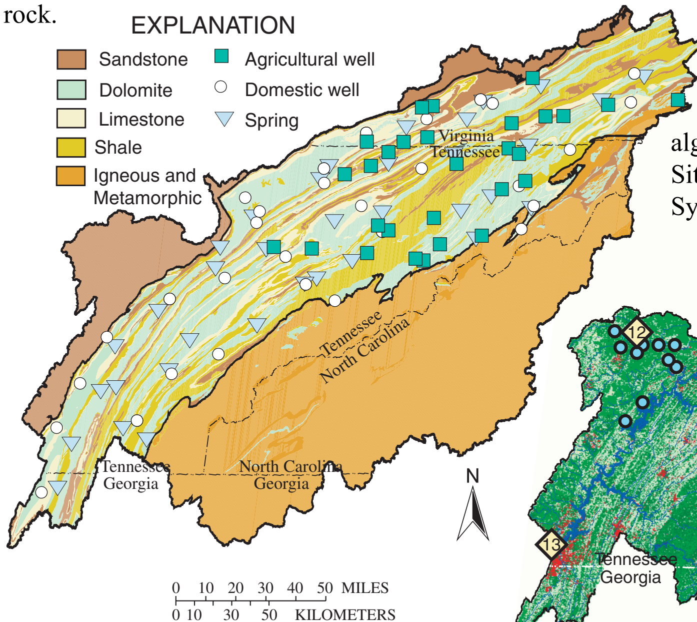
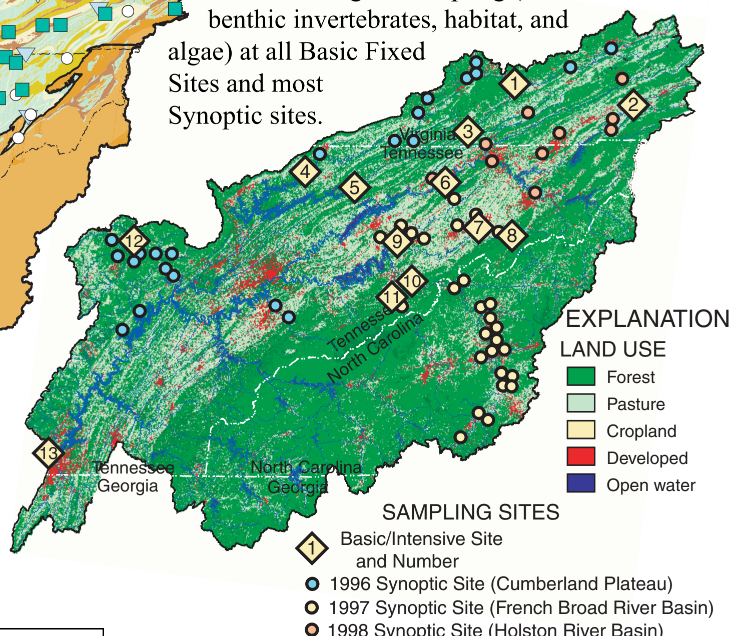
Study designs for both ground-water and surface-water components focused principally on the Valley and Ridge province. The Valley and Ridge is home to the majority of the Study Unit population and is the most highly developed in terms of agriculture and urban land uses. Ground-water studies focused on the carbonate-based dolomites and limestones of the Valley and Ridge. These geologic units form the most prolific aquifers in the Upper Tennessee River Basin and also are the most susceptible to contamination because of their associated karst and solution features. Ground-water resources are very limited in the Blue Ridge and Cumberland Plateau provinces because of the relatively impermeable nature of the bedrock and the low water-storage capacity of the thin soils that overlie the bedrock.

Surface-water studies focused on the unregulated portions of the Upper Tennessee River Basin principally in the Valley and Ridge province, which contains the most intense agricultural activity in the basin. Thirteen basic fixed stream-sampling sites were operated during the study to monitor water-quality conditions with time in various parts of the basin. Data-collection sites were selected to cover the major subbasins of the Upper Tennessee River and to encompass the major land uses. An additional 61 sites were sampled during the study as part of three synoptic networks designed to better describe areal water-quality variations of the subbasins. In keeping with the NAWQA multiple lines of evidence approach to describe water-quality conditions,[34] data-collection activities included water-column chemistry at all sites, bed-sediment and Asiatic clam tissue samples at Basic Fixed Sites, and stream ecological sampling (fish communities, benthic invertebrates, habitat, and algae) at all Basic Fixed Sites and most Synoptic sites.





Site number	*Site name*	*Site type*	*Physio-graphic province**
1	Guest River near Millers Yard, Virginia	Indicator, Mining	CP
2	Middle Fork Holston River at Seven-Mile Ford, Virginia	Indicator, Mixed	VR
3	Copper Creek near Gate City, Virginia	Indicator, Agriculture	VR
4	Powell River near Arthur, Tennessee	Integrator	CP-VR
5	Clinch River at Tazewell, Tennessee	Integrator	VR-CP
6	Holston River at Surgoinsville, Tennessee	Integrator	VR
7	Big Limestone Creek near Limestone, Tennessee	Indicator, Agriculture	VR

Site number	*Site name*	*Site type*	*Physio-graphic province**
8	Nolichucky River at Embreeville, Tennessee	Indicator, Mining	BR
9	Nolichucky River at Lowlands, Tennessee	Indicator, Mixed	BR-VR
10	French Broad River near Newport, Tennessee	Indicator, Agriculture	BR
11	Pigeon River at Newport, Tennessee	Integrator	BR-VR
12	Clear Creek at Lilly Bridge, Tennessee	Integrator	CP
13	Tennessee River at Chattanooga, Tennessee	Integrator	CP-VR-BR

* CP - Cumberland Plateau, BR - Blue Ridge, VR - Valley and Ridge

SUMMARY OF DATA COLLECTION IN THE UPPER TENNESSEE RIVER BASIN, 1994–98

Study component	What data were collected and why	Types of sites sampled	Number of sites	Sampling frequency and period
		Stream Chemistry		
Bottom-sediment survey	Sediment in depositional zones was sampled for pesticides, other synthetic organic compounds, and trace elements to determine the presence of potentially toxic compounds. Water-quality samples also were taken at each site, including major ions, nutrients, organic carbon, pesticides, bacteria, and suspended sediment.	Selected rivers and streams.	15	Once (1995, 1996, 1998)
Water-chemistry sites	Water-chemistry data, including major ions, nutrients, organic carbon, pesticides, bacteria, and suspended sediment, were used to describe concentrations and loads.	Sampling occurred near selected continuous streamflow sites.	13	Variable (1996–98)
Storm sampling program	Water-chemistry data, including major ions, nutrients, organic carbon, pesticides, bacteria, and suspended sediment, were used to describe concentrations and loads.	Samples were taken at water-chemistry sites during high-flow conditions.	variable	Variable (1996–98)
Nutrient/ pesticide synoptic studies	Water-chemistry data, including major ions, nutrients, organic carbon, pesticides, bacteria, and suspended sediment, were used to describe concentrations of selected constituents.	Surface-water sampling sites in the Cumberland Plateau, French Broad River Basin, and the Valley and Ridge were selected to describe conditions across the Study Unit.	64	Variable (1996) (1997) (1998)
Intensive pesticide sampling	Pesticides, major ions, organic carbon, suspended sediment, bacteria, and nutrients were analyzed to determine seasonal variations in concentrations and loads.	Water-chemistry sites located in intensive agricultural basins or mixed land-use basins.	3	Biweekly (March–Nov.,1996)
		Stream Ecology		
Contaminants in Asiatic clams	Asiatic clams were sampled for pesticides, other synthetic organic compounds, and trace elements to determine the presence of potentially toxic compounds.	Selected rivers and streams.	15	Once (1995, 1996, 1998)
Aquatic biology	Biological communities and stream habitat were assessed and fish, macroinvertebrates, and algae were quantitatively sampled.	Biological communities and habitat at basic fixed water-chemistry sites, and biological communities at synoptic sites.	13 fixed sites, 63 synoptic sites	Once (1995–98)
Spring synoptic study	Macroinvertebrates were qualitatively sampled.	Spring sites.	35	Once (Aug.–Nov.,1997)
		Ground-Water Chemistry		
Agricultural land-use survey	Water-chemistry data, including major ions, nutrients, organic carbon, pesticides, and radon, were analyzed to determine the effects of burley tobacco production on shallow ground-water quality.	Shallow 2-inch monitoring wells were installed adjacent to tobacco fields in the Valley and Ridge in northeastern Tennessee and southwestern Virginia.	30	Once (June and July, 1997)
Study Unit spring survey	Water-chemistry data, including major ions, nutrients, organic carbon, pesticides, bacteria, and radon were analyzed to determine the quality of ground water.	Randomly selected springs in the Valley and Ridge.	35 springs	Once (Aug.–Nov.,1997)
Study Unit well survey	Water-chemistry data, including major ions, nutrients, organic carbon, pesticides, bacteria, and radon, were analyzed to determine the quality of ground water.	Randomly selected wells in the Valley and Ridge.	30 wells	Once (Sept. 98–Nov. 99)

Aquatic-life criteria—Water-quality guidelines for protection of aquatic life. Often refers to U.S. Environmental Protection Agency water-quality criteria for protection of aquatic organisms.

Aquifer—A water-bearing layer of soil, sand, gravel, or rock that will yield usable quantities of water to a well.

Basic Fixed Sites—Sites on streams at which streamflow is measured and samples are collected for temperature, salinity, suspended sediment, major ions and metals, nutrients, and organic carbon to assess the broad-scale spatial and temporal character and transport of inorganic constituents of stream water in relation to hydrologic conditions and environmental settings.

Bed sediment—The material that temporarily is stationary in the bottom of a stream or other watercourse.

Bed sediment and tissue studies—Assessment of concentrations and distributions of trace elements and hydrophobic organic contaminants in streambed sediment and tissues of aquatic organisms to identify potential sources and to assess spatial distribution.

Benthic invertebrates—Insects, mollusks, crustaceans, worms, and other organisms without a backbone that live in, on, or near the bottom of lakes, streams, or oceans.

Constituent—A chemical or biological substance in water, sediment, or biota that can be measured by an analytical method.

Contamination—Degradation of water quality compared to original or natural conditions and due to human activity.

Cubic foot per second (ft^3/s, or cfs)—Rate of water discharge representing a volume of 1 cubic foot passing a given point during 1 second, equivalent to approximately 7.48 gallons per second or 448.8 gallons per minute or 0.02832 cubic meter per second.

Degradation products—Compounds resulting from transformation of an organic substance through chemical, photochemical, and/or biochemical reactions.

Detection limit—The minimum concentration of a substance that can be identified, measured, and reported within 99 percent confidence that the analyte concentration is greater than zero; determined from analysis of a sample in a given matrix containing the analyte.

Discharge—Rate of fluid flow passing a given point at a given moment in time, expressed as volume per unit of time.

Drainage area—The drainage area of a stream at a specified location is that area, measured in a horizontal plane, which is enclosed by a drainage divide.

Drinking-water standard or guideline—A threshold concentration in a public drinking-water supply, designed to protect human health. As defined here, standards are U.S. Environmental Protection Agency regulations that specify the maximum contamination levels for public water systems required to protect the public welfare; guidelines have no regulatory status and are issued in an advisory capacity.

Indicator sites—Stream sampling sites located at outlets of drainage basins with relatively homogeneous land use and physiographic conditions; most indicator-site basins have drainage areas ranging from 20 to 200 square miles.

Integrator or Mixed-use site—Stream sampling site located at an outlet of a drainage basin that contains multiple environmental settings. Most integrator sites are on major streams with relatively large drainage areas.

Intensive Fixed Sites—Basic Fixed Sites with increased sampling frequency during selected seasonal periods and analysis of dissolved pesticides for 1 year. Most NAWQA Study Units have one to two integrator Intensive Fixed Sites and one to four indicator Intensive Fixed Sites.

Karst—A type of topography that results from dissolution and collapse of carbonate rocks such as limestone and dolomite, and characterized by closed depressions or sinkholes, caves, and underground drainage.

Load—General term that refers to a material or constituent in solution, in suspension, or in transport; usually expressed in terms of mass or volume.

Main stem—The principal course of a river or a stream.

Metamorphic rock—Rock that has formed in the solid state in response to pronounced changes of temperature, pressure, and chemical environment.

Micrograms per liter (µg/L)—A unit expressing the concentration of constituents in solution as weight (micrograms) of solute per unit volume (liter) of water; equivalent to one part per billion in most stream water and ground water. One thousand micrograms per liter equals 1 mg/L.

Milligrams per liter (mg/L)—A unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water; equivalent to one part per million in most stream water and ground water.

Nonpoint source—A pollution source that cannot be defined as originating from discrete points such as pipe discharge. Areas of fertilizer and pesticide applications, atmospheric deposition, manure, and natural inputs from plants and trees are types of nonpoint source pollution.

Point source—A source at a discrete location such as a discharge pipe, drainage ditch, tunnel, well, concentrated livestock operation, or floating craft.

Synoptic sites—Sites sampled during a short-term investigation of specific water-quality conditions during selected seasonal or hydrologic conditions to provide improved spatial resolution for critical water-quality conditions.

Tributary— A river or stream flowing into a larger river, stream, or lake.

Volatile organic compounds (VOCs)—Organic chemicals that have a high vapor pressure relative to their water solubility. VOCs include components of gasoline, fuel oils, and lubricants, as well as organic solvents, fumigants, some inert ingredients in pesticides, and some by-products of chlorine disinfection.

Water-quality standards—State-adopted and U.S. Environmental Protection Agency-approved ambient standards for water bodies. Standards include the use of the water body and the water-quality criteria that must be met to protect the designated use or uses.

Water table—The point below the land surface where ground water is first encountered and below which the earth is saturated. Depth to the water table varies widely across the country.

Yield—The mass of material or constituent transported by a river in a specified period of time divided by the drainage area of the river basin.

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APPENDIX—WATER-QUALITY DATA FROM THE UPPER TENNESSEE RIVER BASIN IN A NATIONAL CONTEXT

For a complete view of Upper Tennessee River Basin data and for additional information about specific benchmarks used, visit our Web site at http://water.usgs.gov/nawqa/. Also visit the NAWQA Data Warehouse for access to NAWQA data sets at http://infotrek.er.usgs.gov/wdbctx/nawqa/nawqa.home.

This appendix is a summary of chemical concentrations and biological indicators assessed in the Upper Tennessee River Basin. Selected results for this Basin are graphically compared to results from as many as 36 NAWQA Study Units investigated from 1991 to 1998 and to national water-quality benchmarks for human health, aquatic life, or fish-eating wildlife. The chemical and biological indicators shown were selected on the basis of frequent detection, detection at concentrations above a national benchmark, or regulatory or scientific importance. The graphs illustrate how conditions associated with each land use sampled in the Upper Tennessee River Basin compare to results from across the Nation, and how conditions compare among the several land uses. Graphs for chemicals show only detected concentrations and, thus, care must be taken to evaluate detection frequencies in addition to concentrations when comparing study-unit and national results. For example, tebuthiuron concentrations in Upper Tennessee River Basin major aquifers were similar to the national distribution, but the detection frequency was much higher (31 percent compared to 3 percent).

CHEMICALS IN WATER

Concentrations and detection frequencies, Upper Tennessee River Basin, 1995–98—Detection sensitivity varies among chemicals and, thus, frequencies are not directly comparable among chemicals

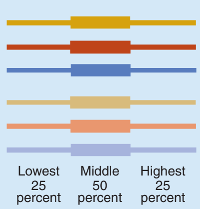
◆ Detected concentration in Study Unit

66 38 Frequencies of detection, in percent. Detection frequencies were not censored at any common reporting limit. The left-hand column is the study-unit frequency and the right-hand column is the national frequency

-- Not measured or sample size less than two

12 Study-unit sample size. For ground water, the number of samples is equal to the number of wells sampled

National ranges of detected concentrations, by land use, in 36 NAWQA Study Units, 1991–98—Ranges include only samples in which a chemical was detected



Streams in agricultural areas
Streams in urban areas
Streams and rivers draining mixed land uses
Shallow ground water in agricultural areas
Shallow ground water in urban areas
Major aquifers

National water-quality benchmarks

National benchmarks include standards and guidelines related to drinking-water quality, criteria for protecting the health of aquatic life, and a goal for preventing stream eutrophication due to phosphorus. Sources include the U.S. Environmental Protection Agency and the Canadian Council of Ministers of the Environment

| Drinking-water quality (applies to ground water and surface water)

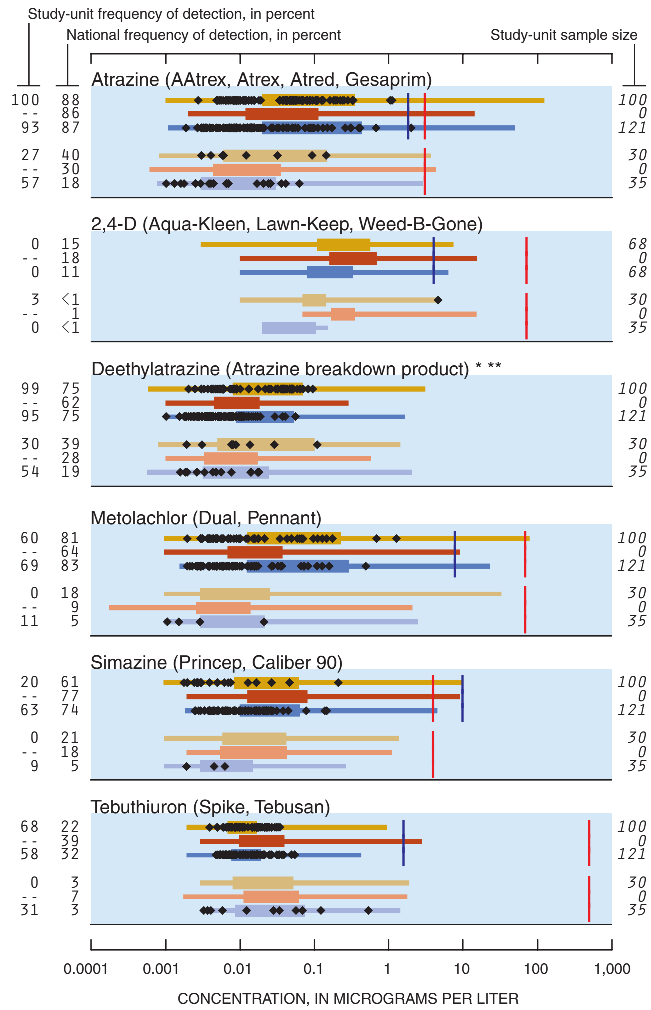
| Protection of aquatic life (applies to surface water only)

| Prevention of eutrophication in streams not flowing directly into lakes or impoundments

* No benchmark for drinking-water quality

** No benchmark for protection of aquatic life

Pesticides in water—Herbicides

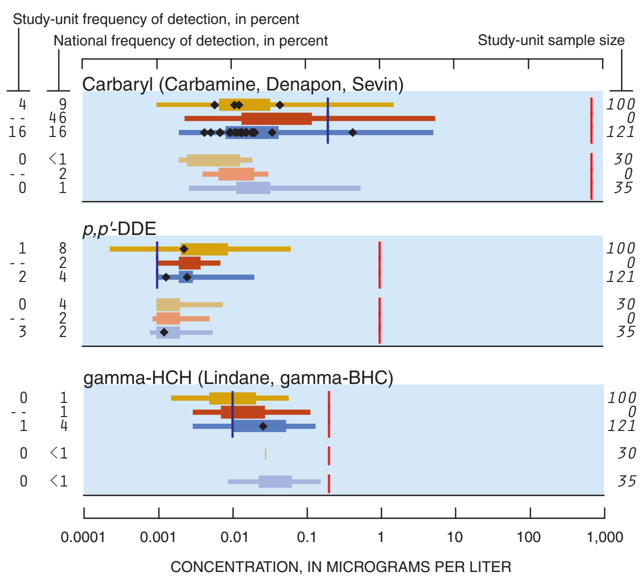


Other herbicides detected
Acetochlor (Harness Plus, Surpass) * **
Alachlor (Lasso, Bronco, Lariat, Bullet) **
Bromacil (Hyvar X, Urox B, Bromax)
Cyanazine (Bladex, Fortrol)
DCPA (Dacthal, chlorthal-dimethyl) * **
Dichlorprop (2,4-DP, Seritox 50, Lentemul) * **
Diuron (Crisuron, Karmex, Diurex) **
Metribuzin (Lexone, Sencor)
Molinate (Ordram) * **
Napropamide (Devrinol) * **
Pendimethalin (Pre-M, Prowl, Stomp) * **
Prometon (Pramitol, Princep) **
2,4,5-T **
2,4,5-TP (Silvex, Fenoprop) **
Trifluralin (Treflan, Gowan, Tri-4, Trific)

Herbicides not detected
Acifluorfen (Blazer, Tackle 2S) **
Benfluralin (Balan, Benefin, Bonalan) * **
Bentazon (Basagran, Bentazone) **
Bromoxynil (Buctril, Brominal) *
Butylate (Sutan +, Genate Plus, Butilate) **
Chloramben (Amiben, Amilon-WP, Vegiben) **
Clopyralid (Stinger, Lontrel, Transline) * **
2,4-DB (Butyrac, Butoxone, Embutox Plus, Embutone) * **
Dacthal mono-acid (Dacthal breakdown product) * **

Dicamba (Banvel, Dianat, Scotts Proturf)
2,6-Diethylaniline (Alachlor breakdown product) * **
Dinoseb (Dinosebe)
EPTC (Eptam, Farmarox, Alirox) * **
Ethalfluralin (Sonalan, Curbit) * **
Fenuron (Fenulon, Fenidim) * **
Fluometuron (Flo-Met, Cotoran) **
Linuron (Lorox, Linex, Sarclex, Linurex, Afalon) *
MCPA (Rhomene, Rhonox, Chiptox)
MCPB (Thistrol) * **
Neburon (Neburea, Neburyl, Noruben) * **
Norflurazon (Evital, Predict, Solicam, Zorial) * **
Oryzalin (Surflan, Dirimal) * **
Pebulate (Tillam, PEBC) * **
Picloram (Grazon, Tordon)
Pronamide (Kerb, Propyzamid) **
Propachlor (Ramrod, Satecid) **
Propanil (Stam, Stampede, Wham) * **
Propham (Tuberite) **
Terbacil (Sinbar) **
Thiobencarb (Bolero, Saturn, Benthiocarb) * **
Triallate (Far-Go, Avadex BW, Tri-allate) *
Triclopyr (Garlon, Grandstand, Redeem, Remedy) * **

Pesticides in water—Insecticides

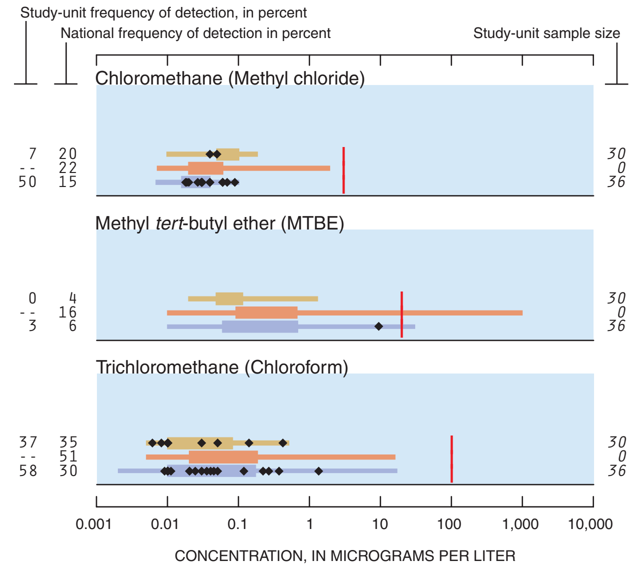


Other insecticides detected
Carbofuran (Furadan, Curaterr, Yaltox)
Chlorpyrifos (Brodan, Dursban, Lorsban)
Diazinon (Basudin, Diazatol, Neocidol, Knox Out)
Malathion (Malathion)

Insecticides not detected
Aldicarb (Temik, Ambush, Pounce)
Aldicarb sulfone (Standak, aldoxycarb)
Aldicarb sulfoxide (Aldicarb breakdown product)
Azinphos-methyl (Guthion, Gusathion M) *
Dieldrin (Panoram D-31, Octalox, Compound 497)
Disulfoton (Disyston, Di-Syston) **
Ethoprop (Mocap, Ethoprophos) * **
Fonofos (Dyfonate, Capfos, Cudgel, Tycap) **
alpha-HCH (alpha-BHC, alpha-lindane) **
3-Hydroxycarbofuran (Carbofuran breakdown product) * **
Methiocarb (Slug-Geta, Grandslam, Mesurol) * **
Methomyl (Lanox, Lannate, Acinate) **
Methyl parathion (Penncap-M, Folidol-M) **
Oxamyl (Vydate L, Pratt) **
Parathion (Roethyl-P, Alkron, Panthion, Phoskil) *
cis-Permethrin (Ambush, Astro, Pounce) * **
Phorate (Thimet, Granutox, Geomet, Rampart) * **
Propargite (Comite, Omite, Ornamite) * **
Propoxur (Baygon, Blattanex, Unden, Proprotox) * **
Terbufos (Contraven, Counter, Pilarfox) **

Volatile organic compounds (VOCs) in ground water

These graphs represent data from 16 Study Units, sampled from 1996 to 1998

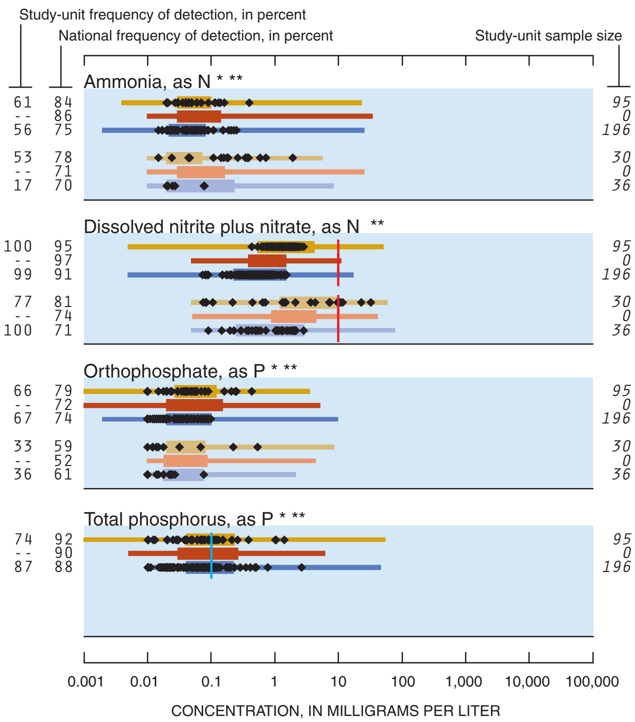


Other VOCs detected
tert-Amylmethylether (*tert*-amyl methyl ether (TAME)) *
Benzene
Bromodichloromethane (Dichlorobromomethane)
2-Butanone (Methyl ethyl ketone (MEK)) *
n-Butylbenzene (1-Phenylbutane) *
Carbon disulfide *
Chlorobenzene (Monochlorobenzene)
Chloroethane (Ethyl chloride) *
1,3-Dichlorobenzene (*m*-Dichlorobenzene)
1,4-Dichlorobenzene (*p*-Dichlorobenzene)
Dichlorodifluoromethane (CFC 12, Freon 12)
1,1-Dichloroethane (Ethylidene dichloride) *
1,1-Dichloroethene (Vinylidene chloride)
cis-1,2-Dichloroethene ((Z)-1,2-Dichloroethene)
Diethyl ether (Ethyl ether) *
Diisopropyl ether (Diisopropylether (DIPE)) *
1,2-Dimethylbenzene (*o*-Xylene)
1,3 & 1,4-Dimethylbenzene (*m*-&*p*-Xylene)
Ethenylbenzene (Styrene)
1-Ethyl-2-methylbenzene (2-Ethyltoluene) *
Ethylbenzene (Phenylethane)
Iodomethane (Methyl iodide) *
Isopropylbenzene (Cumene) *
p-Isopropyltoluene (*p*-Cymene) *
Methylbenzene (Toluene)
2-Propanone (Acetone) *
n-Propylbenzene (Isocumene) *
Tetrachloroethene (Perchloroethene)
1,2,3,4-Tetramethylbenzene (Prehnitene) *
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113) *
1,1,1-Trichloroethane (Methylchloroform)
Trichloroethene (TCE)
1,2,3-Trimethylbenzene (Hemimellitene) *
1,2,4-Trimethylbenzene (Pseudocumene) *
1,3,5-Trimethylbenzene (Mesitylene) *

VOCs not detected
Bromobenzene (Phenyl bromide) *
Bromochloromethane (Methylene chlorobromide)
Bromoethene (Vinyl bromide) *
Bromomethane (Methyl bromide)
sec-Butylbenzene *
tert-Butylbenzene *
3-Chloro-1-propene (3-Chloropropene) *
1-Chloro-2-methylbenzene (*o*-Chlorotoluene)
1-Chloro-4-methylbenzene (*p*-Chlorotoluene)
Chlorodibromomethane (Dibromochloromethane)
Chloroethene (Vinyl chloride)
1,2-Dibromo-3-chloropropane (DBCP, Nemagon)
1,2-Dibromoethane (Ethylene dibromide, EDB)

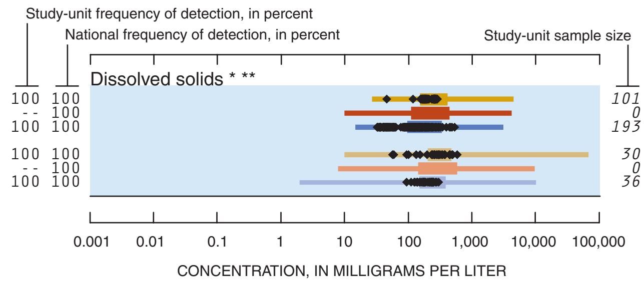
Dibromomethane (Methylene dibromide) *
trans-1,4-Dichloro-2-butene ((Z)-1,4-Dichloro-2-butene) *
1,2-Dichlorobenzene (*o*-Dichlorobenzene)
1,2-Dichloroethane (Ethylene dichloride)
trans-1,2-Dichloroethene ((E)-1,2-Dichlorothene)
Dichloromethane (Methylene chloride)
1,2-Dichloropropane (Propylene dichloride)
2,2-Dichloropropane *
1,3-Dichloropropane (Trimethylene dichloride) *
trans-1,3-Dichloropropene ((E)-1,3-Dichloropropene)
cis-1,3-Dichloropropene ((Z)-1,3-Dichloropropene)
1,1-Dichloropropene *
1-4-Epoxy butane (Tetrahydrofuran, Diethylene oxide) *
Ethyl methacrylate *
Ethyl *tert*-butyl ether (Ethyl-*t*-butyl ether (ETBE)) *
Hexachlorobutadiene
1,1,1,2,2,2-Hexachloroethane (Hexachloroethane)
2-Hexanone (Methyl butyl ketone (MBK)) *
Methyl acrylonitrile *
Methyl-2-methacrylate (Methyl methacrylate) *
4-Methyl-2-pentanone (Methyl isobutyl ketone (MIBK)) *
Methyl-2-propenoate (Methyl acrylate) *
Naphthalene
2-Propenenitrile (Acrylonitrile)
1,1,2,2-Tetrachloroethane *
1,1,1,2-Tetrachloroethane
Tetrachloromethane (Carbon tetrachloride)
1,2,3,5-Tetramethylbenzene (Isodurene) *
Tribromomethane (Bromoform)
1,2,4-Trichlorobenzene
1,2,3-Trichlorobenzene *
1,1,2-Trichloroethane (Vinyl trichloride)
Trichlorofluoromethane (CFC 11, Freon 11)
1,2,3-Trichloropropane (Allyl trichloride)

Nutrients in water

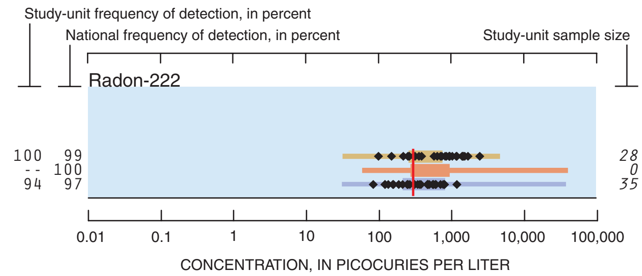


Other nutrients detected
Dissolved ammonia plus organic nitrogen as N * **

Dissolved solids in water



Trace elements in ground water



CHEMICALS IN FISH TISSUE AND BED SEDIMENT

Concentrations and detection frequencies, Upper Tennessee River Basin, 1995–98—Detection sensitivity varies among chemicals and, thus, frequencies are not directly comparable among chemicals. Study-unit frequencies of detection are based on small sample sizes; the applicable sample size is specified in each graph

◆ Detected concentration in Study Unit

66 38 Frequencies of detection, in percent. Detection frequencies were not censored at any common reporting limit. The left-hand column is the study-unit frequency and the right-hand column is the national frequency

-- Not measured or sample size less than two

12 Study-unit sample size

National ranges of concentrations detected, by land use, in 36 NAWQA Study Units, 1991–98—Ranges include only samples in which a chemical was detected

- Fish tissue from streams in agricultural areas
- Fish tissue from streams in urban areas
- Fish tissue from streams draining mixed land uses
- Sediment from streams in agricultural areas
- Sediment from streams in urban areas
- Sediment from streams draining mixed land uses

Lowest 25 percent | Middle 50 percent | Highest 25 percent

National benchmarks for fish tissue and bed sediment

National benchmarks include standards and guidelines related to criteria for protection of the health of fish-eating wildlife and aquatic organisms. Sources include the U.S. Environmental Protection Agency, other Federal and State agencies, and the Canadian Council of Ministers of the Environment

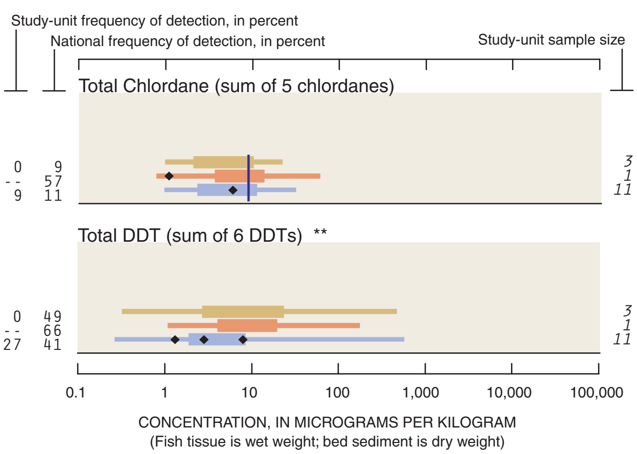
| Protection of fish-eating wildlife (applies to fish tissue)

| Protection of aquatic life (applies to bed sediment)

* No benchmark for protection of fish-eating wildlife

** No benchmark for protection of aquatic life

Organochlorines in fish tissue (whole body) and bed sediment



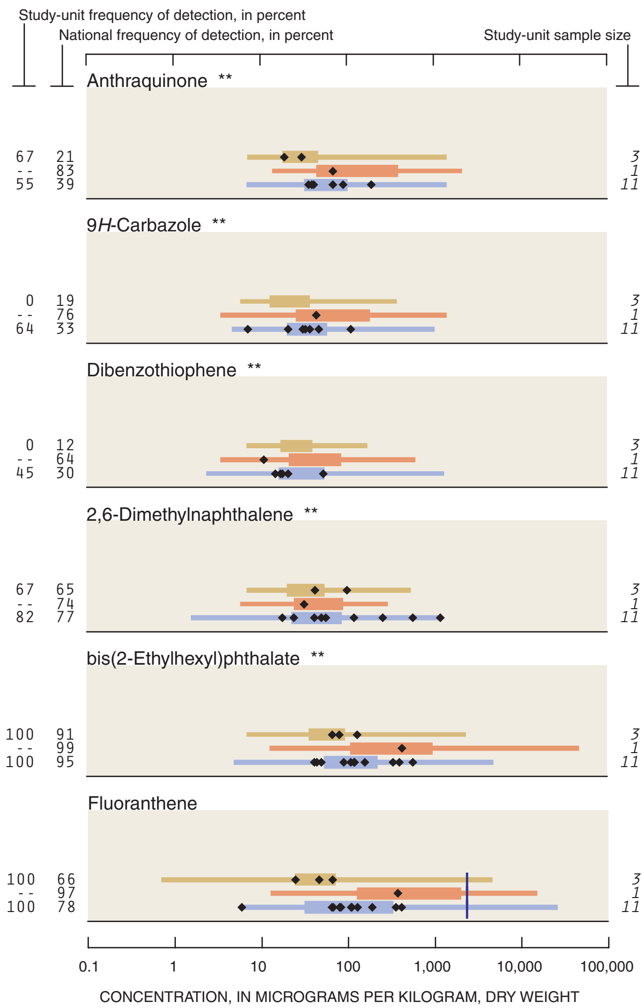
Other organochlorines detected

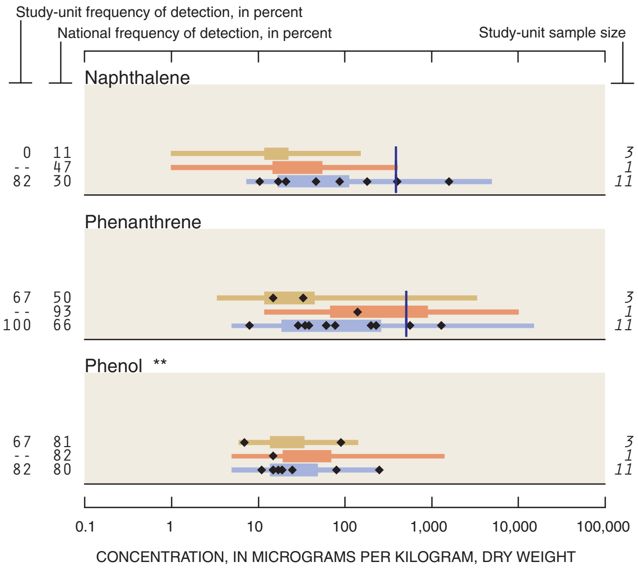
o,p'+*p,p'*-DDD (sum of *o,p'*-DDD and *p,p'*-DDD) *
p,p'-DDE * **
o,p'+*p,p'*-DDE (sum of *o,p'*-DDE and *p,p'*-DDE) *
o,p'+*p,p'*-DDT (sum of *o,p'*-DDT and *p,p'*-DDT) *

Organochlorines not detected

Chloroneb (Chloronebe, Demosan) * **
DCPA (Dacthal, chlorthal-dimethyl) * **
Endosulfan I (alpha-Endosulfan, Thiodan) * **
Endrin (Endrine)
gamma-HCH (Lindane, gamma-BHC, Gammexane) *
Heptachlor epoxide (Heptachlor breakdown product) *
Heptachlor+heptachlor epoxide (sum of heptachlor and heptachlor epoxide) **
Hexachlorobenzene (HCB) **
Isodrin (Isodrine, Compound 711) * **
p,p'-Methoxychlor (Marlate, methoxychlore) * **
o,p'-Methoxychlor * **
Mirex (Dechlorane) **
Total PCB
Pentachloroanisole (PCA) * **
cis-Permethrin (Ambush, Astro, Pounce) * **
trans-Permethrin (Ambush, Astro, Pounce) * **
Toxaphene (Camphechlor, Hercules 3956) * **

Semivolatile organic compounds (SVOCs) in bed sediment

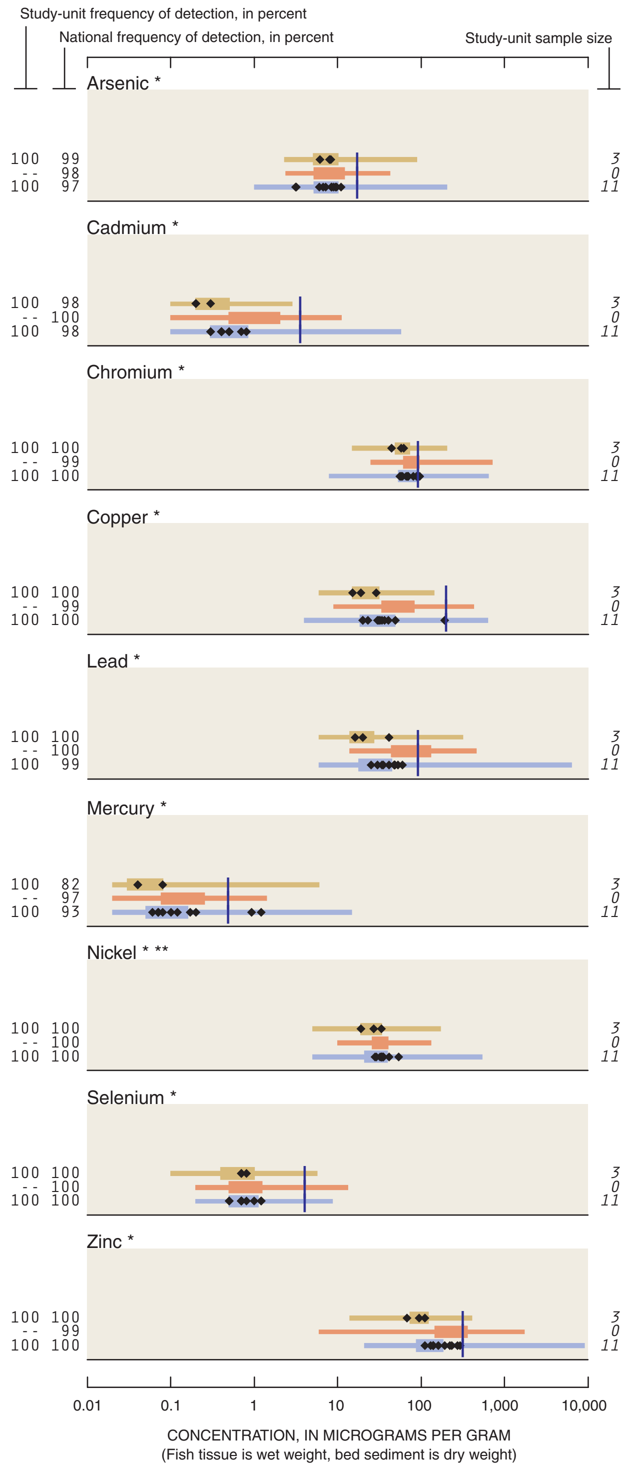




Other SVOCs detected
Acenaphthene
Acenaphthylene
Acridine **
C8-Alkylphenol **
Anthracene
Benz[*a*]anthracene
Benzo[*a*]pyrene
Benzo[*b*]fluoranthene **
Benzo[*ghi*]perylene **
Benzo[*k*]fluoranthene **
2,2-Biquinoline **
Butylbenzylphthalate **
Chrysene
p-Cresol **
Di-*n*-butylphthalate **
Di-*n*-octylphthalate **
Dibenz[*a,h*]anthracene
Diethylphthalate **
1,2-Dimethylnaphthalene **
1,6-Dimethylnaphthalene **
Dimethylphthalate **
2-Ethylnaphthalene **
9*H*-Fluorene (Fluorene)
Indeno[1,2,3-*cd*]pyrene **
Isophorone **
Isoquinoline **
1-Methyl-9*H*-fluorene **
2-Methylanthracene **
4,5-Methylenephenanthrene **
1-Methylphenanthrene **
1-Methylpyrene **
Phenanthridine **
Pyrene
Quinoline **
2,3,6-Trimethylnaphthalene **

SVOCs not detected
Azobenzene **
Benzo[*c*]cinnoline **
4-Bromophenyl-phenylether **
4-Chloro-3-methylphenol **
bis(2-Chloroethoxy)methane **
bis(2-Chloroethyl)ether **
2-Chloronaphthalene **
2-Chlorophenol **
4-Chlorophenyl-phenylether **
1,2-Dichlorobenzene (*o*-Dichlorobenzene) **
1,3-Dichlorobenzene (*m*-Dichlorobenzene) **
1,4-Dichlorobenzene (*p*-Dichlorobenzene) **
3,5-Dimethylphenol **
2,4-Dinitrotoluene **
Nitrobenzene **
N-Nitrosodi-*n*-propylamine **
N-Nitrosodiphenylamine **
Pentachloronitrobenzene **
1,2,4-Trichlorobenzene **

Trace elements in fish tissue (livers) and bed sediment



BIOLOGICAL INDICATORS

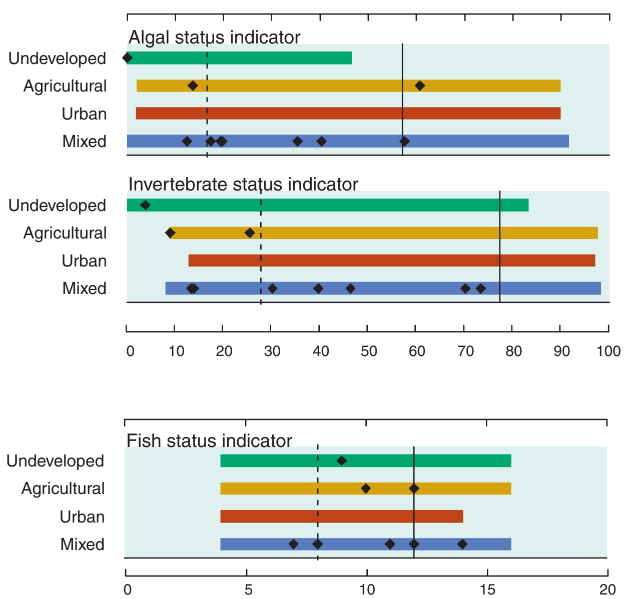
Higher national scores suggest habitat disturbance, water-quality degradation, or naturally harsh conditions. The status of algae, invertebrates (insects, worms, and clams), and fish provide a record of water-quality and stream conditions that water-chemistry indicators may not reveal. **Algal status** focuses on the changes in the percentage of certain algae in response to increasing siltation, and it often correlates with higher nutrient concentrations in some regions. **Invertebrate status** averages 11 metrics that summarize changes in richness, tolerance, trophic conditions, and dominance associated with water-quality degradation. **Fish status** sums the scores of four fish metrics (percent tolerant, omnivorous, non-native individuals, and percent individuals with external anomalies) that increase in association with water-quality degradation

Biological indicator value, Upper Tennessee River Basin, by land use, 1995–98

◆ Biological status assessed at a site

National ranges of biological indicators, in 16 NAWQA Study Units, 1994–98

- Streams in undeveloped areas
- Streams in agricultural areas
- Streams in urban areas
- Streams in mixed-land-use areas
- 75th percentile
- 25th percentile



A COORDINATED EFFORT

Coordination with agencies and organizations in the Upper Tennessee River Basin was integral to the success of this water-quality assessment. We thank those who served as members of our liaison committee.

Federal Agencies
Tennessee Valley Authority
U.S. Fish and Wildlife Service
National Park Service
U.S. Department of Energy,
Oak Ridge National Laboratory
U.S. Environmental Protection Agency
U.S. Forest Service
U.S. Department of Agriculture,
Natural Resources Conservation Service

State Agencies
Tennessee Wildlife Resources Agency
Tennessee Department of Environment and
Conservation
Tennessee Department of Agriculture
North Carolina Department of Environment and
Natural Resources
North Carolina Wildlife Resources Commission
Virginia Department of Environmental Quality
Virginia Department of Game and Inland Fisheries
Virginia Department of Mines, Minerals, and Energy

Local Agencies
Knox County, Tennessee
City of Johnson City, Tennessee

Universities
University of Tennessee
Virginia Polytechnic and State University
Tennessee Technological University

Other public and private organizations
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Program
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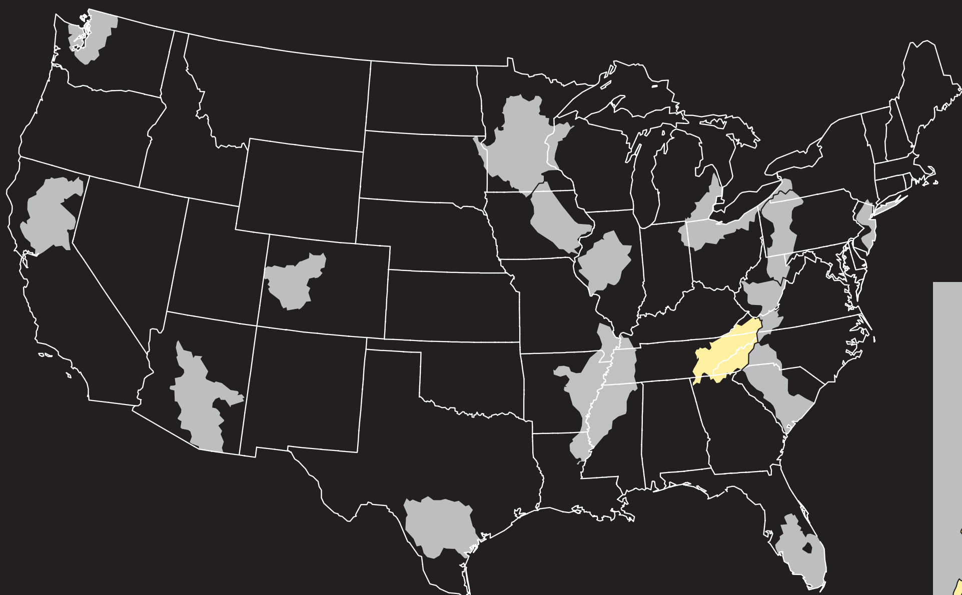
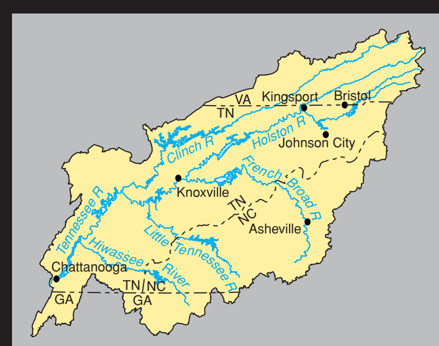
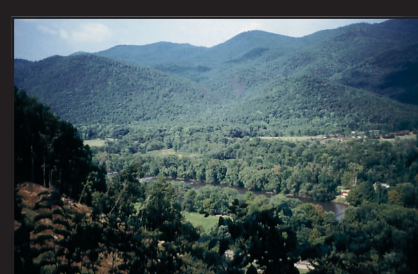
NAWQA

National Water-Quality Assessment (NAWQA) Program
Upper Tennessee River Basin





Hampson and others—Water Quality in the Upper Tennessee River Basin
U.S. Geological Survey Circular 1205



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