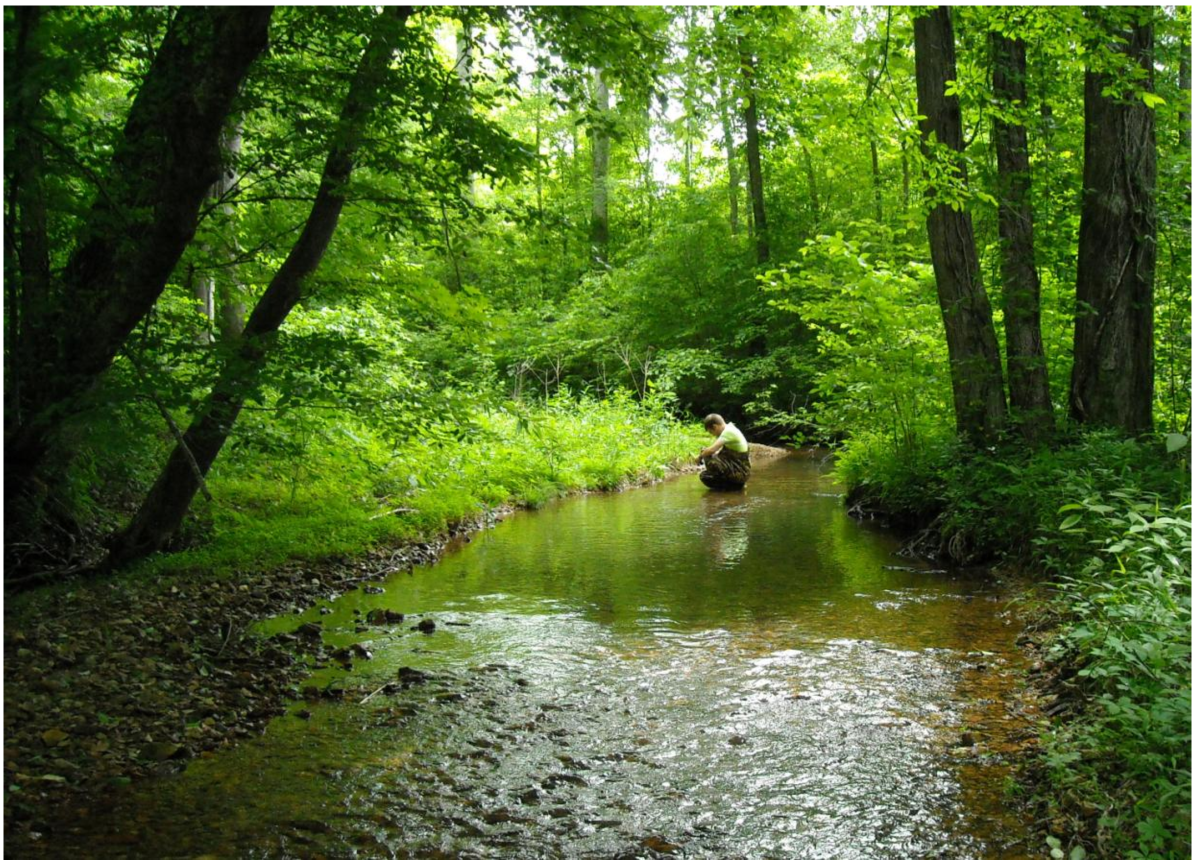
2010 305(b) Report
The Status of Water Quality in Tennessee



Division of Water Pollution Control
Tennessee Department of Environment and Conservation

2010 305(b) Report
The Status of Water Quality in Tennessee

November 2010

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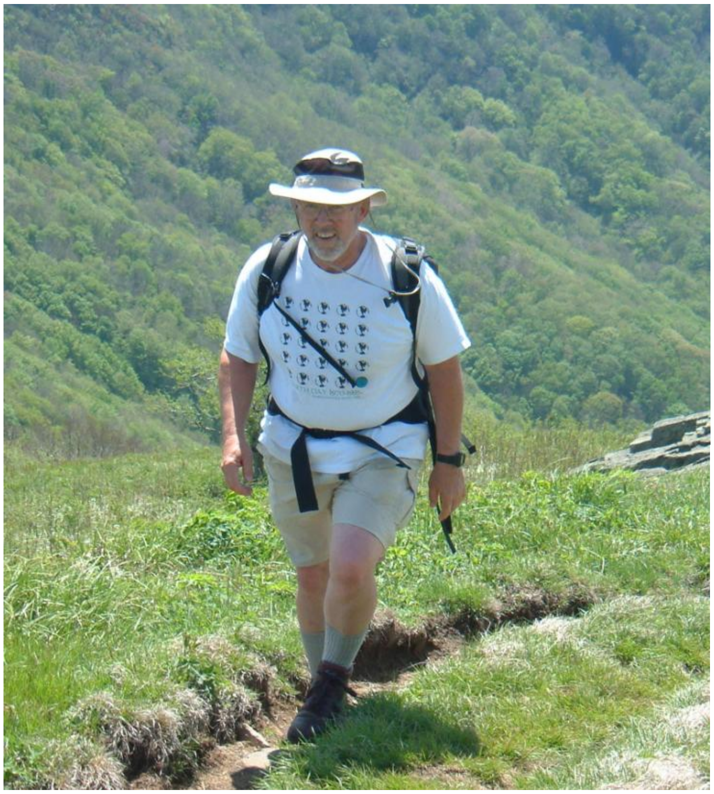

David Draughon on the Appalachian Trail near Big Hump Mountain in northeastern Tennessee.

In Memoriam:

Walter David Draughon, Jr. (1945-2010)

On May 29, 2010, David Draughon lost his courageous battle with cancer. At the time of his retirement due to failing health, he was Senior Director for Water in the Bureau of Environment. Prior to that, he was the Director of the Division of Water Supply for many years where he developed programs to regulate and improve the quality of public water supplies. That Tennessee has long been considered by many, including EPA, to have one of the premier drinking water protection programs in the country is perhaps the ultimate tribute to Mr. Draughon.

David Draughon was born in North Carolina, but grew up in the mountain community of Wise in western Virginia. A graduate of Tennessee Tech with a degree in engineering, he began his career in the Division of Sanitary Engineering in 1971. Involved with the Boy Scouts for most of his life, Mr. Draughon was a Scoutmaster in Nashville for many years and led two groups to the Philmont scout ranch in New Mexico. Additionally, he backpacked the entire southern Appalachian Trail from Springer Mountain in Georgia to Damascus in Virginia.

Mr. Draughon was preceded in death by his wife Carolyn and is survived by two children, Scott and Melissa; two brothers, Lynn and Rodney; four grandchildren; and many friends in the Department of Environment and Conservation, who will miss his friendship and many contributions to protection of public health in Tennessee.

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Cover Photo: Pompey's Branch Transition Hills Reference Stream. *Photo provided by Jackson Environmental Field Office.*

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Introduction to Tennessee's Water Quality

This report was prepared by the Tennessee Department of Environment and Conservation (TDEC), Division of Water Pollution Control (WPC), to fulfill the requirements of both federal and state laws. Section 305(b) of the Federal Water Pollution Control Act, commonly called the Clean Water Act, requires a biennial analysis of water quality in the state. The Tennessee Water Quality Control Act also requires that the division produce a report on the status of water quality.

TDEC's goals for the 305(b) Report include:

- Describing the water quality assessment process (Chapter 1).
- Categorizing waters in the State by placing them in the assessment categories suggested by federal guidance (Chapter 2).
- Identifying waterbodies that pose eminent human-health risks due to elevated bacteria levels or contamination of fish (Chapter 5).

Acknowledgements

The Director of the Division of Water Pollution Control (WPC) is Paul E. Davis and the Deputy Director is Garland P. Wiggins. The Planning and Standards Section of WPC produced this report in cooperation with regional field office staff.

The authors would like to express appreciation to the Water Pollution Control staff of TDEC's regional Environmental Field Offices (EFOs) and the Aquatic Biology staff of the Tennessee Department of Health who collected the stream, river, and reservoir data documented in this report. The managers of the staff in these offices are:

Terry Templeton	Memphis EFO
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The information compiled in this 2010 water quality assessment document included data provided by many state and federal agencies. These agencies include Tennessee Department of Health (TDH), Tennessee Valley Authority (TVA), U. S. Environmental Protection Agency (EPA), Tennessee Wildlife Resources Agency (TWRA), U.S. Army Corps of Engineers (USACE), and U.S. Geological Survey (USGS). The division is grateful for their assistance and cooperation.

Burgess Falls in winter. *Photo provided by Joe E. Holland, NEFO.*

Executive Summary

The *Clean Water Act*, Section 305(b) (US Congress, 2002) and the *Tennessee Water Quality Control Act* (Tennessee Secretary of State, 1999) both require a biennial report about the status of water quality in the state. This report satisfies those requirements.

The Division of Water Pollution Control (WPC) is entrusted with protecting the people's right to enjoy clean water. In order to reach this goal, WPC works to establish clean water objectives, monitor surface water, and determine if the waters of the state support their intended uses.

Water Quality Standards

There are seven designated uses for the waterways of the state. Those uses are defined in Rules of Tennessee Department of Environment and Conservation, Division of Water Pollution Control Chapter 1200-4-4. A different rule, Chapter 1200-4-3 identifies specific water quality criteria, both numeric and narrative, and establishes the state's antidegradation policy, which deals with prevention of future damage to water quality. Water quality standards are established for individual streams by identifying the most stringent criteria for each assigned use, considering the streams antidegradation status. These rules can be reviewed at http://state.tn.us/environment/wpc/publications/#rules.

Monitoring Programs

Tennessee has an abundance of water resources with over 60,000 miles of rivers and streams and over 570,000 lake and reservoir acres. However, this vast system of streams, rivers, reservoirs and wetlands requires efficient use of Tennessee's monitoring resources.

TDEC's watershed approach serves as an organizational framework for systematic assessment of the state's water quality. By viewing the entire drainage area or watershed as a whole, the department is better able to address water quality monitoring, assessment, and permitting activities, plus and stream restoration efforts. This unified approach affords a more in-depth study of each watershed and encourages coordination of public and governmental organizations. The watersheds are addressed on a five-year cycle that coincides with permit issuance.

In addition to systematic watershed monitoring, waterbodies are sampled to fulfill other information needs within the division. Some of these other needs include continuation of the ecoregion reference stream monitoring, Total Maximum Daily Load (TMDL) generation, complaint investigation, antidegradation evaluations, trend analysis, compliance monitoring, and special studies.

Assessment Process

Using a standardized assessment methodology, monitoring data from individual streams are compared to water quality standards. Violations of water quality standards are identified and the degree to which each individual waterbody meets its designated uses is determined. Assessment categories recommended by EPA are used to characterize water quality.

Assessment results are compiled and reported to the public periodically. The principal vehicles for this water quality assessment reporting are the 305(b) Report and the 303(d) List.

Water Quality

Over half of the stream miles and almost all the large reservoirs have recently been monitored and assessed. Waters without data collected within the last five years are usually identified as not assessed unless previously identified as impaired. About 58 percent of assessed streams and 68 percent of assessed reservoir acres are found to be fully supporting of designated uses. The remainder of the assessed waterbodies are impaired to some degree and therefore, not supporting of all designated uses.

Causes and Source of Pollution

Once it has been determined that a stream, river, or reservoir is not fully supporting of its designated uses, it is necessary to determine what the pollutant is (cause) and where it is coming from (source). The most common causes of pollution in rivers and streams are sediment/silt, habitat alteration, pathogens, and nutrients. The main sources of these pollutants are agriculture, hydrologic modification, municipal dischargers, and construction. The leading causes of pollution in reservoirs and lakes are metals, low dissolved oxygen, and organic substances, like PCBs, dioxins, and chlordane. The principal sources of problems in reservoirs and lakes are the historical discharge of pollutants that have accumulated in sediment and fish flesh, plus atmospheric deposition. Other sources include agriculture, hydrologic modifications, municipal dischargers, and construction.

Advisories

When streams or reservoirs are found to have significantly elevated bacteria levels or when fish tissue contaminant levels exceed risk-based criteria, it is the responsibility of the Department of Environment and Conservation to post warning signs so that people will be aware of the potential threat to their health. In Tennessee, the most common reason for a stream or river to be posted is mercury in fish tissue, followed by the presence of high levels of bacteria. In lakes and reservoirs, the most common reason is accumulated PCBs, chlordane, dioxins, or mercury in fish tissue.

Statutory Requirements

Tennessee first created a water pollution regulatory organization in 1927. In 1929, the scope of that agency was expanded to include stream pollution studies to protect potential water supplies. A Stream Pollution Study Board charged with evaluating all available water quality data in Tennessee and locating the sources of pollution was appointed in 1943. The stream pollution study was completed and submitted to the General Assembly in 1945. Subsequently, the General Assembly enacted Chapter 128, Public Acts of 1945.

The 1945 law was in effect until the Water Pollution Control Act of 1971 was passed. In 1972, the Federal Clean Water Act was enacted into law. According to the Act, states are required to assess water quality and report the results to EPA and the public biennially. The Tennessee General Assembly revised the Water Quality Control Act in 1977 and the Department began statewide stream monitoring that same year.

In 1985, the Division of Water Quality Control was divided into the Divisions of Water Pollution Control and Water Supply. WPC monitors, analyzes, and reports on the quality of Tennessee's water. WPC is also responsible for the non-coal surface mining program, permitting of wastewater discharges, review of wastewater construction plans, facility inspections, compliance monitoring, and enforcement of regulations. Stream channel modifications, wetland alterations or gravel dredging are also regulated by WPC.

The Division of Water Supply (DWS) works to ensure that public drinking water supplies are safe. DWS also regulates the construction of non-federal dams, enforces the Water Resources Act, monitors water withdrawals, and regulates the licensing of well drillers and pump setters.

> *Recognizing that the waters of Tennessee are the property of the state and are held in public trust for the use of the people of the state, it is declared to be the public policy of Tennessee that the people of Tennessee, as beneficiaries of this trust, have a right to unpolluted waters. In the exercise of its public trust over the waters of the state, the government of Tennessee has an obligation to take all prudent steps to secure, protect, and preserve this right.* (The Tennessee Water Quality Control Act, 1999)

In addition to the federal requirements, the Tennessee Water Quality Control Act of 1977 requires the Division of Water Pollution Control to produce a report to the governor and the general assembly on the status of water quality in the state. The report can include a description of the water quality plan, regulations in effect, and recommendations for improving water quality. The 2010 305(b) Report serves to fulfill the requirements of both the federal and state laws, which emphasize the identification and restoration of impaired waters.

This report covers only surface waters in Tennessee. The department's Division of Water Supply is developing a report on ground water quality entitled *Tennessee Ground Water 305(b) Water Quality Report* (TDEC, 2008). The ground water report will be available on line at http://www.tn.gov/environment/water.

Tennessee at a Glance

Tennessee is one of the most biodiverse inland states in the nation. Geography ranges from the Appalachian Mountains in the east to the Mississippi River floodplains in the west. Elevations vary from over 6,600 feet at Clingman's Dome in the Great Smoky Mountains National Park, to less than 200 feet near Memphis.

The average statewide precipitation is over 50 inches annually. Most of this rainfall is received between November and May. Historically the driest month is October. The average summer high temperature is 91 degrees Fahrenheit, while the average winter low temperature is 28 degrees Fahrenheit.

Tennessee's population is growing rapidly. According to the 2000 Census, Tennessee's population is over 5,689,000, which is a 14 percent increase in population from the 1990 Census (Secretary of State, 2005). This puts a burden on the state's waterways. Tennessee has over 60,000 stream miles and more than 570,000 lake acres. Several large reservoirs are shared with bordering states including Pickwick Lake, Kentucky Lake, Lake Barkley, and Dale Hollow Lake.

Tennessee has over 60,000 stream miles. *Photo provided by Kim Sparks, NEFO.*

Tennessee Facts

State population (2000 Census)	5,689,283
Largest Cities (2000 Census)	
Memphis	650,100
Nashville	545,524
Knoxville	173,890
Chattanooga	155,554
Clarksville	103,455
Murfreesboro	68,816
Jackson	59,643
Johnson City	55,469
Number of Counties	95
State Surface Area (square miles)	42,244
Number of Major Basins	13
Number of Level III Ecoregions	8
Number of Level IV Ecoregions	31
Number of Watersheds (HUC8)	55
Number of Stream Miles Forming State Border	213

(The Mississippi River forms most of the stream miles shared by another state.)

Stream Miles Statewide (NHD)	60,394
Largest Rivers at Low Flow (7Q10 in ft^3/sec.)	
Mississippi River at Memphis	109,000
Tennessee River at South Pittsburg	12,500
Cumberland River at Dover	2,280
Hiwassee River above Charleston	1,220
Little Tennessee River at Calderwood	1,200
Holston River at Surgoinsville	762
French Broad River near Knoxville	722
South Fork Holston River at Kingsport	550
Duck River above Hurricane Mills	477
Obion River at Megelwood	357
Lake Acres Statewide	572,007
Largest Lakes (size in acres)	
Kentucky Reservoir (Tennessee portion)	117,500
Watts Bar Reservoir	39,000
Barkley Reservoir (Tennessee portion)	37,000
Chickamauga Reservoir	35,400
Estimated Acres of Wetlands	787,000

Cost of Water Pollution

Water pollution is a problem for everyone. The average American uses 140 to 160 gallons of water per day for sanitation, drinking, and many other human needs, such as recreation, transportation, and irrigation. Polluted water must be purified before it can be used for these purposes.

On average, tap water costs slightly more than $2 per 1,000 gallons. The more polluted water is, the more it costs per gallon. There are other costs associated with water pollution as well.

When the water is no longer safe for recreational activities, the community loses an important resource. Two of the most obvious costs of water pollution are the expenses of health care and loss of productivity while people are ill. The biggest health risks encountered in polluted waters are from pathogens and contaminated fish. Individuals who swim in waters polluted by pathogens can become sick. People, especially children and pregnant women, who eat contaminated fish, are at a higher risk for cancer and other health problems than those who do not eat contaminated fish. Subsistence fishermen are faced with the loss of their primary protein source.

When people can no longer eat fish from rivers, streams, and lakes, there is a potential for economic loss in the community. Commercial fishermen lose income when it is no longer legal to sell the fish they catch. As the fishermen move out of the community to find another place to fish, local business can decline.

Another cost of water pollution is the expense associated with keeping waters navigable. Commercial navigation as a means to move goods and services around the country is one of the most economical methods of transportation. As channels fill with sediment from upland erosion, commercial navigation becomes less practical. Silt deposits also reduce the useful lifespan of lakes and reservoirs. They become filled with silt, which decreases the depth of the water until dredging is required or the lake or reservoir is completely filled.

Clean water is important to all ages. *Photo provided by Jimmy Smith, NEFO*

Chapter 1
Water Quality Assessment Process

Using a standardized assessment methodology, existing monitoring data from individual streams are compared to water quality standards in order to categorize the degree of use support (Chapter 2). Violations of water quality standards are identified. Individual assessments are stored in an electronic format, assessment information is compiled into reports such as the 305(b), and geographic referencing tools are used to prepare interactive maps that can be accessed by the public. Since the 2008 305(b) report was published, Group 1 and 2 watersheds have been assessed.

A. Water Quality Standards

The *Tennessee Water Quality Control Act* (Tennessee Secretary of State, 1999) identifies the Water Quality Control Board as the entity responsible for the promulgation of clean water goals. Federal law requires that the water quality standards be revisited at least every three years. Division staff provide technical assistance to the board in the development of criteria and the identification of appropriate use-classifications. Public participation is a vital part of the goal-setting process.

The specific water quality standards are established in *Rules of Tennessee Department of Environment and Conservation Division of Water Pollution Control*, Chapter 1200-4-3, General Water Quality Criteria and Chapter 1200-4-4, Use Classifications for Surface Water (Tennessee Department of Environment and Conservation, Water Quality Control Board, 2007). The 2007 revision became official in October 2007.

Water quality standards have three sections. The first section establishes seven designated uses for Tennessee waterways: Fish and Aquatic Life, Recreation, Irrigation, Livestock Watering and Wildlife, Domestic Water Supply, Navigation, and Industrial Water Supply. The second section identifies numeric or narrative water quality criteria to protect each of the designated uses. The final section is an antidegradation policy designated to protect existing water uses and prevent future damage to water quality.

All waterbodies are classified for multiple uses and may have several criteria for each substance or condition (pollutants). When multiple criteria are assigned for different uses on a stream, the regulation states that the most stringent criterion must be met. The combination of classified uses, the most stringent criterion for those uses, and the requirements of the antidegradation policy create the water quality standard for each pollutant in a waterbody segment.

1. Stream Use Classifications

> **Tennessee's Current Stream-Use Classifications:**
>
> 1. Fish and aquatic life
> 2. Recreation
> 3. Irrigation
> 4. Livestock watering and wildlife
> 5. Drinking water supply
> 6. Navigation
> 7. Industrial water supply

The Tennessee Water Quality Control Board (TWQCB) is responsible for the designation of beneficial uses of waterbodies. All streams, rivers, lakes, and reservoirs in Tennessee are classified for at least two public uses: protection of fish and aquatic life and recreation. These minimum use classifications comply with the goals of the federal act, which requires that all waters provide for the "protection and propagation of a balanced population of …fish and wildlife, and allow recreational activities in and on the water" (U.S. Congress, 2000).

Most waterbodies are also classified for irrigation and livestock watering and wildlife. Three additional classifications apply to specific waterbodies. The drinking water supply designation is assigned to waterbodies currently or likely to be used as domestic water sources in the future. The navigation and industrial water supply classifications are usually limited to waters currently being used for those purposes, but can be expanded to other waters as needed.

a. Fish and Aquatic Life (FAL) – This use classification is assigned to all waterbodies for the protection of fish and other aquatic life such as aquatic insects, snails, clams, and crayfish. While Tennessee does not currently have a system that creates tiers of aquatic life protection (e.g., warm water vs. cold water fisheries), the state has developed regional interpretations of some criteria such as nutrients and biological integrity. Additionally, trout waters have more stringent criteria for dissolved oxygen and temperature.

b. Recreation – All waterbodies in Tennessee are classified for the protection of the public's ability to swim, wade, and fish. Threats to recreational uses of streams include the loss of aesthetic values due to algae or turbidity, elevated pathogen levels, and the accumulation of dangerous levels of metals or organic compounds in fish tissue.

c. Irrigation - This use classification is assigned to most waterways to protect the ability of farmers to use streams or reservoirs as a source of water to irrigate crops.

d. Livestock Watering and Wildlife – This use classification protects waters to be used as an untreated drinking water source for livestock and wildlife.

e. Drinking Water Supply –This use classification is assigned to waterbodies that are currently or are likely to be used for domestic water supply.

f. Navigation – This use classification is designated to protect navigational rivers and reservoirs from any alterations that would adversely affect commercial uses.

g. Industrial Water Supply - This classification is assigned to waters currently used for industrial purposes. If needed, additional waters may be designated as industrial water supplies.

Designated uses are goals, not necessarily a documentation of the current use of that waterbody. Even if a stream or reservoir is not currently used for a given activity, it should be protected for that use in the future.

All streams that are not specifically listed in Use Classifications for Surface Waters are classified for fish and aquatic life, recreation, irrigation, and livestock watering and wildlife. These regulations can be viewed or downloaded at the Tennessee Secretary of State's homepage, at http://state.tn.us/sos/.

Recreation is a designated stream use classification. *Photo provided by Kim Sparks, NEFO.*

2. Water Quality Criteria

The Tennessee Water Quality Control Board has assigned specific water quality criteria to each designated use. These criteria establish the water quality needed to support each use. Since every waterbody has multiple uses, it may have multiple applicable criteria. The standard for each stream is based on the most stringent criterion for the uses assigned to it. The most stringent criteria are for the protection of fish and aquatic life, recreation, or drinking water.

a. **Fish and Aquatic Life (FAL)** – FAL criteria are designed to protect aquatic life from two types of toxicity: acute and chronic. Acute toxicity refers to the level of contaminant that causes death in an organism in a relatively short period of time. Chronic toxicity refers to a lower level of contamination that causes death or other ill effects (such as reproductive failure) over a longer period of time. Since Tennessee does not perform primary research into the toxic effects of pollutants, reliance is placed on EPA's published national criteria, which are based on the following types of research:

- Toxicity tests performed on lab animals.
- The number of cancer incidences in animals after exposure to a substance.
- A substance's tendency to concentrate in the food chain.

FAL have the most protective numeric criteria for many parameters, including: dissolved oxygen (DO), pH, turbidity, temperature, some toxic substances, nutrients, biological integrity, habitat, and flow. The criteria for FAL also have narrative criteria for turbidity, nutrients, biological integrity, habitat, and flow. The department has developed guidance documents to assist in the regional interpretation of narrative criteria for nutrients, biological integrity, and habitat. Additionally, dissolved oxygen and temperature criteria for trout waters are found in this section.

b. **Recreation** – These criteria are established to protect the public's ability to swim and wade in Tennessee waters and to safely eat fish they catch. If fish tissue have dangerous levels of metals or organic substances, or if streams are found to have elevated bacteria levels, warning signs are posted to inform the public concerning the potential health risk. See Chapter 5 for additional information on advisories.

For two parameter categories, pathogens and carcinogens, recreational criteria tend to be the most protective. *E. coli* is used as the primary indicator of risk due to pathogens. Criteria for carcinogens are designed to prevent the accumulation of dangerous levels of metals or organic compounds in the water or sediment that may ultimately accumulate in fish tissue. The criteria also identify the procedure to be used when evaluating fish tissue contamination and for the decision process for stream posting.

c. **Irrigation** – These criteria protect waters to be used for agricultural irrigation purposes. Most of the irrigation criteria are narrative.

d. **Livestock Watering and Wildlife** – These criteria protect waters to be used as untreated drinking water sources for livestock and wildlife. Most of the livestock watering and wildlife criteria are narrative.

e. **Drinking Water Supply** – These criteria protect waters used as domestic water supplies from substances that might cause a public health threat, if not removed by conventional water treatment. Since many contaminants are difficult and expensive to remove, it is more cost effective to keep pollutants from entering the water supply in the first place. For this purpose, the surface water criteria adopt the Maximum Contaminant Levels (MCLs) suggested by EPA for finished water as goals for surface waters used for source waters.

f. **Navigation** – These criteria protect waterways used for commercial navigation. Navigation criteria are narrative.

g. **Industrial Water Supply**- These criteria protect waters used as water supplies for industrial purposes. Criteria for pH, total dissolved solids, and temperature are numerical. The remaining industrial water supply criteria are narrative.

General Water Quality Criteria for surface waters in Tennessee are listed in Rules of TDEC, Chapter 1200-4-3 (TDEC-WQCB, 2007). A copy of these regulations can be viewed or downloaded at the Tennessee Secretary of State's home page at http://tn.gov/sos/rules/1200/1200-04/1200-04.htm

3. Antidegradation Policy

The third section of Tennessee water quality standards contains the antidegradation policy, which protects existing uses of all surface waters and prevents degradation in waters identified as high quality. In high quality waters, degradation can only be allowed if it is in the public interest and there are no other reasonable options. Measureable degradation in impaired waters cannot be authorized for parameters of concern. In 2006, the antidegradation statement was revised and the Tier designations were replaced by the following categories:

1. "Unavailable conditions exist where water quality is at, or fails to meet, the criterion for one or more parameters. In unavailable conditions, new or increased discharges of a substance that would contribute to a condition of impairment will not be allowed." (Note: Adjustments to this language were proposed in 2009, but have not yet been finalized.)

2. "Available conditions exist where water quality is better than the applicable criterion for a specific parameter. In available conditions, new or additional degradation for that parameter will only be allowed if the applicant has demonstrated that the reasonable alternatives to degradation are not feasible." Additionally, the degradation must be in the public interest.

3.   Exceptional Tennessee Waters are waters where no degradation will be allowed unless that change is justified due to necessary economic or social development and will not interfere with or become injurious to any classified uses existing in such waters. Exceptional Tennessee Waters are:

- Waters within state or national parks, wildlife refuges, wilderness areas or natural areas.
- State Scenic Rivers or Federal Wild and Scenic Rivers.
- Federally-designated critical habitat or other waters with documented non-experimental populations of state or federally-listed threatened or endangered aquatic or semi-aquatic plants or animals.
- Waters within areas designated Lands Unsuitable for Mining (as long as water resources were part of the justification for the designation).
- Streams with naturally reproducing trout.
- Waters with exceptional biological diversity as evidenced by a score of 40 or 42 on the Tennessee Macroinvertebrate Index (TMI) (or a score of 28 or 30 in subregion 73a), if the sample is considered representative of overall stream conditions.
- Other waters with outstanding ecological or recreational value as determined by the department.

4. Outstanding National Resource Waters (ONRWs) - These exceptional Tennessee waters constitute an outstanding national resource due to their exceptional recreational or ecological significance (Table 1).

Table 1: Outstanding National Resource Waters

Waterbody	Portion Designated as ONRW
Little River	Portion within Great Smoky Mountains National Park
Abrams Creek	Portion within Great Smoky Mountains National Park
West Prong Little Pigeon River	Portion within Great Smoky Mountains National Park upstream of Gatlinburg
Little Pigeon River	From headwaters within Great Smoky Mountains National Park downstream to the confluence of Mill Branch
Big South Fork Cumberland River	Portion within Big South Fork National River and Recreation Area
Reelfoot Lake	Tennessee portion of the lake and its associated wetlands

According to the regulation, the portion of the Obed River designated as a federal wild and scenic river as of June 22, 1999 is an ONRW. However, if the current search for a regional water supply by the Cumberland Plateau Regional Water Authority results in a determination that it is necessary to use the Obed River as its source of drinking water, for that purpose the Obed shall be designated as an Exceptional Tennessee Water and any permit issued for that project, whether state, federal, or otherwise, shall be considered under the requirements for Exceptional Tennessee Waters.

A current list of known high quality waters, which includes both Exceptional Waters and Outstanding National Resource Waters is available on the state's website at http://tn.gov/environment/water.shtml. Additional high quality waters will be added to the list as they are identified.

B. Water Quality Resource Management

The watershed approach serves as an organizational framework for systematic assessment of the state's water quality problems. By viewing the entire drainage area or watershed as a whole, the department is better able to address water quality problems in a comprehensive manner. This unified approach affords a more in-depth study of each watershed and encourages coordination of public and governmental organizations. The watersheds are addressed on a five-year cycle that coincides with permit issuance.

It is important that watersheds are not confused with ecoregions. The watershed approach is an organizational monitoring framework. Ecoregions serve as a geographical framework for establishing water quality expectations. In addition to systematic watershed monitoring, waterbodies are sampled to fulfill other information needs within the division. Some of these other needs include continuation of ecoregion reference stream monitoring, TMDL generation, complaint investigation, antidegradation tier evaluations, trend investigations, compliance monitoring, and special studies.

Watershed Approach

In the early 1970's, the USGS delineated 55 hydrologic watershed boundaries within Tennessee. In 1996, the division adopted a watershed approach that reorganized existing programs based on management and focused on place-based water quality management (Figure 1). The state's 55 watersheds have been divided into five monitoring groups for scheduling assessments (Figure 2 and Table 2). Each group contains between 9 and 16 watersheds. One group is monitored each year and assessed the following year. This allows intense monitoring of one watershed group each year, with all watersheds monitored every five years. Since the 2008 305(b) report was published, Group 1 and 2 watersheds have been assessed plus Group 3 and 4 watersheds have been monitored.

The watershed approach is a five-year cycle that has the following features:

- Holds two public meetings per watershed within the five-year cycle.
- Commits to a monitoring strategy that addresses all watersheds.
- Partners with other agencies to obtain the most current water quality and quantity data.
- Establishes TMDLs by developing control strategies for regulated and non-regulated sources.
- Synchronizes discharge permit issuance with the development of TMDLs.

The key factors involved in each five-year watershed cycle are as follows:

Year 1. Planning, Data Review, and Public Outreach - Existing data and reports from appropriate agencies and organizations are compiled and used to describe the quality of the state's rivers and streams. Watershed planning meetings are held with interested stakeholders including citizen and environmental groups, other governmental agencies, and permit holders. Monitoring plans are developed.

Year 2. Monitoring - Field data are collected for key waterbodies in the watershed to supplement existing data. Three standard operating procedures (SOPs) have been developed to guide sampling techniques and quality control for macroinvertebrate surveys (TDEC, 2006), chemical and bacteriological sampling (TDEC, 2009), and periphyton sampling (TDEC, 2010)

Year 3. Assessment – Monitoring data are used to determine if the streams, rivers, lakes, reservoirs, and wetlands support their designated uses and to place the waterbodies in the appropriate use support category. Causes and sources of impairment are identified for waterbodies that do not meet their designated uses.

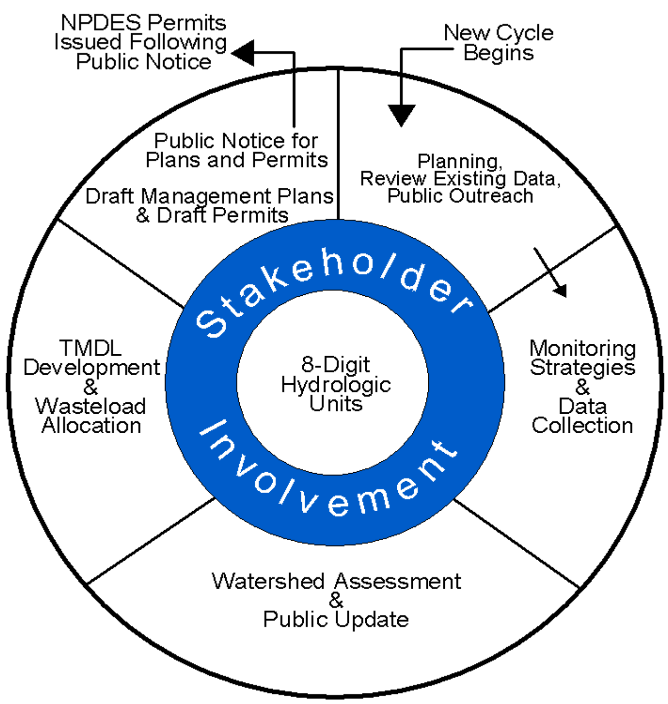


Figure 1: Watershed Cycle

Year 4. Wasteload Allocation/Total Maximum Daily Load (TMDL) - The TMDL program locates, quantifies and identifies continuing pollution problems in impacted waters and then proposes solutions. Monitoring data are used to determine pollutant effluent limits for permittees releasing wastewater to watersheds. Limits are set to assure that water quality is protected. TMDL documents may recommend regulatory or other actions required to resolve pollution problems. Previously Tennessee's TMDL prioritization schedule was based on a 1998 agreement between EPA and TDEC. Under this schedule, TDEC committed to the development of TMDLs for all waterbodies listed in 1998 by 2011. For its part, EPA committed to provide better guidance and new tools for developing TMDLs. TDEC has met the requirements of the consent decree and the TMDL program is no longer under judicial supervision.

The five steps of the TMDL process are:

1. Identify water quality problems in a waterbody.
2. Prioritize water quality problems.
3. Develop TMDL plan to control sources.
4. Implement water quality improvement actions.
5. Assess water quality improvement efforts.

Year 5. Draft Permits and Public Updates – Expiration and issuance of all discharge permits are synchronized based on watersheds. Draft National Pollutant Discharge Elimination System (NPDES) permits are issued. Draft watershed management plans are also developed. In 2009, Group 1 watershed meetings were held throughout the state, to update the public on watershed issues and encourage public involvement.

Year 6/Year 1. Permits and Watershed Management Plans - NPDES permits are issued. Final watershed management plans are issued, consisting of a general watershed description, water quality goals, major concerns, issues and management strategies. Then, the cycle begins again with planning and data collection.

Biologist Jimmy Smith looks for macroinvertebrates to check the health of the aquatic life in a stream. *Photo provided by Kim Sparks, NEFO.*

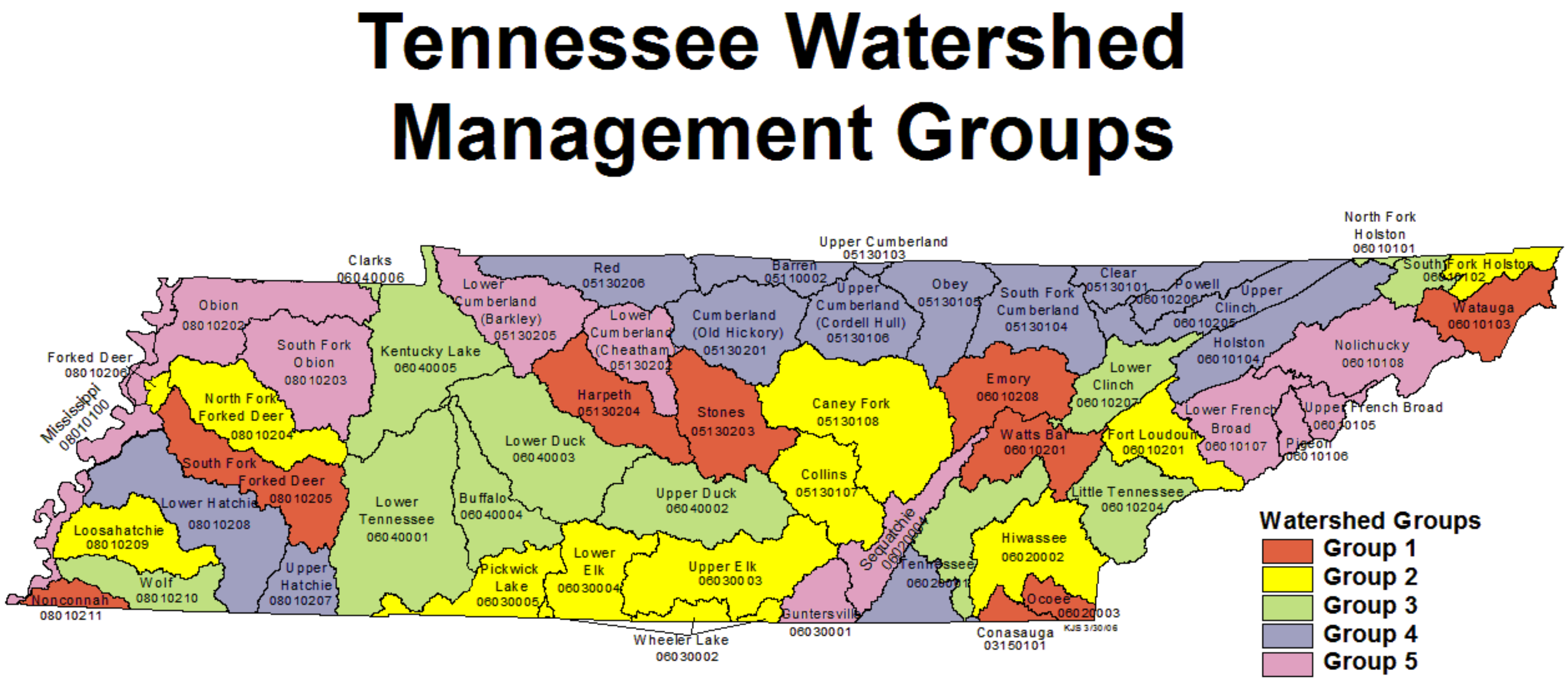


Figure 2: Watershed Monitoring Groups

Table 2: Watershed Groups and Monitoring Schedule

	Monitoring Years	West Tennessee	Middle Tennessee	East Tennessee
Group 1	1996 2001 2006 2011 2016	• Nonconnah • South Fork of the Forked Deer	• Stones • Harpeth	• Upper Tennessee (Watts Bar Res.*)† • Ocoee • Emory* • Watauga • Conasauga
Group 2	1997 2002 2007 2012 2017	• Loosahatchie • North Fork Forked Deer • Forked Deer	• Collins • Caney Fork • Wheeler Res. • Upper Elk • Lower Elk • Pickwick Res.	• Hiwassee • Upper Tennessee (Fort Loudoun Res.*)† • South Fork Holston (part)†
Group 3	1998 2003 2008 2013 2018	• Wolf • TN Western Valley (KY Lake) • TN Western Valley (Beech) • Clarks	• Upper Duck • Lower Duck • Buffalo	• Lower Tennessee (Chickamauga Res.)† • Little Tennessee* • Lower Clinch* • North Fork Holston • South Fork Holston (part)†
Group 4	1999 2004 2009 2014 2019	• Hatchie • Little Hatchie	• Red • Barren • Cumberland (Old Hickory) • Upper Cumberland (Cordell Hull) • Obey	• South Fork Cumberland* • Upper Cumberland* • Powell* • Upper Clinch* • Holston* • Clear Fork • Lower Tennessee (Nickajack Res.)†
Group 5	2000 2005 2010 2015 2020	• Mississippi • Obion • South Fork Obion	• Barkley Reservoir • Cheatham Reservoir • Guntersville Reservoir	• Sequatchie • Upper French Broad* • Lower French Broad* • Pigeon* • Nolichucky

*These watersheds are monitored the following year.
†These watersheds have been split into two watershed groups.

More details may be found on the WPC home page
http://www.tn.gov/environment/water/watershed/.

C. Types of Monitoring

The Division of Water Pollution Control has developed a monitoring strategy based on the need to collect data for various program responsibilities. Biological, chemical, bacteriological, and physical data are collected to supply information for the activities listed below. Additional information concerning the division's monitoring strategy can be found in *Quality Assurance Project Plan (QAPP) for 106 Monitoring in the Division of Water Pollution Control* (TDEC, 2010). This document is posted on the department's webpage.

1. Watershed Monitoring

Consistent with the division's watershed approach, as many additional stations as possible are monitored in order to collect information on waterbody segments that have not previously been assessed. If possible, sampling locations are located near the mouth of each tributary. Minimally, macroinvertebrate biorecons, habitat assessments, and field measurements of DO, conductivity, pH, and temperature are conducted at these sites.

If impairment is observed, and time and priorities allow, additional sites are located upstream of the impaired water reach to define the impairment length. Chemical samples are collected as needed to determine pollutant causes. Bacteriological samples are collected to determine recreational use support.

2. 303(d) Monitoring

During each watershed cycle, 303(d) listed streams are monitored. At a minimum, 303(d) stations are sampled three times for the pollutants of concern and a macroinvertebrate biological sample is collected. Additional monitoring is required for confirmation if water quality appears to have improved.

3. Long Term Trend Station Monitoring

Approximately 60 long-term trend stations are monitored quarterly for chemical and bacteriological quality. These data are used to check for changes in water quality over time.

4. Antidegradation Monitoring

Before activities that degrade water quality can be authorized, a stream's proper status under the antidegradation policy must be determined. The division uses a standardized evaluation procedure for this purpose. These activities are difficult to plan, because waterbodies are evaluated as needed - generally in response to requests for new or expanded NPDES and Aquatic Resource Alteration Permit (ARAP) permits. The type of monitoring utilized for this purpose is the more intensive biological survey since the biological integrity of a stream is an important consideration.

5. Ecoregional Reference Stream Monitoring

Established reference stations are monitored in conjunction with the watershed cycle. Each station is sampled quarterly for chemistry and pathogens as well as in the spring and fall for macroinvertebrates. Both semi-quantitative single habitat and biorecon samples are collected to establish biocriteria and biorecon guidelines. In 2007, the division also began collecting periphyton at these sites. If watershed screening results indicate a potential new reference site, more intensive reference stream monitoring protocols are used to evaluate potential inclusion in the reference database.

6. Permit Compliance/Complaint Investigation

Monitoring is undertaken each year to insure that facilities or other entities are in compliance with permit conditions. These monitoring efforts typically have one of the following designs:

- Above/Below Surveys – Samples are collected above and below an activity to determine the immediate effect the activity is having on the stream.

- Trend Determination – Samples are collected over time downstream of an activity to document whether conditions are getting better or worse.

- Reference Approach - Data collected below an activity are compared to a suitable reference stream. This technique is particularly helpful when the activity is in a headwater reach or where the stream is also impacted upstream of the activity.

Additionally, the department receives numerous water quality complaints each year from citizens. These are handled as a priority activity and any data collected at these streams can be used to assess the waterbody.

7. Probabilistic Monitoring

Statistical survey designs have been used for many years to characterize the condition of large populations based on a representative sample of a relatively few members or sites within the population. The ability of these designs to provide accurate estimates, with documented confidence levels, of the condition of populations of interest is well documented. These surveys are used in a variety of fields including election polls, monthly labor estimates, forest inventory analysis, and the national wetlands inventory.

In 2001, the division began incorporating probabilistic survey design into its monitoring strategy. Probabilistic monitoring means that sites are selected using a random sample design. Every site in the target population has an equal chance of being selected for sampling can be extrapolated to the entire population of waterbodies represented by the subsample. Because of its consistent methods and sampling framework, probabilistic monitoring is useful as a baseline for trend analysis.

8. Fish Tissue Monitoring

Fish tissue samples are often the best way to document chronic low levels of persistent contaminants. Discovery of elevated levels of certain contaminants in fish tissue can lead to use advisories, which are discussed in greater detail in Chapter 5. Fish tissue monitoring in Tennessee is planned by a workgroup consisting of TDEC staff (WPC and DOE-Oversight), TVA (Tennessee Valley Authority), TWRA (Tennessee Wildlife Resources Agency), and ORNL (Oak Ridge National Laboratory). The workgroup meets annually to discuss fish tissue monitoring needs for the following year. Data from these surveys help the division assess water quality and guide the issuance of fishing advisories.

TVA routinely collects fish tissue from reservoirs they manage. ORNL collects fish tissue samples from rivers and reservoirs that receive drainage from the Department of Energy Property in Oak Ridge. TWRA provides fish tissue samples to TDEC that are collected during population surveys. TDEC contracts other needed field collecting and analyses to the Aquatic Biology Section, Tennessee Department of Health. Targeted fish are five game fish, five rough fish, and five catfish of the same species. Samples are generally composited, although large fish may be analyzed individually. Only fillets (including belly flap) are analyzed for routine monitoring although whole body fish may be used for special projects.

9. Sediment Monitoring

Although it is not commonly done, samples of the sediment at the bottom of a creek or lake can be collected to determine the presence of harmful amounts of metals or carcinogens. One of the reasons this type of monitoring is not frequently a part of monitoring plans is that few criteria exist to reliably assess the degree of harm to the waterbody. Recent examples of sediment monitoring in Tennessee include documenting the extent of mercury contamination in Beech Creek in Wayne County, assessing levels of metals in coal ash spilled into the Emory River near Kingston, and looking for pesticides in Cypress Creek in Memphis.

As with all monitoring, field and laboratory staff use standardized procedures for the collection and analysis of sediment samples. Although Tennessee has no numeric sediment criteria, EPA literature and guidance developed by the National Oceanographic and Atmospheric Administration (NOAA) are used to assist in data interpretation.

D. Water Quality Data

1. Data Sources

The division used all reliable data that were readily available for the assessment of Tennessee's waterways. This included data from TDEC, other state and federal agencies, universities, NPDES permit holders, citizens, and the private sector (Table 3). In July 2008, January 2009, and January 2010, the division issued public notices requesting water quality data for use in the statewide water quality assessment. Additionally, the national water quality storage and retrieval (STORET) database was queried for other recent information, including data collected in other states at stations near the state line. State and federal agencies were contacted directly to request any information not available on STORET.

Agency information regarding Tennessee's water quality was received from the Environmental Protection Agency, Tennessee Valley Authority, U.S. Geological Survey, Tennessee Wildlife Resource Agency, and U.S. Army Corps of Engineers. Biological data submitted by NPDES dischargers as part of permit requirements were used. Universities and watershed groups also supplied data. All submitted data were considered in the assessment process. If data reliability could not be established, submitted data were used to screen waters for future studies. In situations where data from the division and another source did not agree, more weight was given to the division's data unless the other data were significantly more recent.

Table 3: Data Submitted to the Division for Consideration in the 2010 Assessment Process

Agency	Physical Data	Biological Data	Chemical Data	Bact. Data
US Army Corp of Engineers		X	X	
Tennessee Valley Authority	X	X	X	X
US Geological Survey	X	X	X	X
Tennessee Wildlife Resources Agency	X	X		
Phase II MS4 permittees	X	X	X	X
NPDES permittees	X	X	X	X
Universities	X	X	X	X
City of Memphis			X	X
City of Nashville				X

2. Data Quality Objectives

To assure the highest confidence in the assessment results, all data must be of reliable quality. As part of this goal, a *Quality Assurance Project Plan for 106 Monitoring* has been compiled by the division. This document defines monitoring, analyses, quality control, and assessment procedures.

In order to specify collection techniques within the state, standard procedures have been developed for collection of water quality samples. The procedures also identify appropriate quality control measures. The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) was first published in March of 2002 and revised in November 2003 and again in October 2006. The *QSSOP for Chemical and Bacteriological Sampling of Surface Waters* (TDEC, 2009) was first published in March 2004 and revised in 2008 and 2009. The *QSSOP for Periphyton Stream Surveys* was published in 2010. These documents are reviewed annually and revised as needed. TDEC staff are trained annually on proper collection techniques.

3. Data Management

The division has several tools that have increased the efficiency, accuracy, and accessibility of assessments. Software programs, combined with increased computer capabilities have greatly expanded the ability to organize, store, and retrieve water quality monitoring and assessment information. These improvements have helped not only with the organization of large quantities of information, but also analysis of specific waterbodies.

a. STORET

Due to the large amount of data collected in monitoring activities, it was paramount that the division utilizes an electronic database to store and easily retrieve data for analyses and assessment. In the early 1970s, EPA developed the national water quality STOrage and RETrieval database called **STORET**. This database allowed for easy access to bacteriological and chemical information collected throughout the state and nation. TDEC WPC station locations and chemical and bacteriological data were uploaded into the database quarterly. In September 2009, EPA ceased support of the current format that the data is uploaded to STORET. The last upload of TDEC WPC data was sent to EPA the end of September 2009. The data can be located at STORET at http://www.epa.gov/STORET.

Currently WPC is working with EARTHSOFT to utilize the software EQUIS to upload data to the EPA WQX database. The Water Quality Exchange (WQX) is a new framework that makes it easier for States, Tribes, and others to submit and share water quality monitoring data over the Internet.

b. Water Quality Database

Tennessee's Water Quality Database (WQDB) has been designed as an interim storage database for water quality data prior to upload to STORET. Additionally, other types of data including macroinvertebrate, habitat, and periphyton are also stored in this database. This database is updated and made available to WPC staff quarterly. Retrievals are made available to the public upon request.

c. Assessment Database

The **Assessment Database (ADB**) was developed by EPA to store assessment information on streams, rivers, and reservoirs, including those used for this report. The ADB allows for specific analysis of small stream segments, as well as overall assessment of total watersheds. Comments placed in this database are critical to the later understanding of the basis for assessments.

All waters are assigned a unique identification number based on the National Hydrology Database (NHD). All waterbody IDs begin with Tennessee's abbreviation (TN). The next 8 digits represent the numerical Hydrological Unit Code (HUC) assigned to each watershed by the U.S. Geological Survey (USGS). The next 3 digits represent a specific reach or subdivision of the waterbody. The final 4 digits specify a unique segment number. The resulting 15-digit waterbody ID is a unique identification number specific to a precise portion of a waterbody.

d. Geographic Information Systems

The ADB system is linked to the division's **Geographic Information System (GIS)**. The combination of these technologies allow for easy access to information on specific waterbodies by locating them on GIS maps.

e. Reach Indexing Tool and National Hydrography Dataset

EPA also developed the **Reach Indexing Tool (RIT)** and **National Hydrography Dataset (NHD)**. These software are linked to the ADB and GIS allowing quick georeferencing of assessment information. RIT and NHD can produce maps with specific waterbody information.

f. Online Water Quality Assessment

An interactive map called Tennessee's Online Water Quality Assessment that links the ADB and GIS through the RIT is available on the division's home page at:

http://tnmap.tn.gov/wpc/

This site allows the user to select a specific waterbody and read the available water quality assessment information. To use the website, it is helpful to be familiar with the toolbar used to navigate the map. On the first page of the website, there is a help file available that explains how to use the toolbar. Upon entering the Tennessee Streams

Assessment, a county map of Tennessee will be displayed. By zooming to the selected area of the state, waterbody and road details will be made available. Once the selected waterbody is located, the reviewer can make the stream assessment layer active to view stream or river use-support information or make the lake assessment layer active to view lake or reservoir information.

g. Water Pollution Information Management System

The division also has an online database available to division employees. This database contains assessment data, plus lists of Exceptional Tennessee Waters and those waters that have been evaluated and are not Exceptional Tennessee Waters. This information is updated monthly. WPC is also developing on-line mapping for this information.

E. Water Quality Assessment Methodology

Water quality assessments are completed by comparing water quality data to the appropriate criteria to determine if waters are supportive of designated uses. To facilitate this process, several provisions have been made:

- Criteria have been refined to help evaluate data. The ecoregion project has dramatically reduced the uncertainty associated with the application of statewide narrative and numerical criteria. Guidance documents have been developed to assist in the interpretation of biological, nutrient, habitat, and periphyton data.

- Critical periods have been determined for various criteria. Certain collection seasons and types of data have proven more important for the protection of specific water uses. For instance, the critical period for parameters like toxic metals or organics is the low flow season of late summer and early fall. Likewise, most water contact, like swimming and wading, occurs in the summer. Therefore, that is the season when pathogen results are considered most significant.

- To ensure defensible assessments, data quality objectives have been set. For some parameters, a minimum number of observations are needed to assure confidence in the accuracy of the assessment.

- Provisions in the water quality criteria instruct staff to determine whether violations are caused by man-induced or natural conditions. Natural conditions are not considered pollution.

- The magnitude, frequency, and duration of violations are considered in the assessment process.

- Streams in some ecoregions naturally go dry or historically have only subsurface flow during prolonged periods of low flow. Evaluations of biological integrity attempt to differentiate whether waters have been recently dry or have been affected by man-induced conditions.

- Ecoregion reference sites are re-evaluated and data are statistically tested annually. New sites are added when possible. Existing sites are dropped if data show the water quality has degraded, the site is not typical of the region, or does not reflect the best attainable conditions. Data from bordering states that share the same ecoregions are used to test suitability of reference sites and augment the dataset. Currently the state is reviewing river, lakes, headwaters, and reservoir data to identify reference conditions in these systems.

1. Application Methodology for Specific Criteria

There are two types of criteria: numeric and narrative. Both types offer challenges. Numeric criteria provide a specific level that should not be exceeded. However, the number of exceedances required for a stream to be considered impaired is open for interpretation. As an additional complication, the regulation instructs staff to consider the frequency, magnitude, and duration of numeric criteria violations and to determine whether the appearance of pollution might be due to natural causes.

Narrative criteria are written descriptions of water quality. These descriptions generally state that the waters should be "free from" particular types or effects of pollution. The division's long-standing position is that narrative criteria should have a regional basis for interpretation. To help provide regional information for narrative criteria, guidance documents based on reference stream data have been developed for biological integrity (Arnwine and Denton, 2001), habitat (Arnwine and Denton, 2001), and nutrients (Denton *et al*., 2001).

a. Toxic Substances (Numeric)

- Metals data are appropriately "translated" according to the water quality standards before comparison to criteria. For example, toxicity of metals can be altered by the waterbody's hardness and the amount of total suspended solids in the water. Widely accepted methodologies are used to translate toxicity data.

- If more than ten percent of the observations of a specific metal is above chronic criteria, the stream is assessed as impaired by that metal.

b. Pathogen Criteria (Numeric)

- Waterbodies are not assessed as impaired due to high bacteria levels with less than four water samples. The only waters assessed with one or two observations are waterbodies previously listed due to elevated bacteria levels or streams with obviously gross conditions, such as failing animal waste lagoons.

- Tennessee utilizes *E.* coli as our indicator since this group is generally considered more reflective of true risk than are fecal coliform data.

- If flow data are available, low flow, dry season data are considered more meaningful than high flow, wet season data. In the absence of flow data, samples collected in late summer and fall are considered low flow or dry season samples. It is important to note that wet season pathogen samples are not disregarded.

c. Dissolved Oxygen (Numeric)

- TDEC's SOP for chemical monitoring calls for dissolved oxygen levels to be measured in flowing water. Data collected at extreme low flows must be interpreted with caution as any violations may be due to natural stagnation rather than pollution.

- If the source of the low DO is a natural condition such as ground water, spring, or wetland, then the low DO is considered a natural condition and not pollution.

d. Nutrient Criteria (Narrative)

- The only designated uses that have nutrient criteria are fish and aquatic life and recreation. A guidance document that provides a regional nutrient criteria translator has been developed for fish and aquatic life use support. A specific nutrient response criterion based on chlorophyll *a* has been adopted for Pickwick Lake.

- Regional nutrient goals (Denton *et al*., 2001) were used as guidance during this assessment cycle.

- Waters are not assessed as impaired by nutrients unless biological or aesthetic impacts, or downstream problems are also documented.

- At least four nutrient observations are needed for a valid assessment, unless biological impairment is also observed. For example, if the biology of a stream is very poor and/or the amount of algae present indicates organic enrichment, then fewer than four nutrient samples could be used to identify a suspected cause of pollution.

e. Turbidity/Suspended Solids Criteria (Narrative)

- Historically, silt has been one of the primary pollutants in Tennessee waterways. The division has experimented with multiple ways to determine if a stream, river, or reservoir is impaired due to silt. These methods include visual observations, chemical analysis (total suspended solids), and macroinvertebrate/ habitat surveys. The most satisfactory method for identification of impairment due to silt has been biological surveys that include habitat assessments.

- Ecoregions vary in the amount of silt that can be tolerated before aquatic life is impacted. Through work at reference streams, staff found that the appearance of sediment/silt in the water is often, but not always, associated with loss of biological integrity. Thus, for water quality assessment purposes, it is important to establish whether or not aquatic life is being impaired. For those streams where loss of biological integrity can be documented, the habitat assessment can determine if this loss is due to excessive silt deposits.

f. Biological Integrity Criteria (Narrative)

- Biological integrity criteria are designed to protect fish and aquatic life.

- Biological surveys using macroinvertebrates as the indicator organisms are the preferred method for assessing use support. Two standardized biological methods, biorecons and semi-quantitative samples, are used to produce a biological index score. These methods are described in *Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys* (TDEC, 2006) and are referenced in the water quality criteria.

- The most commonly utilized biological survey method is the biorecon. Biological scores are compared to the metric values obtained in ecoregion reference streams. Three metrics are examined: taxa richness, number of families or genera of caddisflies, mayflies, and stoneflies (EPT), and number of intolerant families or genera.

- If a more definitive assessment is needed, a single habitat, semi-quantitative sample is collected. Organisms are identified to genus and an index based on seven biological metrics is used for comparison to reference streams. Streams are considered impaired if the biological integrity falls below the target score for that region. Target scores were set at 75% of the reference score for each bioregion.

- If both biorecon and single habitat semi-quantitative data are available and the results do not agree, more weight is given to the single habitat semi-quantitative results. If data from the division and another agency do not agree, more weight is given to the state's data unless the other agency's data are considerably more recent.

- To be comparable to ecoregions guidance, streams must be similar size (order) and drainage as the reference streams in the ecoregion and must have at least 80 percent of the upstream drainage within that ecoregion.

g. pH (Numeric)

- The pH criterion range for wadeable streams is 6.0 - 9.0. For nonwadeable rivers, streams, reservoirs, and wetlands, the pH range is 6.5 – 9.0.

- A complicating factor is that increased acidity causes some metals to become more toxic. In many waterbodies assessed as impaired by acidity, it is difficult to discern whether the harm was caused by the reduced pH or the resulting metal toxicity, especially in areas with historical or active mining present. Conversely, increased alkalinity makes ammonia more toxic.

h. Habitat Data (Narrative)

- Habitat alteration is one of the major causes in stream impairment in the state.

- Division staff use a standardized scoring system developed by EPA to rate the habitat in a stream (Barbour, *et al*., 1999). The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2006) provides guidance for completing a habitat assessment and evaluating the results.

- Habitat scores calculated by division biologists are compared to the ecoregion reference stream database. Streams with habitat scores less than 75 percent of the median reference score for the ecoregion are considered impaired, unless biological integrity meets expectations. If biological integrity meets ecoregional expectations, then poor habitat is not considered an impairment.

- Guidance on interpretation of the narrative habitat criterion has been developed and was used during this assessment cycle (Arnwine and Denton, 2001). The habitat goals are referenced in the 2007 General Water Quality Criteria, (TDEC-WQCB, 2007).

Habitat alteration is one of the leading causes of stream impairment in Tennessee.
Photo provided by Kim Sparks, NEFO.

2. Assessment Rates for 2010

The division maintains a statewide monitoring system of approximately 7,000 stations. Not all stations are monitored in each cycle. In addition, new stations are created every year to increase the number of assessed waterbodies. Approximately 1400 Group 1 and Group 2 stations were monitored in 2006 and 2007 for this report. Monitoring an additional 1400 sites in Group 3 and 4 watersheds will be completed in June 2010. These data will be used to update assessments in the 2012 305(b) report.

> Waterbodies were assessed using current (less than five years old) data, including biological and chemical results, field observations, and any other available information.

Chapter 3 of this report summarizes water quality in Tennessee's streams, rivers, reservoirs, and lakes. In order to determine use support, it must be decided if the waterbody meets the most protective water quality criterion for its assigned uses. Generally, the most stringent criteria are associated with recreational use and support of fish and aquatic life.

With available resources, it is not possible to monitor all of Tennessee's waterbodies during the two-year window covered by this report. A strategy based on watershed cycles has been designed and implemented to systematically sample and monitor as many waterbodies as possible. Some waterbodies are difficult to access or are very small. Other streams have intermittent flows. During periods of low flow, some of these streams go dry or flow underground.

For this report, over half (30,629 miles) of the stream miles (Figure 3) and almost all (565,543 acres) of the reservoir and lake acres (Figure 4) in the state were monitored and assessed. Forty-nine percent (29,765 miles) of Tennessee's streams and rivers were not assessed during this cycle. Only one percent (6,463 acres) of Tennessee's reservoir and lake acres were not assessed during this cycle.

Group 2 waterbodies such as the Loosahatchie River were assessed during this cycle.
Photo provided by Nels Paulsen, MEFO.

3. Data Application – Categorization of Use Support

Waterbodies are assessed by comparing monitored water conditions to water quality standards for the waterbody's designated uses. Data that meet state quality control standards and collection techniques are used to generate assessments. After use support is determined, waterbodies are placed in one of the five categories recommended by EPA.

Use Support Categories

Category 1 waters are **fully supporting** of all designated uses. These streams, rivers, and reservoirs have been monitored and meet the most stringent water quality criteria for all designated uses for which they are classified. The biological integrity of Category 1 waters is favorably comparable with reference streams in the same subecoregion and pathogen concentrations are at acceptable levels.

Category 2 waters are **fully supporting** of some designated uses, but have not been assessed for all uses. In many cases, these waterbodies have been monitored and are fully supporting of fish and aquatic life, but have not been assessed for recreational use.

Category 3 waters are **not assessed** due to insufficient or outdated data. However, streams previously identified as impaired are not moved to this category simply because data are old.

Category 4 waters are **impaired**, but a TMDL has been completed or is not required. Category 4 has been further subdivided into three subcategories.

- **Category 4a** impaired waters that have already had all necessary TMDLs approved by EPA.
- **Category 4b** impaired waters do not require TMDL development since "other pollution control requirements required by local, State or Federal authority are expected to address all water-quality pollutants" (EPA, 2003). An example of a 4b stream might be where a discharge point will be moved in the near future to another waterbody with more assimilative capacity.
- **Category 4c** impaired waters in which the impacts are not caused by a pollutant (e.g., flow alterations).

Category 5 waters have been monitored and found to not meet one or more water quality standards. These waters have been identified as **not supporting** their designated uses. Category 5 waterbodies are moderately to highly impaired by pollution and need to have TMDLs developed. These waters are included in the 303(d) List of impaired waters in Tennessee. The current 303(d) list may be viewed at http://www.tn.gov/environment/water.

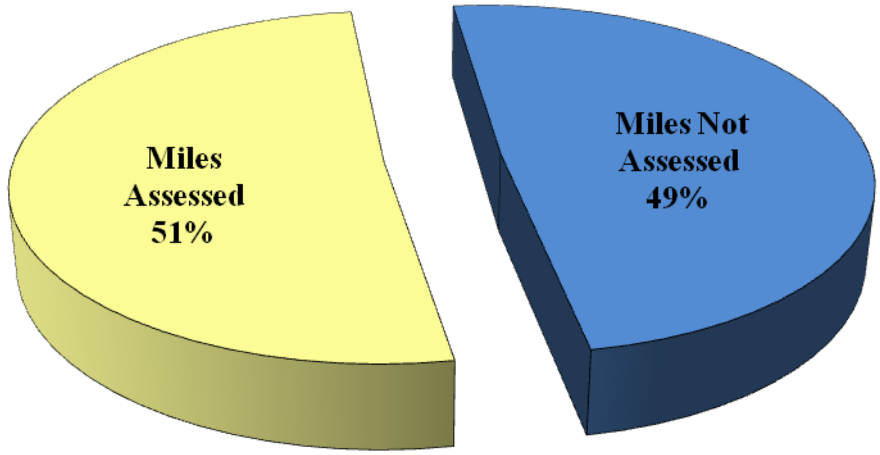


Figure 3: Percent of River and Stream Miles Monitored and Assessed

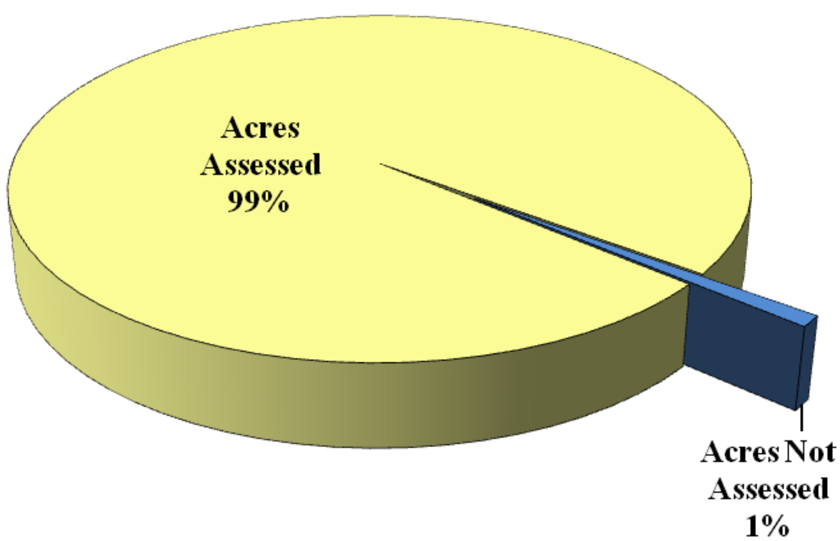


Figure 4: Percent of Reservoir and Lake Acres Monitored and Assessed

Chapter 2
Water Quality Standards Attainment Status

Consistent with the rotating watershed approach, the 9 watersheds in Group 1 and 12 watersheds in Group 2 have been assessed since the last 305(b) report was published in 2008. The assessment process considers existing water quality data to place each waterbody into one of the five categories.

A. Streams and Rivers

According to EPA's National Hydrography Dataset (NHD), there are 60,394 miles of streams and rivers in Tennessee. The division was able to assess half (30,629 miles) of the stream miles in the state (Table 4 and Figure 5). Of the assessed streams, 58 percent are fully supporting of the designated uses for which they have been assessed.

1. 7,189 of the total stream miles (12%) are **Category 1**, fully supporting all designated uses.

2. 10,480 of the total stream miles (17%) are **Category 2**, which is fully supporting of some uses, but not assessed for others. Many of these streams and rivers have been assessed as fully supporting of fish and aquatic life, but have not been assessed for recreational uses.

3. 29,765 of the total stream miles (49%) are in **Category 3**. These waters have insufficient data to determine if classified uses are met.

4. 3,041 of the total stream miles (5%) have been identified as **Category 4,** impaired but TMDLs are not needed. 2,898 stream miles (4.8%) are **Category 4a**, which have had TMDLs for all impairments approved by EPA. 7 miles are **Category 4b**, which are impaired waters that don't require a TMDL. 136 stream miles (0.2%) are **Category 4c** where it has been determined that the source of impairment is not a pollutant.

5. 9,919 of the total stream miles (16%) are in **Category 5**, waters that are impaired or threatened and need TMDLs for the identified pollutants.

Table 4: Assessed Stream Miles

Category Assessment	**Miles**
Total Miles	60,394
Total Assessed Miles	30,629
Category 1	7,189
Category 2	10,480
Category 3	29,765
Category 4a	2,898
Category 4b	7
Category 4c	136
Category 5	9,919

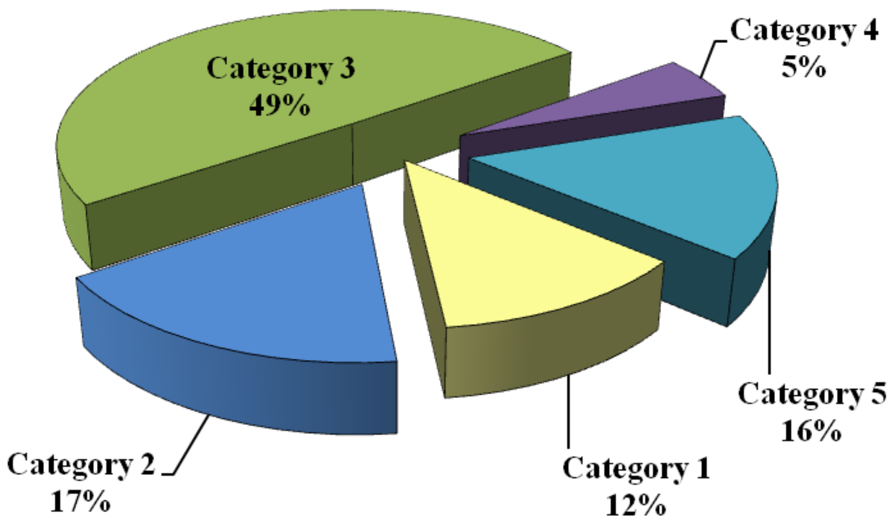


Figure 5: Percent of Rivers and Streams in Each Category

About 43 percent of the stream miles assessed for recreational use failed to meet the criteria assigned to that use. Approximately 33 percent of the assessed stream miles failed to meet fish and aquatic life criteria. Most or all waters classified for domestic water supply, irrigation, navigation, and industrial water supply uses were found to be fully supporting (Table 5 and Figure 6).

Table 5: Individual Classified Use Support for Rivers and Streams

Designated Uses	Miles Of Streams Classified	Classified Miles Assessed	Miles Meeting Use	Percentage Of Assessed Miles Meeting Use*
Fish and Aquatic Life Protection	60,394	29,986	20,113**	67%
Recreation	60,394	16,527	9,421	57%
Irrigation	60,394	30,288	30,288	100%
Livestock Watering and Wildlife	60,394	30,288	30,287	99.99%
Domestic Water Supply	3,696	3,335	3,294	99%
Navigation	1307	1307	1307	100%
Industrial Water Supply	3,381	3,131	3,131	100%

*Note: All waters are classified for more than one use, but may or may not have all uses fully supporting. Thus, this table cannot be used to derive percentages for overall use support in Tennessee. In addition, assessment rates for individual uses may not match overall use assessment rates.

** Note: 39 miles are threatened for the protection of fish and aquatic life.

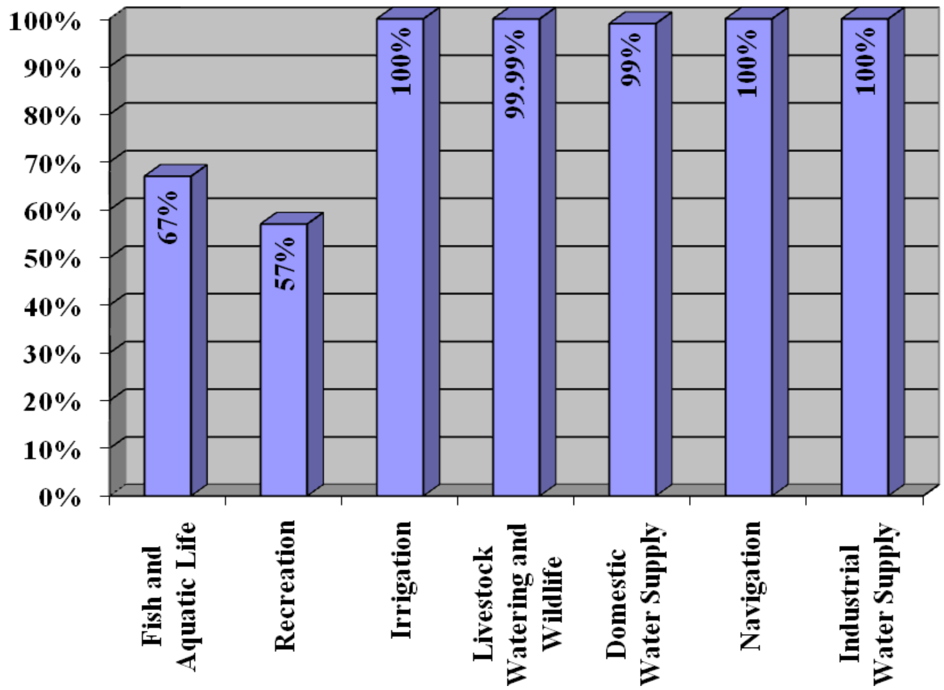


Figure 6: Percent Use Support for Individual Classified Uses in Assessed Rivers and Streams

B. Reservoirs and Reelfoot Lake

Overall Use Support

Table 6: Assessed Reservoir and Lake Acres

Category Assessment	Support Assessment
Total Acres	572,007
Total Assessed Acres	565,543
Category 1	383,635
Category 2	141
Category 3	6,463
Category 4	8,691
Category 5	173,077

Tennessee has over 90 public reservoirs or lakes with a total size of over 570,000 acres (Table 6). For the purpose of this report, a reservoir or lake is a publicly accessible reservoir or lake larger than five acres.

Most lakes in Tennessee are reservoirs that were created by the impoundment of a stream or river. One exception is Reelfoot Lake, thought to have been formed by a series of earthquakes in 1811 and 1812. For the purposes of this report, the generic term “lake acre” refers to both reservoirs and lakes.

By using available data, the Division of Water Pollution Control was able to assess 565,543 lake acres. This means that 98.9 percent of the lake acres in Tennessee have been assessed. Of the assessed lake acres, 68 percent are fully supporting of the designated uses for which they have been assessed. All lake acres were placed into one of five use categories. The majority of lake acres were assessed as Category 1 (Figure 7).

1. 383,635 of the total lake acres (67.1%) are Category 1, fully supporting of all designated uses.

2. 141 of the total lake acres (0.02%) are Category 2, fully supporting of some uses, but without sufficient data to determine if other uses are being met.

3. 6,463 of the total lake acres (1.1%) are placed in Category 3, not assessed, due to insufficient data to determine if uses are being meet.

4. 8,691 of the total lake acres (1.5%) are assessed as Category 4, impaired for one or more uses, but a TMDL is not required.

5. 173,077 of the total lake acres (30.3%) are assessed as Category 5, impaired for one or more uses and needing a TMDL. These reservoirs and lakes are placed on the 303(d) List of impaired waters in Tennessee.

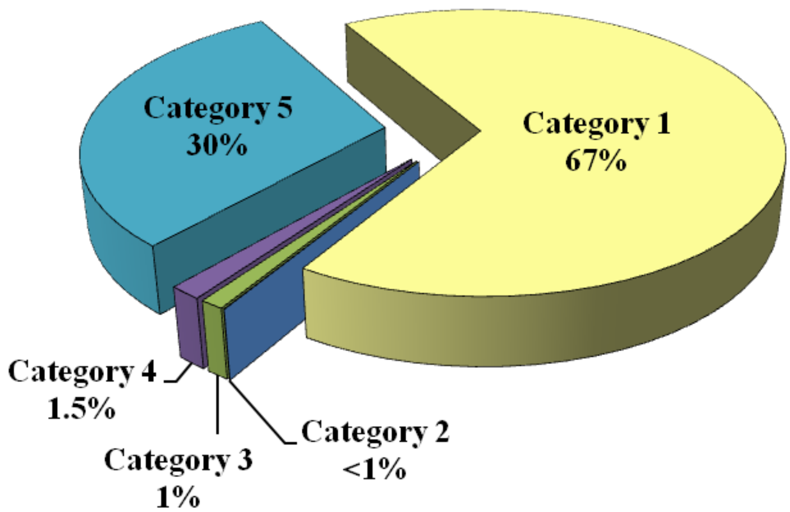


Figure 7: Percent of Reservoir and Lake Acres in Each Category
(Category 2 has less than 1 percent.)

Support of Individual Uses

The two most common use classifications not supported in lakes are fish and aquatic life and recreation (Table 7). Seventy percent of the reservoir/lake acres support recreational uses. Over 90 percent of the reservoir/lake acres support fish and aquatic life uses. All other designated uses, with the exception of 455 acres classified for domestic water supply, were fully supporting for all assessed acres (Figure 8).

Table 7: Individual Classified Use Support for Reservoirs and Lakes

Designated Uses	Acres Classified	Classified Acres Assessed	Acres Meeting Use	Percentage of Assessed Acres Meeting Use*
Fish and Aquatic Life Protection	572,007	563,642	522,485	93%
Recreation	572,007	564,932	396,842	70%
Irrigation	572,007	563,642	563,642	100%
Livestock Watering and Wildlife	572,007	563,642	563,642	100%
Domestic Water Supply	529,025	526,637	526,182	99.9%
Navigation	1,971	1,971	1,971	100%
Industrial Water Supply	428,834	428,819	428,819	100%

*Note: Reservoirs are classified for more than one use, but may or may not have all uses fully supporting. Thus, this table cannot be used to derive percentages for overall use support in Tennessee. Also, assessment rates for individual uses may not match overall use assessment rates.

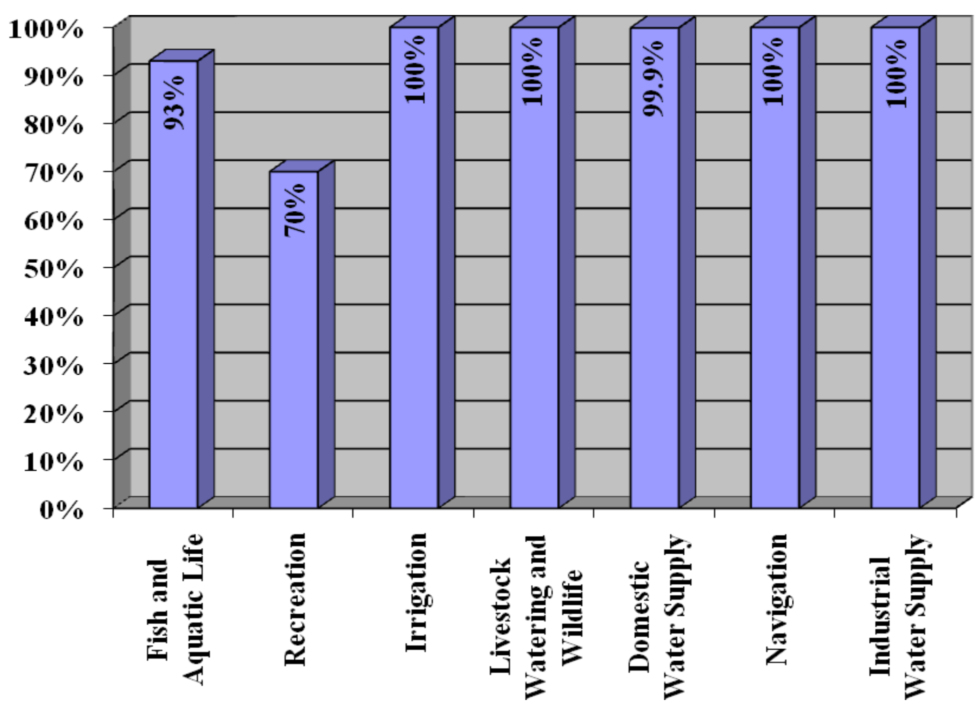


Figure 8: Percent Use Support for Individual Uses in Assessed Reservoirs and Lakes

C. Water Quality in Wetlands

Wetlands are some of Tennessee's most valuable natural resources. Wetlands serve as buffer zones along rivers, help filter pollutants from surface runoff, store floodwaters during times of high flows, serve as spawning areas for fish, and provide habitat for specialized plant and wildlife species. It is estimated that Tennessee has lost over 1 million acres of wetlands over the last century. The largest single cause of impact to those wetlands was channelization and drainage for agricultural conversion.

Tennessee Wetland Facts

Estimated Number of
Historical Wetland Acres…..1,937,000
Estimated Number of
Existing Wetland Acres………787,000
Percentage of Historical
Acres Lost ………………….60%
Number of Existing Wetland
Acres Considered Impaired
by Pollution and/or Loss
of Hydrologic Function………..54,811

Today, land development and transportation projects contribute most of the pollution, and are a significant cause of impacts to wetlands. A few wetlands have been contaminated by historical industrial activities. Several of these wetlands are now Superfund sites. Wetlands that have been altered without prior approval and have not yet been adequately restored are considered impaired. Where alteration permits have been approved, but the plan was not followed, wetlands are also considered impaired. In instances where the wetland was altered, but the state received compensatory mitigation for the loss of water resources, the resource was not considered impaired.

Tennessee was one of the first states in the nation to have a protection strategy and has been recognized by EPA as establishing a national model for wetlands planning. Tennessee's Wetlands Conservation Strategy was first published in 1994, in cooperation with other state and federal agencies, to plan for the protection and restoration of wetlands. To view the strategy, visit the web site at http://tennessee.gov/environment/na/wetlands.

TDEC has sought to stop the decline in wetlands through the adoption of Tennessee's Wetlands Conservation Strategy goal of achieving no overall net loss of the wetland acreage and functions in each hydrologic unit. In addition, the Rules of the Tennessee Water Quality Control Board (Chapter 1200-4-7) establish a standard of no net loss of water resource value in permitting alterations of streams and wetlands through either §401 Certifications or state Aquatic Resource Alteration Permits. The Strategy and the Rules include purchasing wetlands, establishing mitigation banks, and the processing of permits. The Tennessee Wetlands Conservation Strategy will be developed and implemented in a phased approach. A wetlands functional assessment method and procedure will increase the state's capabilities to assess the condition of wetlands as well as to measure the status of wetland acreage, function, and habitat availability.

Tennessee received a grant from EPA to develop a protocol for wetland assessment and to apply the state's antidegradation rules to wetlands permitting issues. This project involves research on other states' antidegradation policies, wetland programs and rapid functional assessment methodologies. These include the short forms of the Tennessee regional hydrogeomorphic (HGM) functional assessment methods, Ohio's Rapid Assessment Method for wetlands and the U.S. Army Corps of Engineers Charleston District compensatory mitigation standard operating procedures (2002). The selected field assessment method will be adapted for use in the specific regions of the state.

This project will allow for the identification of high quality wetlands, aid in assessing the ecological consequences of §401 and ARAP permitting decisions, and assist in implementation the state's antidegradation rules. The development of a third regional HGM functional assessment method will provide a tool to quantify wetlands functions, determine ratios for proposed mitigation, assess compliance and measure the attainment of Tennessee Wetlands Conservation Strategy objectives. A database will enable the permitting program to track compliance and provide a source of wetland impact and mitigation data for use by agencies involved in wetland's monitoring and research.

In 2010, Tennessee will partner with the U.S. Army Corps of Engineers (COE) and The Nature Conservancy to undertake one pilot watershed approach project in Tennessee to fulfill the requirements of the 2008 COE/EPA Compensatory Mitigation Rule. The pilot watershed approach project in Tennessee is targeted for completion by the end of calendar year 2010. The primary goal of this project will be to develop a watershed plan that identifies viable/potential wetland and stream restoration and preservation priorities in the selected watershed. A report will summarize the methodology utilized to apply the watershed approach in development of the plan. The report will be designed to serve as a guide for the application of the watershed approach in the region.

Today, approximately 787,000 acres of wetlands remain in Tennessee, a 60% loss from historic acreage. Pictured is a wetland in the South Fork Forked Deer River Bottom in the west Tennessee Coastal Plains.

Picture provided by Amy Fritz, JEFO.

Chapter 3
Causes of Water Pollution

Pollution is an alteration of the physical, chemical, biological, bacteriological, or radiological properties of water that results in an impairment of designated uses. To assess the causes of pollution in streams, rivers and reservoirs, the division follows the guidance provided by EPA. In order to help standardize the names of impairment causes across the country, EPA has provided a list of potential pollutants in the ADB.

A. Causes of Pollution in Streams and Rivers

Pollutants such as sediment/silt, habitat alteration, pathogens, and nutrients are the leading causes of impairment in Tennessee streams and rivers. Other frequent pollutants in streams and rivers include toxic substances, such as metals and organic pollutants. Flow alteration, pH changes, and low dissolved oxygen are other common causes of pollution (Figure 9 and Table 8).

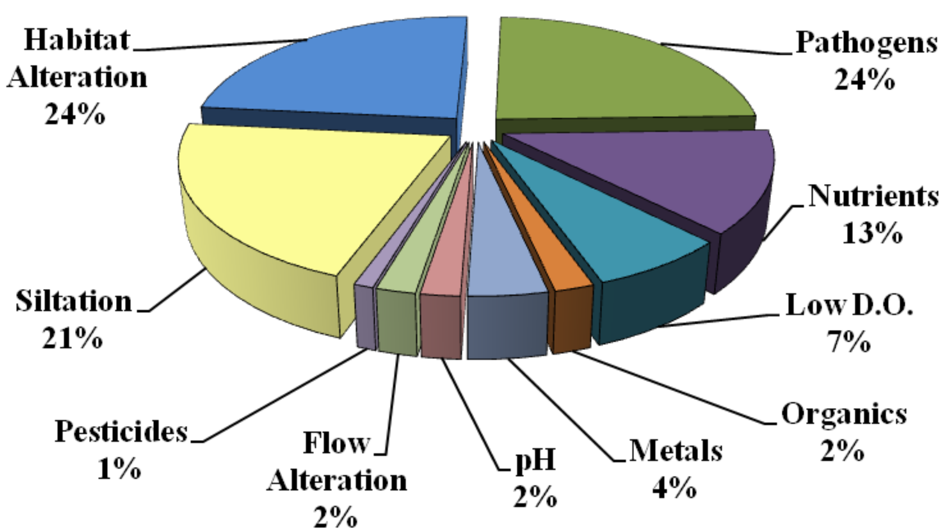


Figure 9: Relative Impacts of Pollution in Impaired Rivers and Streams (Stream Miles)

1. Habitat Alteration

Types of Habitat Alterations

Habitat Alteration	**Stream Miles Impaired**
Alteration in stream-side or littoral vegetative cover…………….....	2,003
Other anthropogenic substrate alterations……………...………	512
Physical substrate habitat alterations……………….…………	4,173

Note: Streams can be impaired by more than one type of habitat alteration. These totals are not additive.

Many streams in Tennessee appear to have impaired biological communities in the absence of obvious chemical pollutants. Often the cause is physical alteration of the stream which results in a loss of habitat. Changes in habitat can lead to a lack of diversity and density of aquatic species.

Habitat alteration is the physical modification of a stream within the channel or along the banks. Common types of habitat alteration include loss of riparian habitat such as cutting trees or mowing along stream banks, destabilization of the banks from riparian grazing or channelization, gravel dredging or filling, culverting or directing streams through pipes, and upstream modifications such as dams.

Riparian habitat (streamside vegetation) is very important to help maintain a healthy aquatic environment. Optimal riparian habitat is a mature vegetation zone at least 60 feet wide on both banks. Riparian vegetation is important because it:

- Provides a buffer zone that prevents sediment in runoff from entering the water.
- Provides roots to hold banks in place, preventing erosion.
- Provides habitat for fish and other aquatic life.
- Provides canopy that shades the stream or river. This shading keeps water temperatures down and prevents excessive algal growth, which in turn prevents large fluctuations in dissolved oxygen levels.
- Provides a food source for aquatic invertebrates that eat fallen leaves and for fish that eat insects that fall from trees.

The division uses an EPA method to score the stream or river habitat by evaluating ten components of habitat stability (Barbour, *et al*., 1999). This is a standardized way to identify and quantify impacts to stream habitat. Tennessee has developed regional guidance based on reference data to evaluate habitat (Arnwine and Denton, 2001).

An Aquatic Resources Alteration Permit (ARAP) is required to modify a stream or river in Tennessee. The permit will not be issued unless the water resources can be protected. Additional information can be found at http://www.tn.gov/environment/permits/whoami.shtml.

2. Pathogens

Pathogens are disease-causing organisms such as bacteria or viruses that can pose an immediate and serious health threat if ingested. Many bacteria and viruses that can be transferred through water are capable of causing serious or even fatal diseases. The main sources for pathogens are untreated or inadequately treated human or animal fecal matter.

Indicator organisms are used for water quality criteria to test for the presence of pathogens. Historically, Tennessee used total fecal coliform counts as the indicator of risk, but has revised criteria to comply with an EPA recommendation to shift to an *E. coli* - based criteria. The *E. coli* group is considered by EPA to be a better indicator of true human risk. Water quality criteria were revised to use *E. coli* in January 2004.

Currently, Tennessee has 48 streams and rivers posted with a water contact advisory due to high pathogen levels. There are 6,700 stream miles are impaired by *E. coli*. See Chapter 5 for specific information on posted streams and rivers.

Problem concentrations of pathogens happen at different times in various streams across the state. High levels can be associated with rainfall events in urban areas with collection system problems and in rural areas with large concentrations of livestock with inadequate buffer zones adjacent to streams. *E. coli* can be elevated under low flows conditions also, especially in areas with failing or inadequate septic systems or places where livestock have direct access to streams.

3. Siltation/Suspended Solids

Silt is one of the most frequently cited pollutants in Tennessee, impacting almost 6,000 miles of streams and rivers. While some erosion is a natural process, tons of soil are lost every year as a result of human activities. Silt is generally associated with land disturbing activities such as agriculture and construction. Some of the significant economic impacts caused by silt are increased water treatment costs, filling in of reservoirs, loss of navigation channels, and increased likelihood of flooding. Silt can affect the biological, chemical, and physical properties of water.

Biological properties of waters are affected by:

- Smothering eggs and nests of fish.
- Transporting other pollutants, in possibly toxic amounts, or providing a reservoir of toxic substances that may become concentrated in the food chain.
- Clogging the gills of fish and other forms of aquatic life.
- Covering substrate that provides habitat for aquatic insects, a main food source of fish.
- Reducing biological diversity by altering habitats to favor burrowing species.
- Accelerating growth of submerged aquatic plants and algae by providing more favorable substrate.

Chemical properties of waters are affected by:

- Interfering with photosynthesis.
- Decreasing available oxygen due to decomposition of organic matter.
- Increasing nutrient levels that accelerate eutrophication in reservoirs.
- Transporting organic chemicals and metals into the water column (especially if the original disturbed site was contaminated).

Physical properties of waters are affected by:

- Reducing or preventing light penetration.
- Changing temperature patterns.
- Decreasing the depth of pools or lakes.
- Changing flow patterns.

Preventive planning in land development projects can protect streams from silt and protect valuable topsoil. Best Management Practices (BMPs) such as the installation of silt fences and maintenance of trees and undergrowth as buffer zones along creek banks can prevent soil from entering the creek. Farming practices that minimize land disturbance, such as fencing livestock out of creeks and no-till practices not only protect water quality but also prevent the loss of topsoil.

4. Nutrients

A common problem in Tennessee waterways is elevated nutrient concentrations. The main sources for nutrient enrichment are livestock, municipal wastewater systems, urban runoff, and improper application of fertilizers. Nutrients stimulate algae growth that produces oxygen during daylight hours, but uses oxygen at night, leading to significant diurnal fluctuations in oxygen levels. Waters with elevated nutrients often have floating algal mats and clinging filamentous algae. Elevated nutrients cause the aquatic life to shift towards groups that eat algae and can tolerate dissolved oxygen fluctuations.

Types of Nutrients

Nutrient	**Stream Miles Impaired**
Nutrient/Eutrophication Biological Indicators……	306
Total Phosphorus……….	1,774
Nitrate/Nitrite…………...	1,440
Ammonia (un-ionized)…	54

Note: Streams can be impaired by more than one type of nutrient. These totals are not additive.

Nutrient pollution is difficult to control. Restrictions on point source dischargers alone may not solve this problem. The other major contributors to nutrient problems are agricultural activities such as over-application of fertilizers and intensive livestock grazing.

Some states have banned the use of laundry detergents containing phosphates. As a result, most commercially available detergents do not contain phosphates.

Many fertilizers for crops or lawn application contain both nitrogen and phosphorus. If fertilizers are applied in heavy concentrations, rain will carry the fertilizer into nearby waterways.

Monitoring data from ecoregion reference streams has increased understanding of the natural distribution of nutrients throughout the state. Using this information, regional goals have been identified as part of the narrative nutrient criteria (Denton *et al*., 2001).

5. Low Dissolved Oxygen

Depleted dissolved oxygen in water will restrict or eliminate aquatic life. The water quality standard for dissolved oxygen in most non-trout streams is 5 mg/L. While some species of fish and aquatic insects can tolerate lower levels of oxygen for short periods, prolonged exposure will affect biological diversity and in extreme cases, cause massive fish kills. Over 1,800 stream miles in Tennessee have been impaired by low dissolved oxygen.

Low dissolved oxygen levels are usually caused by the decay of organic material. This condition can be improved by reducing the amount of organic matter entering a stream or river. Streams and rivers that receive substantial amounts of ground water inflow, or have very sluggish flow rates, can have naturally low dissolved oxygen levels.

The division commonly measures dissolved oxygen during daylight hours in conjunction with biological or chemical monitoring. When diurnal fluctuations are expected, continuous monitoring probes are deployed.

6. Metals

Types of Metals

Metal	**Stream Miles Impaired**
Mercury…………………	263
Iron…………………….	240
Manganese……………..	191
Lead…………………….	91
Arsenic...………………..	84
Zinc…………………….	47
Copper…………..............	46
Aluminum……………….	34
Chromium Hexavalent…..	4

Note: Streams can be impaired by more than one metal. These totals are not additive.

The most common metals impacting Tennessee waters include mercury, iron, manganese, arsenic, and lead. Zinc, copper, and chromium levels can also violate water quality standards. The major concern regarding metal contamination is toxicity to fish and aquatic life, plus the danger it poses to people who come in contact with the water or eat fish from the contaminated waterbody. The precipitation of metals in streams can affect habitat.

In particular, mercury can be a serious threat to human health due to its tendency to bioconcentrate in the food chain. Sections of ten rivers have been posted for dangerous levels of mercury in fish tissue. Chapter 5 discusses this in more detail.

Occasionally, metals are elevated in streams and rivers due to natural conditions. For example, elevated manganese levels in east Tennessee streams and rivers may be naturally occurring in the groundwater. However, it is relatively rare for waterbodies to violate criteria for metals simply based on natural conditions.

7. Organic Contaminants

Types of Organic Contaminants

Organic Contaminant	Stream Miles Impaired
PCBs..........	300
Dioxin...........	256
Chlordane.......	256
RDX.............	63
PAHs.............	26
Creosote........	7
Toluene.......	0.5

Note: Streams can be impaired by more than one type of organic contaminant. These totals are not additive.

Organic contaminants are man-made chemicals containing the element carbon. These include chemicals like PCBs, DDT, chlordane, and dioxins, which are listed by EPA as priority pollutants and classified as probable human carcinogens (cancer causing agents). In some waterbodies, these substances have accumulated in sediment and pose a health threat to those that consume fish or shellfish.

Some organic pollutants in very low concentrations can pose a threat to human health. Many of these compounds have been banned from use for several decades. However, organic pollution that occurred decades ago still poses a serious threat, because these substances tend to remain in the environment for an extremely long time.

Dioxins are man-made by-products of herbicide manufacturing, certain historical paper mill manufacturing processes, and the incineration of chlorine-based chemicals. Dioxins are considered among the most toxic substances released into the environment. EPA has not found a safe exposure level. In fact, EPA has determined that dioxins, in addition to being probable human carcinogens, can cause reproductive and developmental problems.

One problem in identifying organic pollution is that water quality criteria are often below current detection levels. Detection of these substances is generally made either by analyzing fish tissue levels and/or by use of sediment screening values provided by EPA. Since organic contaminants can bioaccumulate in fish, it is important to make sure catfish and other species consumed by people are safe to eat. Children and pregnant or nursing women are the most sensitive populations.

Photo provided by Jimmy Smith, NEFO.

8. pH

Low pH, elevated alkalinity, or a significant change in the pH or acidity of the water over a relatively short period of time, can greatly impact aquatic life. A common reason for a change in pH is acidic runoff from active or abandoned mine sites. Currently, 410 stream miles are listed as impaired by low pH, most in areas with historical mining activities. Disturbance of certain rock formations during road construction can also release acidity to streams. Excessive amounts of algae can cause streams and rivers to violate standards on the alkaline side, but this phenomenon more commonly occurs in lakes.

The pH level also plays an important role in the toxicity of metals, with pH levels below 5.5 generally increasing toxic effects. On the other hand, ammonia toxicity is increased in the presence of high pH. The statewide fish and aquatic life pH criterion for large rivers, reservoirs, and wetlands is 6.5 to 9.0. The pH criterion for wadeable streams and rivers is 6.0 – 9.0.

9. Flow Alteration

Four hundred fifty three (453) stream miles are currently assessed as impaired by flow alteration. Flow alteration is a change to the flow that leads to a loss of instream habitat. Increased water velocities also cause extreme down-cutting of stream and river channels, plus increase the sediment transported downstream. In extreme cases, flow alterations cause stream channels to be dry.

Impoundments often adversely affect macroinvertebrate communities, disrupt habitat, and change water chemistry downstream.

Photo provided by Pat Alicea, TDH.

B. Causes of Pollution in Reservoirs and Lakes

Some of the same types of pollutants that occur in rivers and streams impact reservoirs, although in different magnitudes. The main pollutants in Tennessee reservoirs are toxic organics such as PCBs and dioxins. Other pollutants include mercury, nutrients, sediment/silt, low DO, and pesticides such as chlordane (Figure 10 and Table 8). The effects of most of these pollutants are the same as in flowing water, however, persistent substances are more likely to accumulate and remain in reservoirs for a very long time.

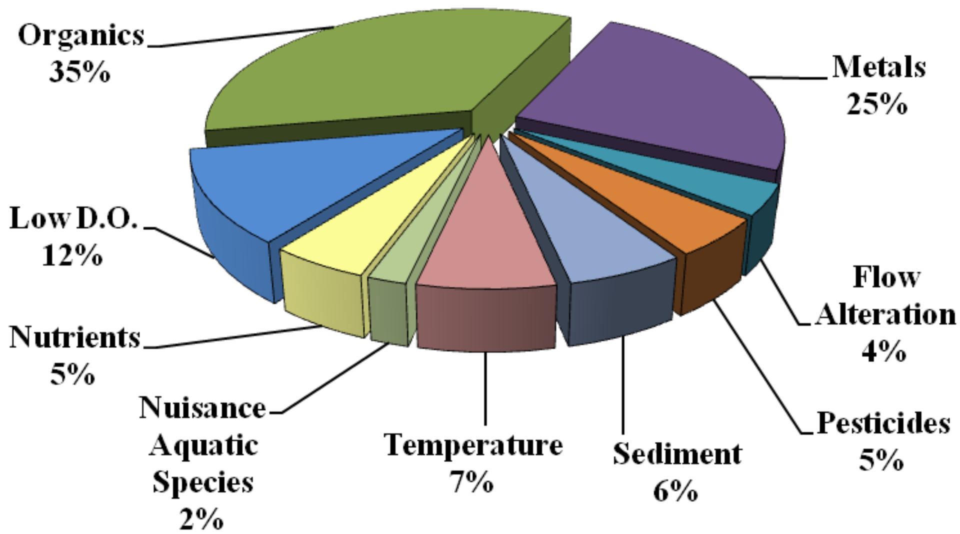


Figure 10: Relative Impacts of Pollution in Impaired Reservoir and Lake Acres (Pathogens were less than 1%)

1. Organic Substances

Priority organic substances such as PCBs and dioxins are the cause of pollution in over a third of the impaired lake acres. Reservoirs serve as sediment traps and once a pollutant gets into the sediment it is very difficult to remove. These materials move through the food chain and can become concentrated in fish tissue. People eating fish from the waterbody may also concentrate these toxic substances in their bodies, which can lead to health problems. Currently, 95,438 lake acres are posted for organic contamination. Chapter 5 has specific information on posted reservoirs and the health hazards associated with eating contaminated fish.

PCBs were extensively used in the U.S. for industrial and commercial uses until they were banned in 1976. Unfortunately, over 1.5 billion pounds of PCBs were produced before the ban. It is not known how many tons ended up in waterways in Tennessee. Elevated levels of PCBs have been found in fish tissue collected from the following reservoirs:

- Fort Loudoun Reservoir
- Boone Reservoir
- Tellico Reservoir
- Watts Bar Reservoir
- Nickajack Reservoir
- Melton Hill Reservoir
- Woods Reservoir

Types of Organic Contaminants

Organic Contaminant	Lake Acres Impaired
PCBs………….	95,438
Dioxins……….	10,370

Note: Lakes can be impaired by more than one organic substance. These totals are not additive.

2. Metals

As in rivers and streams, metals can pose a serious health threat in reservoirs and lakes. The concerns with metals contamination include the danger it poses to people who eat fish from contaminated reservoirs as well as toxicity to fish and aquatic life.

The reservoirs in Tennessee assessed as impaired by metals have been impacted by legacy activities, atmospheric deposition, or industrial discharges. The copper, iron, and zinc found in the Ocoee Reservoirs are from historical mining operations. Mercury in the Clinch River section of Watts Bar Reservoir is from legacy activities at the Department of Energy (DOE) Reservation. Additional reservoirs or embayments impacted by mercury include upper Fort Loudoun, upper Cherokee, Beech, Watauga, South Holston, Tellico, Norris, and the Hiwassee embayment of Chickamauga Reservoir.

Types of Metals

Metal	Lake Acres Impaired
Mercury………	67,562
Copper………..	2,254
Iron……………	2,254
Zinc…………...	2,254
Aluminum…….	455
Arsenic………..	455

Note: Reservoirs can be impaired by more than one metal. These totals are not additive.

3. Temperature

The most stringent criterion for temperature is for the protection of fish and aquatic life. This criterion states:

> *The maximum water temperature change shall not exceed 3C° relative to an upstream control point. The temperature of the water shall not exceed 30.5°C and the maximum rate of change shall not exceed 2C° per hour.*

Reservoir discharges, power plants, and even some types of municipal discharges can cause violations of temperature criteria, usually due to the creation of a temperature change downstream when compared to an upstream point. The rapid changing or "pulsing" of temperature can be a problem below impoundments.

Under Federal law, specifically Section 316(a) of the Clean Water Act, dischargers of heat can apply for an alternative water quality standard. Where granted, a 316(a) permit substitutes a federal requirement to maintain a Balanced and Indigenous Population (BIP) of fish and aquatic life in the place of state numeric temperature criteria.

In the summer of 2007, Barkley Reservoir data collected by the Corps of Engineers revealed temperature and dissolved oxygen problems that extended downstream from Tennessee well into Kentucky. The source of the heat was TVA's Cumberland Steam Plant located near Cumberland City, Tennessee, a problem made worse by the hot summer and the low volume of water being discharged from upstream impoundments such as Wolf Creek Reservoir in Kentucky.

An extensive review of biological data collected by TVA led TDEC to the conclusion that the federal BIP standard was not being maintained in the Tennessee portion of Barkley Reservoir. As a result of this determination, a portion of Barkley was added to the 2008 303(d) List and the lake was identified as being in need of a Total Maximum Thermal Loading study as specified by federal law.

Cumberland Fossil Plant is located northwest of Nashville on the shores of Barkley Reservoir on the Cumberland River. It produces more power than any other plant in the TVA system.

Photo provided by TVA.

4. Nutrients

Another major cause of impacts in reservoirs and lakes is nutrients. Over 15,600 lake acres have been assessed as impaired due to nutrients. When reservoirs and lakes have elevated levels of nutrients, large amounts of algae and other aquatic plants can grow. Plants and algae produce oxygen during daylight hours. As aquatic vegetation dies and decays, oxygen can be depleted and dissolved oxygen may drop below the levels needed for fish and other aquatic life.

As reservoirs and lakes age, they go through a process called eutrophication. When this occurs naturally, it is caused by a gradual accumulation of the effects of nutrients over many of years. Ultimately, eutrophication results in the filling of the lake from soil, silt, and organic matter from the watershed. Pollution from human activities can greatly accelerate this process. Eutrophication that would naturally occur over centuries can be accelerated to a few decades.

Tennessee's water quality criterion for nutrients in lakes and reservoirs is currently narrative. The exception is Pickwick Reservoir where a numeric chlorophyll *a* criterion has been adopted. The assessment basis to consider lakes impaired is the level of eutrophication that interferes with the intended uses of the lake. This process is complicated by the complex nature of the public's uses for lakes and reservoirs. For example, algae production can help some species of fish thrive, benefiting sport fishermen. However, swimmers and boaters prefer clear water.

Stages of Eutrophication:

1. **Oligotrophic** lakes are young lakes with relatively low levels of nutrients and high levels of dissolved oxygen. Since these lakes have low nutrient levels, they also have little algae and aquatic vegetation.

2. **Mesotrophic** lakes have moderate amounts of nutrients, but maintain a high level of dissolved oxygen. This results in more algae and aquatic vegetation that serve as a good food source for other aquatic life yielding a high biological diversity.

3. **Eutrophic** lakes have high levels of nutrients and therefore, high amounts of algae. Often, in the summer, an algae bloom will occur which can cause the dissolved oxygen levels to drop in the lake's lower layer.

4. **Hypereutrophic** lakes have extremely high nutrient levels. The algae at this stage are so thick it can cause the lake to look like pea soup. The dissolved oxygen in the lower layer of the lake may drop to the point where fish and other aquatic life cannot survive. Lakes that are hypereutrophic do not typically support the uses for which they are designated.

5. Sediment/Suspended Solids

Sediment and silt cause significant problems in reservoirs as well as flowing water. Over 18,000 lake acres have been assessed as impaired by sediment and silt. Since reservoirs and lakes serve as sediment traps, once sediment enters a lake it tends to settle out, initially in embayment and headwater areas, but ultimately throughout the reservoir. It is difficult and expensive to remove sediment from reservoirs. Three reservoirs, Ocoee #3, Ocoee #2, and Davy Crockett, have almost filled in with sediment caused by upstream disturbances. Reelfoot Lake has also been impaired by sediment.

6. Dissolved Oxygen

The dissolved oxygen (DO) minimum water quality standard for reservoirs and lakes is 5 mg/L measured at a depth of five feet unless the lake is less than ten feet deep. If the lake is less than ten feet deep, the DO criterion is applied at mid-depth. In eutrophic reservoirs, the DO can be much lower than 5 mg/L. Even in reservoirs that have a DO of 5 mg/L at the prescribed depth, the dissolved oxygen levels can be near zero at greater depths.

The most common reason lakes and reservoirs have fish kills due to low DO is eutrophication. Overproduction of algae raises oxygen levels in sunshine, but on cloudy days and at night the resulting algae die-off can cause DO levels to plummet. Additionally, high levels of biomass will restrict light penetration to a few feet or even inches. Below the depth where light can penetrate, DO levels will be very low.

Lakes that are eutrophic often strongly stratify, which means that there is a layer of warm, well-oxygenated water on top of a cold, poorly oxygenated layer. Stratification limits the dissolved oxygen available to fish and other aquatic life. Currently, almost 38,000 lake acres are listed as impaired by oxygen depletion.

DO levels in lakes and reservoirs can also be affected by discharges from upstream dams. Water released from the bottom of the reservoir may have very low dissolved oxygen levels. Low dissolved oxygen in Barkley Reservoir in 2007 was caused by the discharge of heat from TVA’s Cumberland Steam Plant, combined with low flows due to drought and repairs to upstream reservoirs.

7. Pesticides

Pesticides, if used improperly, can cause harm to humans, animals, and the environment. Many pesticides have been banned in the U.S. but pollution that occurred decades ago still poses a serious threat, because they tend to remain in the environment for an extremely long time. In some waterbodies, these substances have accumulated in sediment and pose a health threat to those that consume fish or shellfish. Nearly 14,000 acres are impaired by chlordane.

Table 8: Causes Of Impairment in Assessed Rivers and Reservoirs*

Cause Category	Impaired Rivers and Stream Miles	Impaired Reservoir/Lake Acres
Flow Alteration		
Low Flow Alterations	453	11,444**
Nuisance Aquatic Species		
Native Aquatic Plants		4,550**
Nutrients		
Nutrient/Eutrophication Biological Indicators	306	15,636**
Phosphate/Total Phosphorus	1,774	
Nitrate/Nitrite	1,440	
Ammonia (un-ionized)	54	
Oxygen Depletion		
Oxygen, Dissolved	1,824	37,979
pH/Acidity/Caustic Conditions		
pH	410	
Sediment		
Sediment/Silt	5,944	18,175**
Solids (Suspended/Bedload)	14	
Pesticides		
Chlordane	256	13,873
Metals		
Manganese	191	
Lead	91	
Copper	46	2,254
Iron	240	2,254
Mercury	263	67,562
Zinc	47	2,254
Arsenic	84	455
Aluminum	34	455
Chromium, Hexavalent	4	
Pathogens		
Escherichia coli	6,700	2,044
Radiation		
Cesium	5	
Strontium	7	

(Table continued on next page)

Table 8: Causes Of Impairment in Assessed Rivers and Reservoirs (continued)

Toxic Organics		
Dioxins	256	10,370
Polychlorinated Biphenyls (PCBs)	300	95,438
Creosote	7	
Polycyclic Aromatic Hydrocarbons (PAHs)	26	
Toluene	0.5	
RDX	63	
Other		
Odor	7	
Taste & Odor		45
Total Dissolved Solids	1	
Impairment Unknown	108	
Habitat Alterations		
Alteration in Stream-side or Littoral Vegetative Cover	2,003	
Other Anthropogenic Substrate Alterations	512	
Physical Substrate Habitat Alterations	4,173	
Toxic Inorganics		
Chloride	22	
Chlorine	3	
Sulfates	31	
Hydrogen Sulfide	7	
Observed Effects		
Color	5	
Oil and Grease		
Oil and Grease	18	
Thermal		
Temperature, Water	130	20,459
Bioassays		
Whole Effluent Toxicity (WET)	4	

*Note - Rivers and reservoirs can be impaired by more than one cause. Rivers include both river and stream miles. Data in this table should only be used to indicate relative contributions. Totals are not additive.
** The majority of impaired lake acres in these categories are in Reelfoot Lake.

Chapter 4
Sources of Water Pollution

Sources of pollutants in streams and rivers include agricultural activities, hydrologic modification (channelization, dams, and navigation dredging), municipal discharges, construction, industrial discharges, and mining activities. The major source of impairment to reservoirs is contaminated sediment from legacy pollutants. Table 9 provides a detailed breakdown of the various sources of pollution in Tennessee's streams, rivers, lakes, and reservoirs.

A. Relative Sources of Impacts to Rivers and Streams

Some impacts, like point source discharges and urban runoff, are evenly distributed across the state, while others are concentrated in particular areas. For instance, channelization and crop related agriculture is most widespread in west Tennessee. Dairy farming and other intensive livestock operations are concentrated in the Ridge and Valley region of east Tennessee and in southern middle Tennessee. An emerging threat in middle Tennessee is rapid commercial and residential development around Nashville and other urban areas. Mining continues to impair streams in the Cumberland Plateau and Central Appalachian regions. Figure 11 illustrates the percent contribution of pollution sources in impaired rivers and streams.

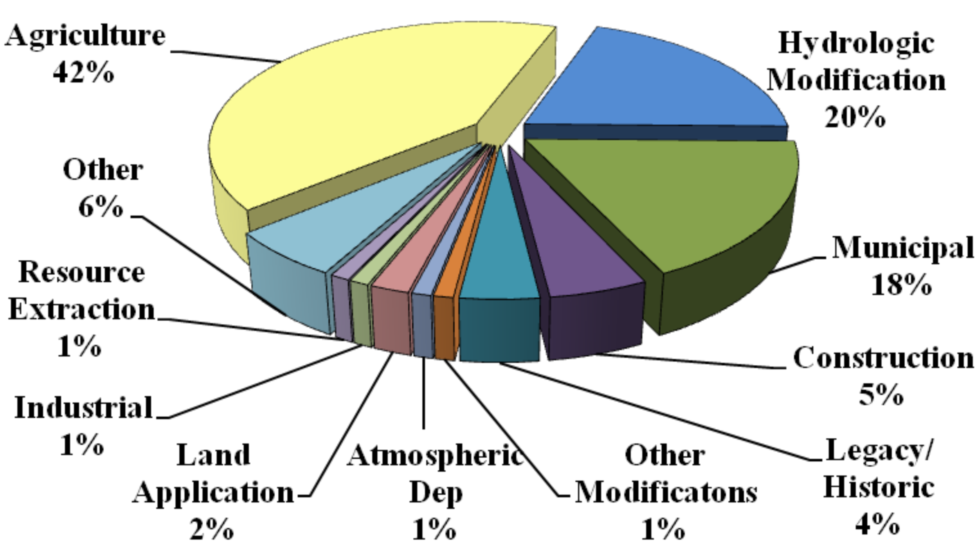


Figure 11: Percent Contribution of Pollution Sources in Impaired Rivers and Streams

Table 9: Sources of Pollutants in Assessed Rivers and Reservoirs*

Sources Category	Total Impaired River Miles	Total Impaired Reservoir/Lake Acres
Industrial Permitted Discharge		
RCRA Hazardous Waste Sites	120	
Industrial Point Source	89	7,791
Stormwater Discharge	30	
Petroleum/Natural Gas	1	
Industrial Thermal Discharges		20,459
Municipal Permitted Dischargers		
Separate Storm Sewer (MS4)	2,304	994
Package Plants	38	
Combined Sewer Overflows	10	994
Sanitary Sewer Overflows	600	
Urbanized (High Density Area)	390	45
Municipal Point Source	584	
Spills and Unpermitted Discharges		
Above Ground Storage Tank Leaks	0.5	
Other Spill Related Impacts	8.4	455
Agriculture		
Specialty Crop Production	44	
CAFOs	30	
Unrestricted Cattle Access	310	
Dairies (Outside Milk Parlor Areas)	12	
Irrigated Crop Production	29	
Grazing in Riparian or Shoreline Zones	5,281	481
Animal Feeding Operations (NPS)	269	34
Livestock (grazing or feeding)	7	
Aquaculture (permitted)	4	
Non-irrigated Crop Production	2,701	15,587**
Manure Run-off	1	
Resource Extraction		
Surface Mining	6	
Subsurface/Hardrock	9	
Sand/Gravel/Rock	80	
Dredge Mining	50	
Coal Mining Discharge (permitted)	59	
Hydrologic Modification		
Channelization	3,424	
Dredging (Navigation Channel)	207	
Upstream Impoundment	592	2,469
Flow Regulation/Modification	15	

(Table continued on next page.)

Table 9: Sources of Pollutants in Assessed Rivers and Reservoirs (continued)

Sources Category	Total Impaired River Miles	Total Impaired Reservoir/Lake Acres
Legacy/Historical		
Contaminated Sediment	344	97,692
CERCLA NPL (Superfund)	31	
Abandoned Mine Lands (Inactive)	450	2,254
Internal Nutrient Cycling		15,500**
Mill Tailings	32	2,254
Mine Tailings	35	2,254
Silviculture		
Forest Roads (construction and use)	2	
Harvesting	87	
Land Application/Waste Sites		
On-site treatment systems (septic systems and similar)	319	4
Land Application of Wastewater Biosolids (Non-agricultural)	9	
Landfills	50	
Leaking Underground Storage Tanks	9	
Construction		
Site Clearance	1,013	10,950**
Hwys. /Roads/Bridges, Infrastructure (new)	67	
Other Modifications (Not directly related to hydromodification)		
Stream Bank Modification/ Destabilization	75	
Loss of Riparian Habitat	13	
Drainage/Filling/Wetland Loss		10,950**
Channel Erosion/Incision from Upstream Modification	25	
Golf Courses	0.3	
Atmospheric Deposition		
Atmospheric Deposition of Acids	12	
Atmospheric Deposition-Toxics	217	67,421
Other Sources		
Sources Outside State Jurisdiction or Borders	251	4,223
Military Base (NPS)	35	
Sources Unknown	1,009	1,050
Off Road Vehicles	53	
Hwy/Road/Bridge (runoff)	25	

*Rivers and reservoirs can be impaired by more than one source of pollutants. Data in this table should only be used to indicate relative contributions. Totals are not additive.
** Majority of impairment sources in these categories are in Reelfoot Lake.

1. Agriculture

Almost half of the land in Tennessee is used for agriculture. These activities contribute approximately 41 percent of the impaired stream miles in the state. Statewide, the largest single source of impacts is grazing of livestock, followed by crop production. In west Tennessee, tons of soil are lost annually due to erosion from crop production (mostly cotton and soybean). In middle Tennessee, cattle grazing and hog farms are the major agricultural activity and result in bank erosion, plus elevated bacteria and nutrient levels. In east Tennessee, runoff from feedlots and dairy farms greatly impact some waterbodies. Figure 12 illustrates the relative contributions of the primary agricultural sources.

Sources of Agricultural Impairment

Agricultural Source	**Stream Miles Impaired**
Grazing in Riparian Zone……...	5,590
Non-irrigated Crop Production..	2,701
Animal Feeding Operations…...	269
CAFOs………………………...	30
Specialty Crop Production…….	44
Dairies (Outside Milk Parlor Areas)………………………….	12
Irrigated Crop Production……..	29
Manure Run-off……………….	1
Livestock (grazing or feeding)...	7
Aquaculture (permitted)……….	4

Note: Pollutants in streams can come from more than one source. These totals are not additive.

The Tennessee Water Quality Control Act does not give the division authority to regulate water runoff originating from normal agricultural activities such as plowing fields, tending animals and crops, and cutting trees. However, agricultural activities that may result in significant point source of pollution, such as animal waste system discharges from concentrated livestock operations, are regulated.

Tennessee has made great strides in recent years to prevent agricultural and forestry impacts. Educational and cost-sharing projects promoted by the Department of Agriculture, Natural Resource Conservation Service (NRCS) and University of Tennessee Agricultural Extension Service have helped farmers install Best Management Practices (BMP's) all over the state. Farmers have voluntarily helped to decrease erosion rates and protect streams and rivers by increasing riparian habitat zones and setting aside conservation reserves.

The division has a memorandum of understanding with the Tennessee Department of Agriculture (TDA). Under this agreement, the division and TDA will continue to jointly resolve complaints about water pollution from agricultural activities. When a problem is found or a complaint has been filed, TDA has the lead responsibility to contact the farmer or logger. Technical assistance is offered to correct the problem. TDEC and TDA coordinate on water quality monitoring, assessment, 303(d) list development, TMDL generation, and control strategy implementation.

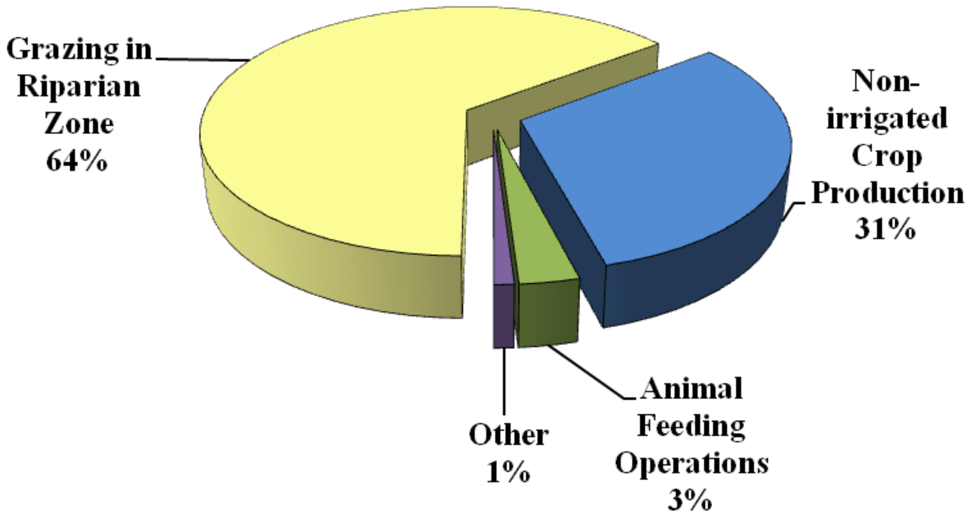


Figure 12: Sources of Agricultural Pollution in Impaired Rivers and Streams

2. Hydrologic Modification

Altering the physical and hydrological properties of streams and rivers is the source of impairment in nearly 20 percent of the impaired streams in Tennessee. Modifications include channelization (straightening streams), impoundments (construction of a reservoir), dredging for navigation, and flow regulation or modification. Figure 13 illustrates the types of modifications most frequently impairing streams and rivers.

Sources of Hydrologic Impairment

Sources of Hydrologic Modification	Stream Miles Impaired
Channelization…………………	3,424
Upstream Impoundment………..	592
Dredging (Navigation Channel)..	207
Flow Regulation/Modification…	15

Note: Pollutants in streams can come from more than one source. These totals are not additive.

Physical alteration of waterbodies can only be done as authorized by the state. Permits to alter streams or rivers called Aquatic Resource Alteration Permits (ARAPs) are issued by TDEC's Natural Resources Section. A 401 certification of a federal 404 permit is also considered an ARAP permit. Failure to obtain a permit before modifying a stream or river can lead to impairment and enforcement actions.

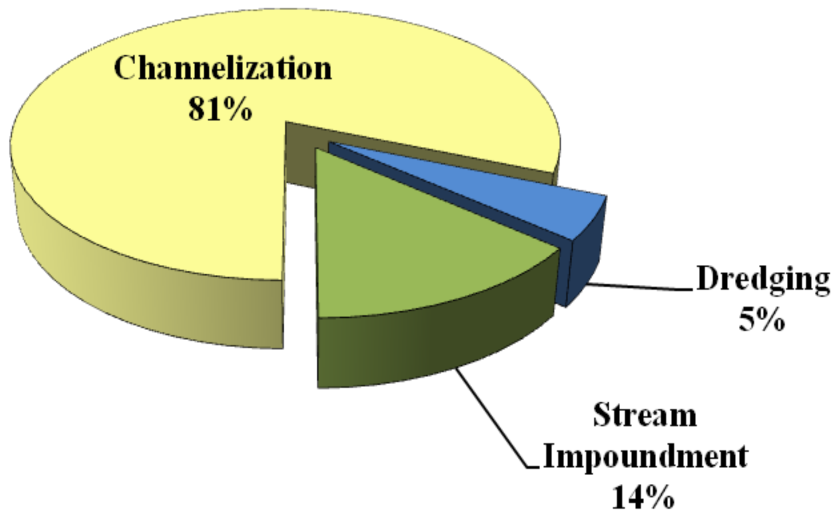


Figure 13: Sources of Hydrologic Impairment in Rivers and Streams. (Flow regulation and modification represent less than one percent of the impairments.)

a. Channelization

Channelization is the source of impairment for 81 percent of the streams and rivers assessed as impacted by habitat alteration. Originally, channelization was implemented to control flooding and protect croplands along rivers. In West Tennessee, channelization was used extensively to drain wetlands to create cropland. Throughout Tennessee, streams continue to be impaired by channelization and bank destabilization from vegetation removal.

Costs associated with channelization or decreasing stream and river meanders include:

- Increased erosion rates and soil loss.
- Elimination of valuable fish and wildlife habitat by draining wetlands and clearing riparian areas.
- Destruction of bottomland hardwood forests.
- Magnification of flooding problems downstream.
- "Down-cutting" of streambeds as the channel tries to regain stability.

In recent years, no large-scale channelization projects have been approved. Tennessee is working with the Corps of Engineers to explore methods to reverse some of the historical damage to water quality caused by channelization.

Some streams and rivers continue to be channelized by landowners. However, stream alteration without proper authorization is a violation of the Water Quality Control Act subject to enforcement.

Channelization can increase bank erosion and removes in-stream habitat such as fallen trees and snags. *Photo provided by Jackson EFO.*

b. Stream and River Impoundment

Problems associated with the impoundment of streams and rivers are increasing as more free flowing streams are dammed. It has been the experience of the division that very few of these impoundments can be managed in such a way as to avoid water quality problems.

Problems often associated with stream and river impoundment include:

- Erosion during dam construction.
- Loss of stream or river for certain kinds of recreational use.
- Changes in the water flow downstream of the dam.
- Elevated metals downstream of the dam.
- Low dissolved oxygen levels in tailwaters, which decrease biological diversity downstream and threaten aquatic life, including endangered species.
- Habitat change resulting in loss of aquatic organisms.
- Barriers to fish migration.

c. Dredging

Photo provided by Jimmy Smith, NEFO

Dredging or removing substrate from a stream or river is done to deepen river channels for navigation or to mine sand or gravel for construction. Dredging can cause habitat disruption, substrate alteration, sedimentation, and erosion. Unfortunately, dredging is sometimes done without the proper permit.

3. Municipal Discharges

a. Municipal Stormwater Discharges

As stormwater drains through urban areas, it picks up pollutants from yards, streets, and parking lots and deposits them into nearby waterways. The runoff can be laden with silt, bacteria, metals, and nutrients. Following heavy rains, streams can contain various pollutants at elevated levels for several days. Water quality standards violations have been documented in Tennessee's four largest cities: Memphis, Nashville, Chattanooga, and Knoxville, plus many other smaller towns.

The federal National Pollutant Discharge Elimination System (NPDES) program regulates stormwater runoff. Industries and large commercial operations must operate under the state's general NPDES permit for industrial stormwater discharge. This permit requires site-specific stormwater pollution prevention plans and mandatory installation of pollution control measures.

Under Tennessee Municipal Separate Storm Sewer Systems (MS4) permits, cities must develop stormwater programs and regulate sources at a local level. In addition to Tennessee's four MS4 Phase I cities (Memphis, Nashville, Chattanooga, and Knoxville) that are covered under individual NPDES permits, 78 other cities and counties are now covered by the MS4 Phase II general permits. There are six Phase II MS4 program elements that result in reductions of pollutants from stormwater discharged into receiving waterbodies. The elements include public education and outreach, along with public participation and involvement. Further, a plan must be implemented to detect and eliminate illicit discharges to the storm sewer system. Municipalities must prevent pollution through stormwater runoff.

Construction sites must obtain coverage under the state's general NPDES permit for construction stormwater runoff if clearing, grading or excavating is planned on any site larger than one acre or any disturbance of less than one acre if it is part of a larger common plan of development or sale. They are required to control erosion and runoff as well as address post-construction stormwater runoff.

b. Combined Sewer Overflows

In Tennessee, only three cities (Nashville, Chattanooga, and Clarksville) have combined sewers (sanitary waste and storm water carried in the same sewer). Permits require that when these sewers overflow during large storm events, monitoring must be conducted. Several water contact advisories are due to combined sewer overflows.

c. Municipal Point Source Discharges

Impairment due to point source discharge from municipal wastewater treatment plants continues to decline. Municipal sewage treatment plants have permits designed to prevent impacts to the receiving waterbody. On rare occasions, sewage treatment systems fail to meet permit requirements. Sometimes, a waterbody downstream of a facility is found to not meet biological criteria and the upstream facility is listed as a potential source of the pollutant of concern, even if permit limits are being met. In those cases, permit requirements must be adjusted along with other watershed improvements to address water quality concerns.

d. Sanitary Sewer Overflows

Collection systems convey raw sewage to treatment plants through a series of pipes and pump stations. Unfortunately, these systems occasionally malfunction or become overloaded, which can result in the discharge of high volumes of untreated sewage to a stream or river. A serious concern near urban areas is children being exposed to elevated bacteria levels while playing in streams and rivers after heavy rains.

Sanitary sewer collection systems are monitored by municipalities to insure that they are not leaking. NPDES permits contain provisions that prohibit overflows and require that any overflows be reported to TDEC. Enforcement action must be taken against cities that fail to report and correct sewage system problems.

4. Construction

The population of many Tennessee communities has rapidly expanded in the last decade. The construction of subdivisions, shopping malls, and highways can harm water quality if the sites are not properly stabilized. The impacts most frequently associated with land development are silt and habitat alteration. Construction sites must obtain coverage under the state's general NPDES permit for construction stormwater runoff if clearing, grading or excavating is planned on any site larger than one acre or any disturbance of less than one acre if it is part of a larger common plan of development or sale.

In addition, local stormwater control programs and regulations have been helpful in controlling water quality impacts from land development. MS4 Phase I cities (Memphis, Nashville, Chattanooga, and Knoxville) already have construction stormwater control programs in effect. The 78 cities and counties covered under the Phase II MS4 general permit have developed construction stormwater control programs. In these cities, local staff help identify sources of stormwater runoff and develop control strategies.

5. Legacy/Historical

a. Impacts from Abandoned Mining

In the 1970's, coal mining was one of the largest pollution sources in the state. "Wildcat" operators strip-mined land without permits or regard for environmental consequences to provide low-priced coal to the growing electric industry. When the miners had removed all the readily available coal, they would abandon the site. In 1983, the price for coal fell so low it was no longer profitable to run "wildcat" mining operations, so most illegal mining operations stopped.

Although many streams and rivers are still impaired by runoff from abandoned mines, which contain pollutants such as silt, pH, manganese, and iron, significant progress has been made in site reclamation. Some abandoned strip mines are being reclaimed under the Abandoned Mine Reclamation program and others are naturally revegetating. New mining sites are required to provide treatment for runoff.

b. Contaminated Sediments

Photo provided by Pat Alicea, TDH

The main problem with toxic contaminants in sediment is they can become concentrated in the food chain. In most places in Tennessee, it is safe to eat the fish. However, in some waterbodies, organic pollutants (primarily PCBs, dioxins, chlordane and other pesticides in the sediment) and mercury are bioconcentrated through the food chain in the fish. See Chapter 5 for a list of streams, rivers, and reservoirs posted due to fish tissue contamination.

Fish tissue samples are collected and analyzed from waterbodies across the state. Results are compared to criteria developed by the Food and Drug Administration (FDA) and EPA. If fish tissue is contaminated and the public's ability to safely consume fish is impaired, the waterbody is posted with signs and assessed as not supporting recreational uses. The advisories are also listed on the TDEC website and included in sport fishing regulations. The Tennessee Valley Authority (TVA) and the Tennessee Wildlife Resources Agency (TWRA) share resources and expertise in this process.

Many substances found in fish tissue today, like DDT, PCBs, and chlordane, were widely distributed in the environment before they were banned. The levels of these substances will slowly decrease over time. Currently companies with permits to discharge organic substances have very restrictive limits.

6. Industrial Discharges

Although the number of waters impaired by industrial pollution is lower than it was a few decades ago, industrial facilities impact some streams and rivers in Tennessee. Streams impaired by industrial discharges include East Fork Poplar Creek, Pigeon River, North Fork Holston River, and Russell Branch. See the current 303(d) list of impaired waters for all waterbodies assessed as impacted by industrial discharges.

Industrial impacts include sporadic spills, temperature alterations, and historical discharge of substances that can concentrate in the food chain. Occasionally, industrial dischargers fail to meet permit requirements. Industries and large commercial operations such as junkyards are required to operate under the state's general NPDES permit for industrial stormwater discharge. This permit requires the development of site-specific stormwater pollution prevention plans and mandatory installation of pollution control measures.

Field staff collect samples to determine if chemical parameters are elevated below industrial discharges.

Photo provided by Jason Mann, KEFO

7. Land Application/Waste Sites

Solid waste and septic systems contribute to water quality problems in various ways. Solid waste in landfills can leach into groundwater and surface water if not prevented. Wastewater in failing septic tanks can leak into the ground causing water contamination. Treated wastewater and sludge are applied to land as fertilizers and can be washed into streams causing nutrient loading. Another concern is the use and maintenance of underground storage tanks that can contain substances like petroleum products, solvents, and other hazardous chemicals and wastes. These can leak into the groundwater and may reach the surface water.

B. Distribution of Sources of Impacts to Reservoirs

Like streams and rivers, reservoirs are impaired by many sources of pollution. However, the dominant pollutant impacting reservoirs is sediment contaminated by legacy toxic organic substances. Other significant sources are atmospheric deposition of mercury, industry, agricultural activities, hydrologic modification, and construction (Figure 14).

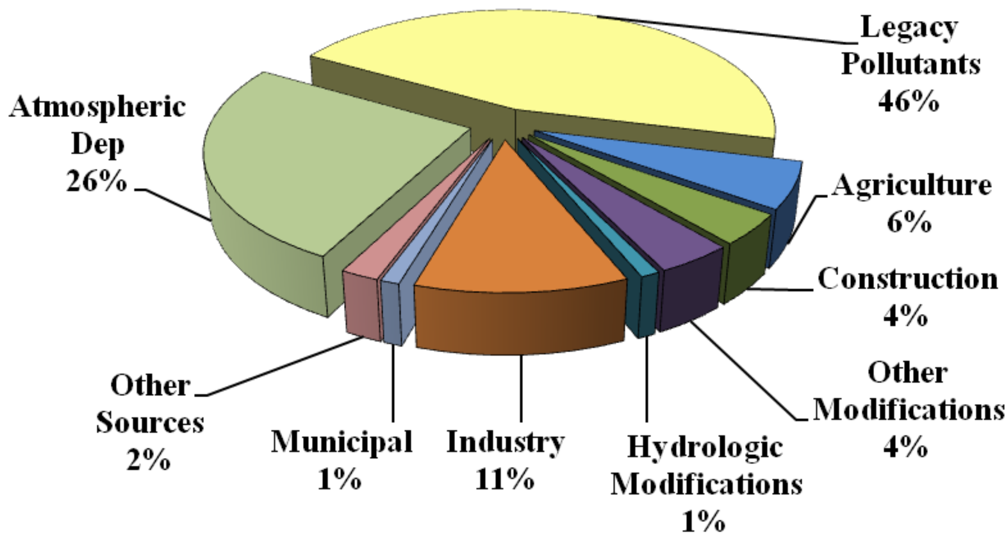


Figure 14: Percent Contribution of Pollution Sources in Impaired Reservoirs and Lakes

1. Legacy Pollutants

Legacy or historical pollutants are the number one source of contamination in reservoirs and lakes. These are pollutants that were introduced into the waterbodies prior to the enactment of water quality regulations or before EPA banned their use. Legacy pollutants include contaminated sediments, superfund sites, and abandoned mine lands (Figure 15).

a. Contaminated Sediments

The biggest problem with legacy pollutants is contaminated sediments. Two organic substances banned in the 1970's, chlordane and PCBs, are responsible for most of the continuing problem of sediment contamination today. These substances bind with the sediment and remain in the environment for a long time. Once in the sediment, they become part of the aquatic food chain. Bioaccumulation in fish tissue has resulted in consumption advisories in several reservoirs (Chapter 5). The levels of these substances will slowly decrease over time.

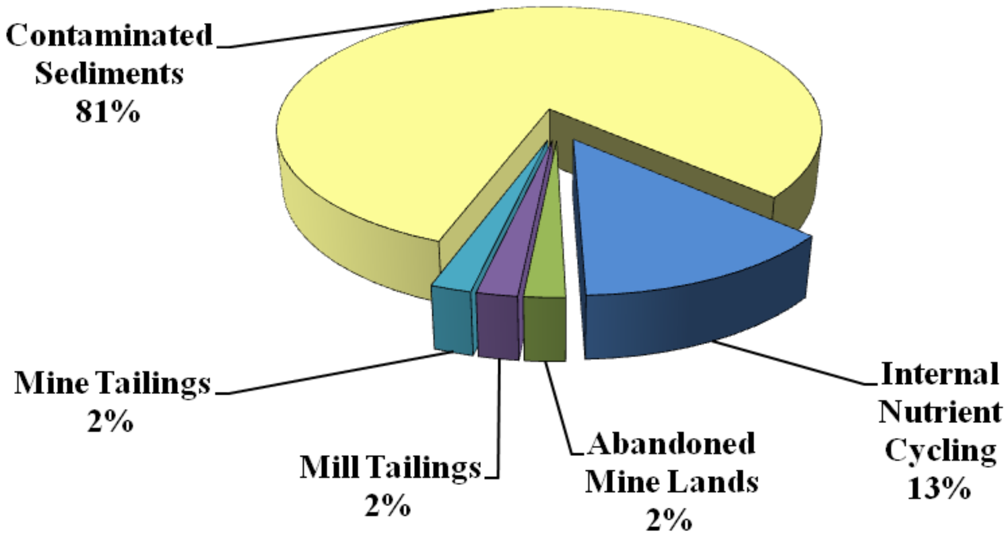


Figure 15: Sources of Legacy Pollutants in Reservoirs and Lakes

b. Internal Nutrient Cycling

Internal nutrient cycling is the release and recapture of nutrients from the sediment of a lake or reservoir, which functions to accelerate eutrophication. Reelfoot Lake in west Tennessee accounts for all the lake acres assessed as impaired by nutrient cycling. This lake is in an advanced state of eutrophication due to sediment and nutrients.

Eutrophication is a natural process that will occur in any lake. It becomes pollution when it is accelerated by human activities, interferes with the desired uses of the lake, or causes water quality standards to be violated in the reservoir or receiving stream. For additional information on eutrophication, see Chapter 3.

c. Abandoned Mines/Mine Tailings/Mill Tailings

The Copper Basin in the tri-state area of Tennessee, Georgia, and North Carolina was extensively mined beginning in 1843. Before 1900, this was the largest metal mining area in the southeast. The last mine closed in 1987. Runoff from disturbed areas has contaminated three downstream reservoirs on the Ocoee River. Much of the area has been reforested. Due to CERCLA activities, water quality in North Potato Creek and Burra-Burra Creek has improved. Although much work remains to be done before water quality goals are met, the transport of pollutants to the Ocoee River appears to have diminished.

2. Agriculture

Similar to streams and rivers, reservoirs can be greatly impacted by agricultural activities. Plowing and fertilizing croplands can result in the runoff of tons of soil and nutrients annually. Over 16,000 lake acres in Tennessee are listed as impaired by farming activities. Most of these acres are represented by Reelfoot Lake, which is listed as impaired due to erosion from agricultural activities. Sources of agricultural impacts include non-irrigated crop production and livestock grazing.

3. Other Modifications

Loss of wetlands in Reelfoot Lake accounts for the majority of lake/reservoir acres impaired due to habitat modification. A small percentage of habitat impairment is due to hydrostructure flow modification and upstream impoundments.

4. Construction

Almost 100 percent of the lake acres assessed as impaired by construction are land development around Reelfoot Lake. Clearing land for development results in increased sedimentation, nutrient runoff, drainage, filling, and loss of wetlands.

5. Industrial and Municipal

Impairment to lakes and reservoirs from municipal sources includes discharges from separate storm sewer systems, collection system failures, and combined sewer overflows. Industrial sources include point source discharges, such as mercury to the Hiwassee and North Fork Holston River, plus heat in Barkley Reservoir.

6. Atmospheric Deposition

Atmospheric deposition occurs when air pollutants are deposited to land or water. Primary anthropogenic sources of pollutants include burning fossil fuels, agricultural activities, and emissions from industrial operations.

Tennessee currently has over 67,000 lake acres impaired by atmospheric deposition of mercury, most found in east Tennessee. The effects of mercury pollution are discussed in detail in Chapter 5. In 2009, the division began a probabilistic study of fish tissue to test a model that may predict mercury air deposition (Chapter 7).

Chapter 5
Posted Streams, Rivers, and Reservoirs

When streams or reservoirs are found to have significantly elevated bacteria levels or when fish tissue contaminant levels exceed risk-based criteria, it is the responsibility of the Department of Environment and Conservation to post warning signs so that people will be aware of the threat to public health. In Tennessee, the most common reasons for a river or reservoir to be posted are the presence of high levels of bacteria in the water or PCBs, chlordane, dioxins, or mercury in fish tissue. Currently 62 streams, rivers, and reservoirs in Tennessee have been posted due to a public health threat. A current list of advisories is posted on the department's home page at http://tn.gov/environment/wpc/publications/pdf/advisories.pdf.

> *The Commissioner shall have the power, duty, and responsibility to…post or cause to be posted such signs as required to give notice to the public of the potential or actual dangers of specific uses of such waters.*
> Tennessee Water Quality Control Act

Consistent with EPA guidance, any stream or reservoir in Tennessee with an advisory is assessed as not meeting the recreational designated use and therefore, included in the biennial 303(d) list of impaired waters. Clearly, if the fish cannot be safely eaten, the waterbody is not fully supporting its goal to be fishable. Likewise, streams, rivers, and reservoirs with high levels of bacteria are not suitable for recreational activities such as swimming or wading.

A. Bacteriological Contamination

About 176 river miles are posted due to bacterial contamination (Table 10). No reservoirs or lakes are posted due to bacterial contamination. (Some stream miles are posted for more than one source of pollution. Totals are not additive.) The presence of pathogens, disease-causing organisms, affects the public's ability to safely swim, wade, and fish in streams, rivers and reservoirs. Bacteria, viruses, and protozoa are the primary water-borne pathogens in Tennessee. Improperly treated human wastes from such sources as septic tanks, collection system failure and improper connection to sewer or sewage treatment plants contaminate 62 percent of the posted river miles (Figure 16). The remaining stream miles are posted due to other sources such as failing animal waste systems or urban runoff (Figure 17).

The division's current water quality criterion for bacteria is based on levels of *E. coli*. While this test is not considered direct proof of human health threats, it can indicate the presence of water-borne diseases. Research is underway to find better indicators of risk and to differentiate between human and animal sources of bacteria. The presence of prescription medicines, caffeine, and hormones in water has been suggested as potential markers for contamination by human waste.

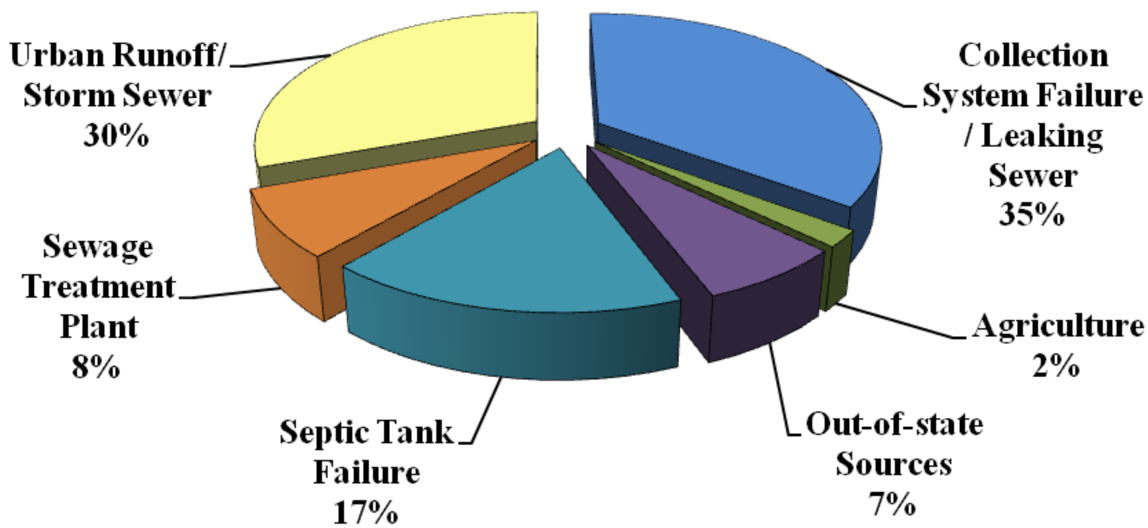


Figure 16: Percent Contribution of Stream Miles Posted for Pathogen Contamination

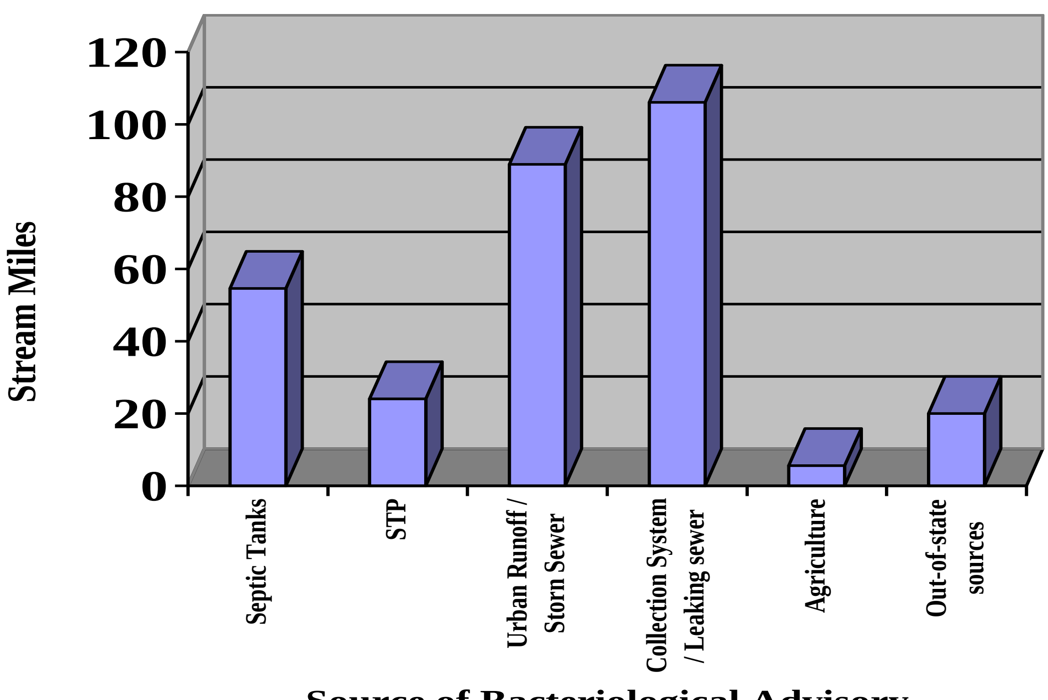


Figure 17: Stream Miles Contaminated by Various Pathogen Sources. (The same stream may be impaired by more than one source of pollution. Totals are not additive.)

Table 10: Bacteriological Advisories in Tennessee

(September 2010. This list is subject to revision.)

For additional information:
http://www.tn.gov/environment/wpc/publications/pdf/advisories.pdf.

East Tennessee

Waterbody	Portion	County	Comments
Beaver Creek (Bristol)	TN/VA line to Boone Lake (20.0 miles)	Sullivan	Nonpoint sources in Bristol and Virginia
Cash Hollow Creek	Mile 0.0 to 1.4	Washington	Septic tank failures.
Coal Creek	STP to Clinch R. (4.7 miles)	Anderson	Lake City STP.
East Fork Poplar Creek	Mouth to Mile 15.0	Roane	Oak Ridge area.
First Creek	Mile 0.2 to 1.5	Knox	Knoxville urban runoff.
Goose Creek	Entire Stream (4.0 miles)	Knox	Knoxville urban runoff.
Leadvale Creek	Douglas Lake to headwaters (1.5 miles)	Jefferson	White Pine STP.
Little Pigeon River	Mile 0.0 to 4.6	Sevier	Improper connections to storm sewers, leaking sewers, and failing septic tanks.
Pine Creek	Mile 0.0 to 10.1	Scott	Oneida STP and collection system.
Litton Fork of Pine Creek	Mile 0.0 to 1.0		
South Fork of Pine Creek	Mile 0.0 to 0.7		
East Fork of Pine Creek	Mile 0.0 to 0.8		
North Fork of Pine Creek	Mile 0.0 to 2.0		
Second Creek	Mile 0.0 to 4.0	Knox	Knoxville urban runoff.
Sinking Creek	Mile 0.0 to 2.8	Washington	Agriculture & urban runoff.
Third Creek	Mile 0.0 to 1.4, Mile 3.3	Knox	Knoxville urban runoff.
East Fork of Third Creek	Mile 0.0 to 0.8	Knox	Knoxville urban runoff.

(Table continued on the next page)

Table 10: Bacteriological Advisories in Tennessee
(Continued from previous page)

East Tennessee (continued)

Waterbody	Portion	County	Comments
Johns Creek	Downstream portion (5.0 miles)	Cocke	Failing septic tanks.
Baker Creek	Entire stream (4.4 miles)	Cocke	Failing septic tanks.
Turkey Creek	Mile 0.0 to 5.3	Hamblen	Morristown collection system.
West Prong of Little Pigeon River	Mile 0.0 to 17.3	Sevier	Improper connections to storm sewers, leaking sewers, and failing septic tanks.
Beech Branch	Entire stream (1.0 mile)		
King Branch	Entire stream (2.5 miles)		
Gnatty Branch	Entire stream (1.8 miles)		
Holy Branch	Entire stream (1.0 mile)		
Baskins Branch	Entire stream (1.3 miles)		
Roaring Creek	Entire stream (1.5 miles)		
Dudley Creek	Entire stream (5.7 miles)		

Southeast Tennessee

Waterbody	Portion	County	Comments
Chattanooga Creek	Mouth to GA line (7.7 mi.)	Hamilton	Chattanooga collection system.
Little Fiery Gizzard	Upstream natural area to Grundy Lake (3.7 miles).	Grundy	Failing septic tanks in Tracy City.
Clouse Hill Creek	Entire Stream (1.9 miles)		
Hedden Branch	Entire Stream (1.5 miles)		
Oostanaula Creek	Mile 28.4 -31.2 (2.8 miles)	McMinn	Athens STP and upstream dairies.
Stringers Branch	Mile 0.0 to 5.4	Hamilton	Red Bank collection system.
Citico Creek	Mouth to headwaters (7.3 miles)	Hamilton	Chattanooga urban runoff and collection system.

(Table continued on the next page)

Table 10: Bacteriological Advisories in Tennessee
(Continued from previous page)

Middle Tennessee

Waterbody	Portion	County	Comments
Duck River	Old Stone Fort State Park (0.2 mile)	Coffee	Manchester collection system.
Little Duck River	Old Stone Fort State Park (0.2 mile)		
Mine Lick Creek	Mile 15.3 to 15.8 (0.5 mile)	Putnam	Baxter STP.
Nashville Area		Davidson	Metro Nashville collection system overflows and urban runoff.
Brown's Creek	Main Stem (4.3 miles)		
Dry Creek	Mile 0.0 to 0.1		
Gibson Creek	Mile 0.0 to 0.2		
McCrory Creek	Mile 0.0 to 0.2		
Tributary to McCrory Creek	Mile 0.0 to 0.1		
Richland Creek	Mile 0.0 to 2.2		
Whites Creek	Mile 0.0 to 2.1		
Cumberland River	Bordeaux Bridge (Mile 185.7) to Woodland Street Bridge (Mile 190.6)		

West Tennessee

Waterbody	Portion	County	Comments
Cypress Creek	Entire Stream (7.7 miles)	Shelby	Urban stormwater runoff.

B. Fish Tissue Contamination

Approximately 124,000 reservoir acres and 295 river miles are currently posted due to contaminated fish (Table 11). The contaminants most frequently found at elevated levels in fish tissue are PCBs, mercury, and chlordane (Figure 18 and 19).

The list of waterbodies with advisories is on the TDEC website and in TWRA fishing regulations given to sports fisherman when they purchase a fishing license. Caution signs are also mounted at public access points to posted waterbodies. There are two types of consumption advisories. The no consumption advisory targets the general population and warns that no one should eat specific fish from this body of water. The precautionary advisory specifies that children, pregnant women, and nursing mothers should not consume the fish species named, while all other people should limit consumption to one meal per month. If needed, TWRA can enforce a fishing ban.

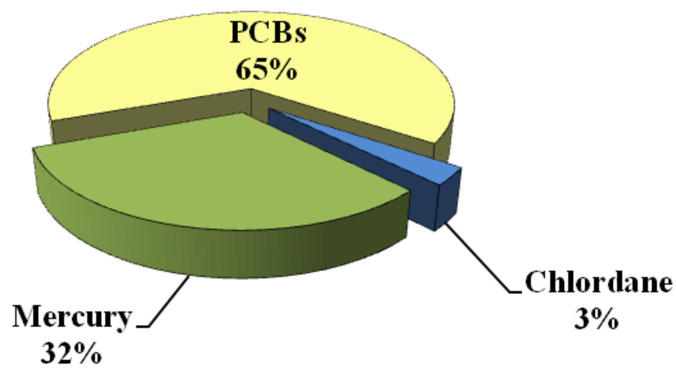


Figure 18: Percent Contribution of Reservoir Acres Posted for Fish Tissue Contamination

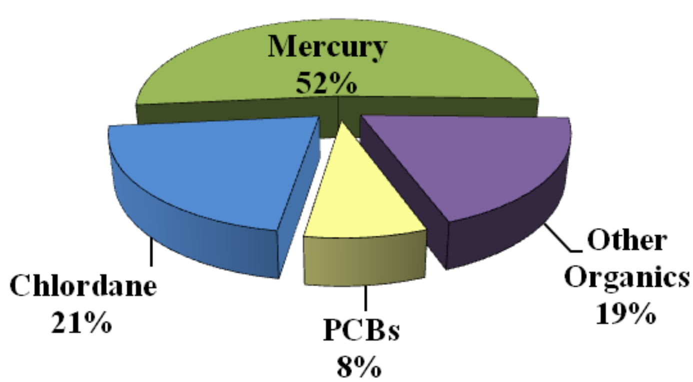


Figure 19: Percent Contribution of Stream Miles Posted for Fish Tissue Contamination

Organic contaminants

The majority of the lake reservoirs and about half of the stream miles posted for fish tissue contamination are affected by organic contaminants (Figures 18 and 19). These organic substances tend to bind with the sediment, settle out of the water, and persist in the environment for a very long time. In the sediment, they become part of the aquatic food chain and over time, bioconcentrate in fish tissue. Contaminants can be found in fish tissue even if the substance has not been used or manufactured in decades. A brief synopsis of the effects of some of these specific carcinogens and/or toxic substances appears below.

1. **PCBs -** PCBs were used in hundreds of commercial and industrial processes including electrical insulation, pigments for plastics, and plasticizers in paints. Over 1.5 billion pounds of PCBs were produced in the U.S. prior to the ban on the manufacture and distribution of PCBs in 1976. Once PCBs enter a river or reservoir, they tend to bind with sediment particles. Over time, they enter the food chain and are concentrated in fish tissue. When people eat contaminated fish, PCBs are stored in the liver, fat tissue, and even excreted in breast milk. EPA has determined that PCBs are a probable human carcinogen (cancer causing agent). Additionally, in high enough concentrations, PCBs are likely to damage the stomach, liver, thyroid gland, and kidneys and cause a severe skin disorder called chloracne.

2. **Chlordane -** Chlordane is a pesticide that was used on crops, lawns, and for fumigation from 1948 to 1978 when EPA banned all above ground use. For the next decade, termite control was the only approved usage of chlordane. In 1988, all use of chlordane in the U.S. was banned. Like PCBs, chlordane bioconcentrates in the food chain and is detected in fish throughout Tennessee. In people, chlordane is stored in the liver and fat tissue. EPA has determined that chlordane is a probable human carcinogen. Other possible effects to people are damage to the liver, plus nervous and digestive system disorders.

3. **Dioxins -** Dioxins are the unintentional by-product of certain industrial processes and the combustion of chlorine-based chemicals. Dioxins refer to a class of compounds with a similar structure and toxic action. Most of these chemicals are produced from the incineration of chlorinated waste, the historical production of herbicides, the production of PVC plastics, and the bleaching process historically used by paper mills. Like many other organic contaminants, dioxins are concentrated in fish. Even at extraordinarily low levels (i.e. parts per quadrillion), dioxins can exert a toxic effect on larval fish. Dioxins are classified as a probable human carcinogen. Other likely effects in people are changes in hormone levels and developmental harm to children.

Mercury

Mercury is a metal with a well-documented link to environmental harm and human health impacts. Ingested mercury is readily carried throughout the body by the bloodstream and easily migrates through the placenta to the developing fetus. The consumption of contaminated fish is considered to be the major pathway of exposure for most people.

There are natural sources of mercury such as volcanoes, geysers, weathering of rocks and forest fires. However, there are significant anthropogenic sources of mercury such as historic industrial uses, waste incineration and the burning of coal.

Prior to 2001, EPA's national mercury criterion for public health protection was based on its concentration in water. The problem with this approach is that mercury is very difficult to detect in water using the equipment commonly available to laboratories. Failure to detect mercury in water does not ensure that it is not causing a problem in a stream or lake.

Since the primary human health exposure pathway for mercury is fish consumption, in 2001 EPA published a new national criterion of 0.3 parts per million (ppm) mercury based on tissue concentrations. Because mercury is not considered a carcinogen, TDEC previously issued "precautionary" fish advisories at half the Food and Drug Administration (FDA) Action Level for fish sold in interstate commerce, which resulted in a trigger point of 0.5 ppm. In 2007, the FDA and EPA determined that 0.3 ppm is the appropriately protective level for mercury in locally-consumed freshwater fish.

EPA recommended that states adopt the new mercury criterion, but allowed them the flexibility to wait until an implementation procedure was developed. By the time the draft implementation procedure was released in 2006, Tennessee was approaching the end of its triennial review of water quality standards. However, the department did revise the regulation under the recreational use to allow the commissioner to base fishing advisory decisions on the new national criterion.

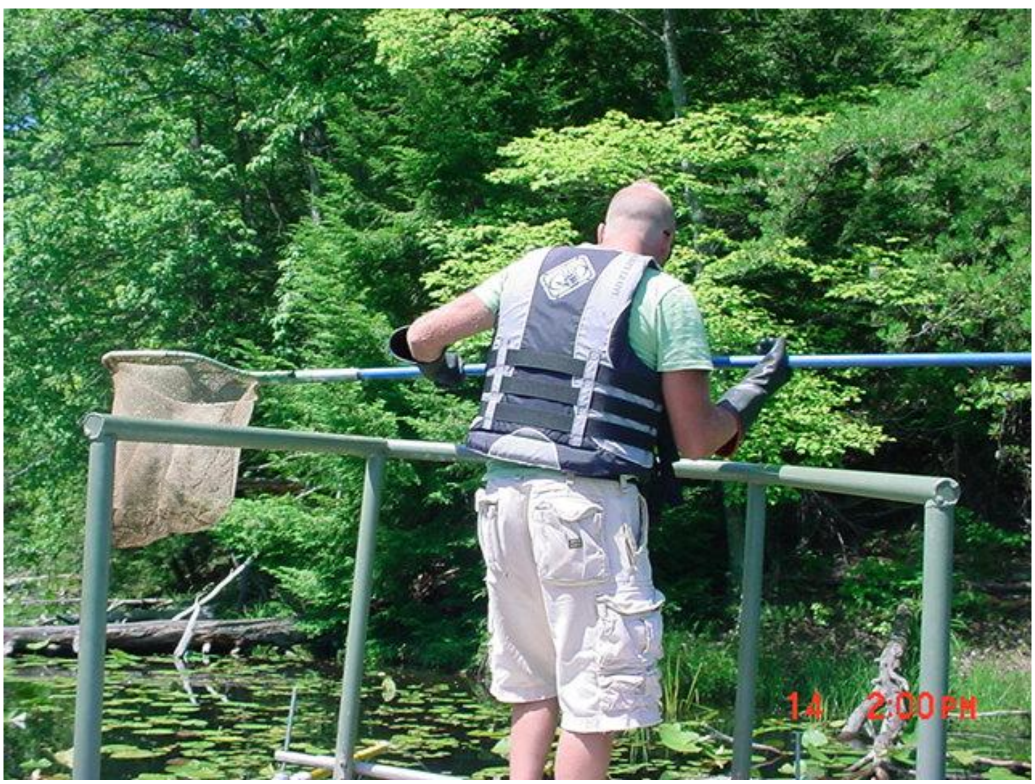
The department considers the evidence compelling that fish tissue mercury levels over 0.3 ppm have a potentially detrimental effect on the health of Tennesseans, particularly children. The department now uses this level as a trigger point for consideration of fishing advisories for Tennessee waters. The type of advisory considered appropriate when mercury levels are over 0.3 ppm, but not above 1.0 ppm will be the "precautionary advisory" which advises pregnant or nursing mothers, plus children, to avoid any consumption of fish. All other persons will be advised to limit fish consumption to one or one meal per month. If 1.0 ppm is exceeded, all persons will be advised to avoid consumption in any amount.

Prior to 2007, Tennessee had two mercury advisories in effect. The first is on East Fork Poplar Creek near Oak Ridge. The other is North Fork Holston River. At these sites, historical industrial discharges are the known source of the mercury. In 2007 and again in 2008, the department issued revised and new advisories based on the 0.3 ppm trigger point.

In 2009, the division began a probabilistic study to test levels of mercury in fish and the water column from waterbodies that may be affected by air deposition. Results from this study are currently being analyzed and will be published soon. A summary of this project is provided in Chapter 7.

In August 2010, the department issued water contact and fish consumption advisories for Beech Creek, a small eastside tributary of the Tennessee River in Wayne County, due to the discovery of visible amounts of elemental mercury in sediment at one location on the creek near Leatherwood. The advisory stated that the public should avoid contact with the sediment and should not eat fish, turtles or other aquatic life from the creek or the embayment on the Tennessee River.

The Tennessee Departments of Environment and Conservation and Health collected and analyzed sediment, fish tissue, creek water, and nearby wells to determine the extent of the contamination. The results of the additional Beech Creek sampling provided the basis for modifying the advisory issued in August 2010. Because mercury was only found in high concentrations near the community of Leatherwood, the public was advised to continue to avoid contact with Beech Creek sediment in the area between Leatherwood Branch and Smith Branch. The fish consumption advisory, however, remains in effect for all of Beech Creek and the embayment until further analysis is complete.



Aquatic biologists use electroshocking to collect fish during a probabilistic air deposition study across the state. *Photo provided by Pat Alicea, TDH.*

Reducing Risks from Contaminated Fish

The best way to protect yourself and your family from eating contaminated fish is by following the advice provided by the Department of Environment and Conservation. Cancer risk is accumulated over a lifetime of exposure to a carcinogen (cancer-causing agent). For that reason, eating an occasional fish, even from an area with a fishing advisory, will not measurably increase your cancer risk.

At greatest risk are children and people who eat contaminated fish for years, such as recreational or subsistence fishermen. People with a previous occupational exposure to a contaminant should also limit exposure to that pollutant. Studies have shown that contaminants can cross the placental barrier in pregnant women to enter the baby's body, thereby increasing the risk of developmental problems. These substances are also concentrated in breast milk.

The Division's goal in issuing fishing advisories is to provide the information necessary for people to make **informed choices** about their health. People concerned about their health will likely choose not to eat fish from contaminated sites. If you choose to eat fish in areas with elevated contaminant levels, here is some advice on how to reduce this risk:

1. **Throw back the big ones.** Smaller fish generally have lower concentrations of contaminants.

2. **Avoid fatty fish.** Organic carcinogens such as DDT, PCBs, and dioxins accumulate in fatty tissue. In contrast, however, mercury tends to accumulate in muscle tissue. Large carp and catfish tend to have more fat than gamefish. Moreover, the feeding habits of carp, sucker, buffalo, and catfish tend to expose them to the sediments, where contaminants are concentrated.

3. **Broil or grill your fish.** These cooking techniques allow the fat to drip away. Frying seals the fat and contaminants into the food.

4. **Throw away the fat if the pollutant is PCBs, dioxins, chlordane, or other organic contaminants.** Organic pesticides tend to accumulate in fat tissue, so cleaning the fish so the fat is discarded will provide some protection from these contaminants.

5. **If the pollutant is mercury, children in particular should not eat the fish.** Fish from the posted waterbodies (see Table 12) are likely to be contaminated with mercury, which is concentrated in the muscle tissue. It is very important that children not eat fish contaminated with mercury, as developmental problems have been linked to mercury exposure.

Table 11: Fish Tissue Advisories in Tennessee

(August 2010. This list is subject to revision.
For additional information: http://www.tn.gov/environment/wpc/publications/advisories.pdf)

West Tennessee

Waterbody	County	Portion	HUC Code	Pollutant	Comments
Beech Reservoir	Henderson	Entirety (877 acres)	06040001	Mercury	Precautionary advisory for largemouth bass. *
Cypress Creek	Shelby	Entirety (7.7 miles)	08010210	Chlordane, Other Organics, PCBs	Do not eat the fish.
Loosahatchie River	Shelby	Mile 0.0 – 17.0 (Hwy 14, Austin Peay Highway)	08010209	Chlordane, Other Organics, Mercury	Do not eat the fish.
McKellar Lake	Shelby	Entirety (13 miles)	08010100	Chlordane, Other Organics, Mercury	Do not eat the fish.
Mississippi River	Shelby	Mississippi Stateline to just downstream of Meeman-Shelby State Park (31 miles)	08010100	Chlordane, Other Organics, Mercury	Do not eat the fish. Commercial fishing prohibited by TWRA.
North Fork Forked Deer River	Gibson	From the mouth of the Middle Fork Forked Deer River (Mile 17.6) upstream to State Highway 188 (Mile 23.6).	08010204	Mercury	Precautionary advisory for largemouth bass. *
Nonconnah Creek	Shelby	Mile 0.0 to 1.8	08010201	Chlordane, Other Organics	Do not eat the fish. Advisory ends at Horn Lake Road Bridge
Wolf River	Shelby	Mile 0.0 – 18.9	08010210	Chlordane, Other Organics, Mercury	Do not eat the fish.

(Table continued on next page)

Table 11: Fish Tissue Advisories in Tennessee
(continued from previous page)

Middle Tennessee

Waterbody	County	Portion	HUC Code	Pollutant	Comments
Beech Creek	Wayne	From mouth to origin (Mile 16.7) including Tennessee River Embayment	06040001	Mercury	Do not eat the fish or wade/swim. Avoid contact with sediment between Leatherwood Branch and Smith Branch.
Buffalo River	Humphreys, Perry	From the mouth upstream to Highway 438 (Mile 31.6)	06040004	Mercury	Precautionary advisory for smallmouth bass. *
Duck River	Humphreys, Hickman	From mouth of Buffalo River (Mile 15.8) upstream to Interstate 40 (Mile 31.8).	06040003	Mercury	Precautionary advisory for largemouth, small mouth, and spotted bass. *
Woods Reservoir	Franklin	Entirety (3,908 acres)	06030003	PCBs	Catfish should not be eaten.

East Tennessee

Waterbody	County	Portion	HUC Code	Pollutant	Comments
Boone Reservoir	Sullivan, Washington	Entirety (4,400 acres)	06010102	PCBs, chlordane	Precautionary advisory for carp and catfish. *
Chattanooga Creek	Hamilton	Mouth to Georgia Stateline (11.9 miles)	06020001	PCBs, chlordane	Fish should not be eaten. Also, avoid contact with water.

(Table continued on next page.)

Table 11: Fish Tissue Advisories in Tennessee (continued from previous page)

Waterbody	County	Portion	HUC Code	Pollutant	Comments
East Fork of Poplar Creek including Poplar Creek embayment	Anderson, Roane	Mile 0.0 – 15.0 (entirety)	06010207	Mercury, PCBs	Fish should not be eaten. Also, avoid contact with water.
Emory River	Roane, Morgan	From Highway 27 near Harriman (Mile 12.4) upstream to Camp Austin Road Bridge (Mile 21.8)	06010208	Mercury	Precautionary advisory for all fish. *
Fort Loudoun Reservoir	Loudon, Blount	Entirety (14,600 acres)	06010201	PCBs Mercury (Upper portion only)	Commercial fishing for catfish prohibited by TWRA. No catfish or largemouth bass over two pounds should be eaten. Do not eat largemouth bass from the Little River embayment. Due to mercury, precautionary advisory for any sized largemouth bass from Highway 129 to the confluence of Holston and French Broad Rivers (534 acres). *

(Table continued on next page.)

Table 11: Fish Tissue Advisories in Tennessee (continued from previous page)

Waterbody	County	Portion	HUC Code	Pollutant	Comments
French Broad River	Cocke	From Rankin Bridge (mile 71.4) to Hwy 321 near Newport (Mile 77.5)	06010105	Mercury	Precautionary advisory for largemouth bass. *
Hiwassee River	Meigs, McMinn, Bradley	From Highway 58 (Mile 7.4) upstream to the railroad bridge just upstream of U. S. Highway 11 (Mile 18.9)	06020002	Mercury	Precautionary advisory for largemouth bass. *
Holston River	Hawkins, Sullivan	From the mouth of Poor Valley Creek Embayment (Mile 89.0) upstream to the confluence of the North and South Forks of the Holston near Kingsport (Mile 142.3).	06010104	Mercury	Precautionary advisory for all fish *
Melton Hill Reservoir	Knox, Anderson	Entirety (5,690 acres)	06010207	PCBs	Catfish should not be eaten.
Nickajack Reservoir	Hamilton, Marion	Entirety (10,370 acres)	06020001	PCBs	Precautionary advisory for catfish. *
Norris Reservoir	Campbell, Anderson, Union, Claiborne, Grainger	Clinch River Portion (Powell River embayment not included in advisory.) (15,213 acres)	06010205	Mercury	Precautionary advisory for largemouth bass, striped bass, smallmouth bass, and sauger. *
North Fork Holston River	Sullivan, Hawkins	Mile 0.0 - 6.2 (VA stateline)	06010101	Mercury	Do not eat the fish. Advisory goes to TN/VA line.

(Table continued on next page.)

Table 11: Fish Tissue Advisories in Tennessee
(continued from previous page)

Sequatchie River	Marion	County from the Tennessee River (Mile 0.0) upstream to State Highway 283 near Whitwell (Mile 22.1)	06020004	Mercury	Precautionary advisory for largemouth bass. *
South Holston Reservoir	Sullivan	Portion within Tennessee (7,206 acres)	06010102	Mercury	Precautionary advisory for largemouth bass. *
Tellico Reservoir	Loudon, Monroe	Entirety (16,500 acres)	06010204	PCBs, Mercury	Catfish should not be eaten.
Watauga Reservoir	Carter, Johnson	Entirety (6,427 acres)	06010103	Mercury	Precautionary advisory for largemouth bass and channel catfish. *
Watts Bar Reservoir	Roane, Meigs, Rhea, Loudon	Tennessee River portion (38,000 acres)	06010201	PCBs	Catfish, striped bass, & hybrid (striped bass-white bass) should not be eaten. Precautionary advisory for white bass, sauger, carp, smallmouth buffalo and largemouth bass. *
Watts Bar Reservoir	Roane, Anderson	Clinch River arm (1,000 acres)	06010201	PCBs	Striped bass should not be eaten. Precautionary advisory for catfish and sauger. *

*Precautionary Advisory - Children, pregnant women, and nursing mothers should not consume the fish species named. All other persons should limit consumption of the named species to one meal per month.

Where contaminants are elevated in fish, they may also be present in other aquatic life as well. Therefore, the public is advised to limit or avoid consumption of other animals such as turtles, crayfish and mussels in waterbodies with a fishing advisory. Additional national fish tissue advisories have been issued for the most sensitive sub-populations: pregnant women, nursing mothers, children, and women who could become pregnant.

Chapter 6 SUCCESS STORIES

A. Shoal Creek

Shoal Creek, in the Pickwick Lake watershed of Lawrence County, has been considered impaired for many years on the basis of impacts from a major industry (Murray-Ohio), a municipal point source (Lawrenceburg), plus general urban construction and agricultural runoff. An impoundment just downstream of the city added to the water quality problems. Within the last five years, the city of Lawrenceburg has upgraded its treatment capabilities, the industrial discharge has been removed, and the impoundment has been taken out. As a result, the stream now meets state biocriteria for the first time.

This is particularly good news for the efforts to reestablish a population of the federally endangered boulder darter in Shoal Creek. The recovery of Shoal Creek is a substantial success story that has taken many years to see to fruition. While levels of nitrate+nitrite were still a little elevated during the most recent monitoring, the recovery of the biological integrity indicates that these nutrients are not causing harm at present. TDEC will continue to monitor this stream.

The Boulder darter is an endangered species found only in the Elk River and 2 tributaries, Richland and Indian Creek. Historically the boulder darter was also found in Shoal Creek.
Photo provided by Conservation Fisheries Organization.

B. West Tennessee Iron Floc Reduction.

Tennessee has a history of mining more different kinds of mineral resources than any other state east of the Mississippi River except North Carolina. Mining influences can be particularly destructive in headwater streams.

Photo provided by Sharon Kington, JEFO

This photograph shows an iron treatment cell constructed to receive drainage from the toe drains in the foundation of a large earthen dam at a sand mine site. Sample results of the drainage before treatment were as high as 118 mg/L total iron. This was reduced to < 4 mg/L total iron through construction of a small treatment cell fed with hay bales to encourage biological treatment by iron-fixing bacteria. If you are viewing the color version of this report (available online), note the orange color in the treatment cell compared to water downstream. Before treatment, the orange discoloration downstream was extensive.

C. Water Quality Investigations of Off Highway Vehicle (OHV) sites in Southern Middle Tennessee

The use of off highway vehicles (OHV) including all-terrain vehicles (ATV), rock crawlers, dune buggies and monster trucks, is an increasing problem for Tennessee streams. Driving these vehicles in and adjacent to streams causes bank erosion, sediment loading, changes in stream contours, disruption of habitat and the flattening of riffle areas.

Eight inches of mud covered stream bottom in a stream at one OHV facility.

Clean rock substrate provides aquatic life habitat upstream of the facility.

Photos provided by Chad Augustin, CLEFO

There are six known organized OHV facilities in southern middle Tennessee. In 2008 and 2009 Division staff investigated and sought improvement in three of these which resulted in the following actions:

- Owners shut down and stabilized sites before reopening.
- Two OHV parks were required to obtain coverage under an individual NPDES permit.
- TDEC began working with OHV groups to write a BMP manual for OHV parks.

Results of these investigations have led division staff to the following conclusions:

- The permitting of commercial OHV sites has shown promising results.
- Owners of the permitted parks have shown the ability to meet permit standards.
- Unpermitted non-commercial riding sites are often more difficult to maintain and regulate.
- Site/trail planning and the use of BMP's will help sites achieve compliance with state water quality laws.

Old trail location through streambed.

New trail location.

Site and trail planning coupled with the use of BMPs such as access barriers, culverts, bank stabilization, stable stream crossings as well as erosion controls can protect the stream while still providing recreational opportunities for Off Highway Vehicles.

Photos provided by Chad Augustin, CLEFO.

D. Stream Mitigation in Wolf River Tributaries

Recently, the Tennessee Stream Mitigation Program (TSMP) restored approximately 7,850 linear feet of two Wolf River tributaries in Fayette County. Using mitigation fees from the West Tennessee mitigation bank, the TSMP transformed two degraded channelized streams into stable, meandering streams. The habitat within the stream was also enhanced through the implementation of instream habitat structures and the creation of riffle/pool sequences. Although the restoration is currently in the monitoring phase, aesthetic improvements to the stream have already been observed. The restoration is well on the way to being successful and we hope to witness lasting benefits to water quality and aquatic habitat in the coming years.

The original channel as it appeared during restoration. A straight channel, lack of instream habitat and eroded banks resulted in an impaired aquatic community.

The channel after meanders had been restored. Riparian vegetation has been planted and instream habitat structures are in place. The site will be monitored after sufficient time has been given for aquatic life to colonize.

Photos provided by Jennifer Lewis, MEFO

Chapter 7
Special Projects

The division carries out special monitoring projects for a number of reasons. One reason is to supplement current narrative criteria and to refine existing numeric criteria to reflect natural regional differences. Another objective is to augment routine monitoring with specific studies. These projects are undertaken to answer specific questions about existing water quality or trends.

A. Kingston Ash Spill

Early in the morning on December 22, 2008, one of the retaining walls at the ash landfill collapsed at the TVA Kingston Fossil Plant in Roane County, Tennessee. More than 5 million cubic yards of coal ash spilled from an on-site holding pond to cover more than 300 acres of surrounding land and water. About half of the ash blocked the main channel of the Emory River; the other half completely eliminated a shallow embayment area off the river. Ash was pushed as far as three miles upstream of the spill site on the Emory. Some ash moved downstream into the Clinch River and Tennessee Rivers.

The Tennessee Department of Environment and Conservation has been actively engaged in this situation since it occurred. Department professionals have been on-site at the Kingston Fossil Plant as part of a coordinated effort to contain the immediate threat to human health and the environment. This has included bi-weekly sampling and analysis for public drinking water systems to assess whether the raw water entering and the finished water produced by the Kingston Water Treatment Plant meets public health standards. All samples received to date indicate municipal water supplies are safe.

Although there is no indication that drinking water supplies have been affected, there has been impact to the environment. Heavy metals are contained in fly ash and present the potential for chemical contamination of waters. Although metals are a concern, the physical properties of the ash are perhaps of greater impact to the aquatic life, clogging gills, smothering habitat and altering flow patterns.

On May 11, 2009 the U.S. Environmental Protection Agency signed an enforceable agreement with TVA to oversee the removal of coal ash at the TVA Kingston Plant. The state of Tennessee welcomed this action and continued to work in partnership with EPA to ensure the cleanup in Roane County is thorough and protective of public health and the environment. Updates on the Kingston project as well as water and fish tissue data can be found at http://tn.gov/environment/kingston/.

The department's sampling plan consists of 4 parts: public water supply monitoring, well monitoring, surface water monitoring, and fish tissue sampling.

The physical properties of ash from the spill is probably the greatest threat to fish and aquatic life.

Photo provided by Jonathon Burr, KEFO.

TDEC is working in conjunction with several water utilities in the area, including Kingston and Rockwood, to support sampling and water testing at their intakes to verify it continues to meet water quality standards. The department continues to sample private drinking water wells within a four-mile radius of the site for heavy metals.

TDEC is monitoring the Emory River embayment of Watts Bar Reservoir on a regular basis. The Tennessee Wildlife Resources Agency (TWRA) began collecting bass and catfish during the week of January 5 and will compare fish tissue results to existing data for those species. TWRA expects to resample on a semiannual basis and will evaluate findings with the other resource agencies. TDEC will issue advisories if fish tissue contaminant levels exceed protection criteria.

The department has collected soil and ash samples, which were analyzed at the state laboratory. Both soil and ash samples were analyzed for total metals, TCLP metals (which helps to determine how likely metals are to leach from the material), radioactivity and polynuclear aromatic hydrocarbons. Soil and ash samples were collected from residential locations, from the landfill itself and near Roane County Park, away from the spill to determine background levels present in unaffected soils for comparison purposes.

A dike has been constructed to temporarily contain ash in the side embayment. Hydraulic dredging of the 2.5 million cubic yards of ash in the Emory River began in late March, 2009 and was completed in 2010. Water, pond and dredge discharges, air (dust), fish and benthic communities, fish tissue and other wildlife effects were monitored heavily throughout the dredging. Metals are of concern, but a big issue is the physical magnitude of the project – cost, time, landfill space and general logistic difficulty.

B. Headwater Reference Streams

Tennessee has established macroinvertebrate and nutrient guidelines for narrative criteria for assessing wadeable streams throughout the state based on reference stream monitoring in each of 25 ecoregions. The reference streams were generally 3rd order or larger and are not appropriate for comparison to headwater streams. In 2008, the division began a 7 year study to identify and monitor first and second order reference streams in 13 Tennessee bioregions to aid in development of biological and nutrient criteria guidelines in headwater streams.

Photo provided by Jonathon Burr, KEFO.

Headwater streams are an important component of every watershed. They comprise the highest percentage of stream miles in the state. The health of larger streams and rivers depend upon an intact primary headwater stream network. These small streams nourish downstream segments with essential supplies of water and food materials. Headwater streams with vegetated buffers assist in reducing sediment delivery to larger streams. They also increase biodiversity in a watershed by offering unique habitat niches and by providing refugia from competitors, predators, and exotic species.

These guidelines will be used to assess headwater streams for the 305(b) and 303(d) reports, locate exceptional headwater streams through the antidegradation process, provide information for point-source discharge and aquatic resource alteration permits as well as provide information for TMDL studies. The study will also help Tennessee achieve three of its nutrient criteria workplan goals (develop nutrient criteria guidelines for headwater streams, develop associated biological criteria for headwater streams, add a second biological indicator group (periphyton) to nutrient and biological criteria.

Project Goals

1. Establish a minimum of 77 headwater reference streams in 13 Tennessee bioregions over a five-year period.

2. Collect and analyze nutrients, habitat, dissolved oxygen, pH, temperature, conductivity, flow, macroinvertebrate during two seasons at each station in accordance with the five year watershed cycle. Collect and analyze periphyton data once during the growing season.

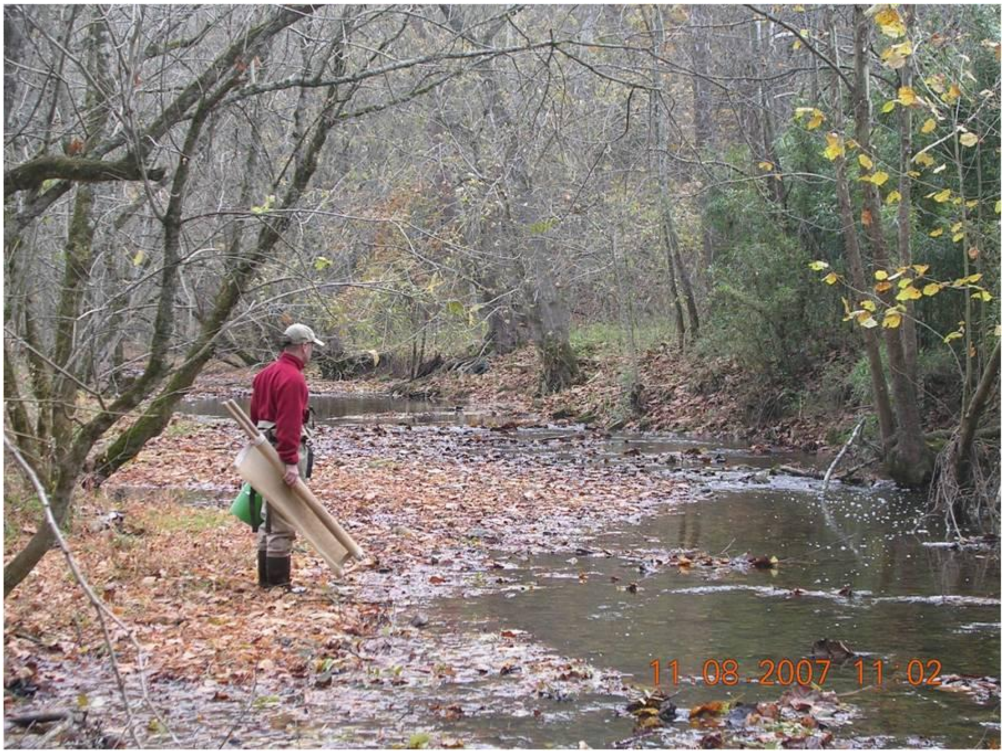
3. Determine appropriate sampling seasons for headwater streams in various bioregions.

4. Identifying appropriate biological metrics for assessment of headwater streams.

5. Develop macroinvertebrate and periphyton indices appropriate for assessment of headwater streams, thereby achieving two of the state's nutrient criteria development workplan goals.

6. Calculate background nutrient levels typical for headwater streams in various Tennessee ecoregions, thereby achieving one of the state's nutrient criteria development workplan goals.

7. Utilize the project to help meet departmental public outreach goals.



Biologist Jonathon Burr surveys a headwater stream in the Ridges and Valleys ecoregion of east Tennessee.

Photo provided by Jonathon Burr, KEFO.

C. Periphyton Index Development

The periphyton community is comprised of sessile algae that inhabit the surfaces of underwater rocks and other stable surfaces. They are the primary producers in the stream ecosystem, turning nutrients into food for aquatic macroinvertebrates and fish. They are good indicators of nutrient enrichment as elevated nutrients in the absence of shade at warm temperatures will result in excessive algal growth. This can reduce stream biodiversity by making rock habitat unsuitable for benthic organisms and by altering diurnal dissolved oxygen patterns.

Michael Graf scrapes periphyton from rocks.
Photo provided by Kim Sparks, NEFO.

In 2008, the division began analysis of samples collected at ecoregion reference sites and at 90 probabilistic monitoring streams that were collected in 2007. The results from the probabilistic study will be used to compare to nutrient and macroinvertebrate samples that were collected at the same time. The data from reference streams will begin the process of developing a second biological index, which is sensitive to nutrient enrichment in accordance with the state's nutrient criteria development plan.

Project Objectives:

1. Initiate development of a second biological index for determination of nutrient impairment in wadeable streams.

2. Identify baseline periphyton assemblages at 34 established, 3rd order or larger, reference sites.

3. Use probabilistic monitoring based on 90 randomly selected sites to determine statewide and aggregated ecoregion periphyton assemblages and compare to nutrient data.

4. Establish randomly selected periphyton stations for use in trend analysis and 305(b) assessments.

5. Use study data to help refine existing narrative nutrient and biological criteria.

6. Begin incorporation of periphyton data into state nutrient assessment process.

D. Mercury Air Deposition

Not all pollutants enter waterbodies directly from point source discharges or surface run-off. Some, such as air-borne mercury, can be carried by rain. In summer and fall 2009, the division contracted with the Aquatic Biology Section, TDH to sample fish and water from 33 stations to test the accuracy of an air deposition model for predicting mercury contamination.

Project Goals

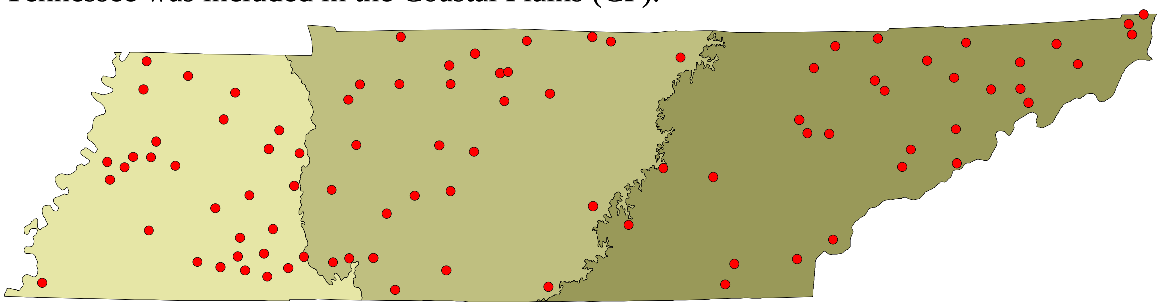
1. Establish 33 fish monitoring stations to test the accuracy of the REMSAD air deposition model for predicting mercury contamination in fish.
2. Determine whether model accurately predicts contaminated and clean waterbodies.
3. Determine whether mercury levels in fish fillets exceed safe levels for human consumption.
4. Work with Division of Air Pollution to locate probable sources of contaminants.
5. Build database of selenium levels in wholebody fish tissue to protect fish eating wildlife.

Aquatic biology staff collect water samples check for possible contaminants from air deposition. *Photo provided by Pat Alicea, TDH.*

E. 2010 Probabilistic Monitoring of Wadeable Streams

In 2007, Tennessee conducted a state wide probabilistic-based study of wadeable streams in Tennessee that built upon EPA's 2004 Wadeable Streams Assessment (WSA) survey of the nation's streams. Biological, physical, and chemical data from a random sub-sampling of 90 Tennessee streams were extrapolated to all wadeable streams in Tennessee. The intention was to provide a baseline to which future efforts could be compared, thus providing an opportunity for scientifically valid trend analysis. Results of the 2007 study are available at http://www.tn.gov/environment/wpc/publications/

In the Tennessee study, the state was divided into three broad categories (east, middle and west). East includes ecoregions 66, 67, 68 and 69. Middle is ecoregion 71 and west is ecoregions 65, 73 and 74. The general location of the monitoring sites is shown below. Tennessee fell into two assessment regions in the National Wadeable Streams Assessment. Middle and east Tennessee were included in the Southern Appalachians (SAP). West Tennessee was included in the Coastal Plains (CP).



Most of the stream condition assessments from the EPA national report were very different from what was found during the state wide probabilistic study. (Figure 20). The national study found only 28% of the macroinvertebrate populations to be in good condition as compared to 41% in the Tennessee study. In the Southern Appalachians, only 21% of the study sites were found to be in good biological condition whereas 57 – 60% of the sites in middle and east Tennessee passed state biocriteria. Conversely, the Coastal Plains fared better than the Southern Appalachians with 36% of the macroinvertebrate populations in the good category. Only seven percent of the sites in west Tennessee passed biocriteria.

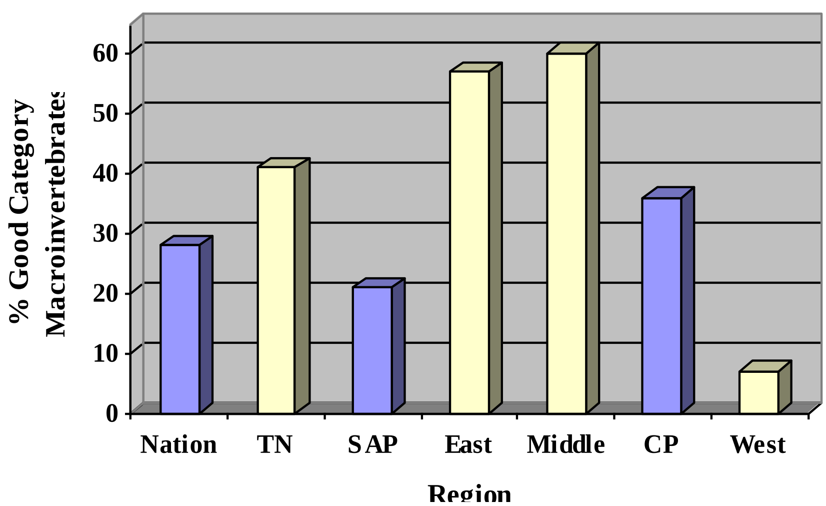


Figure 20: Macroinvertebrate results from Wadeable Streams Project.

Sediment deposition (state study) was compared to streambed sediments in the national study. Although the national study used a much more comprehensive method, both surveys attempted to determine whether there was an increase in the amount of fine sediments over reference condition that resulted in changes to the natural stream substrate and flow patterns. Based on these methods, 20-30% more streams in east and middle Tennessee would fall in the good category than those in the EPA Southern Appalachians assessment region (Figure 21). The condition of west Tennessee streams was comparable to those in the Coastal Plains.

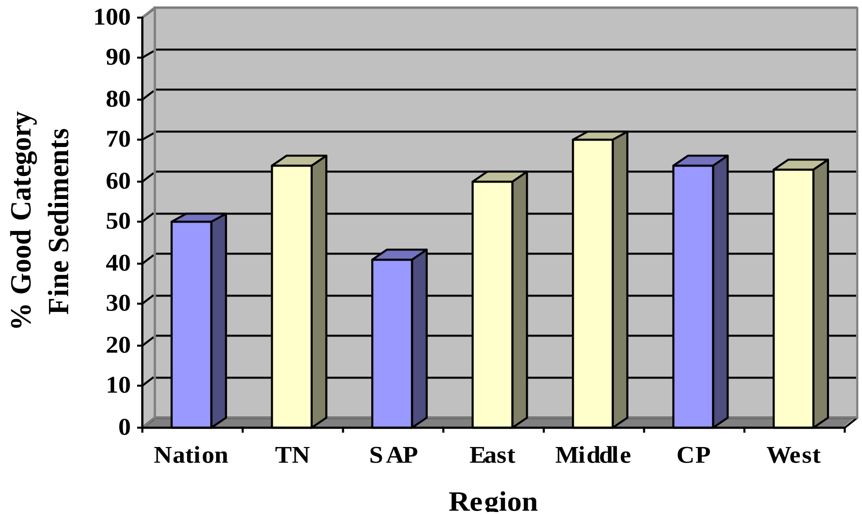


Figure 21: Sediment deposition results from the Wadeable Streams Project.

Riparian disturbance measures the proportion of the riparian zone vegetation that has been disturbed by human activities. This vegetative zone serves to buffer pollutants entering a stream from runoff and controls erosion. The riparian zone also provides habitat and food to stream organisms. Although riparian disturbance was one of the most frequent habitat problems documented at east and middle Tennessee sites, streams were generally in better condition than those in EPA's Southern Appalachian assessment region (Figure 22). However, west Tennessee streams were more likely to have riparian disturbance than those in the Coastal Plains.

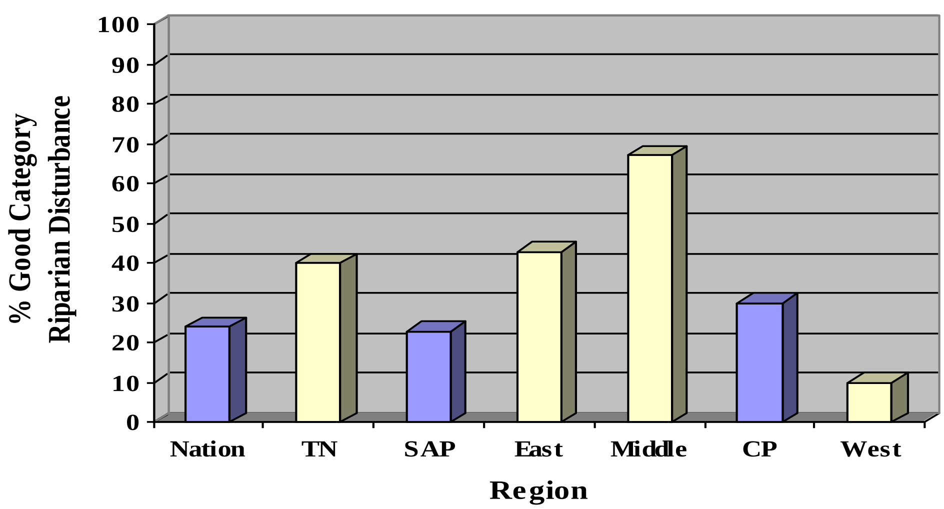


Figure 22: Riparian disturbance results from the Wadeable Streams Project.

Nutrient samples were only collected once during the national study between July and November. This corresponds with summer and fall sampling during the state study, so only these seasons were used for comparison. Statewide, when compairing to the national study, a lower percentage of sites fell in the good category for total phosphorus. (Figure 23). Within the Southern Appalachian assessment region, east Tennessee scored better than the national study while middle Tennessee scored lower. Only half as many streams in west Tennessee met phosphorus guidelines when compared with the Coastal Plain assessment region.

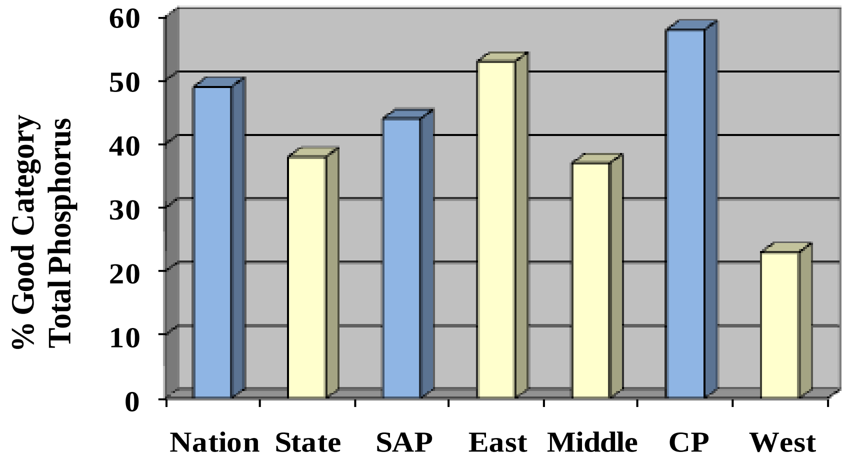


Figure 23: Total phosporus results from the Wadeable Streams Project.

The state study found total phosphorus levels varied by season (Figure 24). Approximately 82% of the probabilistic sites had a least one seasonal sample above ecoregional guidelines. The single sample collected at each site in the national study could have been collected either in summer or fall. If national trends in the Southern Appalachian and Coastal Plain assessment regions follow those in Tennessee streams, fall (October and November) TP levels are generally lower than summer (July and August). Depending on which season individual samples were collected during the national study, the results could have been shifted toward more or fewer streams falling in the good category

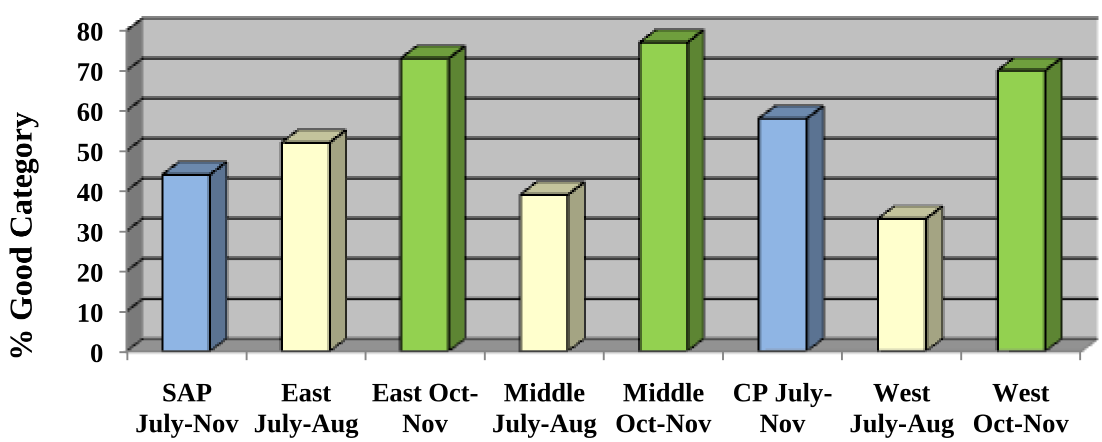


Figure 24: Seasonal total phosphorus results from the Wadeable Streams Project.

The results of the probabilistic monitoring for pathogens show that about 45% of the streams sampled exceeded Tennessee's recreation criteria for *E. coli* (Figure 25). It is important to note that the criteria for recreation are the most stringent of all the classified uses. Pathogens were not collected during the national study.

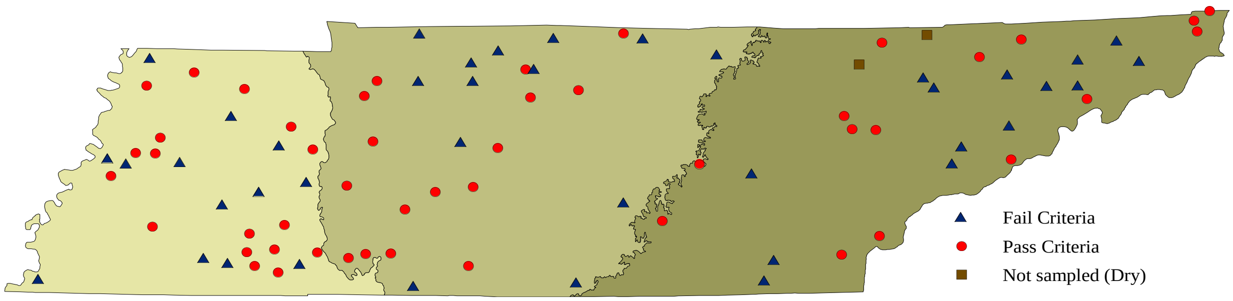


Figure 25: Location of sites from the Wadeable Streams Project that failed *E. coli* water quality criteria for the classified use of recreation

Periphyton can be useful indicators of water quality and pollution levels. The majority of the sites in east Tennessee were classified as fair (Figure 26). Middle Tennessee had the greatest amount of optimal substrate and the least amount of canopy cover. It also had the least algal diversity. This division had the most scores in the poor category. Middle Tennessee had the lowest percentage of sediment tolerant diatom species, possibly indicating lower levels of sedimentation compared to the other divisions. West Tennessee had the most diversity in both the diatom and non-diatom communities. Typically, higher diversity is a result of less impairment. However, this may not be the case in this region. Nutrient enrichment may be causing an increase in diversity. In the western division, the percent of pollution tolerant diatoms was greater and the overall condition of the community was the poorest. However, the bioassessments were the best because the regional expectations in west Tennessee were lower than the rest of the state.

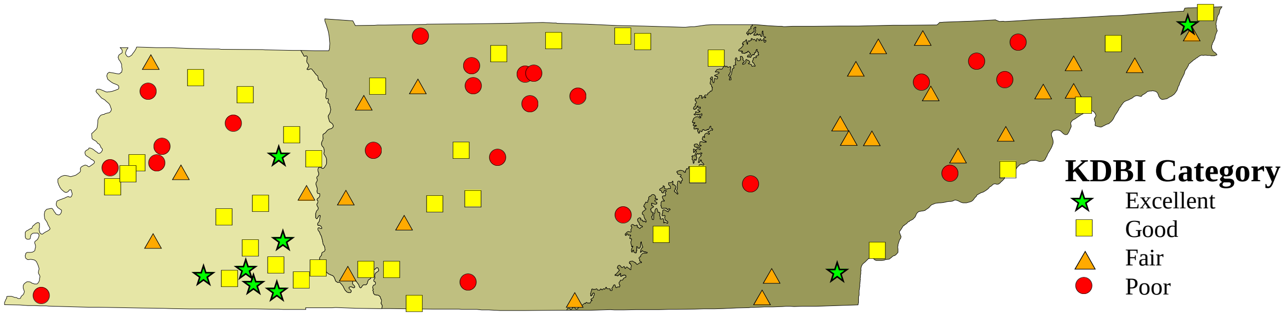


Figure 26: Location of sites from the Wadeable Streams Project showing the Kentucky Diatom Bioassessment Index category

Since 2007 was a record drought year, follow-up sampling is needed to determine how much of the original study was affected by drought conditions and to provide a firm basis for future trend analysis. All 90 of the original study sites will be re-sampled in 2010 for macroinvertebrates, physical parameters and nutrients. Metals, which were not included in the original study, will also be added to provide additional stressor information.

F. Study of Pharmaceuticals and Personal Care Products (PPCP)

In urban areas where many people are concentrated on sewer systems, personal care products such as pain medications, antidepressants, and hormones, may be passed by people into the collection system, through treatment plants not designed to remove them, then ultimately into surface waters.

Over the past decade, water quality surveys have indicated that numerous areas of the United States, including Tennessee, have pharmaceuticals and steroid hormones in their waterways. Additional studies have linked the exposure of fish and amphibians to natural and synthetic steroids to harmful effects such as reproductive and endocrine disruption (estrogen and/or androgen).

Because little is known about the potential for pharmaceutical compounds and/or endocrine disrupting compounds to enter drinking water supplies, the Department is currently teaming up with the University of Tennessee to look for pharmaceutical compounds and endocrine disrupting compounds in the source waters of the State's drinking water facilities. The department will be sampling all surface water plants and selected groundwater plants (where the groundwater is under the direct influence of surface waters) in the State in order to provide information on PPCP issues.

Sampling for this project began in May of 2010 and is scheduled to continue through the summer of 2011. Pharmaceutical compounds selected for monitoring include: caffeine, nicotine, antidepressants, anticonvulsants, insect repellants such as DEET, antibacterials, 17α-ethinyl estradiol, fluoxetine, and ibuprofen. A report of the results of this study will be available in the latter part of 2011.

Chapter 8
Public Participation

Everyone contributes pollution in large or small ways. Often a careless or thoughtless act results in far reaching damage. By understanding how pollution impacts our planet and what each of us can do to reduce pollution, collectively we can make a difference in Tennessee and the world.

Get Involved

Environmental laws encourage public participation. Ask that environmental issues be considered in the local planning process.

Find out which watershed you live in and attend TDEC's watershed meetings. Watershed meetings are held in the third and fifth years of the watershed cycle. The meeting dates and times are posted on the TDEC website at: http://tn.gov/environment/ppo/.

NEFO biologist Annie Goodhue demonstrates how macroinvertebrates can indicate pollution in streams. *Photo provided by Jennifer Watson, WPC.*

Reduce, Reuse, and Recycle

Whenever possible recycle metal, plastic, cardboard, and paper, so it can be reused to make new products. Always dispose of toxic materials properly. Most auto parts stores and many service stations collect used motor oil and auto batteries for recycling. Most counties have annual toxic waste collection days for old paints, pesticides, and other toxic chemicals. Check with your local waste management service for specific dates and times.

Conserve water and electricity both at home and at work. Every gallon of water that enters the sewer must be treated. The production of energy uses natural resources and produces pollution. You will not only prevent pollution, but also save money. For further information on pollution prevention please see the website.
http://tennessee.gov/environment/ea/tp3/

Be Part of the Solution, Not Part of the Problem

1. **Dispose of chemicals properly**

Always dispose of toxic chemicals properly. Never pour oil, paint, or other leftover toxic chemicals on the ground, in a sinkhole, or down a drain. If you have a septic system, check it periodically to make sure it is functioning correctly to protect surface and ground water.

2. **Use chemicals properly**

Use all chemicals, especially lawn chemicals, exactly as the label instructs. Every year millions of pounds of fertilizer and pesticides are applied to crops and lawns and some portion is carried by runoff to streams, rivers, and reservoirs. Over-application of fertilizers and pesticides wastes money, risks damage to vegetation, and pollutes waterways. Therefore, use all chemicals, especially lawn chemicals, cautiously.

3. **Prevent erosion and runoff**

It is important for farmers and loggers to work closely with the Department of Agriculture (TDA) personnel to prevent erosion and runoff pollution. TDA can recommend Best Management Practices (BMP's) to reduce soil loss and prevent pollution of waterbodies.

If you see any of the following problems, please call.

More than just a few dead fish in a stream or lake.

Someone pumping a liquid from a truck into a stream (especially at night).

Unusual colors, odors, or sheen in a stream or lake.

Construction activities without proper erosion control (silt fences, hay bales, matting).

Bulldozers or backhoes in a stream removing gravel or rocks.

Groups of people removing rocks from streams, especially on the Cumberland Plateau.

Sewage pumping stations discharging directly or indirectly into a stream.

Manholes overflowing.

4. Obtain a permit

Contractors wishing to alter a stream, river, or wetland need to obtain a permit from the TDEC, Natural Resources Section. Additionally, construction sites must be covered under a General Permit for the Discharge of Stormwater for a Construction Activity. Coverage can be obtained by contacting the local TDEC Environmental Field Office (EFO) at 1-888-891-TDEC. Never buy gravel or rocks that were illegally removed from streams or rivers.

A work site must be properly stabilized to avoid erosion. All silt retention devices must be properly installed to protect a site from soil loss and waterbodies from siltation. If you hire a contractor to do any work around a stream or river, make sure they obtain the proper permits and know how to protect the waterbody. The landowner is ultimately responsible for any work done on his land.

Report Pollution

The public is an important source of information on pollution. Call your local Water Pollution Control office if you see a water pollution problem. A map of Tennessee's Environmental Field Offices (EFO) appears on the next page (Figure 22). If your EFO is not a local call, please use our toll free number that will connect you to your nearest office.

Call your local Environmental Field Office. See Figure 28 on the next page.

or

If your local EFO is a long distance phone call, please call toll free.
1-888-891-TDEC
1-888-891-8332

You may also contact the division by leaving a message on our website.

http://www.tn.gov/environment/

When a call is received from a citizen, division staff investigates the complaint and attempt to identify the source of pollution. If the polluter is identified, enforcement action can be taken.

JACKSON

1625 Hollywood Drive
Jackson, TN 38305
(731) 512-1300
fax (731) 661-6283

EFO Director - Rudy Collins
(731) 512-1339
Administrative Mgr-Carol Pollan
(731) 512-1303

WPC Manager - Pat Patrick
(731) 512-1301

NASHVILLE

711 R.S. Gass Blvd.
Nashville, TN 37243
(615) 687-7000
fax (615) 687-7078

EFO Director - Barry Brawley
(615) 687-7033
Administrative Mgr - Steve Janes
(615) 687-7016

WPC Manager - Joe Holland
(615) 687-7020

COOKEVILLE

1221 South Willow Avenue
Cookeville, TN 38506
(931) 432-4015
fax (931) 432-6952

EFO Director - Jimmie Lee Clark
(931) 432-7614
Administrative Mgr-Jan Tollett
(931) 432-7605

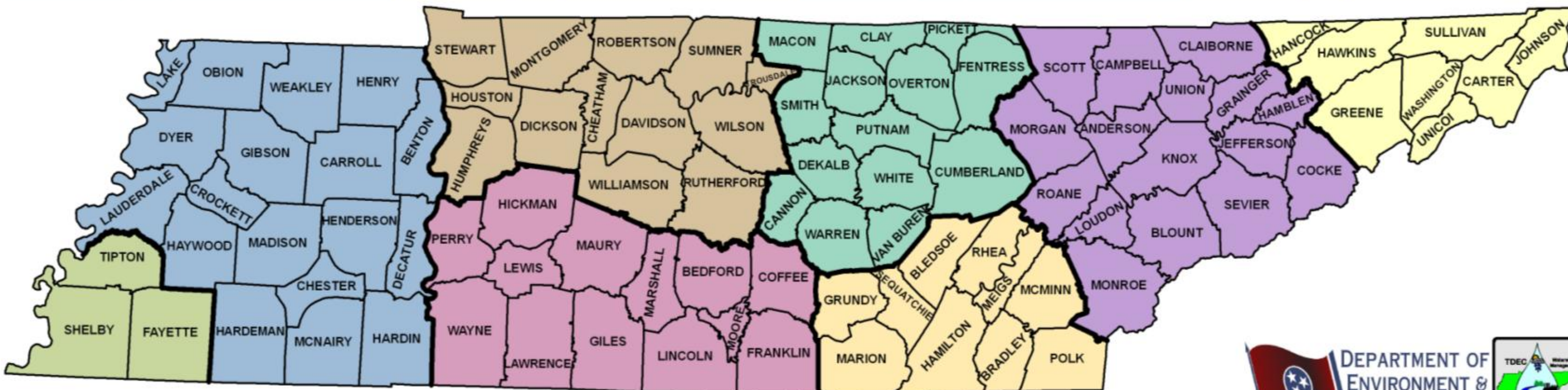
WPC Manager - Rob Howard
(931) 432-7632

JOHNSON CITY

2305 Silverdale Road
Johnson City, TN 37601
(423) 854-5400
fax (423) 854-5401

EFO Director - Mark Braswell
(423) 854-5459
Administrative Mgr-Judy Jarrett
(423) 854-5404

WPC Manager - Jeff Horton
(423) 854-5447



DEPARTMENT OF ENVIRONMENT & CONSERVATION

MEMPHIS

8383 Wolf Lake Drive
Bartlett, TN 38133
(901) 371-3000
fax (901) 371-3170

EFO Director - Cindy Patton
(901) 371-3001
Administrative Mgr-Lauranda Redmond
(901) 371-3002

WPC Manager - Terry Templeton
(901) 371-3018

COLUMBIA

1421 Hampshire Pike
Columbia, TN 38401
(931) 380-3371
fax (931) 380-3397

EFO Director - Joe Holmes
(931) 840-4156
Administrative Mgr-Sheila Colston
(931) 840-4142

WPC Manager - Ryan Owens
(931) 490-3941

CHATTANOOGA

Suite 550 - State Office Building
540 McCallie Avenue
Chattanooga, TN 37402
(423) 634-5745
fax (423) 634-6389

EFO Director - Steve Baxter
(423) 634-5782
Administrative Mgr-Andra Kelley
(423) 634-5731

WPC Manager - Dick Urban
(423) 634-5702

KNOXVILLE

3711 Middlebrook Pike
Knoxville, TN 37921
(865) 594-6035
fax (865) 594-6105

EFO Director - Phil Chambers
(865) 594-5524
Administrative Mgr-Cyndi Mabe-Johnson
(865)594-5450

WPC Manager - Paul Schmierbach
(865) 594-5529
Mgr-WPC - Natalie Harris
(865) 594-5525
Mgr-WPC (Mining) - vacant
(865) 594-5527
Mgr-WPC (Land Reclamation) Tim Eagle
(865) 594-5609

Figure 27: TDEC Environmental Field Office Boundaries

Definitions and Acronyms

Definitions

Acute Toxicity: An adverse effect (usually death) resulting from short-term exposure to a toxic substance.

Benthic Community: Animals living on the bottom of the stream.

Biocriteria: Numerical values or narrative expressions that describe the reference biological condition of aquatic communities and set goals for biological integrity. Biocriteria are benchmarks for water resources evaluation and management decisions.

Biometric: A calculated value representing some aspect of the biological population's structure, function or other measurable characteristic that changes in a predictable way with increased human influence.

Bioregion: An ecological subregion, or group of ecological subregions, with similar aquatic macroinvertebrate communities that have been grouped for assessment purposes.

Chronic Toxicity: Sublethal or lethal effects resulting from repeated or long-term exposure to low doses of a toxic substance.

Diurnal: Having a daily cycle, with periodic fluctuation relating to day and night

Ecoregion: A relatively homogenous area defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, and other ecologically relevant variables.

Ecological Subregion (or subecoregion): A smaller area that has been delineated within an ecoregion that has even more homogenous characteristics than does the original ecoregion.

Ecoregion Reference: Least impacted, yet representative, waters within an ecoregion that have been monitored to establish a baseline to which alteration of other waters can be compared.

Habitat: The instream and riparian physical features such as stones, roots, or woody debris, that influence the structure and function of the aquatic community in a stream.

Macroinvertebrate: Animals without backbones that are large enough to be seen by the unaided eye and which can be retained by a U.S. Standard No. 30 sieve (28 meshes/inch, 0.595 mm).

Periphyton: Benthic algae that are attached to surfaces such as rock or other plants.

Pathogens: Disease causing microorganisms.

Definitions (continued)

Regulated Sources: Pollution originating from sources governed by state or federal permitting requirements. These sources are typically from discrete conveyances, but also include stream alterations, urban runoff, and stormwater runoff from construction sites.

Non-Point Source Pollution: Pollution from diffuse sources as a result of rainfall or snowmelt moving over and through the ground into lakes, reservoirs, rivers, streams, wetlands, and aquifers.

Non-Regulated Sources: Activities exempted from state or federal permitting requirements. In Tennessee, these sources are agricultural and forestry activities which utilize appropriate management practices. Further, sources like atmospheric deposition might be considered unregulated sources, since they are not controllable through the water program.

Point Source Pollution: Waste discharged into receiving waters from a single source such as a pipe or drain.

Riparian Zone: An area that borders a waterbody.

Water Pollution: Alteration of the biological, physical, chemical, bacteriological or radiological properties of water resulting in loss of use support.

Watershed: A geographic area, which drains to a common outlet, such as a point on a larger lake, underlying aquifer, estuary, wetland, or ocean.

Acronyms

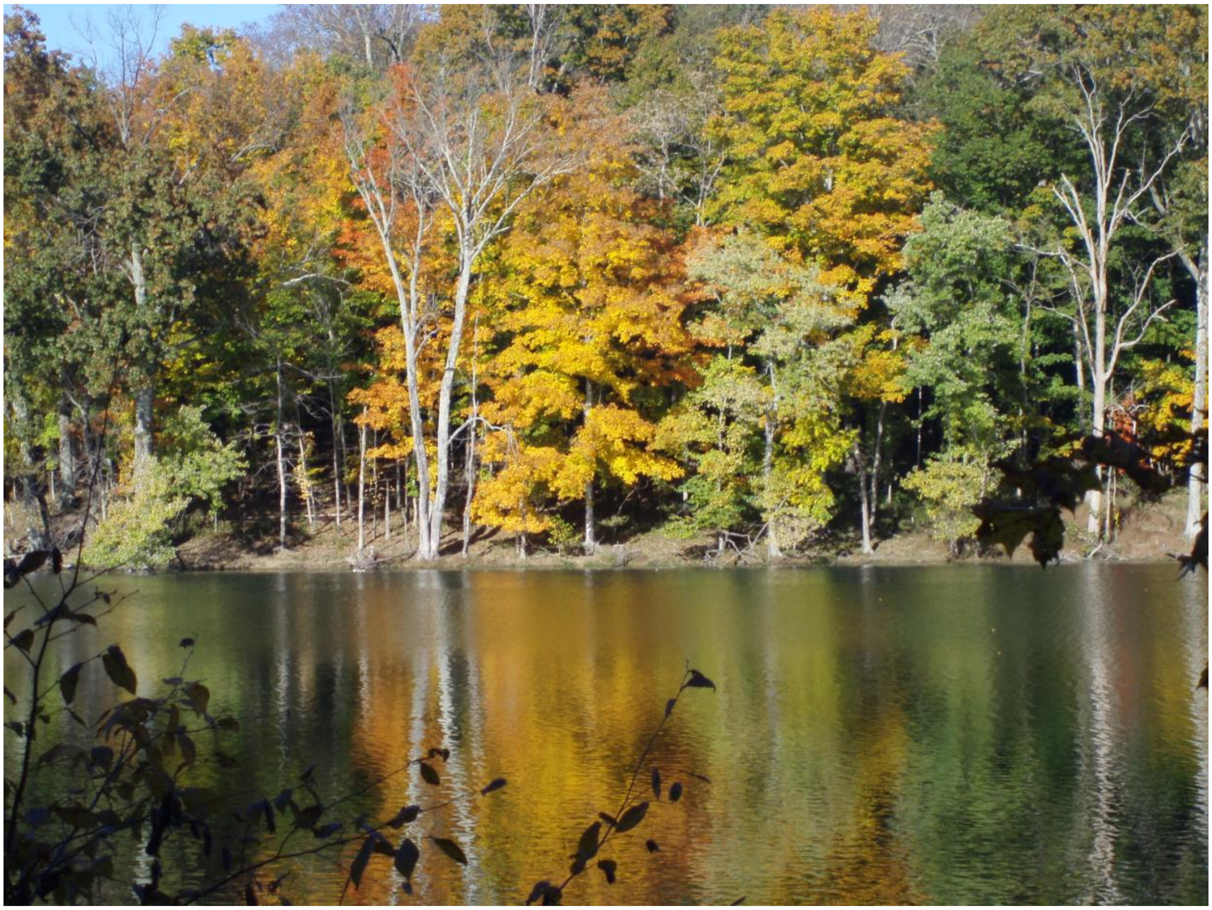
ADB:	Assessment Database
ARAP:	Aquatic Resource Alteration Permit
ATV:	All Terrain Vehicle
BMP:	Best Management Practices
CAFO:	Confined Animal Feeding Operation
CERCLA:	Comprehensive Environmental Response, Compensation, and Liability Act
CHEFO:	Chattanooga Environmental Field Office
CKEFO:	Cookeville Environmental Field Office
CLEFO:	Columbia Environmental Field Office
COE:	U.S. Army Corps of Engineers
CWSRF:	Clean Water State Revolving Fund
DDT:	Dichloro-diphenyl-trichloroethane
DO:	Dissolved Oxygen
DOE:	Department of Energy
DIOSM:	U.S. Department of Interior Office of Surface Mining
EFO:	Environmental Field Office
EMAP:	Environmental Monitoring and Assessment Program

Acronyms (continued)

EPA:	United States Environmental Protection Agency
EPT:	Ephemeroptera (Mayflies) Plecoptera (Stoneflies) Trichoptera (Caddisflies)
ETW:	Exceptional Tennessee Waters
FAL:	Fish and Aquatic Life
FDA:	Food and Drug Administration
GIS:	Geographic Information System
GPS:	Global Positioning System
HGM:	Hydrogeomorphic
HUC:	Hydrological Unit Code (Watershed Code)
JEFO:	Jackson Environmental Field Office
JCEFO:	Johnson City Environmental Field Office
KEFO:	Knoxville Environmental Field Office
MCL:	Maximum Contaminant Level
MEFO:	Memphis Environmental Field Office
MS4:	Municipal Separate Storm Sewer Systems
NHD:	National Hydrography Dataset
NEFO:	Nashville Environmental Field Office
NPDES:	National Pollutant Discharge Elimination System
NPL:	National Priorities List
NPS:	Non-point Source
NRCS:	Natural Resource Conservation Service
OHV:	Off Highway Vehicle
ONRW:	Outstanding Natural Resource Waters
ORNL:	Oak Ridge National Laboratory
OSM:	Office of Surface Mining
PCB:	Polychlorinated Biphenyls
PAH:	Polycyclic Aromatic
PAS:	Planning and Standards Section
QAPP:	Quality Assurance Project Plan
QSSOP:	Quality System Standard Operating Procedure
PPM:	Parts Per Million
RDX:	Cyclotrimethylenetrinitramine
RIT:	Reach Indexing Tools
SOP:	Standard Operating Procedure
STORET:	EPA's STOrage and RETrieval Database
STP:	Sewage Treatment Plant
TDEC:	Tennessee Department of Environment and Conservation
TDA:	Tennessee Department of Agriculture
TDH:	Tennessee Department of Health

Acronyms (continued)

TKN:	Total Kjeldahl Nitrogen
TMDL:	Total Maximum Daily Load
TMI:	Tennessee Macroinvertebrate Index
TVA:	Tennessee Valley Authority
TWRA:	Tennessee Wildlife Resource Agency
USACE:	U.S. Army Corps of Engineers
USGS:	U.S. Geological Survey
USFWS:	U.S. Fish and Wildlife Service
WET:	Whole Effluent Toxicity
WPC:	Water Pollution Control
WSA:	Wadeable Streams Assessment
WQCB:	Water Quality Control Board
WQDB:	Water Quality Database
WWTP:	Waste Water Treatment Plant



Radnor Lake in Autumn. *Photo provided by Kim Sparks, NEFO*.

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