2008 305(b) Report
The Status of Water Quality in Tennessee

Division of Water Pollution Control
Tennessee Department of Environment and Conservation

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Cover Photo: Cumberland Mountain State Park. Photo provided by Kim Sparks, NEFO.

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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 are:

- Describe the water quality assessment process (Chapter 1).
- Categorize waters in the State by placing them in the assessment categories suggested by federal guidance (Chapter 2).
- Identify 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.

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The information compiled in this 2008 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), U.S. Geological Survey (USGS), and U.S. Department of Interior Office of Surface Mining (DIOSM). The division is grateful for their assistance and cooperation.

In addition to the agencies that provided water quality data, the Division of Water Pollution Control acknowledges the assistance provided by the U. S. Environmental Protection Agency's Region 4 staff. In particular, Tom McGill and Paul Gagliano of the West Standards, Monitoring, and TMDL Section supplied information concerning the TMDL Consent Decree.

Little Marrowbone Creek in Davidson County. Photo provided by Jimmy Smith, 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. Chapter 1200-4-3 of those rules defines specific water quality standards, both numeric and narrative, and delineates the state's antidegradation policy, which deals with prevention of future damage to water quality. 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 problems. By viewing the entire drainage area or watershed as a whole, the department is better able to address water quality monitoring, assessment, permitting, 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 investigations, 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 62 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, 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 2008 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 saw a severe drought in 2007. August 2007 was Tennessee's hottest August on record, and this was the second driest summer since 1895 (NOAA, 2007).

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 Jimmy R. Smith, 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)…………………………………	60,417
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………………………………	572,165
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

Clean water provides enjoyment for everyone. Photo provided by Kim Sparks, NEFO.

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.

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 2006 305(b) report was published, Group 4 and 5 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 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.

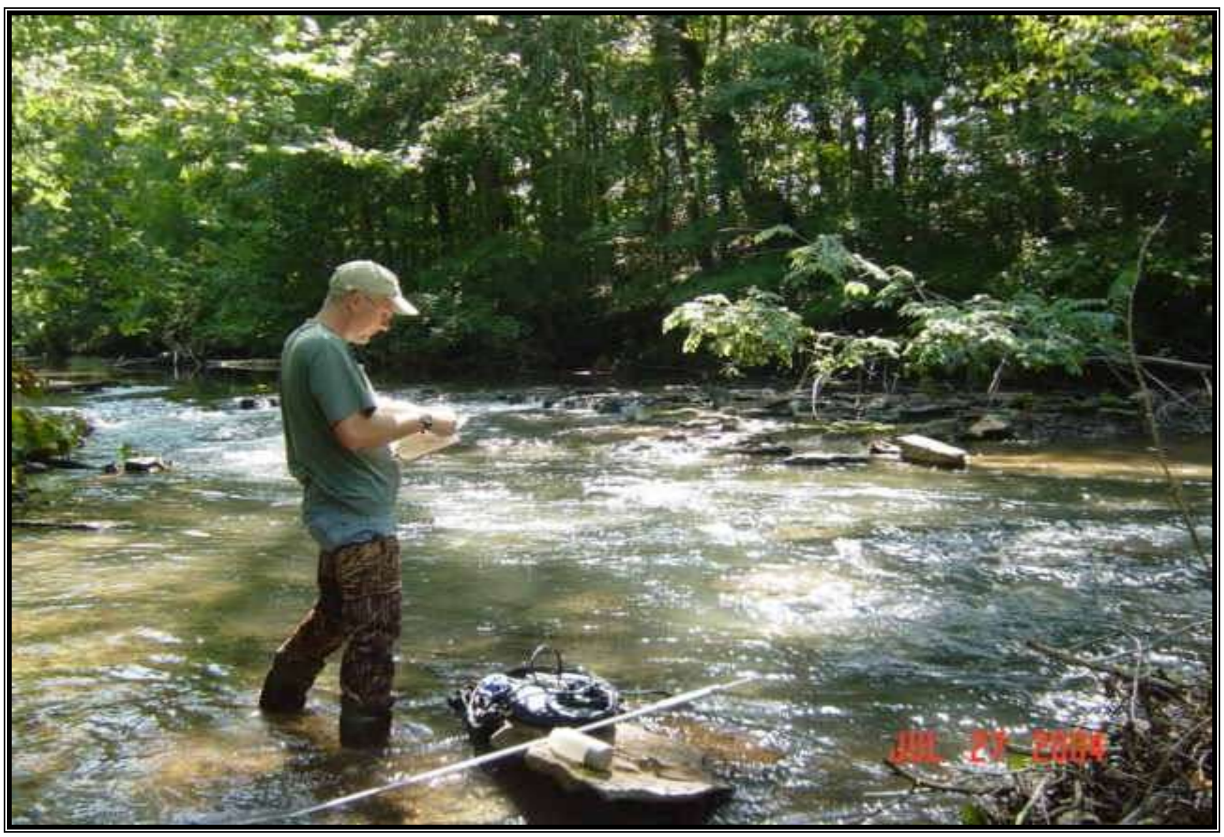
e. **Drinking Water Supply** –This use classification is assigned to waterbodies that are currently or are likely to be used for domestic water supply.

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/.



Jimmy Smith from the NEFO records water quality data. Photo provided by Kim Sparks, NEFO.

1. 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 the 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 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 are 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://www.state.tn.us/sos/rules/1200/1200-04/1200-04-03.pdf.

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. 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."

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."

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

The portion of the Obed River designated as a federal wild and scenic river as of June 22, 1999 is 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 ONRWs is available on the state's website at http://www.state.tn.us/environment/water. 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 2006 305(b) report was published, Group 4 and 5 watersheds have been assessed plus Group 1 and 2 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. Two standard operating procedures (SOPs) have been developed to guide sampling techniques and quality control for macroinvertebrate surveys (TDEC, 2006) and chemical and bacteriological sampling (TDEC, 2004).

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.

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. Tennessee's TMDL prioritization schedule is based on a 1998 agreement between EPA and TDEC. Under this schedule, TDEC is committed to the development of TMDLs for all waterbodies listed in 1998 by 2011. EPA committed to provide better guidance and new tools for developing TMDLs.

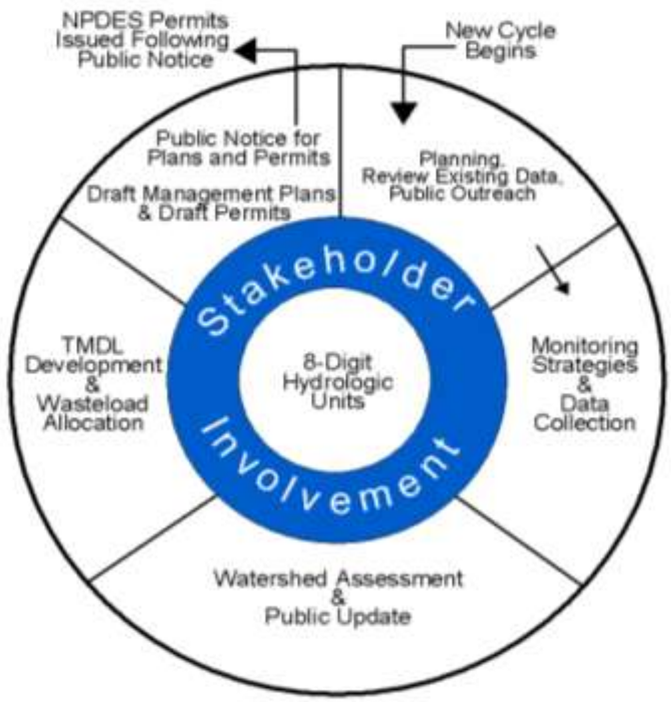


Figure 1: Watershed Cycle

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, then following public participation the permits are issued. Draft watershed management plans are also developed. In 2007, Group 4 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.

NEFO staff member collects a semi-quantitative single habitat sample. Photo provided by Kim Sparks, NEFO.

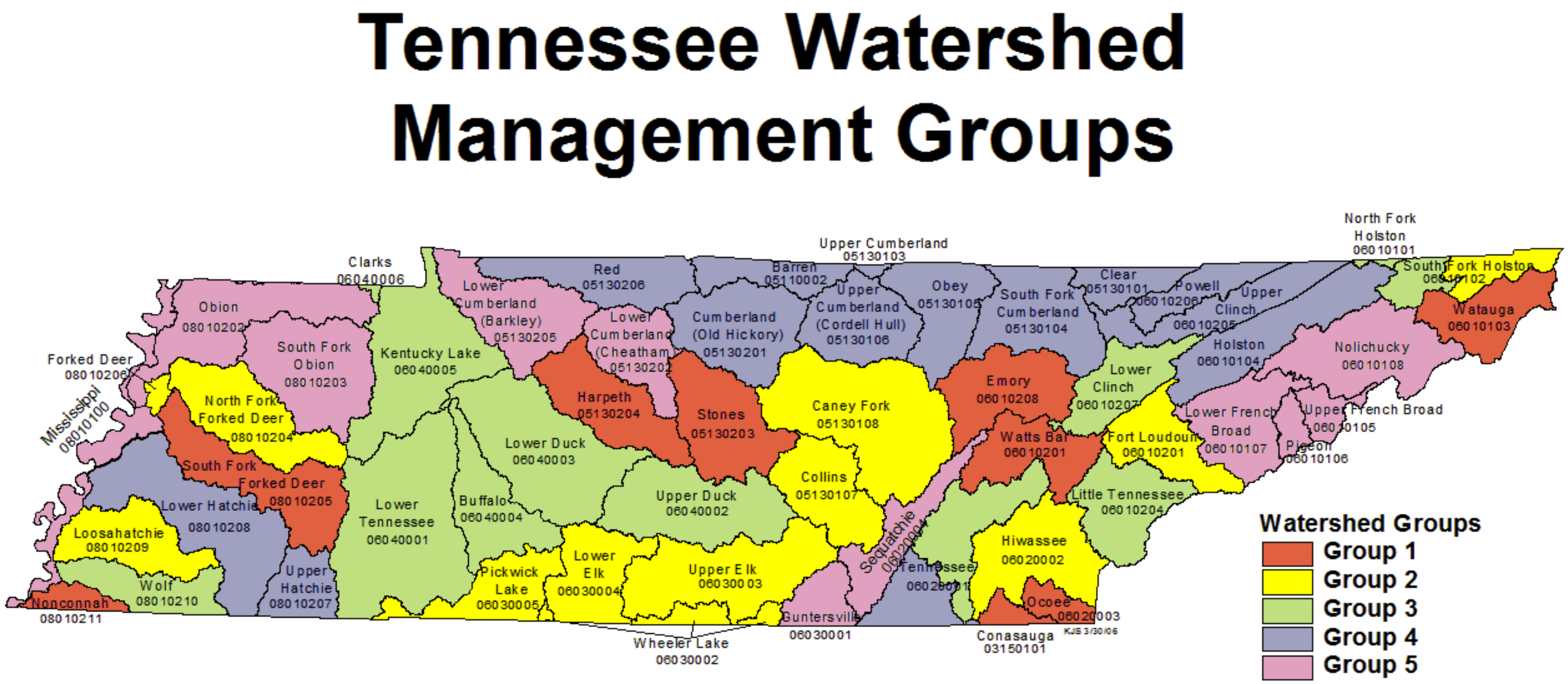


Figure 2: Watershed Monitoring Groups

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, 2006). 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.

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, citizens, and the private sector (Table 3). In December 2006 and January 2008, the division issued a public notice 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 2008 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, 2004) was published in March 2004. Both documents are reviewed annually and revised as needed. 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 utilize 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 recently updated database allows for easy access to bacteriological and chemical information collected throughout the state and nation. TDEC WPC station locations and chemical and bacteriological data are uploaded into the database quarterly. Both current and historical TDEC water quality data are available on STORET at http://www.epa.gov/STORET.

Historical data from the early 1970s through 1999 are stored in the STORET Legacy Data Center. Data uploaded since 1999 are stored in the Modernized STORET database. Both of these databases are accessed through the STORET logo on the first page of the EPA website. Under the heading is a link to an ABOUT STORET webpage, which provides instructions on downloading data from these databases. Data can be retrieved by station name, county, watershed code, or organization name.

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. The ADB was used to store the assessments included in 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://www.state.tn.us/environment/water.shtml.

Information gathered during water monitoring is used to assess water quality. Photo provided by NEFO.

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 has lists of assessment data, 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, and habitat 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 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 impaired. 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.

High levels of silt/sediment can be a problem in many streams. Photo provided by Barbara Loudermilk, Nashville Environmental Field Office.

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 possible 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 the same 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).

2. Assessment Rates for 2008

The division maintains a statewide monitoring system of approximately 6,500 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 600 stations were monitored in Group 1 watersheds in 2006. Another 500 stations were monitored in Group 2 in 2007.

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.

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

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 (31,088 miles) of the stream miles (Figure 3) and almost all (565,805 acres) of the reservoir and lake acres (Figure 4) in the state were monitored and assessed. Forty-nine percent (29,331 miles) of Tennessee's streams and rivers were not assessed during this cycle. Only one percent (6,359 acres) of Tennessee's reservoir and lake acres were not assessed during this cycle.

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. A description of these categories appears below.

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.

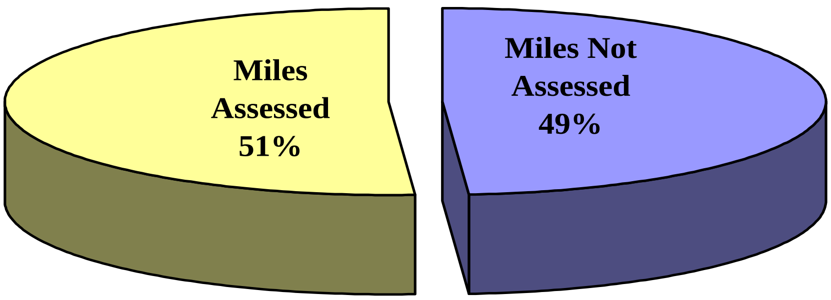


Figure 3: Percent of River and Stream Miles Monitored

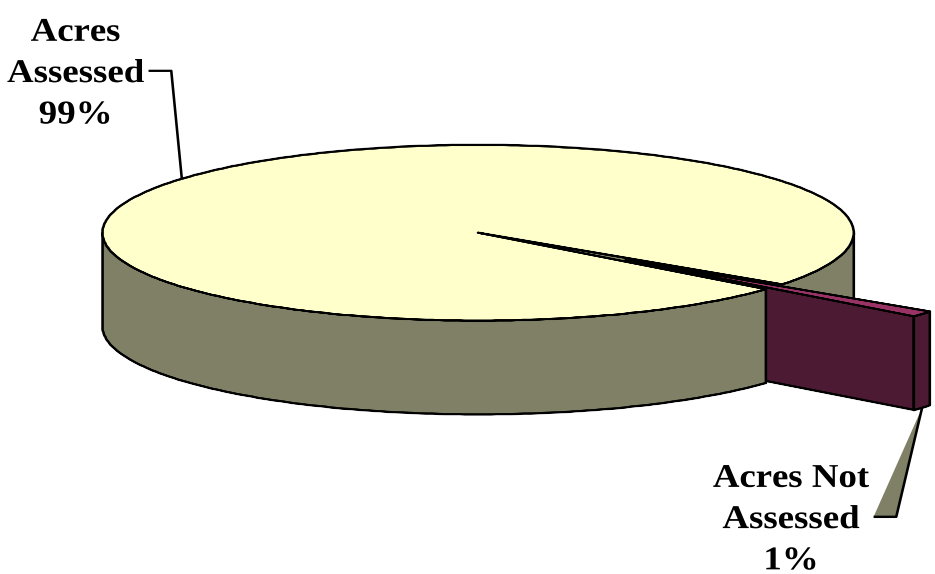


Figure 4: Percent of Reservoir and Lake Acres Monitored

Chapter 2
Water Quality Standards Attainment Status

Consistent with the rotating watershed approach, the 14 watersheds in Group 4 and 11 watersheds in Group 5 have been assessed since the last 305(b) report was published in 2006. 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 60,417 miles of streams and rivers in Tennessee. The division was able to assess half (31,088 miles) of the stream miles in the state (Table 4 and Figure 5). Of the assessed streams, 62 percent are fully supporting of the designated uses for which they have been assessed.

1. 7,121 of the total stream miles (12%) are **Category 1**, fully supporting all designated uses.

2. 12,160 of the total stream miles (20%) 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. 29,331 of the total stream miles (48%) are in **Category 3**. These waters have insufficient data to determine if classified uses are met.

4. 2,392 of the total stream miles (4%) have been identified as **Category 4,** impaired but TMDLs are not needed. 2,272 stream miles (4%) are **Category 4a**, which have had TMDLs for all impairments approved by EPA. 120 stream miles (0.2%) are **Category 4c** where it has been determined that the source of impairment is not a pollutant.

Table 4: Assessed Stream Miles

Category Assessment	Miles
Total Miles	60,417
Total Assessed Miles	31,088
Category 1	7,121
Category 2	12,160
Category 3	29,331
Category 4a	2,272
Category 4c	120
Category 5	9,414

5. 9,414 of the total stream miles (16%) are in **Category 5**, waters that are impaired or threatened and need TMDLs for the identified pollutants. These waters are placed on the 303(d) List.

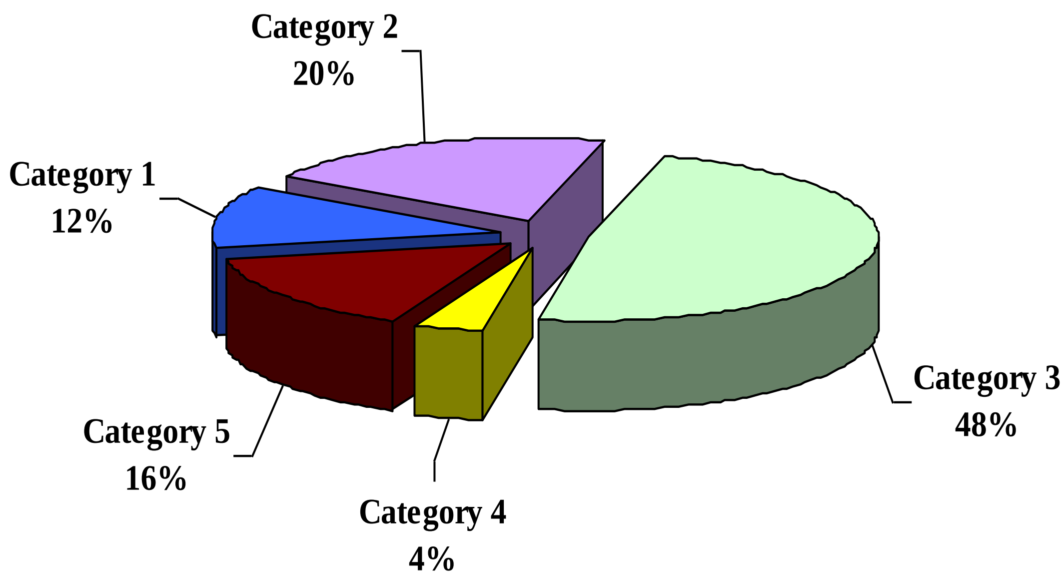


Figure 5: Percent of Rivers and Streams in Each Category

About 39 percent of the stream miles assessed for recreational use failed to meet the criteria assigned to that use. Approximately 30 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	60,417	30,471	21,308	70%
Recreation	60,417	15,400	9,420	61%
Irrigation	60,417	30,942	30,942	100%
Livestock Watering and Wildlife	60,417	30,966	30,962	99.99%
Domestic Water Supply	3,691	3,379	3,354	99%
Navigation	383	0	0	100%
Industrial Water Supply	3,386	3,225	3,225	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.

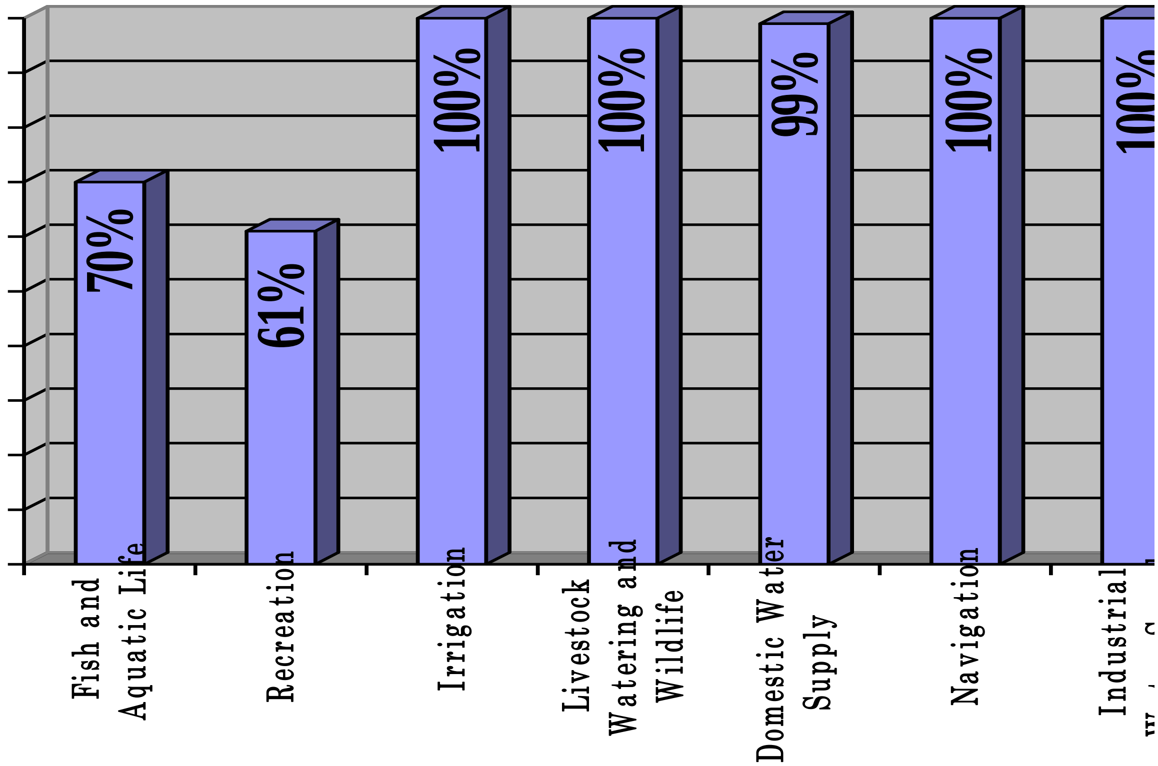


Figure 6: Percent Use Support for Individual Classified Uses in Assessed Rivers and Streams

B. Reservoirs and Reelfoot Lake

Overall Use Support

Table 6: Assessed Reservoir and Lake Acres

Category Assessment	Support Assessment
Total Acres	572,165
Total Assessed Acres	565,805
Category 1	381,561
Category 2	2,319
Category 3	6,359
Category 4	0
Category 5	181,925

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 public 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 565,805 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. 381,561 of the total lake acres (67.4%) are Category 1, fully supporting of all designated uses.

2. 2,319 of the total lake acres (0.4%) are Category 2, fully supporting of some uses, but without sufficient data to determine if other uses are being met.

3. 6,359 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. No lake acres are assessed as Category 4.

5. 181,925 of the total lake acres (31.8%) 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.

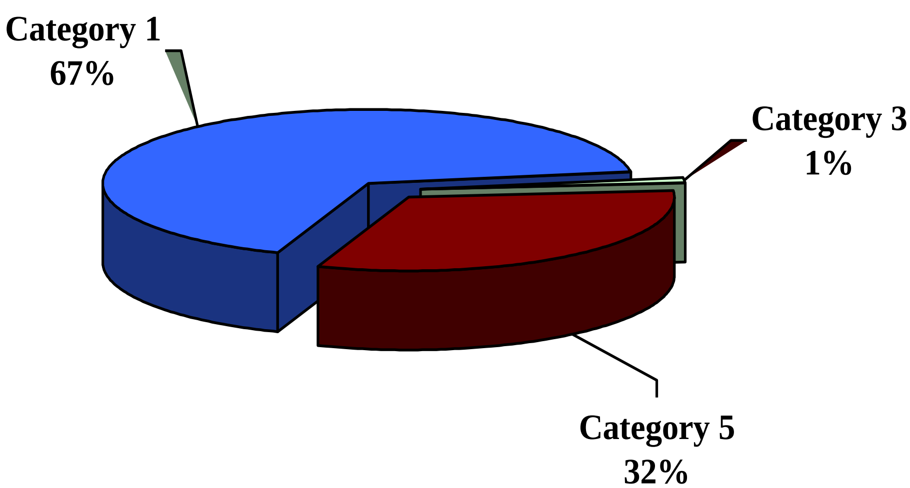


Figure 7: Percent of Reservoir and Lake Acres in Each Category (Category 2 has less than 1 percent. No lake acres were Category 4.)

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 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	572,165	563,904	523,202	93%
Recreation	572,165	565,125	398,289	70%
Irrigation	572,165	563,904	563,904	100%
Livestock Watering and Wildlife	572,165	561,795	561,795	100%
Domestic Water Supply	529,183	526,864	526,864	100%
Navigation	290,741	1,971	1,971	100%
Industrial Water Supply	428,991	428,976	428,976	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.

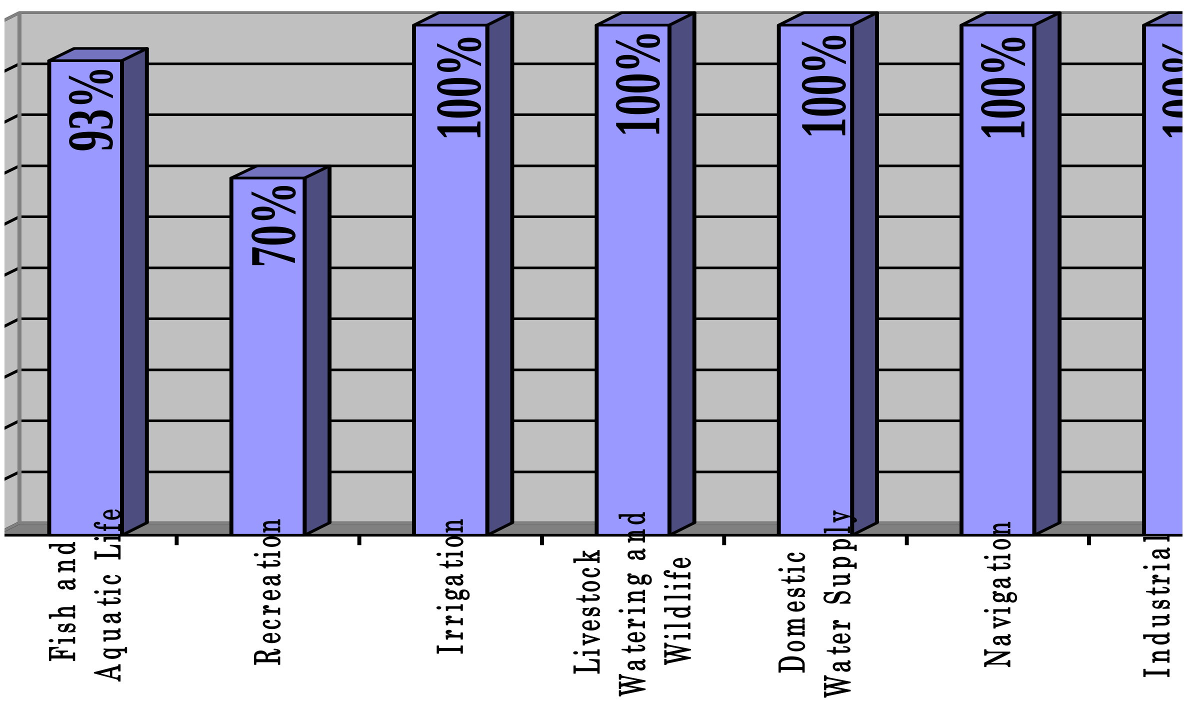


Figure 8: Percent Use Support for Individual Uses in Assessed Reservoirs and Lakes

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.

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

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.

Today, approximately 787,000 acres of wetlands remain in Tennessee, a 60% loss from historic acreage. Of today's existing wetland acres, 7% or 54,811 acres are considered impaired. However, no mechanism exists to accurately measure the loss or gain of wetlands in Tennessee.

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.

Tennessee 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.

Tennessee is developing and implementing the Tennessee Wetlands Conservation Strategy in a phased approach. A wetlands functional assessment method and procedure will increase the state's capabilities assess the condition of wetlands as well as to measure the status of wetland acreage, function, and habitat availability.

Sixty percent of Tennessee's historical wetlands have been lost. Tigrett Wildlife Management Area, Photo provided by Division of Natural Areas.

The purpose of this grant is development of 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.

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).

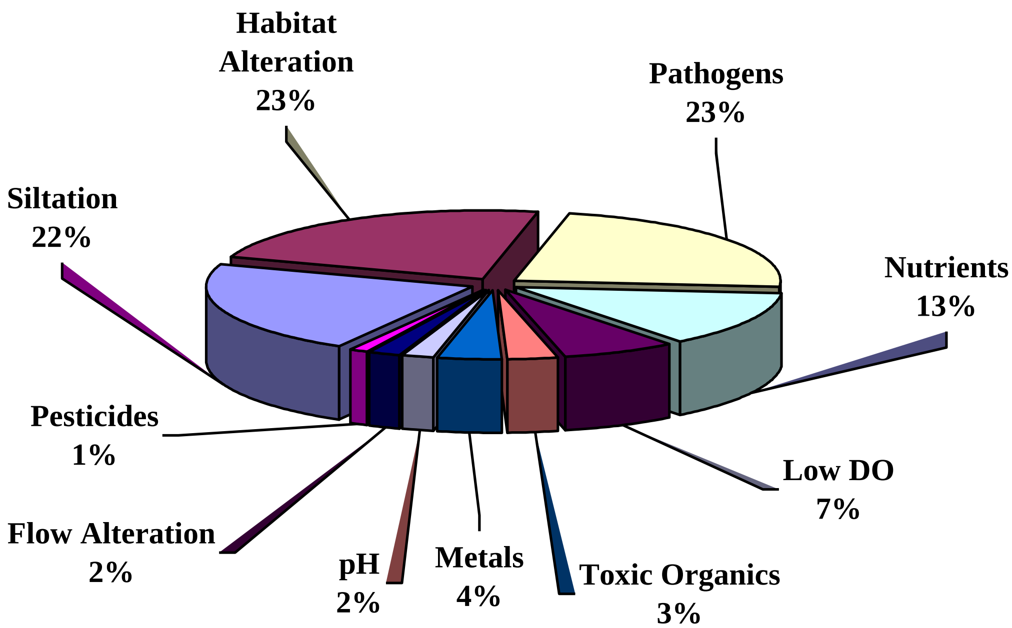


Figure 9: Relative Impacts of Pollution in Impaired Rivers and Streams (Stream Miles)

1. Siltation/Suspended Solids

Silt is one of the most frequently cited pollutants in Tennessee, impacting over 5,500 miles of streams and rivers. 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

Silt in water is one of the largest pollutants in Tennessee. While some erosion is a natural process, tons of soil are lost every year as a result of human activities.

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.

2. Habitat Alteration

Types of Habitat Alterations

Habitat Alteration	Stream Miles Impaired
Alteration in stream-side or littoral vegetative cover…………….....	1,369
Other anthropogenic substrate alterations……………...………	489
Physical substrate habitat alterations……………….…………	3,891

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. Habitat is often removed by agricultural activities, urban development, bridge or other road construction, and /or dredging.

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).

A permit is required to modify a stream or river in Tennessee. The permit will not be issued unless the water resources can be protected. The Natural Resource Section of TDEC issues permits for Aquatic Resource Alteration Permits (ARAP). Additional information can be found at http://www.tn.gov/environment/permits/whoami.shtml.

3. 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 32 streams and rivers posted with a water contact advisory due to high pathogen levels. Over 5,600 stream miles are impaired by *E. coli*. See Chapter 5 for specific information on posted streams and rivers.

4. Nutrients

Another 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. Elevated nutrients cause the aquatic life in a stream or river to shift towards groups that eat algae and that can tolerate dissolved oxygen fluctuations. This can lead to a reduction in biological diversity. Waters with elevated nutrients often have floating algal mats and clinging filamentous algae.

Types of Nutrients

Nutrient	**Stream Miles Impaired**
Nutrient/Eutrophication Biological Indicators………….………	327
Phosphate/Total Phosphorus………………	1,218
Nitrate/Nitrite…………...	1,371
Ammonia (un-ionized)…	30

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. Therefore, 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.

The ecoregion study has increased understanding of the natural distribution of nutrients throughout the state. Using this information, a narrative nutrient criterion has been revised to include goals identified in a document entitled *Development of Regionally-based Interpretations of Tennessee's Narrative Criteria* (Denton *et al*., 2001) or "other scientifically defensible methods" (TDEC-WQCB, 2004).

5. Low Dissolved Oxygen

Depleted dissolved oxygen in water will restrict or eliminate aquatic life. Over 1,700 stream miles have been impaired by low dissolved oxygen. 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.

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.

6. Metals

Types of Metals

Metal	**Stream Miles Impaired**
Mercury…………………	266
Iron.……………………..	211
Manganese….…………..	160
Lead….…………………	96
Arsenic...…………………	84
Copper.………………...	51
Zinc….…………………	51
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. Toxic Organic Contaminants

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. See Chapter 5 for more detail.

Types of Organic Contaminants

Organic Contaminant	**Stream Miles Impaired**
PCBs..………	299
Dioxin………..	256
Chlordane.……	248
RDX….………	63
PAHs………….	31
Creosote……..	7
Acetone…….	2

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

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.

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. 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. Currently, 396 stream miles are listed as impaired by low pH, most in areas with historical mining activities. Disturbance of rock formations during road construction can also release acidity to streams.

9. Flow Alteration

Three hundred seventy-eight (378) 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.

This creek was impaired by an upstream impoundment. Photo provided by Aquatic Biology Section, TDH.

In 2003, the division initiated a study of wadeable streams below small to medium sized impoundments. It was determined that these impoundments often adversely affect macroinvertebrate communities, disrupt habitat, and change water chemistry downstream. The results of this study are discussed in more detail in Chapter 7.

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.

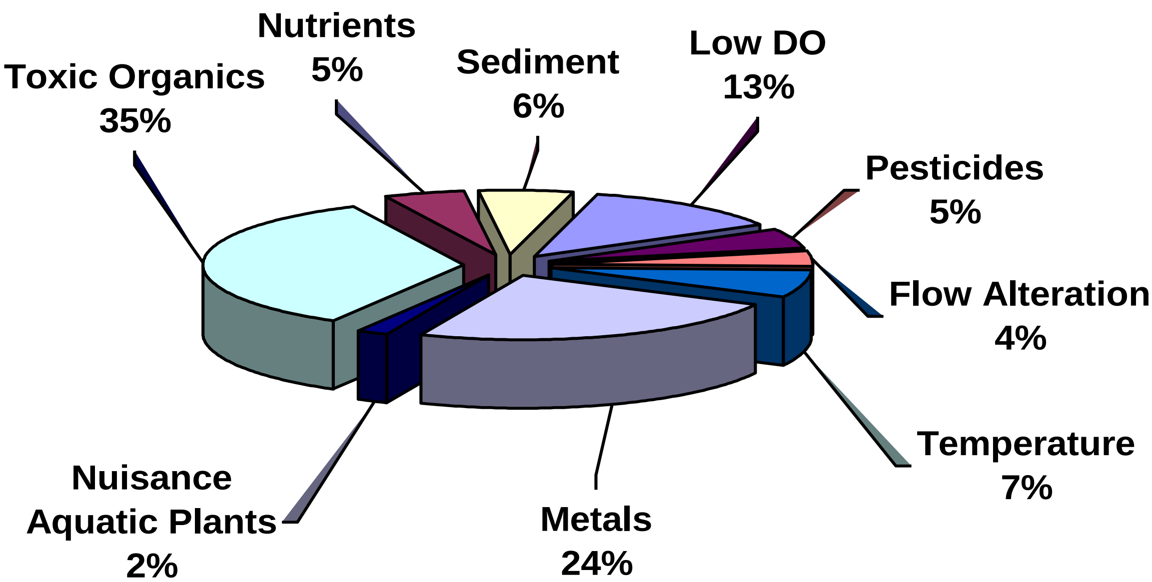


Figure 10: Relative Impacts of Pollution in Impaired Reservoir and Lake Acres

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.

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.

Types of Organic Contaminants

Organic Contaminant	Lake Acres Impaired
PCBs………….	95,596
Dioxins……….	10,370

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

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

Currently, 94,468 lake acres are posted for organic contamination. Chapter 5 has specific information on posted reservoirs and the health hazards of eating contaminated fish.

2. Metals

Types of Metals

Metal	Lake Acres Impaired
Copper………..	2,254
Iron……………	2,254
Mercury………	66,461
Zinc…………...	2,254

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

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.

3. Nutrients

Another major cause of impacts in reservoirs and lakes is 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 hundreds 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.

4. 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.

5. Dissolved Oxygen

Dissolved oxygen is needed for the survival of fish. Longear sunfish photograph courtesy of EPA Image Gallery, Jeff Grabarkiewicz, Wayne Davis and Todd Crail

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 deeper in the reservoir.

The most common reason lakes and reservoirs have fish kills due to low DO is eutrophication. Overproduction of algae raises oxygen levels while the sun is shining, 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 40,000 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. This can result in very low DO levels in the receiving river, stream, or reservoir. Low dissolved oxygen in Barkley Reservoir in 2007 was caused by the discharge of heat from the Cumberland Steam Plant, combined with low flows due to drought and repairs to upstream reservoirs.

6. 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. Over 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	378	11,444**
Nuisance Aquatic Species		
Native Aquatic Plants		4,550**
Loss of Native Species		
Loss of Native Mussel Species	13	
Nutrients		
Nutrient/Eutrophication Biological Indicators	327	15,636**
Phosphate/Total Phosphorus	1,218	
Nitrate/Nitrite	1,371	
Ammonia (un-ionized)	30	
Oxygen Depletion		
Oxygen, Dissolved	1,758	37,979
pH/Acidity/Caustic Conditions		
pH	396	
Sediment		
Sediment/Silt	5,520	18,175**
Solids (Suspended/Bedload)	17	
Pesticides		
Chlordane	248	14,031
Metals		
Manganese	160	
Lead	96	
Copper	51	2,254
Iron	211	2,254
Mercury	262	66,461
Zinc	51	2,254
Arsenic	84	
Chromium, Hexavalent	4	
Pathogens		
Escherichia coli	5,659	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		
Acetone	2	
Dioxins	256	10,370
Polychlorinated Biphenyls (PCBs)	299	95,596
Creosote	7	
Polycyclic Aromatic Hydrocarbons (PAHs)	31	
Toluene	2	
RDX	63	
Other		
Taste & Odor		45
Total Dissolved Solids	1	
Impairment Unknown	164	
Habitat Alterations		
Alteration in Stream-side or Littoral Vegetative Cover	1,369	
Other Anthropogenic Substrate Alterations	489	
Physical Substrate Habitat Alterations	3,891	
Toxic Inorganics		
Chloride	22	
Chlorine	3	
Sulfates	31	
Hydrogen Sulfide	7	
Observed Effects		
Color	5	
Pollutant		
Odor	7	
Oil and Grease		
Oil and Grease	56	
Thermal		
Temperature, Water	105	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.

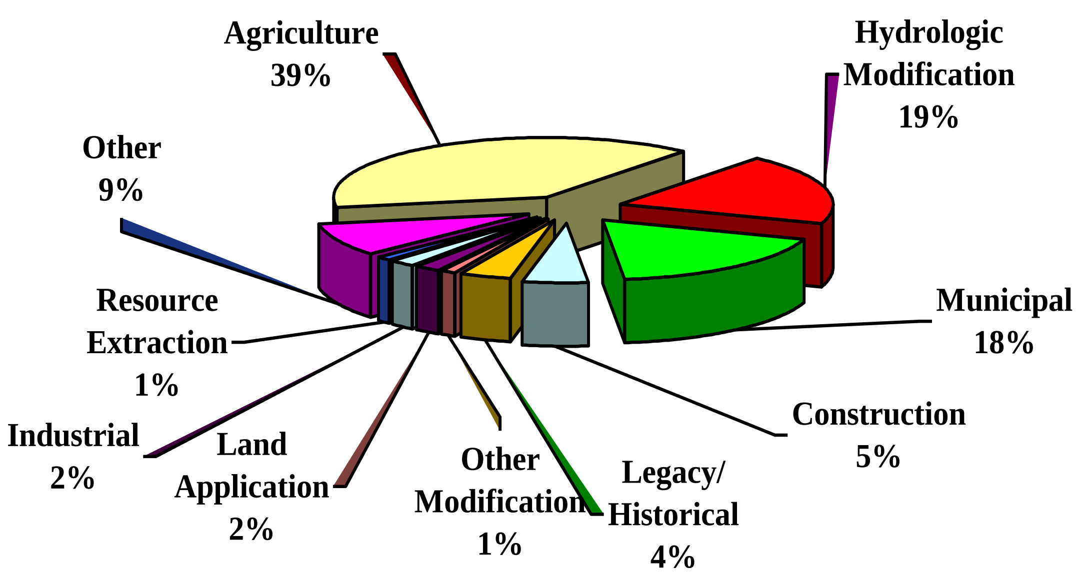


Figure 11: Percent Contribution of Pollution Sources in Impaired Rivers and Streams

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	172	8,767
Stormwater Discharge	25	
Petroleum/Natural Gas	1	
Industrial Thermal Discharges		20,459
Municipal Permitted Dischargers		
Separate Storm Sewer (MS4)	2,059	994
Package Plants	17	
Combined Sewer Overflows	10	994
Sanitary Sewer Overflows	526	1,050
Urbanized (High Density Area)	343	45
Municipal Point Source	574	
Spills and Unpermitted Discharges		
Above Ground Storage Tank Leaks	0.5	
Illicit Storm Sewer Connections	4	
Other Spill Related Impacts	13	
Agriculture		
Specialty Crop Production	14	
CAFOs	22	
Unrestricted Cattle Access	312	
Dairies (Outside Milk Parlor Areas)	12	
Irrigated Crop Production	29	
Grazing in Riparian or Shoreline Zones	4,608	1,531
Animal Feeding Operations (NPS)	210	34
Livestock (grazing or feeding)	7	
Aquaculture (permitted)	3	
Non-irrigated Crop Production	2,294	15,587**
Manure Run-off	1	
Resource Extraction		
Surface Mining	38	
Subsurface/Hardrock	9	
Sand/Gravel/Rock	113	
Dredge Mining	27	
Coal Mining Discharge (permitted)	63	
Hydrologic Modification		
Channelization	3,079	
Dredging (Navigation Channel)	207	
Upstream Impoundment	414	2,469
Flow Regulation/Modification	17	

(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	336	97,850
CERCLA NPL (Superfund)	30	
Abandoned Mine Lands (Inactive)	411	2,254
Internal Nutrient Cycling		15,500**
Mill Tailings	35	2,254
Mine Tailings	35	2,254
Silviculture		
Forest Roads (construction and use)	2	
Harvesting	52	
Land Application/Waste Sites		
On-site treatment systems (septic systems and similar)	262	4
Land Application of Wastewater Biosolids (Non-agricultural)	9	
Landfills	47	
Leaking Underground Storage Tanks	9	
Construction		
Site Clearance	939	10,950**
Hwys. /Roads/Bridges, Infrastructure (new)	105	
Other Modifications (Not directly related to hydromodification)		
Stream Bank Modification/ Destabilization	97	
Loss of Riparian Habitat	119	
Drainage/Filling/Wetland Loss		10,950**
Channel Erosion/Incision from Upstream Modification	25	
Golf Courses	0.5	
Atmospheric Deposition		
Atmospheric Deposition of Acids	12	
Atmospheric Deposition-Toxics	184	66,320
Other Sources		
Sources Outside State Jurisdiction or Borders	234	1,407
Military Base (NPS)	35	
Sources Unknown	1,010	

*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 to approximately 39 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……...	4,608
Non-irrigated Crop Production..	2,294
Unrestricted Cattle Access…….	312
Animal Feeding Operations…...	210
CAFOs………………………...	22
Specialty Crop Production…….	14
Dairies (Outside Milk Parlor Areas)………………………….	12
Irrigated Crop Production……..	29
Manure Run-off……………….	1
Livestock (grazing or feeding)...	7
Aquaculture (permitted)……….	3

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.

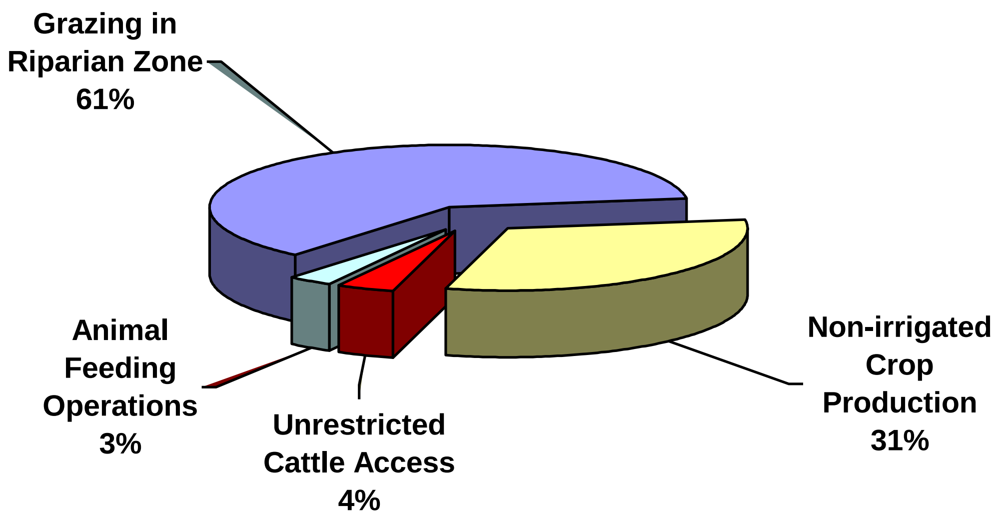


Figure 12: Sources of Agricultural Pollution in Impaired Rivers and Streams

2. Hydrologic Modification

Altering the physical and hydrological properties of streams and rivers is the source of impairment in over 19 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…………………	3,079
Upstream Impoundment………..	414
Dredging (Navigation Channel)..	207
Flow Regulation/Modification…	17

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 unnecessary impairment and enforcement actions.

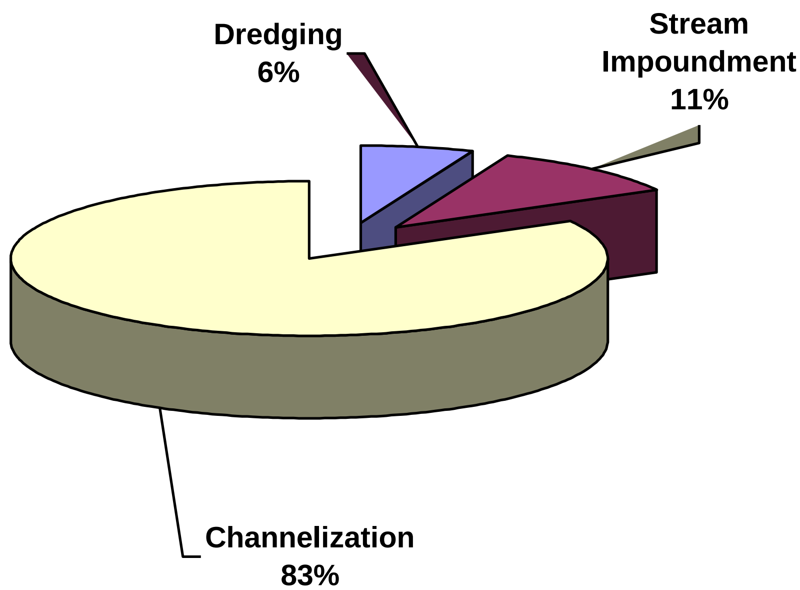


Figure 13: Sources of Habitat Alterations in Impaired Rivers and Streams. (Flow regulation and modification represent less than one percent of the impairments.)

a. Channelization

Channelization is the source of impairment for 83 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.

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. Loss of Riparian Habitat

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 habitat 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

d. Dredging

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.

e. Bank Modification/Destabilization

Modification of river or stream banks causes many water quality and habitat problems. Disturbing banks removes important habitat for fish and other aquatic life. Water quality problems include erosion, sedimentation, and loss of riparian habitat.

3. Municipal Discharges

a. Municipal Stormwater Discharge

As stormwater drains through urban areas, it picks up pollutants from yards, streets, and parking lots and deposits them into nearby waterways. This non-specific 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. 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.

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, 90 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. These program elements are called "minimum control measures" and 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 are now required to control erosion and runoff from their activities, as well as address post-construction stormwater runoff.

b. Combined Sewer Overflow

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 Discharge

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 85 cities and counties covered under the Phase II MS4 general permit are also developing 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

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, 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. The results of these analyses are compared to the 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 stream or river is appropriately 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.

7. Habitat Alteration

Many Tennessee streams have impaired biological communities but do not have obvious chemical pollution. One of the reasons the water quality may be good but the biology of the stream less than expected is the condition of the habitat in which the biological community lives. Changes in habitat can lead to a lack of diversity and density of certain species important to the health of the stream.

Habitat modification can have unfortunate effects. Photo provided by Dan Murray, OSM.

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 down trees along stream banks or mowing to the banks, destabilization of the banks from channelization or riparian grazing, gravel dredging or filling, culverting or directing streams through pipes, and upstream modifications such as dams that impound streams.

8. 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).

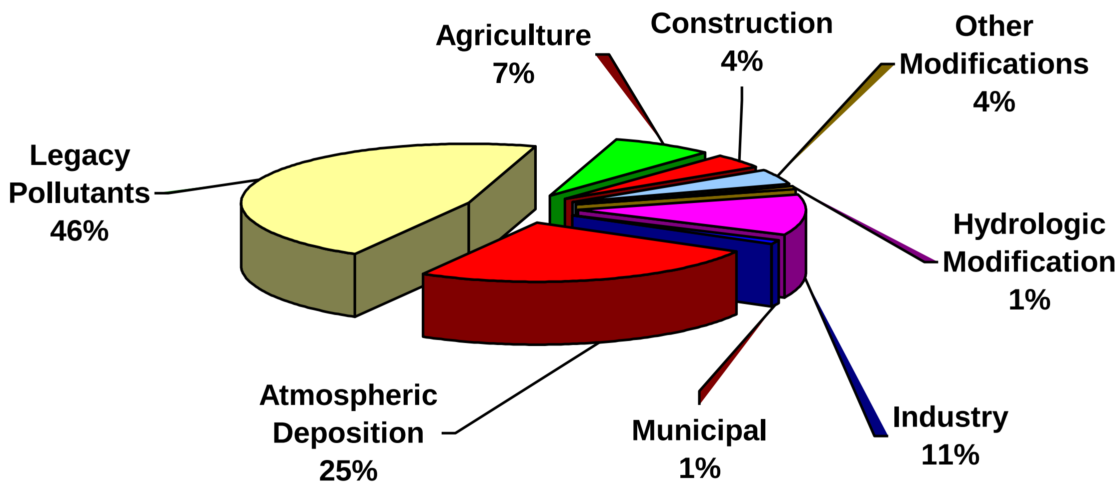


Figure 14: Percent Contribution of Pollution Sources in Impaired Reservoirs and Lakes

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.

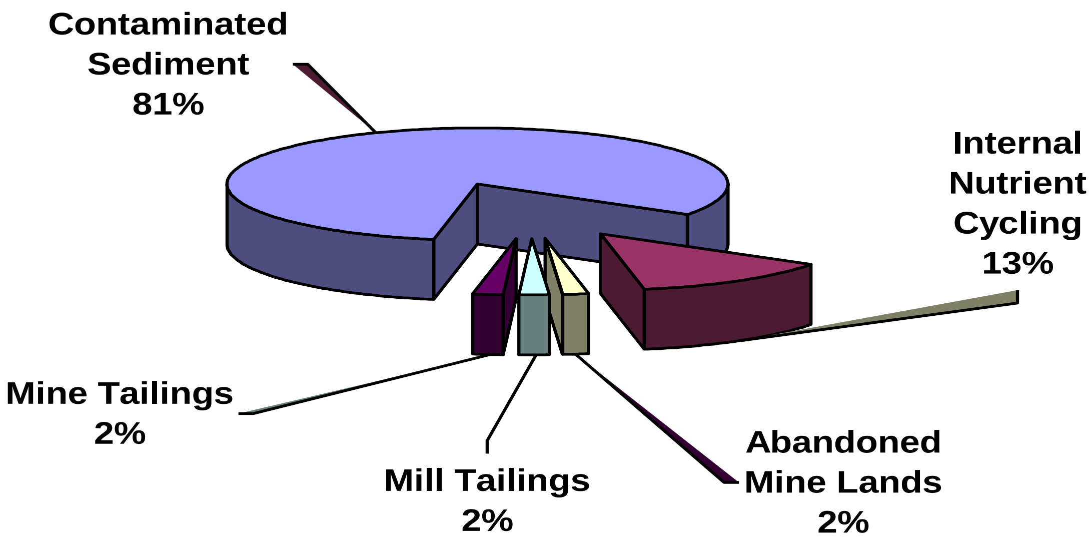


Figure 15: Sources of Legacy Pollutants in Reservoirs and Lakes

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.

Reelfoot Lake is the only lake in Tennessee assessed as affected by internal nutrient cycling. Photo provided by PAS.

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.

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 almost 65,000 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.

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://www.tn.gov/environment/water.

> *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

> Bacteria in Tennessee's streams and reservoirs affect the public's ability to safely swim, wade, and fish in these waters.

About 170 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. 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.

Carp are one of the fish species analyzed for tissue contaminants. Photo provided by Aquatic Biology Section, TDH.

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.

Improperly treated human wastes from such sources as septic tanks, collection system failure and improper connection to sewer or sewage treatment plants contaminate 60 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).

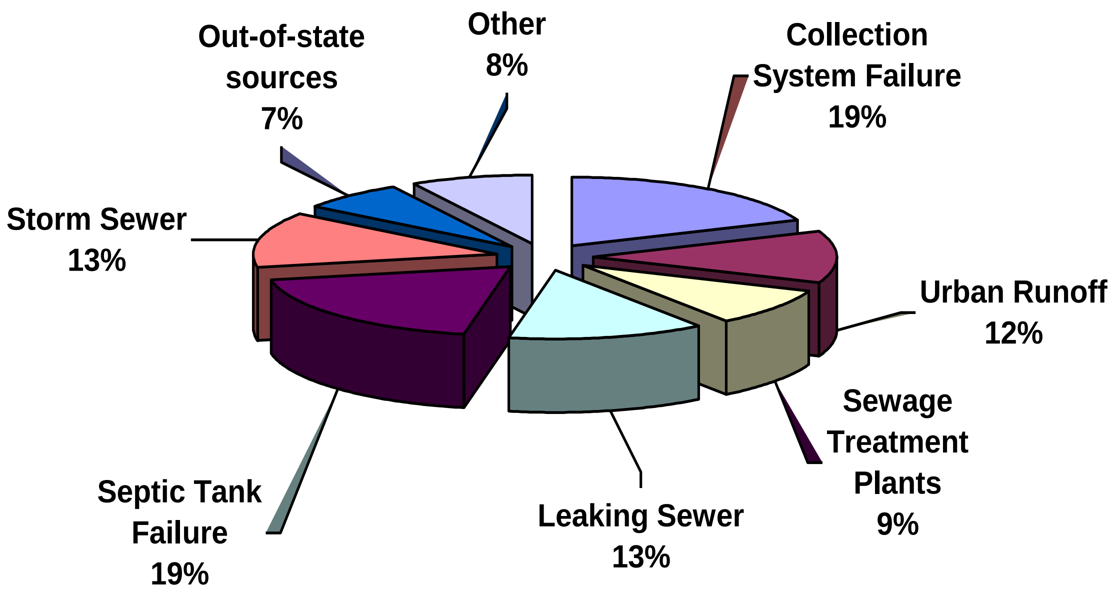


Figure 16: Percent Contribution of Stream Miles Posted for Pathogen Contamination

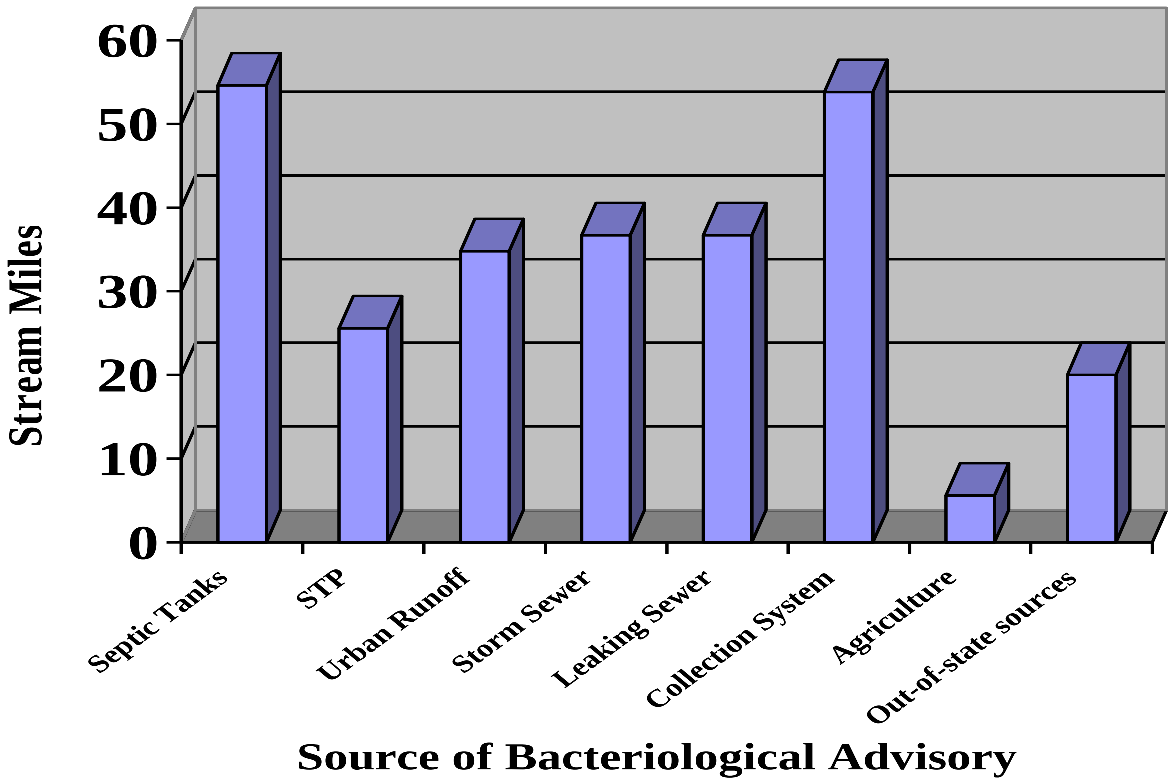


Figure 17: Stream Miles Contaminated by Various Pathogen Sources. (The same stream may be impaired by more than one source of pollution. Totals are not additive.)

TDEC Staff post a sign on the Hiwassee River warning the public to limit or avoid eating largemouth bas due to mercury. Photo provided by Leetha Abazid, Chattanooga Environmental Field Office.

Table 10: Bacteriological Advisories in Tennessee

(April 2008. This list is subject to revision.)

For additional information:
http://www.tn.gov/environment/wpc/publications/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	Mile 0.0 to 1.0		
South Fork	Mile 0.0 to 0.7		
East Fork	Mile 0.0 to 0.8		
North Fork	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.
Sinking Creek Embayment of Fort Loudoun Reservoir	From head of embayment to cave (1.5 miles)	Knox	Knoxville Sinking Creek STP.
Third Creek	Mile 0.0 to 1.4, Mile 3.3	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
East Fork of Third Creek	Mile 0.0 to 0.8	Knox	Knoxville urban runoff.
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)		

B. Fish Tissue Contamination

Approximately 124,000 reservoir acres and 270 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.

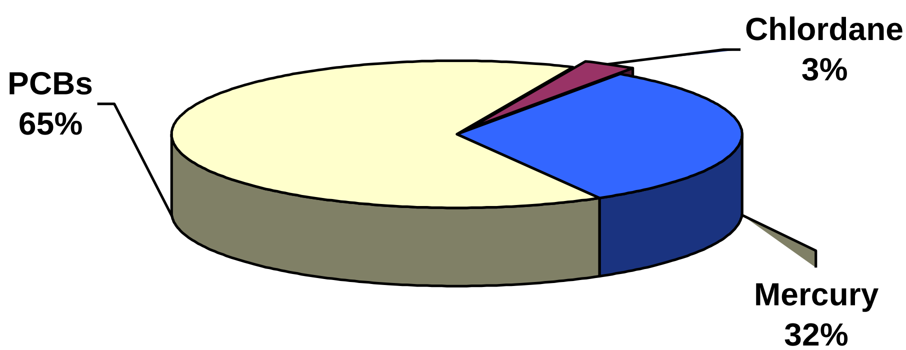


Figure 18: Percent Contribution of Reservoir Acres Posted for Fish Tissue Contamination

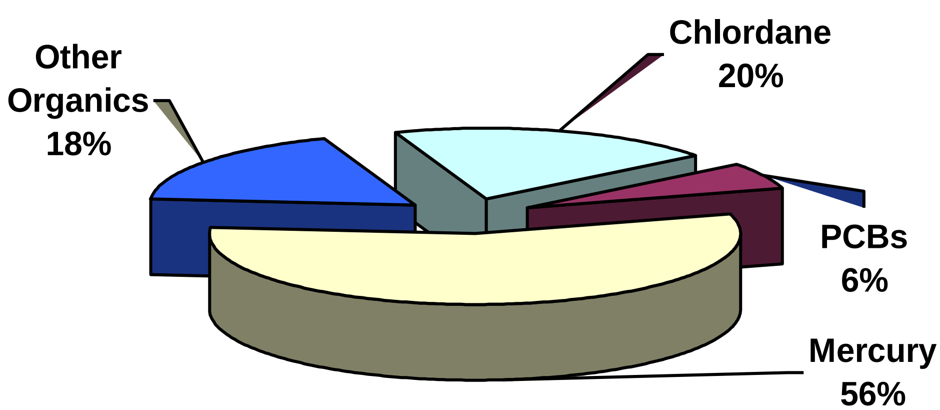


Figure 19: Percent Contribution of Stream Miles Posted for Fish Tissue Contamination

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.

2007 Mercury Advisories

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 implantation procedure was released in 2006, Tennessee was approaching the end of its triennial review of water quality standards. The department decided to not delay the review by attempting to adopt a new mercury criterion after rulemaking had already begun. 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 May 2008, the department issued revised and new advisories based on the new 0.3 ppm trigger point. At several waterbodies with existing “do not consume” advisories for either chlordane or PCBs, the justification for the advisory was modified to include mercury. These waterbodies were the Mississippi River, McKellar Lake, Wolf River, Loosahatchie River, Fort Loudon Reservoir and Tellico Reservoir.

At twelve additional waterbodies (or waterbody segments), new advisories were issued for mercury. These include Duck River, Sequatchie River, French Broad River, North Fork Forked Deer River, Beech Reservoir, Buffalo River, Emory River, Holston River, Hiwassee River, Norris Reservoir, South Holston Reservoir and Watauga Reservoir.

At a few additional sites, mercury levels were over 0.3 ppm in a single species, but an advisory was not issued. The reason was that either few data were available or the data were not recent. In these cases, the waterbodies were put on a 2007 study list. The fish have been collected and at the time of this printing, are being analyzed.

Aquatic Biologist, David Stucki, sets gill nets in Kentucky Reservoir to collect fish for mercury analyses. Photo provided by Aquatic Biology Section, Lab Services, TDH.

For specific information on this federal advisory see EPA’s website at: http://www.epa.gov/waterscience/fishadvice/advice.html.

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

(May 2008. 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. *
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
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.
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.

(Table continued on next page.)

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

Waterbody	County	Portion	HUC Code	Pollutant	Comments
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). *
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. *

(Table continued on next page.)

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

East Tennessee

Waterbody	County	Portion	HUC Code	Pollutant	Comments
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)

Waterbody	County	Portion	HUC Code	Pollutant	Comments
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.

Chapter 6
Success Stories

A. Tennessee's National Leadership in Water Quality Assessment and Waterbody Restoration Tracking, Plus Development of TMDL Studies

Following the approval of the 1998 303(d) Lists, EPA was taken to federal court for the perceived lack of progress in TMDL generation in various states. Tennessee was one of these states.

In the May 10, 2001 Court Order regarding *Tennessee Environmental Council et al. v. United States Environmental Protection Agency et al*. (Civil Action No. 3-01-0032), EPA was required to ensure that the 792 water quality limited segments and associated pollutants identified on the Tennessee's 1998 303(d) list were sufficiently addressed by February 10, 2012 (EPA's deadline). According to the agreement, pollutants on the list could be addressed for one or more of the following reasons:

- a TMDL is submitted by the State of Tennessee
- a TMDL is proposed by EPA
- EPA determines that a TMDL is no longer needed; or,
- a completed TMDL for a water quality limited segment and associated pollutant on a non-1998 list (and of equal or higher TMDL priority) is "substituted" for a 1998 listing.

EPA was required to submit an annual report detailing progress in meeting the requirements of the May 10, 2001 Consent Decree, including an identification of total maximum daily loads (TMDLs) proposed or established in Tennessee each year. Consistent with the schedule set forth in the Consent Decree, EPA was to ensure that 319 water quality limited segments and associated pollutants identified in the 1998 Section 303(d) list were addressed by February 10, 2008 and 438 by February 10, 2009 (Figure 20).

EPA has submitted reports every year from 2002 until 2007 (six reports in all), each report demonstrating Tennessee's compliance with the Consent Decree.

As of March 31, 2008, EPA's National TMDL Tracking System (NTTS) shows that 917 Tennessee water quality limited segments and associated pollutants have had TMDLs approved or established, with TDEC developing TMDLs for all but the Harpeth River Watershed Organic Enrichment/Low Dissolved Oxygen TMDLs. (As a condition of the Consent Decree, EPA developed TMDLs for 15 impacted waters in the Harpeth watershed.)

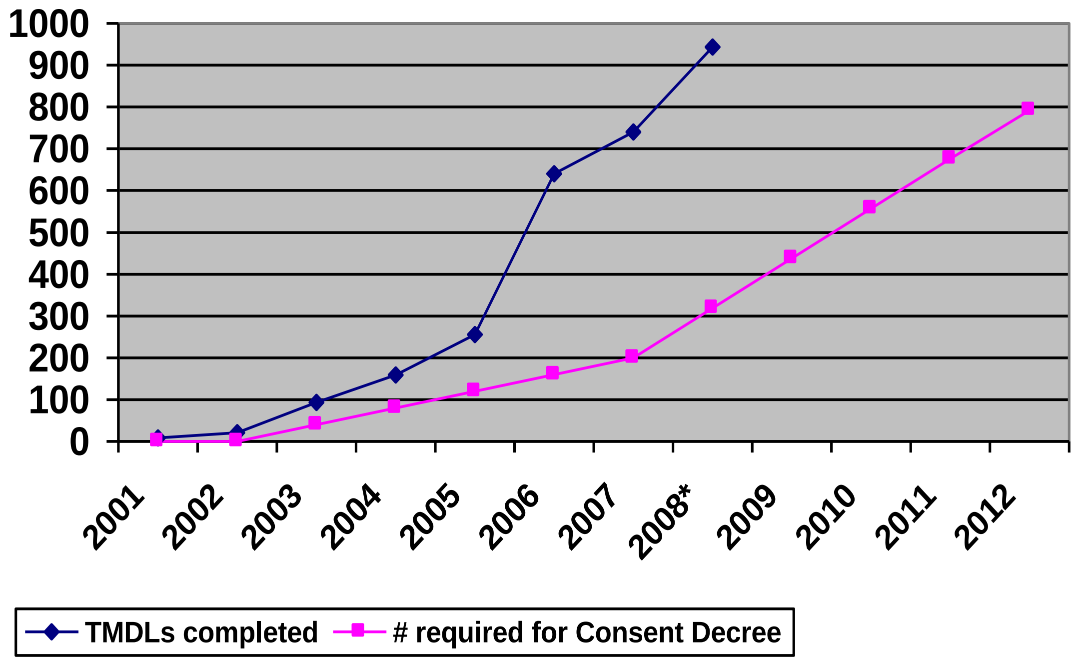


Figure 20: Tennessee's Progress Toward Meeting Consent Decree Goals (2008* as of March 2008)

To underscore WPC's achievements, the State has received two national leadership awards from EPA in the last 16 months:

On October 26, 2006, EPA Regional Administrator Jimmy Palmer presented WPC a special leadership award for developing the second highest number of TMDLs in the entire United States in federal fiscal year 2006 (FY06). In FY08, Tennessee already accounts for approximately 20% of the non-mercury TMDLs approved or established in the U.S. (as reported in NTTS on March 31, 2008).

WPC was also honored with another major award on February 25, 2008, when EPA Assistant Administrator for Water Benjamin H. Grumbles and EPA Region 4 Water Management Division Director Jim Giattina presented an award "for national leadership" in the State's "integrated reporting program through successful tracking of water quality assessments and restoration."

Finally, as of March 31, 2008, Tennessee also accounts for approximately 30% of all reported Section 319 "Nonpoint Source Success Stories" in U.S. waterbodies identified by states as being primarily nonpoint source-impaired and having achieved documented water quality improvements. (See link below.) While this is probably not an indication that Tennessee has more improved streams than other states, it may mean that we are actively tracking and reporting the implementation of control strategies for stream restoration.

http://www.epa.gov/nps/success

From right: Tennessee Department and Conservation Deputy Commissioner Paul Sloan, WPC Director Paul Davis and Rich Cochran accept an award from EPA Assistant Administrator Ben Grumbles.

B. Gradual Increase in Assessment Rates for Rivers and Streams

With over 60,000 miles of streams statewide, it has been a struggle to increase assessment rates (the percentage of streams and rivers statewide than can be assessed in any given cycle), something the department has made a commitment to do. Several factors make the monitoring of previously unassessed streams difficult.

One factor is the pressure to reassess streams previously identified on the 303(d) List. After stream impacts have been documented, WPC makes it a high priority to collect new data in order to either establish that control strategies have improved the stream, or that the stream continues to be degraded. Additionally, specific streams on the 303(d) List may be a high priority for TMDL generation, which may require that new data be collected.

Another constraint is the monitoring required for compliance assurance. Monitoring is frequently directed at sites where permits have been issued in order to evaluate whether or not permit conditions are being met. Additionally, the need to oversee the stormwater program has also diverted resources from monitoring.

In spite of these factors, assessment rates have gradually increased over the last eight years, as shown in the figure 21.

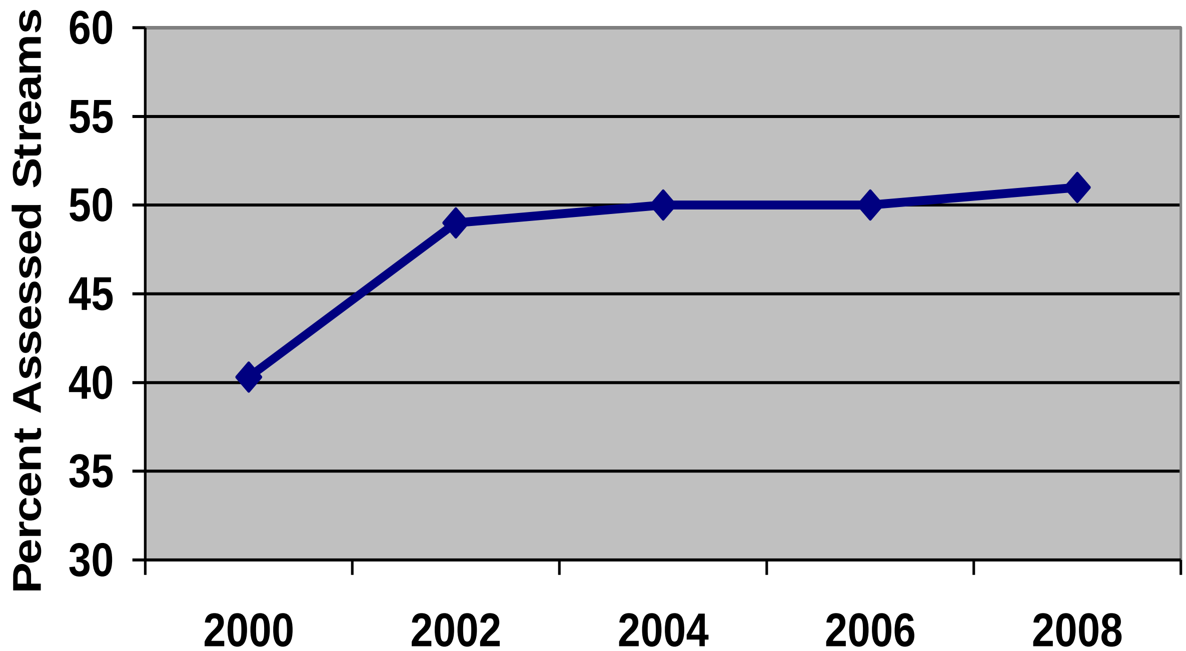


Figure 21: Percent of Stream Miles Assessed per year

While the one percent increase from 2006 to 2008 might on the surface appear small, it should be remembered that each one percent increase represents over 600 miles of newly assessed streams. If stretched out in a straight line, the newly assessed streams in 2008 would reach from Nashville to Dallas.

In each new monitoring cycle, the division tries to identify opportunities to assess new streams. Activities such as complaint investigations, antidegradation reviews, and special monitoring projects based on a randomized station selection, provide chances to assess previously unassessed streams. Additionally, data from other agencies, the regulated community, and citizens are very helpful.

While it might be unrealistic to believe that Tennessee, or any other state, will ever be in a position to assess 100 percent of their waters, it is our intention to continue to make progress toward improving these rates over time.

C. Regulated Municipal Separate Storm Sewer Systems (MS4s)

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, 90 other cities and counties are now covered by the MS4 Phase II general permits.

Each city is required to develop a storm water management plan that will reduce the discharge of pollutants to the maximum extent practicable and not cause or contribute to violations of state water quality standards. The plans must include six minimum control measures:

- Public education and outreach on storm water impacts
- Public involvement/participation
- Illicit discharge detection and elimination;
- Construction site storm water runoff control;
- Post-construction storm water management in new development and re-development;
- Pollution prevention/good housekeeping for municipal (or TDOT) operations.

An example of the success of TDEC's MS4 program is illustrated by the city of Nashville. To address impaired waters in Davidson County, Metro Nashville visually surveyed streams, monitored water quality trends, and reviewed infrastructure repairs and replacements. In 2008, 61 miles of Davidson County streams that were once impaired by pathogens and sedimentation, have shown significant improvements and have been proposed for delisting.

Monitoring data have been collected quarterly. Photo provided by Metro Nashville Water Services.

In order to evaluate effectiveness and demonstrate compliance, MS4s must develop and implement appropriate monitoring programs. Metro Nashville's sampling locations are chosen to correspond with TDEC's ambient monitoring sites so that data could be compared. Data are collected quarterly to examine seasonal variation. During each quarterly event, each site is sampled five times in a 30-day period so that geometric means may be calculated. After obtaining data from the initial two quarters of sampling, Metro and TDEC compared results and found them to be similar. Metro has also compared its current findings to historical data collected during 1996-1997. The data indicate water quality improvements.

Metro Water Services has employed the help of Metro's Police Aviation Department to conduct thermograph investigations. This project utilizes infrared technology and helicopter flights over waterbodies to detect illicit discharges, sewer, and water line breaks not apparent from routine monitoring or stream walking efforts. While much of the current activities are geared toward detection and elimination of point source discharges, Metro plans to increase its efforts on detecting and eliminating non-point sources.

Chapter 7
Special Projects

The division carries out special 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. For example, the dissolved oxygen project looked at regional differences in diurnal dissolved oxygen. Another objective is to augment routine monitoring with specific studies such as the impounded stream project and the national wadeable streams project. These projects are undertaken to answer specific questions about existing water quality or trends.

A. Probabilistic Impounded Stream Project

WPC receives requests to impound streams though the Aquatic Resources Alteration Permit Program (ARAP). Most of these requests are on first to third order streams. Small impoundments are constructed for a variety of reasons including flood control, fishing, livestock, irrigation, industrial use, water supply, and aesthetics. Dams on these small streams not only affect the impounded segment but also could potentially alter downstream reaches. The accumulative effect of multiple headwater impoundments can influence flow regimes and sediment transport in downstream systems.

South Fork Sycamore Creek was one of four streams that supported a healthy macroinvertebrate community downstream of an impoundment. Photo provided by Aquatic Biology Section, TDH.

In 2003, the Tennessee Department of Environment and Conservation, Division of Water Pollution Control was awarded a 104(b)(3) grant to perform a probabilistic monitoring study of 75 streams below small impoundments. The study measured effects of the impoundments on aquatic life, nutrients, dissolved oxygen, pH, iron, manganese, habitat, flow and periphyton density in the downstream stream reaches.

Macroinvertebrate communities were adversely affected in most of the streams sampled. Of the 75 sites below impoundments, only four passed biological criteria guidelines or were comparable to first order references in both seasons sampled. The most frequent change in the benthic community structure was a loss of taxa in the orders that are generally intolerant to pollution: Ephemeroptera, Plecoptera and Trichoptera (EPT).

Lack of adequate flow was one of the biggest problems downstream of impoundments. Approximately one third of the perennial streams that were randomly selected for reconnaissance were dry downstream of impoundments. Of those with flow during the summer reconnaissance, one-fourth had dry channels by the fall sampling period. Thirty-nine percent of the dams with year-round discharge provided insufficient flow to supply adequate habitat for aquatic life during at least one season.

The Rosgen stream classification system was used to characterize the geomorphic effects on streams downstream of dams in the 14 ecoregions surveyed (Rosgen, 1996). Using this classification system, it was apparent that many of the streams below the impoundments had channel structures that were undergoing geomorphic change. Only about half of the streams appeared to have relatively stable channel structures typical of the ecoregion.

Disruption of habitat was a major concern below most of the impoundments. Sediment deposition was the most significant habitat problem in impounded streams. Other frequently documented habitat problems included embeddedness of substrate, instability of banks, loss of stream sinuosity and disruption of bank vegetation.

The most frequently encountered chemical water quality problems below impoundments were elevated iron, manganese and nutrients as well as low dissolved oxygen concentrations. Elevated manganese was the most frequently documented problem. Ammonia was the most frequently elevated nutrient.

Dissolved oxygen in lakes and streams is critical to support fish and aquatic life. Depleted dissolved oxygen may be caused by decay of organic material, respiration of algae, inflow of substantial amounts of ground water, or reduced stream flow. Dissolved oxygen was below criteria in at least one season at 21 of the impounded test sites. Many sites that passed dissolved oxygen criteria during daylight hours did not maintain saturation comparable to reference levels. Streams with dissolved oxygen saturation below this level may not be providing adequate oxygen to support benthic communities appropriate for the ecoregion.

Water temperature is an important component of the aquatic environment. Most facets of life history and distribution of aquatic macroinvertebrates are influenced by temperature. Eight of the impounded streams violated the temperature criterion when sampled. Most of the test sites fell outside the temperature ranges found in regional reference streams.

Approximately half of the impounded test sites had elevated total suspended solids (TSS) compared to regional reference streams. Total suspended solids (TSS) can include a wide variety of material, such as silt and decaying organic matter. High TSS can block light from reaching submerged vegetation. Particles can clog gills, reduce growth rates, decrease resistance to disease and prevent egg and larval development of benthic fauna. Suspended particles absorb heat from sunlight, which can result in higher water temperatures. Pollutants such as bacteria, nutrients, pesticides and metals may attach to sediment particles and be transported to the water where they are released or carried downstream.

High concentrations of heavy metals are toxic to aquatic life while precipitation of metals can render habitat unsuitable for colonization. Iron was above the recommended criterion at 61% of the impounded test sites. Manganese was above the 90th percentile of reference data at almost all sites.

Elevated nutrient concentrations are a common problem in surface waters in Tennessee. Impoundments have a tendency to trap nutrient runoff from surrounding land use, which can accelerate eutrophication. This nutrient rich water is then released to the stream. Nutrients can affect aquatic fauna through the stimulation of algal growth. This in turn can deplete dissolved oxygen levels and render substrates unusable for colonization by aquatic fauna. The presence of excessive nutrients can result in shifts of the benthic community toward organisms that feed on algae and fine organic matter.

Concentrations of total phosphorus, total ammonia, nitrate+nitrite and total Kjeldahl nitrogen (TKN) below each impoundment were compared to the reference database and first order reference streams to determine if excess nutrients were available for algal growth. Ammonia was the most frequently elevated nutrient, followed by total phosphorus, TKN, and nitrate+nitrite.

When compared to ecoregion or first order reference sites, about half of the impounded streams had elevated periphyton density. Algae were abundant at more sites in the fall than in the summer probably due to lower canopy and less flow in the fall. More sites had elevated microalgal density than filamentous macroalgae. However, the sites with filamentous algae had more severely impaired macroinvertebrate communities. Worms and midges dominated most of these samples. Macroalgae abundance showed a direct relationship with nutrients (TKN) and percent canopy. The results of this study can be found at: http://state.tn.us/environment/wpc/publications/isp_report.pdf

B. Nutrient TMDL Development Project in the Tennessee Portion of the Upper Elk River (06030003) and Lower Elk River (06030004) Watersheds

Tennessee and Alabama are collaborating to develop nutrient TMDLs for the Upper and Lower Elk River watersheds. TDEC personnel began collecting nutrient data in June of 2006 and will continue until June 2008. TMDL development requires an intensive sampling effort of the Elk River watershed to determine the sources and extent of nutrient impairment, quantify nutrient loadings and source contributions, and develop cause and effect relationships between nutrient loading and response parameters. This project will verify nutrients loads and source contributions for the Elk River Watershed.

C. National Demonstration of Randomized-design for Assessment of Wadeable River and Streams Project

Between 2000 and 2004, EPA partnered with state and federal agencies to conduct the Wadeable Streams Assessment (WSA), the first statistically valid survey of wadeable streams throughout the conterminous U. S. Nationwide, 1,392 sites were chosen randomly to represent the conditions of all streams in Level II ecoregions. In order to ensure that results were comparable, participants used EPA's Environmental Monitoring and Assessment Programs (EMAP) protocols, which include rigorous quality control.

Tennessee's participation in this study began in 2004 when WPC staff sampled the 20 randomly selected sites and 3 reference sites located in Tennessee (Table 12). Macroinvertebrates were sampled using both EMAP protocols and TDEC's *Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys* (TDEC, 2003).

The duplicate biological samples collected according to TDEC's protocol were used for comparability analyses. Results of the benthic macroinvertebrate sampling methodologies were compared to see if they yielded similar assessments of stream conditions (Table 12). TDEC's approach to monitoring looks at Level IV ecoregions, so it is more sensitive than this nationwide study.

Table 12. Comparison of National Study Sites to Tennessee Sites in the Southern Appalachian Region

	WSA (Good Category)	Tennessee (Met Regional Expectations)
Ecological Condition	21%	61%
Nitrogen	39%	100%
Phosphorus	44%	72%
Acidity	96%	94%
Riparian Disturbance	23%	56%
Fine Sediments	41%	28%
Riparian Vegetative Cover	54%	50%
Instream Habitat	62%	39%

D. Tennessee Probabilistic Wadeable Streams Study 2007

In 2007, Tennessee continued the probabilistic-based study of streams in Tennessee that will build upon work previously accomplished during EPA's 2004 Wadeable Streams Assessment (WSA). Biological, physical, and chemical data from a random sub-sampling of Tennessee streams will be extrapolated to all wadeable streams in Tennessee. These data will provide a baseline to which future efforts can be compared, thus providing an opportunity for scientifically valid trend analysis.

One of the stations in the wadeable streams study was on Indian Creek in Grainger County. Photo provided by Jonathan Burr, KEFO.

The state was divided into three regions with the goal of establishing 30 randomly selected stations on wadeable streams in each region. Stations that were previously sampled during EPA's 2004 National Wadeable Streams Probabilistic Study were identified. A list of additional randomly-selected wadeable streams was acquired from the EPA Corvalis Laboratory following the same protocol as the national study. The lists included both a primary draw and an over-draw to be used if the primary sites were disqualified due to factors such as lack of water or inaccessibility.

Field reconnaissance of randomly selected sites in all three regions was conducted to determine study suitability. Ninety stations were selected, 30 randomly-selected stations in each of three areas based on aggregated Level III ecoregions in Tennessee: East Tennessee including the Blue Ridge Mountains (66), Ridge and Valley (67), Southwestern Appalachians (68) and the Central Appalachians (69); Middle Tennessee including the Interior Plateau (71), and West Tennessee including the Southeastern Plains (65), Mississippi Alluvial Plain (73) and the Mississippi Valley Loess Plains (74).

Four seasons of nutrient sampling, five bacteriological samples, six summer/fall surveys of habitat, macroinvertebrates, and periphyton will be completed by June 2008. TDEC will then begin analyzing data with the final report target for completion in February 2009.

Some of the goals of the study are to:

- Compile the data within each region to calculate results including exceedance rates, support for designated uses, causes of impacts, and sources of pollutants
- Analyze data from within each area to compare and contrast water quality in each of the three regions (east, middle, and west)
- Compile assessment information from all stations to extrapolate results to the entire state
- Compare probabilistic results and extensive targeted monitoring program
- Establish baseline data for trend analyses.

E. National Probabilistic Survey of the Nation's Lakes and Reservoirs

During the summer of 2007, WPC cooperated with states, tribes, and federal agencies in a broad-scale study to assess the Nation's lakes and reservoirs with both confidence and scientific credibility. Twelve reservoirs were randomly selected in Tennessee (Table 13).

Table 13. National Lake Study Sites in Tennessee

Name	County	Area	Type
Nickajack Reservoir	Marion	4,197	TVA
Thousand Oaks	White	38	Private
Barrs Chapel Lake	Henry	80	Private
Lake Ocoee	Polk	745	TVA
Burgess Falls Lake	Putnam	30	State Park
Pickwick Reservoir	Hardin	16,819	TVA
Cedar Lake	Henderson	57	TVA
Elaine Lake	Bedford	12	Private
Lake Woodhaven	Dickson	19	State Park
Cheatham Lake	Montgomery	3,015	USACE
Douglas Lake	Hamblen	11,681	TVA
Lake Catherine	Cumberland	17	Private

This project will estimate the current status, trends, and changes in selected trophic, ecological, and recreational indicators of the condition of the nation's lakes with statistical confidence. It will further seek associations between selected indicators of natural and anthropogenic stresses and indicators of ecological condition. TDEC employees monitored the selected lakes in the summer of 2007. Staff took measurements of dissolved oxygen, temperature, conductivity, pH, water chemistry, turbidity, color, and Secchi disc transparency as trophic indicators. In order to determine ecological integrity, the staff surveyed diatom, macrobenthos, zooplankton, and phytoplankton assemblages and shoreline physical habitats. Pathogen indicator organisms and algal toxins were examined as well. Samples were delivered to EPA. The results should be available in the fall of 2008 from the EPA website.

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 our website at:
http://www.state.tn.us/environment/wpc/ppo/

Annie Goodhue (WPC, NEFO) teaches about aquatic life at Earth Camp in Stewart County. Photo provided by Kim Sparks (NEFO).

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://www.tn.gov/environment/

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.

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 20 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.

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).

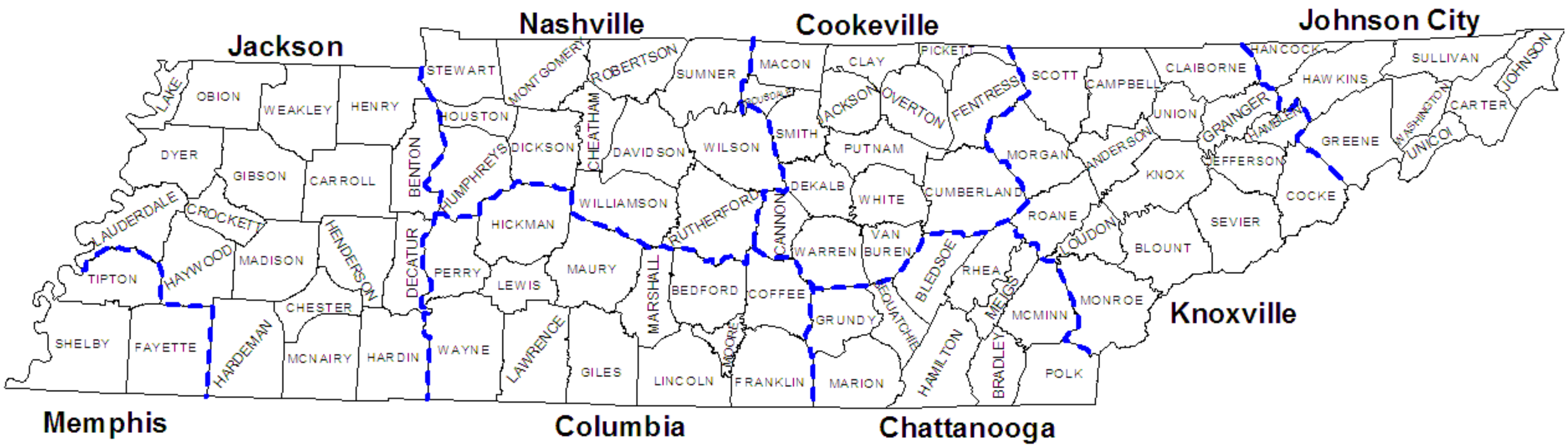
Bulldozers or backhoes in a stream removing gravel or rocks.

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

Sewage pumping stations discharging directly or indirectly into a stream.

Manholes overflowing.

Jackson EFO (J)	**Nashville EFO(N)**	**Cookeville EFO (CK)**	**Johnson City EFO (JC)**
1625 Hollywood Drive Jackson, TN 38305 Fax 731-661-6283 **731-512-1300** WPC Mgr-Pat Patrick Director – Rudy Collins Administrator – Carol Pollan	711 R.S. Gass Blvd. Nashville, TN 37243 Fax 615-687-7078 **615-687-7000** WPC Mgr – Joe Holland Director – Barry Brawley Administrator – Steve Janes	1221 South Willow Ave. Cookeville, TN 38506 Fax 931-432-6952 **931-432-4015** WPC Mgr – Rob Howard Director – Jimmy Lee Clark Administrator – D. Jan Tollett	2305 Silverdale Road Johnson City, TN 37601-2162 Fax 423-854-5401 **423-854-5400** WPC Mgr – Jeff Horton Director – Mark Braswell Administrator – Judy Jarrett



Memphis EFO (M)	**Columbia EFO (CL)**	**Chattanooga EFO (CH)**	**Knoxville EFO (K)**
Suite E-645, Perimeter Park 2510 Mount Moriah Road Memphis, TN 38115-1520 Fax 901-368-7979 **901-368-7939** WPC Mgr – Terry Templeton Director – Cindy Patton Administrator – Bill Relker	2484 Park Plus Drive Columbia, TN 38401 Fax 931-380-3397 **931-380-3371** WPC Mgr – Tim Wilder Director – Joe Holmes Administrator – Shelia Woodard	Suite 550, State Office Bldg. 540 McCallie Ave. Chattanooga, TN 37402 Fax 423-634-6389 **423-634-5745** WPC Mgr – Richard Urban Director-Steve Baxter Administrator – Andra Kelley	3711 Middlebrook Pike Knoxville, TN 37921 Fax 865-594-6105 **865-594-6035** WPC Mgr – Paul Schmierbach Director – Phil Chambers Administrator – Mark Sweat

Figure 22: 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
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
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
EPA:	United States Environmental Protection Agency

Acronyms (continued)

EPT:	Ephemeroptera (Mayflies) Plecoptera (Stoneflies) Trichoptera (Caddisflies)
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
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
TKN:	Total Kjeldahl Nitrogen
TMDL:	Total Maximum Daily Load

Acronyms (continued)

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
WPC:	Water Pollution Control
WSA:	Wadeable Streams Assessment
WQCB:	Water Quality Control Board
WET:	Whole Effluent Toxicity
WQDB:	Water Quality Database
WWTP:	Waste Water Treatment Plant

References

Arnwine, D.H., J.I. Broach, L.K. Cartwright and G.M. Denton. 2000. *Tennessee Ecoregion Project.* Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee.

Arnwine, D.H. and G.M. Denton. 2001. *Development of Regionally-Based Numeric Interpretations of Tennessee's Narrative Biological Integrity Criterion.* Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee.

_________. 2001. *Habitat Quality of Least-Impacted Streams in Tennessee.* Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee.

Arnwine, D.H., Sparks, K. J., and James, R. R. 2006. *Probabilistic Monitoring of Streams below Small Impoundments in Tennessee.* Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers.* EPA 841-B-99-002. U.S. Environmental Protection Agency, Office of Water, Washington D.C.

Denton, G.M., D.H. Arnwine and S.H. Wang. 2001. *Development of Regionally-Based Interpretations of Tennessee's Narrative Nutrient Criterion.* Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee.

Denton, G.M., K.J. Sparks, D.H. Arnwine, and L.K. Cartwright. 2006. *2006 305(b) Report - The Status of Water Quality in Tennessee.* Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee.

Griffith, G.E., J.M. Omernik, and S.H. Azenedo. 1997. *Ecoregions of Tennessee*. EPA/600-R-97-022. U.S. EPA, National Health and Environmental Effects Research Laboratory. Corvallis, OR.

National Oceanic and Atmospheric Administration (NOAA) 2007. *Climate of 2007 August in Historical Perspective, Including Boreal Summer*. U.S. Department of Commerce, National Climatic Data Center, Ashville, North Carolina.

_______. 2007. *Climatological Data Annual Summary Tennessee 2006*. Volume 111, Number 13, U.S. Department of Commerce, National Climatic Data Center, Ashville, North Carolina.

References (continued)

________. 2007. *Climatological Data Tennessee January-October 2007*. Volume 112, Numbers 1-10, U.S. Department of Commerce, National Climatic Data Center, Ashville, North Carolina.

Rosgen, Dave. 1996. *Applied River Morphology*, Wildland Hydrology, Pagosa Springs, Colorado.

Tennessee Department of Environment and Conservation. 2007. *Tennessee Division of Water Pollution Control Monitoring and Assessment Program Plan*, Including Fiscal Year 2007 - 2008 Section 604(b) Information. Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee.

_________. 2006. *Final Version Year 2006 303(d) List.* Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee.

_________. 2006. *Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys.* Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee.

_________. 2006. *Quality Assurance Project Plan for 106 Monitoring in the Division of Water Pollution Control.* Volume I. Revision 3. Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee.

_________. 2006. *Tennessee Ground Water 305b Water Quality Report*. Ground Water Management Section, Tennessee Department of Environment and Conservation, Division of Water Supply. Nashville, Tennessee.

_________. 2004. *Quality Systems Standard Operating Procedures for Chemical and Bacteriological Sampling of Surface Water.* Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee

_________. 2003. *Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys.* Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee.

Tennessee Department of Environment and Conservation, Water Quality Control Board. 2007. *Rules of the Tennessee Department of Environment and Conservation Division of Water Pollution Control*, Chapter 1200-4-3, General Water Quality Criteria. Tennessee Department of Environment and Conservation. Nashville, Tennessee.

References (continued)

________. 2007. *Rules of the Tennessee Department of Environment and Conservation Division of Water Pollution Control*, Chapter 1200-4-4, Use Classifications for Surface Waters. Tennessee Department of Environment and Conservation. Nashville, Tennessee.

Tennessee Secretary of State. 2005. *Tennessee Blue Book 2005-2006*. Secretary of State, Division of Publications. Nashville, Tennessee.

_________. 1999. *The Tennessee Water Quality Control Act of 1977 including the 1998 amendments.* Secretary of State, Division of Publications. Nashville, Tennessee.

United States Congress. 2000. *Federal Water Pollution Control Act As Amended Through P.L. 109-308.* 33 U.S.C. 1251 et. seq. Washington D.C.

United States Environmental Protection Agency. 2006. *Wadeable Streams Assessment: A Collaborative Survey of the Nation's Streams*. Office of Research and Development, Office of Water. Washington, D.C.

________. 2005. *Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d) and 305(b) and 314 of the Clean Water Act.* Watershed Branch. Assessment and Watershed Protection Division, Office of Wetlands, Ocean, and Watersheds, Office of Water. Washington D.C.

_________. 1997. *The Incidence and Severity of Sediment Contamination in Surface Water of the United States:* National Sediment Quality Survey, Volume 1. Office of Science and Technology. Washington, D.C.