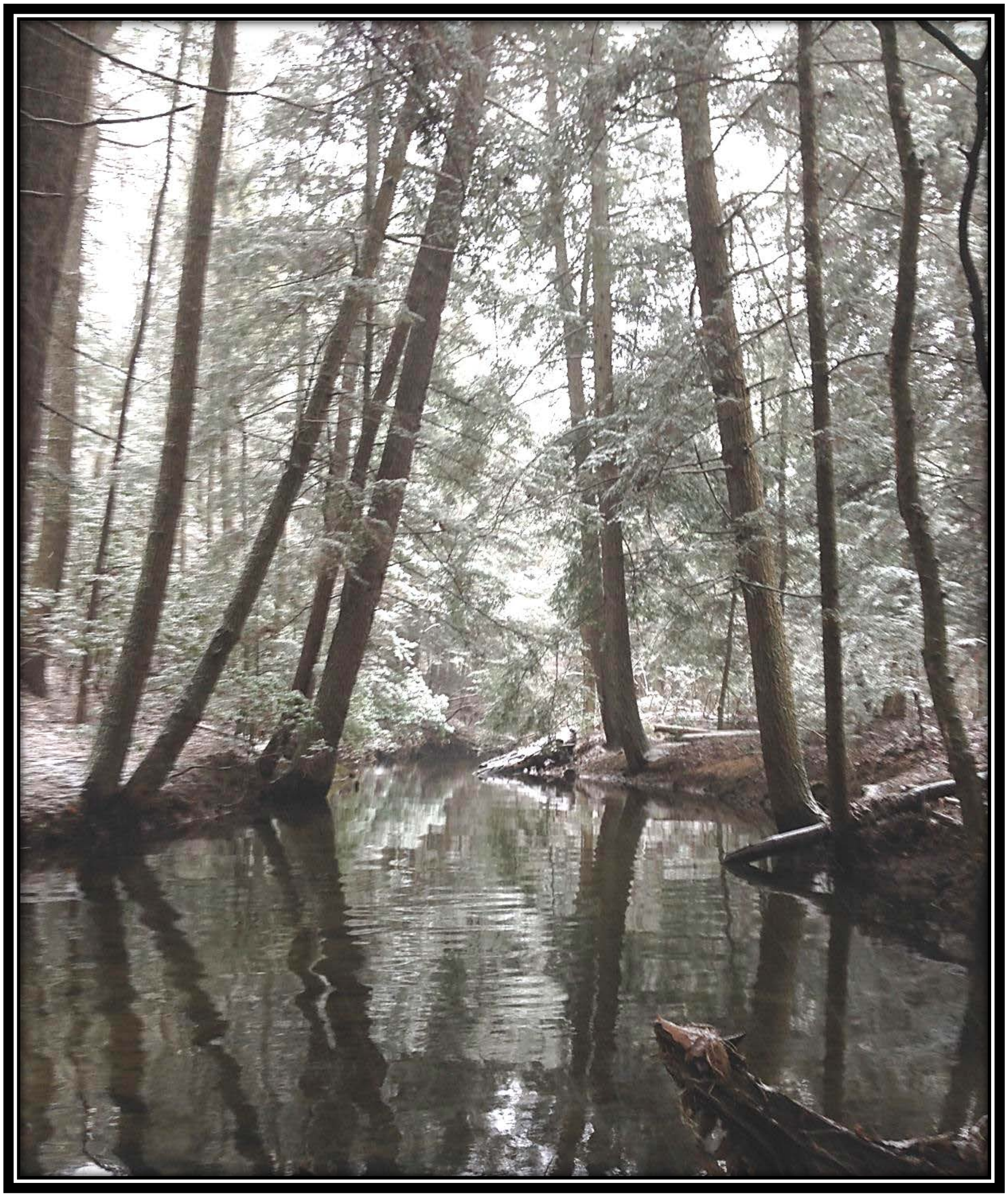
2014 305(b) Report
The Status of Water Quality in Tennessee



Division of Water Resources
Tennessee Department of Environment and Conservation

2014 305(b) Report
The Status of Water Quality in Tennessee

December 2014

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Cover Photo: Myatt Creek in Catoosa Wildlife Management Area. *Photo courtesy of Brandon Chance, Cookeville Environmental Field Office, DWR.*

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Introduction to Tennessee's Water Quality

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

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

- Describing the water quality assessment process (Chapter 1).
- Categorizing waters in the State by placing them in the assessment categories suggested by federal guidance (Chapter 2).
- Determining causes and sources of pollution (Chapters 3 and 4)
- Identifying waterbodies that pose eminent human health risks due to elevated bacteria levels or contamination of fish (Chapter 5).

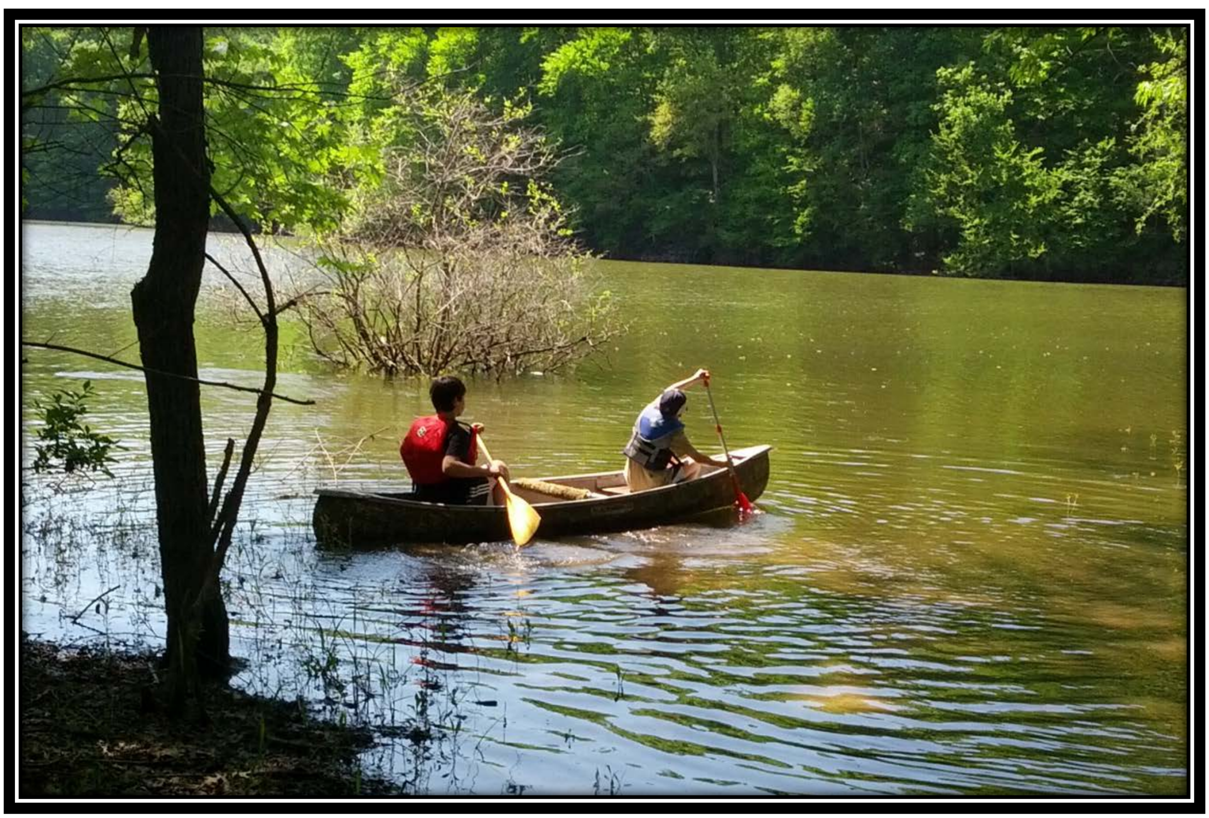


Photo provided by Jimmy Smith, TDEC, DWR, Natural Resources Section

Acknowledgments

The authors would like to express appreciation to the Division of Water Resources staff of TDEC's regional Environmental Field Offices (EFOs) who collected stream, river, lake and reservoir data documented in this report. The managers of the staff in these offices during the period covered by this report were:

Terry Templeton and Joellyn Brazile	Memphis EFO
Pat Patrick and Conner Franklin	Jackson EFO
Joey Holland and Ann Morbitt	Nashville EFO
Dick Urban and Jennifer Innes	Chattanooga EFO
Paul Schmierbach and Michael Atchley	Knoxville EFO
Jeff Horton and Chris Rhodes	Johnson City EFO
Ryan Owens	Columbia EFO
Bill Hall and Johnny Walker	Cookeville EFO

The division recognizes the support of the Department of Health, Environmental Laboratories, which performed the majority of chemical and biological analysis associated with this report. Dr. Bob Read is the laboratory director.

The information compiled in this 2014 water quality assessment document includes data provided by many state and federal agencies. These agencies include Tennessee Department of Health (TDH), Tennessee Valley Authority (TVA), U. S. Environmental Protection Agency (EPA), Tennessee Wildlife Resources Agency (TWRA), U.S. Army Corps of Engineers (USACE), and U.S. Geological Survey (USGS). The division is grateful for their assistance and cooperation.

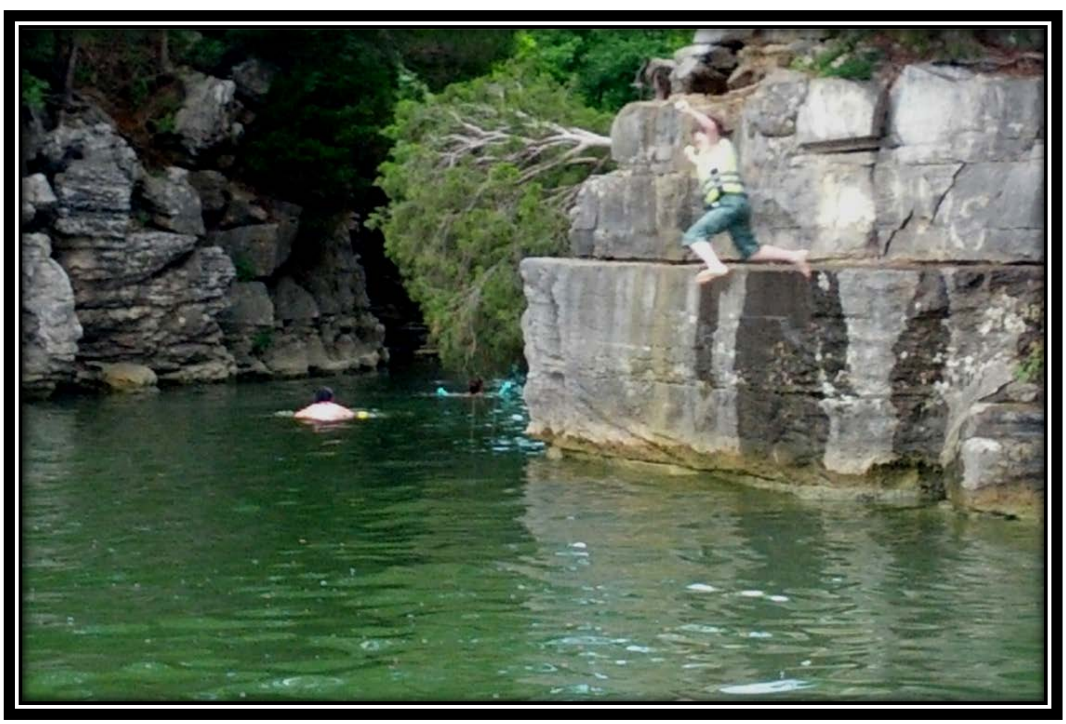


Photo provided by Jimmy Smith, TDEC, DWR, Natural Resources Section

Executive Summary

This publication serves to satisfy the biennial report of the status of water quality in Tennessee required by The *Clean Water Act*, Section 305(b) (US Congress, 2002) and the *Tennessee Water Quality Control Act* (Tennessee Secretary of State, 1999). The Division of Water Resources is entrusted with protecting the citizens of Tennessee's right to enjoy clean water. In order to reach this goal, the division works to establish clean water objectives, monitor surface water, and determine if the waters of the state support their intended uses.

Water Quality Standards

Water quality standards are established for individual waterbodies by identifying the most stringent criteria for each assigned use and considering the antidegradation status. Seven designated uses for the waterways of the State are defined in Rules of Tennessee Department of Environment and Conservation, Chapter 0400-40-04. Chapter 0400-40-03 identifies specific water quality numeric or narrative criteria and establishes the state's antidegradation policy, which deals with prevention of future degradation to water quality. These rules can be viewed at http://tn.gov/environment/water/water-quality_publications.shtml .

Monitoring Programs

Tennessee has a wealth of water resources with over 60,000 miles of rivers and streams and more than 570,000 lake and reservoir acres. Monitoring and protection of these streams, rivers, reservoirs and wetlands requires efficient use of Tennessee's monitoring resources.

TDEC's watershed approach serves as an organizational framework for systematic assessment of the state's water quality. By addressing the drainage area or watershed as a whole, the department is better able to prioritize water quality monitoring, assessment, permitting activities, and stream and river 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 assessed on a five-year cycle that coincides with permits issued with the goal of protecting water quality. This report covers Group 1 and Group 5 watersheds.

In addition to systematic watershed monitoring, sampling data provide for additional information needs within the division. Some of these include ecoregion reference stream monitoring, Total Maximum Daily Load (TMDL) generation, complaint investigation, antidegradation evaluations, trend analysis, compliance monitoring, and special studies.

Assessment Process

Using a standardized assessment methodology, monitoring data from individual waterbodies are compared to water quality criteria. 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. The principal means of disseminating this water quality information are the 305(b) Report and the 303(d) List, plus various databases and mapping features maintained on the Department's website at http://tn.gov/environment/water/

Water Quality

Almost half of the stream miles and nearly all the large reservoirs have 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 50 percent of assessed streams and rivers and 68 percent of assessed reservoir acres are fully supporting of assigned designated uses. The remainder of 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, lake 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 pathogens, habitat alteration, sedimentation, and nutrients. The main sources of these pollutants are agriculture, hydrologic modification and municipal dischargers. The leading causes of pollution in reservoirs and lakes are toxic organics such as PCBs and dioxins as well as metals. The primary sources of problems in reservoirs and lakes are the historical discharge of pollutants that have accumulated in sediment and atmospheric deposition of mercury.

Advisories

When streams, rivers or reservoirs are found to have significantly elevated bacteria levels or contaminants in fish tissue, which exceed risk-based criteria, it is the responsibility of the Department of Environment and Conservation to post warning signs so people will be aware of the potential threat to their health. In Tennessee, the most common reasons for a stream or river to be posted is mercury in fish tissue or the presence of high levels of bacteria. Lakes or reservoirs are most likely to be posted for the accumulation of toxic substances like PCBs, chlordane, dioxins, or mercury in fish tissue. A full list of current advisories may be found at http://tn.gov/environment/water/docs/wpc/advisories.pdf .

Statutory Requirements

Tennessee first created a water pollution regulatory organization in 1927. In 1929, the scope of that agency was expanded to include stream and river 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 Clean Water 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 waterbody monitoring that same year.

In 1983, the Division of Water Resources in the then Department of Conservation was merged with the Division of Water Quality Control. In1985, the Division of Water Quality Control was divided into the Divisions of Water Pollution Control and Water Supply. The Divisions of Water Pollution Control, Ground Water Protection, and Water Supply merged in 2012, forming the Division of Water Resources (DWR). The division monitors, analyzes, and reports on the quality of Tennessee's drinking water, surface water and ground water.

Included in these responsibilities are the permitting, inspection and enforcement of regulations for public water supplies, wastewater treatments facilities, industries and mines, soil-based sewage disposal systems (conventional septic systems and decentralized systems), and non-federal dam safety. Permits are also required for stormwater and sediment control on construction sites, alterations to streams, rivers or wetlands, and well installation and licensing.

> *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 requirement to produce a biennial water quality report, the Tennessee Water Quality Control Act of 1977 requires the Division of Water Resources to produce a report to the governor and the general assembly on the status of water quality in the state. The 2014 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. Another document *Tennessee Ground Water Monitoring and Management Ground Water 305(b) Report* (TDEC, 2014) is available online at http://www.tn.gov/environment/water/water-supply_water-withdrawal-program.shtml .

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 6,643 feet at Clingman's Dome in the Great Smoky Mountains National Park, to only 178 feet above sea level near Memphis.

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

Tennessee's population is growing rapidly. According to the 2013 U.S. Census estimate, Tennessee's population is almost six and half million a 2.4 percent increase from the 2010 Census (United States Census Bureau, 2014). This puts a greater burden on the state's 60,000 miles stream and over 570,000 lake acres.

Several large reservoirs are shared with bordering states including Reelfoot Lake (KY) Pickwick Lake (AL and MS), Kentucky Lake (KY), Lake Barkley (KY), Guntersville Lake (AL), South Holston Lake (VA), and Dale Hollow Lake (KY). The Mississippi River also forms a portion of the state's western border with Missouri and Arkansas.

Cost of Water Pollution

Water pollution is a problem for everyone. The average American family uses 300 to 400 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, treatment and delivery of tap water costs between $4 and $10 per 1,000 gallons. The more polluted water is, the more it costs per gallon to treat. Other costs associated with water pollution include contaminated ground water and wells, loss of tourism and commercial fishing and lower property values.

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, toxins 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. Subsistence fishermen are faced with the loss of their primary protein source.

When people can no longer eat fish from rivers, streams, lakes and reservoirs, 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. Also, water based recreation and tourism like fishing, boating and swimming are eliminated when the water is not safe to swim in.

Recreational activities are one of the most important resources water provides. Photo provided by Jimmy Smith (Natural Resource Section).

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. Siltation decreases the depth of the water until dredging is required or the lake or reservoir is completely filled.

Tennessee Facts

State population (2013 Census estimate)	6,495,978
Largest Cities (2013 Census estimate)	
Memphis	653,450
Nashville	634,464
Knoxville	183,270
Chattanooga	173,366
Clarksville	142,357
Murfreesboro	117,044
Jackson	67,685
Johnson City	65,123
Number of Counties	95
State Surface Area in square miles (Census Bureau)	41,235
Number of Major Basins	13
Number of Level III Ecoregions	8
Number of Level IV Ecoregions	31
Number of Watersheds (HUC8)	55
Number of Stream Miles Forming State Border	213

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

Stream Miles Statewide (NHD)	60,394
Largest Rivers at Low Flow (7Q10 in ft^3/sec.)	
Mississippi River at Memphis	109,000
Tennessee River at South Pittsburg	12,500
Cumberland River at Dover	2,280
Hiwassee River above Charleston	1,220
Little Tennessee River at Calderwood	1,200
Holston River at Surgoinsville	762
French Broad River near Knoxville	722
South Fork Holston River at Kingsport	550
Duck River above Hurricane Mills	477
Obion River at Megelwood	357
Lake Acres Statewide	572,063
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

Chapter 1
Water Quality Assessment Process

Using a standardized assessment methodology, existing monitoring data from individual waterbodies 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 2012 305(b) report was published, Group 1 and 5 watersheds have been assessed.

A. Water Quality Standards

The *Tennessee Water Quality Control Act*, Title 69, Chapter 3 (Tennessee Secretary of State, 2014) identifies the Water Quality, Oil & Gas 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*, Chapter 0400-40-03, General Water Quality Criteria and Chapter 0400-40-04, Use Classifications for Surface Water (TDEC, Water Quality, Oil & Gas Board, 2013).

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 waterbody, the regulation states that the most stringent criterion must be met. The combination of classified uses, the most stringent criterion for those uses, and the requirements of the antidegradation policy create the water quality standard for each pollutant in a waterbody segment.

1. Stream Use Classifications

Tennessee's Current Stream-Use Classifications:

1. Fish and aquatic life
2. Recreation
3. Irrigation
4. Livestock watering and wildlife
5. Drinking water supply
6. Navigation
7. Industrial water supply

The Tennessee Water Quality, Oil & Gas Board 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, 2002).

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, mussels, 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), trout waters have more stringent criteria for dissolved oxygen and temperature. Additionally, the state has developed regional numeric interpretations of some narrative criteria such as nutrients and biological integrity.

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, rivers, lakes and reservoirs 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, rivers, lakes or reservoirs as a source of water to irrigate crops.

d. **Livestock Watering and Wildlife –** This use classification protects waters for their use 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 classification is designated to protect navigational rivers and reservoirs from any physical alterations that would adversely affect commercial transport of goods by barges or other large boats.

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, river, lake or reservoir is not currently used for a given activity, if classified, it should be protected for that use in the future. All waterbodies not specifically listed in General Water Quality Criteria, 0400-40-03 are classified for fish and aquatic life, recreation, irrigation, and livestock watering and wildlife. This regulation can be viewed or downloaded from the Tennessee Secretary of State's webpage, at http://tn.gov/sos/rules/0400/0400-40/0400-40-04.20131216.pdf .

2. Water Quality Criteria

The Tennessee Water Quality, Oil & Gas 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 waterbody is based on the most stringent criterion for the uses assigned to it. The most stringent criteria are typically 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 acute and chronic toxicity. 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, pH, temperature, many toxic substances, and flow. FAL also have narrative criteria with regional numeric interpretations for nutrients, biological integrity and habitat.

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 waterbodies are found to have extremely elevated bacteria levels, warning signs are posted to inform the public concerning the potential health risk. See Chapter 5 for additional information on advisories.

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

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 numeric. The remaining industrial water supply criteria are narrative.

General Water Quality Criteria for surface waters in Tennessee are listed in Rules of TDEC, Chapter 0400-40-03 (TDEC-WQOGB, 2013). A copy of these regulations can be viewed or downloaded at http://tn.gov/sos/rules/0400/0400-40/0400-40-03.20131216.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 provides a process for authorizing degradation in waters identified as high quality. Measureable degradation in impaired waters cannot be authorized for parameters of concern. In high quality waters, degradation above a *de minimis* level can only be allowed if it is in the public interest and there are no other reasonable options. In 2013, the antidegradation statement was revised to clarify the categories.

a. **"Unavailable" parameters** exist where water quality is at, or fails to meet, the criterion for one or more parameters. In unavailable parameters, new or increased discharges of a substance causing impairment will not be allowed.

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

c. **Exceptional Tennessee Waters** are waters where no degradation above a *de minimis* level will be allowed unless that change is justified due to necessary economic or social development.

   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 or rivers 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 extraordinary ecological or recreational value as determined by the department.

d. **Outstanding National Resource Waters (ONRWs)** - These regionally important Tennessee waters constitute an outstanding national resource due to their unique recreational or ecological significance (Table 1). No new discharges, expansions of existing discharges, or water withdraws will be permitted unless it will not result in either measureable degradation or discernible effect.

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
Obed River*	Portion from western edge of Catoosa WMA to Emory River. This section is also a National Wild and Scenic River.
Reelfoot Lake	Tennessee portion of the lake and its associated wetlands

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

A current list of known high quality waters, which includes both Exceptional Waters and Outstanding National Resource Waters is available on the state's website at http://environment-online.state.tn.us:8080/pls/enf_reports/f?p=9034:34304:16191521630406 Additional high quality waters will be added to the list as they are identified.

B. Water Quality Resource Management

In the early 1970's, the USGS delineated 55 hydrologic watershed boundaries within Tennessee. A watershed is the entire land area that drains into a particular watercourse or body of water. In 1996, the division adopted a watershed approach that reorganized existing programs and focused on place-based water quality management.

The watershed approach is a decision making process that reflects a common strategy for information collection and analysis as well as a common understanding of the roles, priorities and responsibilities of all stakeholders within a watershed. Traditional activities like permitting, planning and waterbody monitoring are coordinated.

> The watershed approach is an organizational monitoring framework. Ecoregions serve as a geographical framework for establishing water quality expectations.

A significant change from the past is that the watershed approach encourages integration of traditional regulatory (point source pollution) and non-regulatory (non-point source pollution) programs. Non-point sources such as stormwater runoff in larger cities are regulated through Municipal Separate Storm Sewer Systems (MS_4) permit requirements.

When all pollution sources are considered together, agencies are better able to collaborate with stakeholders and focus on those controls necessary to produce measurable improvements in water quality. Such an approach also results in a more efficient process as it encourages agencies to focus staff and financial resources on prioritized geographic location and makes it easier to coordinate between agencies and individuals with an interest in solving water quality problems.

Four main features are typical of the watershed approach:

- Identifying and prioritizing water quality problems in the watershed.
- Developing increased public involvement.
- Coordinating activities with other agencies
- Measuring success through increased and more efficient monitoring and data gathering.

A watershed or Hydrologic Unit Code (HUC8) is a geographic area that drains to a common outlet.

The 55 watersheds in Tennessee have been divided into five groups based on the year of implementation in a five year cycle (Figure 1). Each group contains between 9 and 16 watersheds (Table 2 and Figure 2). In 2012, adjustments were made in five watersheds to more evenly distribute monitoring resources.

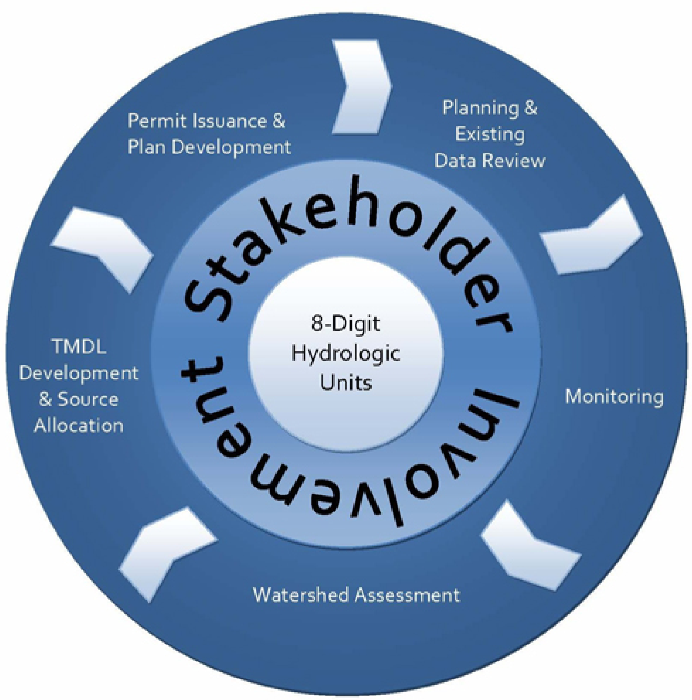


Figure 1: Watershed Cycle

Activities for each group are based on its position in the cycle. One of the following six key activities is occurring in each of the five watershed group each year.

1. **Existing Data Review and Planning.** Existing data and reports from appropriate federal, state, and local agencies and citizen-based organizations are compiled and used to describe the current conditions and status of reservoirs, lakes, rivers and streams. Review of all exiting data and comparison of agency workplans guide the development of an effective monitoring strategy.

2. **Monitoring.** Field data are collected from reservoirs, lakes, rivers and streams. Three standard operating procedures (SOPs) have been developed to guide sampling techniques and quality control for macroinvertebrate surveys (TDEC, 2011), chemical and bacteriological sampling (TDEC, 2011), and periphyton sampling (TDEC, 2010).

3. **Assessment.** Monitoring data are used to determine if the streams, rivers, lakes, reservoirs, and wetlands support their designated uses based on waterbody classifications and water quality criteria. Causes and sources of impairment are identified for waterbodies that do not meet their designated uses. Watershed groups 5 and 1 have been assessed since the 2012 305(b) report was published (Figure 3). These assessments are included in this report.

4. **Total Maximum Daily Load (TMDL) Development/Source Allocation.** TMDLs are studies that determine the point and non-point source contributions of a pollutant in the watershed. The TMDL program locates, quantifies and identifies continuing pollution problems in impacted waters and then proposes solutions. Models are used to determine pollutant effluent limits for permitted dischargers 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.

   The five steps of the TMDL process are:

   - Identify water quality problems in a waterbody.
   - Prioritize water quality problems.
   - Develop TMDL plan to control sources.
   - Implement water quality improvement actions.
   - Assess water quality improvement efforts.

5. **Permits.** Expiration and issuance of discharge permits are synchronized to the five-year watershed cycle.

6. **Watershed Management Plans.** Each existing watershed plan contains a general description, management strategies, and information relevant to water quality. Future plans will focus on TMDL implementation.

More details may be found on the Watershed Management home page. http://tn.gov/environment/water/watersheds/index.shtml

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	• Harpeth • Wheeler Res.^ • Pickwick Res.^	• Upper Tennessee (Watts Bar Res.*)† • Ocoee • Emory* • Watauga • Conasauga
Group 2	1997 2002 2007 2012 2017	• Loosahatchie • North Fork Forked Deer • Forked Deer	• Stones • Caney Fork • Upper Elk • Lower Elk	• 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	• Collins ^ • 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	• Upper Hatchie • Lower Hatchie	• Red • Barren • Cumberland (Old Hickory) • Obey • Upper Duck^	• 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 • Upper Cumberland (Cordell Hull)^	• 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.
^ These watersheds were moved into a different group in 2012.

Accessed 1/17/17 at
http://www.tennessee.gov/assets/entities/environment/attachments/wr_wq_report-305b-2014.pdf

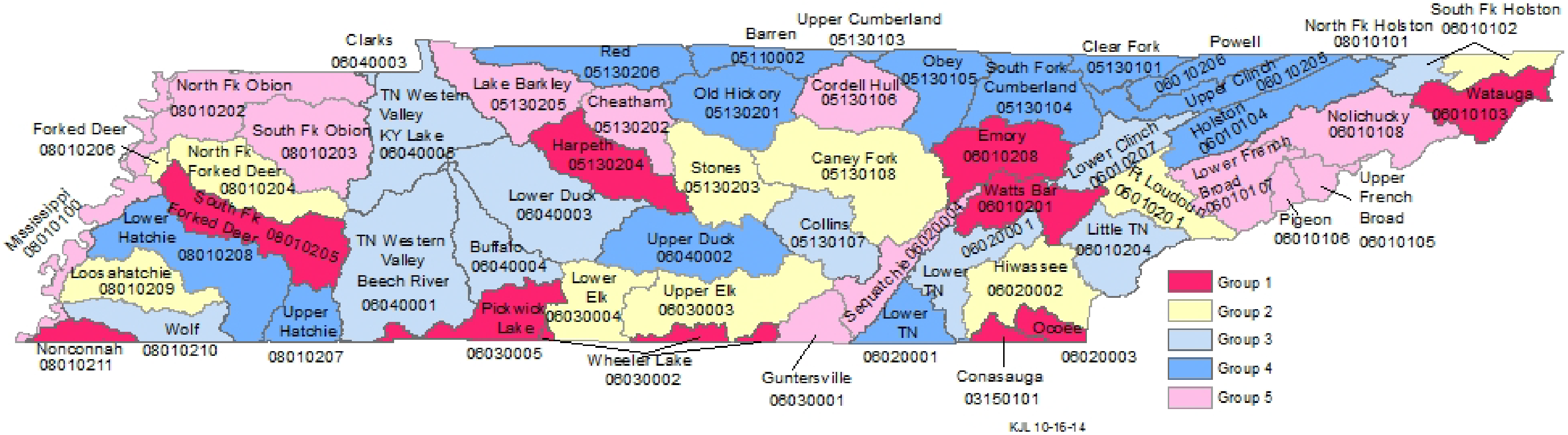


Figure 2: Watershed Monitoring Groups

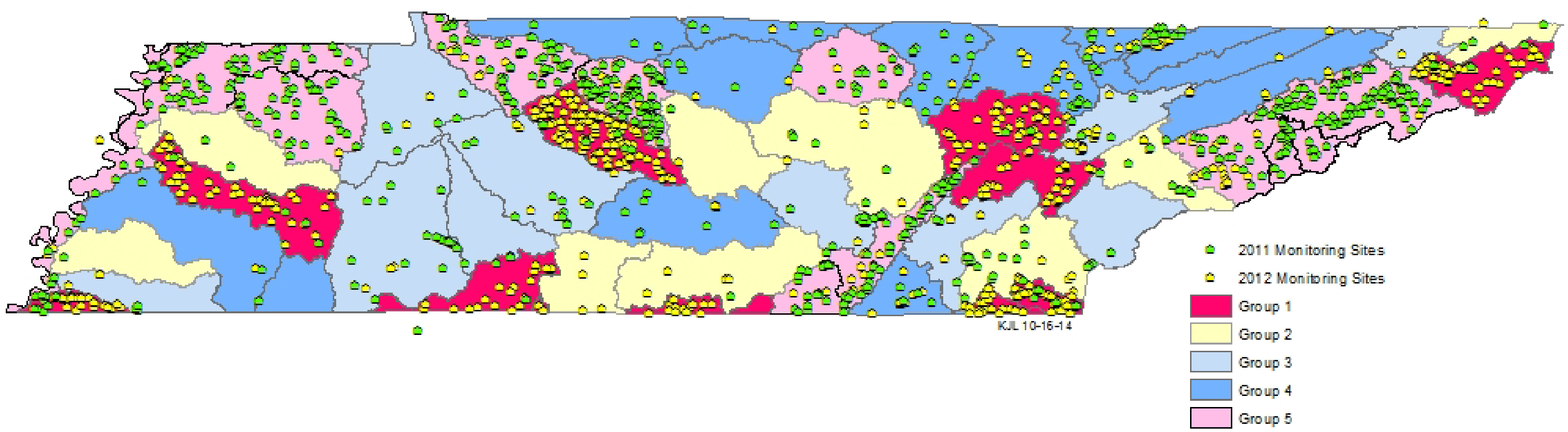


Figure 3: Sites monitored in 2011 & 2012

C. Types of Monitoring

The Division of Water Resources 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 monitoring strategy can be found in the in the Division of Quality Assurance Project Plan for 106 Surface Water Monitoring is posted on the TDEC Water Publications webpage at http://tn.gov/environment/water/water-quality_publications.shtml (TDEC, 2013).

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.

Aana Taylor-Smith conducting a biorecon at Maxwell Branch in Sumner County. Photo provided by Brandon Yates, NEFO.

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 waterbodies 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.

Daniel Lawrence and Steven Turanski collecting water samples at Elmwood Slurry. Photo provided by Dan Murray, Surface Mining Section, KEFO.

3. Long-Term Trend Station Monitoring

Approximately 70 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 waterbody'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 waterbody is an important consideration.

5. Ecoregional Reference Stream Monitoring

An Ecoregion is a relatively homogeneous area defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, and other ecologically relevant variables.

Tennessee relies heavily on ecoregions to serve as a geographical framework for establishing regional water quality expectations. Tennessee has 31ecoregions representing areas with similar climate, landform, soil, natural vegetation and other ecologically relevant variables (Griffith, et. al., 1997). In 1995, the division began reference stream monitoring in most ecoregions (Arnwine, et. al., 2000). Reference sites were selected to represent the best attainable conditions for all streams with similar characteristics within each ecoregion. Reference conditions represent a set of expectations for physical habitat, general water quality and the health of the biological communities in the absence of human disturbance and pollution.

Since 1999, sites have been monitored as part of the five-year watershed cycle. Monitoring includes macroinvertebrates, periphyton, water chemistry, habitat, physical parameters and flow. New reference sites are added as they are located during watershed monitoring, while some of those originally selected sites have been dropped due to increased disturbances or unsuitability. There are approximately 190 active and candidate reference sites. This reference database has been used to establish regional macroinvertebrates, habitat and nutrient guidelines for wadeablestreams.

Southern Metasedimentary Mountains(66g) Ecoregion Reference site Rough Creek in Polk County. Photo provided by Chip Walton, CHEFO.

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 waterbody.

- Trend Determination – Samples are collected over time downstream of an activity to document if 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 waterbody 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 during a complaint investigation at these streams, rivers, reservoirs, and lakes 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 sites are selected using a random sample design. Every site in the target population has an equal chance of selection. Results 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 advisories, which are discussed in greater detail in Chapter 5. Fish tissue monitoring in Tennessee is planned by a workgroup consisting of TDEC staff (Water Resources 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 fish sampling and analyses to the Aquatic Biology Section, Tennessee Department of Health. Targeted fish are five game fish, five rough fish, and five catfish of the same species. Samples are generally composited, although large fish may be analyzed individually. Only fillets (including belly flap) are analyzed for routine monitoring, however whole body fish or other organs may be used for special projects.

Marka Smith and Rob Algood electroshocking in Brimstone Creek in Scott County. Photo provided by Carrie Perry with Aquatic Biology Section, TDH.

9. Sediment Monitoring

Although, not commonly collected, sediment at the bottom of a waterbody can be sampled to determine the presence of harmful amounts of metals or carcinogens. One of the reasons this type of monitoring is not frequently a part of monitoring plans is that few criteria exist to reliably assess the degree of harm to the waterbody.

Recent examples of sediment monitoring in Tennessee include documenting the extent of mercury contamination in Beech Creek in Wayne County, assessing levels of metals in coal ash spilled into the Emory River near Kingston, and a pesticide survey in Cypress Creek in Memphis. As with all monitoring, field and laboratory staff use standardized procedures for the collection and analysis of sediment samples. Although Tennessee has no numeric sediment criteria, EPA literature and guidance developed by the National Oceanographic and Atmospheric Administration (NOAA) are used to assist in data interpretation.

D. Water Quality Data

1. Data Sources

The division used all reliable data that were readily available for the assessment of Tennessee's waterways. This included data from TDEC, other state and federal agencies, universities, NPDES permit holders, citizens, and the private sector (Table 3). In July 2012 the division issued public notices requesting water quality data for use in the statewide water quality assessment.

All submitted data were considered in the assessment process. If data reliability could not be established, 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 2012 Assessment Process

Agency	Physical Data	Biological Data	Chemical Data	Bact. Data
US Army Corp of Engineers	X	X	X	
Tennessee Valley Authority	X	X	X	X
US Geological Survey	X	X	X	X
Tennessee Wildlife Resources Agency	X	X		
Phase I & II MS4 permittees	X	X	X	X
NPDES permittees (mining, municipalities, industries, other point source dischargers)	X	X	X	X
US Forest Service			X	
Universities	X	X	X	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, an annual *Quality Assurance Project Plan for 106 Monitoring* (TDEC, 2013) is compiled by the division and approved by EPA. 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, biological samples. The procedures also identify appropriate quality control measures. The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2011) was first published in March of 2002 and revised in November 2003, October 2006, and July 2011. The *QSSOP for Chemical and Bacteriological Sampling of Surface Waters* (TDEC, 2011) was first published in March 2004 and revised in 2008, 2009, and 2011. The *QSSOP for Periphyton Stream Surveys* was published in 2010.

These documents have been reviewed and approved by EPA and are revised as needed. TDEC staff are trained annually on proper collection techniques. The QAPP and all QSSOPs are available online at http://tn.gov/environment/water/water-quality_publications.shtml

3. Data Management

The division has several tools that have increased the efficiency, accuracy, and accessibility of waterbody assessments. Software programs, combined with increased computer capabilities have expanded the ability to organize, store, and retrieve monitoring and assessment information. These improvements have helped not only with the organization of large quantities of information, but also analysis of specific waterbodies. Such software programs and data management tools also allow for more effective sharing of water quality assessment data to the public.

a. STORET and WQX

Due to the large amount of data collected in monitoring activities, it was paramount for the division to 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 database allowed for easy access to bacteriological and chemical information collected throughout the state and nation. TDEC Water Pollution Control station locations and chemical and bacteriological data were uploaded into the database quarterly.

In September 2009, EPA ceased support of the current format that data are uploaded to STORET. EPA then developed the Water Quality Exchange (WQX), which is a framework that is intended to make it easier for States, Tribes, and others to submit and share water quality monitoring data over the Internet. DWR staff are working with the state lab to receive data electronically. The division has successfully uploaded over 300,000 records of water quality monitoring data to EPA WQX WEB. The data can be located at STORET at http://www.epa.gov/STORET.

b. Water Quality Database

Tennessee's Water Quality Database (WQDB) is an interim storage database for chemical, biological, habitat and fish tissue data prior to upload to WQX. This database is updated and made available to Water Resources 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 results for streams, rivers, lakes and reservoirs. The ADB allows for specific analysis of small waterbody segments, as well as overall assessment of total watersheds. All waters are assigned a unique identification number based on the National Hydrology Database (NHD).

Waterbody IDs begin with Tennessee's abbreviation (TN). The following 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. For example, the South Harpeth River waterbody ID is TN05130204010_1000.

d. Recovery Potential Screening Tool

The RPS tool is a worksheet that weighs ecological, stressor and social values of a watershed to determine an index score of recovery potential. This is a useful tool to plan where future sampling maybe of most value.

e. Geographic Information Systems

The ADB system is linked to the division's **Geographic Information System (ESRI GIS)**. The combination of these technologies allow for easy access to information on specific waterbodies by locating them on GIS maps. The link to this map may be found at http://tnmap.tn.gov/wpc/.

f. Reach Indexing Tool and National Hydrography Dataset

USGS developed the **Hydrography Event Management (HEM) tool** and the **National Hydrography Dataset (NHD)**. The HEM and NHD are used in conjunction with the ADB to develop georeferenced assessment information.

g. Online Water Quality Assessment

Interactive GIS based web applications have been created to easily share water quality assessment information with both the public and staff. These applications allow users to select a specific waterbody and determine the current overall water quality assessment. These maps can be located at http://tnmap.tn.gov/wpc/ or http://tdeconline.tn.gov/dwrwqa

h. Water Pollution Information Management System

The division also has an online database, which contains permit information, Exceptional Tennessee Waters, permit appeals, complaints, inspections and oil and gas wells. This information is available on the State's website at http://www.tn.gov/environment/dataviewers.shtml

An on-line permit map viewer is also available on TDEC's website at http://tdeconline.tn.gov/tdecwaterpermits/ To navigate this webpage, zoom into an area of interest and click on the permit of concern. In the data box, select Permit Data Viewer to see the specific information and documents associated with that permit.

Additional databases including enforcement, groundwater protection, air pollution permits, sold waste and rare species are available on the Divisions dataviewers page at http://www.tn.gov/environment/dataviewers.shtml

E. Water Quality Assessment Methodology

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

- Criteria have been refined to help evaluate data. The ecoregion project has dramatically reduced the uncertainty associated with the application of statewide narrative and numerical criteria. Guidance documents have been developed to assist in the interpretation of biological, nutrient, habitat, and periphyton data. These documents are available on the division's webpage at http://tn.gov/environment/water/water-quality_publications.shtml

- 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 so pathogen results are considered most significant during that time.

- 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 and rivers 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 are affected by man-induced conditions.

- Ecoregion reference sites are re-evaluated and data are statistically tested. 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. Numeric criteria provide a specific parameter or level of a pollutant that is protective of a use, while narrative criteria provide a description of the conditions required to maintain designated uses. The regulation instructs staff to consider the frequency, magnitude, and duration of 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. One of the advantages of this less rigid approach is that an ecoregional basis for interpretation can be developed and applied to stream data in order to make scientifically defensible assessment conclusions. Assessment 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). Guidelines for biological criteria and habitat are re-calibrated every three years and are published in the department's QSSOP for Macroinvertebrate Stream Surveys (TDEC, 2011).

a. Toxic Substances (Numeric)

- Metals data are appropriately "translated" according to the water quality standards before comparison to numeric 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 waterbody 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 waterbodies with obviously gross conditions, such as failing animal waste lagoons.

- Tennessee utilizes *E. coli* as the pathogen 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)

- Dissolved oxygen levels in streams and rivers are measured in flowing water. In lakes and reservoirs, dissolved oxygen is measured at mid-depth or five feet if the water is deeper than ten feet. 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 primary designated uses that have nutrient criteria are fish and aquatic life and recreation. 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 such as excessive algae growth, or downstream problems are also documented.

- At least four nutrient observations are needed for a valid assessment, unless aesthetic or biological impairment is also observed.

e. 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, lake 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 in flowing water has been biological surveys that include habitat assessments.

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

f. Biological Integrity Criteria (Narrative)

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

- Biological surveys using macroinvertebrates as the indicator organisms are the preferred method for assessing use support. Two standardized biological methods, biorecons and semi-quantitative samples, are used to produce a biological index score. These methods are described in *Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys* (TDEC, 2011) 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. This method only uses qualitative data and relies heavily on the expertise of the biologist.

- 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. Waterbodies are considered impaired if the biological integrity falls below the target score for that region. This method provides quantified data that can be used to calculate metrics based on relative abundance as well as richeness.

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

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

- The division is in the process of developing a diatom index to augment the macroinvertebrate surveys, especially in nutrient impaired streams.

g. pH (Numeric)

- The pH criterion range for wadeable streams and rivers is 6.0 - 9.0. For nonwadeable rivers, streams, reservoirs, lakes, 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 of waterbody impairment in the state.

- Division staff use a modified version of 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, 2011) 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 and wadeable rivers with habitat scores less than 75 percent of the median reference score for the ecoregion are considered impaired, unless biological integrity meets expectations.

- The habitat goals are referenced in the 2013 General Water Quality Criteria, (TDEC-WQOGB, 2013).

2. Assessment Rates

The division maintains a statewide monitoring system of over 7,000 stations, however, not all stations are monitored in each cycle. In addition, new stations are created every year to increase the number of assessed waterbodies. Data from approximately 1,400 Group 1 and Group 5 stations assessed July 2010 – December 2012 were used in this report.

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

Chapter 3 of this report summarizes water quality in Tennessee's streams, rivers, reservoirs, and lakes. In order to determine use support, a waterbody must meet the most protective water quality criterion for its assigned uses. With available resources, it is not possible to monitor all of Tennessee's waterbodies. 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.

At the time of this publication, forty-five percent (27,394 miles) of the stream miles (Figure 4) and almost all (565,454 acres) of the reservoir and lake acres (Figure 5) had been assessed. Only group 1 and 5 watersheds represent new assessments since 2012.

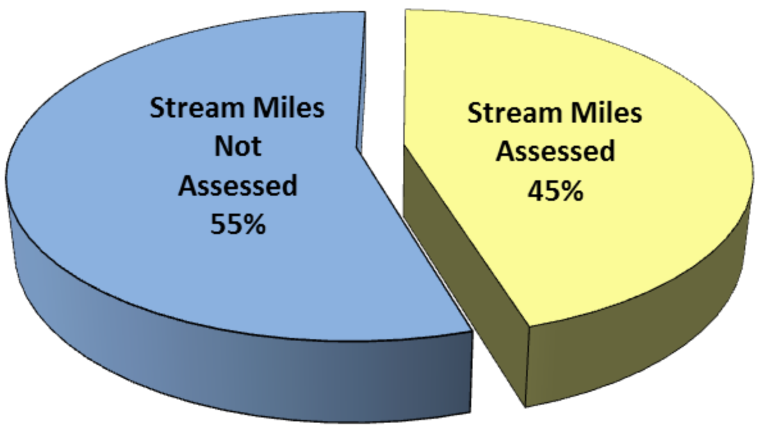


Figure 4: Percent of River and Stream Miles Assessed

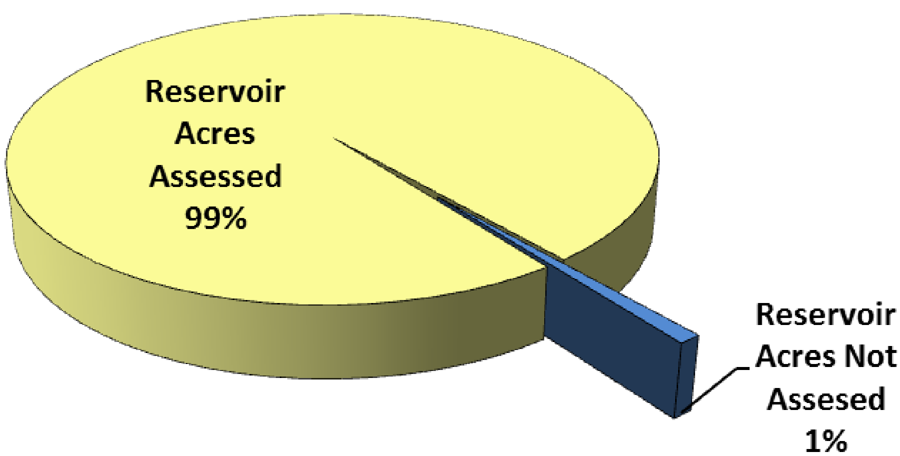


Figure 5: Percent of Reservoir and Lake Acres Assessed

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 are compatible with division collection techniques are used to generate assessments. After use support is determined, waterbodies are placed in one of the five categories recommended by EPA.

Use Support Categories

Category 1 waters are **fully supporting** of all designated uses. These streams, rivers, and reservoirs have been monitored and meet the most stringent water quality criteria for all designated uses for which they are classified.

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** for any use due to insufficient or outdated data. However, waterbodies 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 "use impairment caused by a pollutant is being addressed by the state through other pollution control requirements" (EPA, 2005). An example of a 4b waterbody 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** one or more designated uses. Category 5 waterbodies are moderately to highly impaired by pollution and need to have TMDLs developed. Category 4 and 5 waters are included in the 303(d) List. The current 303(d) list may be viewed at http://tn.gov/environment/water/water-quality_publications.shtml

Chapter 2
Water Quality Standards Attainment Status

Consistent with the rotating watershed approach, the 10 watersheds in Group 1 and 12 watersheds in Group 5 have been assessed since the last 305(b) report was published in 2012. The assessment process considers existing water quality data to place each waterbody into one of the five categories.

Table 4: Assessed Stream Miles

Category Assessment	Miles
Total Miles	60,435
Total Assessed Miles	27,394
Category 1	6,040
Category 2	7,652
Category 3	33,041
Category 4a	3,363
Category 4b	3
Category 4c	183
Category 5	10,153

A. Streams and Rivers

According to USGS's National Hydrography Dataset (NHD) at the 1:100,000 scale there are 60,435 miles of streams and rivers in Tennessee. The division was able to assess almost half (27,394 miles) of the stream miles in the state (Table 4 and Figure 6). Of the assessed streams and rivers, 50 percent are fully supporting of the designated uses for which they have been assessed.

1. 6,040 of the total stream miles (10%) are **Category 1**, fully supporting all designated uses.

2. 7,652 of the total stream miles (12%) 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. 33,041 of the total stream miles (55%) are in **Category 3**. These waters have insufficient data to determine if any classified uses are met.

4. 3,549 of the total stream miles (6%) have been identified as **Category 4,** impaired but TMDLs are not needed. Over 3,360 stream miles (5.6%) are **Category 4a**, which have had TMDLs for all impairments approved by EPA. Only three miles are **Category 4b**, which are impaired waters that do not require a TMDL. More than 180 stream miles (0.3%) are **Category 4c** where it has been determined that the cause of impairment is not a pollutant.

5. 10,153 of the total stream miles (17%) are in **Category 5**, waters that are impaired and need TMDLs for the identified pollutants.

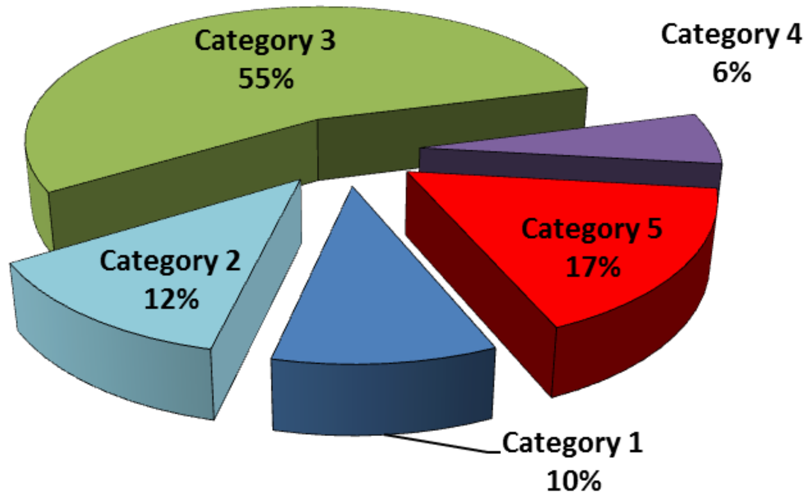


Figure 6: Percent of Rivers and Streams in Each Category

About 48 percent of the stream miles assessed for recreational use failed to meet the criteria assigned to that use. Approximately 40 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 fully supporting (Table 5 and Figure 7).

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	60,435	26,287	15,686**	60%
Recreation	60,435	16,373	8,462	51%
Irrigation	60,435	26,958	26,958	100%
Livestock Watering and Wildlife	60,435	26,945	26,945	100%
Domestic Water Supply	3,696	3,185	3,118	98%
Navigation	1,307	1,307	1,307	100%
Industrial Water Supply	3,383	3,067	3,064	100%

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

** Note: 58 miles are threatened for the protection of fish and aquatic life.

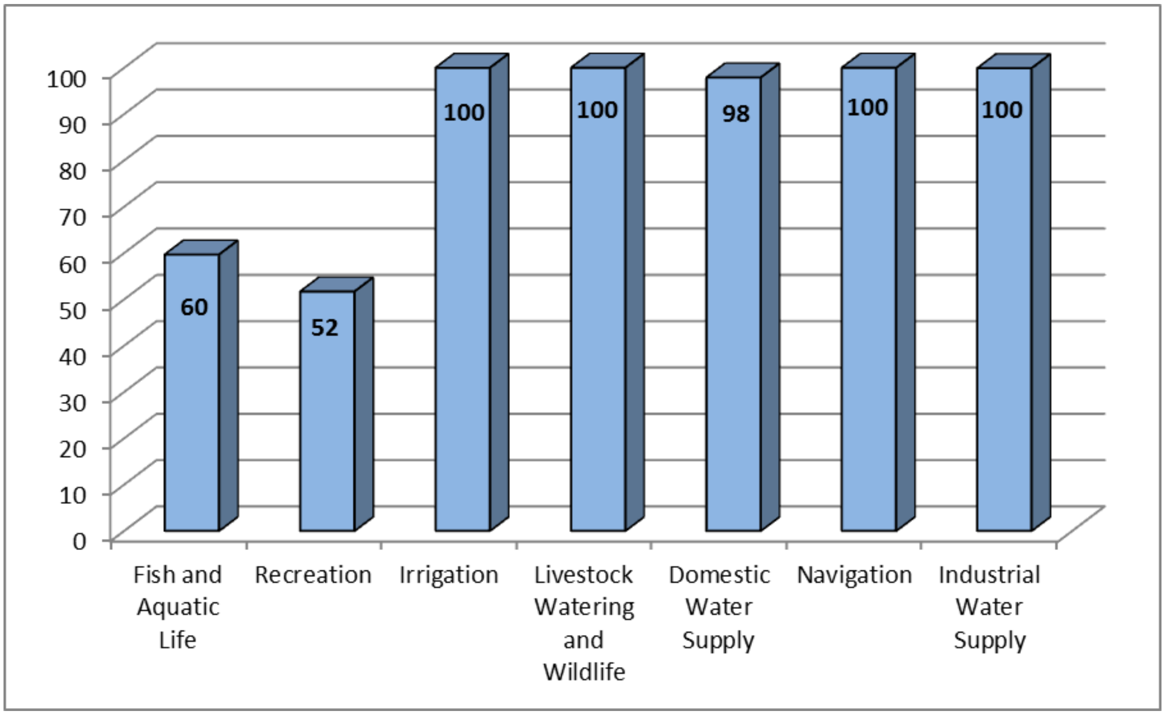


Figure 7: Percent Use Support for Individual Classified Uses in Assessed Rivers and Streams

B. Reservoirs and Reelfoot Lake

Overall Use Support

Tennessee has over 90 public reservoirs or lakes with a total size over 572,000 acres (Table 6). For the purpose of this report, a reservoir or lake is publicly accessible and larger than five acres.

Most lakes in Tennessee are reservoirs that were created by the impoundment of a stream or river. The only large natural lake 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.

Table 6: Assessed Reservoir and Lake Acres

Category Assessment	Support Assessment
Total Acres	572,063
Total Assessed Acres	565,454
Category 1	383,630
Category 2	0
Category 3	6,609
Category 4	62,522
Category 5	119,302

By using available data, the Division of Water Resources was able to assess 565,454 lake acres. This means that 98.8 percent of the lake acres in Tennessee have been assessed. Of these, 68 percent are fully supporting of the designated uses for which they have been assessed. The majority of lake acres were assessed as Category 1 (Figure 8).

1. 383,630 of the total lake acres (67%) are Category 1, fully supporting of all designated uses.

2. No lake acres are assessed as Category 2, fully supporting of some uses, but without sufficient data to determine if other uses are being met.

3. 6,609 of the total lake acres (1%) are placed in Category 3, not assessed due to insufficient data to determine if uses are being met.

4. 62,522 of the total lake acres (11%) are assessed as Category 4, impaired for one or more uses, but a TMDL is not required.

5. 119,302 of the total lake acres (21%) are assessed as Category 5, impaired for one or more uses and needing a TMDL. Along with Category 4 waters, these reservoirs and lakes are placed on the 303(d) List of impaired waters in Tennessee.

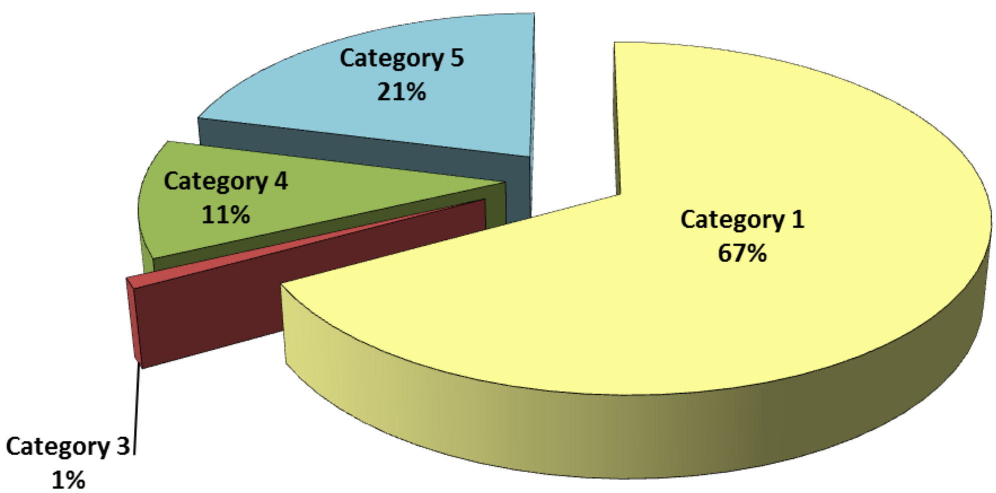


Figure 8: Percent of Reservoir and Lake Acres in Each Category
(No Category 2.)

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 assessed reservoir and lake acres support recreational uses. Approximately 93 percent of assessed reservoir and lake acres support fish and aquatic life uses. All other designated uses, were fully supporting for all assessed acres (Figure 9).

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	572,063	563,553	522,794	93%
Recreation	572,063	564,924	396,834	70%
Irrigation	572,063	563,493	563,493	100%
Livestock Watering and Wildlife	572,063	563,493	563,493	100%
Domestic Water Supply	529,081	526,637	526,637	100%
Navigation	1,971	1,971	1,971	100%
Industrial Water Supply	428,890	428,815	428,815	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.

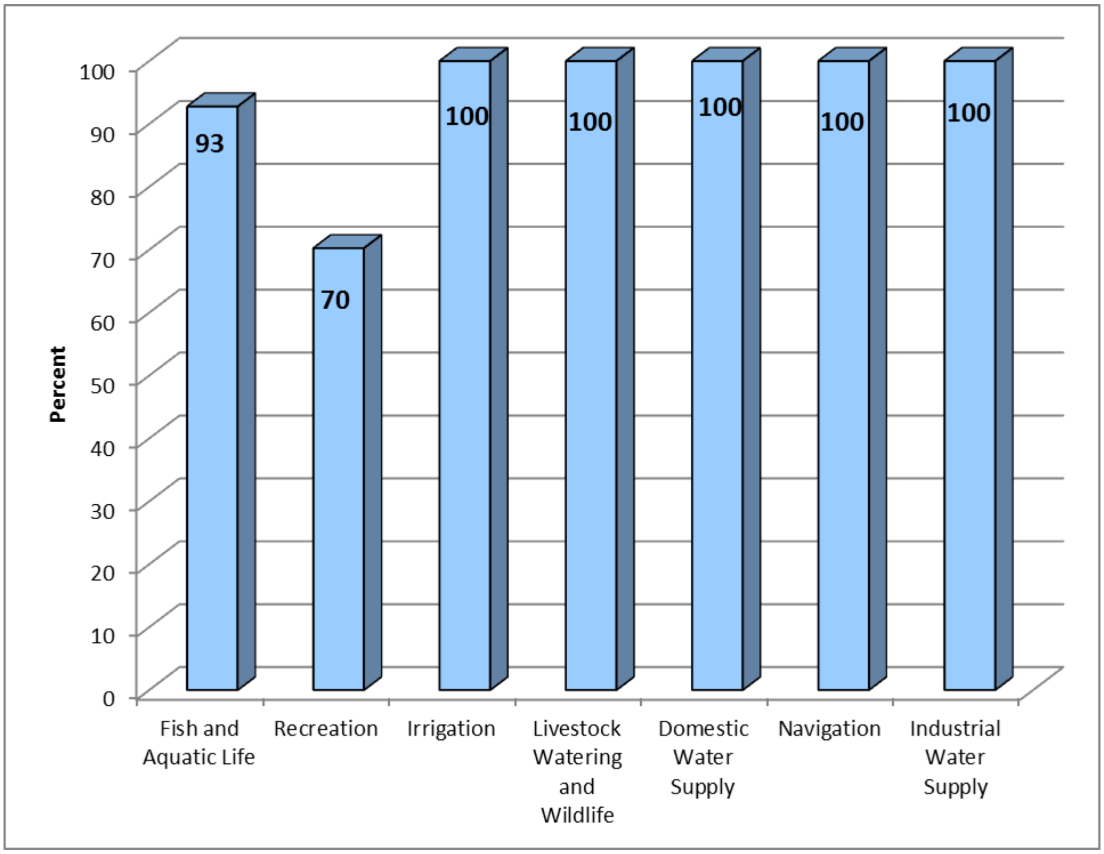


Figure 9: Percent Use Support for Individual Uses in Assessed Reservoirs and Lakes

C. Water Quality in Wetlands

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

Tennessee Wetland Facts

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

Today, land development and other construction projects contribute additional pollutants, to wetlands. A few wetlands have been contaminated by historical industrial activities and several of these 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 to replace water resources, the resource is not considered impaired.

Van Leer Swamp in Van Leer, TN an Exceptional Tennessee Water. Photo provided by Robert Wayne, NRS.

TDEC has sought to stop the decline in wetlands through the adoption of Tennessee's Wetlands Conservation Strategy goal of achieving no overall net loss of the wetland acreage and functions in each hydrologic unit. In addition, the Rules of the Tennessee Water Quality, Oil & Gas Board (Chapter 0400-4-7) establish a standard of no net loss of water resource value in permitting alterations of streams, rivers, reservoirs, lakes and wetlands through either §401 Certifications or state Aquatic Resource Alteration Permits. These rules may be viewed at http://tn.gov/sos/rules/0400/0400-40/0400-40-07.20131216.pdf .

> Today, approximately 787,000 acres of wetlands remain in Tennessee, a 60% loss from historic acreage.

TDEC applied for an EPA Wetland Program Development Grant in 2013 and was awarded $651,000 to accomplish five specific goals focused on strengthening the program. The first goal is to develop a Wetland Program Plan. To develop the plan TDEC invited stakeholders across the state to participate in a collaborative effort to form specific guidance for state wetland priorities and protection efforts. This working group is drafting a document outlining TDEC's short and long term goals in four core elements: regulatory tools, monitoring and assessment, volunteer restoration and protection, and water quality standards.

The second goal, impr oving monitoring and assessment strategies, is aimed at creating a wetlands assessment technique and providing training to TDEC staff. The technique has been developed and statewide training has reached the majority of field staff responsible for resource assessment. An additional result from this effort will be mapping all identified and assessed wetland resources.

Establishing a consistent approach to managing compensatory mitigation, including compliance monitoring and when necessary, enforcement, to ensure no net loss of resources is the third goal. The division is working to identify high priority inspection needs of historic mitigation projects including inspection forms and site visits, and protocols. TDEC is also working to develop a stream functional assessment protocol. This protocol will be a companion to current assessment techniques and will allow regulators to more accurately determine impact losses in order to calculate replacement value of waterbodies.

The fourth goal is to create a prioritized list of vulnerable or important wetland areas via data gathered through collaborative process that considers watershed planning, wildlife habitat and other objectives. This list of sites will then be prioritized for restoration and protection efforts.

Finally, the division will consider opportunities to incorporate specific quality standards for wetlands, including implementation strategies for the antidegradation policy. Initial steps will be to create a procedure for identifying available, unavailable, and Exceptional Tennessee waters. The department will also explore development of an official definition of wetlands and propose inserting it into the rules.

Black Cypress Swamp in the TWRA Obion River Wildlife Management Area. Photo provided by Robert Wayne, NRS.

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, lakes 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 10 and Table 8).

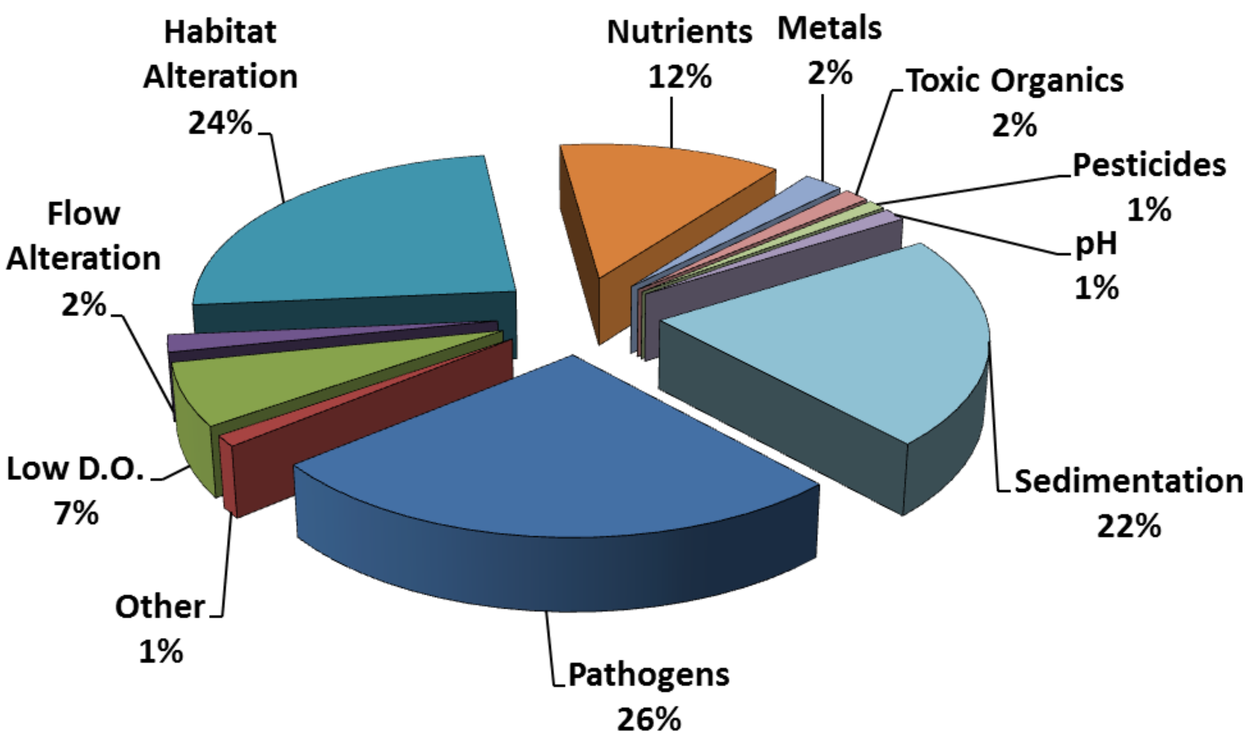


Figure 10: Relative Impacts of Pollution in Impaired Rivers and Streams

1. 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 as water quality criteria to test for the presence of pathogens. The *E. coli* group is considered by EPA to be an indicator of true human risk.

Currently, Tennessee has over 7,500 stream miles assessed as impaired by *E. coli*. Thirty-five streams and rivers (133 miles) are posted with a water contact advisory due to high pathogen levels. See Chapter 5 for specific information on posted streams and rivers.

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

2. Habitat Alteration

Types of Habitat Alterations

Habitat Alteration	Stream Miles Impaired
Alteration in stream-side or littoral vegetative cover…………….....	3,023
Other anthropogenic substrate alterations……………..………	409
Physical substrate habitat alterations……….…………….	4,033

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

Many streams and rivers in Tennessee have impaired biological communities in the absence of obvious chemical pollutants. Often the cause is physical alteration of the stream or river, which results in a loss of habitat.

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

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

Riparian vegetation is important because it:

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

The division uses a modified 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 or river habitat. In 2001 Tennessee developed regional guidance based on reference data to evaluate habitat (Arnwine and Denton, 2001). Guidelines are recalibrated approximately every three years with the most current values as well as scoring guidance published in the macroinvertebrate monitoring QSSOP (TDEC 2011).

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

3. Siltation/Suspended Solids

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

Siltation affects biological properties of waters 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 and lakes.
- Transporting organic chemicals and metals into the water column (especially if the original disturbed site was contaminated).

Physical properties of waters are affected by:

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

Preventive planning in land development projects can protect streams and rivers 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.

A growing concern in Tennessee is the use of Off-Highway Vehicles (OHV) in or near streams and rivers. TDEC is working with commercial operators to design trail systems that minimize erosion and are protective of aquatic systems.

4. Nutrients

A common problem in Tennessee waterways is elevated nutrient concentrations. The main sources for nutrient enrichment are livestock, municipal wastewater systems, urban runoff, and improper application of fertilizers. Nutrients stimulate algae growth that produces oxygen during daylight hours, but uses oxygen at night, leading to significant diurnal fluctuations in oxygen levels. Waters with elevated nutrients often have floating algal mats and clinging filamentous algae. Elevated nutrients cause aquatic life to shift towards groups that eat algae and can tolerate dramatic dissolved oxygen fluctuations. Nutrient pollution is difficult to control. Restrictions on point source dischargers alone may not solve this problem.

Types of Nutrients

Nutrient	Stream Miles Impaired
Nutrient/Eutrophication Biological Indicators……	207
Total phosphorus............	2,539
Nitrate/Nitrite…………...	1,663
Ammonia (un-ionized)…	45

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

Some states have banned the use of laundry detergents containing phosphates. As a result, most commercially available detergents do not contain phosphates. Many fertilizers for crops or lawn application contain both nitrogen and phosphorus. If fertilizers are applied in heavy concentrations, rain will carry the fertilizer into nearby waterways.

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

5. Low Dissolved Oxygen

Depleted dissolved oxygen in water will restrict or eliminate aquatic life. The water quality standard for dissolved oxygen in most non-trout streams and rivers is 5 mg/L. While some species of fish and aquatic insects can tolerate lower levels of oxygen for short periods, prolonged exposure will affect biological diversity and in extreme cases, cause massive fish kills. Over 1,850 stream miles in Tennessee have been impaired by low dissolved oxygen levels.

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

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

6. Metals

Types of Metals*

Metal	Stream Miles Impaired	Metal	Stream Miles Impaired
Mercury	275	Copper	22
Iron	243	Lead	24
Manganese	193	Strontium	7
Arsenic	69	Chromium	6
Zinc	23	Cesium	5
Aluminum	43		

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

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

Sections of 14 rivers and streams have been posted for elevated 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.

Unnamed Tributary to Calfkiller River in Putnum County with iron fixing bacteria growth. Photo provided by Sharon Kington, CKEFO.

7. Organic Contaminants

Types of Organic Contaminants

Organic Contaminant	Stream Miles Impaired
PCBs................................	323
Dioxin..............................	259
Chlordane........................	259
RDX..................................	63
Propylene Glycol............	1.4
Creosote..........................	8
Toluene...........................	0.5

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

Over four-hundred river miles are listed as impaired by organic contaminates which 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. These substances tend to remain in the environment for an extremely long time.

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

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

8. pH

Low pH, elevated alkalinity, or a significant change in the pH or acidity of the water over a relatively short period of time, can greatly impact aquatic life. A common reason for a change in pH is acidic runoff from active or abandoned mine sites. Currently, 367 stream miles are listed as impaired by low pH, most in areas with historical mining activities.

Disturbance of certain rock formations during road construction can also release acidity to streams or rivers. 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, lakes, and wetlands is 6.5 to 9.0. The pH criterion for wadeable streams and rivers is 6.0 – 9.0.

9. Flow Alteration

Over 500 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. Impoundments and channelization are common sources of flow alteration. 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 or river channels to be dry.

B. Causes of Pollution in Reservoirs and Lakes

Some of the same types of pollutants that occur in rivers and streams impact reservoirs and lakes, although in different magnitudes. The main pollutants in Tennessee reservoirs and lakes are toxic organics such as PCBs and dioxins. Other pollutants include mercury, nutrients, sediment/silt, low DO, and pesticides such as chlordane (Figure 11 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 and lakes for a very long time.

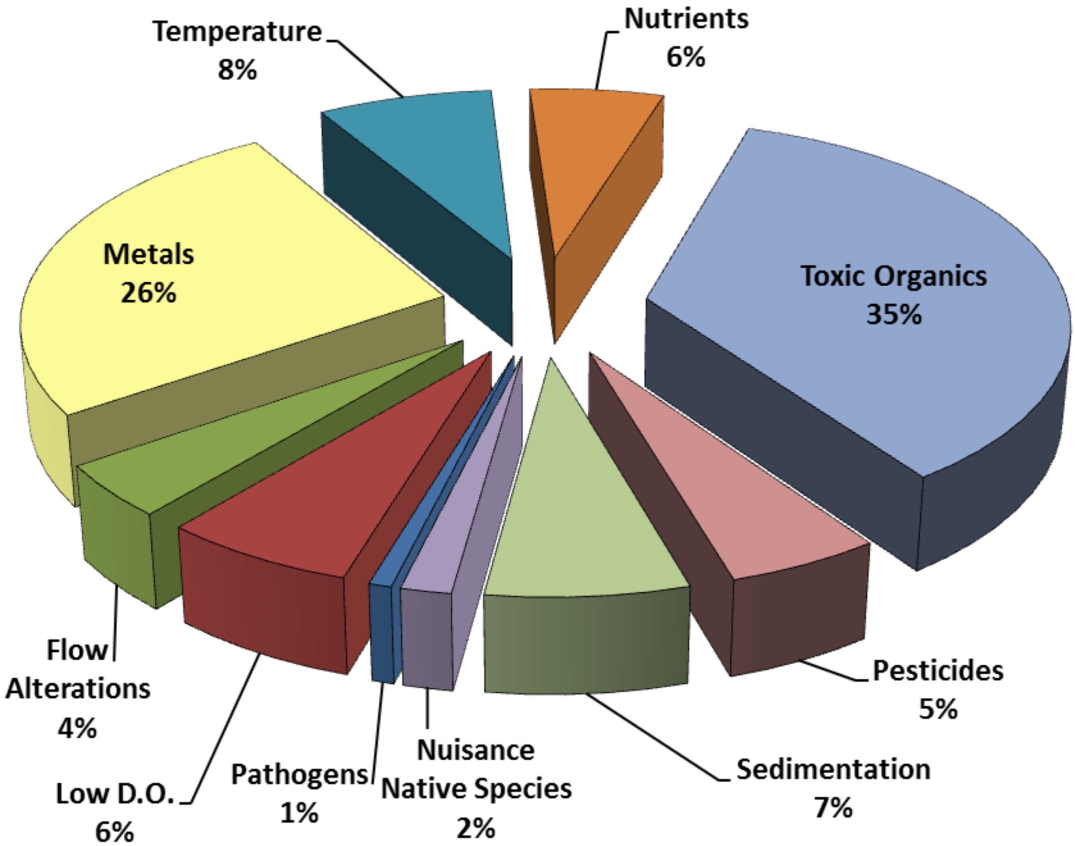


Figure 11: Relative Impacts of Pollution in Impaired Reservoir and Lake Acres

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 and lakes serve as sediment traps and once a pollutant gets into the sediment it is very difficult to remove. These materials move through the food chain and can become concentrated in fish tissue. People eating fish from the waterbody may also concentrate these toxic substances in their bodies, which can lead to health problems.

Currently, portions of eight reservoirs, over 94,000 lake acres, are posted for organic contamination. Chapter 5 has specific information on posted reservoirs and the health hazards associated with eating contaminated fish.

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

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

Types of Organic Contaminants

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

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

2. Metals

As in rivers and streams, toxic substances such as 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 three Ocoee River reservoirs are from historical mining operations.

Mercury in the Clinch River section of Watts Bar Reservoir is from legacy activities at the Department of Energy (DOE) Reservation. Additional reservoirs or embayments impacted by mercury include upper Fort Loudoun, upper Cherokee, Beech, Watauga, South Holston, Tellico, Norris, and the Hiwassee embayment of Chickamauga Reservoir.

Types of Metals

Metal	**Lake Acres Impaired**
Mercury………	67,562
Copper………..	2,254
Iron……………	2,254
Zinc…………...	2,254

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

In December 2008 a dike holding coal ash at TVA Kingston Fossil Plant in Roane County failed, spilling over 5.4 million cubic yards of coal ash. A great percentage of this waste flowed into Watts Bar Reservoir and the Emory River. The coal ash nearly blocked flow in the river and caused elevated levels of arsenic and aluminum. Subsequently TVA has dredged the ash out of the river and with it the source of arsenic and aluminum.

3. Temperature

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

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

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

Under Federal law, specifically Section 316(a) of the Clean Water Act, dischargers of heat can apply for an alternative water quality standard. Where granted, a 316(a) permit substitutes a federal requirement to maintain a Balanced and Indigenous Population (BIP) of fish and aquatic life in the place of state numeric temperature criteria. There are over 20,000 lake acres impaired for thermal pollution.

4. Nutrients

Almost 15,700 lake acres have been assessed as impaired due to nutrients. This includes three small city lakes and one state park lake with 15,500 of the impaired acres represented by Reelfoot Lake. When reservoirs and lakes have elevated levels of nutrients, large amounts of algae and other aquatic plants can grow. Plants and algae produce oxygen during daylight hours. As aquatic vegetation dies and decays, oxygen can be depleted and dissolved oxygen may drop below the levels needed for fish and other aquatic life.

As reservoirs and lakes age, they go through a process called eutrophication. When this occurs naturally, it is caused by a gradual accumulation of the effects of nutrients over many 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.

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 less 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 resemble 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.

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. Om addition, man-made reservoirs are highly managed systems making it difficult to establish a reference condition.

Dr. Dick Urban measuring water parameters. Photo provided by Jennifer Innes, CHEFO.

5. Sediment/Suspended Solids

Sediment and silt cause significant problems in reservoirs and lakes as well as flowing water. Over 18,170 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 inflow areas, but ultimately throughout the reservoir or lake. It is difficult and expensive to remove sediment from reservoirs and lakes. Three reservoirs, Ocoee #3, Ocoee #2, and Davy Crockett, have almost filled in with sediment caused by historic mining activities. Parksville Lake has significant delta formation in its upper reaches. Reelfoot Lake in West Tennessee is also impacted by sediment.

Buck Basin of Reelfoot Lake. Photo provided by Brad Smith, JEFO

6. Dissolved Oxygen

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

The most common reason lakes and reservoirs have fish kills due to low DO is eutrophication. Overproduction of algae raises oxygen levels on sunny days, but on cloudy days and at night the 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, 17,520 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. Due to improvements at the Cumberland Steam Plant discharge and repairs on upstream dams on Barkley Reservoir, dissolved oxygen levels have improved to the point that over 20,000 acres are no longer considered impaired by low DO.

7. Pesticides

Pesticides, if used improperly, can cause harm to humans, animals, and the environment. Many pesticides have been banned in the U.S. but pollution that occurred decades ago still poses a serious threat, since they 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.

A pesticide of particular concern is chlordane because it so persistent in the environment. Although banned in 1988, over 13,870 acres remain impaired by chlordane. Boone Reservoir has fish consumption advisories due to chlordane levels found in carp and catfish. (PCBs are also present in Boone Lake fish tissue.) Pesticides are more likely to bioaccumulate in these fish species since they tend to accumulate more in fattier fish.

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

Cause Category	Impaired Rivers and Stream Miles	Impaired Reservoir Acres
Flow Alteration		
Low Flow Alterations	502	11,444**
Nuisance Aquatic Species		
Native Aquatic Plants		4,550**
Nutrients		
Nutrient/Eutrophication Biological Indicators	211	15,636**
Phosphate/Total Phosphorus	2,539	56
Nitrate/Nitrite	1,663	56
Ammonia (un-ionized)	45	56
Oxygen Depletion		
Oxygen, Dissolved	1,862	17,520
pH/Acidity/Caustic Conditions		
pH	367	
Sediment		
Sediment/Silt	6,234	18,175**
Solids (Suspended/Bedload)	16	
Sludge	8	
Total Dissolved Solids	5	
Pesticides		
Aldrin	9	
Chlordane	259	13,873
DDT	9	
Dieldrin	9	
Endrin	9	
Metals		
Aluminum	43	
Arsenic	68	
Chromium, Hexavalent	6	
Copper	22	2,254
Iron	243	2,254
Lead	24	
Manganese	193	
Mercury	275	67,562
Zinc	23	2,254
Pathogens		
Escherichia coli	7,502	2,044

(Table continued on next page)

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

Cause Category	Impaired Rivers and Stream Miles	Impaired Reservoir Acres
Radiation		
Cesium	5	
Strontium	7	
Organics		
Creosote	8	
Dioxins	259	10,370
Polychlorinated Biphenyls (PCBs)	323	95,438
Propylene Glycol	1	
RDX	63	
Toluene	0.5	
Other		
Odor	7	
Sulfates	31	
Taste & Odor		45
Impairment Unknown	84	
Habitat Alterations		
Alteration in Stream-side or Littoral Vegetative Cover	3,023	
Other Anthropogenic Substrate Alterations	409	
Physical Substrate Habitat Alterations	4,033	
Toxic Inorganics		
Chloride	24	56
Chlorine	4	
Sulfates	31	
Hydrogen Sulfide	10	
Observed Effects		
Color	5	
Oil and Grease		
Oil and Grease	9	
Thermal		
Temperature, Water	138	20,459
Bioassays		
Whole Effluent Toxicity (WET)	4	

*Note – Streams, rivers, lakes 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

Major sources of pollutants in streams and rivers include agricultural activities, hydrologic modification (channelization, dams, and navigation dredging), and municipal discharges. 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 sources, 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 production 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 issue in middle Tennessee is rapid commercial and residential development around Nashville and other urban areas. Mining continues to impair streams and rivers in the Cumberland Plateau and Central Appalachian regions. Figure 12 illustrates the percent contribution of pollution sources in impaired rivers and streams.

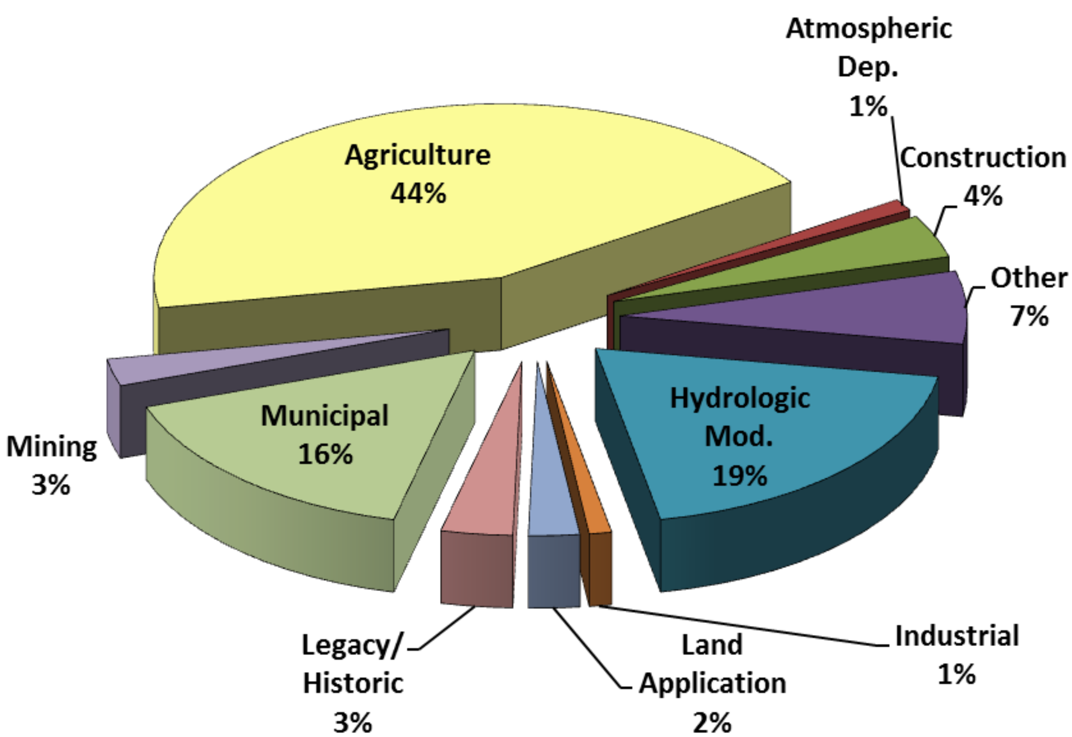


Figure 12: Percent Contribution of Pollution Sources in Impaired Rivers and Streams

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

Sources Category	Total Impaired Stream Miles	Total Impaired Reservoir Acres
Industrial Permitted Discharge		
RCRA Hazardous Waste Sites	84	
Industrial Point Source	60	7,791
Stormwater Discharge	30	
Petroleum/Natural Gas	1	
Industrial Thermal Discharges		20,459
Municipal Point and Non-point Dischargers		
Separate Storm Sewer (MS4)	2,560	994
Package Plants	21	
Combined Sewer Overflows	10	994
Sanitary Sewer Overflows	762	
Urbanized (High Density Area)	420	45
Municipal Point Source	723	
Agriculture		
Specialty Crop Production	65	
CAFOs	27	
Unrestricted Cattle Access	311	
Dairies (Outside Milk Parlor Areas)	15	
Irrigated Crop Production	64	
Grazing in Riparian or Shoreline Zones	6,232	481
Animal Feeding Operations (NPS)	232	34
Livestock (grazing or feeding)	7	
Aquaculture (permitted)	4	
Non-irrigated Crop Production	3,030	15,587**
Permitted Resource Extraction		
Surface Mining	22	56
Coal Mining Discharge (Permitted)	61	
Dredge Mining	50	
Subsurface/Hardrock	9	
Sand/Gravel/Rock	81	
Hydrologic Modification		
Channelization	3,533	
Dredging (Navigation Channel)	207	
Upstream Impoundment	618	2,469
Flow Regulation/Modification	15	
Channel Erosion/Incision from Upstream Modification	12	

(Table continued on next page.)

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

Sources Category	Total Impaired Stream Miles	Total Impaired Reservoir Acres
Habitat Alterations (Not directly related to hydromodification)		
Stream Bank Modification/ Destabilization	57	
Loss of Riparian Habitat	2	
Drainage/Filling/Wetland Loss		10,950**
Legacy/Historical		
Contaminated Sediment	351	97,692
CERCLA NPL (Superfund)	30	
Abandoned Mine Lands (Inactive)	384	2,254
Mill Tailings	19	2,254
Mine Tailings	23	2,254
Silviculture		
Harvesting	75	
Land Application/Waste Sites		
On-site treatment systems (septic systems and similar)	377	4
Land Application of Wastewater Biosolids (Non-agricultural)	9	
Landfills	46	56
Industrial Land Treatment	3	
Land Application of Waste	12	
Construction		
Site Clearance	867	10,950**
Hwys. /Roads/Bridges, Infrastructure (new)	45	
Atmospheric Deposition		
Atmospheric Deposition of Acids	17	
Atmospheric Deposition-Toxics	232	67,421
Other Sources		
Sources Outside State Jurisdiction or Borders	231	4,223
Military Base (NPS)	13	
Sources Unknown	838	1,050
Internal Nutrient Recycling		15,500**
Off-Road Vehicles	68	
Hwy/Road/Bridge (runoff)	23	
Urban Runoff/Storm Sewers	28	
Golf Courses	0.3	

*Streams, rivers, lakes 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.

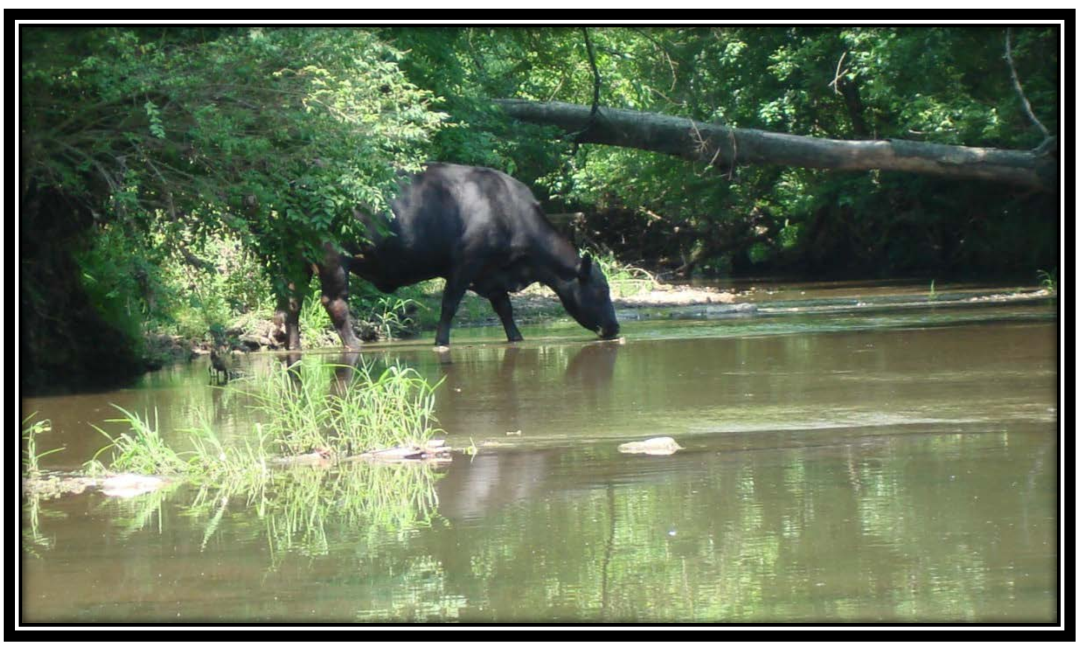
1. Agriculture

Tennessee is fortunate to have over 90,000 farms, averaging 130 acres in size comprising almost half the land use in the state. Farms supply food, earn the state 20 billion dollars annually and provide over 200,000 jobs (Tennessee Department of Agriculture, 2014). Agricultural activities contribute approximately 44 percent of the impaired stream miles in the state. The largest single source of impacts is grazing of livestock, followed by crop production. Crop cultivation can lose 20 tons of soil per acre annually (TDEC, 2012). In west Tennessee, due to erosion from crop production (mostly cotton and soybean) substantial quantities of soil are lost annually. In middle Tennessee, cattle grazing and hog farms are the major agricultural activity and can result in bank erosion, plus elevated bacteria and nutrient levels. In east Tennessee, runoff from feedlots and dairy farms have significantly impacted some waterbodies. Figure 13 illustrates the relative contributions of the primary agricultural sources.

Sources of Agricultural Impairment

Agricultural Source	Stream Miles Impaired
Grazing in Riparian Zone……...	6,232
Non-irrigated Crop Production..	3,030
Unrestricted Cattle Access........	311
Animal Feeding Operations…...	232
Specialty Crop Production…….	65
Irrigated Crop Production……..	64
CAFOs………………………...	27
Dairies (Outside Milk Parlor Areas)………………………….	15
Livestock (grazing or feeding)...	7
Aquaculture (permitted)……….	4

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



Cow in West Harpeth River. Photo provided by Annie Goodhue, NEFO.

The Tennessee Water Quality Control Act does not give the division authority to regulate water runoff originating from normal agricultural activities such as crop production, livestock grazing, and logging. However, agricultural activities that may result in a point source pollution, such as animal waste system discharges from concentrated livestock operations, are regulated.

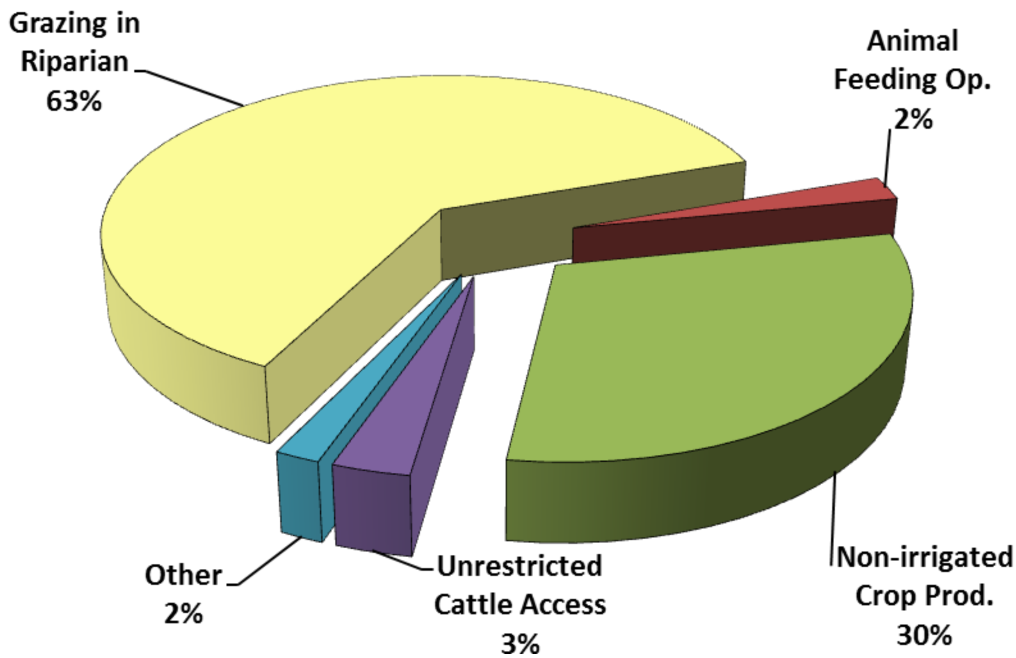


Figure 13: Relative Contributions of Sources of Agricultural Pollution in Impaired Rivers and Streams

Tennessee has made great strides in recent years to prevent agricultural and forestry impacts to water quality. 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 implement Best Management Practices (BMP's) all over the state. Farmers are voluntarily helping 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 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.

2. Hydrologic Modification

Altering the physical and hydrological properties of streams and rivers is the source of impairment in about 18 percent of the impaired streams and rivers in Tennessee. Modifications include channelization (straightening streams), impoundments (construction of a reservoir), dredging for navigation, and flow regulation or modification. Figure 14 illustrates the types of modifications most frequently impairing streams and rivers.

Sources of Hydrologic Impairment

Sources of Hydrologic Modification	Stream Miles Impaired
Channelization………………….	3,533
Upstream Impoundment………..	618
Dredging (Navigation Channel)..	207
Flow Regulation/Modification…	15
Channel Erosion………………..	12

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

It is likely that the extent of streams impacted by the effects of channelization has been under-reported, as many unassessed streams have also been channelized, especially in West Tennessee. It is unlikely that channelized streams can meet water quality standards, but the Department does not assess these streams as impacted without biological data.

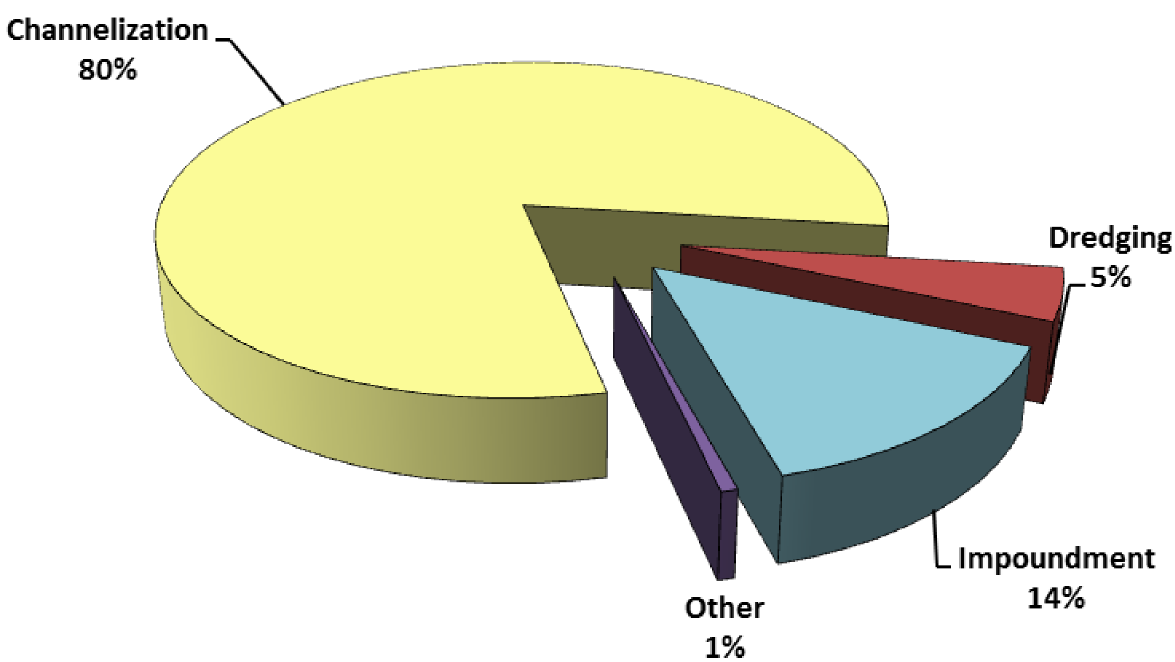


Figure 14: Relative Contributions of Sources of Hydrologic Impairment in Rivers and Streams. (Flow regulation and modification represent less than one percent of the impairments.)

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. This section administers Section 401 of Federal Clean Water Act, which provides Water Quality Certification to ensure that a discharge will not violate Tennessee's water standards. The U.S. Army Corps of Engineers oversees Section 404 of the Federal Clean Water Act, which regulates the discharge of dredge or fill material into waterways. Failure to obtain a permit before modifying a stream or river can lead to enforcement actions.

a. Channelization

Channelization is a source of impairment for 80 percent of the streams and rivers assessed as impacted by hydrologic modification. 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 and rivers continue to be impaired by channelization and bank destabilization from vegetation removal.

Costs associated with channelization 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.

Puckett Creek in Rutherford County. Photo provided by Annie Goodhue, NEFO.

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 free flowing water are increasing as more streams and rivers are dammed. Impoundments are constructed for a variety of reasons including flood control, power generation, fishing, livestock, irrigation, industrial use, water supply, and aesthetics. Dams not only affect the impounded stream segment but also have the potential to alter the physical, chemical and biological components of downstream reaches.

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. In 2006 a random survey of 75 streams below small impoundments across the state showed 95% did not support fish and aquatic life (Arnwine et al 2006). Results of the study can be found at http://www.tn.gov/environment/water/water-quality_publications.shtml

Problems often associated with stream and river impoundment include:

- Downstream habitat alteration including increased sediments, bank instability and embeddedness.
- Geomorphic changes including loss of channel sinuosity downstream.
- Loss of stream or river for certain kinds of recreational use.
- Detrimental changes in flow rates downstream of the dam.
- Elevated metals and nutrients downstream of the dam.
- Low dissolved oxygen levels in tailwaters,
- Barriers to fish migration.
- Altered biological communities in the impounded section and downstream .

c. 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. Dredging cannot be done without authorization from the state.

3. Municipal Discharges

a. Municipal Stormwater Discharges

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

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

Under Tennessee Municipal Separate Storm Sewer Systems (MS4) permits, cities must develop stormwater programs and regulate sources at a local level. In addition to Tennessee's four MS4 Phase I cities (Memphis, Nashville, Chattanooga, and Knoxville) that are covered under individual NPDES permits, 92 other cities and counties are now covered by the MS4 Phase II general permits.

There are six Phase II MS4 program elements designed to further reduce pollutants from stormwater. The elements include public education and outreach, along with public participation and involvement. Further, a plan must be implemented to detect and eliminate illicit discharges to the storm sewer system.

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. Sites receiving coverage under the permit are required to control erosion as well as address post-construction stormwater runoff.

b. Combined Sewer Overflows

In Tennessee, only three cities (Nashville, Chattanooga, and Clarksville) have combined sewers (sanitary waste and storm water carried in the same sewer). Permits require that when these sewers overflow during large storm events, monitoring must be conducted. Six creeks and a five mile portion of the Cumberland River in Nashville have water contact advisories due to combined sewer overflows.

c. Municipal Point Source Discharges

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 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 exposed to elevated bacteria levels while playing in streams and rivers after heavy rains. Municipalities monitor sanitary sewer collection systems to insure that they are not leaking. NPDES permits contain provisions that prohibit overflows and require that they be reported to TDEC. Enforcement can be taken against cities that fail to report and correct sewage system problems.

4. Construction

The populations of many Tennessee communities have rapidly expanded in the last decade. The overall population has grown by ten percent, however the population of the urbanized areas of middle Tennessee has grown even more quickly. 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.

Poor stabilization during construction. Photo provided by Jimmy Smith, NRS.

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 92 cities and counties covered under the Phase II MS4 general permit have developed construction stormwater control programs. In these cities, local staff helps 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 re-vegetating. New mining sites are required to provide treatment for runoff.

b. Contaminated Sediments

The main problem with toxic contaminants in sediment is that it can become concentrated in the food chain. As toxic substances become re-suspended in the water column, they are absorbed in by algae, which in turn are eaten by insects and small fish. Small fish eat insects and big fish eat little fish. This continues up the food chain getting more concentrated in each larger animal.

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

Fish tissue samples are collected and analyzed from waterbodies across the state. Results are compared to criteria developed by the Food and Drug Administration (FDA) and EPA. If fish tissue is contaminated and the public's ability to safely consume fish is impaired, the waterbody is posted with signs and assessed as not supporting recreational uses.

The advisories are listed on the TDEC website and included in sport fishing regulations. . Posted waterbodies list may be viewed at http://www.eregulations.com/tennessee/fishing/contaminants-in-fish/ or http://tn.gov/environment/water/docs/wpc/advisories.pdf 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. 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. 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 waterbodies 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 and Lakes

Like streams and rivers, reservoirs and lakes are impaired by many sources of pollution. Over half of the sources of impact to reservoirs and lakes are legacy toxic substances and atmospheric deposition of mercury (Figure 15).

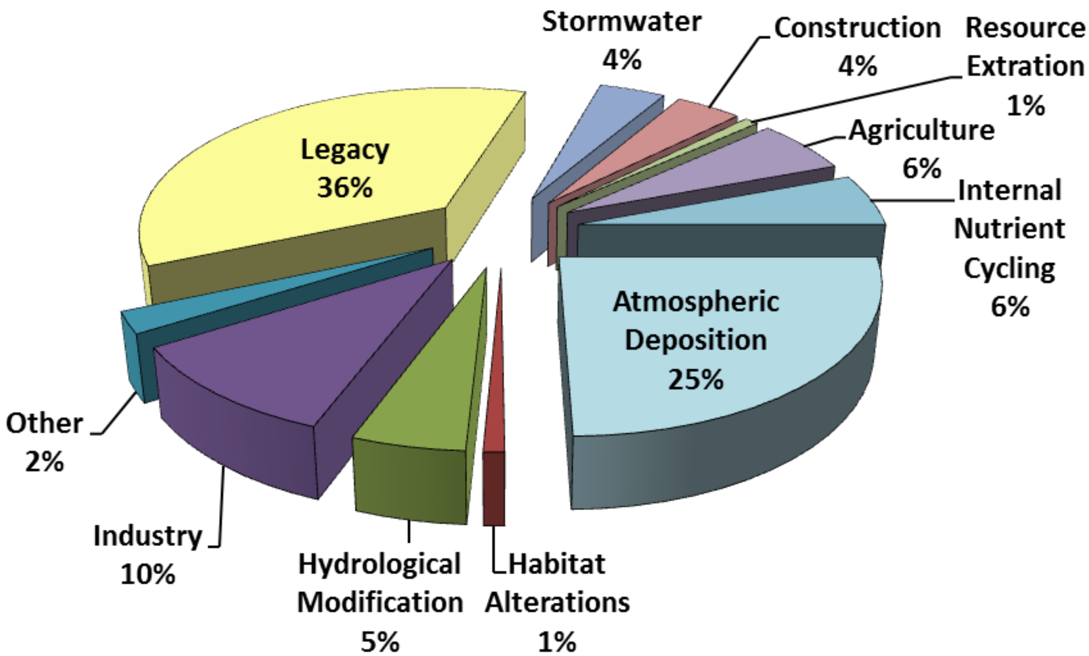


Figure 15: Percent Contribution of Pollution Sources in Impaired Reservoirs and Lakes

1. Legacy Pollutants

Legacy or historical pollutants are the number one source of contamination in reservoirs. These pollutants 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 16).

a. Contaminated Sediments

The biggest problem with legacy pollutants is contaminated sediments. Along with mercury, 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.

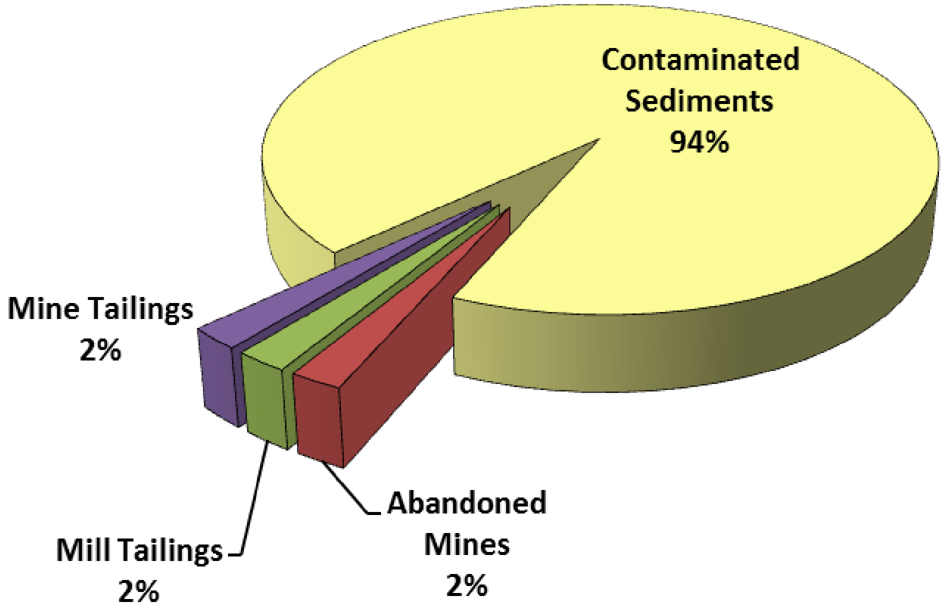


Figure 16: Sources of Legacy Pollutants in Reservoirs and Lakes

b. Abandoned Mines/Mine Tailings/Mill Tailings

The Copper Basin in the tri-state area of Tennessee, Georgia, and North Carolina was extensively mined beginning in 1843. Before 1900, this was the largest metal mining area in the southeast. The last mine closed in 1987. Runoff from disturbed areas has contaminated three downstream reservoirs on the Ocoee River. Much of the area has now been reforested and along with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) activities, commonly known as Superfund, water quality in the Ocoee River watershed has improved. Although much work remains to be done before water quality goals are met, the transport of pollutants to the Ocoee River appears to have diminished.

2. Atmospheric Deposition

Atmospheric deposition occurs when air pollutants are deposited to land or water. Primary anthropogenic sources of pollutants include burning fossil fuels, agricultural activities, and emissions from industrial operations. Tennessee currently has over 67,400 lake acres impaired by atmospheric deposition of mercury, most found in east Tennessee. The effects of mercury pollution are discussed in detail in Chapter 5.

In 2009, the division began a probabilistic study of fish tissue to test a model that may predict mercury air deposition (Chapter 7). The mercury levels found in fish tissue did not correlate with the REMSAD air deposition model that was used to model mercury deposition. Several fish taken from areas with predicted high levels of mercury air deposition contained relatively low levels of contamination. Other fish that had higher concentrations of mercury came from areas with low predicted depositional mercury.

3. 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 embayment and upper Cherokee Reservoir and raising the water temperature in Barkley Reservoir.

4. Agriculture

Similar to streams and rivers, reservoirs and lakes 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 in 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.

5. Internal Nutrient Cycling

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

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

6. Construction

Almost all 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.

7. Other Modifications

Loss of wetlands in Reelfoot Lake accounts for the majority of lake acres impaired due to habitat modification. Upstream impoundments account for the hydrologic modifications in lakes and reservoirs.

Chapter 5
Posted Streams, Rivers, and Reservoirs

When streams, rivers, lakes 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 waterbody to be posted are the presence of high levels of bacteria in the water or PCBs, chlordane, dioxins, or mercury in fish tissue. Currently 65 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 publications page at http://tn.gov/environment/water/docs/wpc/advisories.pdf

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

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

A. Bacteriological Contamination

About 133 river miles are posted due to bacterial contamination (Table 10). No reservoirs or lakes are posted. The presence of pathogens, disease-causing organisms, affects the public's ability to safely swim, wade, and fish. Bacteria, viruses, and protozoa are the primary water-borne pathogens in Tennessee. Improperly treated human wastes from such sources as failing septic tanks, collection system overflows and improper connection to sewer or sewage treatment plants are the reasons for 62 percent of the posted river miles (Figure 17). The remaining stream miles are posted due to other sources such as failing animal waste systems or urban runoff (Figure 18).

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

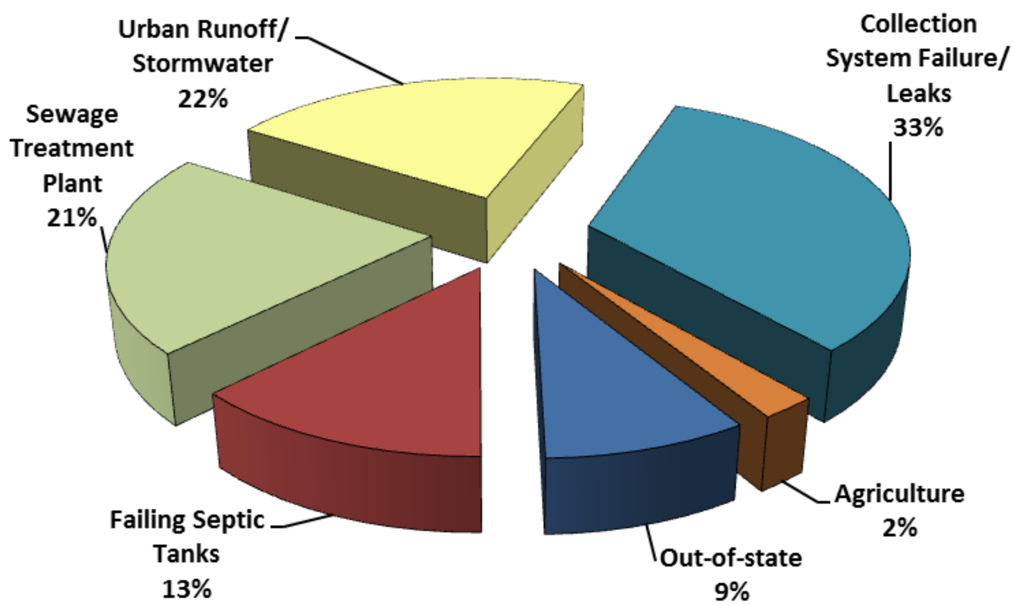


Figure 17: Relative Contribution of Stream Miles Posted for Pathogen Contamination

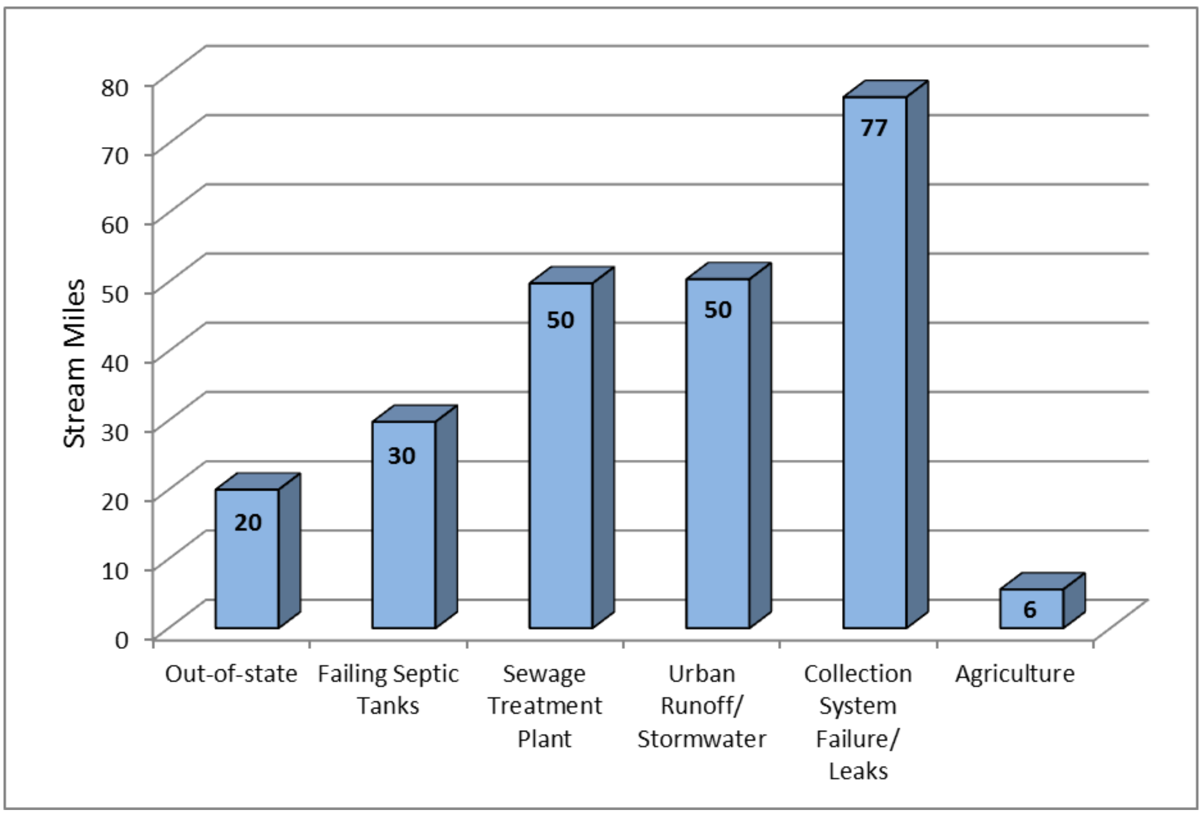


Figure 18: Stream Miles Contaminated by Various Pathogen Sources. (The same waterbody may be impaired by more than one source of pollution. Totals are not additive.)

Table 10: Bacteriological Advisories in Tennessee

For additional information: http://tn.gov/environment/water/docs/wpc/advisories.pdf

Bacteriological Advisories in Tennessee

(December 2014. This list is subject to revision.)

East Tennessee

Stream	Portion	County	Comments
Beaver Creek (Bristol)	TN/VA line to Boone Lake (20.0 miles)	Sullivan	Non-point sources in Bristol and Virginia.
Baker Creek	Entire stream (4.4 miles)	Cocke	Failing septic tanks
Cash Hollow Creek	From Knob Creek to Big Hollow (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 New Hope Pond (Mile 15.0)	Roane, Anderson	Oak Ridge area.
First Creek	From Topeka Street to Ashwood Place (Mile 0.2 to 1.5)	Knox	Knoxville urban runoff
Goose Creek	Entire Stream (4.0 miles)	Knox	Knoxville urban runoff.
Pine Creek	Mouth to Litton Fork (0.0 to 10.1)	Scott	Oneida STP and collection system
East Fork of Pine Creek	Mouth to Park Road (Mile 0.0 to 0.8)		
Litton Fork of Pine Creek	Mouth to Grave Hill Road (Mile 0.0 to 1.0)		
North Fork of Pine Creek	Entire Stream (1.5 miles)		
South Fork of Pine Creek	Mouth to unnamed tributary near Carson Cemetery (Mile 0.0 to 0.7)		
Second Creek	Mouth to headwaters (2.9 miles)	Knox	Knoxville urban runoff.

East Tennessee (continued)

Stream	Portion	County	Comments
Sinking Creek	From point of subsidence to Catbird Creek (Mile 0.0 to 2.8)	Washington	Agriculture & urban runoff
Third Creek	From Fort Loudoun Reservoir to East Fork (Mile 0.0 to 1.4)	Knox	Knoxville urban runoff.
East Fork of Third Creek	From Third Creek to Middlebrook Pike (Mile 0.0 to 0.8)	Knox	Knoxville urban runoff.
Turkey Creek	Mouth to Henry Street (Mile 0.0 to 5.3)	Hamblen	Morristown collection system.
West Prong of Little Pigeon River	Little Pigeon River to North Park Lane (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)		
Dudley Creek	Entire stream (5.7 miles)		

Southeast Tennessee

Stream	Portion	County	Comments
Citico Creek	Mouth to headwaters (7.3 miles)	Hamilton	Chattanooga urban runoff and collection system.
Chattanooga Creek	Mouth to GA line (7.7 mi.)	Hamilton	Chattanooga collection system.
Oostanaula Creek	From Long Mill Bridge Road to Athens STP (Mile 28.4 -31.2)	McMinn	Athens STP and upstream dairies.
Stringers Branch	Mouth to Ormand Drive (Mile 0.0 to 5.4)	Hamilton	Red Bank collection system.

Middle and West Tennessee

Stream	Portion	County	Comments
Duck River	Old Stone Fort State Park (0.2 miles)	Coffee	Manchester collection system.
Little Duck River	Old Stone Fort State Park (0.2 miles)		
Mine Lick Creek	Louisville and Nashville RR to Baxter STP (Mile 15.3 to 15.8)	Putnam	Baxter STP.
Nashville Area		Davidson	Metro Nashville collection system overflows and urban runoff.
Brown's Creek	Main Stem (4.3 miles)		
Dry Creek	Mouth to the second bend of the creek (Mile 0.0 to 0.1)		
Gibson Creek	Mouth to Neeley's Branch (Mile 0.0 to 0.2)		
McCrory Creek	Mouth to unnamed tributary (Mile 0.0 to 0.2)		
Tributary to McCrory Creek	Mouth to driveway (Mile 0.0 to 0.1		
Richland Creek	Mouth to West Park (Mile 0.0 to 2.2)		
Cumberland River	Bordeaux Bridge (Mile 185.7) to Woodland Street Bridge (Mile 190.6)		
Cypress Creek	Entire Stream (7.7 miles)	Shelby	Urban stormwater runoff.

B. Fish Tissue Contamination

Approximately 128,099 reservoir acres and 311 river miles are currently posted due to contaminated fish (Table 11). The contaminants most frequently found at elevated levels in fish tissue in flowing water are mercury and chlordane (Figure 19 and 20). In impoundments and lakes the highest levels of contamination in fish tissue are PCBs and mercury (Figures 21 and 22).

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. 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.

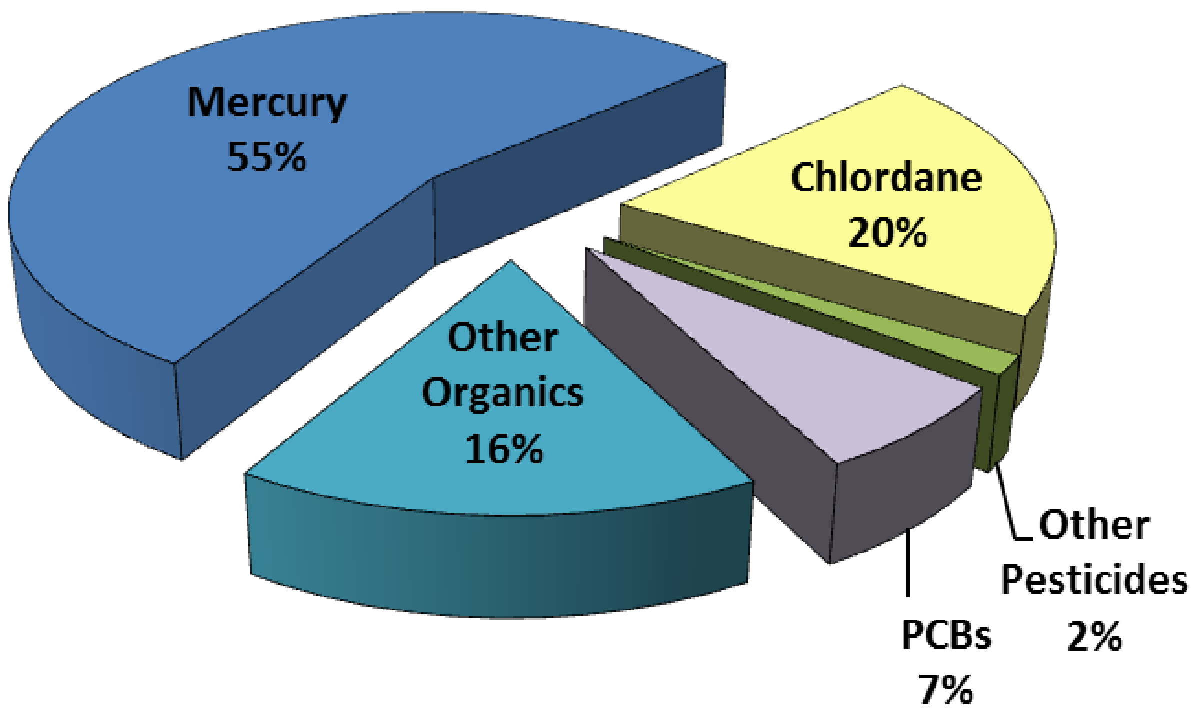


Figure 19: Relative Contribution of Stream Miles Posted for Fish Tissue Contamination

Accessed 1/17/17 at
http://www.tennessee.gov/assets/entities/environment/attachments/wr_wq_report-305b-2014.pdf

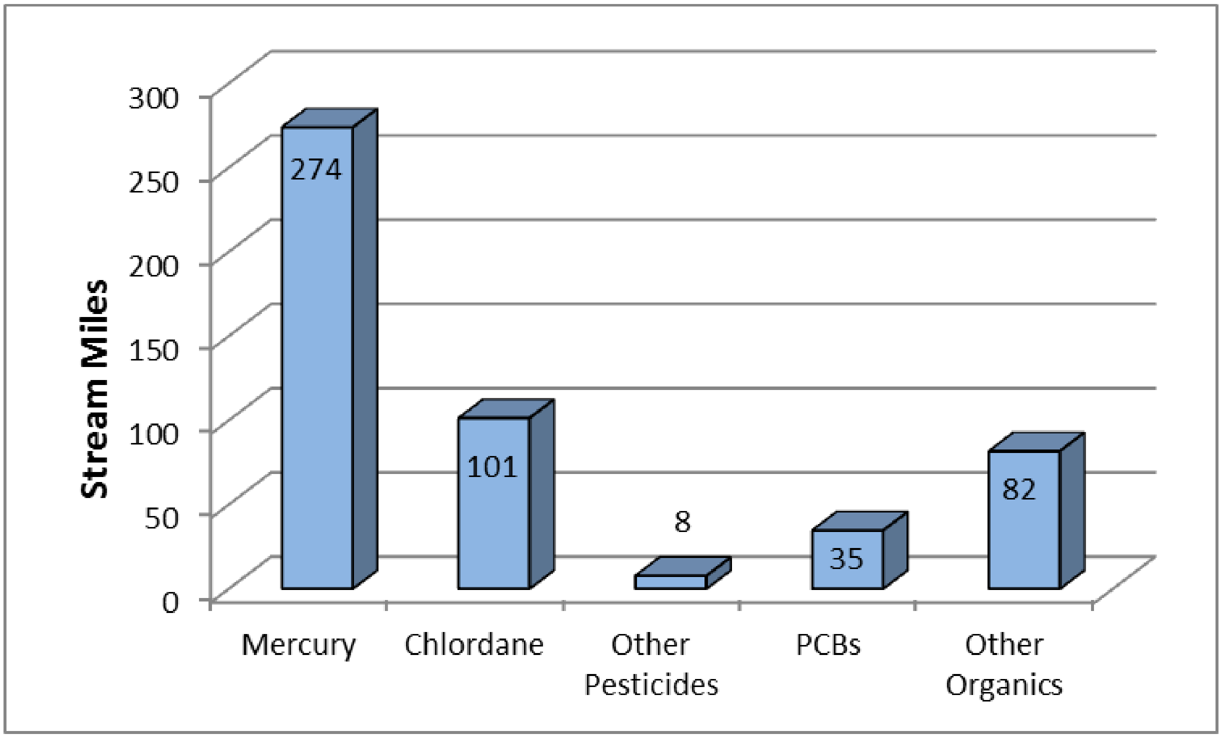


Figure 20: Stream Miles Posted for Fish Tissue Contamination. (The same waterbody may be impaired by more than one cause of pollution. Totals are not additive.)

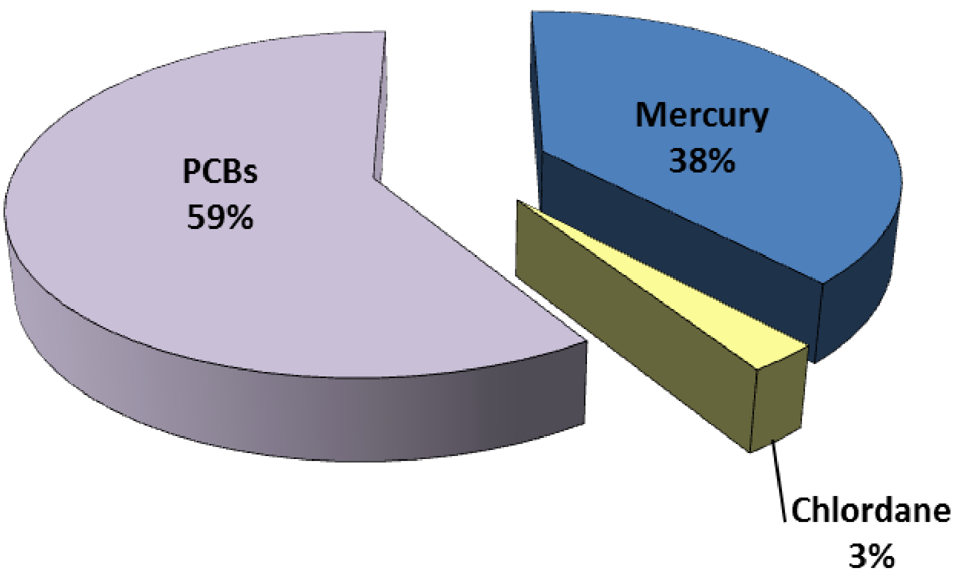


Figure 21: Relative Contribution of Reservoir Acres Posted for Fish Tissue Contamination

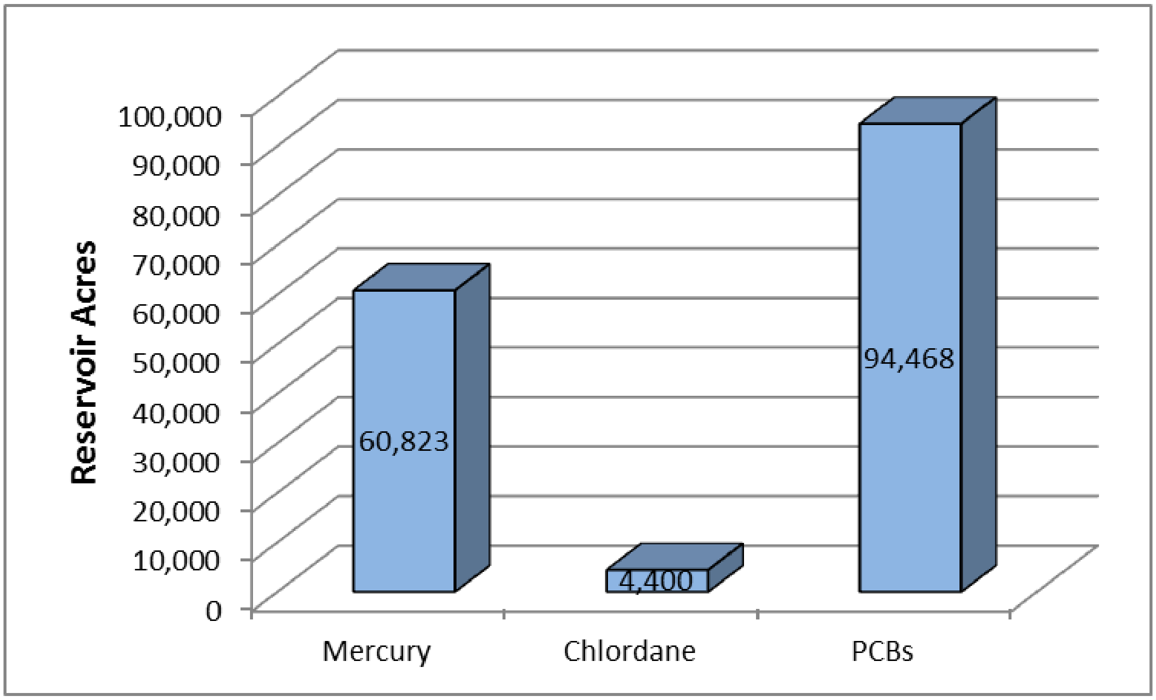


Figure 22: Reservoir Acres Posted for Fish Tissue Contamination. (The same area may be impaired by more than one cause of pollution. Totals are not additive.)

1. Organic contaminants

The majority of the reservoirs and almost half of the stream miles posted for fish tissue contamination are impacted 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 are 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.

a. **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 stream, 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.

b. **Chlordane -** Chlordane is a pesticide 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.

c. **Dioxins -** Dioxins are the 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.

2. Mercury

Mercury is a naturally occurring element found in air, water and soil. It exists in several forms: elemental or metallic mercury, inorganic mercury compounds, and organic mercury compounds. Natural sources of mercury include volcanoes, geysers, weathering of rocks, and forest fires. However, there are significant anthropogenic sources of mercury.

Mercury is naturally found in trace amounts in many rocks including coal. When coal is burned, mercury is released into the environment. According to the EPA 2005 national emissions inventory, coal-burning power plants are the largest human-caused source of mercury air emissions in the United States, accounting for over half of all domestic human-caused mercury emissions.

Air emissions can transport long distances before ultimately being deposited. Mercury deposited within state boundaries may have originated from emission outside the state. Atmospheric deposition of mercury is a primary route of transport of mercury to water. Once in a waterbody, mercury can form chemical compounds with organic molecules through a process known as methylation. Methlymercury is more toxic to humans and other animals than inorganic forms. Mercury methylation rates can be influenced by a number of factors such as acidity, dissolved sulfate, and dissolved organic carbon.

It is the methylated form of mercury that enters the aquatic food chain and can ultimately bioaccumulate in fish tissue to concentrations much higher than in the surrounding water. There is a well-documented link to human health impacts. Exposures to mercury can affect the human nervous system and harm the brain, heart, kidneys, lungs, and immune system. In pregnant women, ingested mercury is readily carried throughout the body by the bloodstream and easily migrates through the placenta to a developing fetus. The consumption of contaminated fish is considered to be the major pathway of mercury exposure for most people.

In 2007, the FDA and EPA issued a joint federal advisory of 0.3 ppm as the appropriately protective level for mercury in locally-consumed freshwater fish. Prior to 2007, TDEC used the FDA Action Level for fish sold in interstate commerce (0.5 ppm) as a trigger for considering advisories. 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 and now uses this level as a trigger point for fishing advisories (Denton, 2007).

The type of advisory considered appropriate when mercury levels are over 0.3 ppm, but not above 1.0 ppm is a “precautionary advisory” which advises pregnant or nursing mothers, plus children, to avoid any consumption of fish. All other persons are 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.

Marka Smith electroshocking in Brimstone Creek in Scott County to collect fish for tissue analyses. Photo provided by Carrie Perry, Aquatic Biology Section, TDH.

Reducing Risks from Contaminated Fish

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

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

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

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

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

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

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

5. **If the pollutant is mercury, children in particular should not eat the fish.** Fish from the posted waterbodies (see Table 11) 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

For most current revisions: http://tn.gov/environment/water/docs/wpc/advisories.pdf

Fish Tissue Advisories in Tennessee

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

West Tennessee

Stream	County	Portion	HUC Code	Pollutant	Comments
Beech Reservoir	Henderson	Entirety (877 acres)	06040001	Mercury	Precautionary advisory for largemouth bass. *
Cypress Creek	Shelby	Entirety (7.7 miles)	08010210	Chlordane, Other Pesticides, PCBs.	Do not eat the fish.
Loosahatchie River	Shelby	Mile 0.0 – 17.0 (Hwy 14, Austin Peay Highway)	08010209	Chlordane, Other Organics, Mercury	Do not eat the fish.
McKellar Lake	Shelby	Entirety (13 miles)	08010100	Chlordane, Other Organics, Mercury	Do not eat the fish.
Mississippi River	Shelby	Mississippi state line 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.
Nonconnah Creek	Shelby	Mouth to Kansas Street (Mile 0.0 to 1.8)	08010201	Chlordane, Other Organics	Do not eat the fish. Advisory ends at Horn Lake Road bridge.
North Fork Forked Deer River	Dyer, Gibson	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. *

West Tennessee (continued)

Stream	County	Portion	HUC Code	Pollutant	Comments
Wolf River	Shelby	From Mouth to Germantown Road (Mile 0.0 – 18.9)	08010210	Chlordane, Other Organics, Mercury	Do not eat the fish.

Middle Tennessee

Stream	County	Portion	HUC Code	Pollutant	Comments
Beech Creek	Wayne	Mouth to origin (Mile 16.7) including Tennessee River Embayment.	06040001	Mercury	Do not eat the fish. Avoid contact with sediment between Leatherwood Branch and Smith Branch.
Buffalo River	Humphreys, Perry	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, smallmouth, and spotted bass. *
Woods Reservoir	Franklin	Entirety (3,908 acres)	06030003	PCBs	Catfish should not be eaten.

East Tennessee

Stream	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 Tennessee (Continued)

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

East Tennessee (Continued)

Stream	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.
Sequatchie River	Marion	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. *

East Tennessee (continued)

Stream	County	Portion	HUC Code	Pollutant	Comments
Tellico Reservoir	Loudoun, 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, Anderson	Clinch River Arm (1,000 acres)	06010201	PCBs	Striped bass should not be eaten. Precautionary advisory for catfish and sauger.
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. *

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

Where contaminants are elevated in fish, they may also be present in other aquatic life as well. Therefore, the public is advised to limit or avoid consumption of other animals such as turtles, crayfish and mussels in waterbodies with a fishing advisory.

Additional national fish tissue advisories have been issued for the most sensitive sub-populations: pregnant women, nursing mothers, children, and women who could become pregnant. See the joint EPA and FDA advisory on EPA's website at http://www.epa.gov/mercury/advisories.htm .

Chapter 6 Success Stories

1. Little Pigeon River Contact Advisory Lifted

In 1993, elevated fecal coliform levels were found in Little Pigeon Creek and several of its tributaries in and around the Great Smoky Mountains National Park and surrounding cities. The pathogen levels were high enough to post a water contact advisory. The high levels of bacteria originated from overflows of municipal wastewater treatment plant, collection systems failures, improperly functioning septic tanks, household waste directly discharged to streams, and stables in the national park.

These issues covered such a large area that it required many stakeholders including, Cities of Sevierville, Pigeon Forge and Gatlinburg, TDEC, Sevier County, the Great Smoky Mountains National Park, and Dudley Creek Stable concessionaire, to work together to eliminate the contamination. The city of Sevierville upgraded their wastewater treatment plant and moved the effluent outfall from Little Pigeon River to the much larger French Broad River. Pigeon Forge and Gatlinburg located and eliminated sewer leaks and improper connections. Septic tank or “straight piping” problems were investigated and corrected where found in Sevier County. In the Great Smoky Mountain National Park, Dudley Creek Stables concessionaire installed a new wash rack for the horses and connected to Gatlinburg WWTP. Also, a mile of the riding trail near Duds Branch was moved further away from the creek.

Key personnel involved in improving water quality in the Little Pigeon. Photo provided by John West, KEFO.

All of these corrections resulted in lower pathogen levels in Little Pigeon Creek, Gnatty Branch, Baskin Creek, King Branch, Roaring Fork and Holy Branch and the water contact advisory was lifted in April of 2014. This is a great boost for the local economy and recreational activities such as fishing and swimming in this beautiful area.

2. Leadville Creek Contact Advisory Lifted

In 1986 it was discovered that Leadville Creek had high levels of pathogens from White Pine Sewage Treatment Plant. White Pine has updated the plant and moved the discharge from Leadville Creek to Douglas Lake. The pathogens levels were much lower after the update, but still elevated due to runoff from the city of White Pine and livestock in the area. A partnership between the Tennessee Department of Agriculture, the Jefferson County Soil Conservation District, the U.S. Department of Agriculture's Natural Resources Conservation Service and the Jefferson County government collaborated to assist landowners to fence cattle out of the creek. As a result of these improvements, pathogen levels were low enough to remove the water contact advisory.

3. Tributaries to Trail Fork Big Creek Contact Advisory Lifted

An outbreak of hepatitis A occurred in Del Rio, TN in Cocke County in 1996. Stream sampling in the area revealed elevated pathogen levels, so water contact advisories were issued on John Creek and Baker Branch . Further investigation revealed that shallow residential wells and streams had been contaminated by failing septic systems. Subsequently the septic systems were repaired and the pathogen levels in the streams have continued to fall until they were low enough for the contact advisory to be lifted in September 2013.

4. Little Fiery Gizzard Creek Contact Advisory Lifted

In 1999 it was discovered that Little Fiery Gizzard Creek was contaminated from Tracy City Elementary School's wastewater treatment package plant and failing septic systems. The high bacteria levels were of particular concern in Little Fiery Gizzard Creek because of its proximity to the school. At the time, Tracy City had been talking to Monteagle about the possibility of connecting to their wastewater treatment plant. The timetable for implementing these improvements was sped up and in 2010, new sewer service was connected to the elementary school and the homes with failing septic systems. Subsequent monitoring revealed the pathogen levels were lowered significantly. The partnership between Tracy City and Monteagle improved water quality in Little Fiery Gizzard Creek to the point that it was safe to remove the warning.

5. Crab Orchard Creek Water Quality Improvements

Crab Orchard Creek located in Morgan County has been severely impacted by acid drainage from several abandoned coal mines. Almost 900,000 dollars were spent to help address these problems: acid water pits have been eliminated, and passive acid drainage such as limestone treatment systems were constructed. Highwalls were filled in, cut and eroded areas were stabilized and the disturbed areas were revegetated. These measures have not only improved water quality in Crab Orchard Creek, but also four tributaries including Mill, Golliher, Fagan and Little Laurel creeks.

Golliher Creek restoration area. Photo provided by Trevor Martin, KEFO.

6. Whites Creek Water Quality Advisory Lifted

Whites Creek in Nashville has historically been impacted by chronic overflows from a sewage pumping station. Nashville Metropolitan Government has invested over 20 million dollars in replacing the old sewage pumping station. Subsequent monitoring has shown that the creek now meets pathogen standards. In December 2014 the water quality advisory was officially lifted.

Removal of the water contact advisory sign at Whites Creek by Commissioner Martineau. Photo provided by David Owenby, CO.

Chapter 7 Special Projects

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

A. Headwater Reference Streams

TDEC has established macroinvertebrate, habitat, and nutrient guidelines for narrative criteria based on reference stream monitoring in 31 ecoregions. These regional translations of narrative criterion are used for assessing wadeable streams throughout the state. These guidelines are designed for streams or rivers with drainage areas greater than two square miles and are not always appropriate for comparison to headwater streams.

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

Annie Goodhue completing paperwork at reference stream for the Western Pennyroyal Karst (71e) in Robertson County. Photo provided by Kim Laster, PAS.

In 2008, the division began a seven year study to identify and monitor first and second order reference streams in 13 Tennessee bioregions to aid in development of biological and nutrient criteria guidelines in headwater streams.

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

B. Coalfields Fish Tissue Monitoring

Tennessee has a history of surface coal mining in the Cumberland Plateau and Cumberland Mountain regions. Over 1000 miles of 45 streams are on the 303(d) list of impaired waters due coal mining activities. Most of the impaired stream miles are downstream of surface mines that were abandoned prior to the Surface Mining Reclamation and Control Act of 1977.

Biologists with the Division of Water Resources routinely collect macroinvertebrate and water chemistry samples downstream of inactive mines while permits require active facilities to perform in-stream monitoring. However, since coal and surrounding rock layers can contain trace amounts of elements such as arsenic, mercury and selenium, there is the potential for human health or environmental effects from the bioaccumulation in fish tissue.

In 2011, 2013 and 2014, the Division of Water Resources used EPA 106 supplemental funds to study potential bioaccumulation of metals in native game fish in streams draining three land-use categories: actively mined areas, abandoned/reclaimed coal mines, non-coal mining activities, and reference streams (Figure 23).

Forty-three sites were originally targeted for sampling in 2011. Four additional sites were added in 2013 and 2014. Fifteen sites have active mining in the watershed. Twenty-six are in areas of historic coal mining. Two stations have active sand and mica mines (one is non-coal and one is a historic large scale copper mine currently under reclamation). Three additional sites in areas with historic mining are considered reference sites due to recovery and/or small area of disturbance.

Mercury in fish fillets at nine sites had concentrations above 0.3 ppm (precautionary level for human consumption). Three of these sites had elevated mercury concentrations in multiple species. Smallmouth bass were generally the largest fish collected and tended to have the highest levels of mercury. Although not present at all sites, smallmouth bass were found in all land-use categories. Mercury levels tended to be highest in the smallmouth collected at reference sites and those downstream of inactive coalfields.

Typically, selenium levels were highest downstream of active coal mines followed by non-coal mining activities. Fish size, diet and species had little influence in selenium concentrations. None of the levels exceed the EPA draft 2004 or 2013 (currently under peer review) guidelines for selenium in fish fillets, ovaries or whole-body fish.

Eight other metals were analyzed from the fish fillet samples collected in 2011. Arsenic, total chromium, copper, iron and zinc were found in low levels in some fish fillets. Arsenic and iron levels were higher downstream of active coal mines. Arsenic was generally below detection at other sites except for the station downstream of historic copper mining. Mercury was found in fish tissue at nine of the sites in concentrations above 0.3 ppm (concern level for human consumption). Other metal concentrations were below levels of concern. Cadmium, lead and thallium were not detected in any fish.

Water column samples were collected during the 2011 fish collection. Results from most sites were well below levels of concern. Monitoring stations with elevated zinc, iron or manganese levels had already been listed as impaired for that parameter from abandoned mines.

The final report was published in December 2014 and can be found on the Division's publication's page: http://www.tn.gov/environment/water/water-quality_publications.shtml

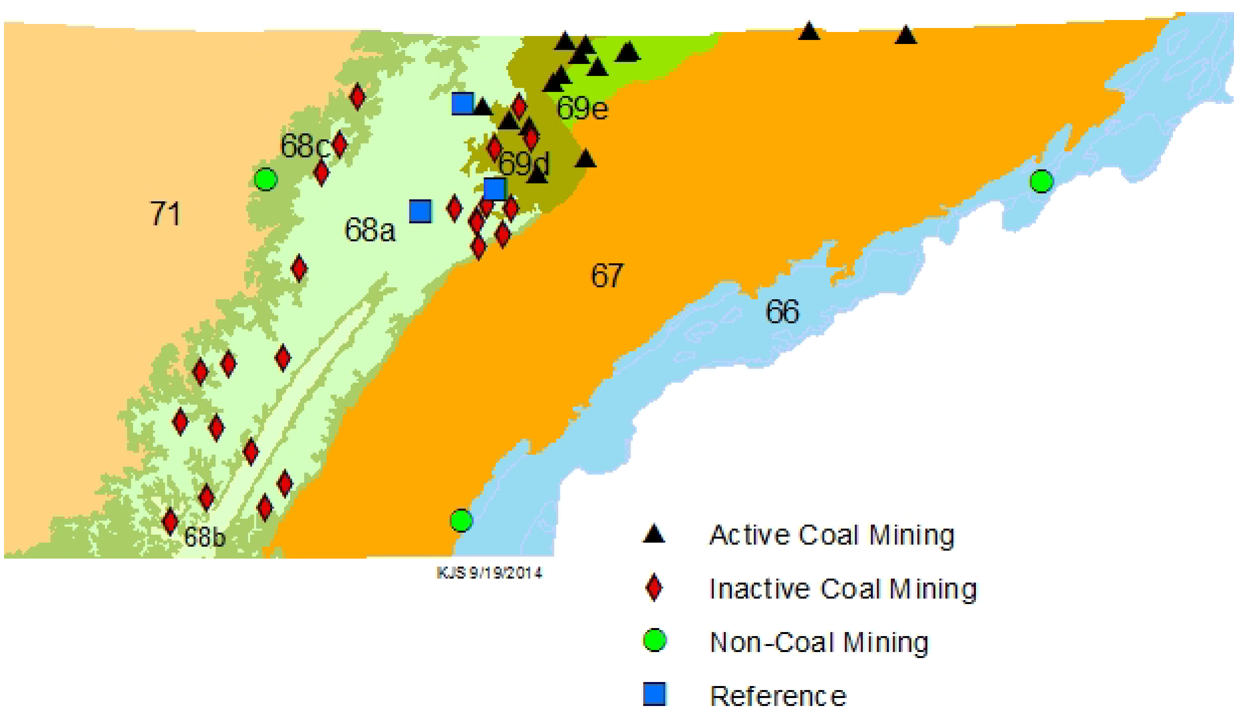


Figure 23: Fish Tissue Monitoring Sites for Coalfields Study.

C. Southeast Monitoring Network Update

In 2011, biologists from six EPA Region 4 states Tennessee, Kentucky, Alabama, Georgia, North Carolina, and South Carolina in partnership with TVA, and EPA created a joint reference stream monitoring network. The primary objective of the fledgling Southeast Reference Monitoring Network (SEMN) was to study the potential for fluctuations in stream biological populations in response to variations in hydrology and temperature from changing climate conditions. Two main goals of the group are to assess existing responses to climate change and identify climate-sensitive indicators. However, it was agreed that a reference network with shared sampling methodology would also be useful for establishing regional reference conditions and would promote consistency in assessments of shared watersheds and ecoregions. Project data can be helpful in assessing the effects of many regional stressors including drought, air deposition and invasive species.

The workgroup agreed on methodologies for continuous water depth and temperature monitoring, plus annual collection of macroinvertebrates, fish, diatoms, surface water samples and habitat. Thirty-nine sites were targeted. Stations are in moderate to high gradient streams ranging from 1 to 56 square mile drainage. The majority are in protected watersheds with a minimum of 90% forest. Others are in relatively undisturbed watersheds where landuse is not expected to change significantly in the next 20 years. Monitoring began at most sites in April 2013 with the remainder starting in April 2014.

Existing state monitoring programs were expanded to include additional parameters so that monitoring would be consistent for all sites in the network. At a minimum, sampling includes macroinvertebrates, habitat assessments, field parameters, flow and continuous temperature monitoring. Some agencies, including TDEC also collect periphyton, water quality, channel profiles and continuous flow. TVA has agreed to sample fish populations at sites which drain into the Tennessee River.

Fifteen of the selected sites are located in Tennessee’s Level III Ecoregions 66, 67, 68 and 71 (Figure 24). Together, TDEC and TVA have collected all of the selected parameters for two and half years.

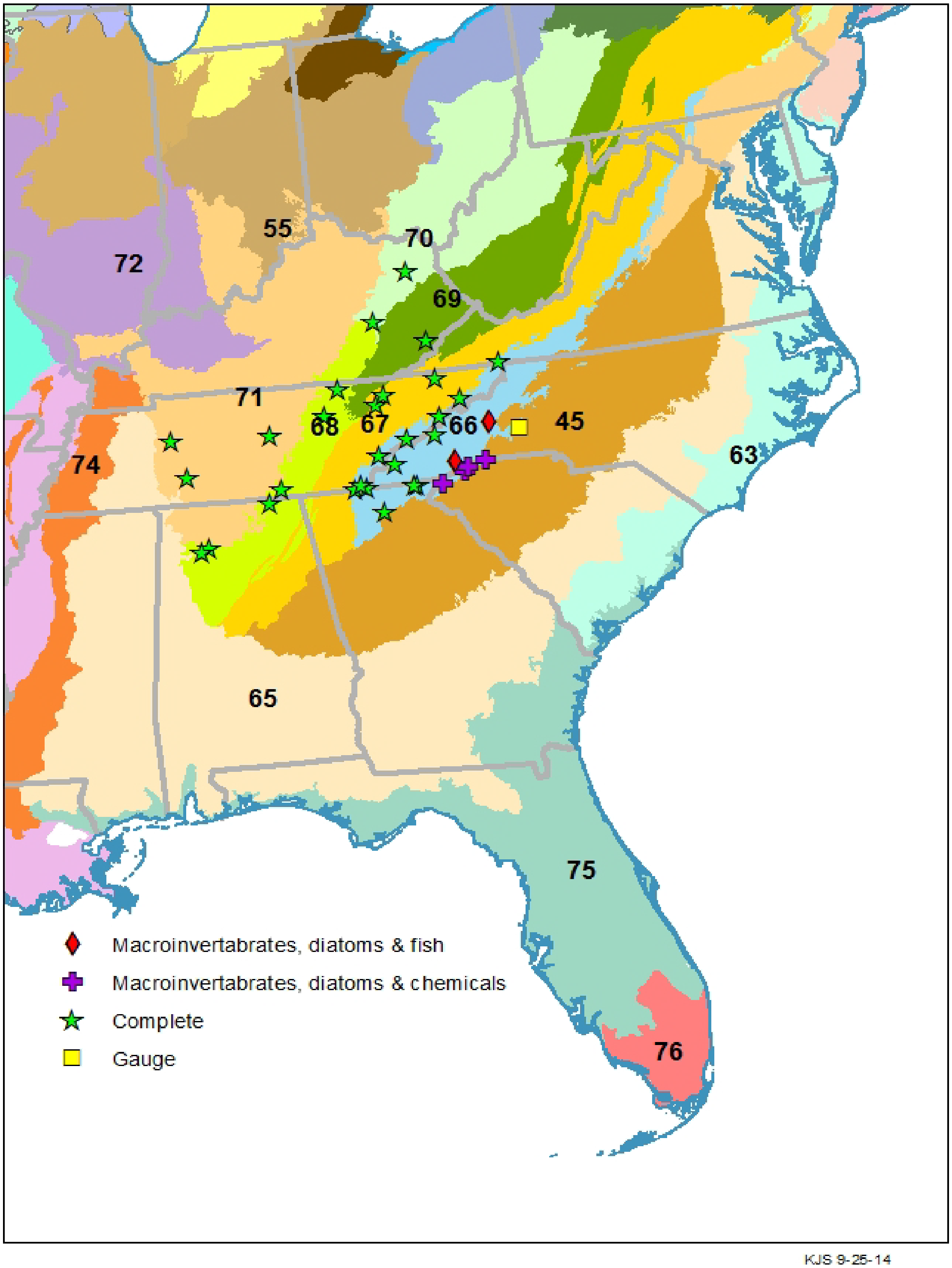


Figure 24: SEMN Monitoring Site Locations.

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 our contributions, 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. The division participates in public outreach and educational activities throughout the state. In fact, in 2013, the division participated in over 35 outreach activities.

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

Exploration of aquatic life during the 2nd Annual Urban 5K in Nashville. Photo provided by Kim Laster, PAS.

Reduce, Reuse, and Recycle

Whenever possible recycle metal, plastic, cardboard, and paper, so the materials 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://tn.gov/environment/sustainable-practices.shtml

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 is carried by runoff to streams, rivers, lakes and reservoirs. Over-application of fertilizers and pesticides wastes money, risks damage to vegetation, and pollutes waterways. Therefore, use all chemicals, especially lawn chemicals, cautiously.

3. Prevent erosion and runoff

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

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

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

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

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

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

Bulldozers or backhoes in a stream removing gravel or rocks.

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

Sewage pumping stations discharging directly or indirectly into a stream.

Manholes overflowing.

4. Obtain a permit

Contractors wishing to alter a stream, river, lake, reservoir 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. More information on permits may be found at http://tn.gov/environment/permits/#water

Report Pollution

The public is an important source of information on pollution. Call your local Water Resources office if you see a water pollution problem. A map of Tennessee's Environmental Field Offices (EFO) appears on the next page (Figure 25). 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 25 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/water

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.

Accessed 1/17/17 at
http://www.tennessee.gov/assets/entities/environment/attachments/wr_wq_report-305b-2014.pdf

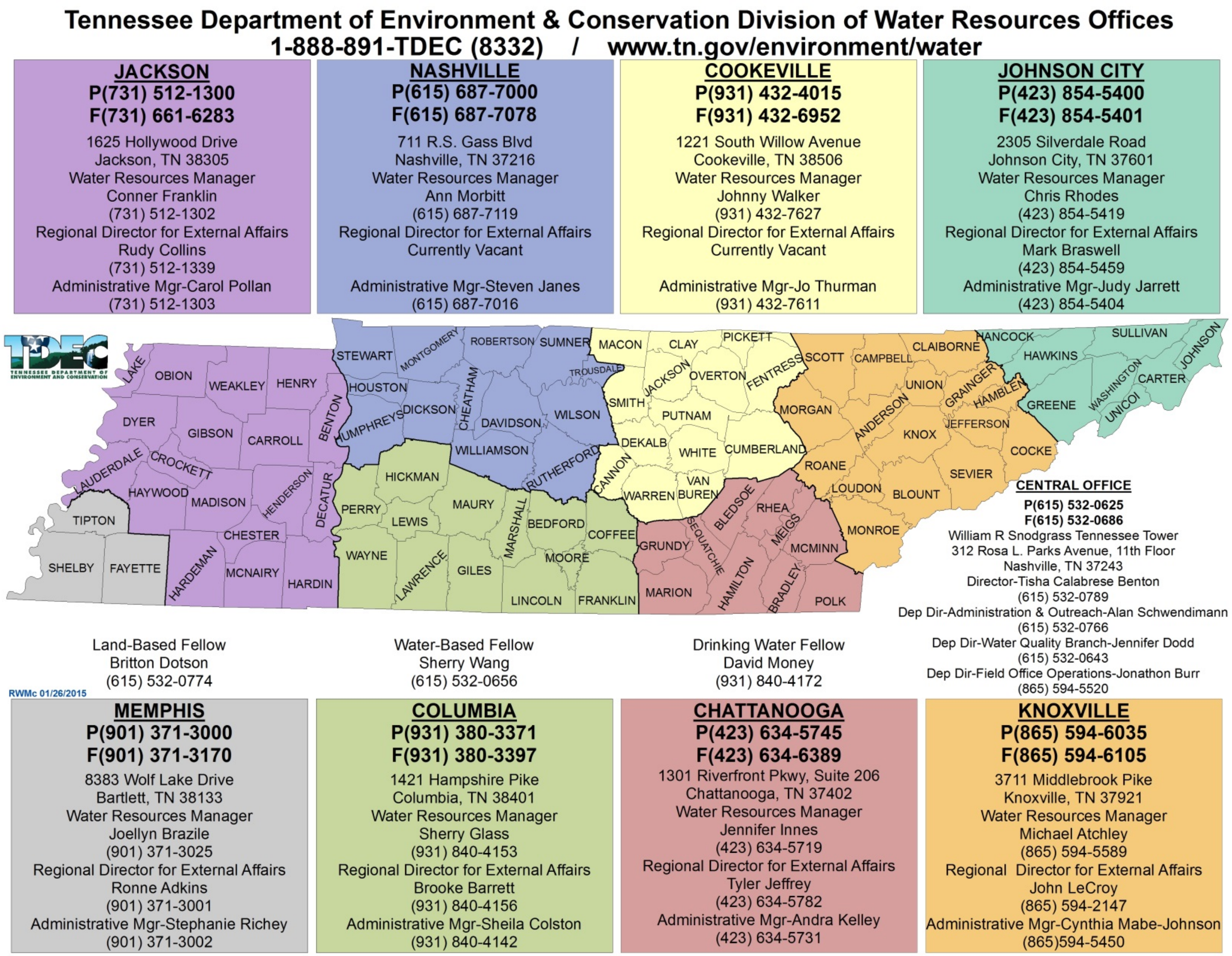


Figure 25: TDEC Environmental Field Office Contacts

On line Resources

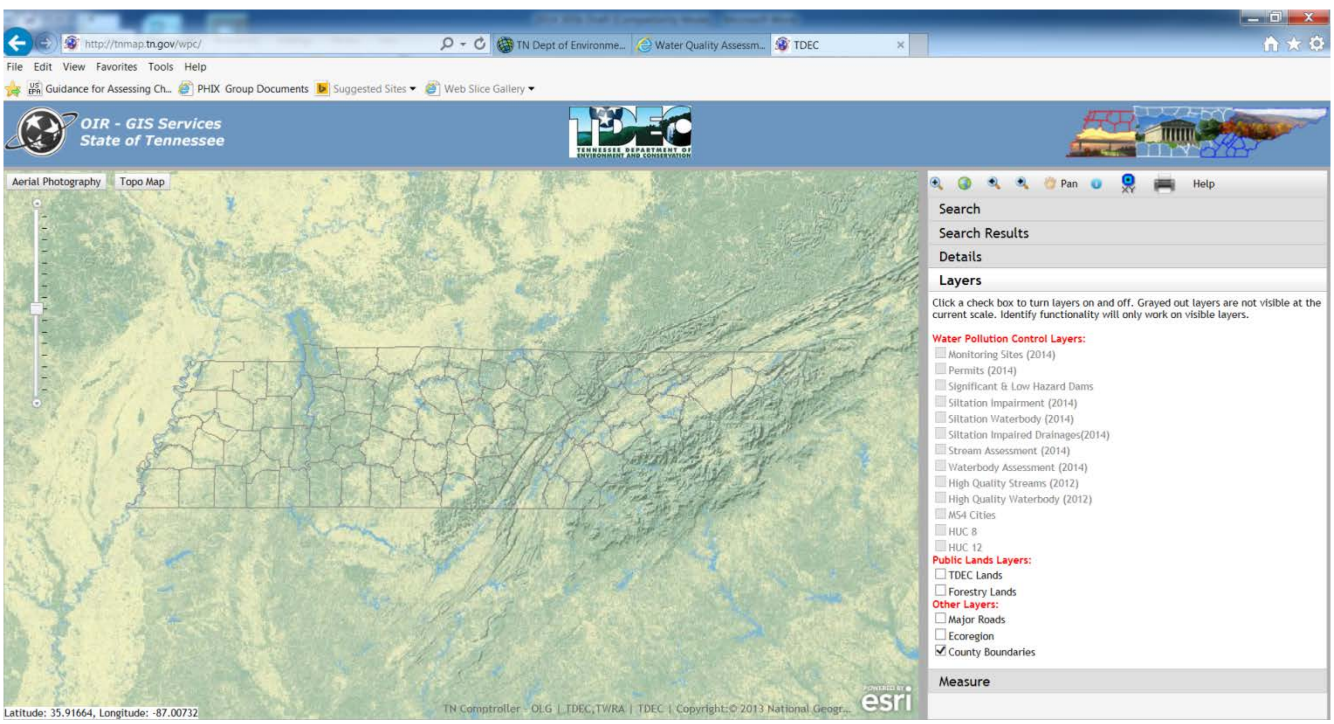
TDEC has developed interactive maps and databases supplying a large amount of information to the public in an easy to access forum.

A. The Online Assessment Database is an interactive map illustrates water quality, monitoring sites, high quality waterbodies as well as Hydrologic Unit Codes and Ecoregions boundaries at the following weblink http://tnmap.tn.gov/wpc/.

B. Another map, the Water Resources Permit Viewer, shows permits issued throughout the state including aquatic resource alteration permits (ARAP), construction permits, national pollutant discharge elimination system (NPDES), underground storage tanks, septic system, and biosolid permits at http://tdeconline.tn.gov/tdecwaterpermits/ .

C. The department also offers a searchable database offering public access to specific information regarding permits, Exceptional Tennessee Waters, complaints, appeals, and inspections at the following weblink: http://environment-online.state.tn.us:8080/pls/enf_reports/f?p=9034:34001:8357139784376 .

D. A link to current Division of Water Resources rules, SOP documents, and other published reports may be found at http://tn.gov/environment/water/water-quality_publications.shtml .



An interactive water quality assessment map is available at http://tnmap.tn.gov/wpc/

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)

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

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

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

Riparian Zone: An area that borders a waterbody.

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

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

Acronyms

ADB:	Assessment Database
ARAP:	Aquatic Resource Alteration Permit
ATV:	All-Terrain Vehicle
BMP:	Best Management Practices
CAFO:	Confined Animal Feeding Operation
CERCLA:	Comprehensive Environmental Response, Compensation, and Liability Act
CHEFO:	Chattanooga Environmental Field Office
CKEFO:	Cookeville Environmental Field Office
CLEFO:	Columbia Environmental Field Office
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
EPT:	Ephemeroptera (Mayflies) Plecoptera (Stoneflies) Trichoptera (Caddisflies)
ETW:	Exceptional Tennessee Waters

Acronyms (continued)

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
NPS:	National Park Service
NRCS:	Natural Resource Conservation Service
OHV:	Off Highway Vehicle
ONRW:	Outstanding National 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 Tool
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
TMI:	Tennessee Macroinvertebrate Index
TVA:	Tennessee Valley Authority
TWRA:	Tennessee Wildlife Resource Agency
USACE:	U.S. Army Corps of Engineers

Acronyms (continued)

USGS:	U.S. Geological Survey
USFWS:	U.S. Fish and Wildlife Service
WET:	Whole Effluent Toxicity
WPC:	Water Pollution Control
WSA:	Wadeable Streams Assessment
WQOGB:	Water Quality, Oil & Gas Board
WQDB:	Water Quality Database
WQX:	Water Quality Exchange
WWTP:	Waste Water Treatment Plant

Virgin Fall State Natural Area. Photo provided by Barbara Loudermilk, NEFO.

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Maddie Denton collecting water samples from Lytle Creek. Photo provided by Greg Denton, PAS.

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To reach your local
ENVIRONMENTAL FIELD OFFICE
Call 1-888-891-8332 or 1-888-891-TDEC