III. Evaluation of Environmental Contamination and Potential Exposure Pathways

III.A. Introduction

In 2001, scientists from ATSDR conducted a review and analysis of the Phase I and Phase II screening evaluation of TDOH's Oak Ridge Health Studies to identify contaminants requiring further public health evaluation. In the Phase I and Phase II screening evaluation, TDOH conducted extensive reviews of available information and conducted qualitative and quantitative analyses of past (1944–1990) releases and off-site exposures to hazardous substances from the entire ORR. Having reviewed and analyzed Phase I and Phase II screening evaluations, ATSDR scientists determined that past releases of uranium, mercury, iodine-131, fluorides, radionuclides from White Oak Creek, and PCBs require further public health evaluation. The public health assessment (PHA) is the primary public health process ATSDR uses to evaluate these contaminants further.

ATSDR scientists are conducting PHAs on the following releases: Y-12 uranium releases, Y-12 mercury releases, X-10 iodine-131 releases, K-25 uranium and fluoride releases, and PCB releases from X-10, Y-12, and K-25. PHAs will also be conducted on other issues of concern such as the TSCA incinerator and off-site groundwater. In addition, ATSDR is screening current (1990 to 2003) environmental data to identify any other chemicals that will require further evaluation.

In this PHA, ATSDR scientists evaluate PCB releases from the ORR that have reached off-site areas, such as East Fork Poplar Creek, the Clinch River, and Watts Bar Reservoir, and assesses whether people who use or live along these waterways are being exposed to harmful levels of ORR-related PCBs.

III.A.1. Exposure Evaluation Process

A release of a contaminant from a site does not always mean the substance will impact negatively on an off-site community member. For a substance to pose a potential health problem, exposure must first occur. Human exposure to a substance depends on whether a person comes in contact with the contaminant—by, for example, breathing, eating, drinking, or touching a substance containing it. If no one comes into contact with a contaminant, no exposure occurs, thus no health effects can occur. That said, however, even if the site is inaccessible to the public, contaminants can move through the environment to locations where people could come into contact with them.

> The five elements of an exposure pathway are
> 1) source of contamination,
> 2) environmental media,
> 3) point of exposure,
> 4) route of human exposure, and
> 5) receptor population.
>
> The source of contamination is where the chemical or radioactive material was released. The environmental media (e.g., ground water, soil, surface water, air) transport the contaminants. The point of exposure is where people come in contact with the contaminated media. The route of exposure (e.g., ingestion, inhalation, dermal contact) is how the contaminant enters the body. The people actually exposed are the receptor population.

ATSDR evaluates site conditions to determine whether people could have been or are currently exposed to site-related contaminants. When evaluating exposure pathways, ATSDR identifies whether exposure to contaminated media (soil, water, air, waste, or biota) has occurred, is occurring, or will occur through ingestion, dermal (skin) contact, or inhalation. ATSDR also identifies an exposure pathway as *completed* or *potential*, or *eliminates the pathway from further evaluation*. Completed exposure pathways exist if all elements of a human exposure are present. A potential pathway is one that ATSDR cannot rule out because one or more of the pathway elements cannot be definitely proved or disproved. A pathway is eliminated if one or more of the elements are definitely absent.

More information about the ATSDR evaluation process can be found in ATSDR's Public Health Assessment Guidance Manual at http://www.atsdr.cdc.gov/HAC/PHAManual/toc.html or by contacting ATSDR at 1-888-42-ATSDR. An interactive program that provides an overview of the process ATSDR uses to evaluate whether people will be harmed by hazardous materials is available at http://www.atsdr.cdc.gov/training/public-health-assessment-overview/html/index.html. Appendix A. ATSDR Glossary of Environmental Health Terms is provided to acquaint the reader with terminology and methods used in this PHA.

III.A.2. Exposure and Health Effects

As stated, exposure does not always result in harmful health effects. The type and severity of health effects a person can experience depend on the amount of exposure (or dose), which in turn is based on age at exposure**,** the exposure rate (how much), the frequency (how often) or duration (how long) of exposure, the route or pathway of exposure (breathing, eating, drinking, or skin contact), and the multiplicity of exposure (combination of contaminants). Once a person is exposed, characteristics such as his or her age, sex, nutritional status, genetics, lifestyle, and health status influence how he or she absorbs, distributes, metabolizes, and excretes the contaminant. The likelihood that adverse health outcomes will actually occur depends on site-specific conditions, individual lifestyle, and genetic factors that affect the route, magnitude, and duration of actual exposure. An environmental concentration alone will not cause an adverse health outcome.

Equally important is that the true level of exposure (or dose) to environmental contamination can never be exactly determined. There is considerable uncertainty in the factors (exposure rate, frequency, duration, route) used to estimate exposure. To account for the uncertainty and yet protect public health, ATSDR scientists typically use worst-case exposure level estimates to determine whether adverse health effects might be *possible*. This stage of the evaluation is known as "screening." In the public health assessment process, similar techniques to those of the quantitative risk assessment methods (i.e., generating quantitative "risk estimates") are used primarily as a screening tool to determine which exposure pathways are clearly not public health hazards and do not need further evaluation, and which exposure pathways require further public health evaluation. The estimated worst-case doses are much higher than the doses to which people are in fact exposed. If the worst-case dose for an exposure pathway is lower than one or more media-specific comparison values (dose-based comparison values or quantitative risk estimates), then the specific exposure pathway is not a public health hazard and is eliminated from further evaluation. If, however, the worst-case dose for an exposure pathway exceeds one or more media-specific comparison values, the public health

> *Screening* is a process to identify potential pathways that are *not* a health concern. It also identifies pathways that need further in-depth health evaluation.

assessment process proceeds with a more in-depth health effects evaluation of that specific exposure pathway.

ATSDR scientists conduct a thorough health effects evaluation. They carefully examine site-specific parameters and exposure conditions about actual or likely exposures. They conduct a critical review of available toxicological, medical, and epidemiological information to ascertain the substance-specific toxicity characteristics (levels of significant human exposure). They also compare an estimate of the amount of chemical exposure (i.e., dose) to which people might frequently encounter at a site to situations that in the past have been associated with disease and injury. This health effects evaluation involves a balanced review and integration of site-related environmental data, site-specific exposure factors, and toxicological, radiological, epidemiological, medical, and health outcome data to assist in determining whether exposure to contaminant levels might result in harmful effects. The goal of the health effects evaluation is to decide whether harmful effects might be possible in the exposed population by weighing the scientific evidence and by keeping site-specific doses in perspective. The output is a qualitative description of whether site exposure doses are of sufficient nature and magnitude to trigger a public health action that will limit, eliminate, or study further any potentially harmful exposures.

III.A.3. Possible Exposure Situations

During the 1970s, PCBs were found to persist and to bioaccumulate in the environment. Traces can be found in the tissues of wildlife, domestic animals, and people. These background levels of PCBs in the environment have been declining since EPA, because of concern for human health, banned PCB production in 1978 (ATSDR 2000; Kimbrough et al. 1999).

Although PCBs are no longer made here, people in the United States are still exposed to them. Many older transformers and capacitors still contain PCBs. When they become overheated, old electrical appliances can leak PCBs and contaminate inside air. Discarded capacitors and transformers can also release PCBs into the environment from landfills. Before the 1970s, heavy electrical power consumers and industrial facilities such as ORR were major sources of environmental PCBs. Since the 1980s, however, the ORR has been under strict regulation by the state and EPA (ChemRisk 1999a).

Major operations that produced PCBs at the ORR took place from the mid-1940s into the 1970s, within the Bear Creek Valley, Upper East Fork Poplar Creek, and Bethel Valley Watersheds. Generally, contamination left the areas either as direct releases to the waterways or as indirect releases to soil, which then washed into the waterways, settling in the sediment. In addition, occasional flooding spread smaller amounts into soil adjacent to the waterways (ChemRisk 1993a; U.S. DOE 1998).

> Biota refers to plants and animals in the environment. The biota evaluated by ATSDR includes fish, turtles, and geese.

On-site waterways are not readily available for public use (e.g., sport or subsistence fishing); therefore, ATSDR considered contamination that traveled to off-site waterways. An overview of the historical uses and disposal of PCBs reveals that potential off-site exposures probably originated from PCB contamination in sediments and biota of East Fork Poplar Creek and the Clinch River.

Thus the primary off-site regions requiring investigation are Lower East Fork Poplar Creek, the Clinch River, and Watts Bar Reservoir. People could come in contact with contaminants along these waterways through distinct exposure pathways. Such PCB exposures near these water bodies could have been by dermal and oral exposure to contaminated water and sediments during recreational activities and by consumption of contaminated fish and other biota. The key issues and concerns evaluated in this PHA are depicted in Figure 15.

ATSDR identified the most critical pathway for evaluation as consumption of Clinch River and Lower Watts Bar Reservoir fish and turtles. Oak Ridge residents say fishing was a relatively common activity and that many of the fish caught were consumed (ChemRisk 1999a). Local anglers, however, told ATSDR that East Fork Poplar Creek is not a very productive fishing location, and very few people actually eat fish from it.

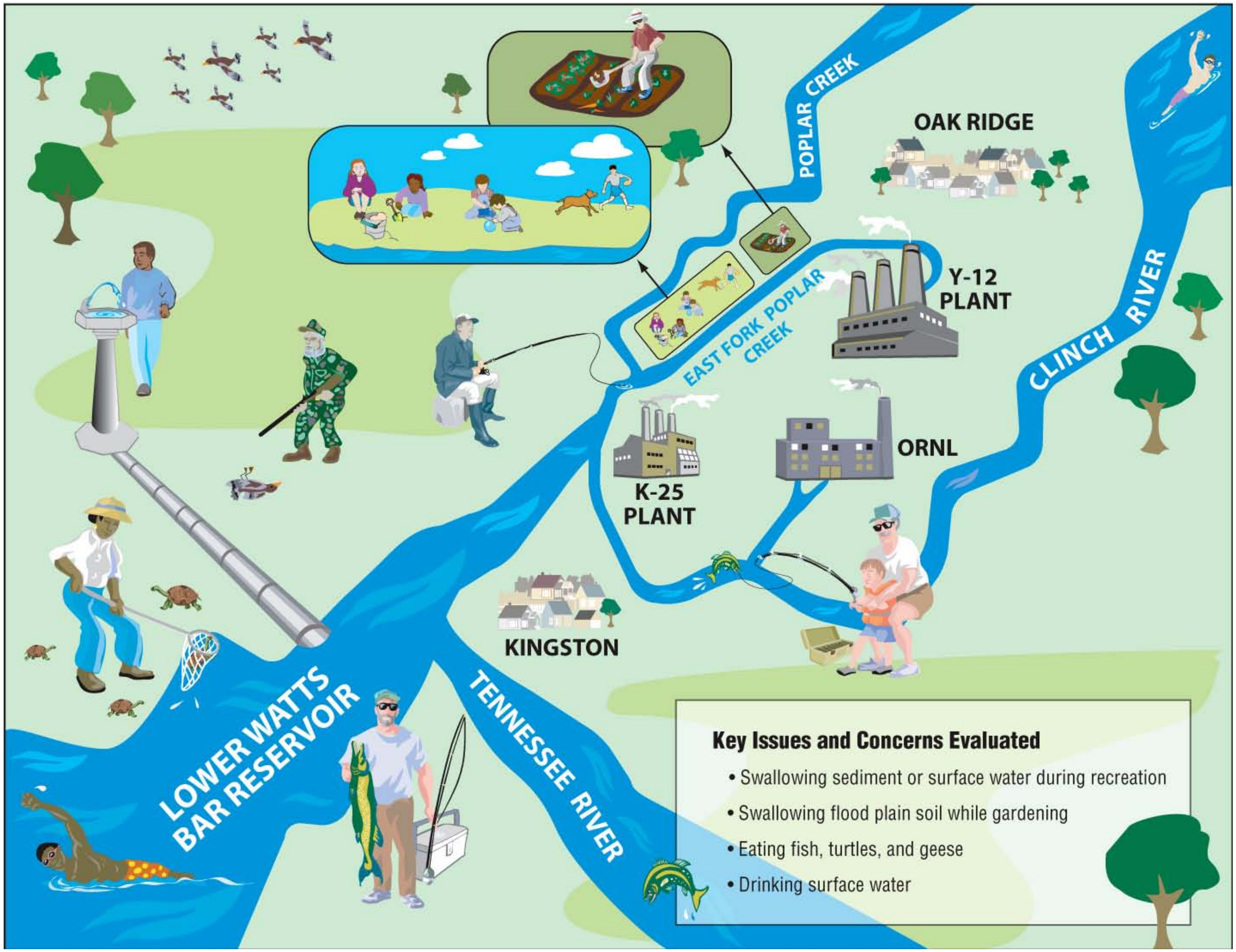
PCBs from sediment enter bottom-feeding species (e.g., worms, invertebrates). These prey become PCB sources to bottom-feeding fish, which themselves become prey to larger fish and to turtles. Birds and land predators—including humans—then eat the fish (and eat the birds, such as geese), and can build up body burdens of PCBs. At each step in this food web, PCBs that accumulated in the fatty tissues of prey animals can appear in greater concentrations (bio-magnification of PCB levels) in predator species that eat them. Unlike nonbiologic media (e.g., sediment), which is recurrently covered by new material, biologic media recirculates persistent contaminants. For example, as dead fish decompose, live fish eat the decaying matter. As a result, contaminant levels in the fish may change little over time (see Appendix C. Examples of Various Aquatic Food Webs).

> Surface water itself is not a major source of exposure—PCBs are not readily water soluble. These oils, when directly spilled into water, are quickly absorbed by underlying sediments and nearby soils. It is not surprising that historical and recent data on surface water PCBs were nearly all below levels of detection (ChemRisk 1999a; OREIS; TopHat).

> Although groundwater often received releases of waste PCBs deposited in the soil, it could not transport significant quantities of the poorly soluble oils. By depositing PCBs onto the surrounding (largely inaccessible) on-site surface soils, groundwater, as well as inaccessible subsurface soil, thus became a barrier to migration (ChemRisk 1999a).

After confirming previous findings that PCBs are not significantly present in surface water or groundwater, ATSDR analyzed PCB contamination data for sediment and biota to determine whether the levels detected could have the potential for past, current, or future public health hazards. When evaluating these media, ATSDR assessed the level of contamination present in the sediment and biota, the extent to which individuals come in contact with the contamination directly (e.g., by eating fish and turtles or by inadvertently ingesting soil or sediment) or indirectly (e.g., from sediment eaten by fish and turtles), and whether this contact would result in harmful health effects. Again, estimating the amount of PCBs that could have reached a person's body from the amount of PCBs in sediment or fish is inherently uncertain. To reduce some of that uncertainty, ATSDR in this PHA used PCB serum levels (which is a measure of the PCB level accumulated in a person's body) from people who ate moderate to large amounts of fish from the Clinch River and Watts Bar Reservoir.

Figure 15. Possible Exposure Situations along ORR Waterways



III.A.4. Deriving Comparison Values

ATSDR maintains a database of standard health-based comparison values for sediment/soil, drinking water, and ambient air. ATSDR does not, however, have standard comparison values for biota such as fish, geese, or turtles. Instead ATSDR developed protective comparison values based on site-specific information about biota consumption. Because Task 3 eliminated cancer as a health concern, the comparison values developed by ATSDR are based on noncancer effects.

ATSDR derived fish, geese, and turtle comparison values from the chronic minimal risk level (MRL) of 0.02 micrograms PCBs per kilogram body weight per day (µg/kg/day). The MRL is an 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. The chronic MRL for PCBs is based on a study in which immunological effects were seen in monkeys. MRLs also have built-in uncertainty, or safety factors, making them considerably lower than doses at which health effects have been observed. See ATSDR's Toxicological Profile for PCBs (ATSDR 2000) for additional information about the study in which the MRL is based.

> 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 health effects.

Fish

Comparison values for fish were generated from the fish consumption study in ATSDR's Watts Bar Exposure Investigation (ATSDR 1998). Some 550 local fish consumers responded to the invitation to participate in a fish consumption study. About 79 percent of the volunteers ate too few fish or turtles to be eligible to participate in the study. The remaining 116 people, or 21 percent, ate at least six fish meals annually, with a mean of 66.5 grams per day (g/day) and a 95th percentile of 108 g/day. From this information, ATSDR derived three ranges of consumption.

- "Low fish consumers" were defined based on the 79 percent of volunteers (and nonvolunteers, who include a higher proportion of people that did not eat any local fish) who ate too few fish to be eligible to participate in the study. They consumed between zero and six 8-ounce meals of fish a year. The midpoint equates to 1.95 g/day, or about one 8-ounce meal every 4 months.
- "High fish consumers" were defined by the 95th percentile (top 5 percent) of the people eligible to participate in the study, which represents about 1 percent of the volunteers. Their mean adult consumption rate was 108 g/day, which equates to about three 8-ounce meals of fish per week.
- "Moderate fish consumers" represent the mean consumption of the group between the 79 percent of those ineligible to participate and the 1 percent who were high consumers. Their consumption rate was 66.5 g/day, which equates to about two 8-ounce fish meals per week. This group represents about 20 percent of fish and nonfish consumers.

To screen the fish exposure pathway, ATSDR derived comparison values for each fish consumption range by dividing the permitted PCB intake[1] (1.4 µg/kg/day for a 70-kg adult and 0.2 µg/kg/day for a 10-kg child) by the amount of fish eaten daily (in kilograms; therefore, the ingestion rates presented above are divided by 1,000). Adults were assumed to weigh 70 kilograms (150 pounds) and children were assumed to weigh 10 kilograms (22 pounds, which represents the weight of a 1-year-old child). Children were assumed to eat about one-third the amount of the adults. The results are presented in Table 3.

Table 3. ORR-Specific Comparison Values for Fish

Consumption Level	*Child (ppb)*	*Adult (ppb)*
High (3 meals/week)	6	10
Moderate (2 meals/week)	9	20
Low (3 meals/year)	300	700

Comparison values are rounded.

Canada Geese

ATSDR conservatively assumed hunters might consume as much as 10 kilograms (about 22 pounds) of goose muscle per year. This amount averages to about one 6 to 8 ounce serving per week, or 27 g/day. When ATSDR surveyed fish consumers sufficient information was obtained to assign adult high, moderate, and low consumption groups in the ratio of 108 / 66.5 / 1.9 g/day of fish. If similar consumption ratios hold for geese, then the amount and ratios for the three 70-kilogram adult goose consumers would be 27 / 17 / 0.5 g/day of goose meat. If, as assumed for the fish, 10-kilogram children eat one-third the portion sizes that adults eat, their consumption levels would be in the ratios of 9 / 5.6 / 0.16 g/day of goose meat.

To derive PCB comparison values for each consumption range, ATSDR divided the permitted PCB intake[1] (1.4 µg/kg/day for a 70-kg adult and 0.2 µg/kg/day for a 10-kg child) by the amount of goose eaten daily (in kilograms; therefore, the ingestion rates presented above are divided by 1,000). Adults were assumed to weigh 70 kilograms (150 pounds) and children were assumed to weigh 10 kilograms (22 pounds, which represents the weight of a 1-year-old child) (see Table 4).

[1] The permitted PCB intake is calculated by multiplying the chronic MRL of 0.02 µg/kg/day by 70 kg for adults and 10 kg for children.

Table 4. ORR-Specific Comparison Values for Canada Geese

Consumption Level	*Child PCB Comparison Values (ppb)*	*Adult PCB Comparison Values (ppb)*
High (1 meal/week)	22	52
Moderate (2 meals/month)	36	82
Low (1 meal/year)	1,250	2,800

Turtles

ATSDR evaluated three turtle consumption levels. From the exposure investigation and interviews with its author, ATSDR learned that moderate consumers eat about 100 grams of turtle meat a year (or 0.27 g/day). High consumers eat turtle meals twice as often as moderate consumers (0.55 g/day), and low consumers eat one-sixth the amount that moderate consumers eat (0.05 g/day) (ATSDR 1998).

To derive PCB comparison values for each turtle meat consumption range, ATSDR divided the permitted PCB intake[2] (1.4 µg/kg/day for a 70-kg adult and 0.2 µg/kg/day for a 10-kg child) by the amount of turtle meat eaten daily (in kilograms). Adults were assumed to weigh 70 kilograms (150 pounds) and children were assumed to weigh 10 kilograms (22 pounds, which represents the weight of a 1-year-old child) (see Table 5).

Table 5. ORR-Specific Comparison Values for Turtle Meat

Consumption Level	*Child PCB Comparison Values (ppb)*	*Adult PCB Comparison Values (ppb)*
High (2 meals/year)	500	2,500
Moderate (1 meal/year)	1,000	5,000
Low (1 meal/six years)	6,000	30,000

Comparison values are rounded.

[2] The permitted PCB intake is calculated by multiplying the chronic MRL of 0.02 µg/kg/day by 70 kg for adults and 10 kg for children.

III.B. Exposure Evaluation of PCBs

ATSDR evaluated past and current exposure to PCB contamination in East Fork Poplar Creek, Poplar Creek, Clinch River, Tennessee River, and the Lower Watts Bar Reservoir. The screening evaluation confirmed that eating biota (fish, turtles, and geese) is the main exposure pathway to PCBs from the ORR. ATSDR also evaluated the body-burden of PCBs in the most frequent fish and turtle consumers. As a result of the screening evaluation, the potential for human health effects from eating fish and geese was further evaluated in Section IV. Public Health Implications.

ATSDR used the following time periods and information in its evaluation.

Past Exposure: "Past" refers to the period from 1942 through 1995. To begin evaluating past exposures, ATSDR reviewed the Task 3 report (*PCBs in the Environment near the Oak Ridge Reservation—A Reconstruction of Historical Doses, and Health Risks*) and associated documents. The complete project can be accessed through TDOH's Web site at www2.state.tn.us/health/CEDS/OakRidge/ORidge.html, and a brief summarizing the Task 3 report is provided in Appendix F. Summary Briefs and Fact Sheets. For in-depth analysis of environmental data, ATSDR compiled data from DOE's OREIS, TVA, and TDEC.

Current Exposure. "Current" refers to the period from 1996 to the present. To evaluate current exposures and doses, ATSDR used data presented in its 1996 Health Consultation entitled *Health Consultation for U.S. DOE Oak Ridge Reservation: Lower Watts Bar Reservoir Operable Unit*, its 1998 Exposure Investigation entitled *Serum PCB and Blood Mercury Levels in Consumers of Fish and Turtles from Watts Bar Reservoir*, and data from OREIS and TDEC. Briefs summarizing the Health Consultation and Exposure Investigation are provided in Appendix F. Summary Briefs and Fact Sheets.

III.B.1. Past Exposure (1942–1995)

Tennessee Department of Health's Task 3 Study

From 1992 to 1995, TDOH conducted the Task 3 study to assess whether persons visiting or living in the areas along East Fork Poplar Creek and the Watts Bar Reservoir contacted harmful levels of PCBs in the past. The wastes generated by Y-12, K-25, and X-10 during the time frame covered in the Task 3 report, 1942 through 1991, included PCBs used in electrical components and in cutting oils.

Drawing on various sources of data for ORR contamination or analogous contamination elsewhere, TDOH made conservative assumptions about total sample PCB content and sample typicality, access to various contamination levels of different environmental media, the frequency of activities leading to occupational or recreational contact with these media, the amount of contamination from media in the resulting exposures that entered and remained in human bodies, and the level of resulting toxicity. To select potential pathways without risk of missing any of those deemed most harmful, the first, or screening, quantitative risk assessment evaluation of exposures was highly conservative. In the second quantitative risk assessment more refined modeling was also carried out, and a third level analysis described uncertainties in the process.

The TDOH Task 3 report estimated exposure intakes using quantitative risk assessment methods to combine these and other conservative exposure point concentrations with equally conservative assumptions about exposure, exposure duration, and fraction of time exposed. Using these conservative assumptions, TDOH determined the following exposure pathways are not a public health hazard and eliminated them from further consideration for both adults and children. In addition, the screening values for ingestion of turtles exceeded the screening criteria, but were not retained for further analysis (ChemRisk 1999a).

- <u>East Fork Poplar Creek</u>
  - Dermal contact with sediment
  - Dermal contact with surface water
  - Incidental ingestion of surface water
  - Inhalation of dust
  - Eating beef from cattle that:
    - Breathed airborne PCBs
    - Ate pasture with PCBs deposited by the air
    - Drank PCBs from the water
  - Drinking milk from cows that:
    - Breathed airborne PCBs
    - Drank PCBs from the water
  - Eating vegetables with PCBs deposited by the air
- <u>Scarboro</u>
  - Breathing airborne PCBs
- <u>Poplar Creek</u>
  - Dermal contact with sediment
  - Dermal contact with surface water
  - Incidental ingestion of sediment
  - Incidental ingestion of surface water
- <u>Clinch River</u>
  - Dermal contact with sediment
  - Dermal contact with surface water
  - Incidental ingestion of sediment
  - Incidental ingestion of surface water
  - Ingestion of drinking water
  - Ingestion of turtles

- Breathing airborne PCBs

➢ Watts Bar
  - Dermal contact with sediment
  - Dermal contact with surface water
  - Incidental ingestion of sediment
  - Incidental ingestion of surface water
  - Ingestion of drinking water
  - Ingestion of turtles

➢ Sale of Waste Oil
  - Dermal contact with soil
  - Ingestion of soil
  - Inhalation of dust

The Task 3 report kept 13 potential pathways for further evaluation. In general, ingested media provided greater doses than did inhaled or touched media. The main exposure pathway with the highest potential for exposure was the consumption of locally caught fish. Following are the remaining locations and exposure pathways that Task 3 kept for further evaluation.

➢ East Fork Poplar Creek
  - Incidental ingestion of sediment
  - Incidental ingestion of soil
  - Dermal contact with soil
  - Eating locally caught fish
  - Eating beef from cattle that:
    - Incidentally ingested soil
    - Ate pasture contaminated by soil
  - Drinking milk from cows that:
    - Incidentally ingested soil
    - Ate pasture contaminated by soil
    - Breathed airborne PCBs and the products of burning them
  - Eating vegetables with PCBs from the soil

➢ Poplar Creek
  - Eating locally caught fish

➢ Clinch River
  - Eating locally caught fish

➢ Watts Bar
  - Eating locally caught fish

After reviewing the Task 3 quantitative risk assessment, TDOH concluded that people who consumed large amounts of fish from the Clinch River and the Lower Watts Bar Reservoir were at risk from the noncancer effects of PCBs. Only three or fewer cases of cancer, however, could have resulted from eating Clinch River and Watts Bar Reservoir fish. Because the estimates and modeling are conservative, “the actual risks and expected number of cases are likely to be smaller and could be zero” (ChemRisk 1999a). Because TDOH eliminated the cancer risk, ATSDR only evaluated noncancerous responses. See Appendix F. Summary Briefs and Fact Sheets for a summary of the Task 3 study.

ATSDR reviewed the Task 3 report and determined that the exposure pathways it eliminated could safely be removed from further consideration. Due to TDOH’s robust conservatism in the Task 3 quantitative risk assessment (i.e., exposure point estimates) ATSDR agrees that the exposure pathways eliminated by Task 3 are not a public health hazard and do not require further evaluation. Because of this same conservatism, however, ATSDR determined that it should perform an independent screening evaluation of the 13 pathways retained by Task 3. Also, because the Task 3 quantitative risk assessment estimated the cancer risk to be less than three cancer cases from the population of people eating Clinch River and Watts Bar Reservoir fish, only noncancer health effects are evaluated by ATSDR in the screening evaluation of these 13 pathways. See Appendix D. ATSDR’s Validation of Task 3 Screening Results for further details.

ATSDR’s Evaluation of the Pathways Retained by Task 3

In this section of the PHA, ATSDR screens for contaminants present conservative comparison values. Comparison values are calculated concentrations of a substance in air, water, food, or soil that are unlikely to cause harmful health effects in exposed people.

ATSDR uses comparison values as conservative screening tools during the public health assessment process. Comparison values are set much lower than the lowest amount shown to affect health. Substances found in amounts greater than their comparison values are selected for further in-depth evaluation. Those contaminants above comparison values do not necessarily cause adverse health effects. Comparison values are used to help ATSDR determine which contaminants need to be more closely evaluated.

Screening is a process to eliminate from consideration those exposures very unlikely to cause illness. Because ATSDR intentionally choose comparison values that are much too low to cause disease, exposures that are not eliminated require further in-depth evaluation to determine whether that exposure is likely to cause illness. Once the elimination process is completed, ATSDR conducts a more in-depth health evaluation for those retained exposures (see Section IV. Public Health Implications).

Oily contaminants, such as PCBs, partition between water and soil or sediment particles. Soil and sediment particles pick up oily PCBs millions of times more readily than does water (ATSDR 2000), and become the principal means by which this contamination can be carried off site.

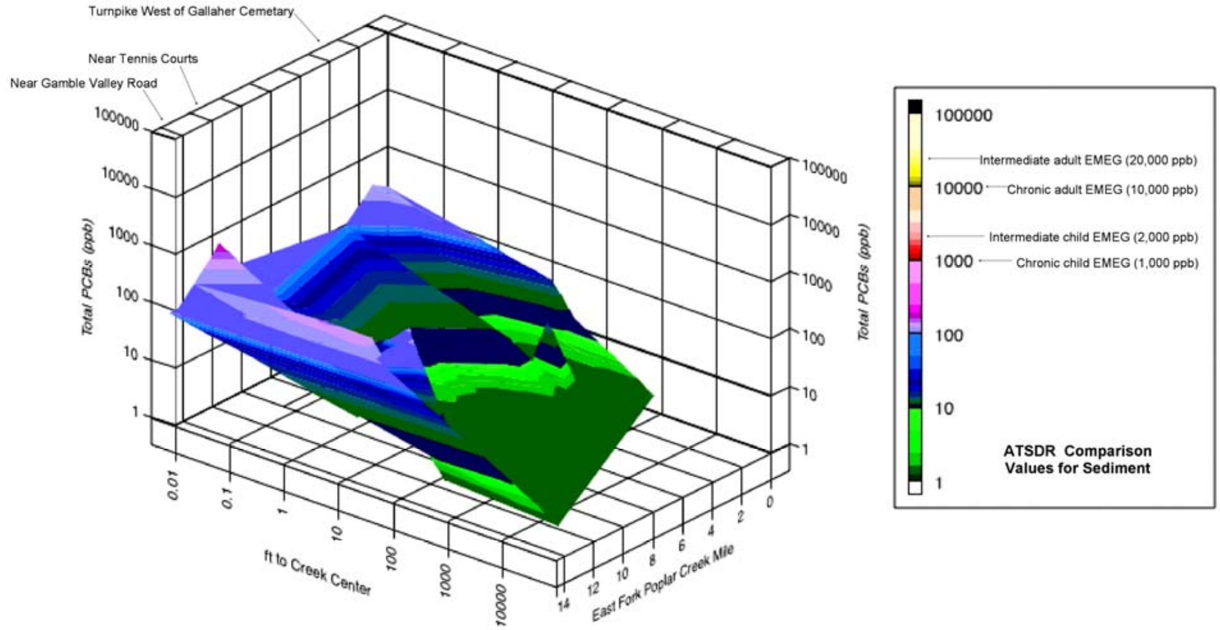
East Fork Poplar Creek Floodplain Soil and Sediment

East Fork Poplar Creek is of concern to residents in the city of Oak Ridge. The creek originates and flows through the Y-12 plant and winds through the city of Oak Ridge, flowing past residents' backyards. Children play on the creek banks and have contact with East Fork Poplar Creek floodplain sediment and soil, although not on a daily basis. Task 3 retained pathways carrying PCBs to floodplain soil, from which PCBs were taken up by local produce and its consumers, such as milk cows, beef cattle, and local gardeners, and transferred to consumers of local beef and milk.

ATSDR collected 1978 data from the OREIS database for East Fork Poplar Creek miles 0 through 14.8 that was tabulated in the Phase I report (ChemRisk 1993a) and 1991 to 1992 data. These data were collected from the creek bed and the floodplain. ATSDR totaled the seven Aroclors (commercial mixtures of PCBs) detected in 75 samples from 63 stations. For samples where no PCBs were found, ATSDR assumed that the PCB concentration for that sample was midway between none and the lowest detected concentration.

To explore the influence of position (creek mile and perpendicular distance from the creek bed center) on the level of PCB contamination, ATSDR plotted sediment/soil sampling results to display a surface representing the three-dimensional relationship between creek mile, feet from the bed center, and sediment/soil PCB concentration in ppb (see Figure 16). Creek mile places contamination near the facilities flanking East Fork Poplar Creek. Distance away from the bed center shows the proportion of creek-bed contamination that has been carried into the floodplain or beyond. ATSDR's comparison values for soil/sediment (e.g., 1,000 ppb is the chronic child environmental media evaluation guide [EMEG]) are also illustrated along the PCB concentration axis in Figure 16. For a more direct illustration of the distribution of sampling, see Figure 17, a map of East Fork Poplar Creek and its sediment sampling points.

Figure 16. PCBs Detected* in East Fork Poplar Creek Sediment



*Samples with no detected PCBs are shown as having one half the lowest detected concentration of Aroclor 1254 (■)

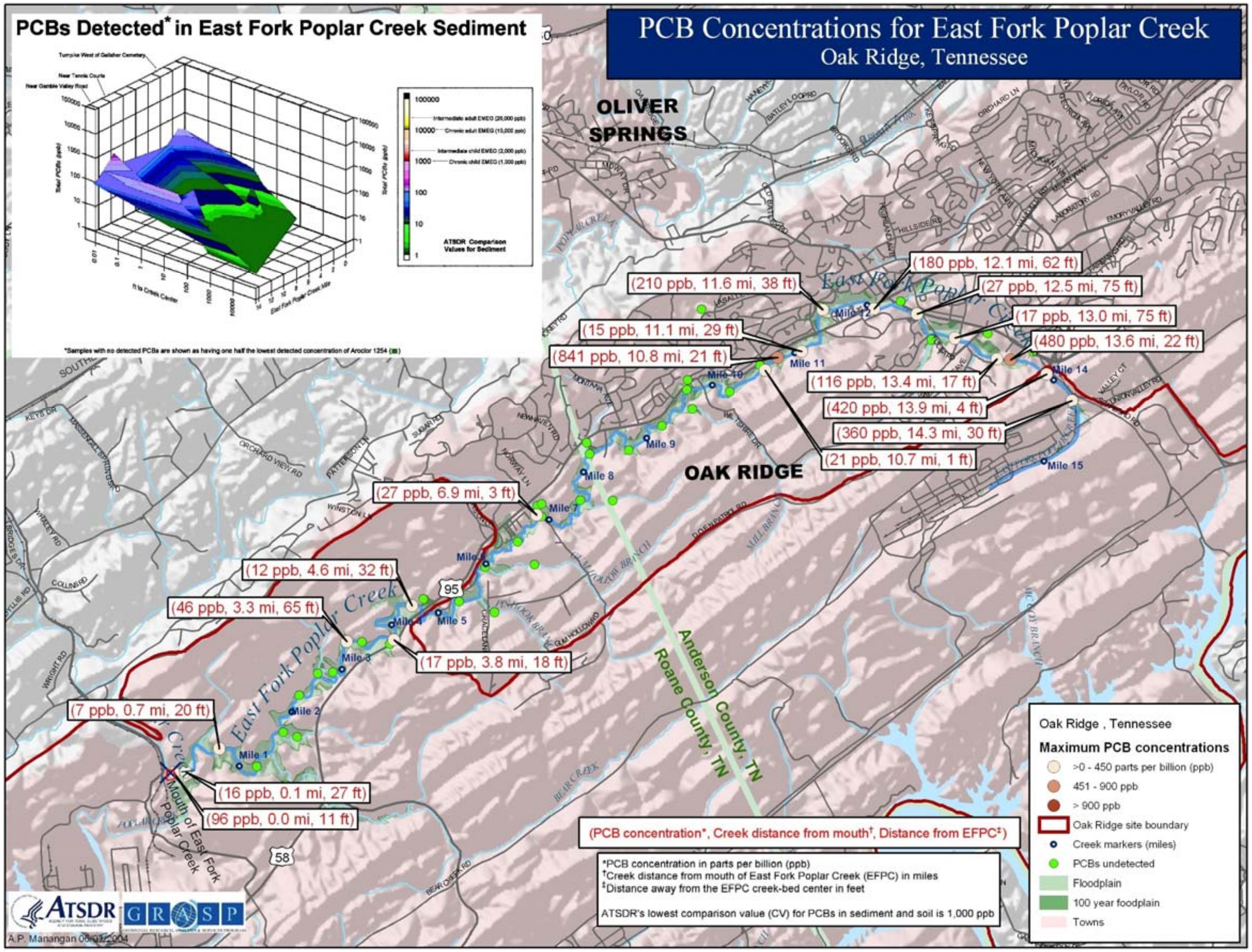
To understand Figure 16, start with picturing a large flat surface, such as the ground. On this large flat area lies a conventional two-dimensional graph. The x-axis indicates mile markers along East Fork Poplar Creek. The y-axis indicates the distance from the center of the creek bed to the exact location where the sample was taken. Next, imagine driving some stakes into the ground at different heights, which indicate the PCB concentration in each of the samples, at each of their creek-mile/distance markers. Now throw a bed sheet over the stakes so that it drapes over them, like a tent. What you arrive at is a three-dimensional depiction of PCB concentrations at different mile markers along the creek at different locations within the creek bed, deviating right or left from the center.

Figure 16 shows that both on site and off site detected contaminant levels in the East Fork Poplar Creek bed sediment are below the lowest sediment comparison value (1,000 ppb). Moreover, these less-than-toxic levels decline still further as they are carried from the creek bed into the floodplain. East Fork Poplar Creek sediment or floodplain soil PCB levels are not a concern. This means that gardening or farming the soil, eating the resulting produce, and eating beef or drinking milk from cattle that grazed the floodplain are all unlikely to cause harmful health effects. Therefore, the following nine East Fork Poplar Creek pathways are not a public health hazard and can safely be eliminated:

> Comparison values are conservative health-based values developed by ATSDR from available scientific literature concerning exposure and health effects. Comparison values are derived for each of the media and reflect an estimated contaminant concentration that is not expected to cause harmful health effects for a given contaminant, assuming a standard daily contact rate (for example, the amount of water or soil consumed or the amount of air breathed) and representative body weight. Because they reflect concentrations that are much lower than those that have been observed to cause adverse health effects, comparison values are protective of public health in essentially all exposure situations. As a result, **concentrations detected at or below ATSDR's comparison values are <u>not</u> considered to be a public health hazard**.

- East Fork Poplar Creek
  - Incidental ingestion of sediment
  - Incidental ingestion of soil
  - Dermal contact with soil
  - Eating beef from cattle that:
    - Incidentally ingested soil
    - Ate pasture contaminated by soil
  - Drinking milk from cows that:
    - Incidentally ingested soil
    - Ate pasture contaminated by soil
    - Breathed airborne PCBs and the products of burning them
  - Eating vegetables with PCBs from the soil

Figure 17. Map of PCB Sediment Sampling Stations Along East Fork Poplar Creek



Eating Fish from East Fork Poplar Creek, Poplar Creek, Clinch River, Tennessee River, and Watts Bar Reservoir

Water and sediment in the waterways in and near ORR do not themselves contain sufficient PCB contamination to result in harmful health effects. But surface water and sediment present opportunities for increased human exposure via biomagnification of PCB levels. Sediment particles bear decaying biomatter that feed small aquatic species. These species are food sources for bottom-feeding fish, such as catfish and gizzard shad. Small predator fish feed on these, and larger, second order predators feed on the smaller ones.

Food chains occur among terrestrial species also. But the effect on human exposure is greater through the aquatic chain because people are more likely to consume the meat of higher-order aquatic predators (e.g., large fish, turtles, and waterfowl) than land predators (e.g., mountain lions and hawks). See Appendix C for examples of various aquatic food chains.

Residents living along or visiting the waterways in and near the ORR were concerned about their consumption of PCB-contaminated fish and turtles. The Task 3 report did conduct a quantitative risk assessment on fish consumption, but not on turtle consumption. Task 3 based its conclusions about fish on screening assumptions. Also, Task 3 conservatively assumed 100 percent efficiency of uptake of PCBs from aquatic biota into the human body. In ATSDR's reevaluation of the fish and turtle pathway, ATSDR intensively reviewed nearly 53,000 biota records, concentrating on species in the aquatic food chain—fish, turtles, and Canada geese.

The data were analyzed to compare Aroclor totals versus congener totals of PCBs. Aroclor totals overstate contamination and congener totals may understate it. In every analysis, total PCBs summed from Aroclors exceeded those from the individual congeners, making total PCB estimates based on Aroclor analyses the more conservative (if less accurate) approach for screening. Appendix E. PCBs Measured as Total Congeners or Total Aroclors discusses this analysis in more detail.

East Fork Poplar Creek

In 1993, ATSDR evaluated a summary of the 1990 and 1991 fish data from East Fork Poplar Creek, which was compiled by the DOE Biological Monitoring and Abatement Program (ATSDR 1993). The concentrations of PCBs in fish fillet samples ranged from less than 10 to 3,860 ppb. While these levels are above the fish comparison values presented in Table 3, ATSDR eliminated East Fork Poplar Creek fish consumption as a pathway of concern because East Fork Poplar Creek is not a very productive fishing location and people do not frequently eat East Fork Poplar Creek fish over a prolonged period of time. Most local fish are caught from the Clinch River and Watts Bar Reservoir, with some from Poplar Creek, especially near its confluence with East Fork Poplar Creek, but very few fish are actually caught and consumed from East Fork Poplar Creek.

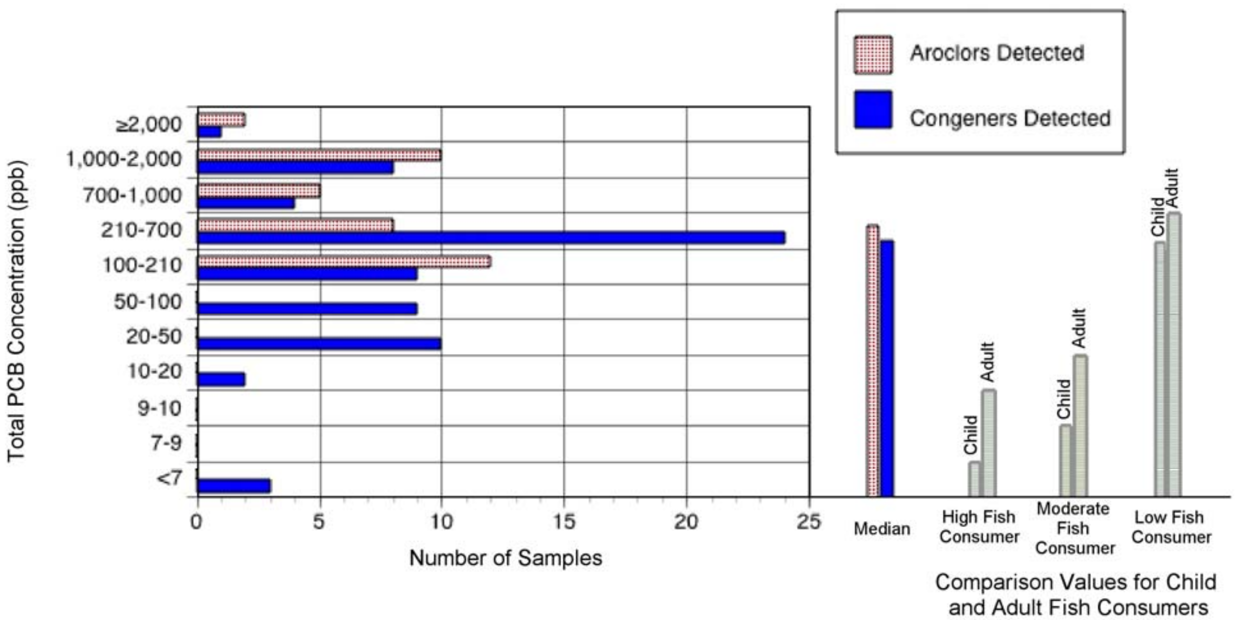
Lower Watts Bar Reservoir Fish

ATSDR evaluated the PCB concentrations in fish from the Lower Watts Bar Reservoir—the area of the Tennessee River from the city of Kingston to the Watts Bar Dam. Figure 18 shows histograms of the levels of PCBs found in Lower Watts Bar Reservoir fish as total Aroclors and total congeners with their respective medians compared to the PCB comparison values derived in Table 3. The median concentrations for adults in the low fish consumption group are below the PCB comparison value. Therefore, adults eating three fish meals per year or less eat too few fish for the PCB contamination in the reservoir to be a public health hazard. The median PCB concentrations, however, exceed not only the PCB comparison values (CVs) for children in the low fish consumption group; they also exceed the CVs for both adults and children in the moderate and high fish consumer groups. Therefore, eating fish from Lower Watts Bar Reservoir is further evaluated in Section IV (Public Health Implications).

Presentation of Fish Data

To illustrate distribution of fish contamination, as well as the number of samples in each range, ATSDR generated histograms from fish data. The histograms show the number of samples with PCB concentrations in a series of ranges selected for comparison to the fish comparison values shown in Table 3. Numbers of samples, rather than the percentages, are presented so that readers can see the numerical strength of the underlying data. Each histogram figure is coupled with additional bars representing median concentration and fish comparison values drawn in proportion to the range limits in the histogram.

Figure 18. PCBs in Fish Taken from the Lower Watts Bar Reservoir Before 1996



● Above CV
○ Below CV

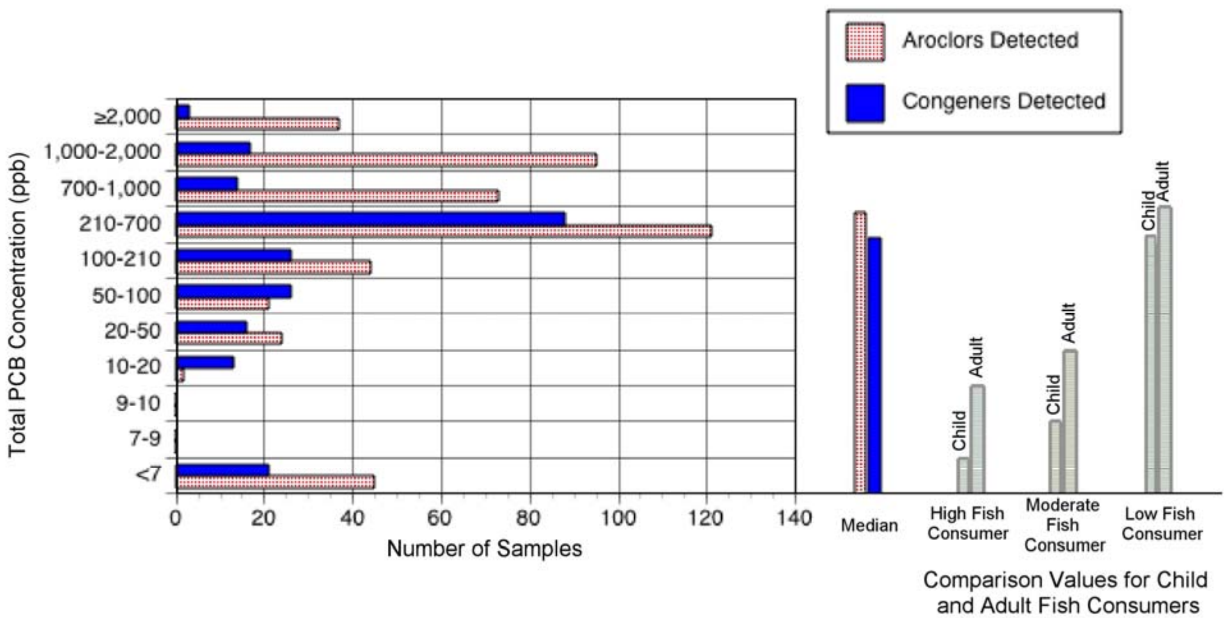
Median Concentration	High Fish Consumer Comparison Values		Moderate Fish Consumer Comparison Values		Low Fish Consumer Comparison Values	
	Child (6 ppb)	Adult (10 ppb)	Child (9 ppb)	Adult (20 ppb)	Child (300 ppb)	Adult (700 ppb)
Aroclors (500 ppb)	●	●	●	●	●	○
Congeners (305 ppb)	●	●	●	●	●	○

Clinch River Fish

ATSDR evaluated the PCB concentrations in fish from the Clinch River—the area from Melton Hill Dam to confluence with the Tennessee River near the city of Kingston.

Figure 19 shows that adults in the low fish consumption group eat too few fish for the PCB contamination in the river to be a public health hazard (i.e., the median concentrations for adults eating about three fish meals a year or less are below the PCB comparison value). However, the median PCB concentrations exceeded the PCB comparison values for children in the low fish consumption group as well as both adults and children in the moderate and high fish consumer groups. Therefore, eating fish from the Clinch River is further evaluated in Section IV (Public Health Implications).

Figure 19. PCBs in Fish Taken from the Clinch River Before 1996



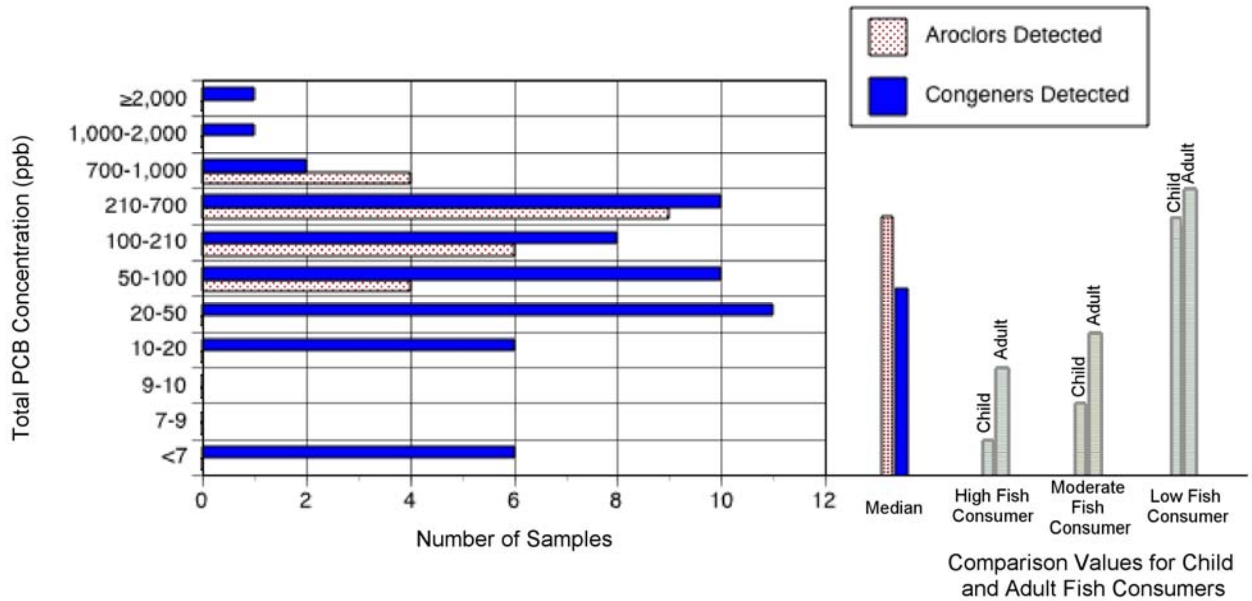
● Above CV
○ Below CV

Median Concentration	High Fish Consumer Comparison Values		Moderate Fish Consumer Comparison Values		Low Fish Consumer Comparison Values	
	Child (6 ppb)	Adult (10 ppb)	Child (9 ppb)	Adult (20 ppb)	Child (300 ppb)	Adult (700 ppb)
Aroclors (595 ppb)	●	●	●	●	●	○
Congeners (257 ppb)	●	●	●	●	○	○

Tennessee River Fish

ATSDR evaluated the PCB concentrations in fish from the Tennessee River from Loudon Dam to the confluence with the Clinch River near the city of Kingston. As shown in Figure 20, the median concentrations for adults in the low fish consumption group are below the PCB comparison value. Therefore, adults eating three fish meals per year or less eat too few fish for the PCB contamination in the river to be a public health hazard. However, the median PCB concentrations exceeded the PCB comparison values for children in the low fish consumption group, as well as the CVs both adults and children in the moderate and high fish consumer groups. Therefore, eating fish from the Tennessee River is further evaluated in Section IV (Public Health Implications).

Figure 20. PCBs in Fish Taken from the Tennessee River Before 1996



● Above CV
○ Below CV

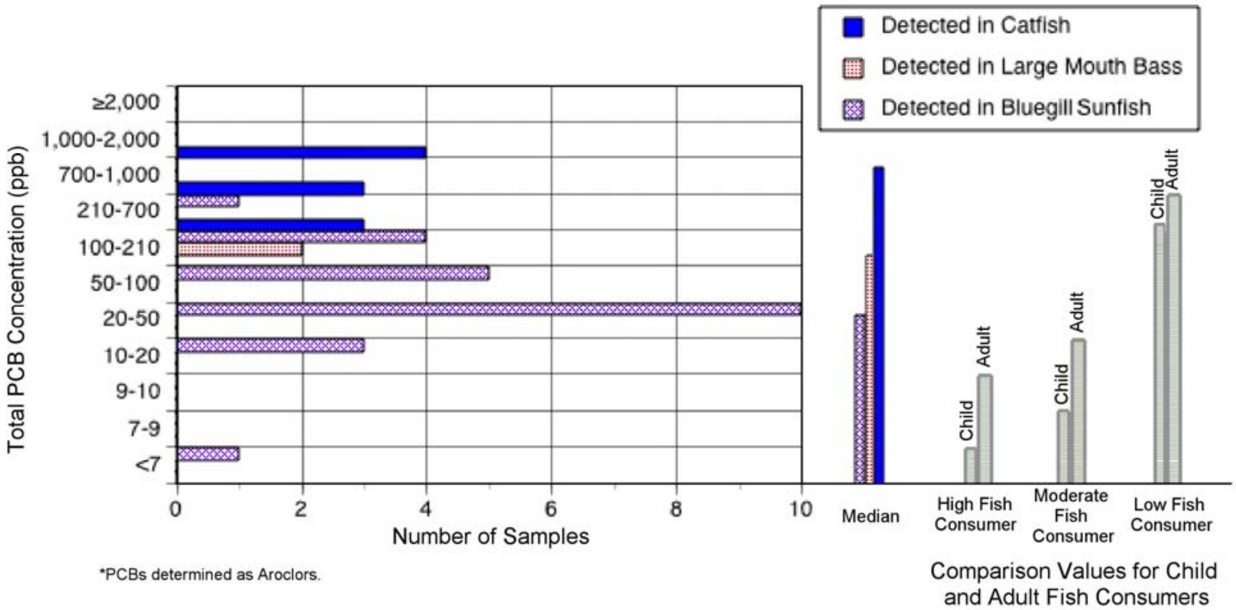
Median Concentration	High Fish Consumer Comparison Values		Moderate Fish Consumer Comparison Values		Low Fish Consumer Comparison Values	
	Child (6 ppb)	Adult (10 ppb)	Child (9 ppb)	Adult (20 ppb)	Child (300 ppb)	Adult (700 ppb)
Aroclors (300 ppb)	●	●	●	●	●	○
Congeners (60 ppb)	●	●	●	●	○	○

Off-site Poplar Creek Fish

Few PCB fish data are available from off-site Poplar Creek, and fewer still from its East Fork Poplar Creek confluence. Ten catfish and two largemouth bass were sampled from the confluence. Twenty-four bluegill sunfish were taken upstream. Data were reported as Aroclors (see Figure 21). The median PCB concentration in the catfish exceeded the PCB comparison values for all fish consumption groups. Eating largemouth bass or bluegill sunfish three or fewer times a year will not result in harmful health effects (i.e., the PCB concentrations were below the comparison values for low fish consumers). The median PCB concentrations of largemouth bass and bluegill sunfish exceeded, however, the comparison values for both moderate and high consumption. Therefore, eating fish from Poplar Creek is further evaluated in Section IV (Public Health Implications).

Aside from spurious variation inherent in small numbers, the variation in contamination levels in the Poplar Creek fish could have resulted either from the location taken, or from the feeding habits of the different species.

Figure 21. PCBs* in Fish Taken from Poplar Creek Before 1996



● Above CV
○ Below CV

Median Concentration	High Fish Consumer Comparison Values		Moderate Fish Consumer Comparison Values		Low Fish Consumer Comparison Values	
	Child (6 ppb)	Adult (10 ppb)	Child (9 ppb)	Adult (20 ppb)	Child (300 ppb)	Adult (700 ppb)
Catfish (920 ppb)	●	●	●	●	●	●
Largemouth Bass (130 ppb)	●	●	●	●	○	○
Sunfish/Bluegill (40 ppb)	●	●	●	●	○	○

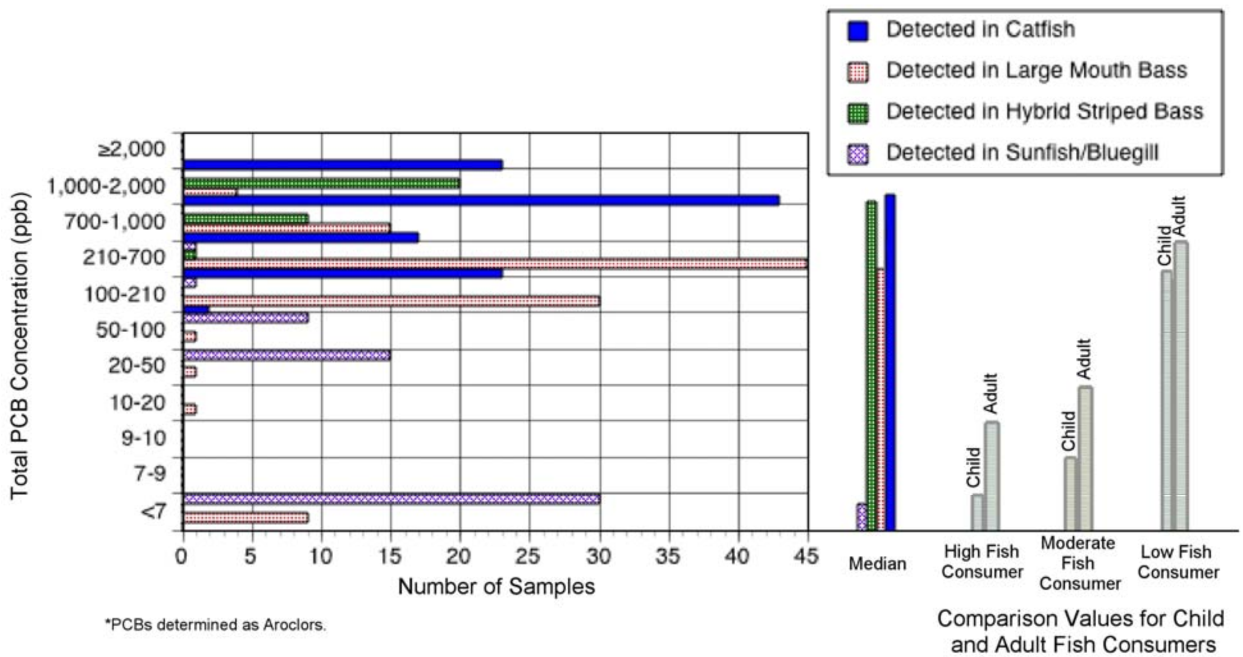
PCB Contamination in Watts Bar Reservoir Fish, by Species

Figure 22 shows PCB distribution by species in the sampling database available from the entire Watts Bar Reservoir. The total numbers of sunfish, largemouth bass, striped bass, and catfish were 60, 106, 30, and 56 samples, respectively. The concentrations of PCBs in sunfish are much less than the concentrations in other fish species. The largemouth bass are less contaminated than the striped bass and channel catfish. Note also that the striped bass found in the Watts Bar Reservoir have about the same PCB concentration, on average, as do the catfish.

These differences in PCB concentrations are to be expected from the species' order of predation, or trophic levels (i.e., who feeds on whom). Medium-sized striped bass and channel catfish feed on sunfish. Catfish, being bottom-feeders, also consume decaying matter from the river bed. Larger catfish and striped bass feed on the smaller predator fish, including some largemouth bass (see Appendix C. Examples of Various Aquatic Food Webs).

> Contamination in fish increases from prey, to predator, to prey again, and so on. Each fish biomagnifies fat-soluble PCBs in the fatty tissues of its food into its own fatty tissues, which then become biomagnified in its predator's fat.

Figure 22. PCBs* in Fillets Taken from Watts Bar Reservoir Before 1996



● Above CV
○ Below CV

Median Concentration	High Fish Consumer Comparison Values		Moderate Fish Consumer Comparison Values		Low Fish Consumer Comparison Values	
	Child (6 ppb)	Adult (10 ppb)	Child (9 ppb)	Adult (20 ppb)	Child (300 ppb)	Adult (700 ppb)
Catfish (1,250 ppb)	●	●	●	●	●	●
Largemouth Bass (300 ppb)	●	●	●	●	●	○
Hybrid Bass (1,050 ppb)	●	●	●	●	●	●
Sunfish/Bluegill (5 ppb)	○	○	○	○	○	○

Figure 22 shows that consumption of sunfish from the Watts Bar Reservoir is safe because the median PCB concentration is well below all PCB comparison values for adults and children. The median PCB concentrations for catfish and hybrid bass exceed, however, the comparison values for all consumption groups. The median PCB concentration for largemouth bass exceeded the adult comparison values for moderate and high consumption and the child comparison values for all three consumption groups. Therefore, eating fish from Watts Bar Reservoir is further evaluated in Section IV (Public Health Implications).

<u>Eating Canada Geese</u>

As an example of a high-order predator in the aquatic food chain, ATSDR chose Canada Geese, which feed on all sizes of fish in waterways in and near the ORR. Data were available for goose liver and muscle. PCBs were undetected in the goose liver samples, but Aroclors were found close to the limit of quantitation of 40 to 80 ppb in all goose muscle samples. The median concentration of all the Aroclors in each of 10 muscle samples was 320 ppb.

Table 6. PCB Levels for Canada Geese Compared to ORR-Specific Comparison Values

Consumption Level	Child PCB Comparison Values (ppb)	Adult PCB Comparison Values (ppb)	Goose Muscle PCBs (ppb)
High (1 meal/week)	22	52	320
Moderate (2 meals/month)	36	82	320
Low (1 meal/year)	1,250	2,800	320

Table 6 shows that the median PCB concentration reported for goose muscle exceeds the PCB comparison values for adults and children who eat moderate to high levels of Canada geese. Therefore, eating Canada geese is further evaluated in Section IV (Public Health Implications).

Summary of ATSDR's Screening Evaluation of Past Exposure (1942–1995)

ATSDR began the evaluation by validating the Task 3 scientists' elimination of the media and exposure pathways deemed unlikely to cause illness. For the 13 pathways not eliminated by Task 3 and for the consumption of geese, ATSDR screened concentrations in each exposure pathway separately. For nonbiological media, such as sediment or soil, ATSDR compared distribution of PCB contamination with protective PCB comparison values developed for children and adults exposed for chronic and intermediate durations. For biological media, such as fish and geese, ATSDR compared distribution of PCB contamination with specially developed ORR-specific PCB comparison values based on self-reported consumption values and conservative assumptions about the relative intake levels of adults and children.

- ATSDR found that no source of sediment below any body of water or at any distance from sediment beds into a floodplain, or taken from any depth (deposited at any time) was sufficiently contaminated with PCBs that illness could result from any duration of exposure to adults or children. Thus, all pathways based on direct or indirect intake of PCB-contaminated sediment are not a public health hazard and were therefore eliminated from further health effects evaluation.
- The median PCB concentrations for some of the fish species in some consumption groups exceeded the ATSDR comparison values for both adults and children. Therefore, consumption of fish was retained for further in-depth health effects evaluation (see Section IV. Public Health Implications).
- The median PCB concentration for goose muscle exceeded the PCB comparison values for adults and children who eat moderate to high levels of Canada geese. Therefore, eating Canada geese was retained for further in-depth health effects evaluation (see Section IV. Public Health Implications).
- Table 7 presents a brief summary of pre-1996 screening results. All retained exposure media and pathways are further evaluated in Section IV (Public Health Implications).

Table 7. Summary of ATSDR's Screening Evaluation of Past Exposure to PCBs (1942–1995)

Medium	***Source/Time/Species***	***Eliminated Not of Public Health Hazard***	***Retained for Further Health Effects Evaluation***
Sediment	East Fork Poplar Creek creek bed	All	None
	East Fork Poplar Creek floodplain	All	None
Fish	East Fork Poplar Creek	All	None
	Combined Watts Bar Reservoir	Low-consuming adults	All other adults & children
	Catfish	None	All
	Striped bass	None	All
	Largemouth bass Watts Bar Reservoir	Low-consuming adults	All other adults & children
	Sunfish Poplar Creek	Low-consumers	Moderate, high consumers
	Sunfish Watts Bar Reservoir	All	None
Geese	All	Low-consumers	Moderate, high consumers

III.B.2. Current Exposures (1996–Present)

Since 1996, TDEC and DOE have continued to collect environmental samples in and near ORR and analyze them for PCBs. ATSDR compiled site-related environmental data on PCBs and other contaminants from areas surrounding the ORR (mainly from OREIS and TDEC). For the evaluation of current exposures, ATSDR reviewed the most recent ORR data.

ATSDR also reviewed the data published in the ATSDR exposure investigation report on serum PCB levels in consumers of fish and turtles from Watts Bar Reservoir (ATSDR 1998), interviewed the author for additional unpublished observations, and presented the results of additional analysis of the data from the blood samples. ATSDR conducted the exposure investigation because of the uncertainties associated with the quantitative risk assessment methods used in previous studies to evaluate the contaminants in the Clinch River and Watts Bar Reservoir. The previous investigations evaluated many contaminants in the Watts Bar Reservoir and Clinch River, but identified only PCBs in reservoir fish as a possible contaminant of health concern. This finding by the previous studies was based on 1) an estimation of PCB exposure doses and conservative modeled increases of cancer likelihood after consuming large amounts of fish over an extended period of time, and 2) an assumption that all the PCBs in the fish was taken up into and remained in the bodies of the consumers. These previous studies only estimated and did not confirm that people were actually being exposed or that sufficient amounts of PCBs had accumulated in the people. The ATSDR exposure investigation measured the actual PCB body-burden (PCBs in the serum) of people who ate moderate to large amounts of fish or turtles from Watts Bar Reservoir. ATSDR also interviewed the anglers about how they prepared their fish for consumption, and how much and how often they ate fish and turtles.

Sediment

Contamination from oily PCBs persists in the particles of sediment and soil for many years after release into the environment. But the contamination becomes less bioavailable over time:

- The oil slowly seeps from the particle surfaces inward towards the particle centers, from which it not easily extracted by the intestines of fish, animals, and people.
- Contaminated particles become overlain with uncontaminated particles carried by wind and water.

East Fork Poplar Creek Sediment

In Section III.B.1., ATSDR showed East Fork Poplar Creek floodplain sediment contamination before 1996, was most frequent between East Fork Poplar Creek Mile 14.5 (Williams Bend), where the creek emerges from Y-12, and East Fork Poplar Creek Mile 10.5, near Louisiana Avenue (see Figure 16 and Figure 17). Sediment in East Fork Poplar Creek at Williams Bend was sampled 11 times from January 1996 to May 2001. PCBs were not detected in any sample. Therefore, PCBs in the East Fork Poplar Creek floodplain are not a public health hazard for people who live and visit the area, and will not be evaluated further.

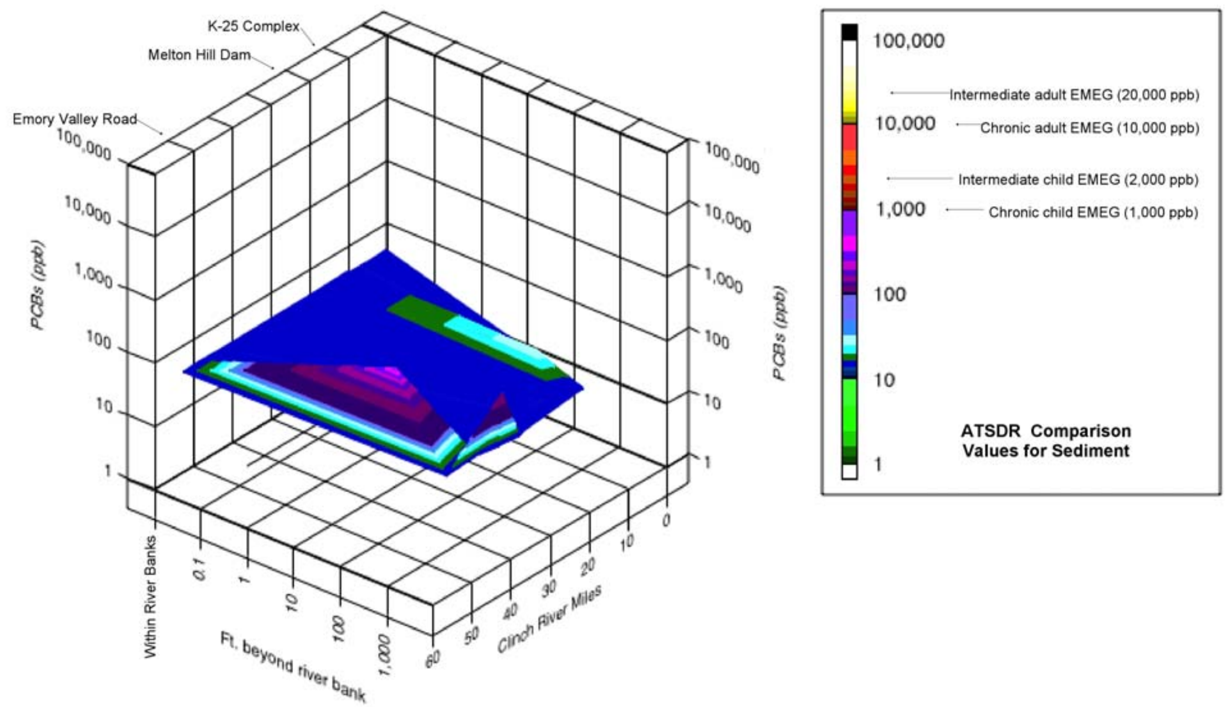
Clinch River Sediment

PCB contamination of Clinch River sediment was primarily in subsurface layers deposited during the years 1950 to 1970, when ORR used PCBs heavily and discarded them into the environment. Most contamination was near the mouth of the Clinch River where the Clinch joins the Tennessee and in the core sample at CRM 9.5, which was about 40 centimeters deep and deposited around 1960. Since 1996, 189 Clinch River surface sediment samples were collected from 28 stations along the river. PCBs were detected at three sampling stations:

- At CRM 14.4 (on site, west of Grassy Creek), PCBs were detected once in 1997, but not in six subsequent sampling events up to 2001.
- At CRM 37.8 (near McCoy Branch), three nondetect samples in 1997 and 1998, were followed by a positive detection in 2000.
- The one sample from the embayment at CRM 51.1 (near Anderson, upstream from the ORR) was positive.

To display positive samples amidst many negative ones at the same station, negative data points were suppressed. Figure 23 shows the resulting three-dimensional surface plot relating Clinch River mile and distance from the riverbed center to the sediment PCB concentrations detected. The color key to the side of the surface plot displays ATSDR's PCB comparison value for soil (e.g., the chronic child EMEG is 1,000 ppb), showing that all samples were below ATSDR PCB comparison value. Thus directly or indirectly swallowing or touching PCB-contaminated sediment in the Clinch River is not a public health hazard for people visiting or living near the river. Exposure pathways related to sediment were not retained for further evaluation.

Figure 23. PCBs Detected* in Clinch River Sediment



*Samples with no detected PCBs are shown as having one half the lowest detected concentration of Aroclor 1260 (■)

Surface Water and Groundwater

Because PCBs are poorly soluble, surface water is not a major source of exposure. Thus ATSDR eliminated surface water as a pathway of concern. These oils, when directly spilled into water, drift down to and are absorbed by underlying sediments and nearby soils. That historical and recent data on surface water PCBs were nearly all below levels of detection is not surprising (ChemRisk 1999a; OREIS). ATSDR identified trace PCB levels in the surface water (OREIS). PCBs in the water, however, could not have been higher than 0.0003 ppb—total sediment PCB concentrations never exceeded 929 ppb (this determination is based on the log octanol-water coefficients for Aroclors 1254 and 1260 (ATSDR 2000; ChemRisk 1999a)). The highest possible surface water concentration (0.0003 ppb) is 667 to 2,333 times less than ATSDR's PCB comparison values for chronic drinking water by adults and children (0.7 and 0.2 ppb, respectively). These PCB comparison values assume children and adults drink one and two liter(s) of water a day, respectively. For recreational water use (e.g., swimming and water-skiing), the average daily water intake is much less (e.g., 0.15 liters represents the amount of water ingested during a 3-hour swimming event; U.S. EPA 1997). Therefore, PCBs in the surface water are not a public health hazard. Both drinking and recreational use of surface water from 1996 onward are eliminated from further consideration. Further, on-site groundwater often received releases of waste PCBs (see Section II Background), but could not transport significant quantities because of the off-site soils' limited solubility. On-site groundwater thus became a barrier to migration by depositing the waste PCBs instead onto (largely inaccessible) on-site surface soil (ChemRisk 1999a) and subsurface soil. ATSDR is addressing exposures to off-site groundwater in a separate PHA.

In addition, TDEC's Division of Water Supply regulates drinking water at all public water systems. According to EPA's Safe Drinking Water Information System, the Kingston and Spring City public water supply systems have not had any significant violations (U.S. EPA 2004b).

Air

PCBs are not currently being released from the ORR into the air. The air pathway makes less of a contribution to PCB exposure than sediment or water. ATSDR has shown that sediment and water pathways did not carry sufficient PCB concentrations to be of health concern. Therefore, the air pathways from 1996 onward are also not of health concern and will not be retained for further investigation.

Fish

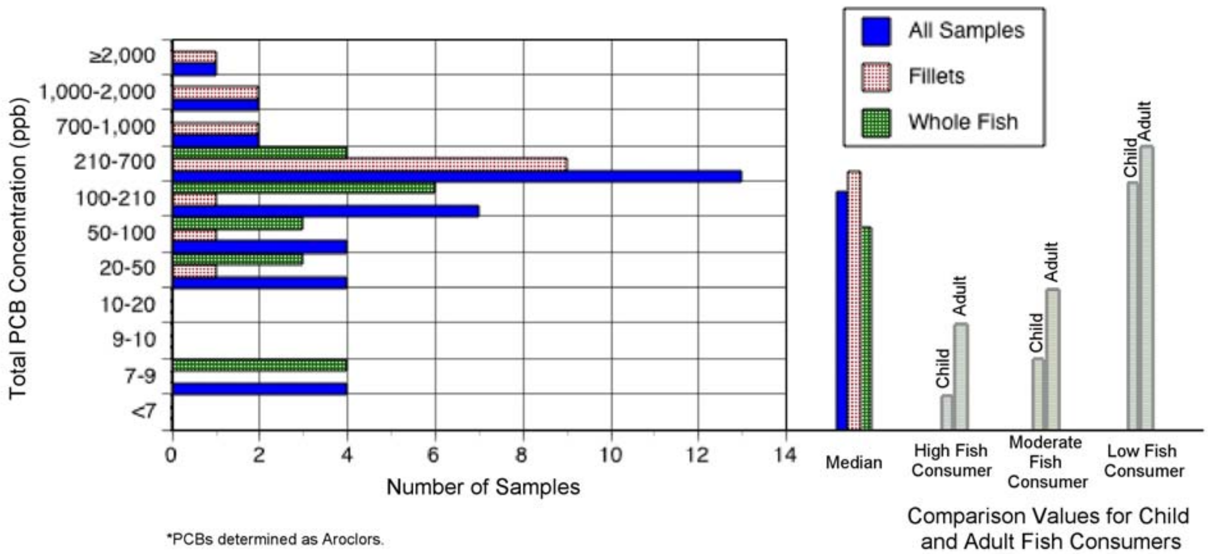
ATSDR evaluated fish data collected in 1996 or later and compared the PCB concentrations to ATSDR's PCB comparison values shown in Table 3. The data are again presented as histograms and medians to show the distribution and central tendencies of the contamination. Because total Aroclors provide more conservative estimates of fish contamination, these measurements were used to assess samples taken in 1996 and later.

The OREIS database contains PCB concentrations for both fillets and whole fish samples in the Lower Watts Bar Reservoir, Clinch River, and Tennessee River. Some people, especially subsistence and ethnic consumers, might prefer whole fish, while others might prepare and serve fillets almost exclusively. PCBs collect in fat; fillet muscle dissected away from the skin would have lower fat (and PCB) content than would whole fish served with skin and internal organs intact. But if only the fins, heads, tails, and innards are removed, the fillets would retain the fat under the skin and could have higher PCB concentrations than whole fish, whose inner organs might have less fat. To evaluate the most conservative PCB concentrations for fish sampled in the waterway, ATSDR compared both types of samples.

<u>Lower Watts Bar Reservoir Fillet and Whole Fish</u>

Figure 24 displays the distribution of PCBs in Lower Watts Bar Reservoir fillets and whole fish. Fillets contain higher PCB concentrations than do whole fish. The median concentrations for adults in the low fish-consumption group are below the PCB comparison value. Therefore, adults eating three fish meals per year or less eat too few fish for the PCB contamination in the reservoir to be a public health hazard. That said, the median PCB concentrations did exceed the PCB comparison values for both adults and children in the moderate and high fish consumer groups. Consequently, eating fish from Lower Watts Bar Reservoir is further evaluated in Section IV (Public Health Implications).

Figure 24. PCBs* in Lower Watts Bar Reservoir Fish



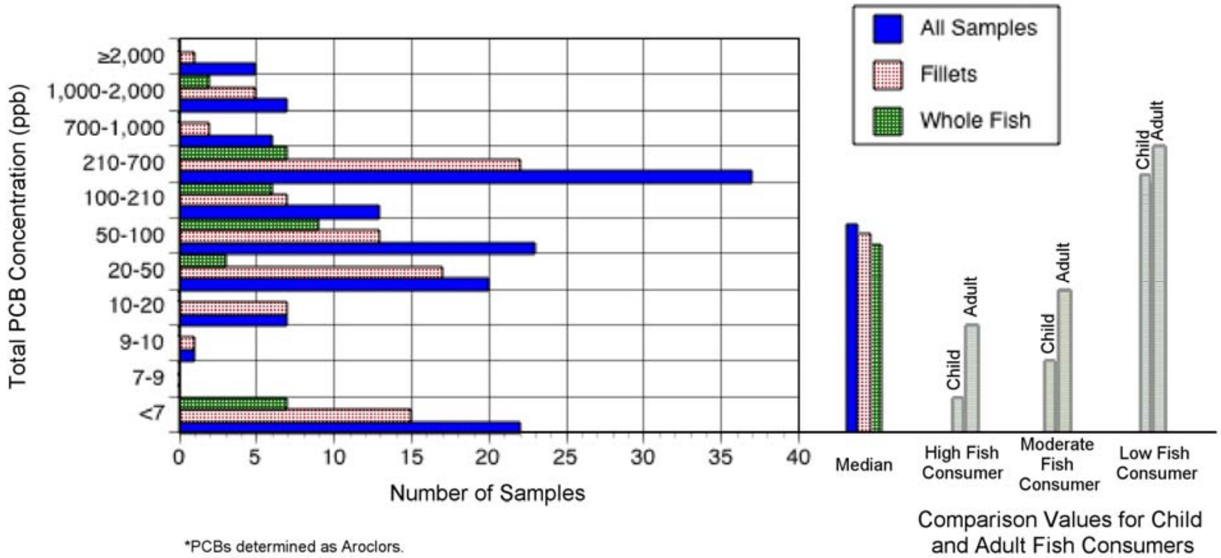
● Above CV
○ Below CV

Median Concentration	High Fish Consumer Comparison Values		Moderate Fish Consumer Comparison Values		Low Fish Consumer Comparison Values	
	Child (6 ppb)	Adult (10 ppb)	Child (9 ppb)	Adult (20 ppb)	Child (300 ppb)	Adult (700 ppb)
All Samples (190 ppb)	●	●	●	●	○	○
Fillets (320 ppb)	●	●	●	●	●	○
Whole Fish (88 ppb)	●	●	●	●	○	○

Clinch River Fillet and Whole Fish

Figure 25 shows a qualitatively similar pattern for fillets and whole fish taken from the Clinch River, although the difference between fillets and whole fish is less pronounced. Adults eating three fish meals per year or less eat too few fish for the PCB contamination in the river to be a public health hazard (i.e., the median concentrations for adults in the low fish consumption group are below the PCB comparison value). The median PCB concentrations did however exceed the PCB comparison values for both adults and children in the moderate and high fish consumer groups. Therefore, eating fish from the Clinch River is further evaluated in Section IV (Public Health Implications).

Figure 25. PCBs* in Clinch River Fish



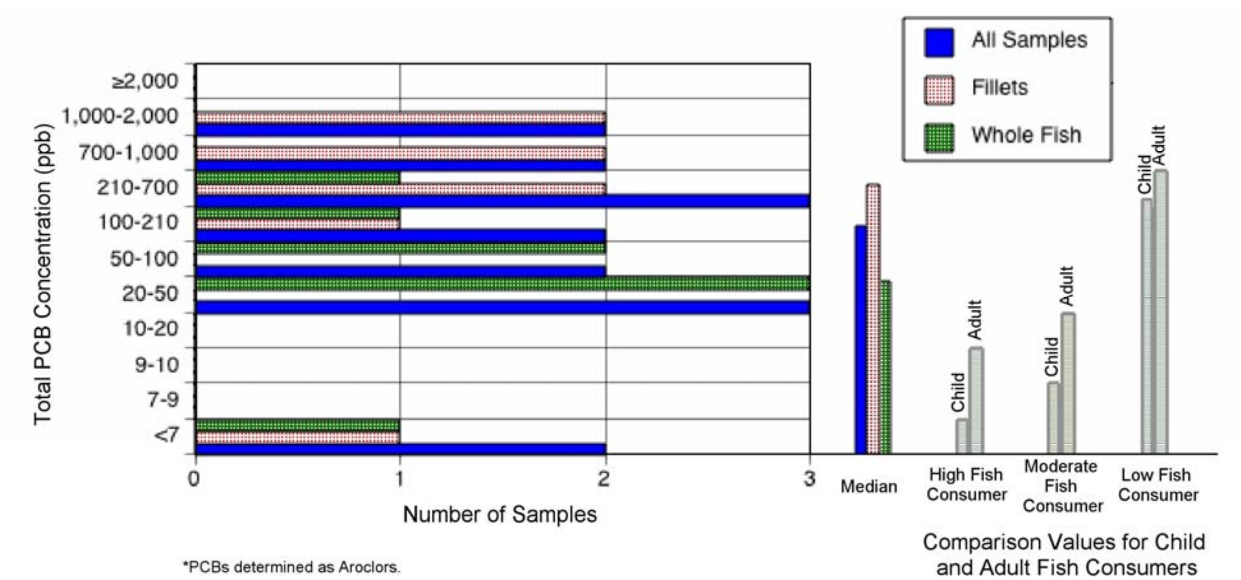
● Above CV
○ Below CV

Median Concentration	High Fish Consumer Comparison Values		Moderate Fish Consumer Comparison Values		Low Fish Consumer Comparison Values	
	Child (6 ppb)	Adult (10 ppb)	Child (9 ppb)	Adult (20 ppb)	Child (300 ppb)	Adult (700 ppb)
All Samples (91 ppb)	●	●	●	●	○	○
Fillets (62 ppb)	●	●	●	●	○	○
Whole Fish (77 ppb)	●	●	●	●	○	○

<u>Tennessee River Fillet and Whole Fish</u>

Figure 26 shows that distribution of PCB contamination of fillets and whole fish in the Tennessee River is more like that in the Lower Watts Bar Reservoir than in the Clinch River. Again, fillets contain higher PCB concentrations than do whole fish. The median concentrations for adults in the low fish consumption group are below the PCB comparison value. Therefore, adults eating three fish meals per year or less eat too few fish for the PCB contamination in the river to be a public health hazard. The median PCB concentrations did however exceed the PCB comparison values for both adults and children in the moderate and high fish consumer groups. Thus eating fish from the Tennessee River is further evaluated in Section IV (Public Health Implications).

Figure 26. PCBs* in Tennessee River Fish



● Above CV
○ Below CV

Median Concentration	High Fish Consumer Comparison Values		Moderate Fish Consumer Comparison Values		Low Fish Consumer Comparison Values	
	Child (6 ppb)	Adult (10 ppb)	Child (9 ppb)	Adult (20 ppb)	Child (300 ppb)	Adult (700 ppb)
All Samples (150 ppb)	●	●	●	●	○	○
Fillets (500 ppb)	●	●	●	●	●	○
Whole Fish (46 ppb)	●	●	●	●	○	○

Turtle Meat

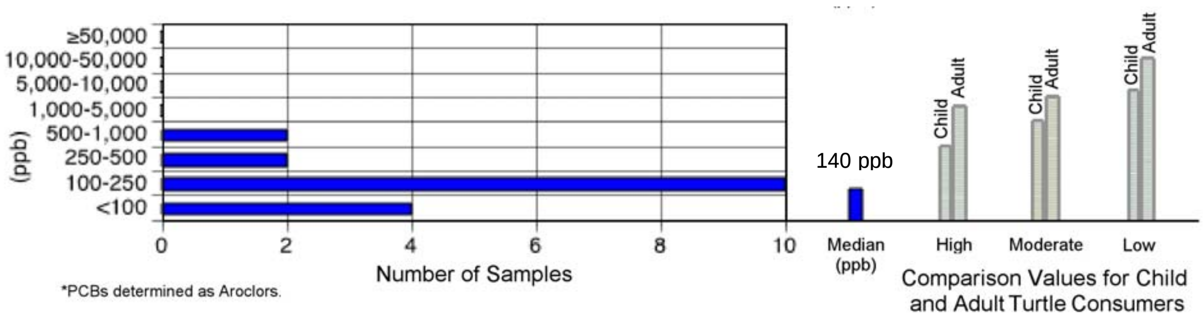
Studies conducted by DOE and TVA documented elevated levels of PCBs in certain species of fish in the Watts Bar Reservoir and Clinch River. As a result, TDEC issued several consumption advisories on fish. Although anglers are known to harvest turtles from the Watts Bar Reservoir, TDEC did not issue any consumption advisories on turtles. Moreover, little information was available on contaminant levels in turtles. Because of these fish advisories, community members were also concerned their consumption of turtle meat could cause illness. To respond to this concern, in the 1996 Health Consultation of the Lower Watts Bar Reservoir ATSDR recommended sampling of turtles for PCBs—previous studies from other states indicated that snapping turtles have a propensity to bioaccumulate PCBs. In the exposure investigation, ATSDR also included questions on turtle meat preparation and consumption patterns.

- **High consumption**
  two meals of turtle per year
- **Moderate consumption**
  one meal of turtle per year
- **Low consumption**
  one meal of turtle every 6 years

To evaluate levels of contaminants in turtles, in 1996 TDEC collected and analyzed the meat, fat, and eggs of 25 snapping turtles from 10 sampling stations in the Watts Bar Reservoir and Clinch River. ATSDR generated ORR-specific PCB comparison values for turtle meat (see Table 5) and used them in a histogram to show Watts Bar Reservoir PCB contamination of turtle meat, its distribution, and median.

The PCB concentrations are listed as Aroclors in Figure 27. The median PCB concentration for turtle meat (140 ppb) is displayed alongside the ATSDR PCB comparison values. Turtle meat is well below ATSDR's PCB comparison values for children and adults at all three turtle consumption levels. Because of the conservative considerations built into the PCB comparison values (e.g., the 300-fold safety factor, the sensitive species [monkeys], and the consumption levels) eating turtle meat is not a public health concern, and the turtle PCB pathway was eliminated from further consideration.

Figure 27. Total PCB* Concentrations in Watts Bar Reservoir Turtle Meat



PCBs in turtles are mostly stored in body fat. The median PCB concentration detected in turtle fat (44,000 ppb) is much higher than the median PCB concentrations detected in any other biota species (see Table 11). Therefore, people should avoid eating turtle fat. Discarding the fat, eggs, and all organs—while only saving the meat (muscle) for eating—can reduce exposure to PCB-contaminated fat and tissue.

Exposure Investigation of ORR Fish Consumers

Previous investigations of the Watts Bar Reservoir and Clinch River evaluated many contaminants but identified only PCBs in reservoir fish as a possible contaminant of health concern. These previous investigations did not, however, confirm that people are actually being exposed or that they have elevated levels of PCBs. ATSDR conducted the exposure investigation primarily because of the uncertainties involved in the quantitative risk assessment method of estimating exposure doses and excess cancer risk from ingestion of reservoir fish and turtles.

The purpose of the exposure investigation was to determine whether people consuming moderate to large amounts of fish and turtles from the Watts Bar Reservoir are accumulating high PCB body burdens. ATSDR invited local anglers to participate in an exposure investigation; 550 people volunteered for the exposure investigation and were screened for eligibility to participate. To be included as participants, within the previous year the volunteers had to eat one or more turtle meals, six or more meals of catfish and striped bass, nine or more meals of white, hybrid, or small mouth bass, or 18 or more meals of largemouth bass, sauger, or carp. They also had to be willing to submit blood samples. About one-fifth of the volunteers (116 people) met these criteria and were enrolled for interviews and collection of serum samples. The 116 participants in the exposure investigation lived in eight Tennessee counties and several other states (e.g., Kentucky, Ohio, and Florida). One participant lived (and fished) the Watts Bar Reservoir 2 months per year and spent the rest of his time living and fishing in Miami, Florida. Appendix F.

Summary Briefs and Fact Sheets contains a summary of ATSDR's exposure investigation (ATSDR 1998).

To collect information about fish consumption patterns of people who eat moderate to large amounts of fish, interviewers questioned participants about species consumed, how servings were prepared, how often they ate Watts Bar Reservoir fish and turtles, and how large the servings were. After reviewing their answers, ATSDR estimated the average consumption rate to be 66.5 g/day for moderate consumers of fish and 108 g/day for high consumers (the mean U.S. adult daily consumption rate is 20 grams of fish per day; U.S. EPA 1997).

ATSDR analyzed the participants' serum samples for PCBs. Of the 116 samples, serum PCB concentrations were below 20 μg/L in 112 samples, between 20 and 30 μg/L in three samples, and 103.8 μg/L in one sample from the person who lived and fished 10 months of the year in Miami, Florida. The median PCB concentration in the serum samples of ORR's highest 20 percent of fish and turtle consumers was 4.3 μg/L, with 95 percent of samples less than 17 μg/L. Although serum PCB levels corresponded poorly with fish consumption, those same levels matched up well with the ages of participants: no child was in the top 25 percent (less than 10 μg/L). The laboratory report included the statement: "Population-based studies by the Centers for Disease Control and Prevention (CDC) demonstrate that most people without occupational exposure have serum PCB levels in the μg/L range, with a median between 5 and 7 μg/L. Approximately 95 percent of the values are below 20 μg/L." By this measure, the serum PCB levels of participants—who identified themselves as moderate to high consumers of fish—are slightly below national norms for total PCBs.

Summary of Screening Results for 1996 to the Present

ATSDR reviewed environmental samples collected from 1996 to the present. As before, ATSDR screened nonbiological and biological exposure media separately. ATSDR also reevaluated data used for the 1998 exposure investigation in the context of ORR neighbors' media exposure. For nonbiological exposures, as well as for fish, ATSDR used the same PCB comparison values developed and discussed in the evaluation of past exposure. For turtle meat, ATSDR derived additional site-specific PCB comparison values based on the information provided during the Watts Bar Reservoir exposure investigation.

- Sediment taken 1996 and later was less contaminated than sediment sampled earlier. PCBs were not detected in most samples, and where PCBs were found, the concentrations were all below the ATSDR PCB comparison values for soil/sediment. As in the case of earlier samples, ATSDR found no sediment below any body of water or at any distance from sediment beds was sufficiently contaminated with PCBs that illness could result from any duration of exposure. Therefore, sediment is not a public health concern and will not be further evaluated.
- PCBs are not currently being released from the ORR into the air. The air pathway makes less of a contribution to PCB exposure than sediment or water. ATSDR has shown that sediment and water pathways did not carry sufficient PCB concentrations to be a public health hazard. Therefore, the air pathway from 1996 onward is also not a public health hazard and was not further evaluated.

- Waterborne PCB contamination is not a likely source of illness. Using the relative sediment and water solubility of PCBs, the potential maximum concentrations in the water are well below ATSDR's PCB comparison values for drinking water. Further, TDEC's Division of Water Supply regulates drinking water at all public water systems. According to EPA's Safe Drinking Water Information System, the Kingston and Spring City public water supply systems have not had any significant violations (U.S. EPA 2004b). Recreational exposure (e.g., from swimming or water-skiing) is even less likely to cause illness than drinking the water. Therefore, surface water and groundwater are not a public health hazard and will not be further evaluated.
- Fillets were more contaminated than whole fish for the Clinch River, Tennessee River, and Lower Watts Bar Reservoir. The median PCB concentrations exceeded the ATSDR comparison values for both adults and children in the moderate and high consumption groups. Therefore, consumption of fish was retained for further in-depth health effects evaluation (see Section IV. Public Health Implications).
- Turtle meat was not sufficiently contaminated to be a likely source of PCB-related illness. Because, however, PCBs in turtles are mostly stored in fat, people should avoid eating turtle fat.
- Serum PCB levels from moderate to high consumers of Watts Bar Reservoir fish are slightly below national norms for total PCBs.

Table 8 presents a brief summary of screening results of ATSDR's evaluation of current exposure to PCBs. All retained exposure media and pathways were further evaluated in Section IV (Public Health Implications).

Table 8. Summary of ATSDR's Screening Evaluation of Current Exposure to PCBs (1996 and Later)

Medium	***Source***	***Eliminated Not a Public Health Hazard***	***Retained for Further Health Effects Evaluation***
Sediment	East Fork Poplar Creek creek bed	All	None
	Clinch River riverbed	All	None
	≤4,393 ft. from Clinch River	All	None
Water	Used for drinking	All	None
	Recreational use	All	None
Air	All	All	None
Fish	Lower Watts Bar Reservoir fillets	Low-consuming adults	All other adults & children
	Lower Watts Bar Reservoir whole fish	Low- consuming adults, children	All other adults & children
	Tennessee River, Watts Bar Reservoir fillets	Low-consuming adults	All other adults & children
	Tennessee River, Watts Bar Reservoir whole fish	Low- consuming adults, children	All other adults & children
	Clinch River fillets	Low- consuming adults, children	All other adults & children
	Clinch River whole fish	Low- consuming adults, children	All other adults & children
Turtles	All	All	None