50microg/l	Nickel Total #	Nickel # > 10microg/l	Nickel # > 50microg/l	Nickel # > 100microg/l
1001	0	0	0					0	0	0	0
1002	3	1	0					0	0	0	0
1003	0	0	0	0	0	0	0				
1004	0	0	0								
1005	0	0	0					0	0	0	0
1012	0	0	0								
1013	4	2	1								
1015	0	0	0					0	0	0	0
1018	0	0	0					0	0	0	0
1022	1	0	0								
1025	6	2	0					0	0	0	0
1027	0	0	0								
1030	0	0	0					0	0	0	0
1031	0	0	0								
1035	0	0	0								
1037	0	0	0								
1060				0	0	0	0				
1072	0	0	0					0	0	0	0
1073	0	0	0								
1075	0	0	0	0	0	0	0				
1077	0	0	0								
1078	0	0	0								
1080	0	0	0								
1081	0	0	0								
1088								0	0	0	0
1093	0	0	0								
1105	0	0	0								
1261	0	0	0	0	0	0	0				
1262	0	0	0	0	0	0	0				
1264	0	0	0	0	0	0	0				
1265	0	0	0	0	0	0	0				
1269	0	0	0								
1271	0	0	0	0	0	0	0				
1272	0	0	0	0	0	0	0				
1273	0	0	0								
1315	0	0	0								
1322	0	0	0	0	0	0	0	0	0	0	0
1324	27	7	0	44	9	1	0	0	0	0	0
1325	66	13	3	93	33	5	1	0	0	0	0
1327								0	0	0	0
1332	0	0	0								
1340	119	25	3	21	7	2	1	22	1	1	1
1342	24	9	1					5	3	2	1
1344	29	7	0					7	5	4	4
1345	35	18	4								
1346	14	3	0								
1602	0	0	0					0	0	0	0
1603								0	0	0	0
1606	23	5	0					11	11	8	7
1726	129	38	5	0	0	0	0	14	3	2	1
1728	0	0	0								
1730	120	37	7					0	0	0	0
1748	0	0	0								
1751	0	0	0								
1753	1	0	0					0	0	0	0
1754	4	2	1								
1760	0	0	0								
1770	0	0	0								
1785	4	1	0	52	7	1	0	0	0	0	0
1794	0	0	0								
1795	0	0	0					0	0	0	0

Summary of K-25 Urinalysis Data by Dept.: 1975 - 1979

Dept #	Fluorides			Mercury				Nickel			
	Total #	# > 1.5mg/l	# > 3mg/l	Total #	# > 5microg/l	# > 20microg/l	# > 50microg/l	Total #	# > 10microg/l	# > 50microg/l	# > 100microg/l
1001	114	10	0					22	16	6	1
1002	505	59	5					29	24	2	0
1003	0	0	0	0	0	0	0				
1004	0	0	0								
1005	0	0	0					0	0	0	0
1012	21	4	0								
1013	5	1	0								
1015	55	4	0					52	45	16	5
1018	2931	349	26					64	48	7	1
1022	324	35	1								
1025	568	50	1					30	21	8	4
1027	0	0	0								
1030	72	7	0					40	30	7	4
1031	0	0	0								
1035	713	119	13								
1037	0	0	0								
1060				0	0	0	0				
1072	767	86	7					35	24	2	0
1073	981	133	4								
1075	12	2	0	0	0	0	0				
1077	12	4	0								
1078	340	29	2								
1080	0	0	0								
1081	0	0	0								
1088								14	10	3	3
1093	8	1	0								
1105	0	0	0								
1261	0	0	0	0	0	0	0				
1262	0	0	0	0	0	0	0				
1264	0	0	0	0	0	0	0				
1265	0	0	0	0	0	0	0				
1269	0	0	0								
1271	0	0	0	0	0	0	0				
1272	0	0	0	0	0	0	0				
1273	0	0	0								
1315	3	1	0								
1322	0	0	0	0	0	0	0	0	0	0	0
1324	272	25	1	76	4	2	0	31	24	5	0
1325	248	30	6	203	34	7	5	70	44	10	0
1327								0	0	0	0
1332	378	33	1								
1340	1	0	0	0	0	0	0	0	0	0	0
1342	64	7	2					23	16	4	1
1344	115	24	1					34	22	3	0
1345	48	6	3								
1346	10	2	0								
1602	130	22	2					112	88	31	10
1603								62	50	34	22
1606	551	142	25					183	95	63	48
1726	0	0	0	0	0	0	0	0	0	0	0
1728	0	0	0								
1730	524	71	5					58	42	6	0
1748	0	0	0								
1751	0	0	0								
1753	355	26	3					11	8	0	0
1754	11	1	0								
1760	0	0	0								
1770	0	0	0								
1785	1303	284	73	133	6	1	0	300	260	123	29
1794	0	0	0								
1795	332	26	0					31	23	7	0

tab_deptsl70s

Summary of K-25 Urinalysis Data by Dept.: 1980 - 1985

Dept #	Fluorides			Mercury				Nickel			
	Total #	# > 1.5mg/l	# > 3mg/l	Total #	# > 5microg/l	# > 20microg/l	# > 50microg/l	Total #	# > 10microg/l	# > 50microg/l	# > 100microg/l
1001	598	86	4					114	43	1	0
1002	1461	235	15					102	8	0	0
1003	0	0	0	0	0	0	0				
1004	0	0	0								
1005	0	0	0					0	0	0	0
1012	117	12	0								
1013	38	3	0								
1015	55	5	1					54	26	2	1
1018	4487	545	46					49	15	1	0
1022	768	86	4								
1025	1447	207	14					67	17	0	0
1027	0	0	0								
1030	354	34	0					128	21	0	0
1031	0	0	0								
1035	1113	163	14								
1037	0	0									
1060				0	0	0	0				
1072	2561	358	19					199	20	0	0
1073	1256	190	14								
1075	16	0	0	0	0	0	0				
1077	17	2	0								
1078	1130	173	4								
1080	0	0	0								
1081	0	0	0								
1088								59	5	0	0
1093	16	4	0								
1105	0	0	0								
1261	0	0	0	0	0	0	0				
1262	0	0	0	0	0	0	0				
1264	0	0	0	0	0	0	0				
1265	0	0	0	0	0	0	0				
1269	0	0	0								
1271	0	0	0	0	0	0	0				
1272	0	0	0	0	0	0	0				
1273	0	0	0								
1315	1	0	0								
1322	1012	118	8	124	1	0	0	78	3	0	0
1324	294	40	0	36	1	0	0	36	8	0	0
1325	154	18	1	109	4	0	0	108	28	0	0
1327								62	3	0	0
1332	1446	157	11								
1340	0	0	0	0	0	0	0	0	0	0	0
1342	43	0	0					35	4	0	0
1344	412	40	0					129	18	0	0
1345	0	0	0								
1346	0	0	0								
1602	40	9	1					36	23	1	0
1603								278	269	203	135
1606	87	30	6					81	17	1	0
1726	0	0	0	0	0	0	0	0	0	0	0
1728	0	0	0								
1730	2277	369	56					303	36	1	0
1748	0	0	0								
1751	0	0	0								
1753	1681	173	16					92	3	0	0
1754	7	0	0								
1760	0	0	0								
1770	0	0	0								
1785	2922	447	77	552	7	1	0	547	75	1	0
1794	0	0	0								
1795	273	32	2					44	18	0	0

tab_deptse80s

Appendix C: K-25 Building / Department Listings

C1: Priority Building / Department Listing
C2: Composite Priority Department Listing

Appendix C1: K-25 Building Department Listing identifying "priority" departments

Bldg #	Dept. Numbers	
K-25		
	1001	
	1002	*
	1005	
	1012	
	1013	
	1022	
	1023	
	1025	
	1027	
	1028	
	1031	
	1035	
	1036	*
	1037	
	1041	
	1042	
	1044	
	1060	
	1061	
	1075	*
	1077	*
	1078	
	1080	
	1081	
	1082	
	1088	
	1093	
	1105	*
	1108	
	1139	
	1140	
	1141	
	1142	
	1143	
	1144	
	1159	
	1160	
	1167	
	1200	
	1204	
	1210	
	1240	
	1262	
	1264	
	1265	
	1266	
	1267	
	1269	
	1272	
	1273	
	1340	
	1722	
	1726	

	1730	*
	1744	
	1745	
	1748	
	1751	
	1752	
	1753	
	1770	
	1779	
	1785	
K-27		
	1001	
	1002	
	1005	
	1012	
	1013	
	1027	
	1035	
	1044	
	1060	
	1075	
	1077	
	1078	
	1093	
	1105	
	1144	
	1269	
	1730	
	1751	
K-29		
	1001	
	1002	
	1005	
	1012	
	1013	
	1025	
	1042	
	1075	
	1077	
	1078	
	1093	
	1105	
	1269	
	1273	
	1730	
K-31		
	1001	
	1002	
	1005	
	1012	
	1013	
	1035	
	1044	

	1075	
	1077	
	1078	
	1088	
	1093	
	1105	
	1269	
	1726	
	1730	
K-33		
	1001	
	1002	
	1005	
	1007	
	1012	
	1013	
	1023	
	1025	
	1028	
	1030	
	1035	
	1041	
	1042	
	1044	
	1060	
	1075	
	1077	
	1078	
	1082	
	1093	
	1105	
	1142	
	1204	
	1262	
	1269	
	1273	
	1730	
K-1037, K-1100		
	1001	
	1002	*
	1003	
	1005	*
	1007	
	1012	
	1013	
	1023	
	1031	
	1035	
	1037	
	1044	
	1060	
	1075	*
	1077	*

	1078	
	1079	
	1093	
	1105	*
	1140	
	1159	
	1262	
	1265	
	1269	
	1273	
	1340	
	1726	*
	1762	
.		
K-1004-L		
	1001	
	1002	*
	1005	*
	1012	
	1013	
	1023	
	1025	
	1031	
	1037	
	1044	
	1060	
	1075	
	1077	
	1078	
	1100	
	1105	
	1260	
	1261	
	1262	*
	1265	
	1266	
	1269	
	1271	
	1272	*
	1340	*
	1730	
K-1420		
	1001	
	1002	
	1003	
	1005	*
	1007	
	1012	
	1013	
	1023	
	1025	
	1027	
	1028	
	1031	
	1033	

	1035	
	1036	
	1037	
	1041	
	1042	
	1044	
	1060	
	1061	
	1075	
	1077	
	1078	
	1079	
	1080	
	1093	
	1105	
	1108	
	1140	
	1142	
	1144	
	1245	
	1262	
	1264	
	1265	
	1267	
	1268	
	1269	*
	1271	
	1272	
	1273	
	1340	
	1730	
	1748	
	1750	
	1751	
	1753	
	1754	
	1770	
	1785	
K-1410		
	1002	
	1005	
	1008	
	1012	
	1023	
	1025	
	1035	
	1041	
	1042	
	1075	
	1077	
	1108	
	1269	*
	1273	*
	1751	

K-1401		
	1001	
	1002	
	1003	
	1004	
	1005	*
	1007	
	1008	
	1012	
	1013	
	1022	
	1023	*
	1025	*
	1027	*
	1028	*
	1030	
	1031	
	1035	*
	1036	
	1037	*
	1041	
	1042	
	1044	
	1060	
	1061	
	1075	
	1076	
	1077	*
	1078	
	1079	
	1080	
	1081	
	1082	
	1091	
	1093	
	1094	
	1105	
	1108	
	1140	
	1141	
	1142	
	1144	
	1262	
	1264	
	1265	
	1266	
	1269	
	1272	
	1273	
	1340	*
	1720	
	1726	
	1748	
	1751	
	1752	*
	1753	

	1759	
	1770	
	1779	
	1794	*
	1852	
K-1131		
	1001	
	1002	*
	1005	*
	1012	
	1013	
	1023	
	1035	
	1037	
	1041	
	1042	
	1044	
	1060	
	1061	
	1075	*
	1077	*
	1078	
	1079	
	1082	
	1088	
	1093	
	1105	
	1108	
	1140	
	1144	
	1160	
	1177	
	1262	
	1265	
	1269	
	1271	
	1273	*
	1340	
	1571	
	1726	
	1728	
	1730	
	1731	
	1748	*
	1750	
	1751	*
	1753	
K-1301,2,3		
	1001	*
	1002	
	1004	
	1005	*
	1013	
	1035	

	1044	
	1075	
	1077	
	1078	
	1105	
	1237	
	1262	
	1269	*
	1273	*
	1340	
	1726	
	1730	
	1743	
	1748	
	1751	
	1753	
	1754	
	1770	
K-1413		
	1001	
	1002	
	1005	*
	1012	
	1013	
	1023	
	1030	
	1031	
	1042	
	1075	
	1077	
	1078	
	1105	
	1144	
	1262	*
	1265	*
	1269	
	1340	*
	1730	
	1770	*
K-1231		
	1002	*
	1003	
	1005	*
	1012	
	1013	
	1028	
	1041	
	1042	
	1044	
	1075	
	1077	
	1078	
	1079	
	1093	

	1105	
	1269	*
	1273	*
	1340	
	1730	
	1751	
	1753	
	1770	
K-1004-A		
	1001	
	1003	
	1005	
	1012	
	1013	
	1025	
	1041	
	1075	
	1077	
	1078	
	1141	
	1261	
	1262	
	1264	
	1266	
	1271	
	1272	
	1340	
K-1004-B		
	1001	
	1005	
	1012	
	1075	
	1077	
	1140	
	1260	
	1262	
	1264	
	1265	
	1266	
	1271	
	1272	
	1340	
K-1004-C		
	1001	
	1002	
	1005	
	1012	
	1013	
	1041	
	1075	
	1077	
	1078	
	1105	

	1261	
	1262	
	1265	
	1266	
	1269	
	1271	
	1272	
	1340	
	1726	
K-1004-D		
	1001	
	1002	
	1005	
	1012	
	1023	
	1030	
	1042	
	1060	
	1075	
	1077	
	1078	
	1088	
	1093	
	1261	
	1262	
	1264	
	1265	
	1266	
	1271	
	1272	
	1340	
K-1024		
	1001	
	1005	
	1012	
	1025	
	1035	
	1042	
	1051	
	1060	
	1075	*
	1077	
	1078	
	1082	
	1105	*
	1142	
K-131		
	1001	
	1002	*
	1005	
	1012	
	1013	
	1023	

	1044	
	1075	
	1077	
	1078	
	1105	
	1144	
	1269	
	1730	
	1751	
	1753	
K-1004-J		
	1001	
	1002	
	1005	
	1012	
	1013	
	1075	
	1077	
	1078	
	1105	
	1262	
	1271	
	1272	
	1340	
K-1023		
	1002	
	1075	
K-413		
	1001	*
	1002	*
	1005	*
	1012	
	1025	
	1042	
	1044	
	1075	
	1077	*
	1078	
	1080	
	1105	
	1142	
	1144	
	1269	
	1730	*
	1750	
	1751	
K-1030		
	1002	
	1005	
	1012	
	1030	
	1075	

	1077	*				
	1078					
	1105					
	1108					
	1140					
	1770					
Centrifuge Complex	1330					
	1331					
	1332					
	1333					
	1334					
	1335					
	1336					
	1337					
	1338					
	1339					
	1016					
	1785					

* Indicates "priority dept." -- accounted for >5% of total urine samples for a given building during either time frame (1955-1959 or 1960 - 1964)

Appendix C-2: Priority Department Listing

Department Code	Department Name
1001	Janitors
1002	Cascade Maintenance Department
1003	Maintenance Shops
1004	Special Maintenance Shops
1005	Maintenance Utilities
1012	Building Department
1013	Grounds Department
1015	Chemical and Barrier Maintenance Department
1018	Project Maintenance Department
1022	Machine Shop Department
1025	Fabrication Shop Department
1027	Electrical Maintenance – Power Division
1030	Shop Services Department
1031	Equipment Shops Labor
1035	Equipment Shops
1037	Equipment Repair Shop Functions Include Assemble Special
1060	Plant Engineering
1072	Cascade Electrical and Instrument
1073	CIP/CUP Electrical and Instrument
1075	Instrument De0artment
1077	Electrical Maintenance
1078	Mechanical Utilities Maintenance
1080	Inspection Dept. Major Functions of Dept. Perform Required
1081	Mechanical and Nuclear Safety Inspections
1088	Industrial Hygiene Department
1093	Fire Department
1105	Recruiters Salary, Travel, Etc.
1261	Mass Spec. Department
1262	Works Laboratory Department
1263 (*)	Barrier Research Department
1264	Chemistry Research Department
1265	Physics Research Department
1269	Chemical Operation Labor Distribution
1271	Isotopic Analysis Department
1272	Barrier Test Dept. Acct. Recv. Direct & Indirect Charges Lab
1273	Feed and Chemicals Prod Payroll Only Account
1315	Centrifuge QC Services
1322	Analytical Chemistry
1324	Analytical Services
1325	Systems Services

1327	Avlis
1332	Test and Operations
1337 (*)	Centrifuge Materials
1340	Gaseous Diffusion Development
1342	Barrier Development
1344	Materials and System Development
1345	Production Barrier Development
1346	Instrumentation and Quality Assurance Development
1602	Turbine Maintenance
1603	Generator Maintenance
1606	Barrier Operations
1726	Barrier Tube Manufacturing
1728	Uranium Recovery From Convertors
1730	C-6516 Manufacturing
1748	Process Flow Laboratory
1751	Manufacture Of Normal And Depleted UF4 From Fluorine, Removal
1752 (*)	Y-12 Tool Grinding
1753	SS Material Handling – U-235 Separation
1754	Utilities Operations Department Administration
1760	Hazardous Material Disposal
1770	Converter Conditioning
1785	Chemical Operations Administration
1794	Converter Shop Department Employees Engaged In Convert
1795	Converter Shop

* Indicates Department that was not identified through review of Urinalysis Data.

Attachment 1

Job Exposure Information Sheet

Job Exposure Information Sheet

Chemical or Agent Name ____________________ Map dot # (from Step #2) ________ Date ____________

Map Identification Number ____________ Building or Area Name and Number __________________

Process Description ____

(In this blank put a general description of the process or processes. Note: If the hazard was found throughout the entire area or building just indicate that it was a General Area hazard)

Job Title or Classification (List the types of workers who would be in the area – example: maintenance, operators, etc.)	Level of Exposure (High, Med, Low)	Frequency of Exposure (Sometimes, Always)	Comments (Any special information such as time period during which hazard existed, accidents, or incidents)

Attachment 2

Building Characteristics Reporting Form

Outline for Risk Mapping Session Reports

I. Site Name
II. Building Name and Number
III. Date the Session was conducted
IV. Investigators Names
V. Number of Participants
VI. Summary of Participants Work Histories

(In a paragraph or two describe the participants job titles, nature of their work, and years of experience – participants should not be identified by name in this description)

VII. Description of major processes or operations

VIII. Describe the major exposures that took place within the building

IX. Describe the Workforce within the Building

X. Other Information of Interest

(This section may include accidents, incidents, information regarding the changes which took place over time within a building, etc.)

NOTE: The information reported above should be based on the risk mapping sessions not on any personal knowledge or information obtained outside the session.

Risk Mapping Session Report

I. Site Name ______________________________

II. Building Name and Number ______________________________

III. Date the Session was conducted ________________

IV. Investigators Names ____

V. Number of Participants ________

VI. Summary of Participants Work Histories

VII. Description of major processes or operations

VIII. Describe the major exposures that took place within the building

IX. Describe the Workforce within the Building

X. Other Information of Interest

FOCUS GROUP RESULTS

MEDICAL SURVEILLANCE FOR FORMER NUCLEAR WORKERS: TARGET COMMUNITY PERSPECTIVES AND EMERGING ISSUES

PRELIMINARY REPORT ON FOCUS GROUPS HELD AT THREE DOE SITES

Elizabeth Averill Samaras, RN, MSN
Alice Hamilton College of the OCAW

September 2, 1997

TABLE OF CONTENTS

EXECUTIVE SUMMARY

In 1996, under the mandate of Section 3162 of the Defense Reauthorization Act of 1993, the OCAW received a one-year grant from the Department of Energy. The purpose was to assist the Department in determining the need for, and design of, medical surveillance programs for its former workers. Former workers from the gaseous diffusion plants at Oak Ridge, Portsmouth and Paducah were invited to participate in a series of Focus Groups designed to gain their perspective, as part of the Phase I Health Needs Assessment process. Sixty-nine individuals, predominantly retirees with many years of service, participated in these sessions. Worker Investigators (OCAW OSHECS, representatives, and selected retirees) were integral members of the Focus Group research team serving as session moderators, recruiters, scribes and coordinators. Each session focused on a range of questions dealing with health concerns, perception of risk, health care utilization and preferences outreach mechanisms and the ways participants gain their information about health.

Various themes emerged as a result of this effort. Several of these were consistent across all sites. One was a widely held perception of being at-risk, both personally and as a group. Another was the looming sense of uncertainty of causation for some of their major health conditions. Distrust with what they were told about their former exposures and by the medical establishment was also a prominent theme. Limitations on insurance coverage (inadequacy, escalating costs, and lack of choice) are intimately tied to workers' perception of vulnerability. Discussions surrounding insurance coverage such as equity of plans, co-payments, and the inability to get some basic services such as a physical exams covered were highly charged and of particular interest to the Portsmouth group.

Participants reported a wide range of exposures. Asbestos was the single most widely reported hazard by participants in all sessions. Other frequently reported exposures included radiation, assorted solvents and heavy metals, several fluoride compounds (including HF acid), PCBs and a host of other toxicants. Noise induced hearing loss was a universal occupational health concern among the hourly workers in these sessions.

One of the central topics under consideration during the Focus Groups dealt with participants' vision and preferences for an Occupational Health program designed to suit their needs. In general, these include accessibility, low or no-cost, the involvement of participants' personal physician, regular/periodic exams, truthfulness in communications and choice. One individual expressed the unwillingness to be involved in programs that simply identified problems without providing appropriate follow-up and treatment. Some participants feared that the government might create roadblocks that would limit the success of the program and felt that the "burden of proof" would prove a barricade to participation. The setting and the choice of who runs the program, are factors that would likely influence their decision to take part in offered programs.

The Focus Group process yielded a wealth of information regarding the best way to contact participants, their current sources of health information and the health care facilities that they prefer. Having an understanding of specific mechanisms by which to notify and offer health education to prospective participants of our future surveillance and risk communication efforts will improve our ability to successfully execute those aspects of the Phase II project. Recommendations for Phase II implementation include:

1. Phase II programs need to be accessible (geographically as well as financially) to participants.
2. To be most effective, notification and risk-communication efforts should focus on the specific mechanisms articulated by the target community.
3. Participants' primary physicians must be integrally involved in all aspects of the program.
4. Addressing pressing insurance issues as part of the Phase II initiative would serve participants' perceived interests.
5. Further Focus Groups would be valuable in determining the utility, validity and acceptability of the implementation of various program elements.

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INTRODUCTION

In 1996, under the mandate of Section 3162 of the Defense Reauthorization Act of 1993, the OCAW received a one-year grant from the Department of Energy. The purpose was to assist the Department in determining the need for, and design of, medical surveillance programs for its former workers. Former workers from the gaseous diffusion plants at Oak Ridge, Portsmouth and Paducah were invited to participate in a series of Focus Groups designed to gain their perspective, as part of the Phase I Health Needs Assessment process.

With the exception of surveys, group processes are the most frequent method for gathering opinions and data as part of the Needs Assessment (NA) process (Witkin and Altschuld, 1995, p. 153). Some advantages of group processes are that they are typically more dynamic and less rigidly constructed than questionnaires. They are particularly important vehicles to elicit the viewpoint of the relevant stakeholders directly and in their own "voice".

The Focus Group is one such group process that has proven valuable in the NA process. It is a qualitative research method of group interviewing born in the late 1930's, with the first published work in 1946 by Robert Merton (Morgan, 1988, p.11). Focus Groups are group interviews typically comprised of 8-14 participants. The purpose is to obtain an in depth perspective on a limited number of topics. Although there are a narrow range of topics under consideration, Focus Group process relies on the interaction of the group, rather than a strict adherence to researchers' questions. It is therefore a relatively non-directive means of interviewing which emphasizes the interviewees rather than interviewer. The structure of the Focus Group, with a specific "focus", or selected questions, allows for a narrowing of the field of inquiry, as compared with other qualitative methods such as participant observation. Participants in Focus Groups are typically selected for relative homogeneity in accordance with the issues of interest (age, sex, work status, etc.). They are particularly well suited for eliciting the range of perceptions of participants, rather than achieving consensus (Witkin and Altschuld,1995; Greenbaum, 1993; Morgan,1988).

Focus Groups have found their ascendancy in market research to identify consumer habits and usage, to aid in new product development and in positioning studies (Morgan, 1988; Greenbaum, 1993). They are very versatile and have been a useful resource in education, business and social science research as a means of eliciting attitudes and perception on a range of topics. There is also precedent for their use in health (perception) research (i.e. Morgan and Spanish,1985; and Bach and McDaniel,1993; Borges, Mullen et. al.,1993 as cited by Lewis,1996). As part of the Phase I Health Needs Assessment process, we undertook a series of Focus Groups at each of the three sites under investigation.

OBJECTIVES

The specific objectives of the Focus Groups were:

1) To gain input from the target community of former DOE gaseous diffusion plant workers;
2) To describe their perception of health-related risk, problems and needs, particularly in light of their work experiences;
3) To determine the target population's health habits and health care utilization and preferences;
4) To determine the desirability and expectations of Occupationally–related Medical Surveillance Programs; and
5) To determine effective channels for notification and education of the target population for Phase II efforts.

METHODS

General Description

Two Focus Groups were held at each of the three sites under study: Portsmouth, Paducah and Oak Ridge. Sessions were held in the respective OCAW union hall at each site. A range of eight to seventeen individuals participated in each session. The OCAW retiree members of the field team, using a recruiting script, primarily recruited subjects. Other OCAW field team members provided additional recruitment support.

The OCAW Occupational Safety and Health Education Coordinator (OSHEC) at each site served as the session moderator using a formal Moderator Guide to assist the process. In preparation for their role as moderator, moderators participated in a daylong training seminar and role-play, as well as contributed to the formulation of the Moderator Guide. Elements covered in the training included: introductions and setting tone, facilitation skills, avoidance of "leading" questions or expressing bias, establishing a "safe" and respectful atmosphere, and other group process skills. The importance of creating a climate of confidentiality was stressed (see copy of the Moderator Guide and Training Materials in Appendix A).

Another OCAW representative served as the scribe for each session -- reporting highlights on flip charts during the group discussion. Elizabeth Samaras, RN, MSN served as the rapporteur for each session. All participants received a participant information sheet and signed informed consent forms that had been read aloud to the group before the session. The sessions were audio taped with the full knowledge and consent of participants.

Sampling

One group at each site was comprised of "experts" selected by the Local Union Officers and OCAW field staff due to their knowledge of the plant and familiarity with plant operations. This was in part due to the fact that these individuals also participated in the subsequent risk mapping sessions at Oak Ridge and Portsmouth, which benefited tremendously from the institutional memory of this group. There was also a significant delay in the provision of lists from which randomized groups could be selected, so we moved forward initially with this expert, convenience sample.

Well into the Phase I grant year we finally received lists from each site. We received a roster of 1000 retirees from LMUS (Paducah), ORISE provided both a separated and retiree roster for the Oak Ridge site and a DOE representative provided LMUS lists of retirees and separated workers from Portsmouth. (In one case, Paducah, the costs quoted by the contractor to provide those lists were prohibitive ($115,000). Therefore, for the separated workers at Paducah, we relied upon OCAW rosters of separated workers.) Both types of rosters had flaws. In the case of the retiree lists, they were not current, and many on the list had died or moved. The separated rosters that we received were fraught with problems, as well. For example, the company had rehired many on the OCAW lists as salaried employees, so they were no longer "former workers". Many from the other separated lists had taken jobs elsewhere and were inaccessible or unavailable for participation. Participants were randomly selected from the rosters of "separated" and "retired" using a pseudo-random number generator. We originally planned to hold an entire session at each site comprised of non-retired, "separated" workers. Due to the problems with the rosters and poor participation from the non-retired separated group, we did not hold a separate session for this group. We included separated workers in the retiree session, in an effort to elicit the non-retired separated worker perspective. An effort was made in each case to involve 8-12 participants as recommended in most literature on Focus Groups (Greenbaum, 1993, p.3; Lewis,1996, p.3). We stopped recruiting once sufficient numbers agreed to participate to form a group, including some provision for no-shows. In one case, we over-recruited for a session, which proved challenging to the moderator, but still fruitful for the purposes of this study.

Analytic Methods

Focus Groups content is typically analyzed for trends or patterns that reappear within or among groups. Computer-based content analysis of transcripts (key words, word frequency lists, key-word-in-context (KWIC) records, variable context display, distribution graphs, etc.) (Weber, 1985; Richards and Richards, 1993) can be helpful in this process and will be employed in the final analysis. Numerous software packages have been identified (e.g. TACTweb and QRS NUD*IST) and will be evaluated on our server for use in the current study. For this preliminary analysis, an initial coding scheme of important themes has been developed. I have undertaken a basic coding and sorting of themes (Wolcott, 1990 p.33) and have provided illustrative quotes (from transcriptions) from which the themes were derived.

Reliability issues exist at multiple levels. These include the reliability with which the rapporteur/scribes captured raw data, reliability of data coding and reduction. Transcripts will be used as a verification source for scribe and rapporteur notes. Coding criteria will be formalized.

Issues of validity similarly exist at many levels. Of particular relevance in the current study is the "validity of the classification scheme or variable derived from it , and the validity of the interpretation relating content variables to their causes and consequences" (Weber, 1985 p.18). Results of the qualitative survey and risk maps, and exposure assessment may be used to validate some information (for example participants' discussion of exposures). Tests of semantic validity will be considered (Krippendorff,

1980) on selected lists of words/themes such as "risk" ", "trust" and "uncertainty". Software programs (i.e. Merge for Q.S.R. Nu*dist) may be used to assess coding validity for the final report.

DATA

The following types of data were collected during the Focus Group sessions: 1) participants completed a demographics questionnaire; 2) sessions were audio taped and transcribed; 3) both a scribe and rapporteur took notes; and 4) participants were (in some sessions) asked to write down the names of the health providers and health care facilities that they utilized.

Participant Demographics

Participants were asked a number of questions in order to characterize the demographic profile of session participants. These question included: age, sex, years of service, job title, type of employee (hourly/salaried), reason for leaving DOE employ, race, marital status, educational and income level and religious preference. The following table highlights some of these findings by group:

	OR(E)*	OR(R)	KY(E)	KY (R)	P(E)	P(R)
Age (x)	74	65.8	70.2	71	67.2	63.6
SD	8.5	10.3	3.2	3.5	3.6	4.9
N	14	9	12	9	17	8
Service (x)	33	30.6	34.7	33.4	29.6	23.3
SD	3.8	10.6	2.8	4.9	9.4	10.8
Hourly (N)	12	9	8	9	14	8
Salaried (N)	2	0	3	0	2	0
Reason Separated						
Retired (regular)	6	2	4	7	4	2
Early retirement	2	3	5	2	7	1
Voluntary package	2	0	1	0	1	1
Laid off	1	1	0	0	0	0
Took non-DOE job	0	0	0	0	0	0
Other (typically medical disability)	1	3	2	0	5	3

* OR(E) and OR(R) = Oak Ridge Expert and Random
KY(E) and KY(R) = Paducah Expert and Random
P(E) and P(R) = Portsmouth Expert and Random

Taken together, sixty-nine individuals from the three sites participated in Focus Group Sessions. All were white, most were male (4 females), most had achieved higher than a high school education, the vast majority were Protestant. Their incomes varied widely. The majority retired, either at the normal age or through early retirement. Interestingly twelve, who reported "other" reasons for leaving the DOE site, stated they had to leave due to medical disability and two retired early for medical reasons. That figure represents more than 20% of the sampled population having left work for health related reasons.

Reporting of findings: Major Themes by Major Discussion Topic

I. Health Concerns/Needs -- Perception of Occupational Health Risks

The following health and risk related themes were evident across all sites:

(1) The first major theme, coined ***At-risk – self,*** was a widespread, virtually universal perception among Focus Group participants of personally having an increased health risk, or adverse health effect, as a result of their employment.

(2) The second, ***At-risk – other,*** was a widespread, virtually universal perception among Focus Group participants of fellow workers' having increased health risks, or adverse health effects, as a result of their employment.

(3) The third major theme, ***Uncertainty,*** reflected a common concern of participants regarding the difficulties in determining and proving causal relationships between their exposures and the adverse health outcomes that they and fellow workers have experienced. Included in this uncertainty is a pervasive sense that much will remain unknown and unknowable.

(4) The fourth theme was one of ***Distrust***. This distrust manifests in workers' feelings of having been betrayed – betrayed by those who should have known and protected them. It also includes a sense that the community medical establishment was complicit in denying real risks. Finally, it engenders a questioning of the credibility of persons in positions of authority within the Department or Company.

The table below lists the major themes and provides illustrative quotes from the Focus Group participants that elucidate these themes.

THEME	ILLUSTRATIVE QUOTES
"At risk"-self	"Cancer over here and my wife also" (OR)[1]
	"I've got emphysema and asbestosis" (OR)
	" My doctor says I have 30% of my breathing left" (OR)
	"I've got asbestosis, too." (OR)
	" I've been told I have mercury and then how it affects my memory and all that horse ---" (OR)
	" (Asbestosis) Right and silicosis... I sandblasted for maybe 15 years. Before they ever had an air hood, we used what they call an 'army assault mask'. They banned the Army assault masks now that they have air hoods. So those are two things right there that concern me." (P)[2]
	"I feel very strongly about radiation exposure ... when they built the draw station, I was one of the first operators on it which dealt with a lot of alpha when you were changing cylinders. I worked there for hours on end with and army assault mask...about the only piece of safety equipment that we owned at the time..." (P)

[1] (OR) -- Respondent from Oak Ridge site
[2] (P) – Respondent from Portsmouth site

	"...in the 50's...in that withdraw room...what was left in the cylinder from the previous filling and it would set off the alarm(?) Every time it came in there which nothing was done about that. So I'm dealing with not only alpha airborne, but also other forms of radiation—beta and gamma." (P)
	"I think we all were exposed (to noise)" (KY)[3]
	"Asbestosis. I worked with asbestos" (KY)
	"Back in the 60's when they had all the changeouts ...sometimes the release was so bad you could hardly see the building...but you'd cut into it and start coming out with no mask or nothing on you just kept going. Of course nowadays they'd probably shut the whole place down for that big a release." (KY)
	"The only thing that bothers me from out there is the hearing. I come back here, I can't hear." (unanimous agreement) (KY)
"At risk"-other	"A lot of them are gone" (OR)
	"We had a friend, we worked together...he died from a blood disease which was some type of leukemia" (OR)
	"our chemical operations... we had a high rate of heart disease and cancer" (P)
	"... I probably got the best collection of photos of anybody that ever worked at the plant ...I see the guys that are gone now and these guys were some of the guys that never smoked a cigarette, never drank a beer or shot of whiskey. The guys that played ball and took care of themselves...so many of these guys are gone..." (P)
	"All of them in the crew that I worked with had exposure to Trichlor and asbestos" (maintenance) (KY)
	"... A lot of things over there that we were exposed to, not only me but a bunch of people that worked there. (KY)
Uncertainty	"The only trouble is you go and they find something wrong with you, well you don't know if it was occupational or not. They don't know and we don't know." "... I have urinary tract trouble all the time and they don't know whether it comes from that or not, 'cause I was contaminated down there several times Medical records show that." (OR)
	"Well my husband is deceased now. He was diagnosed with prostate cancer. It was already into the lymph nodes and into the body by the time he was diagnosed. He worked as a guard for 15 years and did uranium sampling for a year." (Moderator "Do you think there's a direct relation to that?') "Well, I don't know." (P)
	"the only problem really I have is my eyes. But I don't know if its related to anything I had out there or not. I don't have a history of my family having any of it..." (KY)
	"It's hard to prove whether its age...(KY)
	"We've never been able to prove a lot of this stuff. " (KY)
Distrust	"Its kind of funny ain't nothing down there that will hurt ya, but they got all the buildings sealed off now. Won't let nobody go in" (OR)
	"...I'm a Tennessee Hillbilly and I have an assumption that the people I worked for should have told me about the vapors from mercury..." (OR)
	"... It seemed like every doctor you run into around here are owned by the company... the good ones they got rid of in a hurry." (P)
	" Yea, it would have to be on neutral ground.. (KY)

Concern for widows and the sense that it was too late for them were among the other themes that emerged from the Focus Group process.

[3] (KY) – Respondent from Paducah, Kentucky site

The following exposures are examples of those reported during the Focus Group discussions.

Selected List of Exposures as Reported by Participants by Site[4]:

Oak Ridge	Paducah	Portsmouth
Asbestos[5]	Asbestos	Asbestos
Nickel	Magnesium oxide	
Heavy metals	Arsenic	
Cyanide	Coal dust	Silica
Uranium	Radiation	Radiation
Acetone	Trichloroethlene	Trichloroethlene
Fluorides (CLF3, UF6)	HF	
Acids	Sulfuric and HF acids	
	PCBs	PCBs

II. Health Care Delivery/Utilization and Programmatic Issues—

The types of questions asked of Focus Group participants included *"What kind of things would you look for in a health program designed to meet your needs?"* The following elements were frequently reported as important or desirable:

(1) ***Accessibility*** – Programs need to be available (geographically) to the target population. The issue of accessibility as participants portrayed it seemed to transcend geography, and include accessible as in a "personable" connotation.

(2) ***Low or no cost*** – Low or no cost programs were desirable. High cost was frequently referenced as a potential impediment to participation.

(3) ***Primacy of personal physician*** – Many participants indicated their preference that their primary physician would be involved in any programs that are offered.

(4) ***Regular/periodic exams*** -- A common sentiment held by participants is that the program should involve periodic evaluations, rather than a one-time opportunity.

(5) ***Appropriate follow-up and treatment*** – By this, participants were indicating that they considered these as important program elements; identification of problems alone was not sufficient.

(6) ***Primacy of truthfulness* --** Participants simply want to be told the truth. This seems to extend to both truth and clarity in communication of medical results, and in etiology and causation.

(7) ***Control/choice*** – Who controls the programs and who is involved in decisions regarding them is an important factor to Focus Group participants.

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[4] The following list was compiled form scribe notes taken at each site

[5] In a preliminary key word count, the truncated term "asbestos." was the most frequently reported hazard -- twenty-eight times among the four session transcripts.

The following table presents these desirable programmatic elements. The second column of the table provides illustrative quotes from Focus Group participants that support the inclusion of the stated elements.

DESIRABLE ELEMENTS	ILLUSTRATIVE QUOTES
Accessibility	"It oughta be accessible" (OR)
	"Shouldn't have to drive 50 miles (OR)
Low or no cost	"The expense of everything...they just keep on sending you bills, up and up and you can't afford it" (OR)
	"Free if possible" (KY)
Primacy of personal physician	"I want to go to my doctor" (OR)
	"I say use your own family doctor. They could send you where you need to go." (OR)
Regular/periodic exams	"I think they oughta set up a six month check-up" (OR)
Appropriate Follow-up and Treatment	"I heard on the radio that there was a program for screening for thyroid cancer...all it does is check you. They will say go see your personal physician. It doesn't do anything for you other than its scanning thing... that's not really taking care of your problem. That's merely identifying it.(P)
Primacy of truthfulness	"They ought to tell you the truth" (OR)
Control/choice	"Who's gonna have control of it?" (P)
	"Who's gonna make the decisions?" (P)

As part of the Focus Group process, we explored participants' sense of potential impediments to participation in the programs. The following table describes some of the possible roadblocks as perceived by Focus Group participants. It also describes other contingent factors influencing participation. In one case, one Focus Group thought that everyone would be interested in participating.

THEMES	ILLUSTRATIVE QUOTES
Roadblocks	"The biggest roadblock I'd say is the government" (OR)
	"Job scared" (OR)
	"Burden of proof would be a barricade" (KY)
Participation	
Contingent	"Who's gonna run the thing? Is it going to be union run or is it going to be company run? If the company runs it I don't want no part of it" (P)
	"Especially the ones that are just coming out and retiring—the ones that are still employed would be real interested. (KY)
Unanimous	There was consensus in this group that everyone would participate (OR – random)

Although not specifically addressed in the structure of the Focus Group Moderator Guide, Insurance issues emerged as a strong concern in many of the sessions. The following themes specifically related to insurance emerged.

(1) ***Inequity*** -- There was a pervasive concern about disparities on insurance matters. This was largely due to differences among the types of coverage offered by the various Contractors. This was particularly dependent upon the contractor's plan under which an individual retired.

(2) ***Choice*** – Participants were concerned about the limits placed upon them by their insurance regarding their choice of providers and facilities. They were also dissatisfied with the fact that their insurance coverage could be (or had been) changed unilaterally, without their assent.

(3) ***Inadequacy*** – Another significant issue that emerged regarding insurance was that the coverage was inadequate or insufficient to meet their needs, especially in light of the perceived risks they encountered as former DOE workers.

Insurance Related Themes by Site and Illustrative Quotes

INSURANCE THEMES	ILLUTRATIVE QUOTES
Inequity	"I worked under Goodyear until they left. Then I finally retired under (?Carbide?) and my insurance is nothing like the ones that retired under Goodyear." (P)
	"I think plain and simple we would like to have a program like Aetna" (P)
Choice (limits)	"…Now the insurance won't pay for me to go back to James Cancer Center… Now that's my concern. They're telling me that they're out of network and I cannot go back there…" (P)
	" I don't think they should be able to change our insurance" (Moderator: "You mean they changed you insurance after you worked?") "Yes and I don't think should have" (P)
	"Two or three times a year they send me this trying to force me and I wouldn't do it. I received a letter saying you either take this or you don't have any (insurance) so I didn't have a choice." (P)
Inadequacy	The bus drivers' plan is better (P)

III. Outreach, Access and Health Education, Information and Resources

Selected Examples of Outreach Mechanisms by Site[6]

How can you be reached?	Site
Call personally	Portsmouth
Letters	
OCAW Magazine	
Radio/TV (WPAY, WNXT, channel 13)	
	Oak Ridge
Shoney's breakfasts	
Word-of-mouth through retiree networks	
	Paducah
By telephone or letter	

Selected Examples of Current Sources of Health Information by Site[7]

Sources of Health Information	Site
TV Health segments	Paducah
Internet	
Magazines and health letters (Prevention, AARP)	
Doctor's Office	
Pharmacy	
	Portsmouth

[6] Information drawn from Scribe Notes at the Respective sites
[7] Information drawn from Scribe Notes at the respective sites

Newspapers (Portsmouth Times, Columbia Dispatch)	
Internet	
"Wellness" from the Mayo Clinic	
Pharmacy at the shopping center	
	Oak Ridge
Dr. Bob on TV	
Reader's Digest	
Doctor	

Selected Preferred Health Care Facilities by Site

Name	**Site**
Western Baptist Hospital	Paducah
U.T. Hospital	Oak Ridge
Barkwith Hospital	
St. Mary's Hospital	
Scioto Memorial	Portsmouth
Grant Hospital	
Columbus Hospital	

DISCUSSION OF PRELIMINARY RESULTS

There is no guarantee that this preliminary analysis will be born out after the final analysis of results. Unfortunately, the transcripts from the last two Focus Groups sessions held in late July were not completed in time for inclusion in this preliminary report. For those sessions, this report is reliant upon scribe and rapporteur notes alone. However, the direction of results appear to be that among session participants, there is a general sense of being at-risk for occupationally related conditions, both personally and as a group of former workers. There is also widespread interest to participate in occupational health programs. This interest, however, is both optimistic and tempered with a sense of skepticism or fatalism. It is also based on the condition that programs are designed so they meet certain conditions: i.e., that they are low or no-cost and accessible, run by qualified occupational health specialists who are communicative about results and trustworthy. Workers' personal physicians are emerging as a preferred locus of health information and services. This parallels much of the literature that cites them as the most important impetus for health behavior changes, such as smoking cessation[8].

As with any scientific method, the Focus Group has it strengths and limitations inherent to the process (Morgan, 1988). Focus Groups inherently are less "pure" than observational methods in naturalistic settings, because they do impose certain contrivances upon the process. With an inquiry such as the present one, the structured question format allows for a more detailed investigation into the specific Phase I health and programmatic questions of interest.

[8] Cancer Weekly Sept 14 1992 cited in Physician and Smoking Cessation (URL:http://just4u.com/stopsmoking/docsmoke.htm) and
NCI, 1994; Okene, 1987;Pederson,1982 as cited in the *AHCPR Smoking Cessation Clinical Guide* on **Quitnet** (URL:http://www.quitnet.org/QuitNETTA/Documents/Cessation/NIH/Guidelines/smkc3.html)

One critique of the present effort might be the lack of representation from racial minorities and limited female representation. This can be explained largely by the fact that in the early years, these workplaces were predominantly comprised of white males. For this reason, they correctly dominate the current retiree pool from which we drew the majority of Focus Group participants.

At first glance, the samples selected for our sessions seem fairly representative of the current retired hourly workforce of Oak Ridge, Paducah, and Portsmouth at least as far as age, sex, and race. To determine whether the opinions reflected in those sessions are stable and generalize to all former nuclear workers from these three sites, as a whole requires further inquiry. To determine whether the opinions were stable over time requires additional sessions among these same participants at several points in time. To generalize the findings requires additional sampling of other subsets of the population.

The opportunity of using personnel intimately familiar with these plants (OCAW OSHECS) as moderators strengthened the process in many ways. They were able to understand points, help negotiate the nuances of what might be considered classified and what was not, and provide a congenial atmosphere based on their facility knowledge and experience. Despite cautionary training about bias, and rigorous efforts on their part to avoid introducing any, on occasion the Moderators did interject their own opinion to the topic at hand born out of their plant experience. This could probably have been minimized with longer training role-plays and additional practice opportunities. On balance, their presence arguably allowed participants to open more and feel more "heard" because the Moderators were perceived as having "been there".

The number of anecdotes about cancer, heart disease and other major health concerns is striking as one reviews the session transcripts. Similarly, the fact that 20% of the sample had left employment for medical disability reasons is worthy of further exploration. The U.S. Census Bureau reports a much lower percentage of the population ever retiring or leaving a job for health reasons[9]. It would be interesting to hold Focus Group sessions among non-nuclear, non-exposed workers (matched for age, sex and other demographics); to determine if a similar pattern of concern about major health conditions and pattern of disability were evident.

One of the strengths of the Focus Group process is its ability to identify unanticipated (by the researcher) issues of concern to the target population (Morgan, 1988; Greenbaum, 1993). The intensity of participants' sentiments about insurance issues, most strongly evident at Portsmouth, was both dramatic and unforeseen. The adequacy, limited provider choice, and cost of insurance were of central concern to participants. Their sentiments about insurance were related to their perception of being "taken care of" particularly in light of their perceived risks as former nuclear workers.

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[9] The range appears to be 3.6-12% depending on age classification and employment status. Among 65-74 year olds, 8.7% of the entire population sampled ever retired or left a job for health reasons. This figure is somewhat difficult to interpret insofar as the denominator includes those who were never in the work force. The numerator also includes those who reported leaving a job or retiring for health reasons on both a temporary as well as permanent basis. (SOURCE: percentages drawn from a table specifically generated by the U.S. Bureau of Census for the purpose of this study.)

Not surprisingly, the difficulties in obtaining accurate separated (non-retired) worker l and difficulty in recruiting participants from the available lists poses troublesome prob for Phase II. It is our hope that a national, worker-maintained database we are currently launching will help ameliorate this problem in the future. In this first year, we did not receive adequate input to design programs responsive to the concerns of non-retired separated workers. We will have to implement additional measures to reach this group of workers. Obtaining better and more reliable lists would be a critical first step to fully involving this group in any future programmatic initiative. For example, a limitation of the OCAW list is that transition to management upon separation is not identified. This limitation may be circumvented by comparison with contractor management lists, thereby further pinpointing potential groups of interest.

RECOMMENDATIONS

The following recommendations emerged for future **Medical Surveillance Programs**

- Make programs accessible (close proximity, convenient times);
- Make programs No-cost or Low-cost;
- Provide (and arrange for coverage for) appropriate follow-up and treatment.

The following recommendation emerged for future **Notification and Risk Communication Endeavors**

- Prioritize approaches used for notification and communication in Phase II based on the specific vehicles identified by Focus Group participants

- Notification and risk-communication can be accomplished best through a variety of mechanisms.

  These mechanisms include telephone, post-card, meeting at specific gathering places for retiree luncheons, articles in newsletters, newspapers and other publications specifically provided by the target population during the Focus Group process.

- Develop local and national media contacts.

  Develop national and local contacts with the media and staff health writers of the publications named by participants as major sources of health information. This would be a step towards generating health-related stories of relevance to our target population.

Other Recommendations

- Conduct outreach to and education of physicians who serve former nuclear workers

  Personal communication with physicians has been identified a preferred means for the conveyance of health information by many participants. For this reason, we should integrate community physicians who serve former workers in any future programs that are developed. We can design a program of outreach and continuing education specifically for these providers. We can also use the list of physicians provided by

Focus Group participants, as well as the Provider Inventories gathered in Phase I as a starting point for provider outreach.

- Stabilize and Improve Insurance Coverage for Former Workers

  Former workers want assurances that any detrimental health problems will be taken care of that result from their former work. They want control over changes in their policies as well as provider and facility choice.

- Employ Focus Groups in Program Evaluation

  The Focus Group process should be applied during the Program Implementation Phase. This will permit us to ascertain whether programs we design have the intended effect in meeting the needs of the target community of workers. Similarly, they would be useful in eliciting former worker's input on notification and educational materials that we produce.

SUMMARY

As part of our NA, Focus Groups have proven to be a powerful vehicle for eliciting the involvement and perspective of former workers regarding their occupational health concerns and widespread perception of risk. Drawing upon workers-as-investigators has furthered enhanced the process. The description of historical exposures, incidents and health experiences voiced by participants (captured in their own words) make a compelling case for the necessity for occupationally related health programs. In addition, the Focus Group method has provided us with an efficient means of gaining the input of the target community regarding the shape that health programs need to take in order to be responsive to their needs and values.

The specific information gathered regarding health facilities preferences will help us in selecting community partners for the execution of our programs that should enhance the program's credibility with members of the target community. We have obtained a wealth of explicit avenues for outreach, from restaurants where retirees gather to specific media they attend to. This information will be extremely helpful in ensuring that we are reaching the target population as we attempt to provide them with educational information or to notify them about programs for which they may be eligible.

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APPENDIX A. MODERATOR GUIDE AND TRAINING MATERIALS

MODERATOR GUIDE

INTRODUCTION: (20 Minutes)

- Opening Greeting (Moderator)
- Brief description of the Study and Explanation of the Intention of the Focus Group
- Ground Rules (i.e., confidentiality provisions, request for consensus to audiotape)
- Administration of Informed Consent
- Brief Self-Introductions of Participants (name, former job at DOE facility, years of service)

TOPIC I: HEALTH CONCERNS/NEEDS – PERCEPTION OF OCCUPATIONAL HEALTH RISKS (30 minutes)

1. **Do you think you are personally at risk for an occupationally-related health problem?**

    - **If so, what health conditions, and how would you rate your risk (1-10)?** (Note: moderator can expand this question to stimulate discussion – add, **"For instance, cancer from your radiation exposure."**)

    - **How about your fellow workers?**

2. **What kind of things would you look for in a health program designed to meet your needs?** (Note: moderator can expand this question to stimulate discussion – add, **"For instance, lung examinations, low cost, etc."**)

3. **Would you personally be interested in a health program for your occupational health concerns?**

    - **Would you participate? (i.e. would you use it?)**

    - **Do you think your fellow workers would be interested to participate?**

    - **What, if any, medical exams do you currently receive? ... Do these meet your Occupational Health concerns?**

    - **How would you like an Occupational Health Program to be set up?** (Note: moderator can expand this question to stimulate discussion – add, **"For instance, accessibility, affordability, etc."**)

4. **Do you think there might be any road blocks (impediments) to people participating in a program designed to meet their occupational health concerns?** (Note: moderator can

expand this question to stimulate discussion – add **"For instance, fear of discrimination, travel distances, illness, etc.")**

- **If so, how could we address these road blocks to involve more people?**

TOPIC II: HEALTH CARE DELIVERY/UTILIZATION ISSUES (15 minutes)

1. **Where do you currently go for health services?**
   (Note: moderator can expand this question to stimulate discussion – add, **"For instance, Dr. _______, the pharmacy, HMO_____, _____hospital emergency room, (get specific names), etc.")**

2. **If we held an occupational health program, where would you feel most comfortable going for it? ... or follow-up care, if needed?**

3. **Are there specific hospitals, clinics, or health providers that you feel most comfortable going to?**

TOPIC III: OUTREACH/ACCESS AND HEALTH EDUCATION, INFORMATION, RESOURCES (15 minutes)

1. **What are the best ways to reach you? Fellow workers?** (Note: moderator can expand this question to stimulate discussion – add, **"For instance, union newsletters, local AARP newsletter, radio announcements, personal letter or phone call, etc.")**

2. **What, if any, are currently your major sources of health information?** (Note: moderator can expand this question to stimulate discussion – add, **"For instance, Readers' Digest, the newspaper, TV, pamphlets at the grocery store or pharmacy, etc.")**

3. **How do you best like to get your health information?** (Attempt to elicit the gamut from written or in person, video, etc.)

CLOSING COMMENTS: (10 minutes)

- Summarize some of the key points made
- Describe that a Report will be issued, and when, and that copies of highlights of the report will be sent to participants
- Thank all participants for their time and valuable input

Focus Group Research

Elizabeth Averill Samaras
Alice Hamilton College -- OCAW

1/30/97 E. A. Samaras, Alice Hamilton College - OCAW 1

Agenda

- Overview of Focus Group Research
- Specific Goals for the Project
- Guidelines for Focus Group Moderators
- Introduce the Moderator Guide and Elicit Comments
- Role Play

1/30/97 E. A. Samaras, Alice Hamilton College - OCAW 2

Vocabulary

- Focus Group
- Qualitative Research
- Participant Observation
- Moderator

1/30/97 E. A. Samaras, Alice Hamilton College - OCAW 3

Overview of Focus Groups

- Uses of Focus Groups (F.G.s)
- Historical Perspective
- F. G. as a Qualitative Research Method -- Strengths and Weaknesses

1/30/97 E. A. Samaras, Alice Hamilton College - OCAW 4

Overview (cont.)

- Group Composition, Size and Recruitment
- Criteria for Effective Focus Groups
- Content
- Analysis
- Reporting

1/30/97 E. A. Samaras, Alice Hamilton College - OCAW 5

Specific Goals for the Current Project

- #1 Gain Input from Target Community
- Perception of Risk, Problems, Needs
- Determine Health Habits and Usage
- Desirability and Expectations of Medical Surveillance??
- Determine effective channels for notification

1/30/97 E. A. Samaras, Alice Hamilton College - OCAW 6

Role of and Tips for Focus Group Moderator

- Listen, LISTEN!!!
- Be very familiar with Guide and Goals
- Pay Attention to the Non-verbal
- Avoid "leading", remain neutral yet active
- Keep to topics, yet open to unanticipated issues

1/30/97 E. A. Samaras, Alice Hamilton College - OCAW 7

Moderator Techniques

- Projective techniques
- Probing techniques
- Control techniques

1/30/97 E. A. Samaras, Alice Hamilton College - OCAW 8

Moderator Guide and Input

- Walk through the Moderator Guide (Questions, rationale for items)
- Comments on the Guide -- changes, etc.

1/30/97 E. A. Samaras, Alice Hamilton College - OCAW 9

Moderator Role Play

- Setting the Stage
- Beginning the Process

1/30/97 E. A. Samaras, Alice Hamilton College - OCAW 10

Summary

- Overview, strengths and weaknesses of FG
- Rationale for its use in the current study
- What we hope to achieve
- Understanding of the Moderator Role and Practical experience
- Feedback of training session

1/30/97 E. A. Samaras, Alice Hamilton College - OCAW 11

APPENDIX B. DEMOGRAPHICS FORM

Focus Group Participant Demographic Information –

(Please circle the answer that best describes your response or write it in the blank where appropriate.)

What is your gender? (1) Male (2) Female

How old are you? __________

How many years did you work at a DOE site(s)? __________

What was your last job title? ______________________________

Were you an (1) hourly, or (2) salaried employee for most of your employment at the site?

What was your reason for leaving the DOE site that you last worked at?
- (1) reached retirement age and retired
- (2) took early retirement
- (3) took some other "voluntary separation" package
- (4) was "laid off", or "downsized"
- (5) left for another job at a non-DOE facility
- (6) other, (please describe)______________________________

How would you describe yourself?
- (1) African American or Black
- (2) Asian
- (3) Hispanic
- (4) White
- (5) Other____________________

What is your marital status? (1) Single, (2) Married, (3) Widowed, (4) divorced

What is your highest educational level?
- (1) Some high school or less
- (2) High School graduate
- (3) Some college or advanced vocational training
- (4) College degree
- (5) Some post college graduate work
- (6) Graduate degree (i.e. masters, doctorate)

What is your family yearly income?
- (1) under $10,000
- (2) $10,001 to $20,000
- (3) $20,001 to $30,000
- (4) $30,001 to $40,000
- (5) $40,001 to $50,000
- (6) $50,001 to $70,000
- (7) over $70,000

What is your religious preference?
- (1) Catholic, (2) Jewish, (3) Protestant
- (4) Other (specify): ______________________________

APPENDIX C.
INFORMED CONSENT FORM AND PARTICIPANT INFORMATION SHEET

Medical Surveillance of Former Workers at Department of Energy Gaseous Diffusion Plants
Phase I: Needs Assessment

Oil Chemical and Atomic Workers International Union
Principle Investigator: Robert E. Wages
Address: Oil, Chemical, and Atomic Workers International Union
PO Box 281200
Lakewood, Colorado 80228
Telephone no: (303) 987-2229

Project Sponsor: Department of Energy

I. PARTICIPANT INFORMATION SHEET

Purpose of the Study: You are being asked to participate in a study. The purpose of this study is to assess the need for and feasibility of conducting a future medical surveillance program for former workers at three Department of Energy sites. These sites include the gaseous diffusion facilities at Portsmouth, Ohio; Paducah, Kentucky; and Oak Ridge, Tennessee. You qualify for participation in this study, because you formerly worked at one of these sites.

Description of the Study: This study has two components that involve the collection of information directly from people. First, we are mailing a questionnaire to 1200 former workers asking detailed questions about workers' prior exposure, job histories, health concerns, and current health care. If you receive this questionnaire, and if you agree to participate in this study, we ask that you complete the questionnaire in as accurate a fashion as possible and send it back to us. This questionnaire will take about 30 minutes to complete. A self-addressed, stamped envelope is enclosed for the return of the completed questionnaire. Second, we are assembling groups of 10 to 15 workers for 1 day sessions in Oak Ridge, Paducah, and Portsmouth to discuss their knowledge of the plants and their concerns about their health as a result of having worked at the plants. These group discussions will be audiotaped and transcribed for additional review and analysis. All information obtained by questionnaire and from the discussion groups is confidential and will not be identified by individual participant to anyone external to the study team to the extent permitted by law. Furthermore, the information you provide may be reviewed by the Department of Energy as the project's sponsor, in accordance with applicable laws and regulations. You will not be identified in any presentation or publication of the study results. This study involves no administration of medicines or medical testing.

Participation in this study is voluntary. You will suffer no penalty nor loss of any benefits to which you are otherwise entitled should you decide not to participate. Withdrawal from this study will not affect your ability to participate in any medical screening that may ensue later in the program.

Information about significant new findings developed during the course of the study which might be reasonably expected to affect your willingness to continue to participate in the study will be provided to you.

Costs/Reimbursements: You will not be reimbursed or penalized in any way for your participation in this study. By penalty, we mean denial or access to any educational information or medical screening that ensues as part of this program.

Potential Risks: There is no potential for physical risks to you in participating in this study.

Potential Benefits: There are no identifiable benefits that will accrue to you individually as a result of participating in this study.

Termination of Participation. You may choose to not answer any questions on the questionnaire or to leave the discussion group at any time during the course of your participation in this study. There will be no penalty to you for terminating your participation in this manner.

Financial compensation from the Oil Chemical and Atomic Workers International Union will not be provided. If you believe you have suffered an injury related to this study or have any questions at any time about this study or your rights as a participant in this study, you should contact Sylvia Kieding at telephone 303-987-5326. If you still have additional questions, you may discuss them with a member of the Oak Ridge Associated Universities/Oak Ridge National laboratory Committee on Human Subjects (the Institutional Review Board overseeing the informed consent aspects of this program at the DOE gaseous diffusion plants at Oak Ridge (K-25), Paducah, Kentucky; and Portsmouth, Ohio) at telephone number 423-576-1725. A copy of the signed consent form will be given to you.

Medical Surveillance of Former Workers at Department of Energy Gaseous Diffusion Plants
Phase I: Needs Assessment

Oil Chemical and Atomic Workers International Union
<u>Principle Investigator</u>: Robert E. Wages

II. <u>CONSENT TO PARTICIPATE IN THE STUDY AS A VOLUNTEER: PARTICIPANT'S AUTHORIZATION</u>

1. I ____________________________ (participant's name) volunteer to participate in a program under the supervision of Mr. Robert Wages and his associates of the Oil Chemical and Atomic Workers International Union.

   No drugs will be administered or any medical procedures performed as part of this . No body
   body fluids and tissues will be sampled for analyses as part of this program.

2. I acknowledge that I have read, or had explained to me in a language I understand, and that I understand the attached Participant Information Sheet and that Mr Robert Wages or one his designees (Sylvia Kieding, Elizabeth Samaras, or Mark Griffen) has explained to me the nature and purpose of these studies, including the extent, if any, any risks reasonably to be expected, which may arise from both known and unknown causes as a result of this study. I have had the opportunity to ask any questions I had with respect to this study and all questions I asked were answered to my satisfaction. I understand that if I do have questions in the future about this study or my participation in it, I can contact Sylvia Kieding of the Oil, Chemical, and Atomic Workers International Union at telephone (303) 987-5326 or a member of the Oak Ridge Associated Universities/Oak Ridge National Laboratory Committee on Human Studies at telephone (423) 576-1725.

3. I understand that these studies are not intended to be of any direct therapeutic or other benefit to me and I voluntarily accept the risks associated with these studies.

4. I understand that in order to provide the data by which to measure the effectiveness of the study that I am invited to complete a mail questionnaire and/or participate in a focus (targeted) group discussion conducted by Mr. Wages of the Oil, Chemical, and Atomic Workers Internatioual Union , or his delegates, which will be audiotaped. These activities have been fully described and explained to me. I am unaware of any preexisting medical or emotional problem which would make it unwise for me to participate in this study.

5. I understand that my participation in this study is voluntary and that I am free to withdraw this authorization and discontinue participation in this study at any time. The consequences and risks, if any, of such withdrawal during the course of the studies have been explained to me. I understand that such withdrawal will not affect my ability to receive information, education or medical screening that may subsequently ensue as part of this or subsequent studies.

6. I confirm that I have read the foregoing authorization and that all blanks or statements requiring completion were properly completed before I signed.

Signature of Witness	Signature of Participant /Patient/Guardian
Name and Title (please print)	Name (please print)
Address - Number and Street	Relationship
City, State & Zip Code	Date

****

I, ________________________(person obtaining consent), verify having discussed with ____________________ (study participant) all of the objectives, methods, associated risks, and benefits of this study. I have fully explained to the above volunteer the nature and purpose of the above-mentioned study (including the fact that it will not result in any direct therapeutic benefit), the possible complications which may arise from both known and unknown causes as a result thereof and the consequences and risks, if any, if the volunteer decides to discontinue participation. I believe that he/she understands the nature, purposes, and risks of these studies. I have also offered to answer any questions relating to these studies and have fully and completely answered all such questions.

Signature of Principal Investigator or Authorized Delegate Obtaining Consent	Date
Name of Principal Investigator (print) or Authorized Delegate Obtaining Consent	Title

Consent form approved by the ORAU/ORNL Committee on Human Studies (M1394) on _______________ for 12 months.

INVENTORY REPORT

INTRODUCTION AND OBJECTIVES

In 1996, under the mandate of Section 3162 of the Defense Reauthorization Act of 1993, the OCAW received a one-year grant from the Department of Energy. The purpose of the Phase I grant was to assist the Department in determining the need for, and design of, medical surveillance programs for its former workers. Integral to our Phase I efforts was the need to identify health care providers and institutional resources in the local communities were former DOE workers reside. These providers and institutions will be potential resources in the implementation, follow-up and referral for the Phase II Medical Surveillance Programs. Similarly generating a profile of community resources that provide health information, or could serve as gathering places at each site will be valuable in our Phase II health education, risk notification and communication activities. The results reported here reflect the high level of motivation and concern for this issue among the worker population and their field team representatives.

DESCRIPTION

Three inventories were developed (see copies found in the Appendix) as part of the Phase I effort: 1) The Health Care Facility Inventory; 2) The Health Care Provider Inventory; and 3) The Community Services/Resources Inventory. Items covered in the facility inventory include the name, type and location of the facility, services provided, clinics/departments, comments and observations. The Provider inventory includes the name, type and location of the practice, and area of specialization. Both the facility and provider inventories had space for comments. They also include an occupational health related and general rating question, and the rationale for the rating. The community services/resources inventory includes the name and location of the organization, a description of its resources and facilities (e.g. presence of meeting rooms), educational materials, and other outreach mechanisms. It also provides room for the on-site personnel to render an impression as to the resources suitability for phase II education and notification efforts.

The OCAW rank and file partners in the project (OSHECs, retirees, and representatives) were formally trained in the purpose and application of the inventories. They also reviewed the Inventory format. Revisions to the forms were made based on their comments. During the training seminar, we held a brainstorming session on ways to elicit the Inventory information. Various approaches emerged from this process -- on-site visits, cold calls, using the Focus Groups to help identify potential resources, going to retiree groups for ideas, and others. Each OCAW site team had the discretion to choose their methods for gathering the information. They also compiled the Inventories and sent copies to OCAW Headquarters and to Elizabeth Samaras for the summary review, analysis and reporting.

Written by E.A. Samaras, RN, MSN based on inventories collected by Jim Rogers Ed Elders and James Chestnut (Paducah); Connie Reedy, Tom Mooser, Bruce Lawson, Ben Gaylor and Howard Guy (Oak Ridge); Mark Lewis, Larry Fout, Herman Potter, Sam Ray and Robert Whit (Portsmouth).

- **Paducah –**

We received 221 completed inventory forms from this group – 35 on health care facilities, 179 on individual providers and 12 on community resources. Facilities ranged from full service hospitals (Marshall County Hospital, Baptist Medical Center, Parkway Regional, and others) to specialty clinics in occupational medicine, rehabilitation, pain management, and a free clinic, to name but a few (i.e., Biokenetics, Inc., Stonebrook Center for Physical Therapy, St. Nicholas Family Clinic). A broad range of providers from diverse specialties (gastroenterology, general and vascular surgery, radiology, internal medicine, neurology, and many others) were listed. Community resources included: community media resources (specific newspapers, TV. and radio stations), restaurants and senior centers where retirees gather, specialty publications which publish community health news and health resources and others. In addition to the inventories, we received numerous resource publications regarding Paducah community health providers and facilities, including <u>Purchase Area Health Care Guide</u>, <u>Physician Directory "Dr. Finder"</u>, and Parkway Regional Hospital brochures.

- **Portsmouth --**

We received 67 completed inventories from the Portsmouth group. One approach they used was to contact 20 former employees by telephone and complete the forms based on the providers/facilities used personally by those contacted. Forty-six of the inventories covered specific providers and the remaining 21 covered health care facilities. They are finalizing their community inventories, but have identified McDonalds as a regular gathering place for retiree meetings, and as a way to reach a large segment of the retiree population. The health care facilities identified were primarily full service regional hospitals, such as Scioto Memorial, Holzer, Ruby Memorial, Mt Carmel and others. The providers listed were from a wide range of specialties, such as internal medicine and family practice, cardiology, oncology, dermatology, urology, neurology and hematology. Some specific physicians that have been identified, such as one seen by an individual with asbestosis, may be particularly useful to know during our Phase II efforts.

- **Oak Ridge –**

W e received 312 inventories from the Oak Ridge team. They used a variety of approaches in completing the inventories including contacting (by telephone or in person) 74 retirees direct questions regarding health providers and facilities used. They categorized providers by area of specialization, including pathology, urology, radiology, pulmonology and a host of other specialties. They identified some restaurants including the Food Court of the Mall and Shoney's, as well as the OCAW union hall as key gathering sites for retiree meetings. Several full service hospitals, ambulatory care centers and specialty clinics were inventoried.

RECOMMENDATIONS

In Phase II, we envision using the inventory information in a variety of ways. It provides us with valuable information about the provider community that will assist us in identifying potential community-based health providers and facilities available for use in administering Phase II screening, post-screening referrals and notification.

Written by E.A. Samaras, RN, MSN based on inventories collected by Jim Rogers Ed Elders and James Chestnut (Paducah); Connie Reedy, Tom Mooser, Bruce Lawson, Ben Gaylor and Howard Guy (Oak Ridge); Mark Lewis, Larry Fout, Herman Potter, Sam Ray and Robert Whit (Portsmouth).

Furthermore, in some cases, it provides some qualitative information regarding workers' preferred providers.

EPIDEMIOLOGY AND OTHER HEALTH STUDIES

K-25 Plant at Oak Ridge

Mortality: Frome et al. 1997

In 1997, Frome and colleagues described a mortality experience of workers at the Oak Ridge Department of Energy facility between 1943 and 1985. They studied all four plants at the facility, including the K-25 gaseous diffusion plant. The study had several goals, including updating the mortality experience of workers at the plants through 1985; comparing the mortality experience among workers at the various facilities; addressing the issue of workers at Oak Ridge who worked at more than one facility; and finally, to evaluate the dose-response relationship for individuals with potential exposure to external radiation. Evaluation of external radiation dose estimates led the authors to conclude that over 90% of the total recorded external radiation dose was received by the 28,347 white male workers who had ever been employed at X-10 were Y-12 sites. A dose-response analysis for external radiation was not performed for K-25 workers.

The analysis included 27,982 deaths among 106,020 workers employed at least 30 days at Oak Ridge between 1943 and 1985.

The results indicated an all-cause SMR = 100 for white males and 89 for white females. The numbers of non-white males and females were few, and the associated estimates, are therefore, unstable. The all-cancer SMR for white males is 98 and for white females 86. These results demonstrate the absence of a health worker effect among the white males and a relatively mild effect among the white females.

For all Oak Ridge facilities combined, there were elevation in selected SMRs. The results reported here are for white males; similar patterns were seen among white females. The lung cancer SMR was 118. The SMR for bone cancer was 119. For brain cancer, the SMR was 108. The SMR for non-malignant respiratory disease was 112. Conventional p values or confidence intervals were not provided.

Since our study concentrates on employees at K-25, the results for individual facilities and the comparison among these facilities are of great interest. The U.S. population was used as an external reference group. The all-cause mortality was higher at K-25 (SMR = 99) than at any of the other Oak Ridge facilities. In a further comparison with other facilities (X-10 TEC, Y-12, and multiple facilities, mortality at the K-25 plant was highest for all non-cancer causes (SMR = 100); deaths from circulatory system disorders (SMR = 98) non-malignant respiratory disease (SMR = 107); all-cancer deaths (SMR = 95) and bone cancer (SMR = 158). Other sites of excess risk for K-25 workers included lung cancer (SMR = 110),cancer of the brain (SMR = 114), and lympho/reticulosarcoma (SMR = 122).

Of interest is that the SMRs in general for all Oak Ridge facilities tended to increase over calendar time. For white males, for example, all-cause SMR's increased at an average rate of 1.05% per year, including 1.06% for all-cancers, 1.06% for all circulatory system disorders and 1.1% for respiratory diseases. The authors specifically state:

> " the magnitude of changes in SMRs with calendar time and differences in trends
> for causes of death of interest, including cancer and smoking-related diseases,
> suggest the importance of the continued follow-up of these populations.)"
> (p. 75-76)

Unfortunately, the trend with calendar time was not reported for each individual facility, so that this information specifically for K-25 was not available from this report.

Mortality, Dupree et al, 1994

Additional detail about K-25 is available from an unpublished report by Dupree and colleagues at the Center for Epidemiologic Research at the Oak Ridge Institute for Science and Education (ORISE). This mortality analysis included all workers at K-25 who worked at least 30 days and were hired between May 31, 1943 and December 31, 1984. The vital status was based on all reported deaths through December 31, 1989. Of the 47,941 workers ever employed at K-25, the study population include 35,712. The exclusions were mostly due to a number of employees employed less than 30 days (4,804), a number of employees hired after December 31, 1984 (2,208) and a number of employees for whom essential data were missing (5,007). Of the 35,712 workers included in the study, 72% (25,762) were white males, 23% (8,054) were white females and the remaining 5% (1,896) were non-white males and females.

The cohort is highly influenced by distribution of year of hire. Over one- half (20,488, or 57 %) of the 35,712 workers were first hired before 1945 and additional 6,874 (19 %) were hired between 1946 and 1955. Non-whites tended to be hired more recently. About one-half of the non-white females and males (900/1896) were hired after 1965.

The cohort also has a striking profile of length of employment. 44% of the workers (15,701) worked less than one year. An additional 28 % (10,122) workers worked between one and five years. Hence, 72% worked 5 years or less. By contrast, only 5.9%, or 2,090 workers, worked for 20 or more years at K-25.

The study investigators identified 12,848 deaths in the cohort through December 31, 1989. They obtained 98% of death certificates for these individuals. A major limitation of this study is that the vital status for 20,427 workers or 57% of the work force, was not known. About one-half of these workers (10,457) were lost to follow-up prior to January 1, 1979. The vital status for remaining 10,000 workers who were not lost prior to 1979 was not identified in this study.

The all-cause SMR for white males was 103 with similar results obtained for non-white males, and white and non-white females. Note that the SMR of 103 for white males was statistically significant (95% CI: 101 to 105). All-cancer SMR was at or close to 100 for all gender and race combinations. It was 99 for white males; 103 for non-white males; 96 for white females; and 90 for non-white females. Due to the few numbers of non-whites employed at this site, the numbers of deaths for non-whites were few. More detailed cause-specific SMRs for non-whites are highly unstable and will not be reported, unless they achieve a statistical significance.

There was an elevated SMR of 119 (95% CI: 111 to 126) for cancer of the lung among white males. Non-white males and white females showed similar levels of excess risk. Cancer of the bone was also elevated among white males with an SMR of 182 (95% CI: 104 to 296). This was based on 16 cases; only one case occurred among the combined group of non-white males and all females. All-respiratory diseases showed an excess SMR of 119 (95% CI: 111 to 127) for white males. This included pneumonia (SMR = 117 with 95% CI: 104-132) and emphysema with an SMR of 109 (95% CI: 92-128). Deaths from mental disorders was elevated among the white males with an SMR of 159 (95% CI: 128-195). External causes of death, including both all accidents and motor vehicle accidents, showed an elevated SMR among the white males of 111 (95% CI: 104-118). There was a similar excess in deaths from all external causes of death among white and non-white females. Finally, a category entitled "symptoms, senility, and ill-identified conditions" showed an SMR of 301 (95% CI: 269-335) among the white males and similarly excessive SMRs among the non-white males (SMR = 160); non-white females (SMR = 249) and white females (SMR = 227).

Since the time period of follow-up was quite long, over four decades, the trend in deaths by calendar year of death is of interest. Cancer of the lung has shown increasing SMR's over time, with the highest SMR occurring in the 1970 to 1989 time period. Both decades (1070's and 1980's) showed statistically significant SMR's for lung cancer. Cancer of the bone showed an elevated SMR before 1950 and in the 1950-1959 decade, though it never reached statistical significance until the 1980-1989 decade, when the

SMR was 408. Although cancer of the kidney was not in overall excess in the entire cohort, the SMR for this site was 145 in 1980-1989, based on 32 cases. The excess in all-respiratory diseases has remained virtually stable from 1950 to 1989, showing a range of SMR's from 120 to 123 during these decades. The excess has been statistically significant since 1960 and continues to be so through 1989. Deaths from chronic nephritis were at or below an SMR of 110 prior to the decade of 1980-1989 when the SMR jumped to 641 based on 12 cases. This was statistically significant. Deaths from the category "symptoms, senility, and ill-defined conditions" were highly excessive in the early years of follow-up and have a diminishing SMR of 225 by the 1980-1989 decade; each decade, the SMR was statistically significant elevated. Finally, deaths from mental disorders peaked in 1960-1969 with an SMR = 233 but remained elevated with an SMR of 151 (34 deaths) in 1980-1989. This excess was statistically significant. Finally, the SMR for all-causes of death peaked in the 1960-1969 and 1970-1979 decades when the SMR was 108-109. It dropped to SMR = 98 in the 1980-1989 decade, but still remains much higher than one usually sees in occupational cohorts.

Dupree also examined the pattern of mortality by year of birth, splitting the cohort into workers who were born prior to 1910 and those who were born during or after 1910. In general, the excesses for specific causes of death noted above were experienced to a greater extent by the workers born prior to 1910. However, the pattern of mortality was similar in both birth cohorts. The all-cause SMR dropped from 108 among workers born prior to 1910 to 98 among workers born during or after 1910. However, both are relatively high for occupational cohorts. Similar findings were seen for all cancers: 105 for workers born prior to 1910 and 94 for workers born thereafter. For selected sites, specific SMRs remained elevated for the group born on or after 1910, including lung cancer (SMR = 111; 95% CI: 101-120); all respiratory diseases (SMR = 111, 95% CI: 99-123) and mental disorders (SMR = 133, 95% CI: 99-175). Of note is that the risk of chronic nephritis increased for the cohort born during or after 1910 to an SMR = 120 from a SMR = 83 for workers born previous to 1910. Similarly cancer of the bone retained a SMR = 139 for workers born during or after 1910, though the earlier cohort experienced an SMR = 224 for this same site.

To a limited extent, the excesses in the standardized mortality ratios reported thus far are diluted was the mixing of monthly and hourly workers. In general, the hourly workers had considerable higher standardized mortality ratios than the monthly workers. When the analysis is restricted to hourly workers, the magnitude of the SMR's increased and, in some cases, achieved statistical significance, whereas the overall SMR including both hourly and monthly workers may not have achieved such statistical significance. However, the pattern of mortality is similar for the two groups. Furthermore, the effect of mixing monthly and weekly/hourly workers is limited, since only about 8% of the deaths were among the monthly workers.

Finally, Dupree and colleagues looked at the mortality of the K-25 cohort by length of employment. The higher SMR's were observed among workers who worked less than one year at the facility. Conversely, lower SMRs were seen among workers who were employed at the plant for five year or more. However, the SMRs remained elevated for the longer term workers at selected sites, including cancer of the lung, cancer of the bone, and cancer of the kidney. None of these achieved significant statistical significance. Of noted is that this longer-employed group included 2,295 deaths, which was only 18 % of the entire deaths of the cohort. Hence, statistical power was limited for less common causes of deaths.

Although the Dupree study provides most detailed description of mortality pattern at the K-25 site, certain features of the study impose severe limitations on its interpretation. First, the vital status of over one-half of the cohort was unknown. Specifically, among the 35,712 workers in the study, the vital status of 20,427 (57%) was simply not known. Some might argue that this major problem would invalidate the study and make it uninterpretable. In the very least, it severely limits our ability to understand the overall mortality experience of the K-25 cohort.

Secondly, Dupree and colleagues were unable to make any type of analysis of mortality by exposure. Although K-25 had a single chief function, gaseous diffusion of uranium, it had other major operations, including centrifuge, barrier manufacture, decontamination, and others. Exposures at these various departments have varied considerably. Hence, an excess mortality experience of a sub-group of workers with a different type of exposure or a great intensity of exposure could easily be hidden by the global SMR's that Dupree reported, which were only broken down by time factors. Given the heterogeneity of exposures and the intensity of exposures at the plant, the fact that there were any stable patterns of excess among SMRs suggest powerful effects among exposure sub-groups. especially those with the highest exposures.. Third, the authors had no information on cigarette smoking or other potential cofounders and, therefore, could not separate out any occupational effect from the effect of other risk factors.

It is most likely that the mortality pattern of the K-25 work force reflects both occupational and non-occupational exposures. The finding of the highest excess SMR's among the shortest term workers, especially those born before 1910 and those whose employment was restricted to War World II years, cannot be used to support an occupational effect. On the other hand, the finding of excess risks at some of the sites that *a prior* were suspected by Dupree due to a plausible occupational etiology were, in fact, found to be in excess. This includes cancer of the lung, chronic respiratory disease, cancers of the kidney, chronic nephritis, and cancer of the bone. In addition, if cigarette smoking were a major cause of finding of cancer of the lung and excess chronic respiratory disease, then other smoking-related disease excesses would be expected, including cancer of the esophagus, larynx, and bladder. However, these were not found, undermining the notion that cigarette smoking is the exclusive cause of the excesses seen among these workers.

In any event, interpretation of this study must be necessarily limited, due to the fact that the majority of the workforce was not followed up and due to the lack of any exposure-specific analysis. Nor will further mortality analysis be likely to be fruitful. This is true, because the exposure data that would allow a exposure-specific analysis are limited and, secondly, many of the workers who were lost to follow-up, were lost many years ago, making additional follow-up and identification of cause of death very unlikely.

<u>Mortality among K-25 Welders, Wells et al, 1994</u>

Wells and colleagues from ORISE studied the mortality experience among 683 welders at K-25 as part of a larger study of 1,211 welders employed at all three DOE facilities at Oak Ridge (K-25, X-10, and Y-12/TEC). These welders were employed at Oak Ridge during the time period from 1943 to 1985 and causes of death were followed up through 1989. The analyses were restricted to white male welders due to the very few welders who were female or from minority populations. The minimum duration of employment for the study group was 90 days. This study, which was reported in 1994 in an unpublished manuscript, represented an update of the previous study by Polednak that was published in 1981.

K-25 welders differed from welders at the other Oak Ridge facilities by the type of metal on which they routinely worked. K-25 welders welded nickel-alloy pipes, that is, mild steel coated with nickel. Welders at X-10 and Y-12/TEC welded mild steel but also stainless steel and aluminum. Also, K-25 welders principally used the shielded metal arc technique and, to a lesser extent, tungsten inert gas and metal inert gas. By contrast, the tungsten inert method was the overwhelming choice at X-10 and Y-12/TEC.

K-25 welders worked a mean of 4.8 years as welders at the facility. They were, on average, 31 years of age when they began work at K-25 and entered the K-25 workforce in 1956 on average. Welders from the other K-25 facilities worked for longer as welders (mean = 7.2 years) and entered slightly earlier (mean year = 1953) and at a slightly older age (mean = 34 years). The mean number of years of follow-up for the K-25 subgroup of 25 years.

There were 237 deaths among the K-2 welders and 226 deaths among the X-10/Y-12 workers. The all-cause standardized mortality ratio among the K-25 welders was 107 (95% CI = 94-121). Cancer of the lung was elevated among the K-25 welders with an SMR = 143 (95% CI = 93-209). Cancer of the prostate and brain were also elevated in K-25 subgroup, though based on considerably fewer cases. The SMR for prostate cancer was 1.54, based on five observed deaths, yielding a 95% CI = 50-359. There were four brain cancer deaths, yielding an SMR = 261. The authors do not provide confidence intervals for the brain cancer SMR. Diseases of the respiratory system other than cancer were also elevated among the K-25 welders with a SMR = 151 (95% CI: 94-226) with an elevation principally in emphysema with an SMR = 215 (95% CI: 79-471). Other SMR elevations included all-cancer deaths (SMR = 106); deaths from ulcers (SMR = 404, based on five cases) and suicide (SMR = 150, 95% CI: 59-315). The pattern of mortality among other workers at Oak Ridge was similar to that of K-25 with a somewhat higher SMR for prostate cancer and a lower SMR for non-malignant respiratory disease. Of note is that when the subgroups of welders are treated as a single cohort, many of the excesses described above becomes statistically significant. This is true for lung cancer, diseases of the respiratory system other than lung cancer and prostate cancer.

Bladder Cancer Morbidity at K-25, Cragle et al., 1992-1994

In 1987, the Oil Chemical Atomic Workers Union reported that workers at the gas centrifuge operation at K-25 suspected that the occurrence of health problems might be related to work exposures. This operation involve the manufacture and testing of centrifuges for possible use in the enrichment of uranium. Central to the operation was the manufacture of centrifuge rotors that were made of fiber-reinforced epoxy resins. This process operated at Oak Ridge between 1963 and 1985.

The contractor operating the plant, Martin Marietta Energy Systems, invited the Oak Ridge Institute for Science and Education (ORISE) to study of health of the centrifuge workers. In 1992, Cragle, Wells and Tankersley, published the results of their study. The investigators identified the workers in the centrifuge operation who were most likely to have significant exposure to the agents of interest. Potentially exposed workers were drawn from eleven departments that were involved in the centrifuge process. Four of these departments had job titles who were estimated to have the highest potential for exposure to epoxy resins and/or solvents. This higher exposure group consisted of more than 500 workers. A further sub-group was defined as workers who had an minimum of 500 days of work at these higher exposed job titles. The final study group consisted of 281 workers who met these criteria. A control group of workers was drawn from any of the three Oak Ridge facilities (Y-12, X-10, and K-25) matched to the study subjects according to the date of birth, race, sex, date of facility hire, and presence in the plant on the date when the exposed worker began working in the centrifuge operation. A total of 317 control workers were identified.

Exposures of interest in these centrifuge process included 4,4-methylendianiline (MDA), m-phenylenediamine, bis-(2,3-epoxycyclopentyl) ether, diglycidyl ether of bisphenol A, trichloroethylene, and methylene chloride.

The distribution of age and duration of employment among the centrifuge workers studied is of interest. The mean age of the study group at the time of the study (1988-1989) was 47 years. The mean duration of employment at Oak Ridge, and specifically, at the gaseous diffusion plant, was 20 and 17 years respectively.

The most significant finding was the occurrence of excess bladder cancer in the study group compared to the control group. There were five cases of bladder cancer among the centrifuge workers and none in the comparison group. When SEER data from Atlanta are used to construct a comparison rate, the standardized incidence ratio of bladder cancer in the study group was 7.8 (95% CI: 1.1-68.1). None of the five workers who developed bladder cancer had "routine hands-on work" with any of the epoxy resin materials. However, three of the workers worked in decontamination and clean up following centrifuge malfunctions, and the other two workers apparently worked in the immediate proximity of the location where the epoxy resin materials and solvents were used.

Other findings of interest in the study group included excess of dizziness (SIR = 1.98); insomnia (SIR = 2.2); numbness or tingling of a limb (SIR = 1.68); and rashes (SIR = 4.0). All of these reported symptoms were found in statistical significant excess versus the comparison group.

The investigators conclude that the study group needed to be followed and monitored for appearance of cancer.

Of note, is at the time of the study in the late 1980's, only 3% of the workers who had ever worked in the centrifuge process had died.

As a follow-up to the study described above, a second phase of the investigation was undertaken to examine the bladder cancer risk among a larger group of workers who had been employed in the centrifuge process. Included in this Phase 2 study were workers from centrifuge departments (1330-1339), analytical laboratories, and maintenance departments that provided support services to the centrifuge process. Workers who had participated in the original bladder cancer study were eliminated from the Phase 2 study. A control group was drawn from K-25 workers who had never worked in the centrifuge process and were individually matched to the study group by date of birth, race, gender, and date of hire. This analysis no longer was restricted to workers with the highest potential of exposure to epoxy resins and solvents. The minimum period of employment in the centrifuge process was not specified.

The study group included 627 centrifuge workers, 646 centrifuge comparison workers, 228 maintenance (centrifuge workers), and 236 comparison maintenance workers.

The study results showed no excess bladder cancer, with three bladder cancers occurring in the centrifuge and maintenance (centrifuge) workers and 3 bladder cancers occurring among the comparison workers.

However, other differences in health status were documented between the centrifuge and the comparison worker groups. Centrifuge workers experienced 2.35 times more emphysema (SIR = 2.35, 95% CI: 1.0-5.6). There was also more numbness and tingling of the limbs among the centrifuge workers (SIR = 1.5 with 95% CI: 1.1-2.0). Among the maintenance workers, the SIR for asbestosis was 3.1; the SIR for emphysema = 3.2; the SIR for dizziness = 1.9; the SIR for skin rash = 1.9 and the SIR for urinary tract infection = 3.9. The latter three excesses were statistically significant.

The contrast between the results of the initial study and those of Phase 2 are not surprising. Phase 2 study included workers with less exposure to the presumed agents of interest and, therefore, any occupational effect, such as bladder cancer might not be seen among the lesser exposed group. Indeed, several centrifuge departments that were included in Phase 2 were judged in the initial study to have no potential for exposure. This includes departments 1330, which is administrative; departments 1331, which is administrative and clerical; department 1333, which is planning and administration; department 1335, which is budget, accounting, planning, and data systems. At the very least, these departments should have been analyzed separately in Phase 2. Inclusion of these non-exposed groups in combination with the failure to analyze their experience separately severely limits our ability to interpret Phase 2 results.

Indeed, both phases of this centrifuge study seemed to be plagued by problems in exposure characterization. The authors used the best data that were available on job titles, departments and categorical estimates for likelihood of exposure to agents of interest.

Portsmouth Studies

Mortality at Portsmouth, Rinsky, 1996

In 1996, Rinsky of NIOSH reported on a mortality update of workers at the Portsmouth gaseous diffusion plant. These workers have been previously studied by Brown and Bloom, who had issued their findings in 1987. The Rinsky analysis updated and extended the previous NIOSH study.

Rinsky's cohort consisted of all Portsmouth employees who worked at least one day at the facility between September 1954 and December 31, 1991. The final cohort included 8,877 individuals, of whom 6,849 (77%) were white males; 1,462 (17%) were white females; 372 (4%) were non-white males, and 194 (2%) were non-white females.

Rinsky used available industrial hygiene and health physics data to assess mortality risk by exposure. He constructed a job exposure matrix from the extensive urine analysis monitoring program that measured urine alpha counts for uranium. He also selected specific chemical exposures - fluorine/fluoride compounds, uranium, and nickel - to characterize exposure according to available industrial hygiene records. Although a large number of sample results were available for these three compounds, that is 7,185 results, from 1954 through 1991, Rinsky noted important limitations. All samples were area samples. Hence, assignment of exposure levels to departments, job titles, or individuals was a crude process that measured, at best, average levels of these agents present at the time of sampling. In addition, the number of samples available for many individual years was few, and therefore, construction of the job exposure matrix had to rely on five year intervals over the time period, 1954 to 1991. The data were especially sparse for nickel, for which 712 samples had been taken over the 38 year time period covered by the study. 169 nickel samples (24%) were taken at one particular building where considerable nickel welding had occurred. Rinsky concluded that the nickel exposure data from other buildings were too sparse to use in the analysis. Fluorine and uranium industrial hygiene data were distributed in a highly skewed fashion, leading Rinsky to develop exposure scores based on the proportion of time that airborne area concentrations of fluorine or uranium were above specific levels.

Rinsky noted that the history of the Portsmouth plant could be considered in four phases: the start-up period in the 1950's, the production period in the 1960's and 1970's, the upgrade program in the 1980's and the post-upgrade production of the 1990's. There was a large increase in employment during the upgrade program of the 1980's.

There were 1,088 deaths, or 12%, in the cohort during the study period. Overall mortality and deaths rates by major category of disease were significantly lower in the Portsmouth cohort compared to the U.S. general population. The all-cause SMR was 72 (95% CI: 67-76). Other major categories of mortality also had statistically significant decreases in ratios, including deaths from all-cancers (SMR = 82); diseases of the heart (SMR = 75) respiratory system (SMR = 50); accidents (SMR = 61) and violence (SMR =51).

There were small excesses that were not statistically significant for selected cancer sites, including stomach (SMR = 118, 15 cases); female genital organs (SMR = 127, 6 cases); bone (SMR = 168, 2 cases); lympho-reticulosarcoma (SMR = 137, 7 cases) and Hodgkin's disease (SMR = 138, 5 cases). There was no pattern of age, duration of employment, or latency that suggested that any of these excesses might have been work-related.

Among the sub-cohort of 6,827 workers for whom urine samples had been taken to monitor exposure to internal radiation, the SMR was 72 (95% CI = 68-78). Again, there was no dose-response pattern, using cumulative urine alpha disintegrations per minute as the measure of exposure. The small excesses in unusual cancer sites that where seen in the overall cohort were also seen in the sub-cohort.

Additional analyses for sub-cohorts exposed to fluorine, uranium, and nickel revealed similar results, though the numbers of workers in these sub-cohorts and the number of associated deaths were very small.

For the 1,446 workers judged to be exposed to fluorine and related compounds, there were 139 deaths, yielding a SMR = 69 (95% CI: 58-81). Among the 1,832 workers for whom area airborne concentrations of uranium were available, the overall SMR was 68 (95% CI: 59-79). Among the 465 workers for whom airborne concentrations of nickel were available, there were only 35 deaths yielding an SMR of 76 (95% CI: 53-106). For all of these exposure sub-cohorts, there were too few deaths in the sites where excesses were seen in the larger cohort (e.g. - stomach, cancer, lympho-reticulosarcoma, etc.) to make a reasonable analysis about dose-response.

Rinsky regarded the magnitude of the decrease in the overall SMR and in major category-specific mortality ratios in the Portsmouth cohort to be striking. Indeed, he considered possible technical problems in the study that might explain these results. However, further analyses and checks on the data recording and analysis appear to indicate that the mortality rates in his analysis are accurate.

Rinsky noted a number of important limitations in the study. First, he noted that it was relatively young, with only 12% of the cohort having died through the period of 1991. This concern is also reflected in the limited number of workers and person-years that have passed a sufficient period of latency for chronic disease to appear. Over one-half of the workers were hired during or after 1965, so that maximum latency for these workers would only be 26 years. Or, expressed as person-years, about 63,000 of the overall 203,000 person-years (31%) occur during or after 20 years of latency (Table 5A from Rinsky's report). The longest term Portsmouth workers, that is, those who have worked at least 20 years at the plant contribute only 17,108 person-years, or 8% of the total person-years of the study.

Rinsky also notes that mortality studies are insensitive indicators of health risks, even serious ones, that do not routinely produce fatality. A final major limitation as noted above, was the sparse industrial hygiene available for the exposures for which sub-cohort analyses were performed: fluorine compounds, uranium and nickel.

Rinsky planned additional analyses, including internal comparisons of dose-response relationships, and interaction among temporal and other variables using more advanced statistical techniques. He also concluded that additional follow-up of the population was needed, especially given its relatively young age.

Studies at All Three Gaseous Diffusion Plants

Cross-Sectional Surveys of Asbestosis, Provost and Umphrey law Firm, 1990-1997

Under the auspices of the Provost and Umphrey law firm, screening surveys for asbestos-related disease were conducted at Oak Ridge K-25 (1990); Paducah (1991); and Portsmouth (1997). How workers were selected for participation is not known. The job titles participating included most maintenance trades as well as some operators. The chest x-rays were read by a NIOSH-certified B reader. The prevalence of asbestos-related fibrosis on chest x-ray was 85/147 (58%) at Oak Ridge; 49/316 (16%) at Paducah; and 107/296 (36%) at Portsmouth. Results are not available by job title.

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