APPENDIX I

Summary Briefs

ATSDR
AGENCY FOR TOXIC SUBSTANCES

ORRHES Brief

Oak Ridge Reservation Health Effects Subcommittee

Public Health Consultation, Y-12 Weapons Plant Chemical Releases into East Fork Poplar Creek, Oak Ridge, Tennessee, April 5, 1993

Site: Oak Ridge Reservation

Conducted by: Agency for Toxic Substances and Disease Registry

Time Period: Early 1990s

Location: East Fork Poplar Creek and Floodplain Area

Purpose

The purpose of the health consultation was to evaluate published environmental data and to assess health risks associated with Y-12 Weapons Plant releases at the Oak Ridge Reservation.

Background

Between 1950 and 1963, the Department of Energy (DOE) Y-12 Weapons Plant used mercury in a lithium separation process. DOE officials estimate that 110 metric tons of mercury were released to the East Fork Poplar Creek (EFPC), and that an additional 750 metric tons of mercury used during that period could not be accounted for. Releases of mercury to the creek contaminated instream sediments, and periodic flooding contaminated floodplain soils along the creek. Land uses along the floodplain are residential, commercial, and recreational. Furthermore, residents used the sediment to enrich private gardens, and the city of Oak Ridge used creek sediment as fill material on sewer belt lines. In 1983, the state of Tennessee publicly disclosed that sediment and soil in the EFPC floodplain were contaminated with mercury. That same year, the Oak Ridge Task Force initiated remediation of public and private lands within the city of Oak Ridge.

In 1992, during Phase IA of the EFPC remedial investigation, DOE conducted preliminary sampling of soil, sediment, surface water, and groundwater from the EFPC floodplain area. During 1990 and 1991, DOE sampled for contaminants in EFPC fish through its Biological Monitoring and Abatement Program.

Study design and method

This was a health consultation conducted by the Agency for Toxic Substances and Disease Registry (ATSDR). An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, chemical release, or the presence of hazardous material. In this case, DOE requested that ATSDR comment on the health threat posed by past and present chemical releases from the Y-12 Weapons Plant to the East Fork Poplar Creek. To conduct the consultation, ATSDR evaluated DOE's preliminary environmental sampling data for metals, volatile and semivolatile organic compounds, radionuclides, and polychlorinated biphenyls (PCBs).

Health consultations may lead to specific actions, such as environmental sampling, restricting site access, or removing contaminated material, or ATSDR may make recommendations for other activities to protect the public's health.

Study group

ATSDR did not conduct a study.

Exposures

ATSDR estimated human exposure to contaminated EFPC floodplain soil, sediments, surface water, groundwater, fish, and air.

Outcome measure

ATSDR did not review health outcome data.

Results

Only mercury in soil and sediment, and PCBs and mercury in fish, are at levels of public health concern. Other contaminants, including radionuclides found in soil, sediment, and surface water, are not at levels of public health concern. Data were not available on radionuclides in fish.

Elevated levels of mercury, up to 2,240 parts per million (ppm), were found in a few soil and sediment samples from all three creek areas sampled. The mercury in the EFPC soil consisted primarily of some

relatively insoluble inorganic forms of mercury (mercury salts and metallic mercury), with less than 1% of the mercury in organic form.

Mercury Salts in Soil

The primary routes of inorganic mercury exposure for people (particularly for children) who fish, play, or walk along the creek and floodplain, are through ingestion of soil from hand-to-mouth activities and from excessive dermal exposure. Following ingestion, absorption of inorganic mercury compounds across the gastrointestinal tract to the blood is low in both people and animals. Long-term exposure to the EFPC floodplain soil containing elevated levels of mercury may result in body burdens of mercury that could result in adverse health effects. The kidney is the organ most sensitive to the effects of ingestion of inorganic mercury salts. Effects on the kidney include increased urine protein levels and, in more severe cases, a reduction in the glomerular filtration rate, which is a sign of decreased blood-filtering capacity.

Metallic Mercury in Soil

The metallic mercury vapor levels in the ambient air at the three creek areas sampled are not at levels of public health concern. However, excavation of contaminated soil may result in mercury vapor being released from the soil, especially as the air temperature increases. Such releases may increase ambient air levels of mercury vapor, which could pose a health risk to unprotected workers and the public. Once inhaled, metallic mercury vapors are readily absorbed across the lungs into the blood; however, metallic mercury is poorly absorbed through dermal and oral routes. Exposure to mercury vapor may elicit consistent and pronounced neurologic effects.

Organic Mercury in Fish

Organic mercury is the primary form of mercury found in fish. Frequent ingestion of EFPC fish over the long term may result in neurotoxic effects. Concentrations of mercury in EFPC fish samples ranged from 0.08 ppm to 1.31 ppm. Studies on the retention and excretion of mercury have shown that approximately 95% of an oral dose of organic mercury is absorbed across the gastrointestinal tract. Neurodevelopmental effects have been seen in infants following prenatal exposure via maternal ingestion of organic mercury in fish.

PCBs in Fish

Frequent and long-term ingestion of EFPC fish could result in a moderate increased risk of developing cancer. Concentrations of PCBs in EFPC fish samples ranged from 0.01 ppm to 3.86 ppm. PCBs are widely distributed environmental pollutants commonly found in blood and fat tissue of the general population. PCBs are classified as a probable human carcinogen by the U.S. Environmental Protection Agency. PCBs have been shown to produce liver tumors in mice and rats following intermediate and chronic oral exposure. Groundwater samples collected from shallow monitoring wells along the EFPC floodplain were shown to contain elevated levels of metals and volatile organic compounds. There was no evidence, however, that groundwater from shallow aquifers was being used for domestic purposes. The municipal water system, which is used by most Oak Ridge residents, receives water from Clinch River upstream of the DOE reservation.

Conclusions

In some locations along the creek, mercury levels in soil and sediment pose a threat to people (especially children) who ingest, inhale, or have dermal contact with contaminated soil, sediment, or dust while playing, fishing, or taking part in other activities along the creek's floodplain.

Mercury and PCBs were found in fish fillet samples collected from the creek. Although people who eat fish from the creek are not at risk for acute health threats, people who frequently ingest contaminated fish over a prolonged period have a moderate increased risk of (1) adverse effects to the central nervous system and kidney and (2) developing cancer.

ATSDR did not have enough information on groundwater use along the East Fork Poplar Creek to comment on the contamination of groundwater in shallow, private wells along the creek. However, contamination detected in wells along the creek does not pose a threat to people who receive municipal water.

ATSDR made the following recommendations.

- Determine the depth and extent of mercury contamination in the EFPC sediments and floodplain soil.
- As an interim measure, restrict access to the contaminated soil and sediment, or post advisories to warn the public of the hazards.
- Continue the Tennessee Department of Environment and Conservation EFPC fish advisory.
- Continue monitoring fish from the creek for the presence of mercury and PCBs.
- Complete the survey of well water use along the EFPC floodplain.
- Sample shallow private wells near the creek for PCBs, volatile organic compounds, and total and dissolved metals.

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ORRHES Brief
Oak Ridge Reservation Health Effects Subcommittee

Health Consultation, U.S. DOE Oak Ridge Reservation, Lower Watts Bar Operable Unit, February 1996

Site: Oak Ridge Reservation
Study authors: Agency for Toxic Substances and Disease Registry
Time period: 1980s and 1990s
Target population: Lower Watts Bar Reservoir Area

Purpose

This health consultation was conducted to evaluate the public health implications of chemical and radiological contaminants in the Watts Bar Reservoir and the effectiveness of the Department of Energy's proposed remedial action plan for protecting public health.

Background

In March 1995, the Department of Energy (DOE) released a proposed plan for addressing contaminants in the Lower Watts Bar Reservoir. The plan presented the potential risk posed by contaminants and DOE's preferred remedial action alternative. DOE's risk assessment indicated that consumption of certain species of fish from the Lower Watts Bar Reservoir and the transfer of sediment from deeper areas of the reservoir to areas on land where crops were grown could result in unacceptable risk to human health.

The September 1995 Record of Decision for the Lower Watts Bar Reservoir presented DOE's remedial action plan for the reservoir. This remedial action included maintaining the fish consumption advisories of the Tennessee Department of Environment and Conservation (TDEC), continuing environmental monitoring, and implementing institutional controls to prevent disturbance, resuspension, removal, or disposal of contaminated sediment. The U.S. Environmental Protection Agency (EPA) and TDEC concurred with the remedial action plan.

Concerned about the sufficiency of DOE's plan, local residents asked the Agency for Toxic Substances and Disease Registry (ATSDR) to evaluate the health risk related to contaminants in the Lower Watts Bar Reservoir. These residents asked ATSDR to provide an independent opinion on whether DOE's selected remedial actions would adequately protect public health.

Methods

ATSDR agreed to provide a health consultation. A health consultation is conducted in response to a specific request for information about health risks related to a specific site, a specific chemical release, or the presence of other hazardous material. The response from ATSDR may be verbal or written.

To assess the current and recent past health hazards from the Lower Watts Bar Reservoir contamination, ATSDR evaluated environmental sampling data. ATSDR evaluated reservoir studies conducted by DOE and the Tennessee Valley Authority during the 1980s and 1990s. ATSDR also evaluated TVA's 1993 and 1994 Annual Radiological Environmental Reports for the Watts Bar nuclear plant. ATSDR first screened the voluminous environmental data to determine whether any contaminants were present at levels above health–based comparison values. ATSDR next estimated exposure doses for any contaminants exceeding comparison values. It is important to note that the fact that a contaminant exceeds comparison values does

not necessarily mean that the contaminant will cause adverse health effects. Comparison values simply help ATSDR determine which contaminants to evaluate more closely.

ATSDR estimated exposure doses, using both worst case and realistic exposure scenarios, to determine if current chemical and radiological contaminant levels could pose a health risk to area residents. The worst case scenarios assumed that the most sensitive population (young children) would be exposed to the highest concentration of each contaminant in each media by the most probable exposure routes.

Target population

Individuals living along the Watts Bar Reservoir and individuals visiting the area.

Exposures

The exposures investigated were those to metals, radionuclides, volatile organic compounds, polychlorinated biphenyls (PCBs), and pesticides in surface water, sediment, and fish.

Outcome measure

ATSDR did not review health outcome data.

Results

Reservoir Fish and Other Wildlife: Using a realistic exposure scenario for fish consumption that assumed an adult weighing 70 kilogram (kg) consumed one 8-ounce sport fish meal per week, or per month, for 30 years, ATSDR determined that PCB levels in reservoir fish were at levels of health concern. ATSDR estimated ranges of PCB exposure doses from 0.099 to 0.24 micrograms of PCBs per kilogram of human body weight every day (µg/kg/day) for the one fish meal a week scenario and 0.023 to 0.055 µg/kg/day for the one fish per month scenario.

At these exposure doses, ATSDR estimates that approximately one additional cancer case might develop in 1,000 people eating one fish meal a week for 30 years and three additional cancer cases might develop in 10,000 people eating one fish meal a month for 30 years.

At these exposure doses, ATSDR also determined that ingestion of reservoir fish by pregnant women and nursing mothers might cause adverse neurobehavioral effects in infants. Although the evidence that PCBs cause developmental defects in infants is difficult to evaluate and inconclusive, ATSDR's determination was made on the basis of the special vulnerability of developing fetuses and infants.

Using a worst case scenario that assumed adults and children consumed two 8-ounce fish meals a week, containing the maximum concentration of each radioactive contaminant, ATSDR determined that the potential level of radiological exposure, which was less than 6 millirem per year (mrem/yr), was not a public health hazard.

Reservoir Surface Water: Using a worst case exposure scenario that assumed a child would daily ingest a liter of unfiltered reservoir water containing the maximum level of contaminants, ATSDR determined that the levels of chemicals in the reservoir surface water were not a public health hazard.

Levels of radionuclides in surface water were well below the levels of the current and proposed EPA drinking water standards. In addition, the total radiation dose to children from waterborne radioactive contaminants would be less that 1 mrem/yr, which is well below background levels. The radiation dose was estimated using the conservative assumption that a 10-year-old child would drink and shower with unfiltered reservoir water and swim in the reservoir daily.

Reservoir Sediment: ATSDR determined that the maximum chemical and radioactive contaminant concentrations reported in the recent surface sediments data (mercury, Co-60, Sr–89/90, and Cs-137) would not present a public health hazard. The estimated dose from radioactive contaminants was less than 15 mrem/yr, which is below background levels.

ATSDR also evaluated the potential exposure a child might receive if the subsurface sediments were removed from the deep reservoir channels and used as surface soil in residential properties. Using a worst case exposure scenario that included ingestion, inhalation, external, and dermal contact exposure routes, ATSDR determined that the potential radiation dose to individuals living on these properties (less than 20 mrem/yr) would not pose a public health hazard.

Conclusions

ATSDR found that only PCBs in the reservoir fish were of potential public health concern. Other contaminants in the surface water, sediment, and fish were not found to be a public health hazard.

On the basis of current levels of contaminants in the water, sediment, and wildlife, ATSDR concluded the following.

- The levels of PCBs in the Lower Watts Bar Reservoir fish posed a public health concern. Frequent and long-term ingestion of fish from the reservoir posed a moderately increased risk of cancer in adults and increased the possibility of developmental effects in infants whose mothers consumed fish regularly during gestation and while nursing. Turtles in the reservoir might also contain PCBs at levels of public health concern.

- Current levels of contaminants in the reservoir surface water and sediment were not a public health hazard. The reservoir was safe for swimming, skiing, boating, and other recreational purposes. It is safe to drink water from the municipal water systems, which draw surface water from tributary embayments in the Lower Watts Bar Reservoir and the Tennessee River upstream from the Clinch River and Lower Watts Bar Reservoir.

- DOE's selected remedial action was protective of public health.

ATSDR made the following recommendations.

- The Lower Watts Bar Reservoir fish advisory should remain in effect to minimize exposure to PCBs.

- ATSDR should work with the state of Tennessee to implement a community health education program on the Lower Watts Bar fish advisory and the health effects of PCB exposure.

- The health risk from consumption of turtles in the Lower Watts Bar Reservoir should be evaluated. The evaluation should investigate turtle consumption patterns and PCB levels in edible portions of turtles.

- Surface and subsurface sediments should not be disturbed, removed, or disposed of without careful review by the interagency working group.

- Sampling of municipal drinking water at regular intervals should be continued. In addition, at any time a significant release of contaminants from the Oak Ridge Reservation is discharged into the Clinch River, DOE should notify municipal water systems and monitor surface water intakes.

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AGENCY FOR TOXIC SUBSTANCES

ORRHES Brief
Oak Ridge Reservation Health Effects Subcommittee

September 2001 Sampling Report for the Scarboro Community, Oak Ridge, Tennessee, April 2003

Site: Oak Ridge Reservation
Conducted by: U.S. EPA
Time Period: 2001
Location: Scarboro, Tennessee

Purpose

The purpose of the U.S. Environmental Protection Agency (EPA) sampling event was to re-sample 20% of the sampling locations investigated by the Environmental Sciences Institute at Florida Agricultural and Mechanical University (FAMU) for the U.S. Department of Energy (DOE) in 1998. The results of these samples were to be compared to those collected by FAMU. By comparing the results, EPA would:

- Verify the 1998 chemical, metal, and radiological data collected and analyzed by DOE,
- Identify any substance(s) not analyzed by DOE and evaluate those analytical data gaps,
- Determine the source(s) of uranium and other radionuclides, and
- Evaluate whether unreasonable risk to human health may be present.

Background

Beginning in 1997, the Scarboro Chapter of the National Association for the Advancement of Colored People (NAACP) contacted EPA with concerns that the Scarboro community was possibly being exposed to emissions from the Y-12 plant located at DOE's Oak Ridge Reservation (ORR). They were concerned that the community could be experiencing negative health impacts.

In May 1998, DOE responded to the concerns of the citizens by contracting with FAMU to conduct the *Scarboro Community Environmental Study*. FAMU and its contractual partners at the Environmental Radioactivity Measurement Facility at Florida State University, the Bureau of Laboratories of the Florida Department of Environmental Protection, and the Neutron Activation Analysis Group at the Oak Ridge National Laboratory collected and analyzed samples from 48 locations in the Scarboro community. Forty soil and eight sediment and/or surface water samples were collected. The results of the *Scarboro Community Environmental Study* were released in September 1998. However, EPA states they did not receive the DOE sampling and analysis plan for review prior to its implementation nor was EPA able to participate in or observe the FAMU and DOE field sampling. Therefore, to verify the FAMU and DOE's sampling, EPA developed a draft sampling plan, *EPA Proposed Sampling and Analysis Plan for the Scarboro Community*, in July 1999, and presented it to the Oak Ridge Site Specific Advisory Board at its September 1, 1999, meeting. The EPA solicited and received comments from the Oak Ridge community-at-large.

Methods

On September 25, 2001, representatives of the EPA (specifically, Region 4, Science and Ecosystem Division (SESD), Enforcement Investigation Branch (EIB) personnel) collected a total of 10 environmental samples from eight separate properties within the Scarboro community. Six surface soil samples (6 inch interval), two sediment samples, and two surface water samples were collected from nine separate locations (two samples were collected at one

of the eight properties). Additionally, at the request of local residents, core soil samples (12 inch interval) were taken from two locations to determine the depth at which uranium is present. Sample sites were selected based on:

- The May 1998 DOE study,
- Reconnaissance performed in February 23, 1999, by SESD-EIB personnel,
- Information gathered during the February 1999 and September 2001 public meetings held in Oak Ridge, and
- Professional judgment regarding where an unreasonable risk to human health might be found, if such were to exist.

All samples were collected and handled in accordance with the EPA, Region 4, SESD's *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual*, May 1, 1996. Surface soil was collected using a pre-cleaned 3-inch diameter stainless steel hand auger from the interval of 0-6 inches. Core samples were taken at a depth of 0-12 inches to determine the presence of uranium. Samples for volatile organic compounds (VOCs) were not homogenized prior to being placed in the sample container. Because wading was possible in each surface water body, surface water samples were collected directly into the sample container, prior to taking sediment samples. Surface water samples were not filtered in the field. Sediment samples were collected with a stainless steel scoop or spoon and were homogenized.

The samples were analyzed by the EPA National Air and Radiation Environmental Laboratory (NAREL) located in Montgomery, Alabama, for the following contaminants: radionuclides, metals (including mercury), VOCs, semi-volatile organic compounds (SVOCs), pesticides, and polychlorinated biphenyls (PCBs). In order to evaluate the presence of lithium in the samples, the laboratory Lithium Internal Standard for trace metal analysis was used as evidence that there is little, if any, lithium present in the samples collected by EPA.

In addition, personnel from the EPA, Region 4, Office of Technical Services conducted a radiation walkover (a qualitative screening) of the areas selected for sampling to determine whether radiation existed above background levels. The survey was performed using a sodium iodide detector and GM Pancake probe to identify the presence of uranium isotopes and other gamma-emitting isotopes.

Study Subjects: No groups were studied.

Exposures: No exposures were studied.

Outcome Measures: Health outcomes were not studied.

Results: To evaluate the results of the analytical sampling EPA used the following guidance and standards:

- Under the *Safe Drinking Water Act (SDWA)* standards were created to control the level of contaminants that are in drinking water. EPA used this guidance for the surface water samples that were collected. Maximum contaminant limits (MCLs) are legally enforceable health protective standards (National Primary Drinking Water Standards). National Secondary Drinking Water Standards (NSDWS) are non-enforceable standards that provide guidance on cosmetic effects a contaminant might have on the quality of the water.
- *Preliminary Remediation Goals (PRGs)* are risk-based values used for screening soil and sediment samples at contaminated sites. The PRG is a number that represents the lowest risk level of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) protective risk range (1×10^{-6} to 1×10^{-4}) for cancer effects. For non-cancer effects the PRG represents the Hazard Index (HI) value of 1.0 (see next bullet).
- The *Hazard Quotient/Hazard Index (HQ/HI)* is a ratio of the exposure level for a single toxic substance to the reference dose of that substance over the same exposure period.

The HI is the sum of all HQ values from all toxic substances that a person is exposed to from a common source. A HQ or HI less than 1.0 indicates that the exposure is not sufficient to yield a health concern for a lifetime (70 years) of daily exposure.

- *Gamma Spectroscopy* was used as a screen to analyze gamma-emitting isotopes which indicate radioactive decay.

- *Gross Alpha/Gross Beta* levels were used as a screen to determine if individual radionuclides should be sampled.

Radionuclides

The qualitative walkover screening did not detect radiation above background levels. None of the radionuclide analytical values exceeded normal background levels, MCLs, or PRGs. The two core samples collected from 0 to 12 inches below the ground surface indicate that uranium levels are below the PRG or background levels within the U.S.

The uranium results indicated that there was uncertainty associated with uranium enrichment due to the uranium isotope levels being at either background levels and/or detection limits. However, even if there is potentially some uranium enrichment in the uranium isotopes in the Scarboro soil and sediment, the actual levels of uranium isotopes are still within the U.S. and Oak Ridge background ranges.

Lithium. The laboratory results could not support a positive presence of lithium in the samples collected by EPA. The evidence indicates there is little, if any, lithium present in the samples.

Metals

All metals, including mercury, in the surface water, sediment, and soil samples were undetected or below MCLs, NSDWS, or PRGs with the following exceptions:

- *Aluminum.* The NSDWS of 50-200 µg/L for aluminum was exceeded in both surface water samples (1,030 µg/L and 1,640 µg/L).

- *Arsenic.* The PRG of 0.39 mg/kg for arsenic was exceeded in both sediment samples (1.62 mg/kg and 5.17 mg/kg) and four soil samples (5.64 mg/kg, 3.66 mg/kg, 4.68 mg/kg, and 6.39 mg/kg).

- *Iron.* The NSDWS of 300 µg/L for iron was exceeded in both surface water samples (769 µg/L and 1,160 µg/L). The PRG of 23,000 mg/kg for iron was exceeded in three soil samples (23,100 mg/kg, 25,400 mg/kg, and 25,400 mg/kg).

- *Manganese.* The NSDWS of 50 µg/L for manganese was exceeded in one of the surface water samples (65.5 µg/L). The PRG of 1,800 mg/kg for manganese was exceeded in one soil sample (1,930 mg/kg).

VOCs and SVOCs

No VOCs were detected in the surface water samples. The following VOCs were detected in the soil and/or sediment samples: cyclotetrasiloxane, benzoic acid, acetic acid, 1R-alpha-pinene, and dodecane. The following SVOCs were detected in the surface water, soil, or sediment samples: butyl benzyl phthalate, di-n-butyl phthalate, and dibutyl phthalate. These VOCs and SVOCs are generally attributed to sampling and/or laboratory activities and are not considered to be related to the ORR or the Scarboro area.

Pesticides and PCBs

All pesticides and PCBs in the surface water, sediment, and soil samples were undetected or below MCLs, NSDWS, or PRGs with the following exceptions:

Alpha-chlordane and gamma-chlordane were detected in one sediment sample (0.50 J µg/kg and 0.75 J µg/kg, respectively). Alpha-chlordane was detected in two soil samples (11 µg/kg and 14 µg/kg). Gamma-chlordane was also detected in two soil samples (12 µg/kg and 30 µg/kg). Heptachlor was detected in one soil sample (13 µg/kg). Heptachlor epoxide was detected in one soil sample (11 µg/kg).

Conclusions

EPA stated that the results of the analysis did not reveal any chemicals or radionuclides at levels that warrant a health or environmental concern.

- The level of radiation was below background levels and the radionuclide analytical values did not indicate a level of health concern. Uranium levels in the core soil samples were also below background levels. There is no indication that lithium was present in the analyzed samples at levels that would warrant health concern.

- Aluminum, iron, and manganese are naturally occurring in the geologic formations of the Oak Ridge area, indicating that these are not related to releases from DOE operations. Regardless, they are not present at levels of health hazard.

- Arsenic has both carcinogenic and noncarcinogenic health effects. The HI value for arsenic indicates that an assumed exposure level could be above the protective level for noncarcinogenic effects. However, the value did not exceed the CERCLA protective risk range (1×10^{-4}) for its carcinogenic effects.

- The detected VOCs and SVOCs are plasticizers, solvents, softening agents, and/or column artifacts and their presence is generally attributed to sampling and/or laboratory activities. Therefore, they are not considered to be site related and no further evaluation was conducted.

- The presence of pesticides indicates possible past use by the homeowner/resident. They are not considered to be site related and no further evaluation was conducted.

The results of both the EPA and DOE sampling effort are consistent in their findings. These results confirm that existing soil, sediment, and surface water quality pose no risk to human health within the Scarboro community. There is not an elevation of chemical, metal, or radionuclides above a regulatory health level of concern. The Scarboro community is not currently being exposed to substances from the Y-12 facility in quantities that pose an unreasonable risk to health or the environment. The EPA does not propose to conduct any further environmental sampling in the Scarboro community.

If additional environmental information becomes available, EPA proposes that the following recommendations be implemented:

1. DOE should develop a written procedure to receive citizen and community complaints regarding discharges, emissions, or other releases originating from the ORR. The procedure should identify and provide for a timely response and follow-up action. Additionally, DOE should develop a communication strategy to inform the residents and other community members or stakeholders of its findings.

2. If additional environmental information becomes available regarding Scarboro that warrants an investigation by DOE, the sampling plan, if developed, should be reviewed and approved by the EPA and the Tennessee Department of Environment and Conservation (TDEC), as regulatory oversight agencies to the Federal Facility Agreement (FFA).

3. Any future health investigations conducted by DOE of the impacts of its operations on the Scarboro or the greater Oak Ridge community should be coordinated with the Oak Ridge Reservation Health Effects Subcommittee (ORRHES) of the Agency for Toxic Substances and Disease Registry (ATSDR).

4. Upon the release of recommendations by the ORRHES to the ATSDR, DOE, EPA, and TDEC with stakeholder involvement will scope the off-site (off DOE reservation) operable unit. The results of this activity will be the preparation of a Preliminary Assessment/Site Inspection, which is currently planned for September 30, 2005. This commitment is a DOE FFA milestone.

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ORRHES Brief
Oak Ridge Reservation Health Effects Subcommittee

Scarboro Environmental Study

Site: Oak Ridge Reservation

Conducted by: Environmental Sciences Institute at Florida Agricultural and Mechanical University, Environmental Radioactivity Measurement Facility at Florida State University, Bureau of Laboratories of the Florida Department of Environmental Protection, Jacobs Engineering, DOE subcontractors in the Neutron Activation Analysis Group at Oak Ridge National Laboratory

Time Period: 1998

Location: Scarboro, Tennessee

Purpose

The purpose of the study was to address community concerns about environmental monitoring in the Scarboro neighborhood.

Background

This study was conducted in response to Scarboro community residents' concern about the validity of measurements taken at air monitoring station 46 located in the Scarboro community and external radiation results from past aerial surveys.

The study was designed to incorporate community input and meet the requirements of an EPA investigation of this type. The analytical component of the study was conducted by the Environmental Sciences Institute at Florida Agriculture and Mechanical University (FAMU) and its contractual partners at the Environmental Radioactivity Measurement Facility at Florida State University and the Bureau of Laboratories of the Florida Department of Environmental Protection, and by DOE subcontractors in the Neutron Activation Analysis Group at the Oak Ridge National Laboratory.

Method

Soil, sediment and surface water samples were collected in the Scarboro neighborhood and analyzed for mercury, radionuclides, and organic and inorganic compounds. Initial radiological walkover surveys were conducted to identify hot spots prior to sample collection, and some samples were collected from these areas with the highest radiological counts.

A total of 48 samples were collected; 40 were surface soil samples (within top 2 inches) and 8 were sediment/surface water samples. All samples were analyzed for mercury, gross alpha/beta content, uranium, and gamma emitting radionuclides. Gross alpha-beta content was conducted to screen samples for further analysis. Gamma-ray spectroscopy measurements were made to check for the presence of naturally occurring and man made radionuclides. Neutron activation analysis was used to analyze all soil and sediment samples for uranium isotopes (U-238 and U-235).

Approximately 10% of the samples collected (4 soil, 1 sediment and 1 surface water sample) were tested for the presence of analytes on the target compound list (TCL), the target analyte list (TAL), and Strontium-90. Alpha spectroscopy was also used to test these samples for isotopes of uranium, plutonium, and thorium.

To determine whether a sample measurement was within normal background levels, the value was compared to the 95th percentile of the distribution of results obtained in the Background Soils Characterization Project (BSCP) study. Scarboro data were specifically compared to results from the Chickamauga Bethel Valley group in the BSCP study because this geologic formation best approximates the geologic formation underlying the Scarboro community.

[1] The 95th percentile value is the value at or below which 95% of the samples fall in a distribution. For example, if 100 soil samples were collected and tested for mercury, and the 95th percentile value was found to be 0.5 parts per billion (ppb), 95 of the samples would have a value of 0.5 ppb or less.

Study Subjects

No groups were studied.

Exposures

Exposures studied included mercury, gamma-ray emitting radionuclides, TCL organics, TAL inorganics, Strontium-90, and uranium, thorium, and plutonium isotopes.

Outcome Measures

Health outcomes were not studied.

Results

Mercury: Mercury values in the Scarboro soil samples ranged from 0.021 milligrams per kilogram (mg/kg) to 0.30 mg/kg, with a median value of 0.11 mg/kg. Two samples (192 S. Benedict Ave and Parcel 570, Wilberforce) exceeded the 95th percentile value for mercury for the Bethel Valley Chickamauga Group, but were less than the 95th percentile for the K-25 Chickamauga Group.

Mercury was not detected in surface water samples. Mercury values in Scarboro sediment ranged from 0.018 mg/kg to 0.12 mg/kg. Comparison of sediment values to BSCP data was not possible.

Gamma-ray spectroscopy measurements: Most gamma-ray emitting radionuclides fell within the range of expected values. In a few cases the radioisotopes U-238 (Th-234) and U-235 exceeded the 95th percentile values for the BSCP formations; however, the mean values for U-235 and U-238 were within one standard deviation of the BSCP medians. This means that, on average, it is unlikely that uranium was present in Scarboro soil at elevated concentrations.

Uranium Isotopic Analysis by Neutron Activation Analysis: The average Uranium-238 value (1.39 PicoCurie per microgram (pCi/µg) for the Scarboro samples fell within the range of values determined by both alpha spectroscopy and gamma-ray spectroscopy in the BSCP study. The mean ratio of uranium-235 to uranium-238 was 0.0093 + 0.0021. Five soil samples (4 in Parcel 570, and 117/119 Spellman Ave) contained U-235/U-238 weight ratios greater than might be expected, suggesting enrichment in uranium-235.

10% samples: Antimony, selenium, silver, sodium and thallium were rarely detected in any of the samples. Lead and zinc concentrations in one soil sample (117/119 Spellman Avenue) exceeded the 95th percentile for all BSCP geologic formations.

The pesticides alpha-chlordane (1700 ppb), gamma-chlordane (2800 ppb), heptachlor (190 ppb), and heptachlor epoxide (970 ppb) were detected in one soil sample (117/119 Spellman Avenue). No other organic contaminants were detected in Scarboro samples.

The maximum Strontium-90 value fell within the 95th percentile from the BSCP study.

Using alpha-spectroscopy analysis, most of the concentrations and ratio values for uranium, thorium, and plutonium isotopes were within expected ranges when compared to results from the BSCP study. However, one soil sample (117/119 Spellman Avenue) showed enrichment of both U-234 and U-235 relative to U-238.

Conclusions

Mercury concentrations measured in this study ranged from 0.021 mg/kg to 0.30 mg/kg. These values are generally within the range of values given in the BSCP report.

Radionuclide results including total uranium concentrations were within expected ranges. However, approximately 10% of soil samples showed evidence of enrichment in uranium-235.

One of 6 samples contained organic compounds on the TCL (alpha- and gamma-chlordane, heptachlor and heptachlor epoxide) above detection limits. In this same sample, lead and zinc concentrations exceeded typical values obtained in the BSCP study by a factor of two.

ATSDR
AGENCY FOR TOXIC SUBSTANCES

ORRHES Brief
Oak Ridge Reservation Health Effects Subcommittee

An Analysis of Respiratory Illnesses Among Children in the Scarboro Community

Site: Oak Ridge Reservation
Conducted by: Center for Disease Control and Prevention, National Center for Environmental Health, the Tennessee Department of Health, and the Scarboro Community Environmental Justice Council
Time Period: 1997–1998
Location: Scarboro

Purpose

The purpose of this study was to determine whether rates of pediatric respiratory illnesses were higher in Scarboro than elsewhere in the United States and whether exposure to various factors increased residents' risk for health problems.

Background

In November 1997, a Nashville newspaper *(The Tennessean)* article suggested that an unusual number of respiratory illnesses were present among children living in the Scarboro community, a predominantly African American community in Oak Ridge, Tennessee, located near the Y-12 plant at the Oak Ridge Reservation. The article stated that 16 children had repeated episodes of "severe ear, nose, throat, stomach and respiratory illnesses," and implied that contaminants from the Y-12 plant caused the illnesses. Among those respiratory illnesses were asthma, bronchitis, sinusitis, allergic rhinitis, and otitis media. The newspaper article generated considerable community concern, and as a result the Tennessee Commissioner of Health requested Centers for Disease Control and Prevention's (CDC) assistance in investigating the matter.

Study design and methods

The study was a cross-sectional prevalence survey and a follow-up medical evaluation of children under 18 years of age. The authors conducted a community-based door-to-door health survey to assess the prevalence of pediatric respiratory illnesses and other diseases in Scarboro, and compared these rates to national rates obtained from several population-based surveys and published reports.* They identified case subjects as children reported to have ever had a physician's diagnosis of the illnesses of interest, as well as symptoms of the illnesses within the previous year.

The authors also performed medical examinations on a subset of children who had poorly controlled or undiagnosed respiratory illnesses. Medical examinations were conducted to confirm the results of the community survey, to determine whether children with respiratory illnesses were getting the medical care they needed, and to determine whether the children reported in the newspaper to have respiratory medical problems really had these problems.

The questionnaire was developed through a combined effort involving the National Center for Environmental Health, the Scarboro Community Environmental Justice Council, and the Tennessee Department of Health. It was

* The Behavioral Risk Factor Surveillance System (a telephone survey of the U.S. population less than 18 years of age designed to assess the prevalence of behaviors and practices associated with the leading causes of death in the United States), the National Health Interview Survey (NHIS), and the International Study of Asthma and Allergies in Childhood (ISAAC).

based on well-established questionnaires used in national and international health surveys. Although the focus of the survey was child respiratory health, the study also assessed adult health concerns and occupational exposures. Community residents provided substantial input into the development of the questionnaire and the data collection processes.

The National Center for Environmental Health attempted to conduct face-to-face interviews with individuals from every Scarboro home. They identified 264 Scarboro households from an address list obtained from the local utility company and a DOE street directory and map. Trained interviewers administered the questionnaires at the homes of the individuals and at a health fair.

Study subjects

Study subjects included 119 children and 358 adults living in 220 homes. No comparison group was selected.

Exposures

This study evaluated the relationship between self-reported asthma and wheezing illness and indoor (household) and occupational exposures associated with triggering asthma symptoms. This study did not evaluate the relationship between measured environmental contaminants and health outcomes because it was not designed to study the causes of identified illnesses.

Outcome measures

The outcome measures included self-reported information related to general health status and health concerns; health care utilizations, symptoms specific to respiratory illnesses and frequency of episodes; physician diagnoses of hay fever, sinusitis, ear infections, asthma, and bronchitis in children. A subset of children also received medical exams, lung function tests, and blood work.

Data analysis

The authors generated frequency distributions to characterize health concerns and health care utilization; calculated prevalence rates for reported symptoms and illnesses among pediatric participants; and calculated prevalence rate ratios to assess the relationship between asthma and wheezing and identified environmental triggers or occupational exposures.

Results

Of the 264 households identified in Scarboro, questionnaires were completed for 220 households (response rate of 83%); 119 questionnaires were completed for children and 358 for adults.

Half of the residents reported living in Scarboro for at least 40 years. Half of the residents reported living in their current residence for at least 25 years. Fifty-eight percent reported having an annual household income of $20,000 or less. Forty-three percent reported a smoker in the home, and 10% reported pets in the home. Seven percent of respondents (16 households) reported using a gas stove for cooking; 56% of these stoves had an exhaust fan near the stove.

Children's ages ranged from 6 months to 18 years (average: 8 years). Nearly all children were black, and 55% were girls. Eighty-four percent of the children were reported to be under routine care by a physician or health care provider.

Fifty-three percent of the children were reported to have had hay fever symptoms within the previous year, with 9% receiving a physician's diagnosis of hay fever. Thirteen percent receiving a diagnosis of eczema. Thirty-nine percent were reported to have had sinusitis symptoms within the previous year, with 9% receiving a physician's diagnosis of sinus infection. Fifty-eight percent of all the children were reported to have been diagnosed at sometime in their lives with an ear infection, and 29% were reported to have had symptoms of ear infection within the past 12 months.

Forty-eight percent of children were reported as having had a dry cough at night; 35% were reported to have experienced wheezing within the previous year. Fifteen percent had been diagnosed with asthma by a physician. Thirteen

percent had received a physician's diagnosis of asthma within their lifetime and had experienced symptoms within the previous year. The only environmental exposure associated with wheezing in children was living in a household with an unvented gas stove used for cooking. This relationship was statistically significant.

Also, children who wheezed were more likely to have been exposed to environmental tobacco smoke and pets in the home than children who did not wheeze. However, these differences were not statistically significant. This means that, although children with wheezing were more likely to have environmental household exposures, differences of this kind, in a study of this size, could have arisen by chance even if the exposure had no impact on these children.

Of the 34 children invited to have medical examinations, only 23 were physically examined. All of the children examined appeared healthy with no problems requiring urgent medical management; however, 22 had some form of respiratory illness. None were wheezing. Only one had an abnormal lung finding on examination.

Lung function tests were completed on 19 children; 11 had normal results, 5 had results consistent with asthma, and 3 had indeterminate results. Four children had respiratory illness that appeared to be well controlled; all had normal breathing tests.

A team of physicians representing the CDC, TDOH, the Oak Ridge medical community, and the Morehouse School of Medicine thoroughly reviewed the findings of the physical examination and the community survey.

Public health nurses conducted follow-up telephone calls to the parents and provided assistance to a few patents in getting medicines for nasal allergies.

Conclusions

The reported prevalence rate of asthma among children in Scarboro (13%) was higher than the estimated national rate (7% in all children and 9% in black children). Few studies have been conducted on communities similar to Scarboro, and without asthma prevalence information from these communities; it was not possible to determine whether the prevalence of asthma was higher than would be expected. The Scarboro rate was, however, within the range of rates reported in similar studies throughout the United States and internationally. The reported rate of wheezing among children in Scarboro (35%) was also higher than most national and international estimated rates (which range from 1.6% to 36.8%).

The prevalence rates of hay fever and sinus infections in children were comparable to national estimated rates.

No unusual pattern of illness emerged among the children receiving medical exams. The illnesses that were detected were not more severe than would be expected in any community. The findings of the medical exams were consistent with the findings of the community survey.

Because the investigation was not designed to detect associations, and a relatively small group of children was studied, it was not possible to identify causes of the respiratory illnesses.

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AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

ORRHES Brief

Oak Ridge Reservation Health Effects Subcommittee

Dose Reconstruction Feasibility Study Oak Ridge Health Study Phase I Report

Site: Oak Ridge Reservation
Study area: Oak Ridge Area
Time period: 1942–1992
Conducted by: Tennessee Department of Health and the Oak Ridge Health Agreement Steering Panel

Purpose

The Dose Reconstruction Feasibility Study had two purposes: first, to identify past chemical and radionuclide releases from the Oak Ridge Reservation (ORR) that have the highest potential to impact the health of the people living near the ORR; and second, to determine whether sufficient information existed about these releases to estimate the exposure doses received by people living near the ORR.

Background

In July 1991, the Tennessee Department of Health initiated a Health Studies Agreement with the U.S. Department of Energy (DOE). This agreement provides funding for an independent state evaluation of adverse health effects that may have occurred in populations around the ORR. The Oak Ridge Health Agreement Steering Panel (ORHASP) was established to direct and oversee this state evaluation (hereafter called the Oak Ridge Health Studies) and to facilitate interaction and cooperation with the community. ORHASP was an independent panel of local citizens and nationally recognized scientists who provided direction, recommendations, and oversight for the Oak Ridge Health Studies. These health studies focused on the potential effects from off-site exposures to chemicals and radionuclides released at the reservation since 1942. The state conducted the Oak Ridge Health Studies in two phases. Phase 1 is the Dose Reconstruction Feasibility Study described in this summary.

Methods

The Dose Reconstruction Feasibility Study consisted of seven tasks. During Task 1, state investigators identified historical operations at the ORR that used and released chemicals and radionuclides. This involved interviewing both active and retired DOE staff members about past operations, as well as reviewing historical documents (such as purchase orders, laboratory records, and published operational reports). Task 1 documented past activities at each major facility, including routine operations, waste management practices, special projects, and accidents and incidents. Investigators then prioritized these activities for further study based on the likelihood that releases from these activities could have resulted in off-site exposures.

During Task 2, state investigators inventoried the available environmental sampling and research data that could be used to estimate the doses that local populations may have received from chemical and radionuclide releases from the ORR. This data, obtained from DOE and other federal and state agencies (such as the U.S. Environmental Protection Agency, Tennessee Valley

Authority, and the Tennessee Division of Radiological Health), was summarized by environmental media (such as surface water, sediment, air, drinking water, groundwater, and food items). As part of this task, investigators developed abstracts which summarize approximately 100 environmental monitoring and research projects that characterize the historical presence of contaminants in areas outside the ORR.

Based on the results of Tasks 1 and 2, investigators identified a number of historical facility processes and activities at ORR as having a high potential for releasing substantial quantities of contaminants to the off-site environment. These activities were recommended for further evaluation in Tasks 3 and 4.

Tasks 3 and 4 were designed to provide an initial, very rough evaluation of the large quantity of information and data identified in Tasks 1 and 2, and to determine the potential for the contaminant releases to impact the public's health. During Task 3, investigators sought to answer the question: How could contaminants released from the Oak Ridge Reservation have reached local populations? This involved identifying the exposure pathways that could have transported contaminants from the ORR site to residents.

Task 3 began with compiling a list of contaminants investigated during Task 1 and Task 2. These contaminants are listed in Table 1. The contaminants in the list were separated into four general groups: radionuclides, nonradioactive metals, acids/bases, and organic compounds. One of the first steps in Task 3 was to eliminate any chemicals on these lists that were judged unlikely to reach local populations in quantities that would pose a health concern. For example, acids and bases were not selected for further evaluation because these compounds rapidly dissociate in the environment and primarily cause acute health effects, such as irritation. Likewise, although chlorofluorocarbons (Freon) were used in significant quantities at each of the ORR facilities, they were judged unlikely to result in significant exposure because they also rapidly disassociate. Also, some other contaminants (see Table 2) were not selected for further evaluation because they were used in relatively small quantities or in processes that are not believed to be associated with significant releases. Investigators determined that only a portion of contaminants identified in Tasks 1 and 2 could have reached people in the Oak Ridge area and potentially impacted their health. These contaminants, listed in Table 3, were evaluated further in Tasks 3 and 4.

The next step in Task 3 was to determine, for each contaminant listed in Table 3, whether a complete exposure pathway existed. A complete exposure pathway means a plausible route by which the contaminant could have traveled from ORR to offsite populations. Only those contaminants with complete exposure pathways would have the potential to cause adverse health effects. In this feasibility study, an exposure pathway is considered complete if it has the following three elements:

- A source that released the contaminant into the environment;
- A transport medium (such as air, surface water, soil, or biota) or some combination of these media (e.g., air → pasture → livestock milk) that carried the contaminant off the site to a location where exposure could occur; and
- An exposure route (such as inhalation, ingestion, or—in the case of certain radionuclides that emit gamma or beta radiation—immersion) through which a person could come into contact with the contaminant.

In examining whether complete exposure pathways existed, investigators considered the characteristics of each contaminant and the environmental setting at the ORR. Contaminants that lacked a source, transport medium, or exposure route were eliminated from further consideration because they lacked a complete exposure pathway. Through this analysis, investigators identified a number of contaminants with complete exposure pathways.

During Task 4, investigators sought to determine qualitatively which of the contaminants with complete exposure pathways appeared to pose the greatest potential to impact off-site populations. They began by comparing the pathways for each contaminant individually. For each contaminant, they determined which pathway appeared to have the greatest potential for exposing off-site populations, and they compared the exposure potential of the contaminant's other pathways to its most significant pathway. They then divided contaminants into three categories—radionuclides, carcinogens, and noncarcinogens—and compared the contaminants within each category based on their exposure potential and on their potential to cause health effects. This analysis identified facilities, processes, contaminants, media, and exposure routes believed to have the greatest potential to impact off-site populations. The results are provided in Table 4.

The Task 4 analysis was intended to provide a preliminary framework to help focus and prioritize future quantitative studies of the potential health impacts of off-site contamination. These analyses are intended to provide an initial approach to studying an extremely complex site. However, care must be taken in attempting to make broad generalizations or draw conclusions about the potential health hazard posed by the releases from the ORR.

In Task 5, investigators described the historical locations and activities of populations most likely to have been affected by the releases identified in Task 4. During Task 6, investigators compiled a summary of the current toxicologic knowledge and hazardous properties of the key contaminants. Task 7 involved collecting, categorizing, summarizing, and indexing selected documents relevant to the feasibility study.

Study Group

A study group was not selected.

Exposures

Seven completed exposure pathways associated with air, six completed exposure pathways associated with surface water, and ten completed exposure pathways associated with soil/sediment were evaluated for radionuclides and chemical substances (metals, organic compounds, and polycyclic aromatic hydrocarbons) released at the ORR from 1942 to 1992.

Outcome Measures

No outcome measures were studied.

Conclusions

The feasibility study indicated that past releases of the following contaminants have the greatest potential to impact off-site populations.

- **Radioactive iodine**
  The largest identified releases of radioactive iodine were associated with radioactive lanthanum processing from 1944 through 1956 at the X-10 facility.

- **Radioactive cesium**
  The largest identified releases of radioactive cesium were associated with various chemical separation activities that took place from 1943 through the 1960s.

- **Mercury**
  The largest identified releases of mercury were associated with lithium separation and enrichment operations that were conducted at the Y-12 facility from 1955 through 1963.

- **Polychlorinated biphenyls**
  Concentrations of polychlorinated biphenyls (PCBs) found in fish taken from the East Fork Poplar Creek and the Clinch River have been high enough to warrant further study. These releases likely came from electrical transformers and machining operations at the K-25 and Y-12 plants.

State investigators determined that sufficient information was available to reconstruct past releases and potential off-site doses for these contaminants. The steering panel (ORHASP) recommended that dose reconstruction activities proceed for the releases of radioactive iodine, radioactive cesium, mercury, and PCBs. Specifically they recommended that the state should continue the tasks begun during the feasibility study, and should characterize the actual release history of these contaminants from the reservation; identify appropriate fate and transport models to predict historical off-site concentrations; and identify an exposure model to use in calculating doses to the exposed population.

The panel also recommended that a broader-based investigation of operations and contaminants be conducted to study the large number of ORR contaminants released that have lower potentials for off-site health effects, including the five contaminants (chromium VI; plutonium 239, 240, and 241; tritium; arsenic; and neptunium 237) that could not be qualitatively evaluated during Phase 1 due to a lack of available data. Such an investigation would help in modifying or reinforcing the recommendations for future health studies.

Additionally, the panel recommended that researchers explore opportunities to conduct epidemiologic studies investigating potential associations between exposure doses and adverse health effects in exposed populations.

TABLE 1

LIST OF CONTAMINANTS INVESTIGATED DURING TASK 1 AND TASK 2

X-10	K-25	Y-12
Radionuclides		
Americium-241 Argon-41 Barium-140 Berkelium Californium-252 Carbon-14 Cerium-144 Cesium-134,-137 Cobalt-57,-60 Curium-242,-243,-244 Einsteinium Europium-152,-154,-155 Fermium Iodine-129, -131, -133 Krypton-85 Lanthanum-140 Niobium-95 Phosphorus-32 Plutonium-238, -239, -240, -241 Protactinium-233 Ruthenium-103, -106 Selenium-75 Strontium-89, -90 Tritium Uranium-233,-234, -235, -238 Xenon-133 Zirconium-95	Neptunium-237 Plutonium-239 Technetium-99 Uranium-234, -235, -238	Neptunium-237 Plutonium-239, -239, -240, -241 Technetium-99 Thorium-232 Tritium Uranium-234, -235, -238
Nonradioactive Metals		
None Initially Identified	Beryllium Chromium, (trivalent and hexavalent) Nickel	Arsenic Beryllium Chromium, (trivalent and hexavalent) Lead Lithium Mercury
Acids/Bases		
Hydrochloric acid Hydrogen peroxide Nitric acid Sodium hydroxide Sulfuric acid	Acetic acid Chlorine trifluoride Fluorine and fluoride compounds Hydrofluoric acid Nitric acid Potassium hydroxide Sulfuric acid	Ammonium hydroxide Fluorine and various fluorides Hydrofluoric acid Nitric acid Phosgene
Organic Compounds		
None Initially Identified	Benzene Carbon tetrachloride Chloroform Chlorofluorocarbons (Freons) Methylene chloride Polychlorinated biphenyls 1,1,1-Trichloroethane Trichloroethylene	Carbon tetrachloride Chlorofluorocarbons (Freons) Methylene chloride Polychlorinated biphenyls Tetrachloroethylene 1,1,1-Trichloroethane Trichloroethylene

TABLE 2

CONTAMINANTS NOT WARRANTING FURTHER EVALUATION IN TASK 3 AND TASK 4

Radionuclides
Americium-241
Californium-252
Carbon-14
Cobalt-57
Cesium-134
Curium-242, -243, -244
Europium-152, -154, -155
Phosphorus-32
Selenium-75
Uranium-233
Berkelium
Einsteinium
Fermium
Nonradioactive Metals
Lithium
Organic Compounds
Benzene
Chlorofluorocarbons (Freons)
Chloroform
Acids/Bases
Acetic acid
Ammonium hydroxide
Chlorine trifluoride
Fluorine and various fluoride compounds
Hydrochloric acid
Hydrogen peroxide
Hydrofluoric acid
Nitric acid
Phosgene
Potassium hydroxide
Sulfuric acid
Sodium hydroxide

TABLE 3

CONTAMINANTS FURTHER EVALUATED IN TASK 3 AND TASK 4

Radionuclides	Nonradioactive Metals	Organic Compounds
Argon-41	Arsenic	Carbon tetrachloride
Barium-140	Beryllium	Methylene chloride
Cerium-144	Chromium (trivalent and hexavalent)	Polychlorinated biphenyls
Cesium-137	Lead	Tetrachloroethylene
Cobalt-60	Mercury	1,1,1-Trichloroethane
Iodine-129, -131, -133	Nickel	Trichloroethylene
Krypton-85		
Lanthanum-140		
Neptunium-237		
Niobium-95		
Plutonium-238, -239, -240, -241		
Protactinium-233		
Ruthenium-103, -106		
Strontium-89, 90		
Technetium-99		
Thorium-232		
Tritium		
Uranium-234 -235, -238		
Xenon-133		
Zirconium-95		

TABLE 4

HIGHEST PRIORITY CONTAMINANTS, SOURCES, TRANSPORT MEDIA, AND EXPOSURE ROUTES

Contaminant	Source	Transport Medium	Exposure Route
Iodine-131, -133	X-10 Radioactive lanthanon (RaLa) processing (1944-1956)	Air to vegetable to dairy cattle milk	Ingestion
Cesium-137	X-10 Various chemical separation processes (1944-1960s)	Surface water to fish Soil/sediment Soil/sediment to vegetables; livestock/game (beef); dairy cattle milk	Ingestion Ingestion Ingestion
Mercury	Y-12 Lithium separation and enrichment operations (1955-1963)	Air Air to vegetables; Livestock/game (beef); dairy cattle milk Surface water to fish Soil/sediment to livestock/game (beef); vegetables	Inhalation Ingestion Ingestion Ingestion
Polychlorinated biphenyls	K-25 and Y-12 Transformers and machining	Surface water to fish	Ingestion

ORRHES Brief
Oak Ridge Reservation Health Effects Subcommittee

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Uranium Releases from the Oak Ridge Reservation—a Review of the Quality of Historical Effluent Monitoring Data and a Screening Evaluation of Potential Off-Site Exposures, Report of the Oak Ridge Dose Reconstruction, Vol. 5 The Report of Project Task 6

Site: Oak Ridge Reservation

Conducted by: ChemRisk/ORHASP for the Tennessee Department of Health

Time Period: 1999

Location: Oak Ridge, Tennessee

Purpose

The purpose of the Task 6 study was to further evaluate the quality of historical uranium operations and effluent monitoring records, to confirm or modify previous uranium release estimates for the period from 1944 to 1995 for all three complexes on the Oak Ridge Reservation (ORR), and to determine if uranium releases from the ORR likely resulted in off-site doses that warrant further study. The main results of the study are revised uranium release estimates from the Y-12 plant, K-25 gaseous diffusion plant, and the S-50 liquid thermal diffusion plant and screening-level estimates of potential health effects to people living near the ORR. These results, which are called "screening indices," are conservative estimates of potential exposures and health impacts and are intended to be used with the decision guide established by Oak Ridge Health Agreement Steering Panel (ORHASP) to determine if further work is warranted to estimate the human health risks from past uranium releases.

Background

The 1993 Oak Ridge Health Studies, Phase I Dose Reconstruction Feasibility Study by the Tennessee Department of Health indicated that uranium was not among the list of contaminants that warranted highest priority for detailed dose reconstruction investigation of off-site health effects. After receiving comments from several long-term employees at the ORR uranium facilities, a number of ORHASP members recommended that past uranium emissions and potential resulting exposures receive closer examination. In 1994, the Task 6 uranium screening evaluation was included in the Oak Ridge Dose Reconstruction project.

The Oak Ridge Y-12 plant was built in 1945, as part of the Manhattan project. Located at the eastern end of Bear Creek Valley, the Y-12 complex is within the corporate limits of the city of Oak Ridge and is separated from the main residential areas of the city by Pine Ridge. The Y-12 plant housed many operations involving uranium, including the preparation, forming, machining, and recycling of uranium for Weapon Component Operations.

Construction of the K-25 uranium enrichment facility began in 1943, and the facility was operational by January 1945. The K-25 site is located near the western end of the ORR, along Poplar Creek near where it meets the Clinch River. The primary mission of K-25 was to enrich uranium by the gaseous diffusion process.

Located along the Clinch River near the K-25 site was a liquid thermal diffusion plant (the S-50 site) that operated from October 1944 to September 1945. Because of their close proximity, the K-25 and S-50 complexes were generally discussed together in the Task 6 report.

The X-10 facility, which conducted chemical processing of reactor fuel and other nuclear materials, was not a primary focus of the Task 6 study.

Methods

An extensive information gathering and review effort was undertaken by the project team in searching for information related to historical uranium operations at the Y-12, K-25, and S-50 sites. Thousands of documents were searched and many active and retired workers were interviewed.

The Task 6 investigation followed these basic steps:

- Information that described uranium uses and releases on the ORR was collected.
- Effluent monitoring data were evaluated for quality and consistency with previous U.S. Department of Energy (DOE) historical uranium release reports.
- Updated estimates of airborne uranium releases over time were generated using the more complete data available to the project team.
- Air dispersion models were used to estimate uranium air concentrations at selected reference locations near each ORR facility. The reference locations were:
  - — the Scarboro community (for Y-12),
  - — the Union/Lawnville community (for K-25/S-50), and
  - — Jones Island area along the Clinch River (for X-10).

  Because the terrain surrounding the Y-12 facility has complex topography, air dispersion modeling techniques were not employed. Instead, an empirical relative concentration (?/Q) relationship was established between measured releases of uranium from Y-12 and measured airborne concentrations of uranium at Scarboro. The ?/Q relationship was then used to extrapolate airborne uranium concentrations for times in which it was not directly measured.
- The screening evaluation of potential offsite exposures to waterborne uranium was based on environmental measurements of uranium at local surface waters. The sampling sites were: White Oak Dam, downstream of New Hope Pond, and the confluence of Poplar Creek and the Clinch River.
- A screening-level evaluation of the potential for health effects was performed by calculating intakes and associated radiation doses. A two-tiered exposure assessment methodology was employed, which provided both upper bound and more typical results. Because of the scarcity of information regarding estimates of uranium concentrations in the environment over the period of interest, some conservatism was maintained in the uranium concentrations used in the Level II screening.
- Annual radiation doses from uranium intake and external exposure were calculated for the adult age group for each screening assessment and then converted to screening indices using a dose-to-risk coefficient of 7.3% Sv^{-1}.
- Estimates of annual-average intakes of uranium by inhalation and ingestion were also used to evaluate the potential for health effects due to the chemical toxicity of uranium compounds, specifically for damage to the kidneys. Uranium was assumed to be in its most soluble form and safety factors were included to minimize the potential for underestimation of the potential for toxic effects.

Study Subjects

The screening evaluation estimated potential off-site exposure and screening indices for hypothetical individuals in three reference locations (Scarboro, Union/Lawnville, and Jones Island). These reference locations represent residents who lived closest to the ORR facilities and would have received the highest exposures from past uranium releases. Thus, they are associated with the highest screening indices derived by the screening evaluation.

Exposures

The following potential air exposure pathways were evaluated:

1. Air to humans-direct inhalation of airborne particulates
2. Air to humans (immersion in contaminated air)
3. Air to livestock (via inhalation) to beef to humans
4. Air to dairy cattle (via inhalation) to milk to humans
5. Air to vegetables (deposition) to humans
6. Air to pasture (deposition) to cattle beef to humans
7. Air to pasture (deposition) to dairy cattle to milk to humans

The following potential water exposure pathways were evaluated:

1. Incidental ingestion by humans during recreation
2. Water to livestock (ingestion) to beef to humans
3. Water to dairy cattle (ingestion) to milk to humans
4. Water to fish to humans
5. Water to humans via immersion during recreation

The following potential soil exposure pathways were evaluated:

1. Soil to air (dust resuspension) to humans
2. Soil incidental ingestion
3. Soil to livestock (soil ingestion) to beef to humans
4. Soil to dairy cattle (soil ingestion) to milk to humans
5. Soil to vegetables (root uptake) to humans
6. Soil to pasture (root uptake) to livestock to beef to humans
7. Soil to pasture (root uptake) to dairy cattle to milk to humans
8. Soil to humans via external radiation

Outcome Measures

Health outcomes were not studied.

Results

Airborne uranium releases from the Y-12, K-25, and S-50 sites were found to be greater than previously reported. DOE estimated that the amount of uranium released from the Y-12 plant was 6,535 kilograms. The Task 6 team estimated that 50,000 kilograms of uranium was released to the air by the Y-12 plant. DOE estimated that the amount released from the K-25 and S-50 plants (combined) was 10,713 kilograms. The Task 6 team estimated that 16,000 kilograms were released to the air by the K-25/S-50 complex.

The Scarboro community was associated with the highest total screening index attributable to uranium releases from the Y-12 plant. The screening indices were 1.9×10^{-3} for the Level I assessment and 8.3×10^{-5} for the Level II assessment. While the overall Level I screening index for the Scarboro community is above the ORHASP decision guide of 1.0×10^{-4} (1 in 10,000), the Level II value is below that guide value. This indicates that the Y-12 uranium releases are candidates for further study, but that they are not high priority candidates for further study.

For the K-25/S-50 assessment, the total screening index for Union/Lawnville from the Level I assessment (2.7×10^{-4}) exceeded the ORHASP decision guide. The less conservative Level II screening result (4.0×10^{-5}) did not exceed the

guide. This indicates that the K-25/S-50 uranium releases are also candidates for further study, but that they are not high priority candidates for further study.

The X-10 Level I assessment yielded a screening index for Jones Island (7.6×10^{-5}) below the decision guide. This indicates that releases from the X-10 site warrant lower priority, especially given the pilot-plant nature and relatively short duration of most X-10 uranium operations.

The Scarboro community was selected for the initial chemical toxicity evaluation since its screening index for radiological exposures was the highest. Estimated kidney burdens resulting from simultaneous intake of uranium by ingestion and inhalation under the Scarboro assessment do not exceed an effects threshold criterion (1 microgram per gram of kidney tissue) proposed by some scientists, but they do exceed an effects threshold criterion (0.02 micrograms per gram of kidney tissue) proposed by other scientists. The Task 6 team also evaluated the average-annual intakes using a reference dose/Hazard Index approach and concluded that further study of chemical toxicity from past ORR uranium exposures did not warrant high priority.

Conclusions

The Task 6 team reached the following general conclusions:

- Estimates of uranium releases previously reported by DOE are incomplete and; therefore, were not used in the Task 6 screening evaluation.
- Historical uranium releases from the Y-12 plant are likely significantly higher (over seven times higher) than totals reported by DOE. There are several reasons why previous estimates were so much lower.
- Historical uranium releases from the K-25/S-50 complex are likely higher than totals reported by DOE.
- Operations at the S-50 plant are poorly documented.
- The Scarboro community had the highest total screening index from uranium releases at the ORR, specifically the Y-12 plant. Since the Level II screening index is just below the ORHASP decision criterion, with most of the conservative assumptions regarding source term and exposure parameters removed, potential exposure to uranium releases could have been of significance from a health standpoint and should; therefore, be considered for dose reconstruction.
- The Union/Lawnville community evaluation (releases from the K-25/S-50 complex) had a Level II screening index below the ORHASP criterion. However, without quantification of the uncertainties associated with the release estimates and the exposure assessment, it is not possible to say that these releases do not warrant further characterizations.
- The Level I screening index for the Jones Island area (releases from the X-10 site) are below the ORHASP decision criterion.
- Because Pine Ridge separates the Y-12 plant from Scarboro, an alternate approach (?/Q) was used to estimate uranium air concentrations in Scarboro.
- The concentrations of uranium in soil are a major factor in the screening analyses. Because limited soil data are available for the reference locations, alternative approaches should be considered for future analyses.
- While the estimated uranium intake from ingestion and inhalation exceed one effects threshold criterion, they do no exceed another. Calculated hazard indices indicate that further study of chemical effects of the kidneys rank as a low priority.

If the evaluation of ORR uranium releases is to proceed beyond a conservative screening stage and on to a nonconservative screening with uncertainty and sensitivity analyses, activities that should be evaluated for possible follow-up work include:

- Additional records research and data evaluation regarding S-50 plant operations and potential releases.
- Additional searching for and review of effluent monitoring data for Y-12 electromagnetic enrichment operations from 1944 to 1947 and data relating to releases from unmonitored depleted uranium operations in the 1950s through the 1990s.
- Uncertainty analysis of the Y-12 uranium release estimates derived in this study.
- Review of additional data regarding unmonitored K-25 uranium releases.
- Refinement of the approach used to evaluate surface water and soil-based exposure concentrations.
- Evaluation of the effects of the ridges and valleys that dominate the local terrain surrounding Y-12 and Scarboro and investigation of alternative approaches to estimate air concentrations at Scarboro with an emphasis on identifying additional monitoring data.
- Performance of a bounding assessment of the amounts of uranium that were handled at the X-10 site.
- Improvement of the exposure assessment to include region-specific consumption habits and lifestyles, identification of likely exposure scenarios instead of hypothetical upper bound and typical assessments, and inclusion of uncertainty analysis to provide statistical bounds for the evaluation of risk.
- Refinement of the chemical toxicity evaluation, possibly to include other approaches and models, as well as an uncertainty analysis.

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ORRHES Brief
Oak Ridge Reservation Health Effects Subcommittee

Screening-Level Evaluation of Additional Potential Materials of Concern, July 1999—Task 7

Site: Oak Ridge Reservation
Study area: Oak Ridge Area
Time period: 1942–1990
Conducted by: Tennessee Department of Health and the Oak Ridge Health Agreement Steering Panel

Purpose

The purpose of this screening-level evaluation was to determine whether additional contaminants that existed at Oak Ridge Reservation (ORR), other than the five already identified in the Oak Ridge Dose Reconstruction Feasibility Study (iodine, mercury, polychlorinated biphenyls [PCBs], radionuclides, and uranium), warrant further evaluation of their potential for causing health effects in off-site populations.

Background

In July 1991, the Tennessee Department of Health in cooperation with the U.S. Department of Energy initiated a Health Studies Agreement to evaluate the potential for exposures to chemical and radiological releases from past operations at ORR. The Oak Ridge Dose Reconstruction Feasibility Study was conducted from 1992 to 1993 to identify those operations and materials that warranted detailed evaluation based on the risks posed to off-site populations. The feasibility study recommended that dose reconstructions be conducted for radioactive iodine releases from X-10 radioactive lanthanum processing (Task 1), mercury releases from Y-12 lithium enrichment (Task 2), PCBs in the environment near Oak Ridge (Task 3), and radionuclides released from White Oak Creek to the Clinch River (Task 4). In addition, the study called for a systematic search of historical records (Task 5), an evaluation of the quality of historical uranium effluent monitoring data (Task 6), and additional screening of materials that could not be evaluated during the feasibility study (Task 7).

The Oak Ridge Health Agreement Steering Panel (ORRHES) was established to direct and oversee the Oak Ridge Health Studies and to facilitate interaction and cooperation with the community. This group is comprised of local citizens and nationally recognized scientists.

Methods

During the Task 7 Screening-Level Evaluation, three different methods (qualitative screening, the threshold quantity approach, and quantitative screening) were used to evaluate the importance of materials with respect to their potential for causing off-site health effects. Twenty-five materials or groups of materials were evaluated. Please see Table 1 for a summary of the methods used to evaluate each material/group of materials.

- Qualitative Screening—All materials used on ORR were qualitatively screened for quantities used, forms used, and/or manners of use. If it was unlikely that off-site releases were sufficient to pose an off-site health hazard, then these materials were not evaluated quantitatively. If off-site exposures were likely to have occurred at harmful levels, then the materials were evaluated quantitatively.

- Threshold Quantity Approach—When information was insufficient to conduct quantitative screening, inventories of materials used at ORR were estimated based on historical records and interviews of workers. These estimated inventories of materials were

determined to be either above or below a conservatively calculated health-based threshold quantity. If the estimates for a material were below the calculated threshold quantity, then it was determined to be highly unlikely to have posed a risk to human health through off-site releases.

- Quantitative Screening—The quantitative screening used a two-level screening approach to identify those materials that could produce health risks (i.e., doses) to exposed people that are clearly below minimum levels of health concern (Level I Screen) and above minimum levels of health concern (Refined Level I Screen). Health-based decision guides were established by the Oak Ridge Health Agreement Steering Panel and represent minimum levels of health concern.

  — The Level I Screening calculates a screening index for a maximally exposed reference individual who would have received the highest exposure. This conservative (protective) screening index is not expected to underestimate exposure to any real person in the population of interest. If the estimated Level I screening index was below the ORRHES decision guide, then the hazard to essentially all members of the population, including the maximally exposed individual, would be below the minimum level of health concern. In addition, the Level I screening index would be so low that further detailed study of exposures is not warranted because the screening index is below the threshold for consideration of more extensive health effects studies. However, if during the Level I Screening, the screening index was above the ORRHES decision guide, then the contaminant was further evaluated using Refined Level I Screening.

  — The Refined Level I Screen calculates a less conservative, more realistic screening index by using more reasonable exposure parameters than the Level I Screen. In addition, depending upon the contaminant, a less conservative environmental concentration was sometimes used. However, the transfer factors and toxicity values remained the same for both screening levels. The Refined Level I Screening maintains considerable conservatism because of these conservative transfer factors and toxicity values.

  If the Refined Level I screening index was below the ORRHES decision guide, then the hazard to most members of the population would be below minimum levels of health concern. In addition, the Refined Level I screening index would be so low that further detail study of exposure is not warranted because the screening index is below the threshold for consideration of more extensive health effects studies and was given a low priority for further study. However, if during the Refined Level I Screening, the screening index was above the ORRHES decision guide, then the contaminant was determined to be of high priority for a detail evaluation.

Study Group

The screening evaluation focuses on the potential for health effects to occur in off-site residents. The Level I Screen estimates a dose for the hypothetical maximally exposed individual who would have received the highest exposure and would have been the most at-risk. The Refined Level I Screen estimates a dose for a more typically exposed individual in the targeted population. The study group for exposure from lead were children because they are particularly sensitive to the neurological effects of lead.

Exposures

Quantitative screening used mathematical equations to calculate a screening index (theoretical estimates of risk or hazard) from multiple exposure pathways, including inhalation; ground exposure (for radionuclides); ingestion of soil or sediment; and ingestion of vegetables, meat, milk, and/or fish.

Outcome Measures

No outcome measures were studied.

Results

Screening-level analyses were performed for seven carcinogens. They were evaluated according to source, resulting in 10 separate analyses. Three of the Level I Screen analyses (Np-237 from K-25, Np-237 from Y-12, and tritium from Y-12) yielded results that were below the decision guides. Refined Level I Screens were performed on the other seven carcinogenic assessments. The results of five separate analyses (beryllium from Y-12, chromium VI from ORR, nickel from K-25, technetium-99 from K-25, and technetium-99 from Y-12) were below the decision guides, and two analyses (arsenic from K-25 and arsenic from Y-12) were above the decision guides.

Arsenic was released into the air from the burning of coal at several coal-fired steam plants located on the Oak Ridge Reservation and into the soil, sediment, and surface water from coal piles and disposal of fly ash from the steam plants. Lead was likely released into soil, sediment, and surface water from the disposal of liquid waste into the Y-12 storm sewers and may have been released into the air from process stacks and the plant ventilation system.

Screening-level analyses were performed for seven noncarcinogens. These, too, were evaluated according to source, resulting in eight separate analyses. One Level I Screen analysis (beryllium from Y-12) yielded results that were below the decision guide. Refined Level I Screens were performed on the other seven noncarcinogenic assessments. Four analyses (chromium VI from ORR, copper from K-25, lithium from Y-12, and nickel from K-25) were below the decision guides and three analyses (arsenic from K-25, arsenic from Y-12, and lead from Y-12) were above the decision guides.

Three materials (niobium, zirconium, and tetramethylammoniumborohydride [TMAB]) were evaluated using the threshold quantity approach because information was insufficient to perform quantitative screening. None of the three was determined to be present in high enough quantities at the Y-12 Plant to have posed off-site health hazards.

Conclusions

Based on the qualitative and quantitative screening, the materials were separated into three classes in terms of potential off-site health hazards: not candidates for further study, potential candidates for further study, and high priority candidates for further study. (as shown in Table 2).

- Not Candidates—Five materials at the K-25 and 14 materials used at the Y-12 Plant were determined to not warrant further study. All of these chemicals were eliminated because either (1) quantitatively, they fell below Level I Screening decision guides; (2) not enough material was present to have posed an off-site health hazard according to the threshold quantity approach; or (3) qualitatively, the quantities used, forms used, and/or manners of usage were such that off-site releases would not have been sufficient to cause off-site health hazards.

- Potential Candidates—Three materials at the K-25 (copper powder, nickel, and technetium-99), three materials used at the Y-12 Plant (beryllium compounds, lithium compounds, and technetium-99), and one material used at ORR (chromium VI) were determined to be potential candidates for further study. These materials were identified as potential candidates because (1) their Level I Screening indices exceeded the decision guides and (2) their Refined Level I Screening indices did not exceed the decision guides.

- High Priority Candidates—One material used at the K-25 (arsenic) and two at the Y-12 Plant (arsenic and lead) were determined to be high priority candidates for further study. They were chosen as high priority materials because their Refined Level I Screening indices exceeded the decision guides.

Two issues remaining from the Dose Reconstruction Feasibility Study were evaluated during Task 7: the possible off-site health risks associated with asbestos and the composition of plutonium formed and released to the environment.

- Asbestos—Asbestos could not be fully evaluated during the feasibility study; therefore, it was qualitatively evaluated during this task for the potential for off-site releases and community exposure. Available information on the use and disposal of asbestos, as well as, off-site asbestos monitoring was summarized. None of the investigations performed to date have identified any asbestos-related exposure events or activities associated with community exposure, making it very unlikely that asbestos from ORR has caused any significant off-site health risks.

- Plutonium—The records that documented the rate of plutonium release did not specify the isotopic composition of the product formed. As a result, during the feasibility study, the project team made the assumption that the plutonium that was formed and released was plutonium-239. If incorrect, this assumption could have significant ramifications on the screening of past airborne plutonium releases. Therefore, the composition of the plutonium formed and released was evaluated further during this task. Plutonium inventory from X-10 was calculated, and plutonium-239 was found to comprise at least 99.9% of the plutonium present in Clinton Pile fuel slugs. This result confirmed that the assumptions made in the feasibility study did not introduce significant inaccuracy into the screening evaluation that was conducted.

TABLE 1

Summary of Screening Methods Used for Each Material

Qualitative Screening			
Material	**Source**	**Notes**	
Boron carbide, boron nitride, yttrium boride, titanium boride, rubidium nitrate, triplex coating, carbon fibers, glass fibers, and four-ring polyphenyl ether	ORR	Evaluated based on quantities used, forms used, and manners of usage.	
Tellurium	Y-12	Evaluated based on quantities used, forms used, and manners of usage.	
Threshold Quantity Approach			
Material	**Source**	**Media**	**Threshold Values**
Niobium	Y-12 Used in production of two alloys, mulberry and binary	Air Surface Water	Evaluated using a reference dose derived from an LD50, an empirically derived dispersion factor for airborne releases from Y-12 to Scarboro, and estimated average East Fork Poplar Creek (EFPC) flow rates.
Tetramethylammoniumboro-hydride (TMAB)	Y-12 Use classified	Air Surface Water	Inventory quantities and specific applications remain classified.
Zirconium	Y-12 Used in production of an alloy, mulberry	Air Surface Water	Evaluated using a reference dose derived from an ACGIH Threshold Limit Value for occupational exposure, an empirically derived dispersion factor for air released from Y-12 to Scarboro, and estimated average EFPC flow rates.

TABLE 1
Summary of Screening Methods Used for Each Material (continued)

Quantitative Screening			
Material	**Source**	**Media**	**Exposure Values**
Arsenic Level I Screen and Refined Level I Screen	K-25 Y-12 Released as a naturally occurring product in coal, which was used in coal–fired steam plants	Air	Based on coal use and dispersion modeling to Union/Lawnville (K-25) and Scarboro (Y-12).
		Surface Water	Used maximum in Poplar Creek (K-25) and the 95% upper confidence limit (UCL) on the mean concentration in McCoy Branch (Y-12).
		Soil/Sediment	Used sediment core concentration detected in Poplar Creek to represent the early 1960s (K-25) and the 95% UCL on the mean concentration in McCoy Branch (Y-12).
		Food Items	Based on concentrations in air, soil, and water and NCRP biotransfer and bioconcentration factors.
Beryllium compounds Level I Screen and Refined Level I Screen	Y-12 Used in production	Air	Used Y-12 stack monitoring data and an empirical dispersion factor for releases to Scarboro.
		Surface Water	Used maximum concentration measured in EFPC.
		Soil	Used maximum concentration measured in EFPC.
		Food Items	Based on concentrations in air, soil, and water and NCRP biotransfer and bioconcentration factors.
Copper Level I Screen and Refined Level I Screen	K-25 Use of copper powder is classified	Air	Based on airborne concentrations measured at the most-affected on-site air sampler that were adjusted according to the ratio of dispersion model results at that sampler to those at Union/Lawnville.
		Surface Water	Used maximum concentration measured during the Clinch River Remedial Investigation.
		Soil/Sediment	Used highest mean concentration in Clinch River.
		Food Items	Based on concentrations in air, soil, and water and NCRP biotransfer factor and an ATSDR bioconcentration factor.

TABLE 1
Summary of Screening Methods Used for Each Material (continued)

Quantitative Screening (continued)			
Material	**Source**	**Media**	**Exposure Values**
Hexavalent chromium (Chromium VI) Level I Screen and Refined Level I Screen	ORR Used in cooling towers to control corrosion	Air	Based on modeling of emission and drift from K-25 cooling towers to Union/Lawnville.
		Surface Water	Used maximum concentration measured in Poplar Creek before 1970.
		Soil	Used average concentration of total chromium measured during the EFPC Remedial Investigation; assumed to be 1/6 (16.7%) chromium VI.
		Food Items	Based on concentrations in air, soil, and water and NCRP biotransfer and bioconcentration factors.
Lead EPA's Integrated Exposure Uptake Biokinetic model	Y-12 Used in production of components, in paints, and as radiation shielding	Air	Estimated from background concentrations of lead prior to mid-1970s.
		Surface Water	Used maximum concentration measured in EFPC (a higher concentration was detected near Y-12; however it was considered to be anomalous).
		Soil/Sediment	Used maximum concentration measured in the EFPC Remedial Investigation, the 95% UCL, and the 95% UCL multiplied by 3.5 for a higher past concentration.
		Food Items	Based on concentrations in air, soil, and water and biotransfer and bio-concentration factors from literature.
Lithium Level I Screen and Refined Level I Screen	Y-12 Used in lithium isotope separation, chemical, and component fabrication	Air	Used stack sampling data from two lithium processing buildings and an empirical dispersion factor for releases to Scarboro.
		Surface Water	Used highest quarterly average measured in EFPC.
		Soil/Sediment	Used maximum concentration measured in the EFPC floodplain.
		Food Items	Based on concentrations in air, soil, and water and NCRP biotransfer and bioconcentration factors.

TABLE 1
Summary of Screening Methods Used for Each Material (continued)

Quantitative Screening (continued)			
Material	**Source**	**Media**	**Exposure Values**
Neptunium-237 Level I Screen	K-25 Y-12 Found in recycled uranium	Air	Based on levels in recycled uranium, an estimated release fraction, and dispersion modeling to Union/Lawnville (K-25) and Scarboro (Y-12).
		Surface Water	Based on reported releases to Clinch River (K-25) and EFPC (Y-12), corrected for dilution.
		Soil/Sediment	Used maximum concentrations detected in Clinch River (K-25) and EFPC (Y-12).
		Food Items	Based on concentrations in air, soil, and water and NCRP biotransfer and bioconcentration factors.
Nickel Level I Screen and Refined Level I Screen	K-25 Used in the production of barrier material for the gaseous diffusion process	Air	Based on the 95% UCL for the year of the highest measured concentrations in on-site air samplers and dispersion modeling to Union/Lawnville.
		Surface Water	Used 95% UCL for the year of the highest concentrations in Clinch River.
		Soil/Sediment	Used highest mean concentration in Clinch River.
		Food Items	Based on concentrations in air, soil, and water and NCRP biotransfer and bioconcentration factors.
Technetium-99 Level I Screen and Refined Level I Screen	K-25 Y-12 Product of fission of uranium atoms and from neutron activation of stable molybdenum-98	Air	Used an average of concentrations modeled to Union/Lawnville (K-25) and Scarboro (Y-12).
		Surface Water	Used maximum concentration detected in Clinch River (K-25) and EFPC (Y-12).
		Soil/Sediment	Used maximum concentration from the K-25 perimeter and EFPC (Y-12).
		Food Items	Based on concentrations in air, soil, and water and biotransfer and bioconcentration factors from literature.

TABLE 1
Summary of Screening Methods Used for Each Material (continued)

Quantitative Screening (continued)			
Material	**Source**	**Media**	**Exposure Values**
Tritium Level I Screen	Y-12 Used in deuterium gas production and lithium deuteride recovery operations	Surface Water	Evaluated based on deuterium inventory differences and the peak tritium concentration in the deuterium that was processed at Y-12; the release estimate was used with the International Atomic Energy Agency method for tritium dose assessment, assuming all the tritium that escaped was released to EFPC.

TABLE 2
Categorization of Materials Based on Screening Results

Contaminant Source	Not Candidates for Further Study (Level I result was below the decision guide)	Potential Candidates for Further Study (Refined Level I result was below the decision guide)	High Priority Candidates for Further Study (Refined Level I result was above the decision guide)
K-25	Neptunium-237 (cancer) Evaluated qualitatively (quantities, forms, and manner of use were not sufficient): • Carbon fibers • Four-ring polyphenyl ether • Glass fibers • Triplex coating	• Copper powder (noncancer) • Nickel (cancer) • Nickel (noncancer) • Technetium-99 (cancer)	• Arsenic (cancer) • Arsenic (noncancer)
Y-12 Plant	• Beryllium compounds (noncancer) • Neptunium-237 (cancer) • Tritium (cancer) Evaluated using Threshold Quantity Approach (not enough material was present): • Niobium (noncancer) • TMAB • Zirconium (noncancer) Evaluated qualitatively (quantities, forms, and manner of use were not sufficient): • Boron carbide • Boron nitride • Rubidium nitrate • Rubidium bromide • Tellurium • Titanium boride • Yttrium boride • Zirconium	• Beryllium compounds (cancer) • Lithium compounds (noncancer) • Technetium-99 (cancer)	• Arsenic (cancer) • Arsenic (noncancer) • Lead (noncancer) Arsenic was released into the air from the burning of coal at several coal-fired steam plants located on the Oak Ridge Reservation and into the soil, sediment, and surface water from coal piles and disposal of fly ash from the steam plants. Lead was likely released into soil, sediment, and surface water from the disposal of liquid waste into the Y-12 storm sewers and may have been released into the air from process stacks and the plant ventilation system."
ORR (all complexes)		• Chromium VI (cancer) • Chromium VI (noncancer)	