

Dieldrin equaled the 0.10 milligram per kilogram (mg/kg) guideline set by the NAS/NAE (1973) for whole fish. Endrin was detected at a concentration of 0.027 mg/kg, which exceeded the 0.025 mg/kg criteria established by the Niagara River Biota Contamination Project (Newell and others, 1987) for whole fish. According to Schmidt and others (1990), geometric mean concentrations for dieldrin, heptachlor epoxide, and endrin have remained steady across the Nation. This information was the result of the National Contaminant Biomonitoring Program (NCBP) that collected fish tissue samples at 117 locations across the Nation from 1976 until 1984.

Total chlordane (chlordane) is represented by the sum of the concentrations of *cis*- and *trans*-chlordane, *cis*- and *trans*-nonachlor, and oxychlordane, the five major components of technical chlordane (L.H. Nowell, U.S. Geological Survey, written commun., 2000). In August 1998, chlordane was detected at only two whole fish sampling sites (fig. 8) with one site having a concentration of 0.149 mg/kg, above the 0.1 mg/kg NAS/NAE guideline for chlordane for whole fish. Chlordane was detected at 26 fish fillet sampling sites. These sites were sampled between 1985 and 1994, and one sample exceeded the 0.3 mg/kg FDA action level for fish fillets. This sample was collected in November 1990 with a concentration of 0.36 mg/kg; the sampling site was Wheeler Lake at Tennessee River mile 300. Results from the NCBP revealed that chlordane concentrations declined throughout the late 1970's, but then remained steady for a period of time nationwide (Schmidt and others, 1990). Chlordane, like other organochlorine pesticides, is transferred up the food chain to fish. Chlordane can remain active in soils for 20 years and, like other cyclodiene pesticides, was used as a deterrent to termites.

Hexachlorobenzene is a chlorinated benzene derivative that possesses fungicidal properties. This compound was first used in 1945 as a treatment to control fungal activity on seeds (Ware, 1989). No detections of hexachlorobenzene were found in whole fish tissue samples in the LTEN River Basin.

Toxaphene, a polychloroterpene material, was discovered in 1947 and was manufactured by the chlorination of camphene, a pine tree derivative. Primary uses of toxaphene were to kill pests on crops (such as cotton) and on livestock, and to eliminate unwanted fish in lakes. Toxaphene data discussed here were collected from 1991 through 1994, which is 5 years

after the sale and distribution of remaining stocks and 8 years after the compound was banned. Toxaphene is persistent in the soil, but not as persistent as cyclodiene compounds; toxaphene will persist on foliage for 3 to 4 weeks. This short residence time is generally attributed to volatilization rather than metabolism or ultraviolet degradation. Over 670 chemicals make up toxaphene with no one chemical making up a majority of the composition. One component, Toxicant A ($C_{10}H_{10}Cl_6$), however, is itself 36 times more toxic to some fish than the total compound. Toxaphene is easily metabolized once ingested by birds and mammals, but fish are highly susceptible to poisoning (Ware, 1989).

Toxaphene was detected at 5 of 75 (about 7 percent) of the sampling sites in the LTEN River Basin (fig. 9). Concentrations of toxaphene were detected in 6 of 262 fish fillet samples, all of which were below the 5 mg/kg action level for fish fillets (table 1). Mean concentrations of toxaphene from the NCBP revealed that toxaphene reached a plateau during the early 1970's and has steadily declined since that time.

Diphenyl Aliphatics

DDT is a member of the diphenyl-aliphatic chemical class, which was widely used as an insecticide in the United States until 1973 when it was banned except for use in public health emergencies. Initial uses of DDT in the Tennessee River Valley area were for insect control around reservoirs and other wet areas. Technical DDT is composed of three isomers, *para-para* (*p,p'*), *ortho-para* (*o,p'*), and *ortho-ortho* (*o,o'*). The *p,p'* isomer makes up approximately



DDT proved to be extremely effective against flies and mosquitoes, with malaria control being DDT's most beneficial public-health use. More than 4 billion pounds of DDT have been used throughout the world for insect control since 1940 (Ware, 1989). Photo courtesy of the Tennessee Valley Authority Historic Collection.

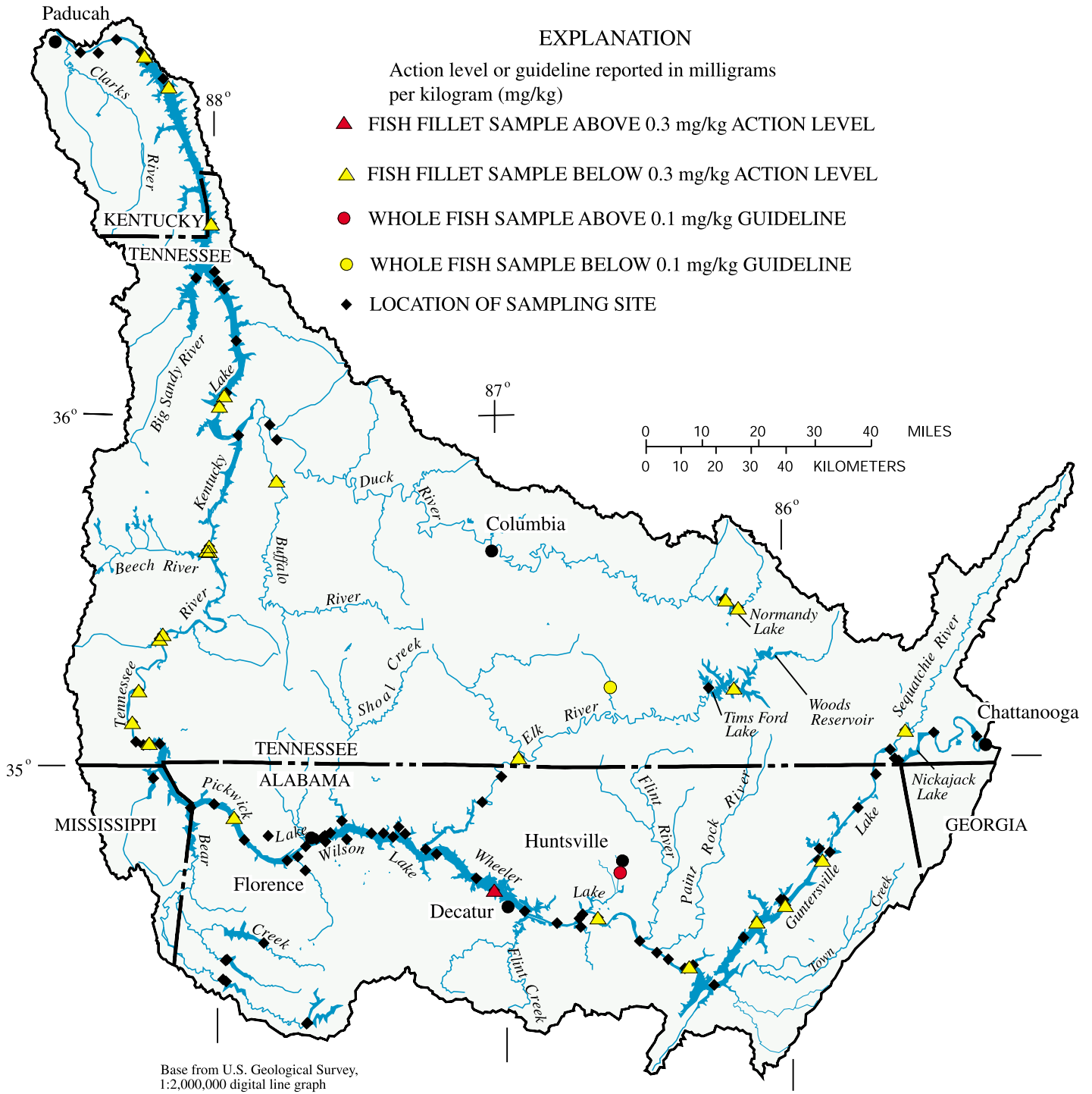


Figure 8. Location of sampling sites with detections of total chlordane in fish tissue in the lower Tennessee River Basin, 1980-98.

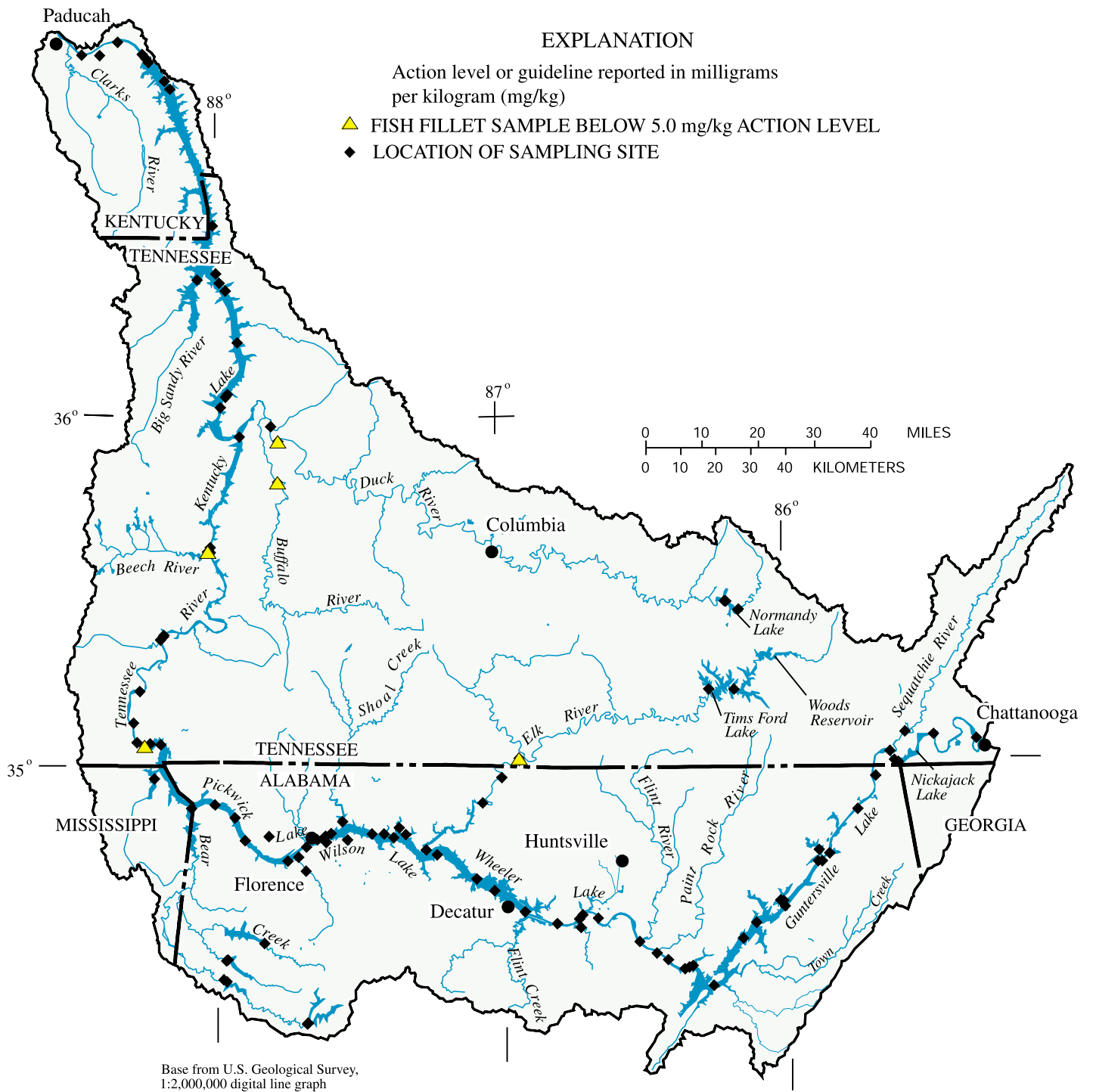


Figure 9. Location of sampling sites with detections of toxaphene in fish tissue in the lower Tennessee River Basin, 1980-98.

77 percent of the total DDT compound and is typically the most frequently analyzed and detected isomer. Although use of DDT has been banned for over 25 years in the United States, concentrations of DDT and its breakdown products are still detected in whole fish and fish fillet samples. The persistence of DDT in fish tissue may be attributed to the fact that this synthesized product is insoluble in water, and extremely soluble in fatty tissue as well as resistant to metabolism (Ware, 1989).

The first breakdown product of DDT is DDD, which subsequently breaks down into DDE. Of these three compounds, the most commonly detected was the DDE isomer, *p,p'*-DDE, which was detected at approximately 80 percent of the sites sampled. The compound *p,p'*-DDE composed approximately 80 percent of the total DDT concentration detected in whole fish and approximately 48 percent detected in fish fillet samples. Because DDE is one of the final breakdown products of DDT, higher percentages of DDE were expected in whole fish sample results for two reasons. First, whole fish samples were collected in the summer of 1998 whereas fish fillet samples were collected from 1985 to 1994 allowing more time for DDT metabolization in the whole fish samples. Secondly, whole fish have a higher fat content compared to fish fillets. Because organochlorine compounds such as DDE are more soluble in fatty tissue, higher concentrations of DDE were expected to be found in whole fish. Because DDE was present in a greater percentage of the samples than either of the parent compounds, these results may indicate that the breakdown of DDT is in the final stages. This finding is parallel with the finding made by Schmidt and others (1990) using the NCBP concentration data. Schmidt and others (1990) noted that the proportional composition of the DDT mixture changed little from the mid-1970's through 1981 and consisted of about 70 percent *p,p'*-DDE, 20 percent *p,p'*-DDD, and 10 percent *p,p'*-DDT. When the data collected by the NCBP from 1984 is included, the proportional composition of *p,p'*-DDE of the total DDT mixture increases to 73 percent, which is similar to data for the LTEN River Basin whole fish samples and may indicate the same transition from parent to metabolite noted in the LTEN River Basin (Schmidt and others, 1990). Concentrations of *p,p'*-DDE were as high as 1.2 mg/kg in whole fish and 12.8 mg/kg in fish fillets (table 1). No detections of *p,p'*-DDT were above action levels or guidelines (fig. 10); however, concentrations of *p,p'*-

DDD in fish fillet samples and *p,p'*-DDE in whole fish and fish fillet samples exceeded action levels and guidelines, respectively (figs. 11 and 12, respectively). Fish fillet samples with concentrations of these compounds that exceeded the action levels were collected between October 1991 and October 1993. Fish fillet samples collected after this time period had concentrations that were below action levels for *p,p'*-DDD and for *p,p'*-DDE.

Although concentrations of *p,p'*-DDT, *p,p'*-DDD, and *p,p'*-DDE were frequently detected in fish tissue across the LTEN River Basin, one area in particular had concentrations that were above action levels and guidelines. The area surrounding Indian Creek, located just west of Huntsville, Alabama, and the confluence of Indian Creek with the main stem of the Tennessee River, had 10 of 17 *p,p'*-DDD and *p,p'*-DDE sample concentrations that equaled or exceeded the action levels or guidelines established by the NAS/NAE, NYDEC, or FDA. Fish tissue samples that exceeded the action levels and guidelines were collected between 1991 and 1998. The highest concentrations of *p,p'*-DDT, *p,p'*-DDD, and *p,p'*-DDE were collected in October 1991 in Wheeler Lake at Tennessee River mile 320. The most recent sample collected in this area was spotted bass (*Micropterus punctulatus*) in August 1998, which had a *p,p'*-DDE concentration of 1.2 mg/kg. This sample was collected in Indian Creek upstream from the posted fish consumption advisory section of the creek. In September 2000, fish advisories recommended that no fish be consumed that are taken from Indian Creek between Redstone Arsenal and the Tennessee River as a result of elevated concentrations of DDT (Alabama Department of Public Health, 2000).

Polychlorinated Biphenyls

Polychlorinated biphenyls (PCB's) are synthetically halogenated aromatic hydrocarbons that were first developed in 1881. Total PCB's refers to the sum of 209 individual chlorinated chemicals known as congeners. By 1930, PCB's were in general use as lubricants, heat transfer agents, flame retardants, and plasticizers. By July 1979, the use of PCB's was restricted by the U.S. EPA as a result of contamination concerns. These restrictions essentially stopped the use, production, and distribution of PCB-containing products except in totally enclosed systems and when special exemption was granted by the U.S. EPA.

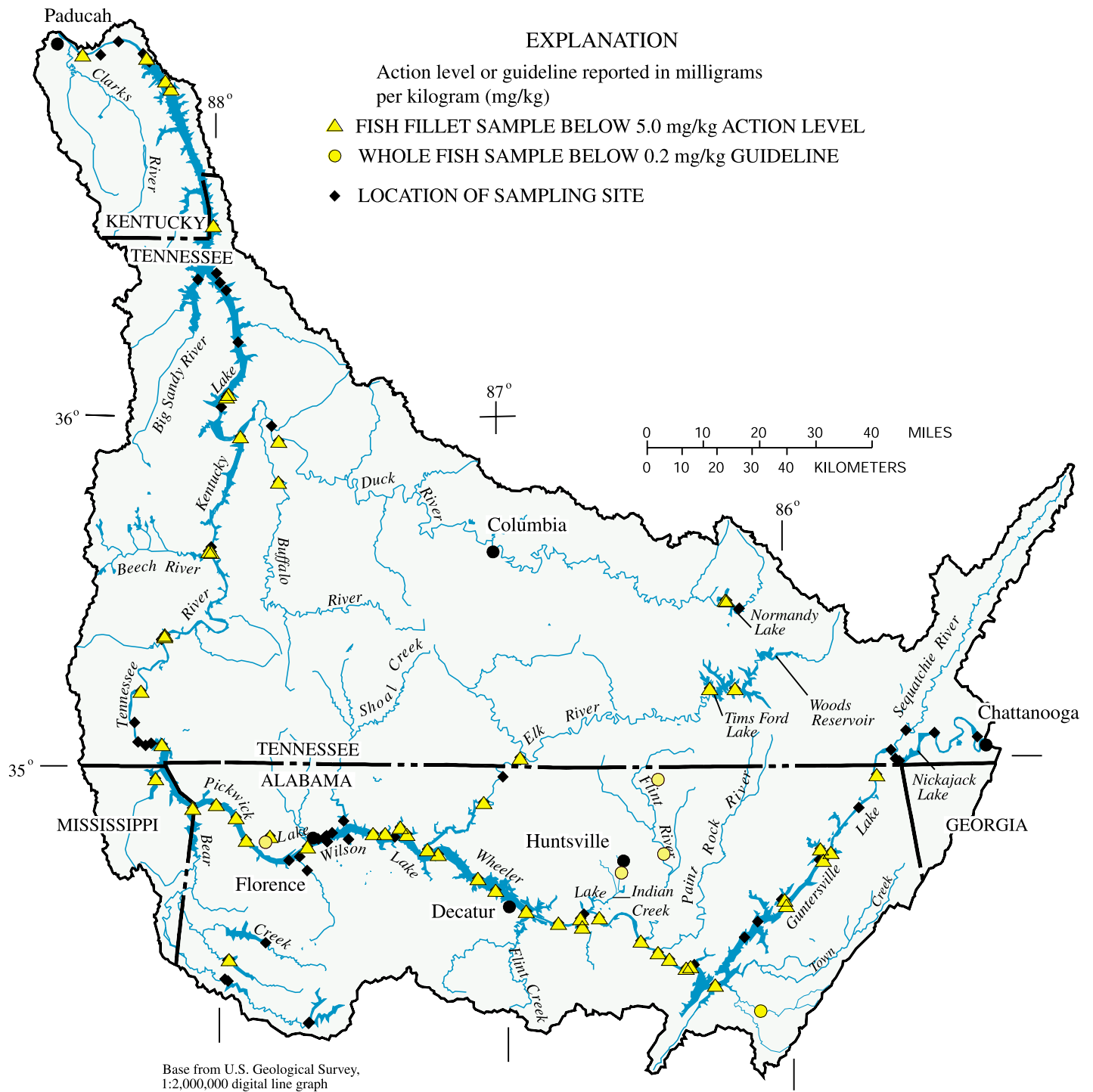


Figure 10. Location of sampling sites with detections of p,p' -DDT in fish tissue in the lower Tennessee River Basin, 1980-98.

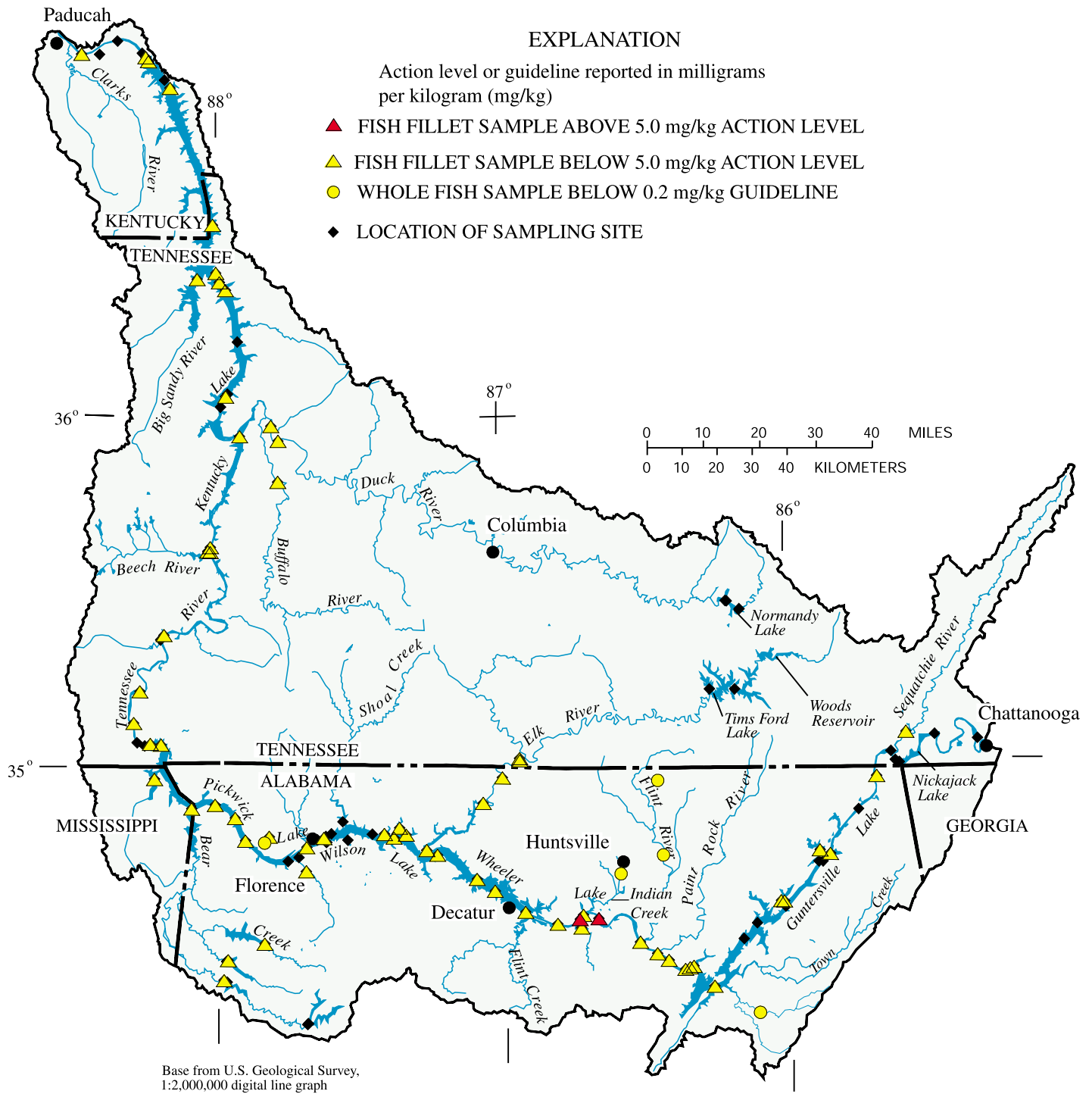


Figure 11. Location of sampling sites with detections of p,p' -DDD in fish tissue in the lower Tennessee River Basin, 1980-98.

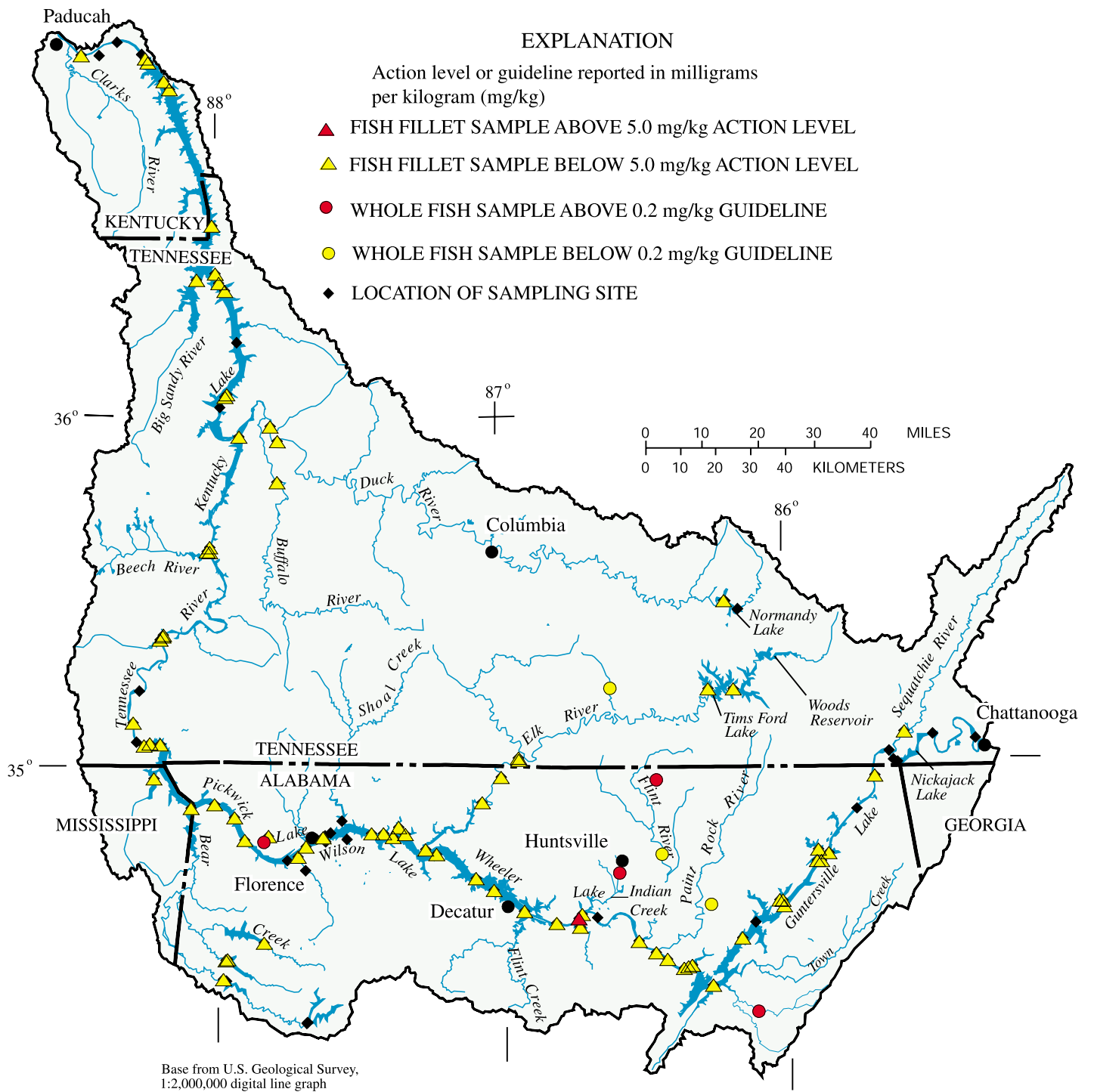


Figure 12. Location of sampling sites with detections of p,p' -DDE in fish tissue in the lower Tennessee River Basin, 1980-98.