IV. Public Health Implications

IV.A. Introduction

In the previous section on evaluating contamination and potential exposure pathways, ATSDR conducted a screening evaluation of the PCB levels in each of the media found in the off-site waterways surrounding the ORR. This screening evaluation compared the measured concentration of PCB in each media to ATSDR's PCB comparison values and analyzed the measured PCB body-burden (serum PCB) of participants in the Watts Bar Reservoir exposure investigation. This screening evaluation allowed ATSDR scientists to confidently eliminate from further evaluation pathways not expected to cause adverse health effects. Most of the exposure pathways were eliminated, including direct and indirect exposures to the sediment, drinking and recreational use of the surface water, inhalation of the air, and consumption of turtles. Eating fish and geese exposure pathways were, however, retained for further in-depth health evaluation.

In this section on public health implications, the fish and geese ingestion pathways—which were not eliminated in the screening evaluation—proceed with a more in-depth health evaluation. ATSDR scientists compared the measured PCB body burdens from the exposure investigation to those found for the general population. ATSDR also conducted a critical review of available toxicological, medical, and epidemiological information to ascertain the PCB toxicity levels from occupational exposures and animal studies (levels of significant human exposure), and compared the estimated PCB doses from eating fish and geese to PCB doses that have been associated with disease and injury in humans and animals.

This health effects evaluation involves a balanced review and integration of site-related environmental data, site-specific exposure factors, and toxicological, epidemiological, and medical data. Its purpose is to help determine whether exposure to PCBs in Watts Bar Reservoir fish and geese might result in harmful effects. ATSDR also reviewed the scientific literature for consistency and the probability of noncancerous and cancerous effects being caused by the estimated doses. 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. The result is a qualitative discussion of whether site-related exposures are of sufficient nature and magnitude to trigger a public health action to limit, eliminate, or further study any potential harmful exposures.

The NOAEL is the highest tested dose of a substance in a study that has been reported to have no harmful (adverse) health effects on people or animals.
The LOAEL is the lowest tested dose of a substance in a study that has been reported to cause harmful (adverse) health effects in people or animals.

ATSDR compared estimated exposure doses to standard toxicity values. For noncancerous effects, ATSDR reviewed toxicological and epidemiological literature to evaluate the weight of evidence for adverse effects under site-specific conditions. ATSDR used the literature to find the PCB levels that represent no-observed-adverse-effect levels (NOAELs) or lowest-observed-adverse-effect levels (LOAELs) in the most sensitive species for the most sensitive outcome. To evaluate the potential for cancer to occur, ATSDR considers the relevance of such extrapolations to the lower exposure levels typical of human exposure to environmental contaminants.

ATSDR scientists evaluated several factors that determine whether health effects could result, and if so, the type and severity of health effects associated with exposure. These include exposure dose (how much of the substance is taken into the body), frequency (how often), and duration (how long); the route of exposure (breathing, eating, drinking, or skin contact); and the multiplicity of exposure (the combination of contaminants and pathways involved). Sometimes it is also possible to measure the amount of the substance that remains in the body (body burden) after exposure. Given an exposure and a resulting body burden, characteristics such as age, sex, nutritional status, genetics, lifestyle, and health status of the exposed person influence how the person absorbs, distributes, metabolizes, and excretes the contaminant. Together, those factors and characteristics determine the health effects that might result from the exposure.

The conclusions and recommendations are based on the professional knowledge and judgment of the health assessment team members. Because, however, of uncertainties regarding exposure conditions and adverse effects associated with environmental levels of exposures and body burdens, definitive answers are not possible on whether health effects will actually occur. Nevertheless, providing a framework that puts site-specific exposures and the potential for harm in perspective is possible. This is one of the primary goals of the public health assessment process.

IV.B. PCB Body Burdens

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. But these previous investigations only estimated the amount of PCB exposure from fish; they did not measure the levels in people, or determine whether the levels of PCBs were elevated. Because of the uncertainties in these previous investigations involving the estimated exposure doses and excess cancer risk from ingestion of fish and turtles, ATSDR conducted an exposure investigation to determine the body burden, or the actual amount of PCBs at a specific time, in the bodies of people who ate moderate to large amounts of fish and turtles.

Serum samples were drawn from the 116 highest fish consumers who volunteered for the study (ATSDR 1998). Serum PCB concentrations were below 20 μg/L in 112 samples, were between 20 and 30 μg/L in three samples, and one level was 103.8 μg/L in the one person who lived and fished 10 months per year in Miami, Florida. The median serum PCB concentration for the highest 20 percent of fish and turtle consumers was 4.3 μg/L, with 95 percent of samples less than 17 μg/L. The laboratory report included the following 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." Table 9 compares the median serum PCB levels from the Watts Bar Reservoir exposure investigation to those reported in other studies.

> PCBs have been found at more than 500 hazardous waste sites and are present in all environmental media. Food consumption is the major contributor to body burden of PCBs in the general population (ATSDR 2000).

Table 9. Median Serum PCB levels (ppb or ng/g lipid) in "fish-eaters"

Year	*Male*	*Female*
1973–1974	17.0	11.0
1979–1982	22.9	14.5
1989–1993	21.1	13.5
	Male/Female	
2000–2001	5.95	
WBR Exposure Investigation[a]	4.3	

Sources: ATSDR 1998; He et al. 2001; Schwartz 2000–2001
[a] Median serum PCB concentration for the highest 20% of fish and turtle consumers.

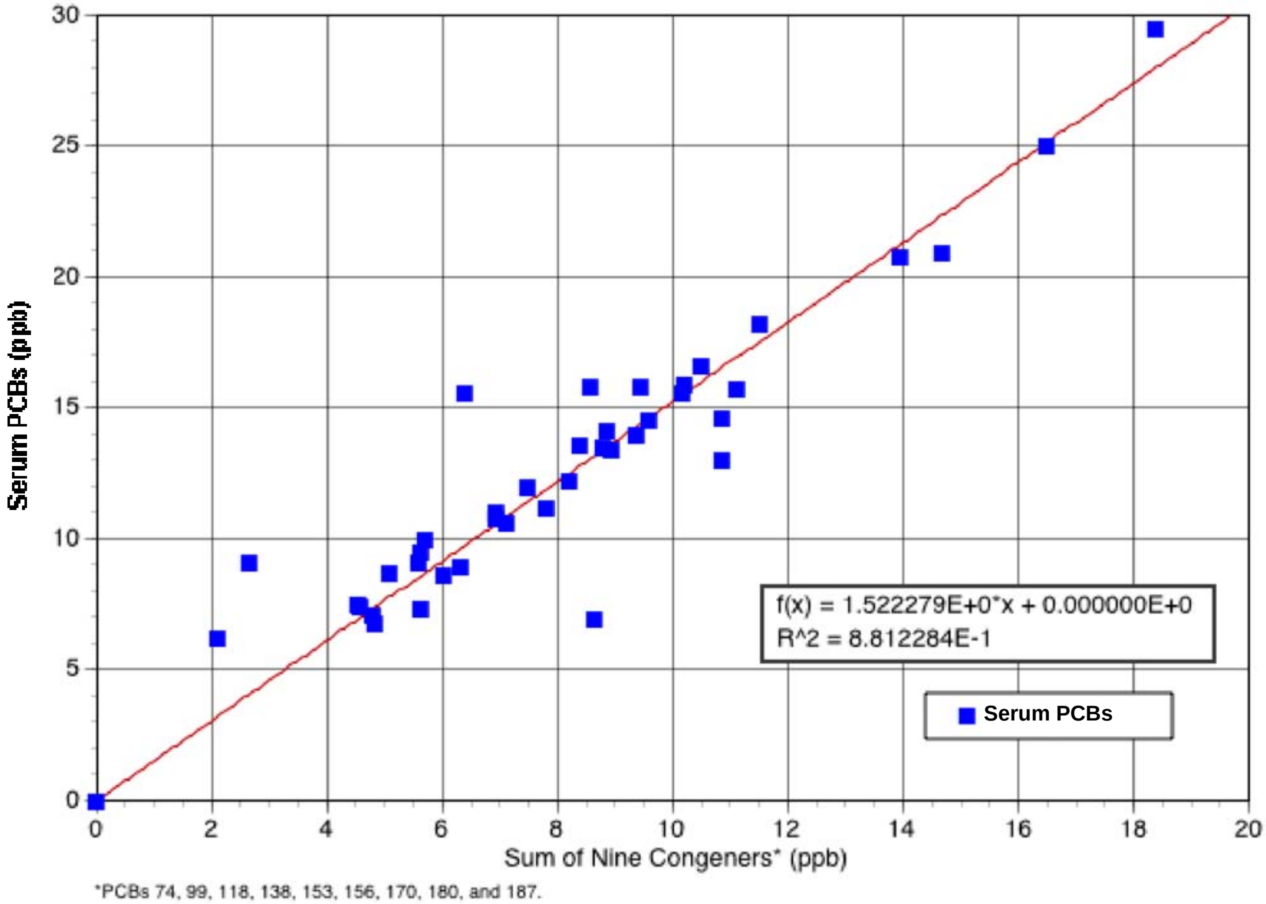
For comparison purposes, ATSDR compiled PCB data from studies available in ATSDR's Toxicological Profile for PCBs (ATSDR 2000). The studies were presented in three tables: 1) serum samples of persons not occupationally exposed who *did not* consume contaminated fish, 2) serum samples of persons not occupationally exposed who *did* consume contaminated fish, and 3) serum samples of persons who were *occupationally exposed*. ATSDR reviewed the original studies in the toxicological profile for additional details, and obtained the most recent laboratory data file from the National Center for Health Statistics on PCBs in the serum samples of the general U.S. population (NHANES 2005).

> The National Health and Nutrition Examination Survey (NHANES) is a nationally representative survey of the United States population. Detailed interviews, clinical, laboratory, and radiological examinations are conducted as part of the survey.

Although the National Health and Nutrition Examination Survey (NHANES) data (1999–2000) listed the serum concentration of individual PCB congeners, equivalent data that would allow comparison to exposure investigation participants were not provided. Nine of the congeners measured in the serum samples of the participants were included in the NHANES data. ATSDR plotted the sum of the serum concentrations of these nine congeners against serum PCB concentrations. ATSDR did this for each participant for which both congener and serum PCB information was available, with the exception of the one outlier. (The outlier's serum PCB levels differed from the mean of the others by more than 17 times their standard deviation. This serum belonged to the person who fished in Miami, Florida, 10 months of each year.) Figure 28 shows the plot, the best straight line passing through zero and the plotted points (called a linear regression), and the equation describing the straight line.

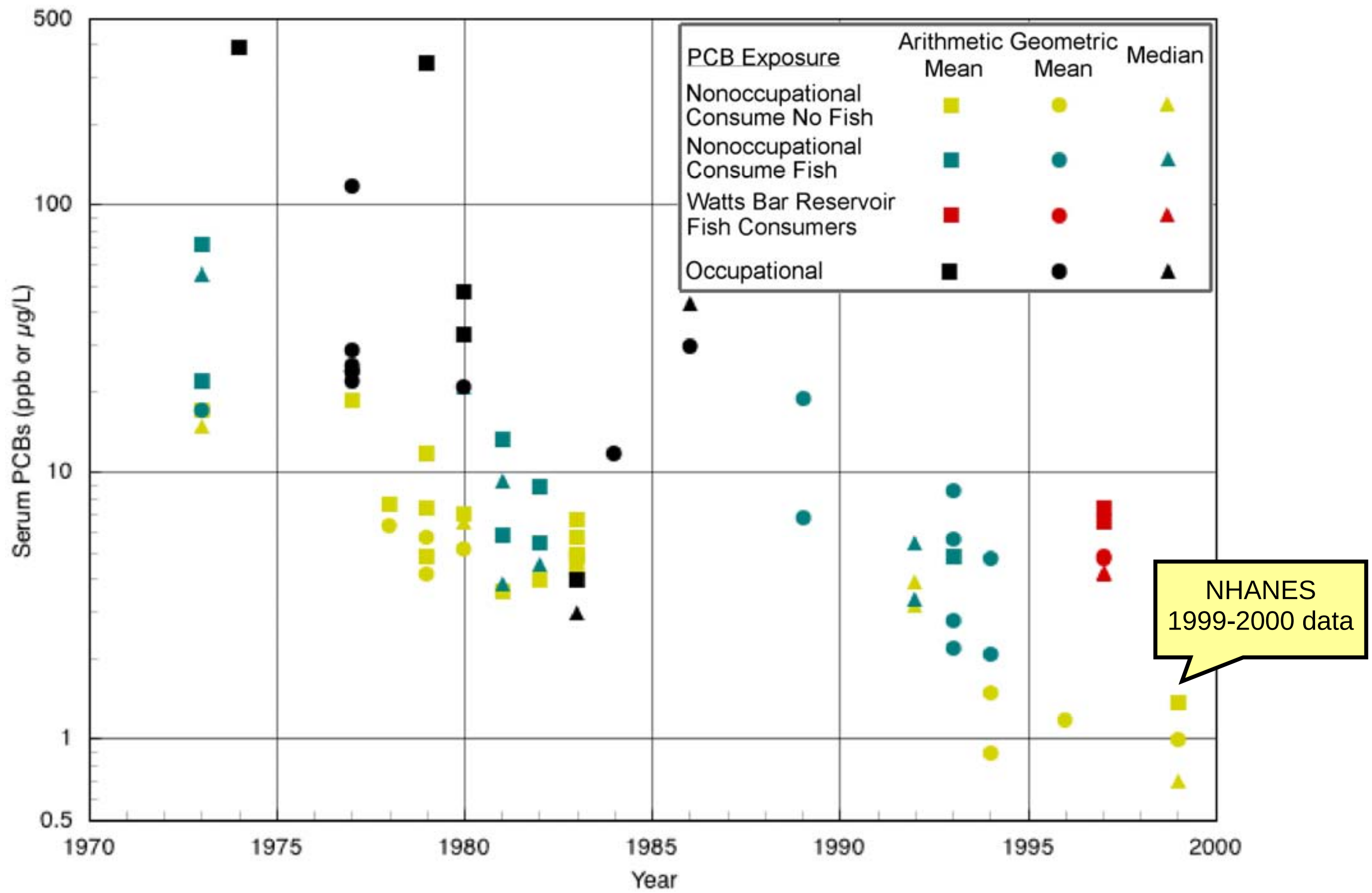
Using this equation, ATSDR assigned an equivalent, ORR-specific level to each serum sample in the NHANES data. This technique allowed ATSDR to compute measures of central tendency such as the median, mode, and arithmetic and geometric means for the NHANES data in the same way as the participants.

Figure 28. Linear Regression of ORR Serum PCBs vs. Congener Sums



ATSDR plotted measures of central tendency for serum PCBs from the toxicological profile, other selected studies, the NHANES data, and the exposure investigation in Figure 29 (ATSDR 1998, 2000; Chase et al. 1982; Fait et al. 1989; Maroni et al. 1981; NHANES 2005; Ouw et al. 1976; Sahl et al. 1985; Schwartz et al. 1983; Smith et al. 1982; Stehr-Green et al. 1986; Wolff et al. 1982). Figure 29 shows that people occupationally exposed to PCBs have greater body burdens of PCBs than people who consume PCB-contaminated fish. Fish consumers have greater body burdens than the general population, and the difference between fish consumers and nonconsumers has increased over time. Body burdens of Watts Bar Reservoir fish consumers are below people exposed occupationally, above nonfish consumers, and within the range for people who consume sport fish.

Figure 29. Comparison of Watts Bar Reservoir Fish Consumers to Exposed and Unexposed People Nationwide



The vertical axis representing serum PCB concentration is shown in logarithmic scale because of the disparity between body burdens resulting from occupational and non-occupational exposure.

IV.C. Health Evaluation

For the screening evaluation in Section III, ATSDR derived conservative ORR-specific PCB comparison values based on ATSDR's MRLs and consumption levels from the exposure investigation. As a result of this evaluation, eating fish and geese was retained for further in-depth evaluation, but eating turtles was eliminated as a potential concern. In this section, ATSDR estimates exposure doses (see text box for definition) and compares them to health effect levels reported in the toxicological literature.

> An exposure dose, expressed in milligrams per kilogram per day (mg/kg/day), represents the amount of contaminant that an individual is estimated to ingest (in milligrams), divided by the body weight of the individual (in kilograms) each day.

IV.C.1. Noncancerous Health Effects

ATSDR reviewed the scientific literature for noncancerous effects from exposure to PCBs. Ingestion of PCBs at high exposure doses has been shown to cause skin irritations, such as chloracne and rashes. The doses required to produce such effects are, however, quite high—daily occupational exposure doses ranging from 0.07 to 0.14 mg/kg/day failed to produce adverse health effects in workers (ATSDR 2000). Immunological effects were observed in female Rhesus monkeys chronically exposed to the LOAEL of 0.005 mg/kg/day of Aroclor 1254. Neurobehavioral effects were observed in infant monkeys exposed to 0.0075 mg/kg/day. A summary of the effects levels is presented in Table 10. See Chapter 3 of ATSDR's Toxicological Profile for Polychlorinated Biphenyls (http://www.atsdr.cdc.gov/toxprofiles/tp17-c3.pdf) for additional information.

Generally, humans appear to be less sensitive to the toxic effects of PCBs than do other animals. In laboratory animals, PCBs have been shown to produce skin effects (similar to those seen in people exposed at high doses) as well as effects on the thyroid, immune system, liver, toenails, and eyelids. Of the laboratory animals tested (i.e., rabbits, minks, mice, rats, ferrets, and monkeys), the rhesus monkey appears to be the most sensitive. PCBs have been shown to impair the monkey's immune system (in addition to producing skin, fingernail, and toenail effects), at doses as low as 0.005 mg/kg/day (Arnold et al. 1993; Tryphonas et al. 1989, 1991). This dose is 28 times lower than the dose shown not to harm people.

Table 10. Summary of Noncancerous Effect Levels from PCB Exposure

Literature on Effect Levels				
	Human, Occupational		Monkeys	
	Chloracne		Immunological	Neurobehavioral
	NOAEL	LOAEL	LOAEL	LOAEL
Estimated Dose (mg/kg/day)	0.14	No data available	0.005	0.0075

Source: ATSDR 2000
NOAEL = no-observed-adverse-effect level
LOAEL = lowest-observed-adverse-effect level

IV.C.2. Cancerous Effects

Overall, human studies provide suggestive evidence that PCBs are carcinogenic (ATSDR 2000). In contrast to human studies, conclusive evidence supports the view that commercial PCB mixtures are carcinogenic in animals (e.g., rats) based on induction of tumors in the liver and thyroid (ATSDR 2000). Scientists who tested PCBs for their cancer effects have only been able to show PCB-induced cancer in rats, which means that cancer did not develop in other animal species. The Department of Health and Human Services (DHHS) has concluded that PCBs may reasonably be anticipated to be carcinogens in humans. Both EPA and the International Agency for Research on Cancer (IARC) have determined that PCBs are probably carcinogenic to humans.

Using data reviewed for this health assessment and estimated exposure doses, ATSDR concludes cancer is an unlikely health outcome for people exposed to PCBs released from the ORR. The highest estimated exposure doses (calculated for people eating the most contaminated fish species at the "high" consumption rate) are 300 to 1,600 times below the levels proven to cause cancer in animals (cancer effect levels). All other estimated exposure doses are even lower. See Chapter 3 of ATSDR's Toxicological Profile for Polychlorinated Biphenyls (http://www.atsdr.cdc.gov/toxprofiles/tp17-c3.pdf) for further discussion.

> The occupational exposure studies strongly suggest that animal-based linear no-threshold estimate of cancer substantially overestimates the risk due to PCB exposures (ChemRisk 1999a; Kimbrough et al. 1999; Kimbrough et al. 2003; Laden et al. 2001b; Loomis et al. 1997; Moysich et al. 2002; Negri et al. 2003).

The occupational studies examining the cancer-causing effect of PCBs often have methodological limitations and have shown a lack of consistency across multiple studies (ATSDR 2000; U.S. EPA 2005). A small excess risk of liver-related cancer was found in studies of workers from two capacitor manufacturing plants in New York (2,567 workers) and Massachusetts (1,599 workers). A 1999 study of more than 7,000 capacitor workers employed at least 3 months and followed an average of more than 30 years described exposures up to 1,500 micrograms per cubic meter ($\mu g/m^3$) of workplace air. The study found no excess liver cancers and could not verify findings of increased incidence of cancers in other organs suggested by previous smaller studies (Kimbrough et al. 1999). The overall cancer rate among women in the Kimbrough study was unchanged from the general population, while the rate among men was significantly *lower* (by 19 percent) than expected. A 5-year follow up of this study of industrial exposures confirmed the earlier results (Kimbrough et al. 2003).

Kimbrough's studies are not the only ones to look for cancer in general or in specific tissues of people exposed to PCBs at their workplaces—ATSDR found numerous studies (e.g., Bertazzi et al. 1987; Bosetti et al. 2003; Brown 1987; Brown and Jones 1981; Charles et al. 2003; Faroon et al. 2001; Golden et al. 2003; Gustavsson and Hogstedt 1997; Gustavsson et al. 1986; Hardell et al. 2003; Loomis et al. 1997; Ritchie et al. 2003; Sinks et al. 1992; Wong 1995; and Yassi et al. 1994). Studies with the most subjects were the least likely to find increased cancer rates, suggesting that other studies were picking up variabilities inherent in small populations or study groups. One study of more than 138,000 utility workers found significantly decreased rates for cancer overall and for cancers of the liver, rectum, pancreas, and respiratory tract. Cancers of blood components were not significantly affected (Loomis et al. 1997). Similarly, the recent scientific literature of breast cancer studies do not support increased risk of breast cancer among women with environmental exposure to PCBs.

A technique known as physiologically based pharmacokinetic (PBPK) modeling incorporates information about how a substance and its degradation products are absorbed, chemically modified, moved within the body, and eliminated. When PBPK was used to compare how different species treat PCBs and their metabolites, many inconsistencies were found, making cross-species predictions highly uncertain (ATSDR 2000). These differences might explain the absence of cancer in animals (other than rats) and humans following exposure.

IV.C.3. Dose Estimation

ATSDR reviewed more than 52,000 records of PCBs in ORR biota. Median PCB concentrations ranged from 22 ppb for sunfish/bluegill fillets from the Clinch River to 1,270 ppb for catfish fillets taken from the Lower Watts Bar Reservoir (see Table 11). Fillet samples had higher concentrations of PCBs than whole fish (see Section III for more details). In addition, total PCBs summed from Aroclors exceeded those from the individual congeners (see Appendix E. PCBs Measured as Total Congeners or Total Aroclors for more details). The median PCB concentration in goose muscle was 320 ppb.

Table 11. Median PCB* Concentrations (ppb) in Biota

Species†	*Poplar Creek*	*Clinch River*	*Tennessee River*	*Lower Watts Bar Reservoir*
Sunfish species	40	22	NS	NS
Largemouth Bass	130	400	300	200
White, Striped, & Hybrid Bass	NS	1,000	730	440
Catfish species	920	900	1,240	1,270
Goose muscle	320 (site-wide)			

*PCBs measured as total Aroclors.
†Includes fillet and muscle samples of known fish species only.
NS = not sampled

During the screening evaluation (see Section III), ATSDR estimated doses from consuming high, moderate, and low amounts of the different species of fish from Poplar Creek, the Clinch River, the Tennessee River, and the Lower Watts Bar Reservoir. To give fish consumers some additional perspective and to determine a safe consumption rate, ATSDR estimated five levels of fish consumption (see text box) during the in-depth evaluation. The following equation was used to estimate ingestion of PCBs:

Fish Consumption Rates

- **High consumption**
  three meals of fish per week
- **Moderate consumption**
  two meals of fish per week
  one meal of fish per week
- **Low consumption**
  one meal of fish per month
  three meals of fish per year

One adult meal of fish is considered to be 8 ounces (227 grams). Children were assumed to eat one-third as much as adults.

$$\text{Estimated exposure dose} = \frac{C \times CR \times IR \times EF \times ED}{BW \times AT}$$

where:

C	=	Concentration (mg/kg): see Table 11
CR	=	Cooking Reduction (unitless): 0.7 for fish*
IR	=	High Consumption: 0.108 kg/day for adults; 0.036 kg/day for children
		Moderate Consumption: 0.0665 kg/day for adults; 0.0222 kg/day for children
		0.032 kg/day for adults; 0.011 kg/day for children
		Low Consumption: 0.00195 kg/day for adults; 0.0025 kg/day for children
		0.0074 kg/day for adults; 0.0222 kg/day for children
EF	=	Exposure Frequency: 365 days/year
ED	=	Exposure Duration: 30 years for adults; 6 years for children
BW	=	Body Weight: 70 kg for adults; 10 kg for children
AT	=	Averaging Time: 10,950 days for adults; 2,190 days for children

* For fish, ATDSR assumed a 30% skinning/trimming/cooking loss associated with PCBs. Several studies have reported PCB reductions ranging from 14 to 80% due to skinning, trimming, or cooking fish (U.S. EPA 2000).

ATSDR used the following equation to estimate doses from consuming high, moderate, and low amounts of Canada geese:

Goose Consumption Rates

- **High consumption**
  one meal of goose per week
- **Moderate consumption**
  two meals of goose per month
- **Low consumption**
  one meal of goose per year

One adult meal of goose is between 6 and 8 ounces. Children were assumed to eat one-third as much as adults.

$$\text{Estimated exposure dose} = \frac{C \times CR \times IR \times EF \times ED}{BW \times AT}$$

where:

C	=	Concentration (mg/kg): see Table 11
CR	=	Cooking Reduction (unitless): 1.0 for geese*
IR	=	High Consumption: 0.027 kg/day for adults; 0.009 kg/day for children
		Moderate Consumption: 0.017 kg/day for adults; 0.0056 kg/day for children
		Low Consumption: 0.0005 kg/day for adults; 0.00016 kg/day for children
EF	=	Exposure Frequency: 365 days/year
ED	=	Exposure Duration: 30 years for adults; 6 years for children
BW	=	Body Weight: 70 kg for adults; 10 kg for children
AT	=	Averaging Time: 10,950 days for adults; 2,190 days for children

* No cooking reduction was assumed for geese.

The following highlight the most noteworthy results (see Table 12, Figure 30, and Figure 31).

- Due to their lower body weights, children's exposures are slightly higher than are adult exposures.
- None of the calculated exposure doses are higher than the LOAEL of 0.005 mg/kg/day.

- The worst-case fish consumption scenario assumes people exclusively eat catfish fillets from the Lower Watts Bar Reservoir (1,270 ppb) at the high consumption rate for a lifetime. The calculated PCB doses for this scenario are 2 to 4 times below the LOAEL. The calculated doses are more than 100 times less than the PCB doses shown to cause cancer in rats.
- The doses from eating catfish from all four water bodies one or more times a week for children and two or more times a week for adults, are within an order of magnitude of the LOAEL.
- Eating sunfish from Poplar Creek or the Clinch River at the high consumption rate would result in child and adult exposure doses that are well below (more than 50 times less than) the LOAEL.[3]
- The estimated exposure doses from low consumption of all species of fish from all four water bodies are well below (86 to 12,000 times less than) the LOAEL.
- Eating Canada geese at high, moderate, or low consumption rates is estimated to result in exposure doses below (at least 17 times less than) the LOAEL.

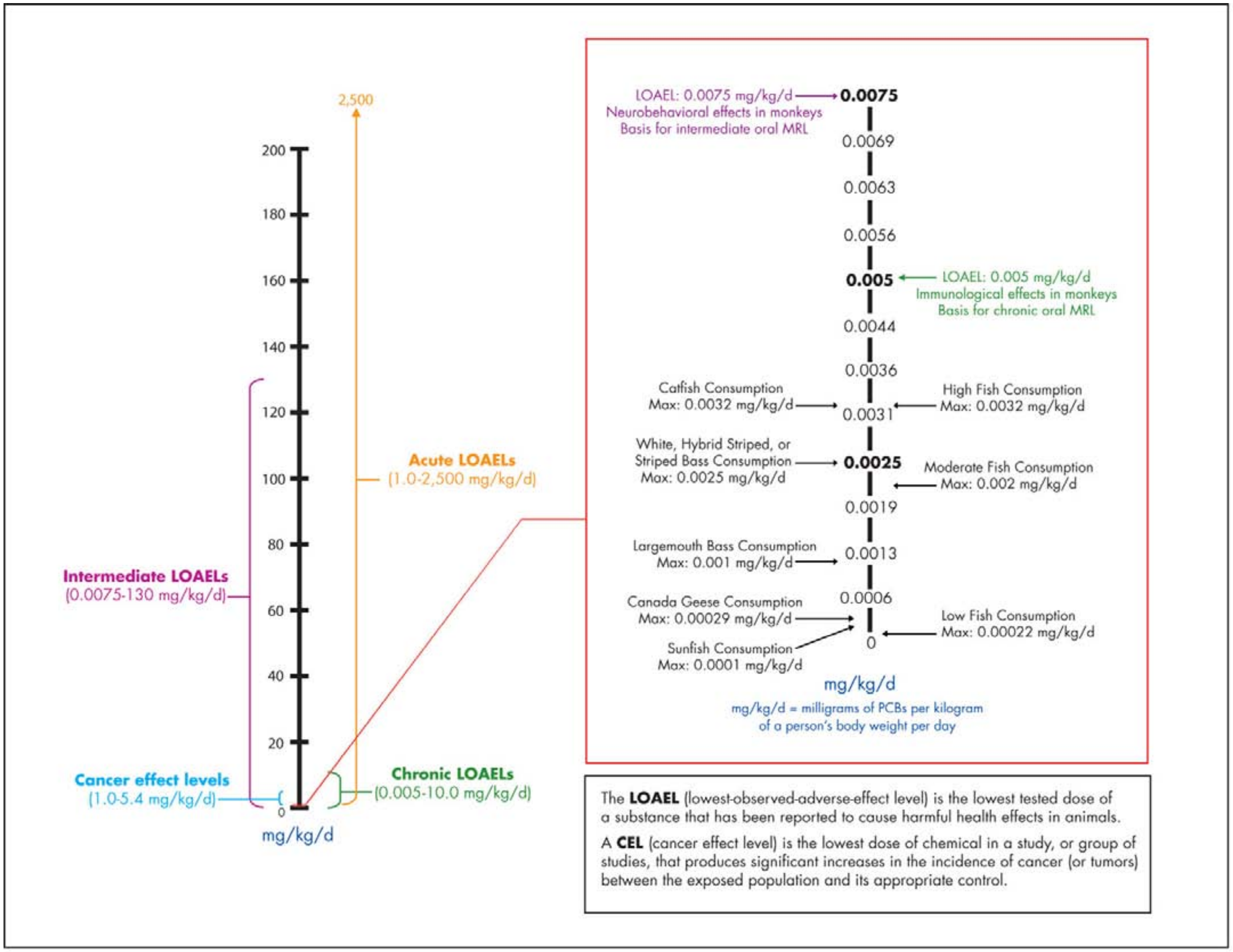
[3] Sunfish, however, were not sampled in the Tennessee River or the Lower Watts Bar Reservoir. After reviewing the levels detected in sunfish from Poplar Creek and the Clinch River and their trophic level in the aquatic food chain, ATSDR does not expect high PCB concentrations in sunfish from either water body.

1 **Table 12. Summary of PCB Doses for Consumers of Fish and Geese**

Location and Species	***High Consumer Doses (mg/kg/day) 3 meals/week***		***Moderate Consumer Doses (mg/kg/day)***				***Low Consumer Doses (mg/kg/day)***			
			2 meals/week		***1 meal/week***		***1 meal/month***		***3 meals/year***	
	Child	***Adult***	***Child***	***Adult***	***Child***	***Adult***	***Child***	***Adult***	***Child***	***Adult***
Poplar Creek										
Sunfish species	1.0E-04	4.3E-05	6.2E-05	2.7E-05	3.1E-05	1.3E-05	7.0E-06	3.0E-06	1.8E-06	7.8E-07
Largemouth Bass	3.3E-04	1.4E-04	2.0E-04	8.6E-05	1.0E-04	4.2E-05	2.3E-05	9.6E-06	5.9E-06	2.5E-06
White, Hybrid, Striped Bass	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Catfish species	**2.3E-03**	**9.9E-04**	**1.4E-03**	**6.1E-04**	**7.1E-04**	2.9E-04	1.6E-04	6.8E-05	4.2E-05	1.8E-05
Clinch River										
Sunfish species	5.5E-05	2.4E-05	3.4E-05	1.5E-05	1.7E-05	7.0E-06	3.9E-06	1.6E-06	1.0E-06	4.3E-07
Largemouth Bass	**1.0E-03**	4.3E-04	**6.2E-04**	2.7E-04	3.1E-04	1.3E-04	7.0E-05	3.0E-05	1.8E-05	7.8E-06
White, Hybrid, Striped Bass	**2.5E-03**	**1.1E-03**	**1.6E-03**	**6.7E-04**	**7.7E-04**	3.2E-04	1.8E-04	7.4E-05	4.6E-05	2.0E-05
Catfish species	**2.3E-03**	**9.7E-04**	**1.4E-03**	**6.0E-04**	**6.9E-04**	2.9E-04	1.6E-04	6.7E-05	4.1E-05	1.8E-05
Tennessee River										
Sunfish species	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Largemouth Bass	**7.6E-04**	3.2E-04	4.7E-04	2.0E-04	2.3E-04	9.6E-05	5.3E-05	2.2E-05	1.4E-05	5.9E-06
White, Hybrid, Striped Bass	**1.8E-03**	**7.9E-04**	**1.1E-03**	4.9E-04	**5.6E-04**	2.3E-04	1.3E-04	5.4E-05	3.3E-05	1.4E-05
Catfish species	**3.1E-03**	**1.3E-03**	**1.9E-03**	**8.2E-04**	**9.5E-04**	4.0E-04	2.2E-04	9.2E-05	5.6E-05	2.4E-05
Lower Watts Bar Reservoir										
Sunfish species	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Largemouth Bass	**5.0E-04**	2.2E-04	3.1E-04	1.3E-04	1.5E-04	6.4E-05	3.5E-05	1.5E-05	9.1E-06	3.9E-06
White, Hybrid, Striped Bass	**1.1E-03**	4.8E-04	**6.8E-04**	2.9E-04	3.4E-04	1.4E-04	7.7E-05	3.3E-05	2.0E-05	8.6E-06
Catfish species	**3.2E-03**	**1.4E-03**	**2.0E-03**	**8.4E-04**	**9.8E-04**	4.1E-04	2.2E-04	9.4E-05	5.8E-05	2.5E-05
Site Wide	***High (1 meal/week)***		***Moderate (2 meals/month)***				***Low (1 meal/year)***			
Canada Geese	2.9E-04	1.2E-04	1.8E-04		7.8E-05		5.1E-06		2.3E-06	

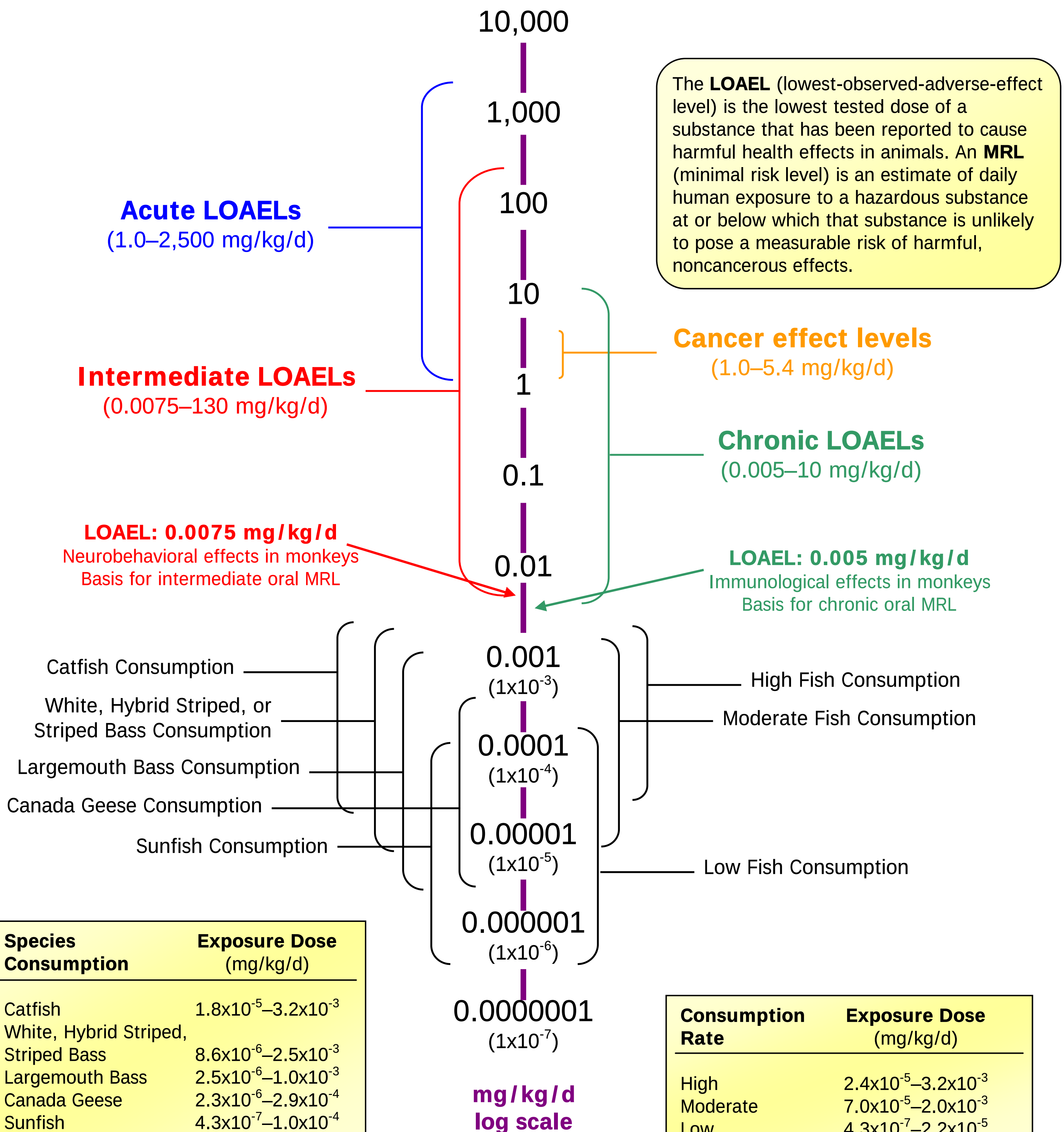
2 ATSDR assumed a 30% reduction of PCBs from skinning, trimming, and cooking the fish. No reduction was applied for eating geese.
3 PCBs measured as total Aroclors.
4 Includes fillet and muscle samples of known fish species only.
5 **Bold text** indicates that the dose *approaches* the LOAEL of 5.0E-03 mg/kg/day (ATSDR 2000) (i.e., are within an order of magnitude). None of the calculated
6 exposure doses are higher than the LOAEL.
7 mg/kg/day = milligrams per kilogram per day NS = not sampled

Figure 30. PCB Effect Levels* and Oral Exposure Doses (linear scale)



*All effect levels were observed in laboratory animals (e.g., rats and monkeys).

Figure 31. PCB Effect Levels* and Oral Exposure Doses (log scale)



Species Consumption	Exposure Dose (mg/kg/d)
Catfish	$1.8x10^{-5}$–$3.2x10^{-3}$
White, Hybrid Striped, Striped Bass	$8.6x10^{-6}$–$2.5x10^{-3}$
Largemouth Bass	$2.5x10^{-6}$–$1.0x10^{-3}$
Canada Geese	$2.3x10^{-6}$–$2.9x10^{-4}$
Sunfish	$4.3x10^{-7}$–$1.0x10^{-4}$

Consumption Rate	Exposure Dose (mg/kg/d)
High	$2.4x10^{-5}$–$3.2x10^{-3}$
Moderate	$7.0x10^{-5}$–$2.0x10^{-3}$
Low	$4.3x10^{-7}$–$2.2x10^{-5}$

mg/kg/d = milligrams of PCBs per kilogram of a person's body weight per day

*All effect levels were observed in laboratory animals (e.g., rats and monkeys).

IV.C.4. Benefits from Fish Consumption

A healthy diet that includes lean sources of protein (such as grilled, broiled, or baked fish) can provide health benefits. Much of the research regarding beneficial effects of consuming fish surrounds species with higher levels of omega-3 fatty acids (e.g., sardines, mackerel, tuna, herring, trout, and salmon). The scientific literature regarding the health benefits from eating fresh water species is not as robust as with saltwater species. The following text provides suggestive evidence that fish consumption provides 1) beneficial developmental effects, 2) decreased incidence or mortality from cancer, and 3) improvements in heart health.

- *Developmental Effects*. Higher developmental scores were reported in children at 15 months of age from women eating fish (omega-3 rich) one to four times per week compared to those of women who seldom ate fish. The children were tested for social activity, vocabulary, and language; all improved with increased fish consumption (Daniels et al. 2004). Further, another study found that maternal fish intake in late pregnancy decreased the frequency of intrauterine growth retardation (Rogers et al. 2004).
- *Cancer*. Observations of protection against breast cancer among fisherman's wives in Norway date back at least a decade (Lund and Bonaa 1993). Larsson et al. (2004) reviewed studies showing that omega-3 fatty acid (fish) consumption protects against breast cancer by several mechanisms. The incidence of both breast and colorectal cancer is decreased to the degree people consume increasing amounts of omega-3 rich fish (Caygill et al. 1996; de Deckere 1999).
- *Heart Disease*. One of the most serious complications of diabetes is increased risk of mortality from coronary artery disease. But fish (omega-3 rich) intake shows significant protection, at least in women, against atherosclerosis (Connor 2004; Erkkila et al. 2004), as well as against coronary heart disease and total mortality (Hu et al. 2003). Fish intake (tuna or other broiled or baked fish, but not fried fish) also lowers the risk of incident atrial fibrillation (Mozaffarian et al. 2004).

IV.C.5. Conclusions

All of the estimated exposure doses that ATSDR calculated are below the lowest health effect level reported in the scientific literature (LOAEL of 0.005 mg/kg/day). Eating moderate to high amounts (i.e., one or more meals per week for children and two or more meals per week for adults) of catfish, white bass, hybrid bass (striped bass-white bass), or striped bass from Poplar Creek,[4] the Clinch River, the Tennessee River, and the Lower Watts Bar Reservoir are, however, less than an order of magnitude below this dose (LOAEL). The doses for children eating moderate to high amounts (two or more times a week) of largemouth bass from the Clinch River and the Tennessee River are also within an order of magnitude of the LOAEL.

Estimated exposure doses within an order of magnitude of the LOAEL are of health concern and warrant further consideration. This effect level is reported in a study in which female Rhesus monkeys were chronically exposed to Aroclor 1254 (Tryphonas et al. 1989, 1991). The effects

[4] White, hybrid striped, and striped bass were not sampled in Poplar Creek.

were measurable, but whether the clinical relevance of the effects from the study has been demonstrated is the subject of some debate. Interpretation of the adversity of the reported effects is "complicated by a lack of data on immunocompetence and the essentially inconclusive findings in the other tested end points" (ATSDR 2000). Therefore, it is unclear whether the reported effects would actually cause adverse health effects.

> Cancer is not expected to result from eating PCB-contaminated fish near the ORR.

Despite the uncertainties involved, prudent public health practice would limit consumption of *certain species of fish* from Poplar Creek, the Clinch River, Tennessee River, and Lower Watts Bar Reservoir, due to the level of PCBs detected (see Table 13 and Figure 1). Certain sensitive populations, such as children and pregnant women, should be particularly careful to avoid eating *certain species of fish* from these water bodies, since exposure to PCBs might cause developmental problems.

- Children should avoid eating moderate to high amounts (one or more 2.7-ounce meals of fish per week) of catfish, white bass, hybrid bass, or striped bass from Poplar Creek,[5] the Clinch River, the Tennessee River, and the Lower Watts Bar Reservoir.
- Adults should avoid eating moderate to high amounts (two or more 8-ounce meals of fish per week) of catfish, white bass, hybrid bass, or striped bass from Poplar Creek,[5] the Clinch River, and the Tennessee River.
- Children should avoid eating moderate (two or more 2.7-ounce meals of fish per week) to high (three or more 2.7-ounce meals of fish per week) quantities of largemouth bass from the Clinch River and the Tennessee River, respectively.

ATSDR's chief mission in conducting a PHA is to address issues of public health, not simply to assess toxicity levels. Fish is a healthy food—often more so than food that might be substituted for it. Eating less fish than necessary to protect oneself from contaminants means receiving less of the nutritional benefits. Therefore, it is also important to point out what species of fish are safe to eat and from where those species may safely be taken.

- Sunfish species are safe to eat in any amount from Poplar Creek, the Clinch River, the Tennessee River,[6] and the Lower Watts Bar Reservoir.[6]
- Largemouth bass from Poplar Creek and the Lower Watts Bar Reservoir are safe to eat, even in high amounts (three 8-ounce meals of fish per week). Adults can also safely consume high amounts of largemouth bass from the Clinch River and the Tennessee River. Children can safely consume moderate amounts (one 2.7-ounce meal of fish per week from the Clinch River and two 2.7-ounce meals of fish per week from the Tennessee River) of largemouth bass.

[5] White bass, hybrid striped bass, and striped bass were not sampled in Poplar Creek, however, based on the levels detected in the other water bodies, children and adults would be well advised to limit their consumption from Poplar Creek as well.

[6] Sunfish were not sampled in the Tennessee River or the Lower Watts Bar Reservoir. Nevertheless, given the levels detected in sunfish from Poplar Creek and the Clinch River and their trophic level in the aquatic food chain, ATSDR does not expect high PCB concentrations in sunfish from either water body.

- Low quantities (i.e., up to one fish meal per month) of any species of fish are safe to eat, even catfish.
- Canada geese are safe to eat in any amount.

Of course whenever possible, exposure to environmental contamination should be reduced. If concerned community members wish to reduce their exposure to PCBs without forfeiting the healthy benefits from eating fish, they can follow the suggestions in EPA and ATSDR's *A Guide to Healthy Eating of the Fish You Catch* (see Appendix F. Summary Briefs and Fact Sheets):

- Eat the less fatty parts of the fish; throw away skin, fat deposits, head, guts, kidneys, and liver.
- Remove the skin and the strip of light-colored fat that remains along the belly flap at the bottom of the fillet as well as any fat that may be present along the sides and the midpoint of the back.
- Grill, broil, or bake fish on a rack to allow fat—and chemicals—to drain away. This helps remove pollutants stored in the fatty parts of the fish. Avoid frying for larger, fatty fish.
- Do not reuse cooking liquids or fat drippings from the fish since these liquids retain PCBs.
- Choose to eat younger (or smaller) fish and those lower on the food chain (e.g., sunfish).
- 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.

Table 13. Recommended Number of Fish and Geese Meals, Based on Levels of PCBs Detected

Species	***Child Consumption***					***Adult Consumption***					***Location***
	High	***Moderate***		***Low***		***High***	***Moderate***		***Low***		
	1/week	***2/month***		***1/year***		***1/week***	***2/month***		***1/year***		
Canada Geese	○	○		○		○	○		○		Site-wide
	High	***Moderate***		***Low***		***High***	***Moderate***		***Low***		
	3/week	***2/week***	***1/week***	***1/month***	***3/year***	***3/week***	***2/week***	***1/week***	***1/month***	***3/year***	
Sunfish species	○*	○*	○*	○*	○*	○*	○*	○*	○*	○*	LWBR
	○	○	○	○	○	○	○	○	○	○	Poplar Creek
	○	○	○	○	○	○	○	○	○	○	Clinch River
	○*	○*	○*	○*	○*	○*	○*	○*	○*	○*	Tennessee River
Largemouth Bass	○	○	○	○	○	○	○	○	○	○	LWBR
	○	○	○	○	○	○	○	○	○	○	Poplar Creek
	●	●	○	○	○	○	○	○	○	○	Clinch River
	●	○	○	○	○	○	○	○	○	○	Tennessee River
White, Hybrid, Striped Bass	●	●	○	○	○	○	○	○	○	○	LWBR
	●*	●*	●*	○*	○*	●*	●*	○*	○*	○*	Poplar Creek
	●	●	●	○	○	●	●	○	○	○	Clinch River
	●	●	●	○	○	●	○	○	○	○	Tennessee River
Catfish species	●	●	●	○	○	●	●	○	○	○	LWBR
	●	●	●	○	○	●	●	○	○	○	Poplar Creek
	●	●	●	○	○	●	●	○	○	○	Clinch River
	●	●	●	○	○	●	●	○	○	○	Tennessee River

○	Safe to eat
●	Limit Consumption[§]

*Not sampled

[§]It would be prudent public health practice to limit consumption.

One adult meal of fish is considered to be 8 ounces (227 grams). One adult meal of goose is between 6 and 8 ounces. Children were assumed to eat one-third as much as adults.

LWBR = Lower Watts Bar Reservoir

V. Health Outcome Data Evaluation

Health outcome data are measures of disease occurrence in a population. Common sources of health outcome data are existing databases (cancer registries, birth defects registries, and death certificates) that measure morbidity (disease) or mortality (death). Health outcome data can provide information on the general health status of a community—where, when, and what types of diseases occur and to whom they occur. Public health officials use health outcome data to look for unusual patterns or trends in disease occurrence by comparing disease occurrences in different populations over periods of years. These health outcome data evaluations are descriptive epidemiologic analyses. They are exploratory in that they provide additional information about human health effects and they are useful in that they help identify the need for public health intervention activities (for example, community health education). That said, however, health outcome data cannot—and are not meant to—establish cause and effect between environmental exposures to hazardous materials and adverse health effects in a community.

ATSDR scientists generally consider health outcome data evaluation when a plausible, reasonable expectation emerges of adverse health effects associated with the observed levels of exposure to contaminants. In this PHA on PCB releases, ATSDR scientists determined that people eating *certain species of fish* from Poplar Creek, the Clinch River, Tennessee River, and Lower Watts Bar Reservoir could be exposed to PCBs.

Criteria for Conducting a Health Outcome Data Evaluation

To determine how to use or analyze health outcome data in the public health assessment process, or even whether to use it at all, ATSDR scientists receive input from epidemiologists, toxicologists, environmental scientists, and community involvement specialists. These scientists consider the following criteria, based only on site-specific exposure considerations, to determine whether a health outcome data evaluation should be included in the PHA.

1. Is there at least one current (or past) potential or completed exposure pathway at the site?
2. Can the time period of exposure be determined?
3. Can the population that was or is being exposed be quantified?
4. Are the estimated exposure doses(s) and the duration(s) of exposure sufficient for a plausible, reasonable expectation of health effects?
5. Are health outcome data available at a geographic level or with enough specificity to be correlated to the exposed population?
6. Do the validated data sources or databases have information on the specific health outcome(s) or disease(s) of interest—for example, are the outcome(s) or disease(s) likely to occur from exposure to the site contaminants—and are those data accessible?

Using the findings of the exposure evaluation in this PHA, ATSDR sufficiently documented completed exposure pathways from eating fish. ATSDR conducted an exposure investigation to determine the body burden, or the actual amount of PCBs at a specific time, in the bodies of people who ate moderate to large amounts of fish and turtle. The results of this investigation showed that body burdens of Watts Bar Reservoir fish consumers are below those of people exposed occupationally, above nonfish consumers, and within the range for people who consume sport fish. ATSDR also calculated estimated exposure doses and found that all of the calculated doses are below levels associated with health effects. Still, as a conservative measure, ATSDR determined prudent public health practice would limit consumption of *certain species of fish* from Poplar Creek, the Clinch River, Tennessee River, and Lower Watts Bar Reservoir because some of the doses approached (but did not exceed) the health effects level.

Because the estimated doses are not expected to cause health effects, no further analysis of health outcome data is appropriate. Further, fish consumption provides beneficial developmental effects, decreased incidence or mortality from cancer, and improvements in heart health. Analysis of site-related health outcome data is not scientifically reasonable unless the level of estimated exposure is likely to result in an observable number of health effects. And because such an estimate of exposure is not feasible, the requirement to consider analysis of site-related health outcome data on the basis of exposure is complete.

Responding to Community Concerns

Responding to community health concerns is an essential part of ATSDR's overall mission and commitment to public health. During the public health assessment process concerns of all community members are important and must be addressed. The individual community health concerns addressed in the Community Health Concerns section (Section VI) of this PHA are concerns from the ATSDR Community Health Concerns Database that are related to issues associated with PCB exposures.

Area residents have also voiced concerns about cancer. Citizens living in the communities surrounding the ORR have expressed many concerns to the ORRHES about a perceived increase in cancer in areas surrounding the ORR. A 1993 TDOH survey of eight counties surrounding the ORR indicated that cancer was mentioned as a health problem more than twice as much as any other health problem. The survey also showed that 83 percent of the surveyed population in the surrounding counties believed it was very important to examine the actual occurrence of disease among residents in the Oak Ridge area.

To address these concerns, ORRHES requested that ATSDR conduct an assessment of health outcome data (cancer incidence) in the eight counties surrounding the ORR. Therefore, ATSDR conducted an assessment of cancer incidence using data already collected by the Tennessee Cancer Registry. This assessment of cancer incidence is a descriptive epidemiologic analysis that provides a general picture of the occurrence of cancer in each of the eight counties. The purpose of conducting this evaluation was to provide citizens living in the ORR area with information regarding cancer rates in their county compared with those in the state of Tennessee as a whole. This evaluation only examines cancer rates at the population level—not at the individual level. It is not designed to evaluate specific associations between adverse health outcomes and documented human exposures, and it does not—and cannot—establish cause and effect.

> "Cancer incidence" refers to newly diagnosed cases of cancer that are reported to the Tennessee Cancer Registry.

The results of the assessment of cancer incidence, released in 2006, indicated both higher and lower rates of certain cancers in some of the counties examined when compared with cancer incidence rates for the state of Tennessee. No consistent pattern of cancer occurrence was, however, identified. The reasons for the increases and decreases of certain cancers are unknown. The document is available online at http://www.atsdr.cdc.gov/HAC/oakridge/phact/cancer_oakridge/index.html.

In addition, over the last 20 years, local, state, and federal health agencies have conducted public health activities to address and evaluate public health issues and concerns related to chemical and radioactive substances released from the ORR. For more information, please see the Compendium of Public Health Activities at http://www.atsdr.cdc.gov/HAC/oakridge/phact/c_toc.html.

VI. Community Health Concerns

Responding to community health concerns is an essential part of ATSDR's overall mission and commitment to public health. ATSDR actively gathers comments and other information from those who live or work near the ORR. ATSDR is particularly interested in hearing from area residents, civic leaders, health professionals, and community groups. ATSDR is addressing these community health concerns in the ORR PHAs that are related to those concerns.

To improve the documentation and organization of community health concerns at the ORR, ATSDR developed a *Community Health Concerns Database* specifically designed to compile and track community health concerns related to the site. The database allows ATSDR to record, track, and respond appropriately to all community concerns, and also to document ATSDR's responses to these concerns.

Since 2001, ATSDR compiled more than 2,500 community health concerns obtained from the ATSDR/ ORRHES community health concerns comment sheets, from written correspondence, phone calls, newspapers, comments made at public meetings (ORRHES and work group meetings), and surveys conducted by other agencies and organizations. These concerns were organized in a consistent and uniform format and imported into the database.

The community health concerns addressed in this PHA are those concerns in the ATSDR Community Health Concerns Database related to PCB releases from the ORR. Table 14 contains the actual comments and ATSDR's responses. These concerns and responses are sorted by category (concerns about PCBs, concerns about fish or turtles that could be related to their PCB contamination, and PCB-related concerns about the Clinch River and East Fork Poplar Creek).

Table 14. Community Health Concerns from the Oak Ridge Reservation Community Health Concerns Database

	Actual Comment	*ATSDR's Response*
Concerns about PCBs		
1	The multiple exposure problem-There is no coefficient for this phenomenon. It is not possible to assess the toxicity of all known compounds, never mind of their combinations. The most obviously suspicious cases were exposures to PCBs and mercury, in which similar symptoms occurred elsewhere in the country. All interactions in the body have not been studied and understood, but he felt that they were not likely.	ATSDR could find only one such peer-reviewed study in which Oswego, New York children exposed in the womb to the highest levels of highly chlorinated PCBs were said to be more sensitive to the effect of exposures to mercury on cognitive development, although levels of mercury exposure did not affect sensitivity to PCBs (Stewart, et al. 2003). The difference in performance of the exposure groups was, however, within the internal consistency and reliability expected of the test used, and the difference seen at age 38 months was gone at age 54 months, when one of the sub tests showed better performance in the highest PCB group than in the group for which PCBs were not detected. The authors considered their results inconclusive until they could be repeated by other scientists. Although the Watts Bar Reservoir Exposure Investigation (EI) found total serum PCBs in ORR fish consumers to be higher than in unexposed people, but similar to other fish consumers nationally, ATSDR did not find the proportion of highly chlorinated PCBs to be higher in ORR sera than in that of unexposed people. So the Stewart et al. (2003) study, if its results can be replicated in the future, might not have relevance to ORR fish/biota consumers. The commenter is probably correct about the likelihood of harmful interactions among site-related contaminants. It is true that many medicines, intentionally prescribed at doses high enough to have an effect, will interact with other medicines. Doctors commonly ask their patients for lists of all their drugs and doses to avoid harmful interactions among the effects the different medicines can cause. But exposures to environmental pollutants are commonly at doses near their MRLs or reference doses, which are usually hundreds to thousands of times less than those observed to cause effects (ATSDR 2004, 2005; U.S. EPA 2005). Pollution levels need to be orders of magnitude higher than these standards to have any effect, or be able to cause interactions (Groten et al. 1997; Jonker et al. 1993). Hazardous sites rarely release that much pollution to the areas where people live (see our Web site http://www.atsdr.cdc.gov/). Therefore we do not usually expect toxic interactions in such environments, including residential areas near the ORR.

	Actual Comment	*ATSDR's Response*
2	I had some questions about your study of the hundred and sixteen people in the southern Watts Bar area. I don't know if I am being premature in my questions to you, but did you all come to the conclusion that there was no danger from eating the fish for anything other than PCBs, when that was the only thing you tested for? A public health study takes the exposure data and health outcome data and tries to find a correlation between them. "Study" in this sense is a very specific term and should not be taken lightly. It should not be confused with "investigations" such as the one at Watts Bar. Concerning studies of PCBs and blood samples in people who eat fish, I wonder how valid the information would be. Do PCBs stay in the blood, for example, and were they are a lot higher, one would presume, right after eating a meal than a week later? Were those factors taken into account in the study? So finding one or two people that were in the high risk category might be pretty misleading, if indeed the study didn't really reflect how-I mean stored PCBs in people. If your testing was accurate and your conclusions were accurate, why hasn't something changed so far as all of those fish advisories? I don't think the community would mind if you had an advisory on don't eat the turtles.	ATSDR conducted the Watts Bar Reservoir EI in March 1998. The EI evaluated the levels of PCBs (and mercury) in people who consumed moderate to large quantities of turtles and fish from the Watts Bar Reservoir. The EI reported: (1) the participants' serum levels are slightly below national norms for total PCBs and (2) of the 116 people tested, only 5 (4%) had a serum PCB level above the level that is regarded as elevated for total PCBs, and only one participant had a serum PCB level that was above the distribution seen in the general population. In this PHA's additional extensive review of the scientific literature, ATSDR found that body burdens of ORR fish consumers are below those of people exposed occupationally, above those of nonfish consumers, and within the national norm for those who do consume sports fish (see Figure 29). Follow-up counseling was provided for participants with elevated PCB blood levels. PCBs are persistent organic pollutants and remain in the environment or in the body a long time. After a fish meal, blood PCB levels are elevated for 24–48 hours, until the PCBs equilibrate into the tissues. If they are ingested repeatedly, they accumulate. That is why the oldest participants in the EI had the highest body burdens. By comparing ORR body burdens to those nation wide and researching the scientific literature about effects of body burden levels, ATSDR took this age-related effect into account. TDEC is the state agency responsible for issuing these public health advisories. They may be seen at http://www.state.tn.us/environment/wpc/publications/advisories.pdf. ATSDR recommends that the advisories be followed as a prudent public health practice. To lower PCB exposure without decreasing consumption, ATSDR recommends that people should skin fillets, remove belly fat from fish, and cut away excess fat from turtles and geese taken near ORR. Fish and turtles should be prepared by methods that permit fat to drain away. Under the Tennessee Oversight Agreement, TDEC established a DOE Oversight Division office in Oak Ridge, Tennessee. This division conducts annual monitoring of chemical and radioactive substances from the ORR to assure that the levels of contaminants are not a public health concern. DOE publishes its findings in an annual report that is accessible to the public. Given these findings, TDEC may or may not issue public health advisories. Monitoring data and additional information are available from the Oak Ridge office at 761 Emory Valley Road, Oak Ridge, TN. For more information about advisories Oak Ridge advisories, call John Owsley at 865-481-0995. Visit http://www.state.tn.us/environment/doeo/ for details about this division (TDEC 2003b). This PHA found that at the consumption levels reported in the EI, eating turtle meat does not expose people to levels of PCBs sufficient to cause illness. People should not, however, eat the turtle fat.

	Actual Comment	ATSDR's Response
3	Uranium, mercury, iodine, and PCBs have been detected in Scarboro. There are 6 initial contaminants of concern (which include iodine-131, mercury, uranium, radionuclides in White Oak Creek, polychlorinated biphenyls, fluorine/fluoride), although there may be others.	ATSDR will continue to evaluate contaminants and pathways of concern to the community surrounding ORR. In addition to this evaluation of PCBs from ORR, ATSDR has released a PHA on uranium from the Y 12 plant and is evaluating uranium from the K-25 facility, iodine-131, mercury, White Oak Creek releases in the 1950s, fluorides, the TSCA incinerator, and groundwater. ATSDR will also screen data from 1990 to the present to determine whether additional contaminants of concern need to be addressed. In 1998, Florida Agriculture and Mechanical University (FAMU) collected soil and sediment from Scarboro and analyzed 10 percent of the samples for 150 organic and inorganic chemicals (FAMU 1998). ATSDR evaluated these data and determined that none of the chemicals that were detected (over 100 chemicals were not detected) were at concentrations that would cause harmful health effects from exposure to the soil or sediment. In this PHA, ATSDR found that PCBs in East Fork Poplar Creek (EFPC) sediment and associated floodplain soil near the Scarboro region (which is elevated 40 feet above EFPC) were at levels too low to affect the most sensitive residents, who are the children playing there on a daily basis (see Figure 16 and Figure 17).
4	There is one other very important thing in the 1990s. I believe about 1993 or 1994 is when the most concern was raised about the TSCA Incinerator and PCBs.	From the dose reconstruction, "Based upon the data collected, it is unlikely that oils containing high concentrations of PCBs were incinerated. Waste oils containing high concentrations of PCBs are nonflammable and would have been disposed in burial pits. In addition, the only documented wastes with high concentrations of PCBs (the cutting fluids) were disposed in the 1970s after the practice of burning waste oils had been discontinued. It is possible, however, that wastes containing lower concentrations of PCBs (up to several hundred parts per million) could have been burned at the facility, potentially resulting in PCB levels in ambient air and also causing the formation of low levels of chlorinated dioxins and furans" (ChemRisk 1999a). The authors of the dose reconstruction considered air transport a less significant source of the total PCB dose than transport via water and sediment (and fish). Direct air pathways were eliminated as sources of illness by the dose reconstruction. In this PHA, ATSDR validated and accepted pathway elimination by the dose reconstruction because the dose reconstruction used conservatively estimated and modeled environmental concentrations even when actual concentration data were lower than those modeled.

	Actual Comment	*ATSDR's Response*
5	The dose reconstruction missed a lot of PCBs that came from the lab, and there are no records of what came from White Oak Creek. Two community members noted that there was a barrier at White Oak Creek, but that people still fished there. The community members continued that the barrier was simply a cable that went across with a sign that said not to enter the area. They said that people would lift this up, go under the cable, and fish at the creek.	The dose reconstruction said, "Although records of the last 15 years indicate that releases from [X-10] have been negligible, measurable levels of PCBs exist in White Oak Creek Embayment and White Oak Lake. This suggests that PCBs have been released from X-10 operations. It is not clear whether these observed levels have resulted from releases that occurred prior to the late 1970s or from ongoing low level releases. . . It should be noted that PCBs likely entered the Clinch River from White Oak Creek. This contribution was included in the evaluation of exposures from the consumption of Clinch River Fish" (ChemRisk 1999a). White Oak Creek joins the Clinch River at CRM 21. In this PHA, ATSDR reviewed Clinch River sediment PCBs by CRM, depth (year deposited), and distance from the river up to 1/4 mile along the creek. From Figure 23, ATSDR's CV protective of toddlers playing daily on creek sediment is 10 to 100 times higher than the highest PCB levels found. ATSDR's CVs include a 300-fold safety factor. White Oak Creek sediment PCBs are not high enough to cause illness.
6	Has physician training on polychlorinated biphenyls and cyanide had any benefit and if the referrals were helpful.	Yes, it resulted in counseling patients about their exposures and referrals to specialists.
7	What about area contamination sources? Can ATSDR estimate the contamination resulting from ORR operations?	The Task 3 team investigated historical uses and releases of PCBs at the ORR. They also identified more than 22 additional facilities that managed PCB-containing wastes upstream from the ORR. The noted that "it is difficult…to discern what fraction of the PCBs in fish in the vicinity of the ORR may have been contributed by these other facilities" (ChemRisk 1999a). Please see Section 3.1 and 3.2 in the Task 3 report for additional details.
8	Do plants uptake PCBs?	PCBs are strongly sorbed by soil organic matter and clay, which inhibits the uptake of PCBs in plants through the roots (Bacci and Gaggi 1985; Chu et al. 1999; Gan and Berthouex 1994; Paterson et al. 1990; Strek et al. 1982b; Webber et al. 1994; Ye et al. 1992a). Plant bioconcentration factors of PCBs from soil are estimated to be <0.02 for most terrestrial plant species (Cullen et al. 1996; O'Connor et al. 1990; Pal et al. 1980). PCBs adhere to the outer surfaces of plants, especially root crops such as carrots. To remove PCBs from such crops, especially when they are grown in contaminated soil, peel before eating.
Concerns about Fish or Turtles that Could Be Related to their PCB Contamination		
9	The units are confusing and meaningless in mg/kg/day, could the expression use so many sized fish consumed per day? People in the area consume a lot of local fish and locally grown foods so there should be site-specific intake rate values.	Please see Figure 1 for ATSDR's recommended maximum number of fish meals that can safely be eaten from the waterways near the ORR. One adult meal is considered to be 8 ounces (227 grams). Children were assumed to eat one-third as much as adults.

	Actual Comment	ATSDR's Response
10	They fish out of the local lakes and streams and the streams are contaminated for a hundred miles. Having grown up along lakes and creeks, I'd like to point out that people were not limited to one area, fishing people went everywhere. Because of this, it is difficult to pinpoint one single location. What about the levels of PCBs in the fish? Since vegetables and fish are the dominant pathways, are people who live downstream at higher risk?	In this PHA, ATSDR evaluated levels of PCBs in fish in the local lakes and streams (all along the three arms of the WBR, including the Clinch and Tennessee Rivers), and Poplar Creek. ATSDR made the following conclusions: • Sunfish species can safely be eaten in any amount. • All fish species can safely be eaten in low amounts from any water body near ORR. • Eating moderate to high amounts of certain species of fish (catfish, white bass, hybrid bass, and striped bass) is not recommended. ATSDR recommends that people follow the fish advisory to reduce their exposures. • 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. Please see Figure 1 for ATSDR's recommended maximum number of fish meals that can safely be eaten from the waterways near the ORR.
11	Concentrations of PCB in fish of upper East Fork Poplar Creek are not decreasing.	ATSDR eliminated East Fork Poplar Creek fish consumption as a pathway of concern. East Fork Poplar Creek is not a very productive fishing location, and very few people actually eat fish from this creek. Most local fish are caught from the Clinch River and Watts Bar Reservoir. Further, in 1996 and 1997, 34,220 loose cubic meters of mercury-contaminated soils were removed from the floodplain near the NOAA Atmospheric Diffusion Laboratory off Illinois Avenue and across the Oak Ridge Turnpike from the Bruner's Shopping Center on the Wayne Clark Property. PCB-contaminated soils in these areas would also have been removed during this remediation.
12	Since the contamination from fish ingestion will not necessarily be measurable in the blood stream at high levels at all times, a challenge test is needed to detect it. This was not used by ATSDR and is not normally used in a standard physician's office visit test. The ATSDR study results are countered by other studies, and communities in the southeast whose problems were addressed by ATSDR were not helped.	There are medical tests that measure the level of PCBs in the body by analyzing blood, body fat, and breast milk. These are not routine tests, but they could be requested from a doctor. These tests can indicate if a person was exposed to PCBs, but they cannot determine the amount of exposure, type of PCBs, or if adverse health effects will occur. Thus, these tests do not enable physicians to provide better care for their patients (ATSDR 2000). For more information on PCBs, visit http://www.atsdr.cdc.gov/toxprofiles/phs17.html.

	Actual Comment	ATSDR's Response
13	I'm very concerned/interested in how ATSDR addresses PCBs in turtles in the final report. We sample turtles every 5 years and find PCBs significantly higher then in fish. There is no consumption advisory on turtles and this seems to be a contradiction. It must be based on a lower intake of turtle flesh per year. It would be great if ATSDR could address this head on in their PHA and state very clearly whether there is any risk from consuming turtles and if not why.	The median PCB concentration detected in turtle meat (140 ppb) is about equal to the median PCB concentration detected in largemouth bass from Poplar Creek (130 ppb); that is higher than the concentrations in sunfish (22–40 ppb) and lower than the concentrations in white, striped, hybrid-bass, and in catfish species (440–1,270 ppb). 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). In this PHA, ATSDR evaluated three turtle meat consumption levels—eating two meals of turtle per year, eating one meal of turtle per year, and eating one meal of turtle every 6 years. These consumption rates were established from the information gathered during ATSDR's exposure investigation. ATSDR's evaluation determined that eating turtle meat up to twice a year is not a public health concern. Because, however, the level of PCBs detected in turtle fat (44,000 ppb) is so much higher than turtle meat and all the other fish species, 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.
14	What is the national PCB average in fish?	EPA's National Study of Chemical Residues in Fish reported an arithmetic mean of 1.89 ppm (wet weight) for total PCBs (U.S. EPA 1999a). EPA Region 5 and the Upper Mississippi River Conservation Committee compiled a database of fish tissue data collected throughout the Upper Mississippi River from 1970 through 1998 (U.S. EPA 2002b). For additional perspective on PCB levels in fish, please see their report at the following Web site: http://www.epa.gov/region5/water/umr_wq_assess.htm.
15	Do species that are higher on the food chain contain higher PCB levels?	Yes. PCBs bioaccumulate through the aquatic food chain. Species that are higher on the food chain typically contain higher PCB concentrations. See Appendix C. Examples of Various Aquatic Food Webs.
16	Is it safe to eat carp?	Due to their high lipid content, carp are a suitable species for assessing PCB contamination and would closely mirror the levels found in ORR catfish. Therefore, ATSDR recommends following the same advisory for carp as catfish (i.e., children should avoid eating more than one carp meal per month and adults should avoid eating more than one carp meal per week).
17	Is it safe to eat crappie?	Crappie are members of the sunfish family, Centrarchidae. Therefore, it is likely that some crappie were captured and reported as "sunfish spp.," which were among the species evaluated during this health assessment. The concentrations of PCBs detected in sunfish spp. were below levels of health concern. Therefore, ATSDR presumes that it is also safe to eat crappie based on the PCB levels found in sunfish.
18	What is the lifespan of catfish?	According to FishBase, Channel catfish (*Ictalurus punctatus*) can live a maximum of 16 years, flathead catfish (*Pylodictis olivaris*) can live a maximum of 20 years, and blue catfish (*Ictalurus furcatus*) can live a maximum of 21 years (www.fishbase.org).

	Actual Comment	ATSDR's Response
PCB-Related Concerns about the Clinch River		
19	What is the probability of a clinic for residents closely associated and who live close by incinerators and the Clinch River and East Fort Poplar Creek?	On August 27, 2002, ORRHES determined that discussion of public health activities related to establishment of a clinic, clinical evaluations, medical monitoring, health surveillance, health studies, or biological monitoring is premature. The ORRHES recommended postponing formal consideration of these issues until the ATSDR PHA process identifies and characterizes an exposure of an off-site population at levels of health concern. ATSDR scientists generally consider recommending follow-up public health activities that are service- or research-oriented (e.g., medical monitoring, health studies, health surveillance, or research) when there is a plausible, reasonable expectation of adverse health effects associated with the observed levels of exposure to contaminants. In this PHA on PCB releases, ATSDR scientists determined that people eating certain species of fish from Poplar Creek, the Clinch River, Tennessee River, and Lower Watts Bar Reservoir could be exposed to PCBs. The results of ATSDR's exposure investigation on people who ate moderate to large amounts of fish and turtles from the Watts Bar Reservoir investigation showed, however, that body burdens of Watts Bar Reservoir fish consumers are below people exposed occupationally, above nonfish consumers, and within the range for people who consume sport fish. ATSDR also calculated estimated exposure doses and found that all of the calculated doses are below levels associated with health effects. Because the estimated doses are not expected to cause health effects, analysis of health outcome data, medical monitoring, or surveillance is not appropriate. Further public health activities are not scientifically reasonable unless the level of estimated exposure is likely to result in an observable number of health effects. And because such an estimate of exposure cannot be made, the requirement to consider further public health activities on the basis of exposure is complete. But as a conservative measure, ATSDR determined be prudent public health practice would limit consumption of *certain species of fish* from Poplar Creek, the Clinch River, Tennessee River, and Lower Watts Bar Reservoir; some of the doses approached (but did not exceed) the health effects level. Therefore, ATSDR recommends people follow the TDEC's fish consumption advisories for Poplar Creek, the Clinch River, Tennessee River, and the Lower Watts Bar Reservoir. The advisory is available at the following Web site: http://www.state.tn.us/environment/wpc/publications/advisories.pdf. ATSDR will also develop health education materials to help community members understand fish consumption advisory and ways to minimize exposure to PCBs in fish.
20	Are the impacts of solid waste storage areas on groundwater considered in any of the PHAs? Today's Knoxville newspaper reported on the impacts on the Clinch River and downstream reservoir of solid waste storage areas.	ATSDR evaluated exposures to off-site groundwater in a pathway-specific PHA. It was released final in 2006, and can be accessed at http://www.atsdr.cdc.gov/HAC/PHA/region_4.html#tennessee.

	Actual Comment	***ATSDR's Response***
21	There was more PCBs coming down the Tennessee River than the Clinch River.	That was the result modeled by the dose reconstruction: loading to the riverbed and fish for these two rivers deposited more PCBs to the Tennessee River. It also seemed logical because the ORR would have been the primary contributor to Clinch River pollution, while multiple sources released PCBs to the Tennessee River. The only sediment core with detectible PCBs was, however, one taken from the Clinch River at CRM 9.5 (see Figure 16 and Figure 17). From the more than 52,000 records of biota ATSDR reviewed for this document, the median PCB levels in fish taken before 1996 from the LWBR (a part of the Tennessee River widened by the Watts Bar Dam) and the Tennessee River were about half that taken from fish in the Clinch River (see the distribution graphs in Figure 18, Figure 19, and Figure 20). Because of regulatory oversight, ORR began to remediate sources of PCBs as early as the 1970s, and that may have been earlier than other facilities were able to begin. From samples taken 1996 and after, Clinch River fish PCB medians were 20–25 percent of the medians from LWBR and the Tennessee River (see Figure 24, Figure 25, and Figure 26).
PCB-Related Concerns about East Fork Poplar Creek (EFPC)		
22	Lower EFPC flows through the Scarboro community; so does Scarboro Creek.	Scarboro is located at an elevation of about 40 feet higher than EFPC and avoided direct contact with discharges of waterborne Y-12 contaminants (such as the PCBs carried by EFPC sediment). In 1998, FAMU collected soil and sediment from Scarboro and analyzed 10 percent of the samples for 150 organic and inorganic chemicals (FAMU 1998). ATSDR evaluated these data and determined that none of the chemicals that were detected (over 100 chemicals were not detected) were at concentrations that would cause harmful health effects from exposure to the soil or sediment.
23	East Fork Poplar creek has been identified by TDEC as the most contaminated creek in Tennessee according to the Oak Ridger newspaper.	In this PHA, ATSDR mapped PCB contamination in the sediment under EFPC and the floodplain alongside (Figure 17) and graphically showed that PCB contamination of EFPC sediment and associated floodplain soil is all below CVs (Figure 16). Thus, for PCBs the EFPC is not the most contaminated creek in Tennessee.

VII. Child Health Considerations

ATSDR recognizes that infants and children can be more sensitive to environmental exposure than are adults in communities faced with contamination of their water, soil, air, or food. This sensitivity is a result of 1) children's higher probability of exposure to certain media (for example, soil or surface water) because they play and eat outdoors; (2) children's shorter height, which means that they can breathe dust, soil, and vapors close to the ground; and (3) children's generally smaller stature, which means childhood exposure will result in higher doses of chemical exposure per body weight. Children can sustain permanent damage if these factors lead to toxic exposure during critical growth stages. As part of ATSDR's Child Health Initiative, ATSDR is committed to evaluating the special interests of children at sites such as the ORR.

Children could have been exposed to PCBs in the womb during their mothers' pregnancies and while nursing if their mothers ate fish from the creeks and rivers near ORR. As they were weaned and began eating food from their parents' plates, they could have been exposed to PCBs in the fish their parents ate, but in smaller amounts. ATSDR estimated that the youngest, most vulnerable children could have eaten as much as one-third the amount of the adults. In addition, children living near the ORR could have been exposed to small amounts of PCBs if they played in the sediment and soil along Watts Bar Reservoir. From the exposure scenarios considered, however, the highest doses would have come from fish consumption—still, these doses are not expected to have caused them harm.

Nursing infants represent a subpopulation especially sensitive to PCB exposure. Breast milk has a high fat content, and PCBs are excreted in the milk. Breast-fed infants have an additional risk caused by a steroid that is excreted in human breast milk that inhibits the infants' ability to excrete PCBs. A study by Gladen et al. (1988),however, did not demonstrate any effect on infant psychomotor response associated with exposure through breastfeeding. Further, the advantages to breastfeeding are many, including improved nutrition, increased resistance to infection, protection against allergies, and better parent-child relationships. "With full regard for the uncertainty over the toxic effects of organochlorines in human milk, the known benefits of breastfeeding are extensive and serve as a strong rationale for advising mothers to continue to breast feed their newborns unless cautioned by their local health care worker to reduce or stop" (Van Oostdam et al. 1999).

Studies of development effects and low birth-weight and hypothyroidism in animals have yielded weak and inconsistent results. Monkeys dosed with imitation milk containing PCBs showed subtle developmental neurotoxicity. In another study, monkey infants had blood PCB levels lower than PCB levels in populations in the United States. Yet monkeys developed skin symptoms at PCB blood levels orders of magnitude less than PCB levels that failed to affect occupationally exposed humans. In addition, human studies reported maternal exposure to fish improved babies' performance in neurobehavioral tests and decreased incidence of lowered birth-weight. Because of these and other data ATSDR reviewed in the Toxicological Profile for PCBs (ATSDR 2000), ATSDR does not expect adverse health effects to fetuses, infants, and children from ORR PCB releases to the environment.

VIII. Conclusions and Recommendations

Having evaluated the release of PCBs from the ORR and the potential past and current exposure to PCBs, ATSDR has reached the following conclusions:

- Exposure to PCBs in the sediment, soil, surface water, turtle meat, and geese pose ***no apparent public health hazard***. The levels of PCBs released to off-site waterways such as East Fork Poplar Creek, Popular Creek, Clinch River, Tennessee River, and the Lower Watts Bar Reservoir, or their associated sediment and nearby soils, are not expected to cause harmful health effects to people who live or visit near these waterways, and who engage in recreational activities, drink the water, garden in the soil, consume turtles, or eat geese.

> ATSDR's category of no apparent public health hazard means that people were, are, or could be exposed, but the level of exposure would not be likely to cause harm to people's health.

- ATSDR's review of PCB body burdens nationwide found that body burdens of people who ate fish from Watts Bar Reservoir or the Clinch River are below those of people exposed occupationally, above those of nonfish consumers, and within the national range for those who consume sport fish.

- Frequent eating of moderate to large amounts (one or more meals a week for an extended period of time) of certain fish species (catfish, white bass, hybrid striped bass (striped bass-white bass), striped bass, and largemouth bass) is potentially a ***public health hazard***. Noncancer health effects (immunological and developmental) have been observed in animals exposed to doses similar to those ATSDR estimated for people who frequently eat large amounts of these fish. Certain sensitive populations, such as pregnant women and children, should be particularly careful and limit intake of certain species.

> ATSDR's public health hazard category means that long-term exposures (greater than 1 year) to a substance could result in harmful health effects.

Given these findings, ATSDR believes prudent public health practice would limit consumption of certain species of fish. The agency recommends people follow the TDEC's fish consumption advisories for Poplar Creek, the Clinch River, Tennessee River, and the Lower Watts Bar Reservoir. The advisory is available at the following Web site: http://www.state.tn.us/environment/wpc/publications/advisories.pdf.

Fish is a healthy food that provides many nutritional benefits. People can safely (i.e., **not** a public health hazard) eat any amount of sunfish species. Children can safely eat largemouth bass up to once a week; adults can safely eat any amount of largemouth bass. People can without undue risk eat small amounts (up to one fish meal a month) of catfish, white bass, hybrid bass, and striped bass. If community members wish to reduce their exposure to PCBs without forfeiting the benefits from eating fish, they can follow these suggestions:

- Eat the less fatty parts of the fish; throw away skin, fat deposits, head, guts, kidneys, and liver.
- Remove the skin and the strip of light-colored fat that remains along the belly flap at the bottom of the fillet as well as any fat that may be present along the sides and the midpoint of the back.
- Grill, broil, or bake fish on a rack to allow fat—and chemicals—to drain away. This helps remove pollutants stored in the fatty parts of the fish. Avoid frying for larger, fatty fish.
- Do not reuse cooking liquids or fat drippings from the fish since these liquids retain PCBs.
- Choose to eat younger (or smaller) fish and those lower on the food chain (e.g., sunfish).

- In 1996 PCBs in turtle fat were found at extremely high concentrations in the turtles collected from the Watts Bar Reservoir and Clinch River. Care should be taken to avoid eating turtle fat. ATSDR recommends the following precautions to reduce your exposure to contaminants that may be present in the turtle fat:

ATSDR's evaluation of PCBs in turtle meat indicates that it is safe for people to eat turtle meat.

  - Lay the turtle on its back shell (carapace).
  - Remove the shell that faces you (the plastron) by carefully cutting through the two bony ridges (on both sides of the turtle) between the fore and hind limbs.
  - Remove carefully and discard any fat and eggs present, and all organs, such as the liver and kidneys. Save only the muscle (meat) for eating.
  - Remove claws from the fore and hind limbs.
  - Remove skin from the neck, tail, and fore and hind limbs.
  - Combine all meat portions you wish to save.

- ATSDR recommends informing the community about ATSDR's conclusions.

IX. Public Health Action Plan

The public health action plan (PHAP) for the ORR describes the actions to be taken by ATSDR and other government agencies at the vicinity of the site after the completion of this PHA. The purpose of the PHAP is to ensure that the PHA not only identifies potential public health hazards, but that it also provides a plan of action designed to mitigate and/or prevent adverse human health effects potentially resulting from exposure to harmful substances in the environment. If additional information about ORR releases to nearby waterways—especially those that could affect the biota therein—becomes available, that could change this PHA's conclusions. If that occurs, then human exposure pathways should be reevaluated and these conclusions and recommendations should be amended, as necessary, to protect public health.

Upon request from the public, ATSDR will develop and implement additional environmental health education materials to help community members understand the findings and implications of this PHA.

Please see Section II.F. for a summary of public health activities pertaining to PCB releases and Appendix B for a summary of additional public health activities.

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Appendix A. ATSDR Glossary of Environmental Health Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency in Atlanta, Georgia, with 10 regional offices in the United States. ATSDR serves the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases from 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 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. For additional questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

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.

Biologic indicators of exposure study
A study that uses (a) biomedical testing or (b) the measurement of a substance [an analyte], its metabolite, or another marker of exposure in human body fluids or tissues to confirm human exposure to a hazardous substance [also see exposure investigation].

Biologic monitoring
Measuring hazardous substances in biologic materials (such as blood, hair, urine, or breath) to determine whether exposure has occurred. A blood test for lead is an example of biologic monitoring.

Biologic uptake
The transfer of substances from the environment to plants, animals, and humans.

Biomedical testing
Testing of persons to find out whether a change in a body function might have occurred because of exposure to a hazardous substance.

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 occur when cells in the body become abnormal and grow or multiply out of control.

Cancer risk
A theoretical risk for 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.

CERCLA [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980]

Chronic
Occurring over a long time [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]

Cohort Study (or Prospective Study)
An epidemiologic study comparing those with an exposure of interest to those without the exposure. These two cohorts are then followed over time to determine the differences in the rates of disease between the exposure subjects.

Comparison value
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The comparison value is used as a screening level during the public health assessment process. Substances found in amounts greater than their comparison values 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. This law was later amended by the Superfund Amendments and Reauthorization Act (SARA).

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

Confounding Factor
A condition or variable that is both a risk factor for disease and associated with an exposure of interest. This association between the exposure of interest and the confounder (a true risk factor for disease) may make it falsely appear that the exposure of interest is associated with disease.

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.

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 prevention
Measures used to prevent a disease or reduce its severity.

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

DOE
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 milligram (amount) 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 got 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).

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
United States Environmental Protection Agency.

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.

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

Food Chain
A community of organisms where each member is eaten in turn by another member [compare with food web].

Food Web
A community of organisms where there are several interrelated food chains [see food chain].

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.

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

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

Hazardous Substance Release and Health Effects Database (HazDat)
The scientific and administrative database system developed by ATSDR to manage data collection, retrieval, and analysis of site-specific information on hazardous substances, community health concerns, and public health activities.

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. Health consultations are therefore more limited than a public health assessment, which reviews 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 evaluate the possible association between the occurrence and exposure to hazardous substances.

Health promotion
The process of enabling people to increase control over, and to improve, their health.

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].

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 in a study.

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

Metabolite
Any product of metabolism.

mg/kg
Milligram per kilogram.

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, a condition, or an injury) is stated.

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 where the exposure 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 in a study.

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]

Physiologically based pharmacokinetic model (PBPK model)
A computer model that describes what happens to a chemical in the body. This model describes how the chemical gets into the body, where it goes in the body, how it is changed by the body, and how it leaves the body.

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 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].

Prevalence survey
The measure of the current level of disease(s) or symptoms and exposures through a questionnaire that collects self-reported information from a defined population.

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
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 from 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
Public health hazard categories are 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. The public health statement explains how people might be exposed to a specific substance and describes the known health effects of that substance.

Public health 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.

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

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.

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.

Registry
A systematic collection of information on persons exposed to a specific substance or having specific diseases [see exposure registry and disease registry].

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.

RFA
RCRA Facility Assessment. An assessment required by RCRA to identify potential and actual releases of hazardous chemicals.

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], or 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.

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.

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.

Superfund [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Superfund Amendments and Reauthorization Act (SARA)

Superfund Amendments and Reauthorization Act (SARA)
In 1986, SARA amended the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

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

Surveillance [see public health 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 [see prevalence survey].

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.

Tumor
An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Uncertainty factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors 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].

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.

Volatile organic compounds (VOCs)
Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

Other glossaries and dictionaries:
Environmental Protection Agency (http://www.epa.gov/OCEPAterms/)
National Library of Medicine (NIH) (http://www.nlm.nih.gov/medlineplus/mplusdictionary.html)

Appendix B. Summary of Other Public Health Activities

Agency for Toxic Substances and Disease Registry (ATSDR)

Clinical Laboratory Analysis. In June 1992, William Reid, M.D., an Oak Ridge physician, notified the Oak Ridge Health Agreement Steering Panel (ORHASP) and the Tennessee Department of Health (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, including immunosuppression, increased cancer incidence, neurological diseases, bone marrow damage, chronic fatigue syndrome, autoimmune disease, and abnormal blot clots. Howard Frumkin, M.D., Dr.PH., of Emory University's School of Public Health, requested clinical laboratory support to evaluate Dr. Reid's patients. As a result, ATSDR and the Center for Disease Control and Prevention's (CDC's) National Center for Environmental Health (NCEH) facilitated this laboratory support from 1992 to 1993 through the NCEH Environmental Health Laboratory (ATSDR and ORREHS 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 were not provided to public health agencies (ATSDR and ORREHS 2000). In an April 26, 1995 letter to the Commissioner of the TDOH. Dr. Frumkin suggested, however, 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."

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 whether exposure to metals was related to these patients' illnesses. ATSDR determined that the case data were insufficient to support an association between these diseases and low levels of metals. TDOH also evaluated the information and reached the same conclusion as ATSDR. In September 1992, ATSDR provided a copy of its review to Dr. Reid (ATSDR and ORREHS 2000).

ATSDR Science Panel Meeting on the Bioavailability of Mercury in Soil, August 1995. After reviewing an evaluation of the U.S. Department of Energy (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., U.S. Environmental Protection Agency [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 regard 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 cleanup level in East Fork Poplar Creek 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 and ORREHS 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 East Fork Poplar Creek floodplain soil. The final health consultation, 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 and ORREHS 2000).

Health Professional Education on Cyanide. In January 1996, an employee from East Tennessee Technology Park (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 effects 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 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. ATSDR also established a system that area physicians could use to make patient referrals directly to the Association of Occupational and Environmental Clinics (AOEC) (ATSDR and ORREHS 2000).

Workshops on Epidemiology. ATSDR responded to Oak Ridge Reservation Health Effects Subcommittee (ORRHES) members' requests, by conducting two epidemiology workshops for the subcommittee. The first session took place at the June 2001 ORRHES meeting. Both Ms. Sherri Berger and Dr. Lucy Peipins of ATSDR's Division of Health Studies presented an overview of the science of epidemiology at the first session. Dr. Peipins also presented at the second epidemiology workshop at the December 2001 ORRHES meeting. The purpose of this second session was to help the ORRHES members build the skills that are required for analyzing scientific reports (ATSDR and ORREHS 2000). At the August 28, 2001 Public Health Assessment Work Group meeting, Dr. Peipins demonstrated the systematic and scientific approach of epidemiology by guiding the group as they critiqued a sample report (Mangano J. 1994. *Cancer Mortality Near Oak Ridge, Tennessee*. International Journal of Health Services: 24(3):521). Based on this critique, ORRHES concluded:

1. The Mangano paper is not an adequate, science-based explanation of cancer mortality rates of the off-site public.
2. The Mangano paper fails to establish that radiation exposure from the ORR contributed to cancer mortality rates in the general public.
3. ORRHES recommended that in the ORR public health assessment process, ATSDR exclude the Mangano paper from consideration (ATSDR and ORREHS 2000).

Assessment of Cancer Incidence in the Eight-county Area Surrounding the DOE Oak Ridge Reservation, March 2006. Some area residents expressed concerns about the number of cancer cases in communities around the Oak Ridge Reservation (ORR). To address these concerns, the ORRHES requested that ATSDR conduct an assessment of cancer incidence to evaluate cancer rates in these communities. For the consultation, ATSDR obtained cancer incidence data—data on newly diagnosed cases of cancer—from the Tennessee Cancer Registry for 42 different cancer types. Data from 1991–2000 were obtained for the eight-county area surrounding the ORR, including Anderson, Blount, Knox, Loudon, Meigs, Morgan, Rhea, and Roane Counties. To analyze the data and determine any increases of cancer incidence, ATSDR compared the number of observed cases in each of the eight counties to the expected number of cases in the state of Tennessee. The findings indicated both higher and lower rates of certain cancers in some of the counties examined when compared to the cancer incidence rates in the state. No consistent pattern of cancer occurrence was identified however, and the reasons for the increases and decreases of cancer occurrence remain unknown. For more information, the assessment of cancer incidence is available at
http://www.atsdr.cdc.gov/HAC/oakridge/phact/cancer_oakridge/index.html.

Public Health Assessments (PHAs). In addition to evaluating the releases of polychlorinated biphenyls (PCBs) from the ORR, ATSDR scientists are conducting PHAs on uranium releases from Y-12, mercury releases from Y-12, iodine-131 releases X-10, radionuclides released to White Oak Creek from X-10, uranium and fluorides release from K-25, and on other topics, such as the Toxic Substances Control Act (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 these PHAs, ATSDR scientists evaluate and analyze the data and findings from previous studies and investigations to assess the public health implications of past and current exposure.

Tennessee Department of Health (TDOH)

Pilot Survey of Mercury Levels in Oak Ridge. In the fall of 1983, TDOH set an interim soil mercury level to use for environmental management decisions. CDC evaluated the methodology for this mercury level and advised the TDOH to conduct a pilot survey to determine whether populations with the greatest risk for mercury exposure had elevated mercury body burdens. From June to July 1984, TDOH and CDC surveyed the inorganic mercury levels of Oak Ridge residents who had the greatest risk of being exposed to mercury via contaminated fish and soil. The survey also assessed whether exposure to mercury through contaminated fish and soil represented an immediate health hazard for the Oak Ridge community. In the October 1985 release of the pilot survey findings, results showed people living and working in Oak Ridge were unlikely to have a greater risk for significantly high mercury levels. The mercury concentrations in hair and urine samples were lower than levels associated with health effects (ATSDR and ORREHS 2000).

Health Statistics Review to Address Oak Ridge Physician's Concerns. In June 1992, William Reid, M.D., an Oak Ridge physician, told ORHASP and TDOH he believed that about 60 of his patients had been exposed to heavy metals through their occupation or environment. Dr. Reid felt that these exposures had caused a number of adverse health outcomes, including immunosuppression, increased cancer incidence, neurological diseases, bone marrow damage, chronic fatigue syndrome, autoimmune disease, and abnormal blot clots. That year, 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 found some counties' rates were low and some were high compared to the state's rates, but could find no site-related patterns. These findings are detailed in an October 19, 1992 TDOH memorandum to Dr. Mary Yarbrough from Mary Layne Van Cleave. Handouts and minutes from Ms. Van Cleave's presentation at the ORHASP meeting on December 14, 1994, are available from TDOH (ATSDR and ORREHS 2000).

Health Statistics Review of Amyotrophic Lateral Sclerosis and Multiple Sclerosis Mortality Rates. In 1994, area residents reported that several community members had amyotrophic lateral sclerosis (ALS) and multiple sclerosis (MS). TDOH, in consultation with Peru Thapa, M.D., M.P.H. of Vanderbilt University's School of Medicine, performed a health statistics review of mortality rates for ALS and MS within certain Tennessee counties. TDOH also received technical support for the health statistics review from ATSDR (ATSDR and ORREHS 2000).

Because ALS and MS are not reportable, TDOH could not calculate reliable incidence rates for these diseases. Mortality rates for 1980 and 1992, in the counties surrounding ORR were analyzed and compared with mortality rates for the state of Tennessee. The mortality rates did not differ significantly from the rates in the rest of the state (ATSDR and ORREHS 2000). At the August 18, 1994 OHHASP public meeting, TDOH reported the following results.

- In none of the counties did ALS mortality differ significantly from that in the rest of the state.

- For Anderson County, the age-adjusted mortality rate for chronic obstructive pulmonary disease (COPD) was significantly higher than that for the rest of the state. But for 1979 to 1988, rates for total deaths, deaths from stroke, deaths from congenital anomalies, and deaths from heart disease were significantly lower than statewide. The cancer rate overall did not significantly differ from that for the rest of the state. Mortality rates from uterine and ovarian cancer were significantly higher than in the rest of the state. Deaths from liver cancer were, however, significantly lower than that for the rest of the state.

- For Roane County, between 1979 and 1988 the rates of total deaths and deaths from heart disease were significantly lower than the rates in the rest of the state. 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 all 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. A comparison of the Knox County total cancer death rate with the statewide rate revealed no significant difference.

- No cause of mortality studied in Knox, Loudon, Rhea, and Union Counties significantly exceeded its counterpart in the rest of the state.

- Rates of total deaths were significantly higher in Campbell, Claiborne, and Morgan Counties than in the rest of the state.

- Cancer mortality was significantly higher in Campbell County than in the rest of the state. The excess in number of deaths from cancer were primarily in the earlier part of the time period (1980 to 1985). The rate of deaths from cancer was not higher in Campbell County than in the rest of the state from 1986 to 1988 and from 1989 to 1992.

- From 1980 to 1982, cancer mortality was significantly higher in Meigs County than in the rest of the state, but from 1983 to 1992, it was not.

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) examine the public's attitudes and perceptions regarding environmental contamination and public health problems associated with the ORR; 2) determine the public's level of awareness and their assessment of the ORHASP; and 3) gather recommendations from the residents for improving public outreach programs. The results of the study were released on August 12, 1994, and are available from TDOH (ATSDR and ORREHS 2000). Following is a summary of the findings (Benson et al. 1994):

- Most respondents considered their local environmental quality to be better than the national environmental quality. Most people rated the quality of their air and drinking water as good or excellent. Almost half of those surveyed rated the local groundwater as good or excellent.

- Most respondents thought activities at the ORR created some health problems for nearby residents, and most thought activities at the ORR created health problems for site employees. Most respondents felt researchers should examine the actual disease rates among Oak Ridge residents. Of those surveyed, 25 percent knew of a specific local environmental condition that they believed had adversely affected people's health; but many of these appeared unrelated to the ORR. Less than 0.1 percent of those surveyed had personally experienced a health problem they attributed to the ORR.

- About 25 percent of the respondents had heard of the Oak Ridge Health Study, and newspapers were their primary source of information. Approximately 33 percent of the people surveyed rated the study performance as good or excellent, and 40 percent thought that the study would improve public health. Also, 25 percent thought that communication about the study was good or excellent.

Presentation. On February 16, 1995, Dr. Joseph Lyon of the University of Utah gave a TDOH-sponsored presentation at an ORHASP public meeting. The presentation informed 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 and ORREHS 2000).

Feasibility of Epidemiologic Studies. Another study examined the feasibility of performing analytical epidemiological studies (e.g., case-control or cohort) to address health concerns of people living near the ORR. TDOH and the ORHASP contracted with a physician from Vanderbilt University's Department of Preventive Medicine to conduct the study, which was released July 1996 (ATSDR and ORREHS 2000). The study found the dose reconstruction results would significantly impact the feasibility of conducting analytical epidemiologic studies because the dose reconstruction would clarify the extent and potential human exposure from past releases of radioactive iodine, mercury, PCBs, uranium, and other radionuclides, including cesium-137 (Thapa 1996).

Health Assessment of the East Tennessee Region. TDOH conducted a health assessment on the eastern region of Tennessee. This health assessment reviewed the health status of the population, evaluated accessibility and utilization of health services, and developed 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 reviewed data from 1986 to 1990. The second edition, released in 1996, reviewed data from 1990 to 1995. A copy can be obtained from the East Tennessee Region of TDOH (ATSDR and ORREHS 2000).

Loudon County Hazardous Air Pollutants Public Health Assessment, May 2005. Under a cooperative agreement with ATSDR, TDOH examined available environmental data on hazardous air pollutants in Loudon County, Tennessee, and possible health impacts. Seven hazardous air pollutants were carefully evaluated; none, however, were detected at levels that presented a health concern. To more thoroughly understand disease trends and community concerns about respiratory and heart-related illnesses, TDOH also studied health data for 40 specific diseases and reported two major findings: 1) Loudon County's increased in-patient and out-patient hospitalization rates for chronic rhinitis and sinusitis are statistically significant compared to Franklin County and to Tennessee for females, males, and both sexes combined and 2) Loudon County is ranked first in overall cancer rate in Tennessee for both sexes combined, is ranked second in overall cancer rate for males, and is ranked third in overall cancer rates for females (TDOH 2005).

Centers for Disease Control and Prevention (CDC)

Scarboro Community Health Investigation. In November 1997, a Nashville newspaper published an article about children's illnesses in the Scarboro community—a neighborhood close to the Y-12 plant. The article said that Scarboro residents had frequent respiratory illness, and that 16 children 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 suggested ORR releases caused these illnesses, especially because these children live in the vicinity of the Y-12 plant (ATSDR and ORREHS 2000; Johnson et al. 2000).

On November 20, 1997, the Commissioner of TDOH responded to this article with a request that CDC assist 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 less than 18 years of age. Both the survey and the exam were 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 designed to determine the cause of the illnesses (ATSDR and ORREHS 2000; Johnson et al. 2000).

In 1998, the Scarboro Community Environmental Justice Oversight Committee joined CDC and TDOH in the development of 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 compare rates of specific diseases in Scarboro to rates in the rest of the United States, and to identify factors that increased Scarboro residents' risk for health problems. The survey collected information from adults about their occupations, occupational exposures, and general health concerns. The health investigation survey had an 83 percent response rate, interviewing members of 220 out of 264 households. The surveys collected 119 questionnaires about children and 358 questionnaires about adults in these households (ATSDR and ORREHS 2000; Johnson et al. 2000).

In September 1998, CDC released the initial survey findings. Scarboro children's asthma rate was 13 percent. Nationally, the estimated rate was 7 percent for children from birth to 18 years old, and 9 percent for African American children birth to 18 years old. The Scarboro rate fell within the range of rates (6 percent to 16 percent) found in comparable studies across the United States, however. The wheezing rate was 35 percent for Scarboro children. The worldwide estimated rates fell between 1.6 percent and 36.8 percent. With the exception of unvented gas stoves, the study found no statistically significant link between asthma or wheezing illness and typical environmental asthma triggers (e.g., pests, environmental tobacco smoke) or occupational exposures (i.e., living with an ORR employee) (ATSDR and ORREHS 2000; Johnson et al. 2000).

Using the survey results, 36 children, including those discussed in the 1997 newspaper article, were invited for physical examinations. In November and December 1998, the medical examinations were conducted to verify the community survey results, to evaluate whether the children with respiratory illnesses were receiving necessary medical care, and to verify that the children detailed in the newspaper actually had those reported respiratory medical problems. The invited children had one or more of the following: 1) severe asthma, defined as more than three wheezing episodes or going to an emergency room as a result of these symptoms; 2) severe undiagnosed respiratory illness, defined as more than three 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. Some eligible children had moved away from Scarboro; others were not available or opted not to participate (ATSDR and ORREHS 2000; Johnson et al. 2000).

During the physical examinations nurses asked the participating children and their parents questions about the children's health. Volunteer physicians evaluated the findings from the nurse interviews and examined the children. The children were also given blood tests and a special breathing test. On a case-by-case basis, the physician ordered x-rays. The tests, examinations, and transportation to and from the examinations were free of charge (Johnson et al. 2000).

When the examinations were completed, the results were evaluated to see if any children required immediate intervention—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, the children's parents and doctors were notified about the results by letter or telephone. If the parents did not want their child's results sent to a physician, then the parents alone received the results over the telephone. The parents of children who had any health problems identified from the physical examination were sent a personal letter from Paul Erwin, M.D., of the East Tennessee Regional Office of the TDOH, advising the parents to follow up 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, to help them find a provider or register with TennCare or Children's Special Service (ATSDR and ORREHS 2000; Johnson et al. 2000).

Physicians from the CDC, TDOH, the Oak Ridge medical community, and the Morehouse School of Medicine met on January 5, 1999, and thoroughly reviewed the findings from the community health survey, the physical examinations, the laboratory tests, and the nurse interviews. Of the 23 children examined, 22 evidenced some type of respiratory illness discovered during the nurse interviews or during the doctor's physical examinations. Otherwise, the children appeared healthy and had no problems that would necessitate immediate assistance. Many children had mild respiratory illnesses, but a lung abnormality was diagnosed in only one child. None of the children wheezed during examination. No unusual illness pattern was identified among Scarboro community children. The severity of the identified illnesses was not more than would be expected, and they were typical of illnesses in any community. 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 and ORREHS 2000; Johnson et al. 2000).

Efforts to telephone the examined children's parents followed 3 months after the letters to the parents and physicians about the results. Eight parents (of 14 child participants) were contacted successfully. Despite multiple attempts, the parents of nine children could not be reached (Johnson et al. 2000).

The contacted parents said that 7 of the 14 children had been to a doctor since the examinations. In general, the children's health was about the same. But one child had been in the hospital because of asthma and another child's asthma had worsened, requiring increased medication. Several parents reported their children had nasal allergies, and many parents noted problems getting medicines because of the expense and the lack of coverage by TennCare. Subsequently, TDOH nurses helped these parents obtain the needed medicines (Johnson et al. 2000).

U.S. Department of Energy (DOE)

Lower East Fork Poplar Creek Remedial Investigation/Feasibility Study. Under the Federal Facility Agreement, DOE, EPA, and Tennessee Department of Environment and Conservation (TDEC) prepared a Remedial Investigation/Feasibility Study at Lower East Fork Poplar Creek that was released in 1994. The study was conducted to evaluate the floodplain soil contamination in Lower East Fork Poplar Creek, 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 of contamination levels, and 3) determine if remedial action was necessary. The investigation found 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, a September 1995 Record of Decision requested remedial action at the creek. Remedial activities began in June 1996 and were completed in October 1997. The activities consisted of 1) excavating four sections of floodplain soil with mercury concentrations above 400 ppm, 2) confirming the mercury concentration by sampling during excavation, 3) disposing of contaminated soil at a Y-12 plant landfill, 4) refilling the excavated areas with clean soil, and 5) providing new vegetative cover over the excavated areas (ATSDR and ORREHS 2000).

Scarboro Community Environmental Study. In May 1998, soil, sediment, and surface water were sampled 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 with the requirements of an EPA 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 laboratory analysis for 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 (i.e., 0.021 to 0.30 ppm). The radionuclide findings were within the predicted ranges, including concentrations of total uranium. Uranium 235 was, however, enriched in about 10 percent of the soil samples. In one sample alpha-chlordane, gamma-chlordane, heptachlor, and heptachlor epoxide exceeded the detection limits. Concentrations of lead and zinc in this sample were twice as high as those found in the BSCP. On September 22, 1998, the final Scarboro Community Environmental Study was released (ATSDR and ORREHS 2000).

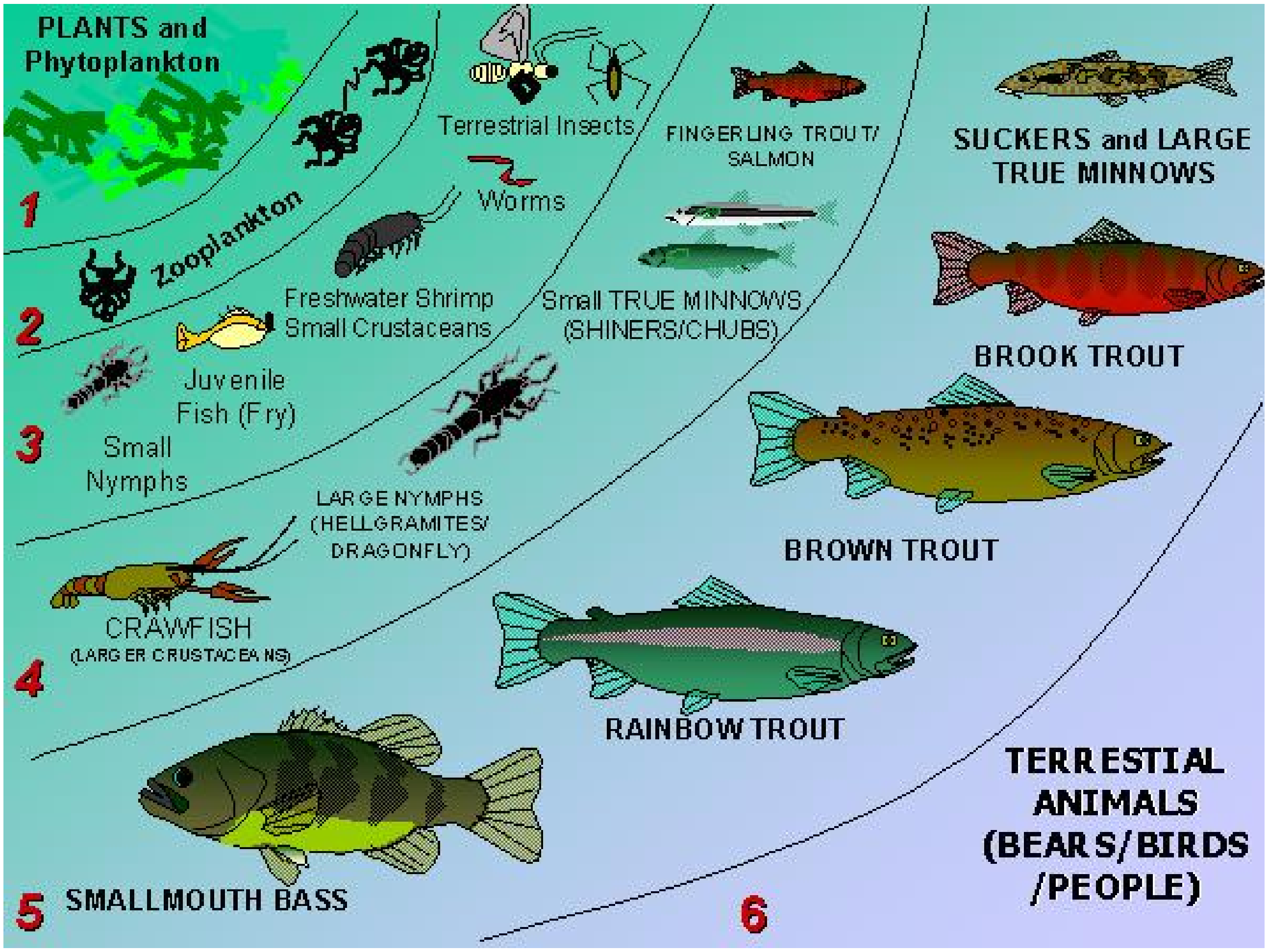
Scarboro Community Assessment Report. Since 1998, the Joint Center for Political and Economic Studies (with the support of DOE's Oak Ridge Operations) has worked with the Scarboro community on residents' economic, environmental, health, and social needs. In 1999, the Joint Center for Political and Economic Studies surveyed the Scarboro community to identify environmental and health concerns. The surveyors achieved an 82 percent response rate. Because Scarboro is a small community, this community assessment provided new information about the area and its residents not available from sources that evaluate more populated areas, such as the U.S. Census Bureau. The assessment illustrated the relatively low rank of environmental and health issues among the community's primary concerns. 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).

U.S. Environmental Protection Agency (EPA)

Scarboro Community Environmental Sampling Validation Study. To respond to community concerns, to identify data gaps, and to validate the May 1998 sampling by FAMU, in 2001 EPA's Science and Ecosystem Division Enforcement Investigation Branch collected sediment, soil, and surface water samples in Scarboro. EPA analyzed these samples and compared the results to those from May 1998. EPA concluded that its findings supported the 1998 sampling, and that residents within the sampled areas in Scarboro were not currently exposed to harmful levels of substances from the Y-12 plant. Because of its findings, EPA did not recommend additional action for the Scarboro community (U.S. EPA 2002a).

Appendix C. Examples of Various Aquatic Food Webs[7]

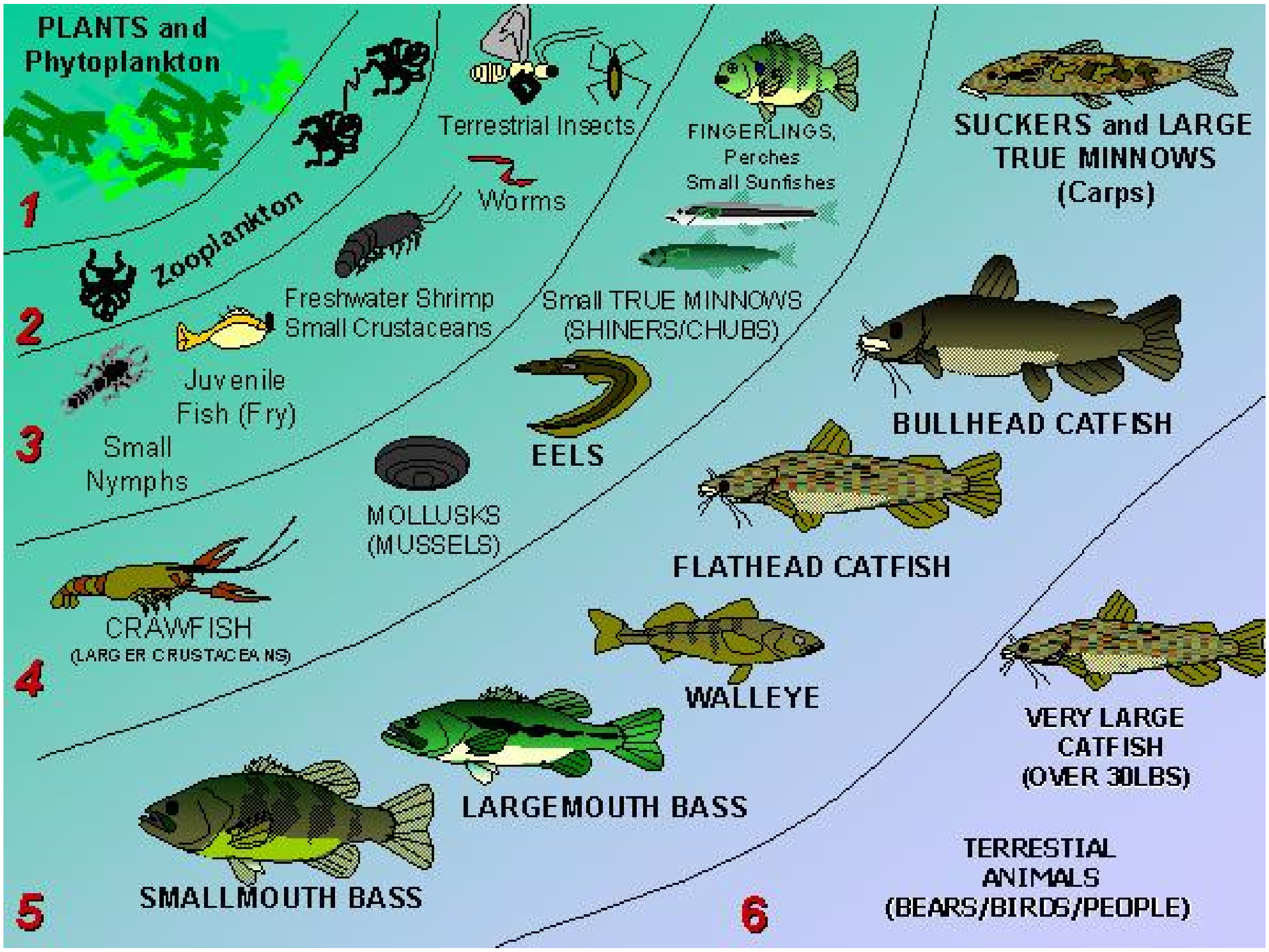
Figure C-1. Food Web for a Upper River—Cold Water Stream System



Courtesy of Bryce Meyer, Webmaster for http://www.combat-fishing.com/streamecology.html.

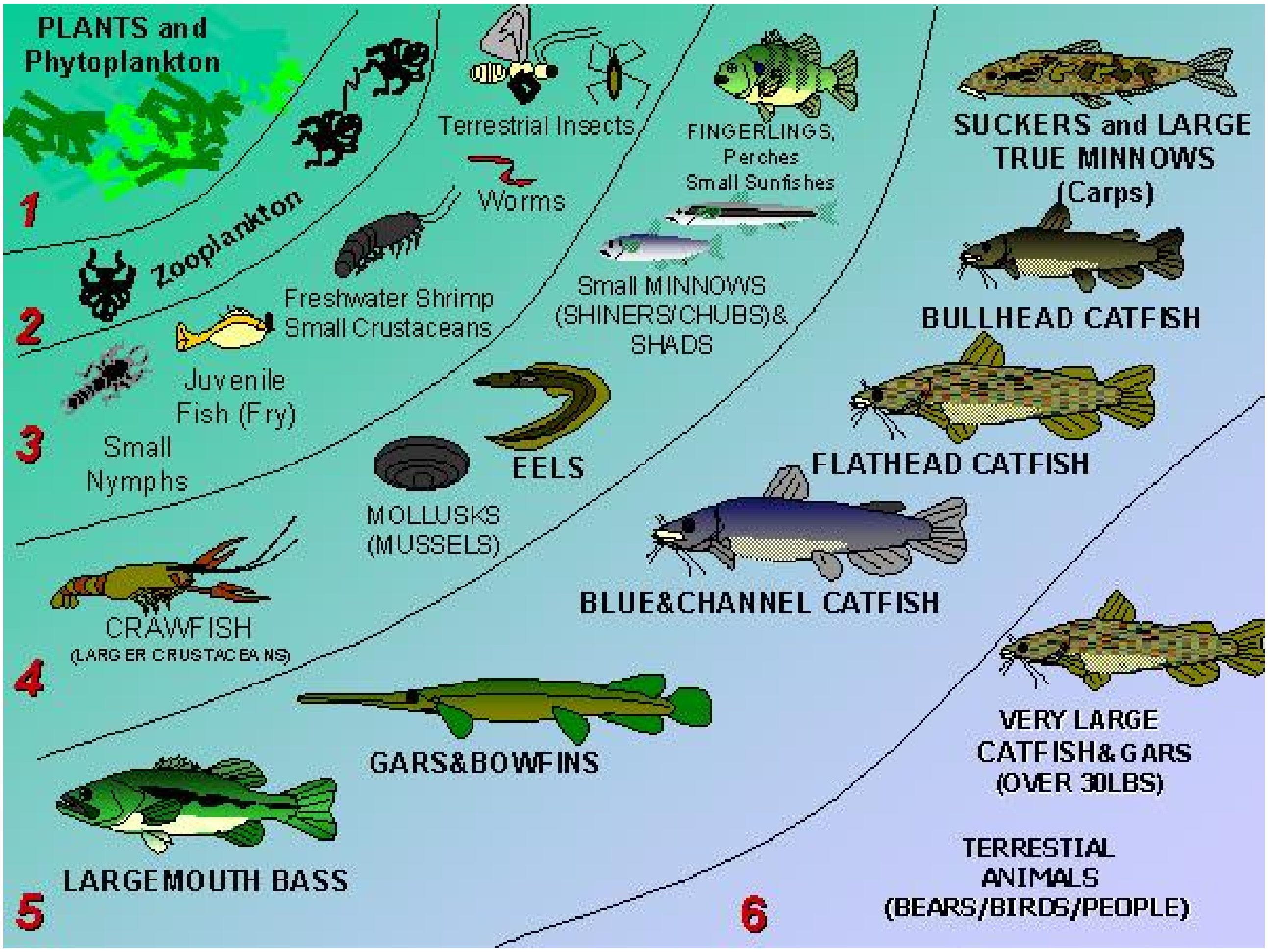
[7] A food web is a community of organisms where there are several interrelated food chains (a community of organisms where each member is eaten in turn by another member).

Figure C-2. Food Web for a Mid River—Cool Water River System



Courtesy of Bryce Meyer, Webmaster for http://www.combat-fishing.com/streamecology.html.

Figure C-3. Food Web for a Lower River—Warm River System



Courtesy of Bryce Meyer, Webmaster for http://www.combat-fishing.com/streamecology.html.

Appendix D. ATSDR's Validation of Task 3 Screening Results

Surface Water and Groundwater

ATSDR agrees with Task 3: eliminate exposure pathways dependent on drinking water contaminated by ORR activities. Surface water itself was not a major source of exposure. PCBs are poorly soluble. 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 reviewed by ChemRisk were nearly all below levels of detection is not surprising (ChemRisk 1999a). ATSDR also reviewed surface water in all three arms of the Watts Bar Reservoir (the Lower Watts Bar Reservoir, the Clinch River up to the Melton Hill Dam at Mile 23, and the Tennessee River between Miles 567 and 602) and found no PCBs detected (OREIS).

Groundwater often received releases of waste PCBs, but was unable to transport significant quantities of the poorly soluble oils off site. Groundwater thus became a barrier to migration by depositing PCBs onto the surrounding (largely inaccessible) on-site surface soils (ChemRisk 1999a), as well as the inaccessible subsurface soil. Some soluble metals can be transported by groundwater, but even for these substances off-site migration was infrequent. Groundwater is contaminated with metals throughout much of the on-site Upper East Fork Poplar Creek area; no one, however, is currently using the groundwater in the area where a groundwater plume extends past the ORR boundary (i.e., in Union Valley to the east of ORR) (U.S. DOE 2002b). ATSDR evaluated exposures to off-site groundwater in a pathway-specific public health assessment, which was released final in 2006, and can be accessed at http://www.atsdr.cdc.gov/HAC/PHA/region_4.html#tennessee.

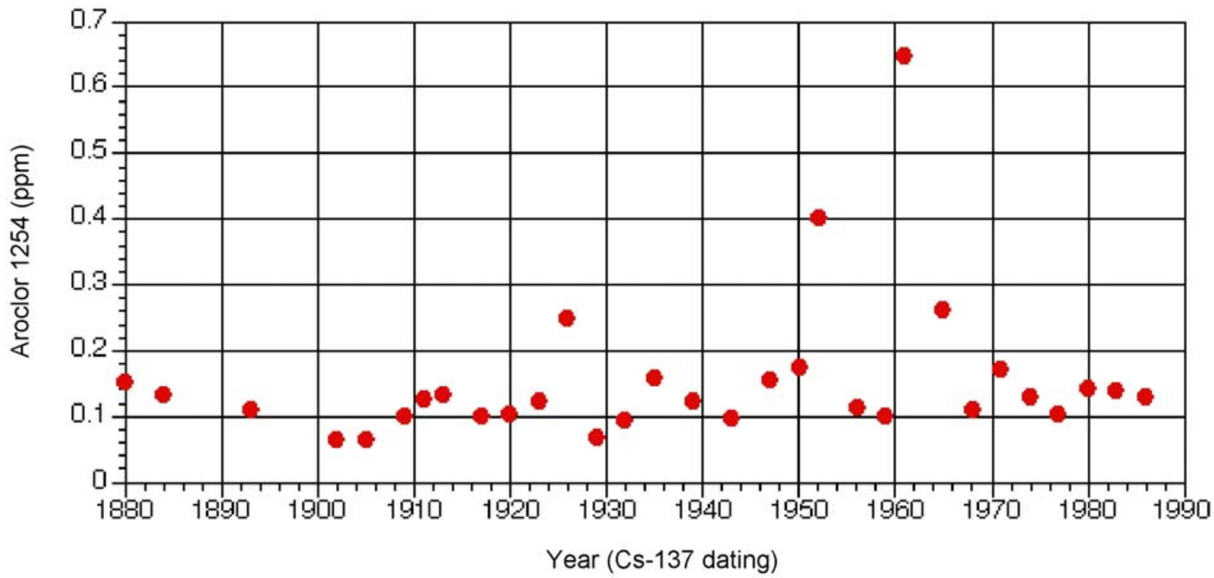
Task 3 based its analysis leading to the elimination of PCB drinking water pathways on the assumption that PCBs could have been present at its limit of detection. PCBs were undetected in surface water. Thus Task 3 scientists assumed them to be at the 100-ppb detection limit even though dissolved PCBs partition with underlying sediment that could absorb 3 million to 6 million times the PCBs that remain in water (from log octanol-water coefficients for Aroclors 1254 and 1260) (ATSDR 2000; ChemRisk 1999a). Total sediment PCB concentrations found beneath surface water was consistently below 1,000 ppb, so PCBs in the water could not have been above 0.00032 ppb. Given Task 3's elimination of drinking water as a significant exposure pathway—assuming its concentration averaged 100 ppb—and this agency's demonstration that PCB's physical properties prevent surface water from containing levels higher than 0.00032 ppb, ATSDR can quite confidently eliminate drinking water as a significant pathway.

Clinch River Sediment

Task 3 eliminated direct ingestion or contact with Clinch River sediment. But ATSDR found so much more recreational and commercial activity on this waterway than on East Fork Poplar Creek, which Task 3 retained, that ATSDR also screened Clinch River sediment.

Clinch River sediment deposited in layers annually. Although river flow can mix layers to some degree, a rough correlation of depth to age can be constructed using peak cesium-137 during 1960s maximum atmospheric fallout for calibration. Minimum PCB detection levels were well below comparison values (see Figure 23), but they were not always high enough to show PCB deposition layers. Nevertheless, one core sediment sample at CRM 9.5 yielded a timeline that allowed comparison of PCBs deposited while ORR was active to recent data. See Figure D-1 for the core's PCB distribution.

Figure D-1. PCBs in Sediment Core from Clinch River at CRM 9.5



From the discussion above and Figure D-1, ATSDR constructed a timeline:

Table D-1. Timeline for PCB Deposition to Sediment

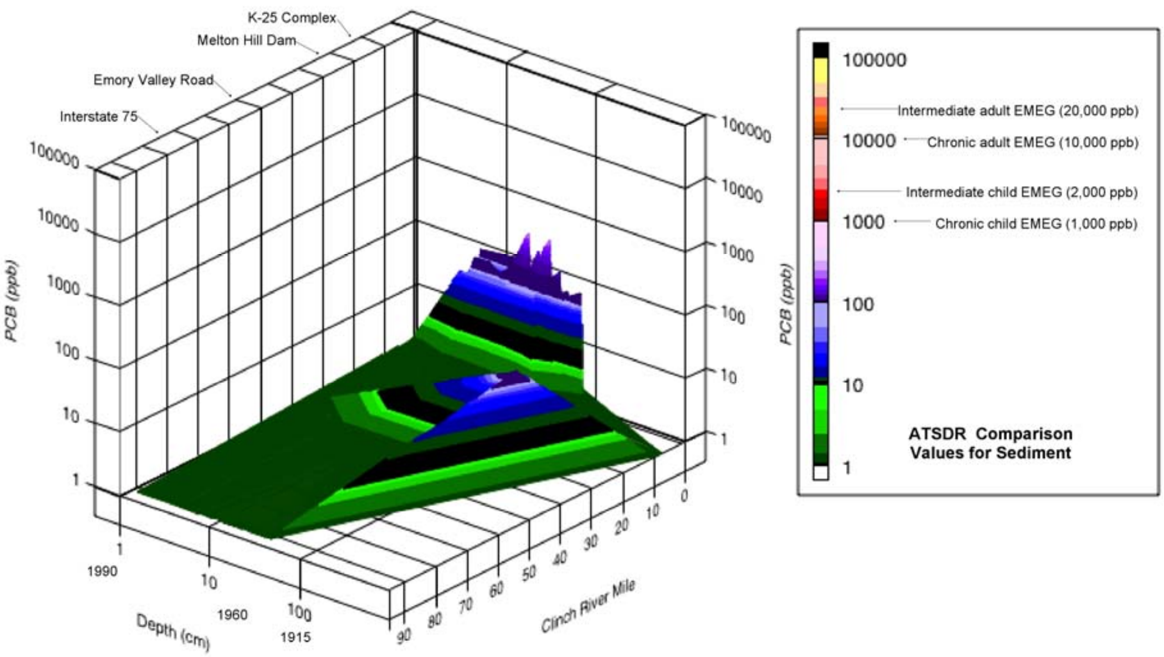
cm depth	***100***	***90***	***80***	***70***	***60***	***50***	***40***	***30***	***20***	***10***	***0***
deposited	***1910***	***1918***	***1927***	***1935***	***1944***	***1952***	***1960***	***1968***	***1977***	***1985***	***1993***
event			A		B————————>C				D		
Dividing the data into three time periods:											
PCB (ppm)	Before 1930				1950–1970				1980–1993		
mean	0.13				0.26				0.14		
range	0.07–0.24				0.10–0.62				0.13–0.14		

A PCBs first manufactured on commercial scale 1927–1929.
B ORR started up in 1942.
C ORR operations using PCBs continued to 1970.
D ORR PCB use and disposal discontinued and remediation began.

This analysis differs from that in Task 3, which used the CRM 9.5 core to argue for consistent environmental loading of PCBs over time. ATSDR finds contamination from PCB deposits during ORR operations is twice the 1993 level of PCB contamination, which in turn, is close to the level before PCBs were commercially manufactured in quantities adequate for electrical power transmission. ATSDR used a graphic technique similar to the one described for East Fork Poplar Creek sediment to display Clinch River sampling, with the exception that for the *y* axis, ATSDR used depth (or time of deposition), instead of distance from the river bed, *versus* CRM on the *x* axis.

Figure D-2 confirms that the highest deposited contamination in the Clinch River was during ORR operation, but shows that contamination levels never exceeded any of ATSDR's comparison values at any location along the river. Over the years, less-than-toxic levels declined still further. As with East Fork Poplar Creek, sediment contamination is (and was) insufficient to cause illness. ATSDR agrees with Task 3 that Clinch River sediment exposure pathways need not be retained for further consideration.

Figure D-2. PCBs Detected* in Clinch River Sediment Before 1996



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

Source: OREIS

Tennessee River Sediment

Even though the limit of detection for sediment PCBs is well below all ATSDR comparison values, none of the sediment samples taken from 1983 to 1993, from more than 25 stations on the Tennessee River, yielded detectible PCBs (OREIS 2004).

Appendix E. PCBs Measured as Total Congeners or Total Aroclors

Polychlorinated biphenyls (PCBs) are a class of related chemicals. They have in common a molecular structure in which two six-member benzene rings of carbon atoms are joined by a single carbon-carbon bond, and one or more of the available carbon atoms are bonded to chlorine atoms. There are 209 possible ways to distribute 1–10 chlorines among the 10 available carbon atoms on the two rings. Individual members of the class of 209 chemicals are called congeners. Commercial mixtures of the congeners were once widely used in electrical components, for example. Some mixtures were called Aroclors, and they were named after the percentage of chlorine in their chemical compositions—Aroclor 1260 was 60 percent chlorine when manufactured; Aroclor 1254 was 54 percent chlorine, and so on.

Some PCB analytical methods use the congeners present in the Aroclor mixtures and the ratios of their concentrations to estimate the amounts of each Aroclor mixture in a sample. Because less-chlorinated congeners degrade fastest, estimates of Aroclor concentrations determined from more highly chlorinated compounds overstate contamination, especially when concentrations of reported Aroclors sharing common congeners are totaled to estimate total PCB concentration.

PCBs in some fish samples were reported as individual congeners. Adding the congeners present in a sample provide a more accurate total of PCBs present than adding the Aroclors. But laboratories did not measure all 209 congeners, only the most common 40, and so contamination could be understated if rare congeners are present. PCBs in samples of fish taken before 1996 were sometimes reported as Aroclors, sometimes as individual congeners, and sometimes as both. Samples of fish taken during and after 1996 were generally only reported as Aroclors.

To provide an overview of the distribution of the different congeners in Watts Bar Reservoir fish in the database, ATSDR used data for congeners in all 370 samples for which congener data were reported. Data were available for 40 congeners in 366 of these samples. Of the 40 congeners, 16 were among the 21 congeners for which human serum samples were also analyzed in ATSDR's 1998 Watts Bar Reservoir Exposure Investigation (ATSDR 1998). ATSDR calculated the median (50^{th} percentile) concentration in Watts Bar Reservoir fish for each of these 16 shared congeners.

ATSDR also calculated the concentration for each congener at the 10^{th}, 25^{th}, 75^{th}, 90^{th}, and 95^{th} percentile. The concentration of congener number 105 at, for example, the 25^{th} percentile, is the concentration for which 25 percent of all samples had a lower concentration of PCB number 105. At least half the samples did not exceed the declared limit of detection (LOD, or 10 ppb) for one or more of the congeners. But concentrations less than the declared LOD were sometimes estimated for congeners. To use the entire database for these calculations, ATSDR substituted 2.5 ppb, or one half of the lowest concentration (5 ppb) as an estimate of the undetected congeners.

An analytical method has a range of concentrations for which it is most valid, and that range generally starts at two or three times the method's LOD. Therefore, in Table E-1, there is more confidence in congener concentrations greater than 20 ppb. To show how all congeners were distributed within a sample relative to one of them (intra-sample distribution), ATSDR calculated each congener as a percent of the one congener most retained by humans (PCB number 153) for each of the 156 samples in which PCB number 153 exceeded its LOD. This distribution is displayed in Table E-2. This table represents a "fingerprint," or database-specific characterization, of the way congeners are distributed in Watts Bar Reservoir fish.

Table E-1. Concentration of Congeners in Watts Bar Reservoir Fish by Percentile

Percentile	Congener #															
	28	52	66	99	101	105	118	138	153	156	170	180	183	194	195	201
10th	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
25th	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
50th	2.5	2.5	2.5	2.5	10	2.5	10	10	10	2.5	2.5	2.5	2.5	2.5	2.5	2.5
75th	10	10	2.5	20	20	2.5	40	40	60	10	10	40	10	7	2.5	10
90th	10	10	10	110	40	10	80	90	120	20	10	100	30	10	10	20
95th	10	30	20	130	60	10	100	150	230	30	40	160	50	30	10	40

Concentrations as parts per billion (ppb).

Table E-2. Fish Congeners as Percent of PCB #153 by Percentile

Percentile	Congener #															
	28	52	66	99	101	105	118	138	153	156	170	180	183	194	195	201
10th	1.1	1.5	2.3	1.2	3.1	1.3	9.1	3.3	100	2.8	1.1	4.2	2.8	2.5	2.1	2.8
25th	2.5	4.2	3.1	2.8	8.3	2.8	19	6.3	100	4.2	2.8	8.3	6.7	4.2	3.1	4.2
50th	5	10	6.3	5.3	20	5	27.1	12.5	100	8.3	6.3	38.1	12.5	8.3	6.3	8.3
75th	9.1	25	12.5	33.3	50	12.5	50	33.3	100	12.5	12.5	81.8	20	12.5	12.5	12.5
90th	12.5	33.3	20	80	100	16.7	83.3	66.7	100	25	33.3	140	33.3	18.8	16.7	20
95th	20	45	25	280	100	25	100	191.7	100	50	50	171	47.7	25	22.5	26.7

Concentrations as ppb.