Evaluation of Employee Health Concerns and Suspected Contamination at an Office Complex

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Contents

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The cover photo is a close-up image of sorbent tubes, which are used by the HHE Program to measure airborne exposures. This photo is an artistic representation that may not be related to this Health Hazard Evaluation. Photo by NIOSH.

Highlights of this Evaluation

The Health Hazard Evaluation Program received a request from managers of a federal government office complex. Employees were concerned about health problems (cancer, gallbladder problems, and chronic obstructive pulmonary disease) and possible contamination of the complex with polychlorinated biphenyls, solvents, metals, and other chemicals.

What We Did

- We looked at records of past exposure assessments at the complex.
- We toured 13 buildings at the complex to evaluate potential exposures from past or current contamination.
- We held town hall meetings, small group meetings, and spoke individually with several hundred employees.
- We offered a test for sensitization to beryllium to former or current employees diagnosed with sarcoidosis. Sarcoidosis is an inflammatory disease that is nearly identical to chronic beryllium disease.

We evaluated exposure and health concerns at an office complex. We reviewed environmental sampling records, spoke with employees about their health, and tested some employees for beryllium sensitization. We found no overexposures. None of the employees we tested had beryllium sensitization. We found no excess of cancer or abnormal pattern of other disease.

What We Found

- None of the previous assessments we reviewed found employee overexposures to volatile organic compounds, polychlorinated biphenyls, beryllium or other metals, solvents, formaldehyde, or radon.
- None of the current or former employees who participated in our evaluation and had sarcoidosis was sensitized to beryllium.
- We found no excess of cancer or abnormal pattern of disease.

What The Employer Can Do

- Encourage employees to learn about their personal cancer risk factors.
- Educate employees on what they can do to reduce their risk for cancer.
- Stop all investigations of cancer incidence.
- Stop routine air and surface wipe sampling for chemicals.

What Employees Can Do

- Report work-related health concerns to your supervisor.
- Learn about cancer risk factors and how you can reduce your risk for cancer.
- Participate in cancer screening programs offered at work.

Abbreviations

μg/100 cm^2	Micrograms per 100 square centimeter
cm^2	Centimeters squared
PCB	Polychlorinated biphenyl
BeLPT	Beryllium lymphocyte proliferation test
CFR	Code of Federal Regulations
CBD	Chronic beryllium disease
DOE	Department of Energy
EPA	Environmental Protection Agency
mg/L	Milligrams per liter
NIOSH	National Institute for Occupational Safety and Health
OEL	Occupational exposure limit
OSHA	Occupational Safety and Health Administration
ppm	Parts per million
VOC	Volatile organic compound

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Introduction

The Health Hazard Evaluation Program received a request for an evaluation at a federal government office complex. Managers at the complex reported that employees were concerned about health problems including cancer, gallbladder problems, and chronic obstructive pulmonary disease among employees. Some employees believed their health problems were associated with contamination of the buildings, soil, and groundwater (past and present) from an adjoining weapons component agency.

In June 2010, we visited the complex. We held opening and closing meetings with union representatives, managers, and tenant agency representatives. We toured the complex (13 buildings) and visually examined the ventilation systems of Building 1 and 2. We held larger town hall and smaller group meetings with employees and interviewed employees individually. We became aware that beryllium was machined in the weapons component agency and that pathways were present that potentially allowed for migration of beryllium to parts of the complex. Because pulmonary sarcoidosis is clinically almost identical to chronic beryllium disease (CBD), we noted that complex employees with sarcoidosis who were unaware of the potential for exposure to beryllium may have been misdiagnosed with sarcoidosis when they actually had CBD. Therefore, we returned three times in 2010 to conduct blood beryllium lymphocyte proliferation tests (BeLPT), which test for sensitization to beryllium. During this time, we also reviewed all of the exposure assessment documentation that was provided to us by the complex managers.

In April 2011, we sent a letter with findings and recommendations to union representatives, the managers of the complex, and tenant agency representatives. The letter included our initial findings of:

- no overexposures to substances used now or in the past by the weapons component agency
- no cancer cluster
- no beryllium sensitization among the 22 individuals to whom we provided a BeLPT.

We also stated that we would wait to prepare our final report until the Environmental Protection Agency (EPA) finished their updated site evaluation and the complex completed their environmental sampling.

Facility Description

The entire facility consists of 300 acres and 13 buildings and was constructed during World War II for building aircraft engines. Aircraft engine manufacturing continued in the complex until the 1960s. In 1942, a weapons component agency began assembling non-nuclear weapons components there.

When we refer to “the complex” we are referring to the federal government agency that manages the complex as well as the multiple federal agencies and their employees that are housed in the complex. For the purposes of this report the weapons component agency is not part of the complex. The complex and the adjoining weapons component agency plan to discontinue use of the site and move to separate facilities by the end of 2014. Because the health hazard evaluation request was submitted by the complex managers, the focus of our evaluation was the complex and not the adjoining weapons component agency.

The largest structure at the site contained over 1 million square feet of leasable space across three floors. This structure contains two main areas: (1) the complex's Buildings 1 and 2 (mostly office and warehouse space) and (2) the weapons component agency (non-nuclear weapons component manufacturing). A floor-to-ceiling secured fire wall divided the structure approximately in half; Buildings 1 and 2 were physically separated from the weapons component agency. The fire wall had no unsecured openings. Buildings 1 and 2 have separate ventilation systems from the weapons component agency's ventilation systems. Figure 1 illustrates the locations of the complex's Buildings 1 and 2 in relation to the weapons component agency.

While a majority of the complex's employees work in Buildings 1 and 2, freestanding buildings are located throughout the complex. These buildings serve a wide variety of functions that range from daycare facilities to warehouse space to fleet maintenance and shipping docks. The freestanding buildings are also known by number (for example, Buildings 4, 6, 41, 50, and 52) or by their street address.

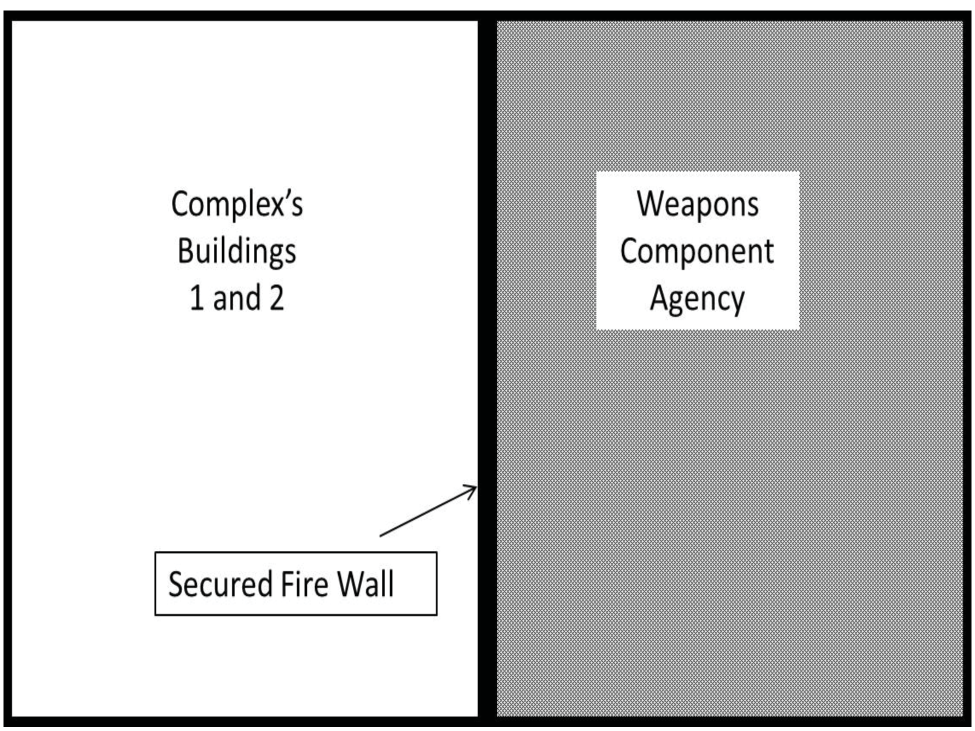

Figure 1. Large structure illustration depicting the complex's Buildings 1 and 2 in relation to the weapons component agency.

The facility had a history of environmental contamination, primarily from the weapons component agency. This led to concern among complex employees. Part of the facility was evaluated by EPA in 1987, but did not meet the criteria to be placed on the National Priorities List, a listing of sites eligible for long-term remedial cleanup of hazardous substances. Concerns of complex managers and employees that led to this health hazard evaluation prompted EPA to reassess the site around the time of our evaluation to see if it would be listed on the National Priorities List under current criteria. However, in August 2012, EPA and the state agency with environmental authority over the weapons component agency instead issued final hazardous waste permit modifications under the Resource Conservation and Recovery Act that allow better coordination of environmental investigations and hasten cleanup of the complex. EPA's assessment of outdoor environmental exposures may not pertain to workplace exposures but was a concern of managers and employees. Therefore, we evaluated complex employees' potential exposures during the course of their work (which takes place indoors), addressing complex operations and potential contamination from the weapons component agency.

Methods

A primary concern from complex managers, tenant agencies, and employees we interviewed was that potential contamination from substances used by the weapons component agency was affecting their health. We focused our evaluation on Buildings 1 and 2 due to their proximity to the weapons component agency. While the focus was on Buildings 1 and 2, our walk-through survey of the complex covered 13 buildings. Our visual inspection of Building 1 and 2 ventilation systems included rooftop outdoor air intakes and exhausts, and ventilation mechanical rooms. We also reviewed ventilation system designs for Buildings 1 and 2, sub-slab vapor intrusion mitigation systems in Buildings 50 and 52, and areas of concern identified by tenants during the opening meeting and town hall meetings. We participated in a short, guided tour of a small section of the weapons component agency even though it was not a part of this evaluation.

We considered six potential exposure pathways by which current or past contamination could be present in the complex or migrate from the weapons component agency to the complex:

- Legacy (or past) contamination
- Ongoing contamination from employees of the weapons component agency unknowingly tracking contamination into the complex when they patronized the credit union, cafeteria, and other common areas in Building 1
- Ventilation systems shared between the complex and the weapons component agency
- Potentially contaminated exhaust air from the weapons component agency entering the outdoor air intake(s) of the complex's ventilation systems
- Openings in the fire wall separating the complex from the weapons component agency
- Contamination in the drinking water

Chemical and Physical Exposures

We reviewed records provided to us by complex managers. These records included exposure assessments for metals (including beryllium), volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), ionizing radiation, and drinking water quality. Historically, complex environmental and health staff, other government agencies, and private contractors hired by complex managers collected area air samples, surface wipe samples, and environmental soil and groundwater samples. Following our evaluations, contractors hired by complex managers conducted exposure assessments in 2010 and 2011; we reviewed those exposure assessment documents. Exposure assessment documents are publicly available on a website maintained by the complex management and are categorized by building and year: http://www.gsa.gov/portal/category/102611#. While we reviewed all the exposure monitoring reports provided to us by complex managers, we did not verify that each report provided to us was also available on the publicly accessible website. From 2010 through 2012, we received 18 compact discs that contained exposure assessment reports, private contractor exposure assessment reports, ventilation design specifications, injury/illness logs, and environmental site assessments. During this period, complex managers also provided additional electronic reports and information via e-mail and a file-sharing website. In all, we reviewed 105 documents/reports provided to us by complex managers.

Table 1 lists a subset of contaminants we reviewed during our evaluation. While we reviewed all exposure assessment information provided to us, we chose to focus our evaluation on the contaminants listed in Table 1 because they met one or more of the following assumptions: illustrated the wide range of chemical and physical hazards that have been evaluated throughout the years at the complex; are related to the facility's outdoor environmental concerns addressed by EPA; were of concern to complex managers or employees; or are toxic at low concentrations. The complete list of contaminants described in reports we reviewed can be found in Appendix A. Appendix B includes information on occupational exposure limits (OELs) and health effects for many of these contaminants.

Table 1. Substances identified in the exposure monitoring reports

Substance	Years	Sampling method used
Acetone	2002–2004	PS
Antimony	1997–2010	AC, GR, SW
Beryllium	2002–2011	AC, SW
Chloroform	2002	GR
Chromium	2009	AC, SW
Cobalt	2009	AC, SW
Cooper	1997–2012	AC, GR, SW
1,1-Dichloroethane	2002	GR, PS
cis-1,2-Dichloroethene	2001–2012	GR
trans-1,2-Dichloroethene	2002–2012	GR, PS
Formaldehyde	2002	PS
n-Hexane	2004	PS
Iron	1997–2012	AC, GR, SW
Lead	1997–2012	AC, GR, SW
Manganese	2009–2010	AC, SW
Naphtha	2001–2004	GR, PS
Nickel	1997–2012	AC, GR, SW
Petroleum distillates	2004	PS
Polychlorinated biphenyls	2001–2012	AC, GR
Radon	1989–1997	PS
Toluene	2002–2004	GR, PS
Trichloroethylene	2001–2012	AC, GR, PS
Uranium	2010–2011	AC, SW
Vinyl Chloride	2001–2012	AC, PS
Xylene	2004	PS
Zinc	2009	AC, SW

AC = active air sample
GR = grab sample
PS = passive air sample
SW = surface wipe

Biological Monitoring

We offered blood BeLPT testing to individuals with medically confirmed sarcoidosis (an inflammatory disease that can affect many organs in the body), as well as those with other lung conditions that could be mistaken for CBD. We took this action on the basis of the following information:

- Because pulmonary sarcoidosis is almost identical clinically to CBD, we believed it possible that complex employees with sarcoidosis may have been misdiagnosed with sarcoidosis when they actually had CBD.
- Beryllium-copper alloy was reportedly machined at the weapons component agency.
- Several current and former employees of the weapons component agency had been either sensitized to beryllium or had CBD. The fact that some of these employees did not work with beryllium suggests that beryllium exposures may not always have been well controlled.
- Small amounts of beryllium had been detected on wipe samples collected in Building 41 of the office complex.
- A lumber delivery employee and a roofer at the complex, neither of whom entered the weapons component agency assembly areas, had been documented to be sensitized to beryllium.
- Beryllium can persist in the environment until cleaned up.
- Beryllium is a sensitizer and can cause health effects at very low levels of exposure.

We returned three times in 2010 to offer the blood BeLPT to 22 individuals who used to work at the complex. For 19, we were able to split the blood sample and have it analyzed by two laboratories (National Jewish Health and Oak Ridge Institute for Science and Education). For 3, the sample could not be split and was analyzed by only one laboratory. An individual with two abnormal BeLPTs was considered sensitized to beryllium.

Employees Interviews

Prior to the site visits, complex managers notified employees that we were conducting telephone interviews with concerned current or past employees and provided our contact information. In addition, we were available for in person interviews during the site visit. We continued to receive telephone calls and emails after the site visit. In all, we interviewed 362 current or former employees including 214 former complex employees, 72 current complex employees, and 76 current or former employees of the weapons component agency. We interviewed employees of the weapons component agency because they thought that our evaluation covered their agency and because they had medical concerns we could address. We conducted the interviews in person, by telephone, and through e-mail.

Walk-through Evaluation and Ventilation

We collected spot measurements of the indoor temperature, relative humidity, and carbon dioxide concentrations in Building 1 using a TSI® Q-TrakTM Plus Model 8554 to compare to recommended comfort and odor guidelines [ANSI/ASHRAE 2010, 2013].

We visually inspected the air handling units and ventilation system fans and ductwork in Buildings 1 and 2, evaluated potential cross-connections with the weapons component agency's ventilation system, examined the installation and condition of the air filters, and noted the general cleanliness of the mechanical rooms. We evaluated the ventilation systems for instances of shared ventilation currently and in the past.

Results

Chemical and Physical Exposures

Metals

Conversations and medical interviews with complex managers, tenant agency representatives, and employees identified beryllium as an exposure of interest at the complex due to beryllium's use at the weapons component agency. During our review of exposure assessment documents, we noted a small number of sampling results of interest. With a few exceptions, beryllium was not detected in surface wipe samples, and all of the surface wipe results were below the Department of Energy (DOE) guideline for surface contamination of 0.2 micrograms per 100 square centimeters (μg/100 cm^2) for non-beryllium uses and public release. The DOE guideline is appropriate when releasing previously contaminated property for use by the general public and is not intended to be an OEL [DOE 1999]. No exposure guidelines or OELs exist for beryllium surface concentrations in an office environment.

In January 2002, the complex hired a contractor to collect 10 surface wipe samples for beryllium in Building 41 which, at that time, was occupied by a tenant. Beryllium was not detected (< 0.038 μg/100 cm^2) in eight wipe samples. Two wipe samples (described as "Basement Wall" and "Outside, beneath north side of air intake") measured beryllium at the lowest quantification limit of the analytical method, 0.13 μg/100 cm^2. In May 2002, an additional 10 surface wipe samples for beryllium were collected near the January 2002 sampling locations; all results were below the limit of detection (< 0.04 μg/100 cm^2). The reports did not state if any activities that may have removed beryllium from the area (decontamination, cleaning, vacuuming, etc.) were performed between the two sampling dates.

In February 2010, a contractor collected area air and surface wipe samples in Building 1 for uranium oxide, beryllium, lead, zinc, antimony, manganese, copper, and iron. The contractor collected air samples at nine locations and surface wipe samples at 29 locations. Only one surface wipe sample was above the limit of detection (0.5 μg per sample) for uranium oxide at 0.63 μg/100 cm^2. The location for this sample was on the "1st Floor-Hallway Mezz at Column E-16" with the description "Floor Surface – top of stairwell." This was a non-occupied space accessible only to maintenance personnel. No subsequent uranium oxide data reported detectable levels.

The metal concentrations that we reviewed were very low or not detected. For the surface wipe samples (other than beryllium and uranium oxide), the highest concentrations of metals (predominately lead, zinc, iron, and manganese) were found in samples collected in non-occupied spaces such as mechanical or maintenance areas. These mechanical or maintenance areas would have been used for fork truck battery charging, welding, and other activities that would have involved these types of metals. OELs for metals on surfaces do not exist.

Volatile Organic Compounds

Conversations with complex managers, tenant agency representatives, and employees identified VOCs as an exposure of interest at the complex due to past environmental contamination. Area air sampling was conducted in occupied areas of the complex (primarily in Buildings 1 and 2) as well as typically unoccupied locations such as slab or sub-slab locations and mechanical and storage rooms.

In general, the VOC concentrations that we reviewed were very low or not detected, and did not exceed applicable OELs. VOCs were most often detected in sub-slab or utility areas rather than occupied spaces in the complex. Some VOCs were listed as exceeding the regional screening level, an EPA term that identifies areas, contaminants, and conditions that require further attention at a particular site. A regional screening level is not an OEL and is not intended to pertain to a workplace.

We also reviewed area air sampling data for formaldehyde, a chemical that can irritate the eyes, nose, and throat if present in sufficient concentrations. These results were well below 0.05 parts per million (ppm) [Wallingford 2009], a limit suggested by National Institute for Occupational Safety and Health (NIOSH) investigators for office environments based in part on indoor environment quality specifications developed for new office buildings by the State of Washington [State of Washington 1989].

Ionizing Radiation

Ionizing radiation exposure from cross contamination with materials used by the weapons component agency was of concern to some complex employees we interviewed. Representatives from the weapons component agency told us that they only manufactured non-nuclear (non-ionizing) products, and had never manufactured nuclear products.

We reviewed NIOSH exposure reconstruction documents developed for the Energy Employees Occupational Illness Compensation Program Act for the weapons component agency. These records did not indicate ionizing radiation exposures other than to weapons component agency employees who used certain analytical laboratory technologies and nondestructive testing equipment [NIOSH 2006].

Radon, a naturally occurring radioactive gas, had been sampled at the complex by contractors hired by complex managers. All of the radon levels we reviewed were well below the Occupational Safety and Health Administration (OSHA) permissible exposure limit.

Drinking Water

The complex received drinking water from the municipal water services department, so routine work activities at the complex would not bring employees into contact with potentially contaminated soil or groundwater. In the event of drinking water distribution system malfunctions (water line breaks or ruptures, backsiphonage, cross-connections, etc.), contamination in the soil and groundwater can enter into the complex's drinking water system. Multiple drinking water monitoring samples have been collected over the years. Below, we briefly summarize and discuss selected results that indicated concentrations above EPA regulations and guidelines.

A contractor collected 23 drinking water samples from 1997–2001 for copper, iron, lead, barium, nickel, antimony, and zinc. All but two were below EPA drinking water guidelines. These two samples, from Building 50, contained iron above the EPA maximum contaminant level.

Drinking water was tested again in 2010 and 2011. In 2010, a contractor collected 384 samples from drinking water fountains in Buildings 1, 2, 4, 6, 41, 50, 52, and 2306 and tested them for trichloroethylene, total suspended solids, iron, copper, and lead. All but three samples were below EPA guidelines. One sample identified as "hose at column line U6 from the Plaza level within Building #1" contained 0.018 milligrams per liter (mg/L) of arsenic, exceeding the EPA maximum contaminant level of 0.01 mg/L. Another sample identified as "sink in the vacant space at column line BOE 1.5 within Building #2" contained 0.016 mg/L of lead, exceeding the EPA action level of 0.015 mg/L. However, another sample taken at this location measured lead below the EPA action level. The third sample, identified as "drinking water dispenser in the island in the middle of the cafeteria on the mall level in building #1," contained 5.9 and 3.6 mg/L of copper, above the EPA action level of 1.3 mg/L.

In 2011, a contractor collected additional drinking water samples and analyzed them for trichloroethylene, iron, copper, lead, and PCBs. A small number of these samples were above the maximum contaminant level for lead and the secondary maximum contaminant level for iron.

Beryllium Sensitization Testing

We confirmed the diagnosis of sarcoidosis or a similar lung condition in 22 individuals. None of the 22 individuals we tested had an abnormal blood BeLPT. This means that they likely were not sensitized to beryllium. Only sensitized individuals can develop CBD. In rare instances, an individual can have a normal blood BeLPT, but an abnormal BeLPT when tested using bronchoalveolar lavage fluid, which is obtained with a scope inserted into the lung. The BeLPT cannot determine if an individual was ever exposed to beryllium, just if they are sensitized to beryllium.

Employee Interviews

We detected no unusual patterns of disease in the 362 current or former employees we interviewed. Common diseases reported included diabetes, hypertension, gallbladder disease, heart disease, depression, chronic obstructive pulmonary disease, asthma, and uterine fibroids.

Employees also reported common, nonspecific symptoms such as cough, fatigue, memory problems, rashes, abdominal pain, and joint pain. In addition, some employees had less common diagnoses such as Charcot Marie Tooth disease (a hereditary disorder that affects the nerves in the arms and legs), histiocytosis X (an increase in a type of white blood cells), and systemic mastocytosis (also known as mast cell disease). Some employees requested to be interviewed, but did not have any health issues. One current and one former employee of the federal government property management agency reported asbestosis from past work removing asbestos.

Cancer was commonly reported and was the focus of our initial meetings because of concern about a possible pancreatic cancer cluster. Sixty-nine current or former complex employees reported having cancer. The most common type reported was breast (26 employees), followed by pancreas (11 employees), bladder (11 employees), lung (10 employees), prostate (8 employees), and nonmelanoma skin cancer (4 employees). A variety of other cancers were each reported by three or fewer employees. Thirty-five current or former employees of the weapons component agency reported cancer. The most commonly reported cancers in this group were lung and pancreas (5 each), prostate (4), and chronic leukemia (4). A variety of other cancers were each reported by three or fewer employees.

Walk-through Observations and Ventilation Assessment

Measurements of the indoor temperature, relative humidity, and carbon dioxide concentrations in Buildings 1 and 2 were within recommended comfort and odor guidelines during our June 2010 evaluation [ANSI/ASHRAE 2010, 2013]. Most workplaces were standard office settings with computers, office furniture, and office equipment and included both private offices and cubicles. We observed minor isolated instances of past water damage such as stained ceiling tiles and drywall in occupied offices, but no widespread water damage. We reported these to the appropriate complex personnel for follow-up.

The air filters in all air handling units in Buildings 1 and 2 were properly installed and replaced on a regular schedule. The mechanical rooms were clean and uncluttered, and the ventilation equipment appeared well maintained.

The ventilation systems in Buildings 1 and 2 were separate from the ventilation systems for the weapons component agency. One air handling unit rooftop housing, which contained air handling units for the complex and the weapons component agency, had a wall with a secure door separating the air handling units of the complex and of the weapons component agency. The rooftop outdoor air intakes and exhausts for Buildings 1 and 2 were not adjacent to the air intakes or exhausts for the weapons component agency. This configuration limits the potential for bringing air exhausted from the weapons component agency into the complex's ventilation intake. We did not measure the distance between intakes and exhausts because a chain-link security fence on the roof prevented movement between the complex's side of the roof and the weapons agency's side of the roof. We estimated the distance to be more than 25 feet. We found no instances of shared ventilation equipment between the complex and the weapons component agency.

We visually examined every fire door and utility line that penetrated the fire wall separating the complex from the adjoining weapons component agency in Buildings 1 and 2. All of the fire doors were closed and the utility line wall penetrations were sealed. Complex managers told us that the fire doors remained closed (for security) and alarms would sound if the doors were opened.

Buildings 50 and 52 are physically separate from Buildings 1 and 2. A sub-slab ventilation system had been installed to control potential migration of trichloroethylene, vinyl chloride, and other chemical vapors from the contaminated soil beneath Buildings 50 and 52 into occupied spaces. Past air monitoring measured little or no chemicals in the occupied spaces in Buildings 50 and 52.

Our review of exposure assessment documents did not reveal any past or current problems with indoor environment quality at the complex. These documents along with our walk-through evaluation and ventilation design review did not indicate any shared ventilation between Buildings 1 and 2 and the weapons component agency. Additionally, none of the outdoor air intakes for the complex were near the air exhausts from the adjoining weapons component agency.

Discussion

Many complex employees we interviewed suspected that contamination from substances used by the weapons component agency was affecting their health. Each of the potential exposure pathways we considered is discussed below.

Air and Surface Contamination

A wide variety of chemicals, ionizing radiation, and metals had been evaluated at the complex from 1980 up to the time of our evaluation. Exposure records provided by the complex indicated little evidence of past or current contamination at levels of concern in the office environment and other occupied areas in the complex.

Because of the work at the adjoining weapons component agency, potential exposures to beryllium and depleted uranium were ongoing concerns of complex employees. In response to these concerns, complex managers hired a contractor to routinely sample air and surfaces. For most of these samples neither beryllium nor depleted uranium was detected. However, beryllium and uranium were found in some surface wipe samples in areas that were neither routinely occupied nor cleaned.

Beryllium is a naturally occurring element and can be found in the soil. The amount in the soil varies by location, but is typically 0.003 grams/kilogram [ATSDR 2002]. It can also be present in the air and soil from emissions from burning coal and oil. Higher levels are often present in soil surrounding industries that process or use beryllium [ATSDR 2002]. Therefore, beryllium in the soil surrounding the complex could have been naturally occurring, from power plant emissions, or from the weapons component agency.

In some situations, analysis of the beryllium/yttrium ration can help determine the source of beryllium (natural or industrial). Too little beryllium was found on the wipe samples from the complex to do this test. Considering that the weapons component agency used beryllium for many years, and some weapons component agency employees previously developed beryllium sensitivity and CBD, it is possible that the beryllium in the wipe samples originated at the weapons component agency. However, we consider the potential for ongoing occupational exposure to beryllium to be low at the complex because the positive samples came from areas where complex employees do not routinely work, despite a few positive samples most of the sample results were negative, we found no evidence of current cross-contamination pathways, and none of the employees we tested had evidence of beryllium sensitization.

On the basis of our review of the sampling records provided by complex managers, our visual inspection of the complex, and the nature of the work performed at the complex, we consider the potential for occupational exposures to depleted uranium to be low currently and in the past for complex employees.

Ventilation

It is unlikely that ventilation system design or operation facilitated contamination of the complex. None of the air handling units we surveyed in Building 1 shared any components with the ventilation systems for the weapons component agency. Additionally, none of the outdoor air intakes for the complex were near the air exhausts from the weapons component agency, thus the physical distance between the two would have made re-entrainment unlikely under the current configuration.

Openings in the Fire Wall

We visually examined each fire door and utility line that penetrated the security wall separating the complex from the weapons component agency. At the time of our site visit all of the doors were closed, and the spaces surrounding utility lines were sealed. Complex managers told us that under the current system the fire doors remained closed (for security) and alarms would sound if the doors were opened.

Drinking Water

Drinking water samples have not shown elevated concentrations of any known contamination from the soil and groundwater pollution at the complex. The contaminants found at elevated concentrations in a few samples often are present in older water distribution systems such as the one at the complex. Lead and arsenic are listed in the EPA National Primary Drinking Water Regulations which limit the concentrations that are allowed in drinking water [EPA 2013a]. These standards are legally enforceable and are intended to protect human health. Iron and copper are in the EPA Secondary Maximum Contaminant Level guidelines which give recommended limits for contaminants that affect the aesthetic (odor, taste, cloudiness) quality of the water. The Secondary Maximum Contaminant Levels are guidelines and are not determined on the basis of human health considerations [EPA 2013b].

Cancer Clusters

Cancer was commonly reported as a concern by current and past employees we interviewed. Cancer is a group of different diseases that have the same feature, the uncontrolled growth and spread of abnormal cells. Each different type of cancer may have its own set of causes. Cancer is common in the United States. One of every four deaths in the United States is from cancer. Among adults, cancer is more frequent among men than women, and is more frequent with increasing age.

Many factors play a role in the development of cancer. The importance of these factors is different for different types of cancer. Most cancers are caused by a combination of several factors. Some of the factors include (1) personal characteristics such as age, sex, and race; (2) family history of cancer; (3) diet; (4) personal habits such as cigarette smoking and alcohol consumption; (5) the presence of certain medical conditions; (6) exposure to cancer-causing agents in the environment; and (7) exposure to cancer-causing agents in the workplace. In many cases, these factors may act together or in sequence to cause cancer. Although some causes of some types of cancer are known, we do not know everything about the causes of cancer. One important point is that the absence of a risk factor does not mean there is no risk for developing cancer. For example, employees often say that they got breast cancer and they have no family history of it, so it must be due to their work. While having a first degree relative with breast cancer increases the risk, most people who get breast cancer do not have a family history of it.

Cancers often appear to occur in clusters, which scientists define as a greater than expected number of cancer cases that occurs within a group of people in a geographic area over a defined period of time [CDC 2012]. A cluster also occurs when the cancers are found among employees of a different age group or sex than is usual. A statistically significant excess of cancer cases may have a common cause, but can occur without a clear cause and can occur by chance [Aldrich and Sinks 2002; Thun and Sinks 2004]. In many workplaces the number of cases is small. This makes detecting whether the cases have a common cause difficult, especially when no apparent cancer-causing exposures are present. It is common for the borders of the "cluster" to be drawn around where the cases of cancer are located, instead of defining the population and geographic area first. This often leads to "clusters" that are not real. This is referred to as the "Texas sharpshooter effect" because the Texas sharpshooter shoots at the barn and then draws his bull's eye around the bullet hole.

In this evaluation breast, prostate, bladder, lung, and pancreatic cancers were the most commonly reported cancers by current and former employees that asked to speak with us. A detailed discussion of the risk factors for each of these cancers is provided in Appendix C. To assess whether the cancers among employees could be related to occupational exposures, we consider the number of cancer cases, the types of cancer, the likelihood of exposures to potential cancer-causing agents, and the timing of the diagnosis of cancer in relation to the exposure. These issues are discussed in the following questions.

Do complex employees have more cancer than people who did not work at the complex?

The number of cases of cancer does not appear excessive. Cancer is a common disease. In the United States, one in two men and one in three women will develop cancer over the course of their lifetimes. These numbers do not include basal or squamous cell skin cancers, which are very common (more than 1 million diagnosed annually), or any in-situ carcinomas other than bladder. In-situ refers to cancer that has not yet spread beyond where it began; it is considered a precursor form of cancer. If these were included, rates would be even higher.

The complex has employed thousands of people since opening in the 1940s. At the 50th anniversary of the complex more than 10,000 individuals were employed. Because thousands of individuals have worked at the complex over the last 70 years, we would expect several thousand current or former employees to be diagnosed with cancer in their lifetimes. For example, out of 10,000 employees, depending on the gender distribution, we expect 3,000–5,000 cases of cancer, of which about 128 would be pancreatic cancer. Obviously, many more current and former complex employees have been diagnosed with cancer than those who were reported to us, but the numbers and types of the reported cancers do not suggest a need for further case finding.

Is there an unusual distribution of types of cancer?

No. Cancer clusters thought to be related to a workplace exposure usually consist of the same types of cancer, and this was not the case at this complex. When several cases of the same type of cancer occur and that type is not common in the general population, it is more likely that an occupational exposure is involved. When the cluster consists of multiple types of cancer, without one type predominating, then an occupational cause of the cluster is less likely. The types of cancers reported among office complex employees are among the most commonly reported and diagnosed in the United States.

Is there exposure to a specific chemical or physical agent known or suspected of causing cancer occurring?

No. Our review of monitoring results revealed little potential for exposure to carcinogenic agents at the complex.

On the basis of the age of many of the buildings and reports from interviewed employees, asbestos has been present across the entire facility. The federal government management agency reported that maintenance employees were in an asbestos surveillance program. However, exposures to occupants of buildings containing asbestos would typically be minimal if the asbestos is identified and properly managed in place, as it appeared to be at this facility. Asbestos exposure most commonly causes lung cancer and mesothelioma, but is suspected to cause other respiratory tract and gastrointestinal tract cancers such as stomach cancer. With the exception of mesothelioma, these cancers occur with heavy asbestos exposure, such as insulation work or shipyard repairs, not in office occupants.

Has enough time passed since exposure began?

The time between first exposure to a cancer-causing agent and clinical recognition of the disease is called the latency period. Latency periods vary by cancer type, but usually are a minimum of 10–12 years [Rugo 2004]. Latency is not an issue in this evaluation because the numbers and types of cancers do not appear unusual.

Conclusions

We did not find evidence that complex employees had exposures to metals, VOCs, PCBs, or ionizing radiation, either currently or from past contamination from the adjoining weapons component agency at levels of concern. This conclusion is based on our review of monitoring and exposure records, our walk-through surveys of the complex and its ventilation systems, and our interviews with employees, managers, and supervisors. We also do not believe there was a cancer cluster among current and former complex employees. This conclusion is based on our review of the data in relation to the scientific criteria for determining whether a cluster of occupational cancer exists. Finally, none of the 22 employees we tested had an abnormal BeLPT, a test that indicates sensitization to beryllium.

Recommendations

On the basis of our findings, we recommend the actions listed below. We encourage the managers of the complex to use a labor-management health and safety committee or working group to discuss our recommendations and develop an action plan. Those involved in the work can best set priorities and assess the feasibility of our recommendations for the specific situation at the complex.

Our recommendations are based on an approach known as the hierarchy of controls (Appendix B). This approach groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees. Until such controls are in place, or if they are not effective or feasible, administrative measures and personal protective equipment may be needed.

Engineering controls

Engineering controls reduce employees' exposures by removing the hazard from the process or by placing a barrier between the hazard and the employee. Engineering controls protect employees effectively without placing primary responsibility of implementation on the employee.

1. Inspect the physical barriers (walls, doors, etc.) separating the complex and the adjoining weapons component agency at least annually to ensure there are no openings.
2. Ensure that ventilation work at the complex does not result in cross-connection with the ventilation system(s) serving the weapons component agency.

3. Install filtration or other abatement equipment to reduce drinking water contaminant levels to below EPA drinking water limits.

Administrative Controls

The term administrative controls refers to employer-dictated work practices and policies to reduce or prevent hazardous exposures. Their effectiveness depends on employer commitment and employee acceptance. Regular monitoring and reinforcement are necessary to ensure that policies and procedures are followed consistently.

1. Encourage employees to learn about cancer risk factors, measures that can be taken to reduce their risk for preventable cancers, and the availability of cancer screening programs for some types of cancer. More information on reducing cancer risk factors is presented in Appendix D.
2. Ensure there is a mechanism for employees to discuss health and safety concerns. Concerns about potential exposures or questions about workplace safety should be addressed by the appropriate personnel and employees should be kept informed about followup actions.
3. Stop the routine air and surface wipe sampling for metals, VOCs, and other suspected contaminants in the occupied, non-industrial work areas of the complex.
4. Continue monitoring drinking water to ensure compliance with EPA drinking water regulations and guidelines.

Appendix A: Tables

Table A1. Substances and hazards identified in the exposure monitoring reports (A–B)

Substance/Hazard	Time period	Sampling method used
Acenaphthene	2011	GR
Acetone	2002–2011	GR, PS
Acetonitrile	2011	PS
Acrolein	2011	GR
Acrylonitrile	2011	GR, PS
Allyl chloride	2011	Summa
Antimony	1997–2010	AC, GR, SW
Arsenic	2008	GR
Asbestos	1997	AC
Barium	1997–2008	GR
Benzene	2002–2011	GR, PS
Benzidine	2011	GR
Benzo(a)anthracene	2008–2011	GR
Benzo(a)pyrene	2008–2011	GR
Benzo(b)fluoranthene	2008–2011	GR
Benzo(g,h,i)perylene	2008–2011	GR
Benzyl chloride	2011	Summa
Beryllium	2002–2011	AC, SW
Bis(2-chlorethoxy)methane	2011	GR
Bis(2-chloroethyl)ether	2011	GR
Bis(2-chloroisopropyl)ether	2011	GR
Bromobenzene	2002–2011	GR
Bromochloromethane	2002	GR
Bromodichloromethane	2002–2011	GR, PS
4-Bromofluorobenzene	2002	GR
Bromoform	2002–2011	GR, PS
Bromomethane	2002–2011	GR, PS
4-Bromophenyl-phenylether	2011	GR
Butane	2011	GR, PS
1,3-Butadiene	2011	GR, PS
2-Butanone (MEK)	2002–2011	GR,PS

AC = active air sample
DR = direct reading instrumentation
GR = grab sample
PS = passive air sample
SW = surface wipe

Table A2. Substances and hazards identified in the exposure monitoring reports, (C)

Substance/Hazard	Time period	Sampling method used
Cadmium	2008	GR
Carbon dioxide	2002	DR
Carbon disulfide	2011	PS
Carbon monoxide	2002	DR
Carbon tetrachloride	2002–2011	GR, PS
Chlorine, Total Residual	2007	GR
Chlorobenzene	2002, 2011	GR, Summa
Chlorodibromomethane	2011	GR, PS
Chlorodifluoromethane	2011	GR, PS
Chloroethane	2002, 2011	GR, PS
2-Chloroethyl vinyl ether	2011	GR
Chloroform	2002–2011	GR
Chloromethane	2002, 2011	GR, PS
4-Chloro-3-methylphenol	2011	GR
2-Chloronaphthalene	2011	GR
4-Chlorophenyl-phenylether	2011	GR
2-Chlorotoluene	2002–2011	GR
4-Chlorotoluene	2002–2011	GR
Chromium	2009	AC, SW
Chrysene	2008–2011	GR
cis-1,2-Dichloroethene	2001–2012	GR
cis-1,3-Dichloropropene	2002–2011	GR, PS
Cobalt	2009	AC, SW
Cooper	1997–2012	AC, GR, SW
Cyclohexane	2011	PS

Table A3. Substances and hazards identified in the exposure monitoring reports, (D–H)

Substance/Hazard	Time period	Sampling method used
Dibenz(a,h)anthracene	2011	GR
Dibromochloromethane	2002	GR
1,2-Dibromo-3-chloropropane	2002–2004	GR
Dibromofluoromethane	2002	GR
Dibromomethane	2002–2011	GR
1,2-Dibromoehtane (EDB)	2002–2011	GR, PS
1,2-Dichlorobenzene	2002–2011	GR, Summa
1,3-Dichlorobenzene	2002–2011	GR, Summa
1,4-Dichlorobenzene	2002–2011	GR, Summa
3,3-Dichlorobenzidine	2011	GR
Dichlorodifluoromethane	2002–2011	GR, PS
1,1-Dichloroethane	2002–2011	GR, PS
1,2-Dichloroethane	2002–2011	GR, PS
1,2-Dichloropropane	2002–2011	GR
1,3-Dichloropropane	2002	GR
2,2-Dichloropropane	2002–2004	GR
1,1-Dichloropropene	2002	GR
1,2-Dichloroethylene	2004	GR
1,2-Dichloro-1,1,2,2-tetrafluoroethane	2011	Summa
2,4-Dinitrotoluene	2011	GR
2,6-Dinitrotoluene	2011	GR
Diesel fuel	2001	GR
Diethyl Ether	2011	GR, PS
Dimethyl phthalate	2011	GR
Dinitrophenol	2011	GR
Ethylbenzene	2002–2011	PGR, S
Fluoranthene	2008–2011	GR
Fluorene	2011	GR
Formaldehyde	2002	PS
Water hardness	1997	GR
Heptane	2011	GR, PS
Hexachloro-1,3-butadiene	2002–2011	GR
Hexachlorobenzene	2011	GR
Hexachlorobutadiene	2004–2011	GR, PS
Hexachlorocyclopentadiene	2011	GR
Hexachloroethane	2011	GR
Hexane	2011	GR, PS
2-Hexanone	2002–2011	GR, PS

Table A4. Substances and hazards identified in the exposure monitoring reports, (I–P)

Substance/Hazard	Time period	Sampling method used
Iron	1997–2012	AC, GR, SW
Isophorone	2011	GR
Isopropylbenzene	2011	GR, PS
Isopropylbenzene (Cumene)	2002	GR
Lead	1997–2012	AC, GR, SW
Manganese	2009–2010	AC, SW
4-Methyl-2-pentanone (MIBK)	2002–2011	GR, PS
Methyl tert-Butyl Ether	2002–2011	GR, PS
Methylene chloride	2002–2011	GR, PS
Mold	1997	AC
Molybdenum	2009	AC, SW
Naphtha	2001–2004	GR, PS
Naphthalene	2001–2011	PS, Grab
n-Butylbenzene	2002–2011	GR
n-Decane	2011	Summa
n-Hexane	2004	PS
Nickel	1997–2012	AC, GR, SW
Nitrobenzene	2011	GR
2-Nitrophenol	2011	GR
4-Nitrophenol	2011	GR
n-Nitrosodimethylamine	2011	GR
n-Nonane	2011	GR, PS
n-Octane	2011	GR, PS
Noise	1997	DR
Non-ionizing radiation	1997	DR
n-Pentane	2011	GR, PS
n-Propylbenzene	2002–2011	GR, PS
n-Undecane	2011	GR, PS
o-Xylene	2002–2011	GR, PS
PCB	2001–2012	AC, GR
Pentachlorophenol	2011	GR
Petroleum distillates	2001–2004	GR, PS
Phenanthrene	2008	GR
Phenol	2011	GR
p-Isopropyltoluene	2002–2011	GR
Pyrene	2008–2011	GR

Table A5. Substances and hazards identified in the exposure monitoring reports, (R–Z)

Substance/Hazard	Time period	Sampling method used
Radon	1989–1997	PS
Relative humidity	2002	DR
sec-Butylbenzene	2002–2011	GR
Selenium	2008	GR
Styrene	2002–2011	GR, PS
Sulfide	2001	GR
Temperature	2002	DR
tert-Butylbenzene	2002–2011	GR
1,2,3-Trichlorobenzene	2002–2004	GR
1,2,4-Trichlorobenzene	2002–2011	GR, PS
1,1,1-Trichloroethane	2002–2011	GR, PS
1,1,2-Trichloroethane	2002–2011	GR, Summa
2,4,6-Trichlorophenol	2011	GR
1,2,3-Trichloropropane	2002–2011	GR
1,1,2-Trichlorotrifluoroethane	2011	GR, PS
1,1,2-Trichloro-1,2,2-trifluoroethane	2011	GR
1,2,3-Trimethylbenzene	2011	GR
1,2,5-Trimethylbenzene	2011	PS
1,3,5-Trimethylbenzene	2002–2001	GR
1,1,1,2-Tetrachloroethane	2002–2004	GR
1,1,2,2-Tetrachloroethane	2002–2011	GR, PS
Tetrachloroethene	2002–2011	GR, PS
Tin	2009	AC, SW
Toluene	2002–2011	GR, PS
Total Dust	1997	AC
Total Suspended Solids	2010	GR
trans-1,2-Dichloroethene	2002–2012	GR, PS
trans-1,3-Dichloropropene	2002–2011	GR, PS
Trichloroethene	2002–2011	GR
Trichloroethylene	2001–2012	AC, GR, PS
Trichlorofluoromethane	2002–2011	GR, PS
trimethylbenzene	1997	AC
Uranium	2010–2011	AC, SW
Vanadium	2009	AC, SW
Vinyl acetate	2011	GR, PS
Vinyl Chloride	2001–2012	AC, GR, PS
Xylene	2002–2011	GR, PS
Yttrium	2011	PS
Zinc	2009	AC, SW

Appendix B: Occupational Exposure Limits and Health Effects

NIOSH investigators refer to mandatory (legally enforceable) and recommended occupational exposure limits (OELs) for chemical, physical, and biological agents when evaluating workplace hazards. OELs have been developed by federal agencies and safety and health organizations to prevent adverse health effects from workplace exposures. Generally, OELs suggest levels of exposure that most employees may be exposed to for up to 10 hours per day, 40 hours per week, for a working lifetime, without experiencing adverse health effects. However, not all employees will be protected if their exposures are maintained below these levels. Some may have adverse health effects because of individual susceptibility, a pre-existing medical condition, or hypersensitivity (allergy). In addition, some hazardous substances act in combination with other exposures, with the general environment, or with medications or personal habits of the employee to produce adverse health effects. Most OELs address airborne exposures, but some substances can be absorbed directly through the skin and mucous membranes.

Most OELs are expressed as a time-weighted average exposure. A time-weighted average refers to the average exposure during a normal 8- to 10-hour workday. Some chemical substances and physical agents have recommended short term exposure limit or ceiling values. Unless otherwise noted, the short term exposure limit is a 15-minute time-weighted average exposure. It should not be exceeded at any time during a workday. The ceiling limit should not be exceeded at any time.

In the United States, OELs have been established by federal agencies, professional organizations, state and local governments, and other entities. Some OELs are legally enforceable limits; others are recommendations.

- The U.S. Department of Labor OSHA permissible exposure limits (29 CFR 1910 [general industry]; 29 CFR 1926 [construction industry]; and 29 CFR 1917 [maritime industry]) are legal limits. These limits are enforceable in workplaces covered under the Occupational Safety and Health Act of 1970.
- NIOSH recommended exposure limits are recommendations based on a critical review of the scientific and technical information and the adequacy of methods to identify and control the hazard. NIOSH recommended exposure limits are published in the *NIOSH Pocket Guide to Chemical Hazards* [NIOSH 2010]. NIOSH also recommends risk management practices (e.g., engineering controls, safe work practices, employee education/training, personal protective equipment, and exposure and medical monitoring) to minimize the risk of exposure and adverse health effects.
- Other OELs commonly used and cited in the United States include the Threshold Limit Values®, which are recommended by the American Conference of Governmental Industrial Hygienists, a professional organization, and the Workplace Environmental Exposure Levels™, which are recommended by the American Industrial Hygiene Association, another professional organization. These OELs are developed by

committee members of these associations from a review of the published, peer-reviewed literature. These OELs are not consensus standards. Threshold Limit Values are considered voluntary exposure guidelines for use by industrial hygienists and others trained in this discipline "to assist in the control of health hazards" [ACGIH 2014]. Workplace Environmental Exposure Levels have been established for some chemicals "when no other legal or authoritative limits exist" [AIHA 2013].

Outside the United States, OELs have been established by various agencies and organizations and include legal and recommended limits. The Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (Institute for Occupational Safety and Health of the German Social Accident Insurance) maintains a database of international OELs from European Union member states, Canada (Québec), Japan, Switzerland, and the United States. The database, available at http://www.dguv.de/ifa/Gefahrstoffdatenbanken/GESTIS-Internationale-Grenzwerte-für-chemische-Substanzen-limit-values-for-chemical-agents/index-2.jsp, contains international limits for more than 1,500 hazardous substances and is updated periodically.

OSHA requires an employer to furnish employees a place of employment free from recognized hazards that cause or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970 (Public Law 91–596, sec. 5(a)(1))]. This is true in the absence of a specific OEL. It also is important to keep in mind that OELs may not reflect current health-based information.

When multiple OELs exist for a substance or agent, NIOSH investigators generally encourage employers to use the lowest OEL when making risk assessment and risk management decisions. NIOSH investigators also encourage use of the hierarchy of controls approach to eliminate or minimize workplace hazards. This includes, in order of preference, the use of (1) substitution or elimination of the hazardous agent, (2) engineering controls (e.g., local exhaust ventilation, process enclosure, dilution ventilation), (3) administrative controls (e.g., limiting time of exposure, employee training, work practice changes, medical surveillance), and (4) personal protective equipment (e.g., respiratory protection, gloves, eye protection, hearing protection). Control banding, a qualitative risk assessment and risk management tool, is a complementary approach to protecting employee health. Control banding focuses on how broad categories of risk should be managed. Information on control banding is available at http://www.cdc.gov/niosh/topics/ctrlbanding/. This approach can be applied in situations where OELs have not been established or can be used to supplement existing OELs.

Below we provide the OELs and surface contamination limits for the compounds we measured, as well as a discussion of the potential health effects from exposure to these compounds.

The following is a discussion of specific compounds of concern in this evaluation.

Beryllium

Beryllium is a lightweight metal used in industrial applications because of its elasticity, high thermal conductivity, permeability to x-radiation, resistance to oxidation, and high melting point. Beryllium is also used in dental prosthetics and is in tobacco. It was used by the adjoining weapons component agency but was not used in the area of the complex that we evaluated.

Exposures to high levels of beryllium can cause acute pneumonitis (lung inflammation), but these cases are no longer seen because of reduced occupational exposures. Exposure to beryllium can lead to sensitization, or allergy, which in turn can lead to CBD, a granulomatous lung condition. A granuloma is a small area of inflammation due to tissue injury. Clinically, CBD is almost identical to sarcoidosis, another granulomatous disease. A history of exposure to beryllium is the key to distinguishing between the two. If individuals with sarcoidosis have a history of even minimal contact with beryllium, including living with a person who works with beryllium, they should be tested with the BeLPT. This is a blood test that measures sensitivity to beryllium and is very specific to determine if a person has an allergic reaction to beryllium. Exposure to beryllium also slightly increases the risk for lung cancer [Schubauer-Berigan 2010].

Depleted Uranium

Depleted uranium, a byproduct of uranium enrichment for nuclear fuel, was used by the agency that assembled weapons components for many years. Although depleted uranium emits alpha particles (blocked by skin), beta particles (blocked by most clothing), and gamma rays, the amount of gamma radiation emitted is very low. Therefore the primary toxicity concern of depleted uranium is due to its chemical and not its radiological properties [Hooper et al. 1999; McDiarmid et al. 2000].

Cancer has not been documented in humans as a result of exposure to either natural uranium or depleted uranium [Institute of Medicine 2008; ATSDR 2013]. Data indicate that uranium compounds (including depleted uranium) are not highly toxic in humans [ATSDR 2013]. Although the kidney is the main target organ, a study of Gulf War veterans with retained fragments of depleted uranium shrapnel showed no significant evidence of renal dysfunction 16 years after first exposure, despite persistently elevated urine levels of uranium [McDiarmid et al. 2011]. There was no evidence of other health effects, including hematological, bone, neurocognitive, reproductive, or genotoxic [McDiarmid et al. 2011]. Epidemiologic studies of uranium miners and millers have not shown elevated rates of kidney disease [ATSDR 2013].

Trichloroethylene

Trichloroethylene was a solvent used by the weapons component agency. Environmental testing found trichloroethylene in the soil and groundwater contamination plume at the facility and was a basis for the concern mentioned by some complex employees.

Like many organic solvents, trichloroethylene can irritate the skin and the respiratory system.

Respiratory irritation is usually restricted to the upper airways, mucous membranes, and eyes, and it generally resolves quickly without long-term effects. Trichloroethylene (and almost all volatile, fat-soluble organic solvents) can cause acute, nonspecific central nervous system depression. At high exposures these symptoms are similar to those from drinking too many alcoholic beverages, including headache, nausea, vomiting, dizziness, slurred speech, impaired balance, disorientation, and confusion. These symptoms go away quickly when exposure stops.

Polychlorinated Biphenyls

PCBs were previously used by the adjoining weapons component agency in insulating fluids for transformers, hydraulic fluids, and other products and had been found in the soil and groundwater beneath the facility. High exposures to PCBs have been associated with chloracne, a specific skin condition (different from a skin rash) that is characterized by blackheads, cysts, and pustules [ATSDR 2000]. Many different types of skin rashes have causes that are not related to PCBs. In animal studies, exposure to PCBs has been associated with an increase in the rate of certain types of cancer, such as liver cancer. Some studies of medically diagnosed causes of death among workers exposed to PCBs have shown higher than expected rates for certain types of cancer. But longer-term follow-up studies have not shown a clear link between exposure to PCBs and human cancer [ATSDR 2000; Shields 2006].

Radiation

Ionizing radiation is energy that is able to ionize atoms or molecules of the substance in which the energy is absorbed. This causes chemical changes that damage tissues and the body's biological structural materials. Ionizing radiation can cause many types of cancer. The thyroid gland and the bone marrow are the most sensitive to radiation, and the bladder, kidney, and ovary are the least sensitive [American Cancer Society 2010]. Humans can be exposed to three kinds of ionizing radiation, (1) natural background radiation from cosmic rays and the soil, (2) nonmedical synthetic radiation from weapons testing and workplaces, and (3) medical radiation from x-rays and other medical tests [American Cancer Society 2010].

Radon is a colorless, tasteless radioactive gas that is formed via the radioactive decay of radium. Radium is common in many soils and rocks, though its concentration can vary widely. Because radon is a gas it can leave the soil or rock where it formed and enter the surrounding air. Therefore, radon levels can build up when ventilation rates are low or when a large amount of radium is present.

Radon is the most common cause of lung cancer in nonsmokers, and second most common cause of lung cancer overall, accounting for over 20,000 cases of lung cancer annually in the United States. Almost 3,000 of these cases occur in people who have never smoked [EPA 2012]. Inhalation is the primary route of radon exposure.

Appendix C: Epidemiology of Selected Cancers

Breast Cancer

An estimated 232,340 cases of invasive breast cancer will be diagnosed in women in the United States in 2013, making it the most common cancer in women in the United States [American Cancer Society 2013b]. One in eight women in the United States will develop breast cancer in her lifetime. Although epidemiologic studies have identified some factors that appear to be related to increased risk for breast cancer, much remains unknown about the causes of breast cancer. The International Agency for Research on Cancer has classified alcoholic beverages of all types, in utero exposure to diethylstilbestrol, estrogen-progesterone oral contraceptives and hormone replacement therapy, and exposure to x-rays and gamma rays (types of ionizing radiation) as "carcinogenic to humans" with regard to breast cancer [Weiderpass et al. 2011]. The risk from ionizing radiation is highest if exposure occurs during childhood and is negligible after age 40. The International Agency for Research on Cancer states that the evidence for an association between female breast cancer and extremely low frequency (nonionizing radiation) does not support an association, and that the evidence is sufficient to "give confidence that magnetic fields do not cause" breast cancer [WHO 2007]. In addition, the report states that research into the association between breast cancer and extremely low frequency radiation should be given low priority for further research. Other recent studies have reached similar conclusions [Feychting and Forssen 2006; Kheifets et al. 2009]. The International Agency for Research on Cancer classifies estrogen hormone replacement therapy, smoking, and shift work as "probably carcinogenic to humans" [Weiderpass et al. 2011].

Well-established risk factors include family history of breast cancer, biopsy-confirmed atypical hyperplasia, early menarche (first menstrual period), late menopause, not having children or having the first child after 30, overweight or obesity (especially after menopause), never breastfeeding a child, low physical activity levels, and higher levels of education and socioeconomic status [Wiederpass et al. 2011; American Cancer Society 2013b].

Several studies have found teachers and other professional and managerial employees to have an increased risk for developing breast cancer [Rubin et al. 1993; King et al. 1994; Pollán and Gustavsson 1999; Bernstein et al. 2002; Snedeker 2006; MacArthur et al. 2007] but others have not [Coogan et al. 1996; Calle et al. 1998; Petralia et al. 1998]. No causative workplace exposures have been identified for these occupations, and it is postulated that the possible increase in risk is a result of non-occupational risk factors such as parity (number of times a woman has given birth), maternal age at first birth, contraceptive use, diet, and physical activity [Threlfall et al. 1985; Snedeker 2006; MacArthur et al. 2007]. Women with higher educational status are also more likely to have mammograms, thus increasing detection of breast cancer. One study compared the incidence of invasive breast cancer among women who were screened once between ages 50 and 64 to women screened three times between ages 50 and 64. Distribution of known risk factors was similar between the two groups, but the rate of invasive breast cancer was 22% lower in the group screened only once, suggesting that some breast cancers regress without treatment [Zahl et al. 2008]. These findings were supported by a 2009 study of breast cancer screening that found that one third of breast cancers found during screening were over diagnosed [Jørgensen and Gøtzsche 2009]. Overdiagnosis means the detection of a cancer that would not have ever become clinically evident, i.e., would not have progressed or caused harm.

Prostate Cancer

Prostate cancer is the most commonly diagnosed cancer among men in the United States, with an estimated 238,590 cases to be diagnosed in 2013 [American Cancer Society 2013e]. One in six men in the United States will be diagnosed with prostate cancer in his lifetime. The main risk factor is increasing age; blacks are at higher risk. No occupational or environmental risk factors for prostate cancer are known. Exposure to certain substances, such as polycyclic aromatic hydrocarbons, pesticides, and cadmium have been suspected to increase the risk for prostate cancer, but study results conflict [Verougstraete et al. 2003; Boers et al. 2005; Sahmoun et al. 2005; Van Maele-Fabry et al. 2006; Huff et al. 2007; Mink et al. 2008].

Bladder Cancer

An estimated 72,570 new cases of bladder cancer will be diagnosed in 2013 [American Cancer Society 2013a]. Smoking is the greatest risk factor for bladder cancer; the risk of developing bladder cancer is 2 to 4 times higher in smokers than in nonsmokers [Pelucchi et al. 2006]. Men are much more likely than women to get bladder cancer and whites are more likely than blacks [American Cancer Society 2013a]. Known occupational causes of bladder cancer include some aromatic amines, historically found in the dye, rubber, leather, metals, and mining industries [Kogevinas et al. 2003].

Lung Cancer

Lung cancer is the most common cause of cancer death in men and women. An estimated 228,190 new cases of lung cancer will be diagnosed in 2013 [American Cancer Society 2013c]. The most significant risk factor for lung cancer is cigarette smoking, which accounts for 90% of cases in men and 80% in women [Ettinger 2008]. A lifelong nonsmoker has a relative risk ratio of 1 of getting lung cancer. The relative risk ratios for cigarette smokers are 15 (less than 0.5 packs per day), 17 (0.5–1 pack per day), 42 (1–2 packs per day), and 64 (more than 2 packs per day) [Ettinger 2008]. The risk for former smokers depends on how long ago they quit smoking. It takes about 30 years to bring the risk ratio down to 1.5 to 2.0 [Ettinger 2008]. Radon is the most common cause of lung cancer in nonsmokers, and second most common cause of lung cancer overall, accounting for over 20,000 cases of lung cancer annually in the United States. Almost 3,000 of these cases occur in people who have never smoked [EPA 2012]. Secondhand smoke is the third most common cause of lung cancer in the United States, with more than 3,000 cases annually [EPA 2012; American Cancer Society 2013f]. Known occupational causes of lung cancer include asbestos, arsenic, chromium, nickel, cadmium, coke oven emissions, tars, and soot [American Cancer Society 2007].

Pancreatic Cancer

The lifetime risk of having pancreatic cancer is about 1 in 78. An estimated 45,220 new cases of pancreatic cancer will be diagnosed in 2013 [American Cancer Society 2013d]. The most significant risk factor for pancreatic cancer is cigarette smoking; 20%–30% of cases are likely due to smoking. Chewing tobacco also increases risk. Other risk factors include being African-American, obesity, sedentary lifestyle, diabetes, chronic pancreatitis, and cirrhosis of the liver. No occupational causes of pancreatic cancer are proven, but heavy exposure to pesticides and dyes are suspected [American Cancer Society 2013d].

Appendix D: Reducing Cancer Risk Factors

Employees can take an active role in changing personal risk factors that are associated with certain types of cancer. In fact, the American Cancer Society estimates that in 2012 about 173,200 cancer deaths will be caused by tobacco use alone. This is one third of all cancer deaths. Another one third of cancer deaths are due to poor nutrition, physical inactivity, overweight, and obesity [American Cancer Society 2012]. It is well known that tobacco use increases the risk of cancer of the lung, mouth, nasal cavities, larynx, pharynx, esophagus, stomach, colorectum, liver, pancreas, kidney, bladder, uterine cervix, and ovary (mucinous), and myeloid leukemia [American Cancer Society 2012]. There is limited evidence that tobacco smoking causes female breast cancer. High alcohol consumption, a diet low in fruits and vegetables, physical inactivity, overweight, and obesity are other modifiable personal risk factors that increase the risk of certain cancers. Being overweight or obese is clearly associated with increased risk for developing cancer of the breast (in postmenopausal women), colon and rectum, endometrium, kidney, and pancreas, and adenocarcinoma of the esophagus. Obesity increases the risk of gallbladder cancer and possibly cancers of the liver, cervix, and ovary; multiple myeloma; non-Hodgkin lymphoma; and aggressive forms of prostate cancer [American Cancer Society 2012].

The American Cancer Society posts general information about cancer on its website at http://www.cancer.org/ by clicking on “Learn about Cancer”. For information about a specific type of cancer, click on “Select a Cancer Type,” select a type of cancer, then click “Go.” Additionally, NIOSH posts information about occupational cancer and cancer cluster evaluations on its website at http://www.cdc.gov/niosh/topics/cancer/.

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Availability of Report

Copies of this report have been sent to the employer and employees at the facility. The state and local health department and the Occupational Safety and Health Administration Regional Office have also received a copy.

This report is available at http://www.cdc.gov/niosh/hhe/reports/pdfs/2010-0061-3206.pdf.

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