Appendix A. ATSDR Glossary of Environmental Health Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

Absorption
The process of taking in. For a person or animal, *absorption* is the process through which a substance gets into the body through the eyes, skin, stomach, intestines, or lungs.

Activity
The number of radioactive nuclear transformations occurring in a material per unit time. The term for *activity* per unit mass is specific activity.

Acute
Occurring over a short time [compare with chronic].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate-duration exposure and chronic exposure].

Adverse health effect
A change in body function or cell structure that might lead to disease or health problems.

Ambient
Surrounding (for example, *ambient* air).

Analytic epidemiologic study
A study that evaluates the association between exposure to hazardous substances and disease by testing scientific hypotheses.

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Background radiation

The amount of radiation to which a member of the general population is exposed from natural sources, such as terrestrial radiation from naturally occurring radionuclides in the soil, cosmic radiation originating from outer space, and naturally occurring radionuclides deposited in the human body.

Biota

Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden

The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

Cancer

Any one of a group of diseases that occurs when cells in the body become abnormal and grow or multiply out of control.

Cancer risk

A theoretical risk of getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen

A substance that causes cancer.

Case-control study

A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

Central nervous system

The part of the nervous system that consists of the brain and the spinal cord.

CERCLA

[See Comprehensive Environmental Response, Compensation, and Liability Act of 1980.]

Chronic

Occurring over a long time (more than 1 year) [compare with acute].

Chronic exposure

Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate-duration exposure].

Committed Effective Dose Equivalent (CEDE)

The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to the organs or tissues. The *committed effective dose equivalent* is used in radiation safety because it implicitly includes the relative carcinogenic sensitivity of the various tissues. The unit of dose for the CEDE is the rem (or, in SI units, the sievert—1 sievert equals 100 rem.)

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway
[See exposure pathway.]

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
CERCLA, also known as Superfund, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by *CERCLA,* is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances.

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other medium.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Curie (Ci)
A unit of radioactivity. One *curie* equals that quantity of radioactive material in which there are 3.7×10^{10} nuclear transformations per second. The activity of 1 gram of radium is approximately 1 Ci; the activity of 1.46 million grams of natural uranium is approximately 1 Ci.

Decay product/daughter product/progeny
A new nuclide formed as a result of radioactive decay: from the radioactive transformation of a radionuclide, either directly or as the result of successive transformations in a radioactive series. A *decay product* can be either radioactive or stable.

Depleted uranium (DU)
Uranium having a percentage of U 235 smaller than the 0.7% found in natural uranium. It is obtained as a byproduct of U 235 enrichment.

Dermal
Referring to the skin. For example, *dermal* absorption means passing through the skin.

Dermal contact
Contact with (touching) the skin [see route of exposure].

Descriptive epidemiology
The study of the amount and distribution of a disease in a specified population by person, place, and time.

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Disease registry
A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

DOE
The United States Department of Energy.

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. *Dose* is a measurement of exposure. *Dose* is often expressed as milligrams (a measure of quantity) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the *dose*, the greater the likelihood of an effect. An “exposure dose” is how much of a substance is encountered in the environment. An “absorbed dose” is the amount of a substance that actually gets into the body through the eyes, skin, stomach, intestines, or lungs.

Dose (for radioactive chemicals)
The radiation *dose* is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.

Dose-response relationship
The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).

EMEG
Environmental Media Evaluation Guide, a media-specific comparison value that is used to select contaminants of concern. Levels below the EMEG are not expected to cause adverse noncarcinogenic health effects.

Enriched uranium
Uranium in which the abundance of the U 235 isotope is increased above normal.

Environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil, and biota (plants and animals). *Transport mechanisms* move contaminants from the source to points where human exposure can occur. The *environmental media and transport mechanism* is the second part of an exposure pathway.

EPA
The United States Environmental Protection Agency.

Epidemiologic surveillance
The ongoing, systematic collection, analysis, and interpretation of health data. This activity also involves timely dissemination of the data and use for public health programs.

Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Equilibrium, radioactive
In a radioactive series, the state that prevails when the ratios between the activities of two or more successive members of the series remain constant.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. *Exposure* can be short-term [see acute exposure], of intermediate duration [see intermediate-duration exposure], or long-term [see chronic exposure].

Exposure assessment
The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure-dose reconstruction
A method of estimating the amount of people's past exposure to hazardous substances. Computer and approximation methods are used when past information is limited, not available, or missing.

Exposure investigation
The collection and analysis of site-specific information and biological tests (when appropriate) to determine whether people have been exposed to hazardous substances.

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An *exposure pathway* has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the *exposure pathway* is termed a completed exposure pathway.

Exposure registry
A system of ongoing follow up of people who have had documented environmental exposures.

Feasibility study
A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

Grand rounds
Training sessions for physicians and other health care providers about health topics.

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].

Half-life ($t_{1/2}$)
The time it takes for half the original amount of a substance to disappear. In the environment, the *half-life* is the time it takes for half the original amount of a substance to disappear when it is changed to another chemical by bacteria, fungi, sunlight, or other chemical processes. In the human body, the *half-life* is the time it takes for half the original amount of the substance to disappear either by being changed to another substance or by leaving the body. In the case of radioactive material, the *half-life* is the amount of time necessary for one half the initial number of radioactive atoms to change or transform into other atoms (normally not radioactive). After two *half-lives,* 25% of the original number of radioactive atoms remain.

Hazard
A source of potential harm from past, current, or future exposures.

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. *Health consultations* are focused on a specific exposure issue. They are therefore more limited than public health assessments, which review the exposure potential of each pathway and chemical [compare with public health assessment].

Health education
Programs designed with a community to help it know about health risks and how to reduce these risks.

Health investigation
The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to estimate the possible association between the occurrence and exposure to hazardous substances.

Health statistics review
The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A *health statistics review* is a descriptive epidemiologic study.

Indeterminate public health hazard
The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence
The number of new cases of disease in a defined population over a specific time period [contrast with prevalence].

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

Intermediate-duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].

Ionizing radiation
Any radiation capable of knocking electrons out of atoms and producing ions. Examples: alpha, beta, gamma and x rays, and neutrons.

Isotopes
Nuclides having the same number of protons in their nuclei, and hence the same atomic number, but differing in the number of neutrons, and therefore in the mass number. Identical chemical properties exist in *isotopes* of a particular element. The term should not be used as a synonym for “nuclide,” because “isotopes” refers specifically to different nuclei of the same element.

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Metabolism
The conversion or breakdown of a substance from one form to another by a living organism.

mg/kg
Milligrams per kilogram.

mg/m^3
Milligrams per cubic meter: a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Migration
Moving from one location to another.

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. *MRLs* are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). *MRLs* should not be used as predictors of harmful (adverse) health effects [see reference dose].

Mortality
Death. Usually the cause (a specific disease, condition, or injury) is stated.

Mutagen
A substance that causes mutations (genetic damage).

Mutation
A change (damage) to the DNA, genes, or chromosomes of living organisms.

National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or NPL)
EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The *NPL* is updated on a regular basis.

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL
[See National Priorities List for Uncontrolled Hazardous Waste Sites.]

Parent
A radionuclide which, upon disintegration, yields a new nuclide, either directly or as a later member of a radioactive series.

Plume
A volume of a substance that moves from its source to places farther away from the source. *Plumes* can be described by the volume of air or water they occupy and the direction in which they move. For example, a *plume* can be a column of smoke from a chimney or a substance moving with groundwater.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see exposure pathway].

Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

ppb
Parts per billion.

ppm
Parts per million.

Prevalence
The number of existing disease cases in a defined population during a specific time period [contrast with incidence].

Prevention
Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public comment period
An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public health action plan
A list of steps to protect public health.

Public health advisory
A statement made by ATSDR to EPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

Public health assessment (PHA)
An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed by coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with health consultation].

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Public health hazard categories
Statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five *public health hazard categories* are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

Public health statement
The first chapter of an ATSDR toxicological profile. The *public health statement* is a summary written in words that are easy to understand. It explains how people might be exposed to a specific substance and describes the known health effects of that substance.

Public meeting
A public forum with community members for communication about a site.

Quality factor (radiation weighting factor)
The linear-energy-transfer-dependent factor by which absorbed doses are multiplied to obtain (for radiation protection purposes) a quantity that expresses - on a common scale for all ionizing radiation - the approximate biological effectiveness of the absorbed dose.

Rad
The unit of absorbed dose equal to 100 ergs per gram, or 0.01 joules per kilogram (0.01 gray) in any medium [see dose].

Radiation
The emission and propagation of energy through space or through a material medium in the form of waves (e.g., the emission and propagation of electromagnetic waves, or of sound and elastic waves). The term “radiation” (or “radiant energy”), when unqualified, usually refers to electromagnetic *radiation.* Such *radiation* commonly is classified according to frequency, as microwaves, infrared, visible (light), ultraviolet, and x and gamma rays and, by extension, corpuscular emission, such as alpha and beta *radiation*, neutrons, or rays of mixed or unknown type, such as cosmic *radiation.*

Radioactive material
Material containing radioactive atoms.

Radioactivity
Spontaneous nuclear transformations that result in the formation of new elements. These transformations are accomplished by emission of alpha or beta particles from the nucleus or by the capture of an orbital electron. Each of these reactions may or may not be accompanied by a gamma photon.

Radioisotope
An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

Radionuclide
Any radioactive isotope (form) of any element.

RBC
Risk-based Concentration, a contaminant concentration that is not expected to cause adverse health effects over long-term exposure.

RCRA
[See Resource Conservation and Recovery Act (1976, 1984).]

Receptor population
People who could come into contact with hazardous substances [see exposure pathway].

Reference dose (RfD)
An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Rem
A unit of dose equivalent that is used in the regulatory, administrative, and engineering design aspects of radiation safety practice. The dose equivalent in *rem* is numerically equal to the absorbed dose in rad multiplied by the quality factor (1 *rem* is equal to 0.01 sievert).

Remedial investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA)
This act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

RfD
[See reference dose.]

Risk
The probability that something will cause injury or harm.

Route of exposure
The way people come into contact with a hazardous substance. Three *routes of exposure* are breathing [inhalation], eating or drinking [ingestion], and contact with the skin [dermal contact].

Safety factor
[See uncertainty factor.]

Sample
A portion or piece of a whole; a selected subset of a population or subset of whatever is being studied. For example, in a study of people the *sample* is a number of people chosen from a larger population [see population]. An environmental *sample* (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sievert (Sv)
The SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose, in gray, multiplied by the quality factor (1 sievert equals 100 rem).

Solvent
A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A *source of contamination* is the first part of an exposure pathway.

Special populations
People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, gender, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered *special populations.*

Specific activity
Radioactivity per unit mass of material containing a radionuclide, expressed, for example, as Ci/gram or Bq/gram.

Stakeholder
A person, group, or community who has an interest in activities at a hazardous waste site.

Statistics
A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance
A chemical.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

Surveillance
[see epidemiologic surveillance]

Survey
A systematic collection of information or data. A *survey* can be conducted to collect information from a group of people or from the environment. *Surveys* of a group of people can be conducted by telephone, by mail, or in person. Some *surveys* are done by interviewing a group of people.

Toxicological profile
An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A *toxicological profile* also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology
The study of the harmful effects of substances on humans or animals.

Uncertainty factor
A mathematical adjustment for reasons of safety when knowledge is incomplete—for example, a factor used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). *Uncertainty factors* are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use *uncertainty factors* when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].

Units, radiological

Units	*Equivalents*
Becquerel* (Bq)	1 disintegration per second = 2.7×10^{-11} Ci
Curie (Ci)	3.7×10^{10} disintegrations per second = 3.7×10^{10} Bq
Gray* (Gy)	1 J/kg = 100 rad
Rad (rad)	100 erg/g = 0.01 Gy
Rem (rem)	0.01 sievert
Sievert* (Sv)	100 rem

*International Units, designated (SI)

Urgent public health hazard
A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Watershed
A watershed is a region of land that is crisscrossed by smaller waterways that drain into a larger body of water.

Other Glossaries and Dictionaries

Environmental Protection Agency http://www.epa.gov/OCEPAterms/
National Center for Environmental Health (CDC) http://www.cdc.gov/nceh
National Library of Medicine http://www.nlm.nih.gov/medlineplus/mplusdictionary.html

Appendix B. Detailed Remedial Activities Related to the Study Area

Bethel Valley Watershed

The major operations at X-10 take place within the Bethel Valley Watershed. The main plant, key research facilities, primary administrative offices, as well as various forms of waste sites, are situated in Bethel Valley. Over the past 60 years, X-10 releases have contaminated the Bethel Valley Watershed. Mobile contaminants primarily leave the Bethel Valley Watershed via White Oak Creek. These contaminants travel from the Bethel Valley Watershed to the Melton Valley Watershed, where further contaminants enter White Oak Creek. Then, the contaminants that have been discharged to White Oak Creek are released over White Oak Dam and into the Clinch River (U.S. DOE 2001b). The main remedial activities conducted in Bethel Valley are listed below. Please see Figure 10 in Section II.C.1. for a map of Bethel Valley that includes these areas.

- *Corehole 8 Plume*. The Corehole 8 Plume, which was identified at X-10 in 1991, is a plume of groundwater contaminated with Sr 90 (SAIC 2002; U.S. EPA 2002a). In 1994, a remedial action assessment revealed that contaminated groundwater was leaching into X-10's storm drain system and was being released into First Creek. First Creek is a stream that feeds into White Oak Creek and ultimately flows into the Clinch River. Additional evaluation indicated that the contaminated groundwater was seeping into the storm drain system via three catch basins on the western portion of X-10 (SAIC 2002). In November 1994, an action memorandum was approved; by March 1995, a groundwater collection and transmission system at the Corehole 8 Plume prevented groundwater infiltration (SAIC 2002; U.S. EPA 2002a). Through this system, groundwater is treated by X-10's Process Waste Treatment Plant (PWTP) and then released through a National Pollutant Discharge Elimination System (NPDES) outfall. In August 1995, DOE prepared a removal action report that required monthly monitoring of the storm drain outfall close to the joining of First Creek and the Northwest Tributary.

  See Figures 3 and 10 for the location of First Creek and the Northwest Tributary. In addition, based on suggestions from the 1997 remediation effectiveness report (RER), monthly composite samples are taken at this area, as well as at the Corehole 8 sump (SAIC 2002).

  Surface water monitoring in October 1997 revealed elevated levels of Sr 90 and uranium 233 (U 233) in First Creek. In December 1997, further investigation indicated that this contamination was entering the area through two unlined storm drain manholes. As a result, in March 1998, DOE established another interceptor trench that linked to one of the plume's collection sumps. An addendum to the original action memorandum was approved in September 1999. This addendum, which was intended to increase the effectiveness of the initial remedial action, endorsed more groundwater extraction and treatment activities at the

Corehole 8 Plume (SAIC 2002). Composite samples are collected monthly at the First Creek Weir, located near First Creek's confluence with the Northwest Tributary, and at the Corehole 8 sump (SAIC 2004).

- *Gunite and Associated Tanks (GAAT)*. The GAAT are eight underground gunite tanks that were installed at the X-10 site in 1943 and were the primary holding tanks for liquid low-level waste (LLLW) at X-10 (SAIC 2002; U.S. DOE 2001c). These inactive tanks are located in two tank farms—the North Tank Farm and the South Tank Farm—that are located in the middle of X-10's central facility area. The North Tank Farm consists of Tanks W-3 and W-4, and the South Tank Farm consists of Tanks W-5 through W-10 (U.S. DOE 2001c). The majority of mixed waste was removed from the GAAT in the 1980s. However, following these removal actions, waste still remained in the tanks (SAIC 2002; U.S. DOE 2001c).

  In September 1997, an Interim Record of Decision (IROD) was signed (SAIC 2002; U.S. DOE 2001c). DOE identified the GAAT cleanup as a priority because of the amount of radiation associated with the tanks, the decaying composition of the tanks, and the considerable risk to X-10 workers and to the environment if a tank leaked or collapsed (U.S. DOE 2001c). The interim action transferred a total of 87,000 gallons of sludge and 250,000 gallons of liquid waste (78,000 curies) from the GAAT to the Melton Valley Storage Tanks (MVST). The transferred waste was to be treated in the MVST and then shipped to a DOE's Waste Isolation Pilot Plant in New Mexico for disposal. This interim action, which reduced the contamination in the tanks by 95%, was completed in September 2000. The empty tanks were left in place and grouted in 2001; the removal action report was released in June 2001 (SAIC 2002; U.S. DOE 2001c).

- *Inactive LLLW tanks*. The inactive LLLW tanks are situated in Bethel Valley, within the central plant area of X-10. In April 1999, an Engineering Evaluation/Cost Analysis (EE/CA) suggested removal of these steel tanks, but that a time-critical action was not necessary. In an action memorandum in May 1999, this EE/CA recommendation was approved. The action memorandum focused on 11 tanks holding sludge and residue that presented a risk to public health. The removal operations included the following:

  - extracting the liquid and solid waste from the tanks;
  - moving waste that was not within the waste acceptance criteria (WAC) to suitable treatment facilities;
  - moving liquid waste that was within the WAC to the X-10 LLLW system and moving solid waste to the X-10 solid waste storage facility;
  - separating vents, piping, and support connections;
  - filling tanks with grout for stabilization;
  - extracting tanks if appropriate storage and removal facilities were available; and
  - using soil to cover unmoved tanks and to fill excavated areas (SAIC 2002).

  In September 1999, an addendum was made to this action memorandum. It added 13 tanks to the original removal action (for a total of 24 tanks). The removal action was finished in September 2001. Once the tanks were emptied, they were filled with grout and stabilized (SAIC 2002).

- *Surface Impoundments Operable Unit*. This OU consists of four impoundments—Impoundments A, B, C, and D—used to hold liquid low-level wastes that were by-products of material processing and various experiments at X-10. Impoundments A and B were unlined; Impoundments C and D were lined with clay. Consequently, Impoundments A and B contained a total of 4,560 cubic yards of radioactive-contaminated sediments, whereas Impoundments C and D contained a total of only 40 cubic yards of low-level, radioactive-contaminated sediments. A two-phase remedial alternative took place at this OU. The initial remedial action phase was conducted from August to September 1998. During this time, more sediment samples were collected at Impoundments C and D, and sediment, soil, and water were removed from the impoundments (C and D) and placed into Impoundment B. Following the removal, fresh soil was placed into the excavated areas. In April 1999, the remedial action report was approved for the initial remedial phase. During the next phase, sediment from Impoundment A was moved to Impoundment B, and the excavated area was filled with new soil (SAIC 2002). The sediment in Impoundment B, which contained sediment from all four impoundments, was excavated, treated, and disposed off site (SAIC 2002, 2004). By summer 2003, all of the sediments had been removed and shipped off site for disposal. No monitoring or institutional controls are required (SAIC 2004).

- *Record of Decision (ROD)*. In May 2002, a ROD was signed to address several interim remedial actions in Bethel Valley. For environmental restoration purposes, Bethel Valley was divided into the following four areas: Central Bethel Valley, East Bethel Valley, West Bethel Valley, and Raccoon Creek. Various remedial activities, such as removal, containment, monitoring, treatment, stabilization, and land use controls, will be implemented under this ROD to address contaminated media, inactive units, and accessible contamination sources. The following will be addressed: underground LLLW tanks, contaminated buildings, decontamination and decommissioning (D&D) buildings, accessible underground and LLLW transfer pipelines, buried waste, contaminated surface and subsurface soil that is accessible, and contaminated groundwater, sediment, and surface water. As of fiscal year 2003, the Bethel Valley Groundwater Engineering Study was the only remedial action started under the Bethel Valley ROD (SAIC 2004).

Melton Valley Watershed

X-10 disposed of its radioactive wastes (liquid and solid) in Melton Valley, and also operated its experimental facilities within this watershed (U.S. DOE 2002a, 2002b). Discharges from Melton Valley's waste areas have produced secondary contamination sources that include sediment, groundwater, and soil contamination. Furthermore, contaminants that are discharged from Melton Valley travel off the reservation through surface water and flow into the Clinch River (SAIC 2002). As a result, the waste sites in the Melton Valley Watershed "…are the primary contributors to off-site spread of contaminants" from the ORR (U.S. DOE 2002b).

The main remedial activities conducted in Melton Valley are detailed below (SAIC 2002; U.S. DOE 2001d; U.S. EPA 2002a). Please see Figure 12 in Section II.C.2. for a map of Melton

Valley that includes these areas. Also, please refer to Figure B-1 for the details concerning the completed, current, and future remediation activities in Melton Valley and see Figure B-2 for the Melton Valley projected closure schedule for the current and future activities. The current schedule was accelerated by nine years to have all closure activities completed by fiscal year 2006 (U.S. DOE 2003b).

- *Cesium Plots Research Facility*. This facility is located next to and within 50 yards of the Clinch River (SAIC 2002; U.S. EPA 2002a). Eight "experimental" plots were created at X-10's Waste Area Grouping (WAG) 13 to study the fallout from nuclear weapons. Four of these plots were filled with Cs 137. In July 1992, an interim remedial investigation was conducted. This study found that the gamma radiation levels released from the plots were elevated, and that the plots presented a possible threat to public health and to the environment. In October 1992, the IROD was approved (SAIC 2002). Remedial actions were conducted and finished in July 1994 (SAIC 2002; U.S. EPA 2002a). The main aspects of the interim action were

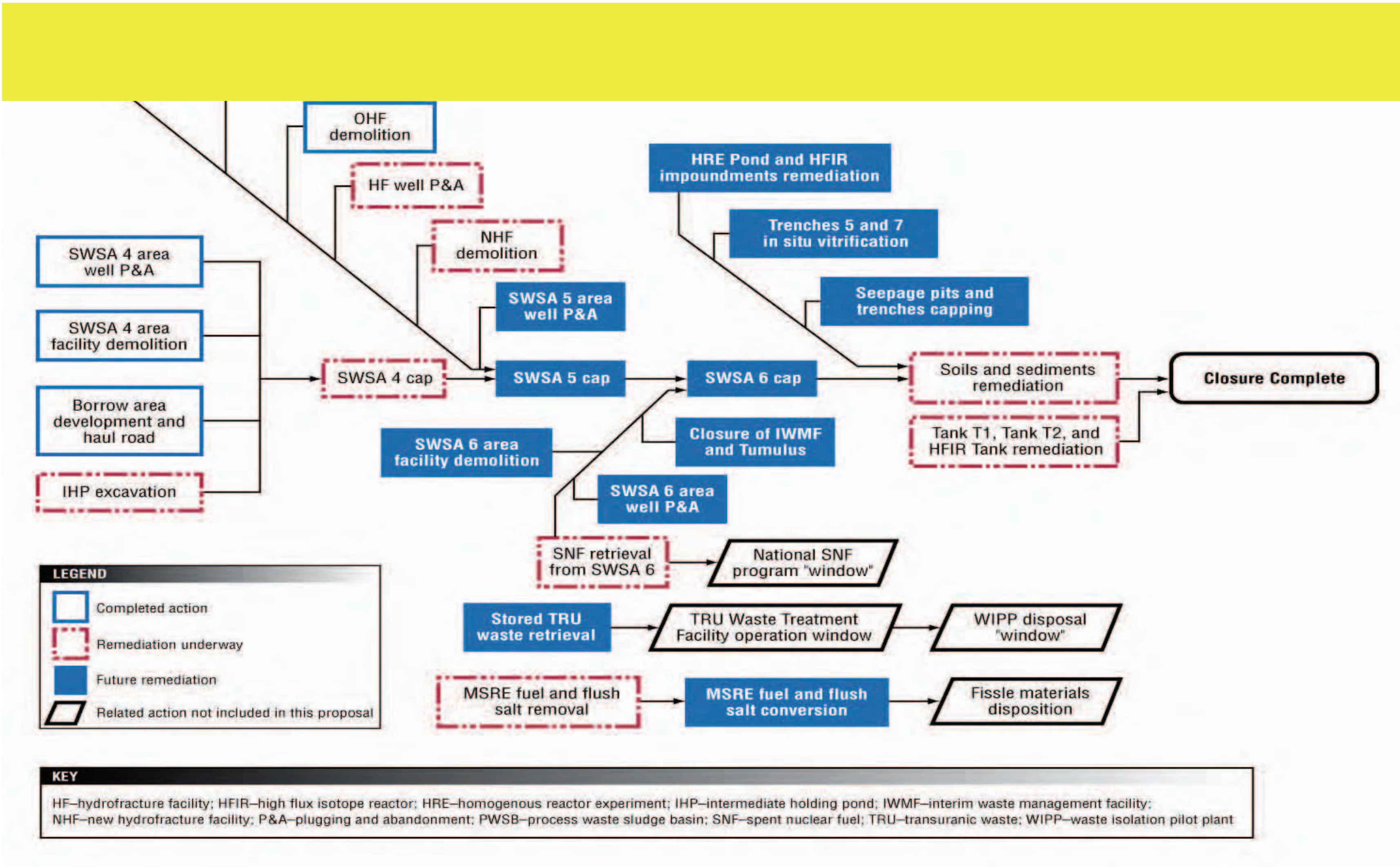
    - excavating soil until contamination was reduced to permissible levels;
    - placing extracted soil into boxes made to store low-level radioactive waste;
    - moving the soil to the low-level waste silos at WAG 6; and
    - placing a porous liner, clean fill material, and a clean top layer of soil into each excavated plot.

  Since the interim action, a fence with many locked gates has enclosed WAG 13. Several signs are posted to notify people that there is on-site soil contamination and restricted access to the site. In addition, the site is inspected on a quarterly basis (SAIC 2002).

- *White Oak Creek Embayment (WOCE)*. From the X-10 site, White Oak Creek flows into White Oak Lake, over White Oak Dam, and into the WOCE before joining the Clinch River at Clinch River Mile (CRM) 20.8 (ChemRisk 1993b, 1999a; TDOH 2000; U.S. DOE 2002a). Thus, the WOCE represents a hydrologic connection between the White Oak Dam and the Clinch River (U.S. DOE 1996c). In 1991, a time-critical removal action was conducted at the WOCE. This action was performed because site-related data suggested that the embayment represented an "uncontrolled" source of sediment-binding substances, including Cs 137 and other contaminants as well (SAIC 2002).

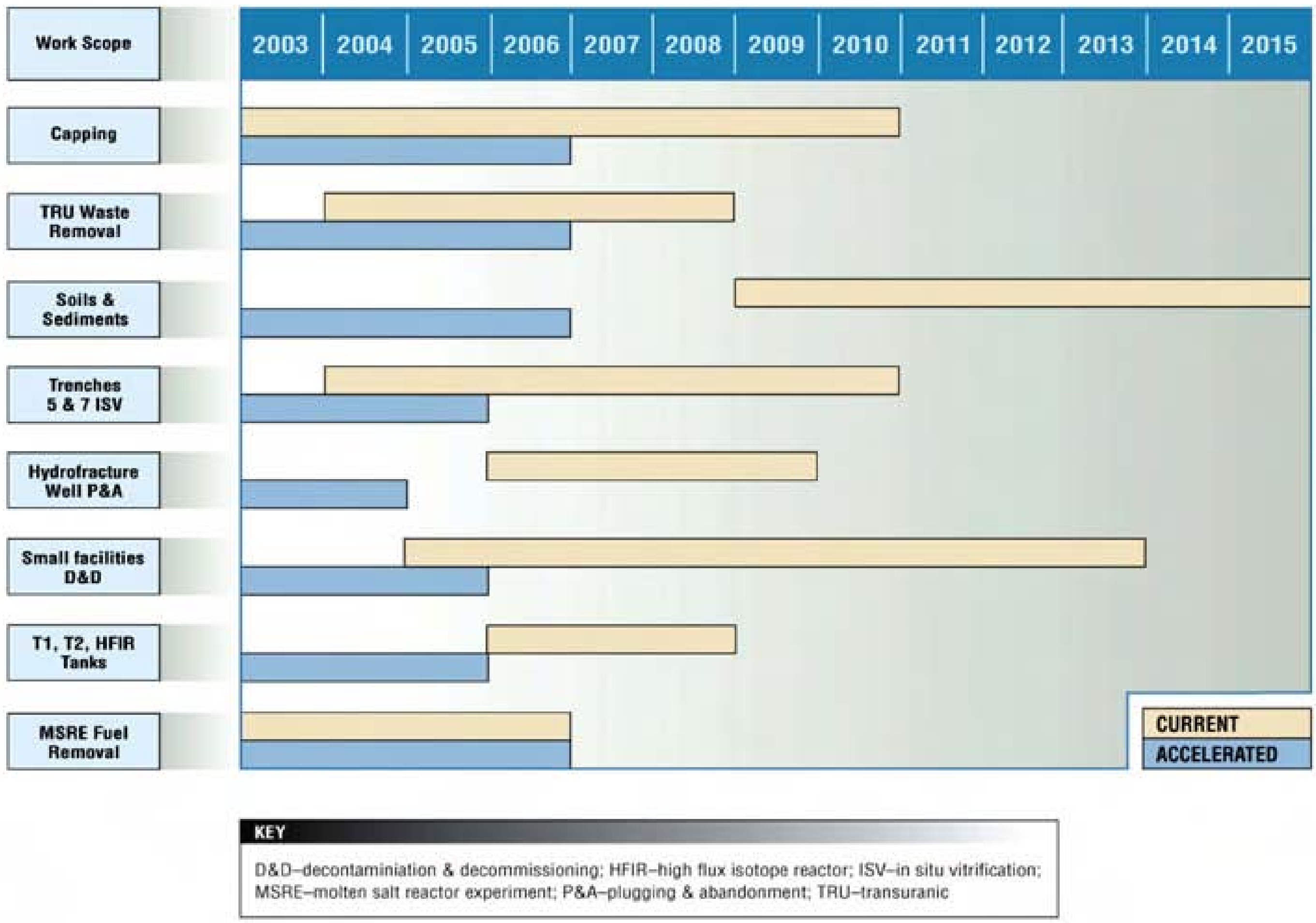
  In the early 1990s, a removal action was conducted at the site. This action consisted of building a sediment retention structure (SRS) at the mouth of White Oak Creek that would retain the sediments in the lower embayment and reduce the off-site movement of sediments to the Watts Bar Reservoir and to the Clinch River (SAIC 2002; U.S. EPA 2002a). In 2001, the RER suggested the discontinuation of regular water level monitoring in the WOCE and in the Clinch River. This suggestion was based on about 10 years of information, which showed that the SRS could sustain sediment water coverage and also prevent scouring of the WOCE (SAIC 2002).

Figure B-1. Completed, Current, and Future Remedial Activities in Melton Valley



Source: Adapted from U.S. DOE 2003b

Figure B-2. Melton Valley Closure Schedule



Source: U.S. DOE 2003b

- *WAG 4*. The WAG 4 seeps area is located at the X-10 site (U.S. DOE 2001e). Data collected at the ORR suggest that releases from WAG 4 have contributed to approximately 25% of the overall strontium 90 that is discharged over White Oak Dam (SAIC 2002). As a result, an action memorandum was prepared in February 1996, and DOE conducted an investigation to identify the X-10 sources that discharged Sr 90 (SAIC 2002; U.S. DOE 2001e). The main contamination source of WAG 4 was found to be SWSA 4, which consists of 23 acres that were used between 1951 and 1974 for industrial and radioactive waste burial (SAIC 2002).

  DOE's investigation revealed that two seeps produced about 70% of the overall Sr 90 that was discharged from WAG 4 (SAIC 2002; U.S. DOE 2001e). Because contaminants from these waste trenches migrated into White Oak Creek, grouting techniques were used to reduce the releases of Sr 90 from these trenches; these activities were completed in October 1996. The removal action report, which was completed in January 1997, identifies five monitoring locations at WAG 4 (SAIC 2002; U.S. EPA 2002a). For five years, monthly sampling has been conducted at these monitoring stations, and as of 2001, the Sr 90 releases had been reduced by about 33% (SAIC 2002).

- *WAG 5—Seeps C and D*. In 1994, DOE conducted an assessment and remedial activities at WAG 5 Seeps C and D. The assessment found that Sr 90 was discharged from the X-10 site, and that Seeps C and D were major sources of off-site releases. Seeps C and D are located in the southern portion of WAG 5, which consists of a burial site used for radioactive waste disposal between 1951 and 1959 (SAIC 2002; U.S. DOE 2001f). Since Sr 90 constitutes a significant threat to off-site populations, one of DOE's main goals was to minimize these discharges from WAG 5 into the White Oak Creek system (SAIC 2002; U.S. DOE 2001f; U.S. EPA 2002a). The objective of these remedial activities was to reduce the quantity of Sr 90 in collected groundwater by at least 90% (SAIC 20002; U.S. DOE 2001f).

  - Seep *C*. DOE's investigation in 1994 showed that Seep C was a major source of strontium 90 releases to White Oak Creek (SAIC 2002). Of the strontium detected at White Oak Dam between 1993 and 1994, 20% to 30% was released from Seep C. In March 1994, an action memorandum was accepted, and by November 1994, a "French" drain had been installed at Seep C. The French drain collects the groundwater and directs it to a unit for treatment; this treatment unit consists of drums filled with minerals that filter the Sr 90. Once the groundwater is treated, it is released into Melton Branch. Thus, the primary goal of these remediation activities is to lower the amount of Sr 90 that is released to Melton Branch, and therefore, to off-site locations (SAIC 2002; U.S. DOE 2001f).

    According to samples taken in 2000 and 2001, the treatment unit has prevented over 99% of the Sr 90 at Seep C from entering Melton Branch (SAIC 2002). The amount of Sr 90 is greater downstream from Seep C than upstream, which suggests that a portion of the Sr 90 from WAG 5 bypasses the treatment unit (SAIC 2002; U.S. DOE 2001f). In 2002, bimonthly sampling and weekly inspections of the treatment unit at Seep C continued to occur (SAIC 2002). Monitoring of the unit was, however, discontinued in September 2003, and the unit was shut down in fiscal year 2004 (SAIC 2004).

- *Seep D*. DOE's investigation in 1994 revealed that Seep D was also a major source of Sr 90 to the White Oak Creek watershed (SAIC 2002). Of the Sr 90 detected at White Oak Dam between 1993 and 1994, 7% was released from Seep D. In July 1994 an action memorandum was passed, and by November 1994 a groundwater treatment unit was installed and functioning at Seep D. The treatment unit collects groundwater from the bed of Melton Branch and pumps it through a group of mineral-filled columns that filter out Sr 90. Once the groundwater has been treated, it is restored to Melton Branch. Thus, the primary goal of these remediation activities is to decrease the quantity of Sr 90 that is discharged to Melton Branch, and therefore to off-site areas via White Oak Dam (SAIC 2002; U.S. DOE 2001f).

  Data collected in 2000 and 2001 showed that this treatment unit has prevented over 99% of the Sr 90 at Seep D from entering Melton Branch (SAIC 2002). However, the amount of Sr 90 is greater downstream at Seep D than upstream. This suggests that small quantities of Sr 90 going into Melton Branch did not originate from the Seep D pumping location (SAIC 2002; U.S. DOE 2001f). Daily inspections are conducted at Seep D and monthly sampling is performed on the treatment unit, as well as upstream and downstream of Melton Branch (SAIC 2002). In addition, as of fiscal year 2004, stream samples were being collected to identify the entry point of strontium 90 into the stream (SAIC 2004).

- *Old Hydrofracture Facility (OHF) Tanks*. The OHF is located at the Oak Ridge National Laboratory within Melton Valley (SAIC 2002; U.S. DOE 2002c). In 1963, this facility was built for low-level radioactive waste disposal (U.S. DOE 2002c). Between 1963 and 1980, the radioactive waste was combined with grout and injected 1,000 feet below ground by hydraulically fracturing a shale layer and pumping the grouted waste into a thin layer that extended over many acres. The grout would then harden and become a part of the shale formation (SAIC 2002; U.S. DOE 2002c). Five LLLW underground storage tanks were left at the OHF that contained an approximate total of 52,600 gallons (30,000 curies) of radioactive waste and other byproduct waste (e.g., sludge) (SAIC 2002; U.S. DOE 2002c; U.S. EPA 2002a). Because there were concerns about the proximity of the tanks to White Oak Creek, the potential threat to environmental receptors, and the possibility of tank leakage, an action memorandum was prepared in September 1996 to move and treat the tank waste. From June to July 1998, more than 98% of the waste was moved through a pipeline to the MVST, where additional treatment will occur (SAIC 2002; U.S. DOE 2002c).

  Another action memorandum for the OHF was prepared in May 1999. This memorandum focused on tank stabilization and on the surface impoundment sediments associated with the OHF. The tank stabilization activities identified in the memorandum included removing the piping system, placing submersible pumps into the tanks, using mixer spool pieces, and grouting the tanks. For the surface impoundment, the remedial activities consisted of applying grout for sediment stabilization, placing grout into standpipes, removing excess water, treating any excess water at the PWTP, and using filler material to replenish the impoundment (SAIC 2002). These remedial activities were completed, and in May 2001 a removal action report was released (SAIC 2002; U.S. EPA 2002a).

- *Record of Decision*. In September 2000, a ROD was signed to address several remedial actions in Melton Valley. These actions focused on the prevention of contaminant releases into surface waters and groundwater in Melton Valley. They included the actions listed below (SAIC 2002). All of these remedial activities were ongoing in fiscal year 2003 (SAIC 2004). Please see Figure 8 for the locations of these areas at X-10 and Figure B-2 for the completion schedule for these activities in Melton Valley.
    - Placing multi-layered caps over SWSA 4, SWSA 5 North (the upper four trenches), SWSA 5 South, SWSA 6, and sections of the seepage pits and trenches area.
    - Using trenches to divert upgradient surface water and stormflow at SWSA 4 and SWSA 6 (when needed).
    - Using trenches to intercept downgradient contaminated groundwater at SWSA 4, SWSA 5 South, and the seepage pits and trenches (when needed).
    - Discarding contaminated soils from 23 trenches in SWSA 5 North.
    - Removing contaminated soils and backfill from the homogeneous reactor experiment (HRE) pond.
    - Removing contaminated sediment from the high flux isotope reactor (HFIR) ponds.
    - Grouting the HRE fuel wells.
    - Stabilizing, isolating, and removing inactive waste pipelines (as needed).
    - Using in situ vitrification[15] (ISV) for seepage trenches 5 and 7.
    - Removing the Intermediate Holding Pond and additional floodplain soil that was contaminated if levels were above 2,500 microroentgen per hour (μR/hr).
    - Isolating and removing contaminated soils at leak and spill locations, as well as additional locations, if the soils exceeded remedial limits.
    - Plugging and abandonment (P&A) of unnecessary wells.
    - Decontaminating and decommissioning buildings.
    - Conducting groundwater, ecological, and surface water monitoring.
    - Using land use controls.

[15] In situ vitrification (ISV) is a process that applies electrical power to contaminated soil in order to produce the heat needed to melt and blend the soil and waste into an immobile form (U.S. DOE 1995b).

Appendix C. Summary of Other Public Health Activities

Summary of ATSDR Activities

Review of clinical information on persons living in or near Oak Ridge. Following a request by William Reid, M.D., ATSDR evaluated the medical histories and clinical data associated with 45 of Dr. Reid's patients. The objective of this review was to assess the clinical data for patients who were tested for heavy metals, and to establish if exposure to metals was related to these patients' various illnesses. ATSDR determined that the case data did not provide sufficient evidence to support an association between these diseases and low levels of metals. The TDOH, which also evaluated the information, reached the same conclusion as did ATSDR. In September 1992, ATSDR provided a copy of its review to Dr. Reid (ATSDR et al. 2000).

Clinical laboratory analysis. In June 1992, William Reid, M.D., an Oak Ridge physician, notified the ORHASP and the TDOH that he believed that about 60 of his patients had been exposed to numerous heavy metals through their occupations or through the environment. Dr. Reid believed that these exposures had caused a number of adverse health outcomes, which included immunosuppression, increased cancer incidence, neurologic diseases, bone marrow damage, chronic fatigue syndrome, autoimmune disease, and abnormal blot clots. Howard Frumkin, M.D., Dr.PH., from the Emory University School of Public Health, requested facilitated clinical laboratory support to evaluate the patients referred by Dr. Reid. As a result of Dr. Frumkin's request, ATSDR and the CDC's NCEH facilitated this laboratory support from 1992 to 1993 through the NCEH Environmental Health Laboratory (ATSDR et al. 2000; ORHASP 1999).

Because of the confidentiality among physicians, as well as the confidentiality between physicians and their patients, the findings of these clinical analyses have not been provided to public health agencies (ATSDR et al. 2000). Nevertheless, in an April 26, 1995, letter to the Commissioner of the Tennessee Department of Health, Dr. Frumkin suggested that one should "not evaluate the patients seen at Emory as if they were a cohort for whom group statistics would be meaningful. This was a self-selected group of patients, most with difficult to answer medical questions (hence their trips to Emory), and cannot in any way be taken to typify the population of Oak Ridge. For that reason, I have consistently urged Dr. Reid, each of the patients, and officials of the CDC and the Tennessee Health Department, not to attempt group analyses of these patients."

Health education. Another essential part of the public health assessment process is designing and implementing activities that promote health and providing information about hazardous substances in the environment.

- *Health professional education on cyanide*. In January 1996, an employee from ETTP (formerly the K-25 facility) requested ATSDR's assistance with occupational cyanide exposure. As a result, in August 1996, ATSDR held a physician health education program in Oak Ridge to teach physicians about health impacts that could result from potential cyanide intoxication. The purpose of the education program was to help community health care providers respond to concerns from ETTP employees. ATSDR gave the following materials to the concerned employee and to the area physicians: the ATSDR public health statement for cyanide, the NIOSH final health hazard evaluation, and the ATSDR Case Studies in Environmental Medicine publication entitled *Cyanide Toxicity*. ATSDR led the environmental health education workshop for physicians at the Methodist Medical Center in Oak Ridge, Tennessee. The session focused on supplying area physicians and other health care providers with information to assist with the diagnosis of acute and chronic cyanide intoxication, and also to assist with answering patient's questions. In addition, ATSDR established a system that area physicians could use to make patient referrals directly to the Association of Occupational and Environmental Clinics (AOEC) (ATSDR et al. 2000).

- *Workshops on epidemiology*. Following requests from ORRHES members, ATSDR conducted two epidemiology workshops for the subcommittee. The first session took place at the ORRHES meeting on June 2001. During this meeting, Ms. Sherri Berger and Dr. Lucy Peipins of ATSDR's Division of Health Studies presented an overview of the science of epidemiology. Dr. Peipins also presented at the second epidemiology workshop, which was held at the ORRHES meeting on December 2001. The purpose of this second session was to help the ORRHES members build the skills that are required for analyzing scientific reports (ATSDR et al. 2000). In addition, at the EEWG (formerly known as PHAWG) meeting on August 28, 2001, Dr. Peipins demonstrated the systematic and scientific approach of epidemiology by guiding the group as they critiqued a report by Joseph Mangano entitled *Cancer Mortality Near Oak Ridge, Tennessee* (International Journal of Health Services, Volume 24: 3, 1994, page 521, as cited in ATSDR et al. 2000). Based on the EEWG critique, the ORRHES made the following conclusions and recommendations to ATSDR.

    1. The Mangano paper is not an adequate, science-based explanation of any alleged anomalies in cancer mortality rates of the off-site public.

    2. The Mangano paper fails to establish that radiation exposure from the ORR is the cause of any such alleged anomalies of cancer mortality rates in the general public.

    3. The ORRHES recommends to ATSDR that the Mangano paper be excluded from consideration in the ORR public health assessment process (ATSDR et al. 2000).

Coordination with other parties. Since 1992 and continuing to the present, ATSDR has consulted regularly with representatives of other parties involved with the ORR. Specifically, ATSDR has coordinated its efforts with TDOH, TDEC, NCEH, NIOSH, and DOE. These efforts led to the establishment of the Public Health Working Group in 1999, which then led to the establishment of the ORRHES. In addition, ATSDR provided some assistance to TDOH in its study of past public health issues. ATSDR has also obtained and interpreted studies prepared by academic institutions, consulting firms, community groups, and other parties.

Establishment of the ORR Public Health Working Group and the ORRHES. In 1998, under a collaborative effort with the DOE Office of Health Studies, ATSDR and CDC embarked on a process to develop credible, coherent, and coordinated agendas for public health activities and for health studies at each DOE site. In February 1999, ATSDR was given the responsibility to lead the interagency group's efforts to improve communication at the ORR. In cooperation with other agencies, ATSDR established the ORR Public Health Working Group to gather input from local organizations and individuals regarding the creation of a public health forum. After careful consideration of the input gathered from community members, ATSDR and CDC determined that the most appropriate way to meet the needs of the community would be to establish the ORRHES.

Exposure investigations, health consultations, and other scientific evaluations. In addition to the Watts Bar Reservoir, ATSDR health scientists have addressed current public health issues and community health concerns related to other areas affected by ORR operations.

Following are summaries of other ATSDR public health activities involving EFPC:

- *Health consultation on Y-12 Weapons Plant chemical releases into East Fork Poplar Creek, April 1993*. As a result of community concerns, ATSDR conducted this health consultation to examine the potential health effects that could result from exposure to contaminants discharged into EFPC from the Y-12 plant (past and present). The Phase IA data assessed for this consultation suggest that the sediment, surface water, soil, fish, groundwater, and air in EFPC are contaminated with various chemicals. However, the only levels of public health concern are PCBs and mercury detected in fish, and mercury detected in soil and sediment. Based on these data, ATSDR made the following conclusions.

    1. Sediments and soil in specific areas along the EFPC floodplain are contaminated with mercury levels that present a public health concern.

2. Fish in EFPC have mercury and PCB levels that present a moderately increased risk of adverse health effects for people who consume fish regularly over extended time periods.

3. Shallow groundwater along the EFPC floodplain has metals that are at levels of public health concern; however, the shallow groundwater along EFPC is not utilized for drinking water or for other domestic purposes.

4. Other contaminants, including radionuclides found in soil, sediment, surface water, and fish, were not detected at levels of public health concerns (ATSDR et al. 2000).

- *ATSDR science panel meeting on the bioavailability of mercury in soil, August 1995*. Based on an evaluation of the DOE studies conducted on mercury, ATSDR concluded that outside expertise was needed to assess technical details related to mercury. As a result, a science panel was created that consisted of experts from various government agencies (e.g., EPA), private consultants, and other individuals with experience in metal bioavailability research. The panel's goal was to select procedures and strategies that could be used by health assessors to create site-specific and data-supported estimates with regards to the bioavailability of inorganic mercury and other metals (e.g., lead) from soils. ATSDR applied the data from the panel to its assessment of the mercury clean up level in the EFPC soil. In 1997, the International Journal of Risk Analysis (Volume 17:5) published three technical papers and an ATSDR overview paper that detailed this meeting's results (ATSDR et al. 2000).

- *Health consultation on proposed mercury cleanup levels, January 1996*. Following a request from community members and the city of Oak Ridge, ATSDR prepared a health consultation to assess DOE's cleanup levels for mercury in the EFPC floodplain soil. The final health consultation, which was released in January 1996, concluded that DOE's clean up levels of 180 milligrams per kilogram (mg/kg) and 400 mg/kg would protect public health and would not present a health risk to adults or to children (ATSDR et al. 2000).

Summary of U.S. Department of Health and Human Services Activities

U.S. Department of Health and Human Services' evaluation of data in The Tennessean *article, September 29, 1998.* In a November 2,1998 letter, the Honorable William H. Frist, M.D., United States Senator, requested that Donna E. Shalala, Secretary of the Department of Health and Human Services (DHHS), have the CDC, ATSDR, and the National Institutes of Health (NIH) evaluate the data that the *Tennessean* article describes as reporting a pattern of illnesses among residents living near nuclear plants, including the DOE ORR.

In particular, Senator Frist requested the following:

- Assess the quality and usefulness of the data on which the report is based.
- Examine the data for any patterns of illness and assess whether there is sufficient data to establish a relationship to the nuclear plants.

- Summarize the current DHHS studies that are currently underway at the 11 sites.
- Estimate how the key questions raised by the newspaper article could be addressed in a potential study.
- Describe any existing programs at the three agencies that may help address the medical needs of people living near nuclear plants.

In a letter dated February 22, 1999, Donna E. Shalala, Secretary of DHHS, responded to Senator Frist's request. The DHHS evaluated *The Tennessean* article and responded to Senator Frist's five specific issues. DHHS concluded the following:

1. The data in the *Tennessean* article were not compiled from an epidemiologic study and thus have many limitations. It is impossible to calculate rates for the reported illnesses or to determine whether rates of the illnesses were abnormal. It is also difficult to relate excess illnesses to specific nuclear plants because primary exposures differ among the plants.
2. Epidemiologically, it is neither acceptable to tabulate data collected in an unstandardized manner, nor to assess illnesses and symptoms based on limited diagnostic information. Thus, it is not possible to determine if data in this report represent a new or unusual occurrence of symptoms in this population.
3. DHHS has a significant number of ongoing studies that seek to analyze environmental exposure at each of the 11 sites rather than focusing on general medical evaluations of the populations near the sites. However, clinical data from the Fernald Medical Monitoring Program and the Scarboro, Tennessee, survey focus on respiratory illnesses in children and, although quite limited, are most relevant to the issues raised by the report.
4. Sound data using standardized information is essential in order to establish increased prevalence of a disease and linkage to the nuclear plants.
    - First, the occurrence of a single, definable illness would have to be assessed.
    - Second, studies including structured population surveys would need to be developed for general health and illness data in well-defined population groups near the nuclear sites. The finding would then be compared to results from other well-defined populations living elsewhere.
    - Third, any attempt to determine a causal relationship between disease or illness rates in these populations and exposures to hazards would be difficult since historic exposures are difficult to identify and measure.
5. CDC, ATSDR, and NIH are working with DOE to plan appropriate public health follow-up activities to address the concerns of communities and workers regarding the nuclear weapons complexes. Embarking on such a comprehensive program will require considerable resource, planning, and evaluation. Please note that CDC, ATSDR, and NIH do not provide direct primary medical services to communities. However, where possible, CDC, ATSDR, and NIH will continue to support community leaders and existing medical

care systems to address public health concerns of communities that are near nuclear plants.

Summary of TDOH Activities

Pilot survey. In the fall of 1983, TDOH established an interim soil mercury level to use for making environmental management decisions. CDC evaluated the methodology for this mercury level, and advised the TDOH to conduct a pilot survey to determine if populations with the greatest risk for mercury exposure had elevated mercury body burdens. Between June and July 1984, TDOH and CDC conducted a pilot survey to record the inorganic mercury levels of Oak Ridge residents who had the greatest risk of being exposed to mercury-contaminated fish and soil. In addition, the survey assessed if exposure to mercury through contaminated fish and soil represented an immediate health hazard for the Oak Ridge community. In October 1985, the findings of the pilot study were released; these results indicated that people who lived and worked in Oak Ridge, Tennessee, were unlikely to have a greater risk for significantly high mercury levels. Further, concentrations of mercury detected in hair and urine samples were lower than levels associated with known health effects (ATSDR et al. 2000).

Health statistics review. In June 1992, William Reid, M.D., an Oak Ridge physician, informed the ORHASP and the TDOH that he believed that about 60 of his patients had been exposed to numerous heavy metals through their occupation or through the environment. Dr. Reid felt that these exposures had caused a number of adverse health outcomes that included immunosuppression, increased cancer incidence, neurologic diseases, bone marrow damage, chronic fatigue syndrome, autoimmune disease, and abnormal blot clots. In 1992, TDOH conducted a health statistics review that evaluated the cancer incidence rates for the counties around the reservation between 1988 and 1990, and compared these rates to the state rates for Tennessee. The health statistics review determined that some of the counties' rates were low and some were high when compared to the state's rates; however, the review was unable to distinguish any patterns associated with the site. More detailed findings of the review can be found in a TDOH memorandum dated October 19, 1992, from Mary Layne Van Cleave to Dr. Mary Yarbrough. In addition, the handouts and minutes from Ms. Van Cleave's presentation at the ORHASP meeting on December 14, 1994, are available through TDOH (ATSDR et al. 2000).

Health statistics review. In 1994, area residents reported that there were several community members who had amyotrophic lateral sclerosis (ALS) and multiple sclerosis (MS). TDOH consulted with Peru Thapa, M.D., M.P.H., from the Vanderbilt University School of Medicine, to perform a health statistics review of mortality rates for ALS and MS within certain counties in Tennessee. TDOH also received technical support for the health statistics review from ATSDR (ATSDR et al. 2000).

Because ALS and MS are not reportable, TDOH determined that it was impossible to calculate reliable incidence rates for these diseases. Mortality rates for counties surrounding the ORR were analyzed for the time period between 1980 and 1992, and then compared with mortality rates for the state of Tennessee. The review found that the mortality rates did not differ significantly from the rates in the rest of Tennessee (ATSDR et al. 2000). The following results were reported by TDOH at the ORHASP public meeting on August 18, 1994.

- There were no significant differences in ALS mortality in any of the counties in comparison with the rest of the state.
- For Anderson County, the rate of age-adjusted deaths from chronic obstructive pulmonary disease (COPD) was significantly higher than rates in the rest of the state, but the rates for total deaths, deaths from stroke, deaths from congenital anomalies, and deaths from heart disease were significantly lower for the period from 1979 to 1988. There were no significant differences in the rates of deaths due to cancer, for all sites, in comparison to rates for the rest of the state. Rates of deaths from uterine and ovarian cancer were significantly higher than the rates in the rest of the state. The rate of death from liver cancer was significantly lower in comparison with the rest of the state.
- For Roane County, the rates of total deaths and deaths from heart disease were significantly lower than the rates in the rest of the state for the period from 1979 to 1988. Although the total cancer death rate was significantly lower than the rate in the rest of the state, the rate of deaths from lung cancer was significantly higher than the rate in the rest of the state. Rates of deaths from colon cancer, female breast cancer, and prostate cancer were also significantly lower than the rates in the rest of the state.
- For Knox County, the rates for total deaths and deaths from heart disease were significantly lower than the rates in the rest of the state. There was no significant difference in the total cancer death rate in comparison to the rest of the state.
- There were no significant exceedances for any cause of mortality studied in Knox, Loudon, Rhea, and Union counties in comparison to the rest of the state.

- Rates of total deaths were significantly higher in Campbell, Claiborne, and Morgan counties in comparison to the rest of the state.

- Cancer mortality was significantly higher in Campbell County in comparison to the rest of the state. The excess in number of deaths from cancer appeared to be attributed to the earlier part of the time period (1980 to 1985); the rate of deaths from cancer was not higher in Campbell County in comparison to the rest of the state for the time periods from 1986 to 1988 and 1989 to 1992.

- Cancer mortality was significantly higher in Meigs County in comparison with the rest of the state from 1980 to 1982. This excess in cancer deaths did not persist from 1983 to 1992.

Knowledge, attitude, and beliefs study. TDOH coordinated a study to evaluate the attitudes, beliefs, and perceptions of residents living in eight counties around Oak Ridge, Tennessee. The purpose of the study was to (1) investigate public perceptions and attitudes about environmental contamination and public health problems related to the ORR, (2) ascertain the public's level of awareness and assessment of the ORHASP, and (3) make recommendations for improving public outreach programs. The report was released in August 1994 (ATSDR et al. 2002; Benson et al. 1994). Following is a summary of the findings (Benson et al. 1994):

- A majority of the respondents regard their local environmental quality as better than the national environmental quality. Most rate the quality of the air and their drinking water as good or excellent. Almost half rate the local groundwater as good or excellent.

- A majority of the respondents think that activities at the ORR created some health problems for people living nearby and most think that activities at the ORR created health problems for people who work at the site. Most feel that researchers should examine the actual occurrence of disease among Oak Ridge residents. Twenty-five percent know of a specific local environmental condition that they believe has adversely affected public health, but many of these appear to be unrelated to the ORR. Less than 0.1% have personally experienced a health problem that they attribute to the ORR.

- About 25% have heard of the Oak Ridge Health Study and newspapers are the primary source of information about the study. Roughly 33% rate the performance of the study as good or excellent and 40% think the study will improve public health. Also, 25% feel that communication about the study has been good or excellent.

Health assessment. The East Tennessee Region of TDOH conducted a health assessment on the eastern region of Tennessee. The purpose of this health assessment was to review the health status of the population, to evaluate the accessibility and utilization of health services, and to develop priorities for resource allocation. The East Tennessee Region released its first edition of

A Health Assessment of the East Tennessee Region in December 1991; this edition generally contained data from 1986 to 1990. The second edition, which was released in 1996, generally included data from 1990 to 1995. A copy of the document can be obtained from the East Tennessee Region of TDOH (ATSDR et al. 2000).

Presentation. On February 16, 1995, Dr. Joseph Lyon of the University of Utah gave a TDOH-sponsored presentation at an ORHASP public meeting. The purpose of the presentation was to inform the public and the ORHASP that several studies had been conducted on the fallout from the Nevada Test Site, including the study of thyroid disease and leukemia (ATSDR et al. 2000).

Other Agencies

Assessment reports, environmental studies, health investigations, remedial investigation/feasibility studies, and sampling validation studies. Other agencies have also addressed community health concerns and public health issues through studies and investigations. Two areas that have been investigated by other agencies—Scarboro and Lower East Fork Poplar Creek (LEFPC)—are discussed below.

Following are summaries of investigations related to the Scarboro community:

- *Scarboro Community Assessment Report*. Since 1998, the Joint Center for Political and Economic Studies (with the support of DOE's Oak Ridge Operations) has worked with the Scarboro community to help residents express their economic, environmental, health, and social needs. In 1999, the Joint Center for Political and Economic Studies conducted a survey of the Scarboro community to identify the residents' environmental and health concerns. The surveyors attempted to elicit responses from the entire community, but achieved an 82% response rate. Because Scarboro is a small community, the community assessment provided new information about the area and its residents that would not be available from sources that evaluate more populated areas, such as the U.S. Census Bureau. In addition, the assessment identified Scarboro's strengths and weaknesses, and illustrated the relative unimportance of environmental and health issues among residents in comparison to other community concerns. The assessment showed that environmental and health issues were not a priority among Scarboro residents, as the community was more concerned about crime and security, children, and economic development. The Joint Center for Political and Economic Studies recommended an increase in active community involvement in city and community planning (Friday and Turner 2001).

- *Scarboro Community Environmental Study*. In May 1998, soil, sediment, and surface water samples were taken in the Scarboro community to address residents' concerns about previous environmental monitoring in the Scarboro neighborhood (i.e., validity of past measurements).

The study was designed to integrate input from the community, while also fulfilling the requirements of an EPA-type evaluation. The Environmental Sciences Institute of Florida Agriculture and Mechanical University (FAMU), along with 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, as well as DOE subcontractors in the Neutron Activation Analysis Group at the ORNL, conducted the analytical element of this study. These results were compared with findings from an October 1993 report by DOE, entitled *Final Report on the Background Soil Characterization Project (BSCP) at the Oak Ridge Reservation, Oak Ridge, Tennessee*. In general, mercury was detected within the range that was seen in the BSCP, which was between 0.021 mg/kg and 0.30 mg/kg. The radionuclide findings were within the predicted ranges, including concentrations of total uranium. However, about 10% of the soil samples indicated an enrichment of uranium 235. Alpha-chlordane, gamma-chlordane, heptachlor, and heptachlor epoxide exceeded the detection limits in one sample. This same sample also had concentrations of lead and zinc that were twice as high as those found in the BSCP. On September 22, 1998, the final Scarboro Community Environmental Study was released (ATSDR et al. 2002).

- *Scarboro Community Health Investigation*. In November 1997, a Nashville newspaper published an article that described various illnesses seen among children who lived in the Scarboro community—a neighborhood located close to the ORR's nuclear weapons facility. The article stated that the Scarboro residents experienced high rates of respiratory illness, and that there were 16 children who repeatedly had "severe ear, nose, throat, stomach, and respiratory illnesses." The reported respiratory illnesses included asthma, sinus infections, hay fever, ear infections, and bronchitis. The article implied that these illnesses were caused by exposure to the ORR, especially because of the proximity of these children's homes to the ORR facilities (ATSDR et al. 2002; Johnson et al. 2000).

  In response to this article, on November 20, 1997, the Commissioner of TDOH requested that the CDC assist the TDOH with an investigation of the Scarboro community. TDOH coordinated the *Scarboro Community Health Investigation* to examine the reported excess of pediatric respiratory illness within the Scarboro community. The investigation consisted of a community health survey of parents and guardians, and a follow-up medical examination for children younger than 18 years of age. Both of these components (survey and exam) were essentially designed to measure the rates of common respiratory illnesses among Scarboro children, compare these rates to national rates for pediatric respiratory illnesses, and determine if these illnesses had any unusual characteristics. The investigation was not, however, designed to determine the cause of the illnesses (ATSDR et al. 2002; Johnson et al. 2000).

  In 1998, CDC and TDOH were assisted by the Scarboro Community Environmental Justice Oversight Committee to develop a study protocol. After the protocol was created, a community health survey was administered to members of households in the Scarboro neighborhood. The purpose of the survey was to assess if the rates of specific diseases were higher in Scarboro when compared to the rest of the United States, and to determine if exposure to different factors increased the Scarboro residents' risk for health problems. In addition, the survey collected information from adults about their occupations, occupational exposures, and general health concerns. The health investigation survey had an 83% response rate, as 220 out of 264 households were interviewed; this included 119 questionnaires about children and 358 questionnaires about adults in these households (ATSDR et al. 2002; Johnson et al. 2000).

In September 1998, CDC released its initial findings from the survey. For children in Scarboro, the asthma rate was 13%; this was compared to nationally estimated rates of 7% for children between the ages of 0 and 18, and 9% for African American children between the ages of 0 and 18. Still, the Scarboro rate fell within the range of rates (6% to 16%) found in comparable studies across the United States. The wheezing rate was 35% for children in Scarboro, which was compared to international estimates that fell between 1.6% and 36.8%. With the exception of unvented gas stoves, the study did not find any statistically significant link between exposure to typical environmental asthma triggers (e.g., pests, environmental tobacco smoke) or possible occupational exposures (i.e., living with an adult who works at the ORR) and asthma or wheezing illness (ATSDR et al. 2002; Johnson et al. 2000).

After review of information obtained in the health investigation survey, 36 children were invited to have a physical examination; this number included the children who were discussed in the November 1997 newspaper article. In November and December 1998, these medical examinations were conducted to verify the community survey results, to evaluate if the children with respiratory illnesses were receiving necessary medical care, and to confirm if the children detailed in the newspaper actually had those reported respiratory medical problems. The children who were invited to have medical examinations had one or more of the following conditions: 1) severe asthma, which was defined as more than three wheezing episodes or going to an emergency room as a result of these symptoms; 2) severe undiagnosed respiratory illness, which was defined as more than 3 wheezing episodes and going to an emergency room as a result of these symptoms; 3) respiratory illness and no source for regular medical care; or 4) identified in newspaper reports as having respiratory illness. Out of the 36 children invited, 23 participated in the physical examination. A portion of the eligible children had moved away from Scarboro, whereas others were unavailable or opted not to participate (ATSDR et al. 2002; Johnson et al. 2000).

During the physical examinations, nurses asked the participating children and their parents a series of questions about the health of the children; volunteer physicians evaluated the findings from the nurse interviews and examined the children. In addition to these physical examinations, the children were given blood tests and a special breathing test. The examining physician sometimes took an x-ray of the child, but this was determined on a case-by-case basis. All of the tests, examinations, and transportation to and from the examinations were provided without charge (Johnson et al. 2000).

As soon as the examinations were completed, the results were evaluated to see if any children required immediate intervention, but none of the children needed urgent care. Several laboratory tests revealed levels that were either above or below the normal range, which included blood hemoglobin level, blood calcium level, or breathing test abnormality. After a preliminary review of the findings, laboratory results were conveyed to the parents of the children and their doctors by letter or telephone. If the parents did not want their child's results sent to a physician, then the parents received the results over the telephone. The parents of children who had any health concern identified from the physical examination were sent a personal letter from Paul Erwin, M.D., of the East Tennessee Regional Office of the TDOH, that informed the parents that follow-up was needed with their medical provider. If the children did not have a medical provider, the parents were told to contact Brenda Vowell, R.N.C., a Public Health Nurse with the East Tennessee Regional Office of the TDOH, for help locating a provider and about possibly receiving TennCare or Children's Special Service (ATSDR et al. 2002; Johnson et al. 2000).

On January 5, 1999, a group of physicians from the CDC, TDOH, the Oak Ridge medical community, and the Morehouse School of Medicine, conducted a thorough review of the findings from the community health survey, the physical examinations, the laboratory tests, and the nurse interviews. From the 23 children who were physically examined, 22 of these children had evidence of some type of respiratory illness, which was discovered during the nurse interviews or during the doctor's physical examinations. Overall, the children seemed to be healthy and no problems requiring immediate assistance were identified. Many of the children had mild respiratory illnesses at the time of their examination, but only one child was found to have a lung abnormality during the examination. In addition, none of the children experienced wheezing at the time of their examination. The examinations did not indicate an unusual illness pattern among children in the Scarboro community. The illnesses that were identified from these examinations were not more severe than would be expected, and they were characteristic of illnesses that could be found in any community. Basically, the results of these examinations validated the results from the community health survey. On January 7, 1999, the results from this team review were presented at a Scarboro community meeting. In July 2000, the final report was released (ATSDR et al. 2002; Johnson et al. 2000).

Three months after the letters had been sent to the parents and to the physicians about the results, efforts were made to telephone the parents of the children who had been examined. Eight of the parents were contacted successfully. Since some of the parents had more than one child who participated in the examination, the questions for the eight parents were applied to 14 children. Despite many attempts on different days, the parents of nine children could not be contacted by telephone (Johnson et al. 2000).

Out of the 14 children whose parents had been contacted, seven of the children had been to a doctor since the examinations. For the most part, the health of the children was about the same. However, since the examinations, one child had been in the hospital because of asthma and another child's asthma medication had been strengthened due to worsening asthma. In addition, several parents reported that their children had nasal allergies, and many parents noted problems with obtaining medicines because of the expense and the lack of coverage by TennCare for the specific medicines. Subsequently, TDOH nurses have helped these parents obtain the needed medicines (Johnson et al. 2000).

- *Scarboro Community Environmental Sampling Validation Study*. In 2001, EPA's Science and Ecosystem Division Enforcement Investigation Branch collected soil, sediment, and surface water samples from the Scarboro community to respond to community concerns, identify data gaps, and validate the sampling performed by FAMU in 1998 (FAMU 1998). All samples were subjected to a full analytical scan, including inorganic metals, volatile organic compounds, semi-volatile organic compounds, radiochemicals, organochlorine pesticides, and PCBs. In addition, EPA collected uranium core samples from two locations in Scarboro and conducted a radiation walkover of the areas selected for sampling to determine whether radiation existed above background levels.

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. EPA concluded that the results support the sampling performed by FAMU in 1998, and that there is not an elevation of chemical, metal, or radionuclides above a regulatory health level of concern. The residents of Scarboro are not currently being exposed to harmful levels of substances from the Y-12 plant. The report stated that “based on EPA’s results, the Scarboro community is safe. Therefore, additional sampling to determine current exposure is not warranted.” A final report was released in April 2003 (EPA 2003).

Following is a summary of a remedial investigation/feasibility study (RI/FS) for LEFPC:

- *Lower East Fork Poplar Creek Remedial Investigation/Feasibility Study*. Under the Federal Facility Agreement, DOE, EPA, and TDEC performed an RI/FS at Lower East Fork Poplar Creek (LEFPC) that was completed in 1994. The study was conducted to evaluate the floodplain soil contamination in LEFPC, which has resulted from Y-12 plant discharges since 1950. The goals of the study were to 1) establish the degree of floodplain contamination, 2) prepare a baseline risk analysis according to the level of contaminants, and 3) determine if remedial action was necessary. The findings of the investigation suggested that sections of the floodplain were contaminated with mercury, and that floodplain soil with mercury concentrations above 400 parts per million (ppm) represented an unacceptable risk to human health and to the environment. As a result of this conclusion, a ROD was approved in September 1995 that requested remedial action at LEFPC. Remedial activities began in June 1996 and were completed in October 1997. The activities consisted of the following: 1) excavating four sections of floodplain soil that had mercury concentrations above 400 ppm, 2) recording the removal by taking confirmatory samples during excavation, 3) disposing of contaminated soil at a Y-12 plant landfill, 4) re-filling the excavated areas with soil, and 5) providing a new vegetative cover over the excavated areas (ATSDR et al. 2002).