State of Oklahoma

STATUS OF WATER QUALITY MONITORING IN OKLAHOMA

Final Report to the Oklahoma Legislature For Year 2000

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EXECUTIVE SUMMARY

With the passage of Senate Bill 549, the statutory responsibilities of the various state environmental agencies were identified, assigned or further clarified. One of the new responsibilities assigned to the Oklahoma Water Resources Board was the submittal of a biennial report to the Oklahoma Legislature discussing the status of water quality monitoring in Oklahoma. This document is the culmination of that charge and outlines current monitoring activities being conducted by the State of Oklahoma and our federal partners. The focus of this document will be on surface water quality monitoring, however, some abbreviated discussions related to ground water monitoring initiatives is included. The focus of this document is on surface water resources, as a comprehensive groundwater monitoring network looking at groundwater quality does not currently exist. The Oklahoma Department of Environmental Quality (ODEQ) does engage in groundwater monitoring through their public water well sampling program. But at the present time their program falls short, both in terms of areal extent of the network and in terms addressing the water quality of the more shallow alluvial aquifers, of adequately looking at the states groundwater quality in a holistic manner.

This report may also be used by the ODEQ for Environmental Protection Agency (EPA) reporting requirements pertaining to the State's Water Quality Monitoring Strategy. The Clean Water Act (CWA) specifies that "the Administrator shall not make any grant under this section to any State which has not provided or is not carrying out as a part of its program- the establishment and operation of appropriate devices, methods, systems, and procedures necessary to monitor, and to compile and analyze data on (including classification according to trophic condition), the quality of navigable waters and to the extent practicable ground waters including biological monitoring; and provision for annually updating such data...". This report outlines the various activities undertaken by the state to monitor water quality, compile information and analyze environmental data.

State agencies are in the process of coordinating water quality monitoring activities. The Oklahoma Water Quality Monitoring Council (OWQMC) could and should be pivotal in this coordination effort. Numerous state agencies have monitoring programs that are conducted for a variety of purposes. Much of the monitoring being conducted is related to federal programs or federal requirements. The monitoring programs of various state agencies are discussed in detail in the rest of this document. The various monitoring programs can be summarized as follows:

- The Oklahoma Water Resources Board (OWRB) conducts monitoring on surface waters to assess beneficial use support attainment through the "Beneficial Use Monitoring Program" (BUMP). The OWRB assists other state agencies with their monitoring needs through the BUMP (i.e. Oklahoma Corporation Commission, Oklahoma Department of Agriculture). In addition, the OWRB conducts monitoring on numerous lakes and rivers across the state to diagnose water quality problems, make recommendations for actions or activities which can be implemented to improve water quality, document attainment of pollutant reduction goals, develop criteria for Oklahoma's Water Quality Standards, perform bathymetric mapping, and conduct specific groundwater basin studies. Monitoring of wetlands and performance of Use Attainment Analyses (UAAs) are also performed on a limited basis or as needed basis. The OWRB also conducts a volunteer monitoring program, Oklahoma Water Watch. The OWRB also conducts hydrological investigations and groundwater basin studies to assess water quantity needs and water resources available to be put to a beneficial use. The OWRB has conducted numerous groundwater basin studies in cooperation with the United States Geological Survey (USGS) looking at the quality of Oklahoma's groundwater resources and assessing the vulnerability of groundwater basins to pollution.

- The Oklahoma Conservation Commission (OCC) monitors rivers and streams across Oklahoma to assess the impacts of nonpoint source (NPS) pollution on our state waters in support of the § 319 (h) Nonpoint Source Program. The OCC performs monitoring for four basic reasons: 1) to determine whether a waterbody is being impacted by NPS pollution, 2) to determine the significant sources of that NPS pollution, 3) to determine whether education, best management practices (BMPs), or other remediation efforts are successful at reducing NPS impacts, and 4) to educate citizens about water quality. To accomplish these goals, OCC collects baseline water quality, habitat, and biological monitoring statewide primarily through a rotating basin sampling program. OCC also collects information on land-use and other activities in a watershed that might be sources of NPS pollution. This data is collected for inclusion in numerous state water quality lists and reports and specifically for the 319 Nonpoint Source Assessment Report. OCC also performs project-specific monitoring to document success of implemented BMPs at improving water quality. The OCC assists the Department of Environmental Quality in their wellhead protection program. The OCC also conducts an education and volunteer monitoring program, Blue Thumb. Monitoring of wetlands has not historically occurred at the OCC, but is currently being examined as a possibility.

- The Oklahoma Department of Environmental Quality (ODEQ) conducts certain surface water quality monitoring, in terms of the presence of selected toxic substances in fish tissue, through its Toxics and Reservoirs Program, biotic integrity/aquatic habitat trends, through its Fish Community Biotrend Monitoring Program, and segment-specific pollutant loading characteristics and capacities, through it's Total Maximum Daily Load (TMDL) studies. On a site or segment specific basis, selected surface water quality monitoring may also be conducted as an adjunct to complaint investigations. However, much of the DEQ surface water and ground water quality monitoring activities are a function of their regulatory programs in Point Source Discharge (OPDES) Permitting, Public Water Supply, Solid Waste Management, Hazardous Waste Permitting and Corrective Action, Underground Injection Control, Radiation Management, Brownfields Redevelopment and Superfund.

- The Oklahoma Corporation Commission conducts routine monitoring activities related to the Oil & Gas Industry. The OWRB Beneficial Use Monitoring Program is currently assisting the Corporation Commission with some aspects of their monitoring program.

- The United States Geological Survey (USGS) conducts a monitoring program on many rivers and streams across Oklahoma, looking at stream flow and water quality conditions. The USGS coordinates with the state of Oklahoma through the Cooperative Program managed by the OWRB.

In general, the OWRB, OCC, ODEQ, and USGS are the entities in Oklahoma that are currently involved in conducting state-wide water quality monitoring programs with a primary focus of assessing beneficial use support. Numerous other state agencies are involved to a lesser degree in water quality monitoring in Oklahoma, predominantly on a project specific basis. For the purposes of this report, they will not be discussed. The point the reader should glean from this is that this report should not be construed as a comprehensive document of **all** water quality monitoring efforts occurring in Oklahoma, just a brief discussion of the major state-wide efforts currently being conducted.

Historically, little state or federal monies have been devoted to conducting routine water quality monitoring. In the last few years with increased federal funding in connection with the §319 nonpoint source program and the §106 program and with state funding of the BUMP, Oklahoma is beginning to make progress in terms of understanding current water quality conditions. This has resulted in Oklahoma more effectively identifying and prioritizing areas where dollars and manpower should be devoted to protect and preserve our water resources. There is still much work to be done in terms of monitoring and coordinating our efforts, but we have taken a major step in the right direction. However, some problems still remain and should be addressed. Though federal funding for monitoring activities not associated with specific localized project areas has increased, monitoring is still often geared towards statutory authorities and requirements. This sometimes results in a lack of coordination between the various localized water quality monitoring projects. This lack of a holistic state monitoring program is being addressed by the Oklahoma Water Quality Monitoring Council. More effective coordination of efforts is still a goal of the various agencies involved in water quality monitoring. A comprehensive holistic program for monitoring Oklahoma's waters is not currently in place and is vitally needed if we are to effectively manage our water resources in the 21st century.

Historically, the perception has been that state agencies were not always consistent in their determination of beneficial use support. To address this problem the OWRB along with our sister environmental agencies has worked to develop standardized beneficial use support assessment protocols. Through the promulgation into rules of the use support assessment protocols (USAP) developed by the workgroup, a standardized protocol for identifying beneficial use threats or impairments has been developed. This effort led by Oklahoma's state and federal agencies as well as representatives from state academic institutions is a major step forward in our state monitoring initiative. The USAP will continue to undergo modification and refinement. The rules need flexibility to address more complex water quality problems, use support areas not included in this initial USAP, or changing state priorities.

It should be stressed that work remains to be done to monitor our water resources in a more systematic and comprehensive fashion. There are several water quality monitoring initiatives that could be initiated or enhanced. While biological monitoring is aggressively conducted on small and mid-size streams by the Oklahoma Conservation Commission, biological monitoring on our lakes and larger streams should be increased or implemented where not currently occurring. At this time very little biological monitoring is being conducted on our lakes and larger streams. This needs to be addressed presently.

Collection of fish tissue samples for analysis of toxics is certainly an area of water quality monitoring that could be greatly enhanced with an increase of monies for monitoring. In general, the current levels of water quality monitoring are sufficient as a base level of monitoring but much more extensive monitoring will be required in the future to allow Oklahoma to meet our goal of protecting and preserving our water resources. Federal funding alone does not currently meet the water quality monitoring needs of Oklahoma. It is envisioned that a joint state and federal initiative is required to accomplish the goal of protecting, preserving and restoring our water resources for the citizens of Oklahoma.

Recommendations

Improvements to the states monitoring efforts should be pursued. Some recommendations to enhance the state's monitoring efforts are presented for consideration.

- It is highly recommended that state monitoring programs coordinate more effectively. Coordination of efforts would result in less duplication of work and would allow agencies to leverage resources to gather the desired information needed for decision-making purposes. No one agency has the resources to conduct all of the monitoring necessary to manage our waters. Through better coordination, each agency can bring their unique talents and abilities to the table so that our resources can be managed to the best extent possible. Certainly one avenue to facilitate coordination and exchange of information is the Oklahoma Water Quality Monitoring Council (WQMC). The council has been modestly successful in ensuring that coordination occurs, but improvements could be made.

- It is recommended that numerical biological criteria continue to be developed and, if possible, the time frame for development should be accelerated. It is also recommended that biological monitoring programs be implemented on a widespread basis to document attainment of beneficial uses. Currently, the Oklahoma Conservation Commission (OCC) is the only state agency conducting a comprehensive biological monitoring program on Oklahoma's smaller to mid-size streams. Additional monitoring should be implemented on lakes and larger streams.

- A database to house the state's water quality data would be very beneficial and would certainly facilitate the sharing of information. More effective sharing of information is critical if correct management decisions are to be made. The Department of Environmental Quality is currently working on developing such a database. In addition, the EPA STORET database may offer a solution to the data-sharing problem.

- Further work needs to be pursued in the development of Use Support Assessment Protocols (USAP). New protocols still need to be developed and current ones refined over time. For example, new protocols are needed to provide support to agencies interpreting narrative criteria in the OWQS to determine water quality threats or impairments.

- More diurnal dissolved oxygen monitoring and sampling for water borne pathogens should be conducted.

- Work needs to be carried out in the identification of sources of pollution. Currently there are no statewide protocols on the identification of sources of pollution when a problem is documented. Identification of sources is necessary as part of the state's reporting procedures to the United States Environmental Protection Agency for such things as the 305(b) Report and the 303(d) list. State agencies are following EPA guidance for identification of pollution sources, but further refinement to the process is ongoing. The OCC is in the process of forming a work group to develop source identification standard operating procedures, however only limited funding is available for source identification through the 319 program.

- Flow monitoring should be implemented on a more widespread scale. It is not necessary to have exact measurements of flow, but it is necessary to know if stream flow is at seasonal base flow to make numerous beneficial use support determinations. More exact measurements for flow are necessary for such state activities as Total Maximum Daily Load (TMDL) studies and other technical studies.

- Ambient groundwater monitoring should be implemented on a larger and more holistic scale. Currently groundwater monitoring is conducted on a project by project basis or as part of compliance monitoring (ODEQ Public Water Well Sampling Program). The ODEQ and OWRB are pursuing groundwater-monitoring initiatives and look forward to working together in instituting an comprehensive ambient groundwater-monitoring program that is larger in areal scope and more effective at looking at the vertical component of our groundwater resources (i.e. examining the water quality of our shallower aquifers).

- Metals and organics sampling occurs on a very limited basis and much more extensive ambient sampling for these types of compounds would be very beneficial to Oklahoma. Toxics monitoring related to fish consumption by humans is also an area that could be greatly expanded in the future. The ODEQ currently conducts a fish tissue toxics monitoring program on a limited scale.

- More work needs to be conducted in monitoring our state's lake resources. Our lakes are utilized extensively as water supply sources and as recreational outlets for our citizens and visitors to our state. In comparison to the dollars spent monitoring our stream resources, a relatively small amount of money is spent monitoring lakes. It is also necessary that Nutrient Limited Watershed (NLW) studies be conducted on identified lakes to assess if nutrient impairments are present.

- More work needs to be done to incorporate use of geographical information systems (GIS) into the State's water quality programs. Although the state has made significant strides in using GIS, there is still great untapped potential. Specifically, more work needs to focus on information sharing. Similar to a statewide database for water quality data, the State needs a system for sharing GIS information.

- It is recommended that Oklahoma consider implementing a rotating, randomly sampled stream station program. Fixed sites are necessary to document trends, however, they still leave a large portion of the state's waters unassessed. If Oklahoma implemented a program to sample randomly selected sites in each stream segment in addition to fixed stations, the state would be assessing its' waters more thoroughly and would likely be able to identify sources of problems more effectively. Fixed station monitoring allows the assessment of a stream for some distance upstream and downstream of the monitoring site. Fixed station data is necessary to look at trends or at effects of cities or other specific targets, but an additional methods of assessing all of the unassessed water and the ability to make statistically sound estimates regarding water quality is needed. If sites are randomly selected, statements concerning percentages of various stream classes that are supporting or not supporting all their different uses, and how certain we are of our estimates can be made.

- It is recommended that Oklahoma pursue a probabilistic sampling regime to aid in assessing the status of our state's waters. Probabilistic sampling can be very effective at assessing the quality of our waters from a small number of samples and extrapolating to the quality of all of our waters. Probabilistic sampling would be a very useful tool for the state's 305(b) reporting process and is a sampling regime that the United States Environmental Protection Agency is very much interested in Oklahoma pursuing.

- It is recommended that waters listed on the 303(d) list be given serious consideration as priority waters for monitoring purposes. It is imperative that data be collected to confirm or refute 303(d) listings. The level of effort demanded to conduct TMDL studies on our state's waters is considerable, both in terms of money and manpower. Oklahoma needs to focus it's efforts on waters that are in the greatest need for protection or remediation and to facilitate this process it is essential that waters that are in need of help be positively identified.

INTRODUCTION

Status of Water Quality Monitoring in Oklahoma

Numerous agencies are engaged in water quality monitoring in Oklahoma for a variety of purposes. Often, monitoring is conducted as part of a federal project and the type of monitoring and duration of monitoring is very strictly outlined as a condition of the grant award. Before any meaningful discussion of monitoring in Oklahoma can begin, it is essential that the reader be aware of the various types of monitoring which occur, the strengths and weaknesses of each type of monitoring, and the reasons why one type of monitoring approach would be favored over another.

The type of monitoring conducted in Oklahoma by the various state and federal agencies is predicated on the monitoring objective. For example, if water quality monitoring is required as part of a federal grant then in most instances the monitoring will be initiated to document water quality concerns or impairments to a specific water body or watershed or in the case of remedial activities the monitoring program will be designed to document the success of failure of the remediation. What this means in basic terms is that the objectives of the monitoring program will determine the type of monitoring which will be required.

The reader may at this point be asking the question "so what?" and may be thinking to themselves that "monitoring is monitoring, what's the big deal?". It is very important for the reader to understand the concept that a water quality monitoring program with the goal of documenting the effectiveness of Best Management Practices (BMPs) at improving water quality in the Washita River is fundamentally different than a monitoring program designed to look at long-term water quality trends in the Illinois River Basin.

Over the past few years heightened interest in the State's 303(d) list and development of Total Maximum Daily Loads (TMDLs) for waters listed on the 303(d), has served to shine the spotlight on the monitoring efforts of the various state environmental agencies. In general, development and refinement of the 303(d) list has resulted in a greater understanding by all concerned parties that improvements in the states monitoring initiatives were and are necessary to better serve the citizens of Oklahoma. Several key points can be made when discussing the states water quality monitoring programs;

- Monitoring has historically been conducted by various environmental agencies with the express purpose of meeting federal program requirements and under the various Oklahoma statutory mandates assigned for each agency. This has resulted in a fragmented monitoring program for the state as a whole. Numerous agencies are conducting monitoring with some degree of coordination and much quality data is being collected, but improvements could be made. At this time, a coordinated holistic monitoring program for Oklahoma does not exist.

- Monitoring of our water resources has historically been inadequate to assess the water quality status of much of our water resources. In recent years this problem has been mitigated through increased monitoring by many of the state environmental agencies, however there is still much room for improvement.

- Due to lack of historical baseline information and consistent protocols for assessing use support, the job of protecting and preserving our water resources has been made much more difficult. It is absolutely essential to understand what "normal" is so that we can confidently identify an "abnormal" water quality condition. Numerous environmental agencies, such as the OCC, ODEQ, and OWRB have collected environmental data and the OCC has worked extensively to identify baseline conditions across Oklahoma

- Lastly, little money and effort has been spent on monitoring programs when compared to the monies spent on other aspects of the water quality management arena (i.e. lake and stream restoration, permitting and permit compliance, regulation, etc.).

In general, the efforts of the state's environmental agencies in terms of water quality monitoring have greatly improved. With funding of the Oklahoma Water Resources Board's Beneficial Use Monitoring Program, a major step has been taken by the state to address some of the monitoring deficiencies discussed above. In addition, increased understanding at the federal level has resulted in additional monies being spent for monitoring activities (i.e. recent guidance changes in the 319 nonpoint source program have been very instrumental in fostering more monitoring activities). With the requirement to develop TMDLs for waters listed on the 303(d), Oklahoma should continue to develop and support monitoring activities for our precious state waters. Financial resources are limited and it is vital that a greater understanding of our water quality conditions be fostered and that monies be spent in areas where adverse water quality impacts are greatest or where some of our most outstanding water resources are threatened.

Several other tools have been provided to facilitate monitoring in Oklahoma. One such tool currently being developed would be the state environmental database. The database development is being overseen by the Oklahoma Department of Environmental Quality to assist their sister environmental agencies and the state in managing our data and water resources. Though the database does not currently exist in a useable form, progress is being made. Another tool at our disposal is the upgrade of the United States Environmental Protection Agency Storage and Retrieval (STORET) database. STORET is a national database that in theory is used to house environmental data collected using federal dollars. In addition, the United States Geological Survey (USGS) enters their data into STORET. Though not easily understood and requiring the purchase on some moderately expensive software, STORET does offer some very desirable tools for data collectors and data users. Historically, data has not been entered into STORET, as it should have been, due to the difficulty in using STORET. In addition, much of the data in STORET does not have any known quality assurance protocols associated with it. In other words, the quality and reliability of the data cannot be easily determined. The recent updates to STORET have addressed many of the historical problems associated with the database. In addition, the USGS stores and manages data using the National Water Information System (NWIS). Recently, NWIS data have been made available on the Internet at water.usgs.gov/nwis.

What follows in this document is a brief discussion of the monitoring initiatives currently being conducted by our state agencies and federal partners in the area of surface water quality monitoring. It is undoubtedly true that in a discussion of water quality monitoring in Oklahoma some program being conducted by a state or federal agency will be inadvertently left out of the discussion. For example, the Indian Nation Council of Governments (INCOG), the Association of Central Oklahoma Governments (ACOG), and the United States Fish and Wildlife Service (USF&W), all engage in water quality monitoring to a greater or lesser degree within their areas of authority and expertise. In the interest of brevity, the discussion within this document will focus on state agencies and their federal partners who perform the “lions share” of monitoring in Oklahoma. This is not to say that other monitoring programs being conducted are less important, but in general they are more localized in nature and are not conducted on a statewide scale. Special mention is given to one federal agency who is very heavily involved in water quality monitoring and is a vital partner to many state environmental agencies, namely the United States Geological Survey (USGS). For many years the USGS has engaged in water quality monitoring and plays an incalculable role in assisting state agencies in the water quality and quantity arena.

CHAPTER

1

Water Quality Monitoring Programs at the Oklahoma Water Resources Board

Introduction

The Oklahoma Water Resources Board (OWRB) conducts numerous monitoring activities as part of its statutory requirements. The OWRB conducts monitoring on both surface and groundwater resources. Discussion of the major OWRB surface water monitoring programs is included in this chapter.

Beneficial Use Monitoring Program (BUMP)

Introduction

Oklahoma works to protect and manage its water resources through a number of initiatives with Oklahoma's Water Quality Standards (OWQS) being the cornerstone of the state's water quality management programs. The Oklahoma Water Resources Board (OWRB) is designated by state law as the agency responsible for promulgating water quality standards and developing the corresponding implementation framework. Specifically, the OWQS are housed in OAC 785:45 and consist of three main components. These components are (1) beneficial uses, (2) criteria to protect beneficial uses, and (3) an anti-degradation policy. A critical fourth component is a monitoring program to assure that beneficial uses are maintained and protected. If uses are not being maintained, the cause of that impairment must be identified and restoration activities should be implemented.

All state agencies are currently required to implement Oklahoma's Water Quality Standards within the scope of their jurisdiction. This process, called OWQS Implementation, allows the OWQS to be utilized by other state agencies in the permitting process to manage water quality or to facilitate best management practice initiatives. Since 1996, the implementation portion of the OWQS has been housed in OAC 785:46.

Recently, the need for a protocol to determine beneficial use impairment has been identified, so that state agencies can direct resources to the areas in most need of protection or remediation. In addition, the protocol must be coupled with a trend monitoring system to detect threatened waters before they become seriously impaired. It is essential that the state's waters meet assigned beneficial uses and that OWQS implementation protocols are appropriate.

The OWRB has developed beneficial use support assessment protocols (USAP), which were promulgated into OAC 785:46 in 1999. Work is ongoing to enhance the utility of the USAP for the state environmental agencies and the EPA.

Background & Problem Definition

The State of Oklahoma currently has numerous monitoring programs conducted by several state and federal agencies. Historically, most water quality monitoring programs in Oklahoma are designed and implemented by each agency to collect information for one specific purpose or project (i.e. development of Total Maximum Daily Loads, OWQS process, lake trophic status determination, water quality impacts from point source dischargers, stream flow measurements, document success of best management practices, etc.). Information of this type is very specific to each individual project's data quality objectives and is often limited to a very small geographic area. In recent years through the efforts of the various environmental agencies and the Oklahoma Water Quality Monitoring Council greater coordination between the state and federal agencies has occurred. In addition, numerous state agencies are currently conducting state-wide ambient trend monitoring activities that have greatly improved the dataset available to decision makers and scientists. Room for improvement in terms of coordination between the agencies and in terms of the water quality information collected still exists. The OWRB and it's sister environmental agencies are working to improve data collection efforts through such programs as the OWRB BUMP, the ODEQ groundwater and surface water monitoring programs and the OCC's stream monitoring efforts.

Beneficial Use Monitoring Program

The overall program goal of the monitoring effort is as follows;

Overall Monitoring Program Goal: The goal of the proposed monitoring program is to document beneficial use impairments, detect water quality trends, provide needed information for the OWQS and facilitate the prioritization of pollution control activities.

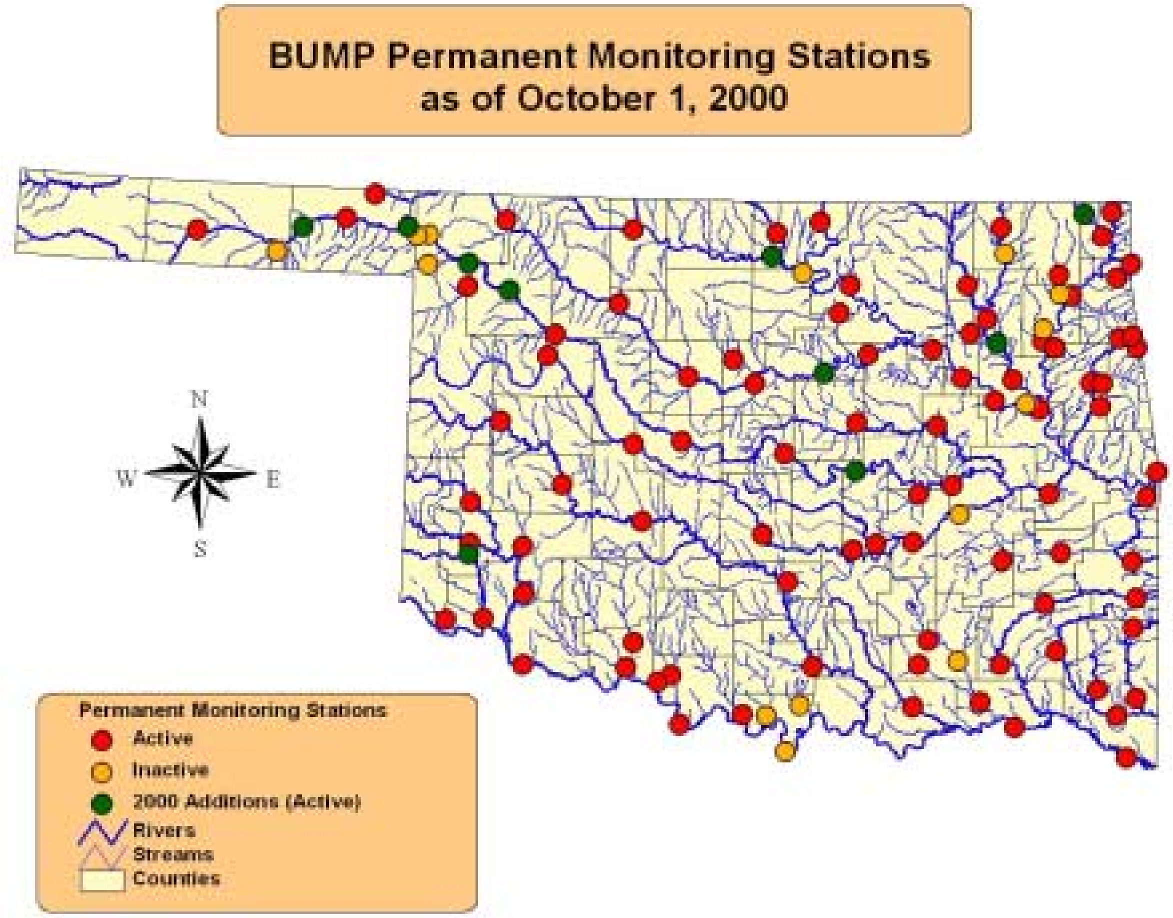
The Monitoring Program is composed of six (6) elements or tasks. Tasks conducted as part of the assessment and monitoring program are outlined below. The OWRB will also develop a quality assurance and quality control (QAPP) document for all monitoring activities conducted as part of this program. Development of data quality objectives (DQOs) and collection of data sufficient to meet the stated DQOs is essential to program success.

1) **Monitoring Rivers & Streams** - The OWRB monitors approximately one-hundred forty (140) to two-hundred (200) sites annually. These sites are segregated into two discrete types of monitoring activities. The first monitoring activity focuses on fixed station monitoring on rivers and streams and the second monitoring activity focuses on a set number of sample stations whose location rotates on an annual basis. The two monitoring components are in the following narrative.

a) **Fixed Station Monitoring on Rivers & Streams** - Fixed station monitoring is generally based upon the sixty-seven (67) USGS 8-digit hydrologic unit code (HUC) basins. In general, at least one (1) sample station is located in each of the 67 HUC watersheds. Each of these stations is used to identify beneficial use impairments, beneficial use threats, and water quality trends. At this time, the OWRB is monitoring ninety-nine (99) permanent stations. Samples are collected for nutrient analysis at all stations annually on ten (10) occasions from January through November of each year. Numerous other water quality parameters such as dissolved oxygen, alkalinity, temperature, hardness, chlorides, oxidation/reduction potential, specific conductance, nephelometric turbidity, salinity, total dissolved solids, pH, sulfate, total suspended solids, total settleable solids, and % dissolved oxygen (D.O.) saturation are monitored in situ at or samples are collected for laboratory analysis at every station on every sampling event. Analysis for metals occurs three times annually, analysis of pesticides occurs once annually, and analysis for bacteria occurs from five to ten times annually depending on the bacteriological test being performed. With continued funding sampling will increase to ten (10) times per year at each station for some bacteria variables and five (5) times per year for others. Short sample holding times preclude sampling for *Escherichia coli* and Enterococci bacteria ten (10) times per year at all monitoring stations (See Table 1 below). For these two bacterial species, sampling is conducted five (5) times annually.

- Table 1. **Stream Monitoring Sample Variables.**

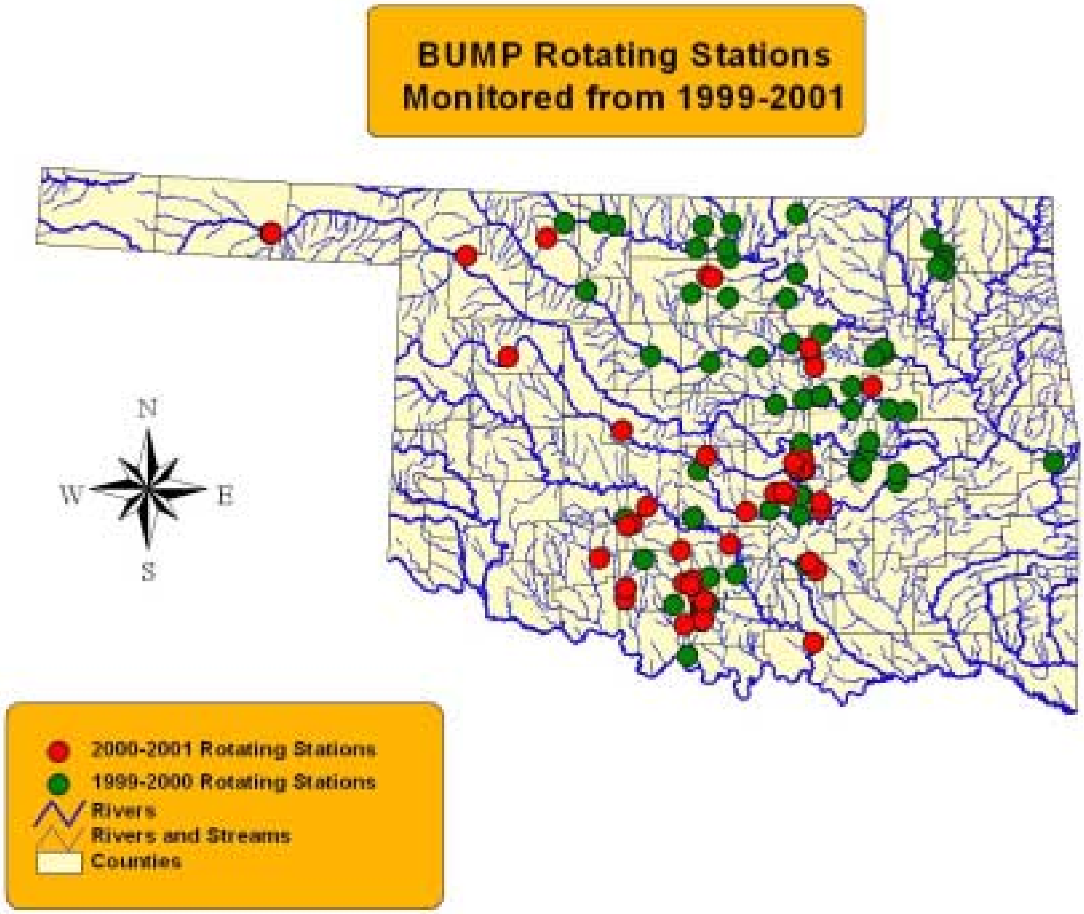
SAMPLE VARIABLES		
General Water Quality Variables (Sampled 10 times annually)		
Dissolved Oxygen	pH	Specific Conductance
Temperature	Alkalinity	% D.O. Saturation
Salinity	Oxidation/Reduction Potential	Total Hardness
Chloride	Nephelometric Turbidity	Sulfate
Total Dissolved Solids	Total Suspended Solids	Total Settleable Solids
Nitrate Nitrogen	Nitrite Nitrogen	Ammonia Nitrogen
Kjeldahl Nitrogen	Total Nitrogen (Calculated)	Ortho-Phosphorus
Total Phosphorus		
Metals (Sampled 3 time annually)		
Arsenic	Cadmium	Chromium (Total)
Copper	Lead	Mercury
Nickel	Selenium	Silver
Zinc	Thallium	
Pesticides (Sampled 1 time annually)		
General Pesticide Scan		
Bacteriological (Sampled 5 Times During Recreational Season at a Minimum)		
Escherichia coli	Enterococci	Fecal Coliform



•Figure 1. **BUMP Permanent Stream Monitoring Stations.**

b) **Rotating Station Monitoring on Rivers & Streams** - Sampling as part of the rotating stream sampling program has occurred at eighty-nine (89)stations for numerous water quality variables from the winter of 1998 through March of 2000. Sample stations and parameters monitored were based upon Oklahoma's 303(d) list and input from other state, federal, and tribal entities. For example; Ballard Creek (stream segment # OK121700030370) is listed on the 303(d) list as impaired due to ammonia, nutrients, fish kills, and organic enrichment/DO. Monitoring occurred on this stream segment of Ballard Creek for nutrients and dissolved oxygen on 10 occasions from January to November of 1999. Variables monitored as part of this program component are specific for each stream segment monitored. If metals were identified as the cause of beneficial use impairment to a water body segment, then metals are monitored on 10 occasions annually. In-situ determination of dissolved oxygen, pH, specific conductance, temperature, oxidation-reduction potential, salinity, and nephelometric turbidity was determined at all sample stations. With continued funding, the OWRB will solicit recommendations for continued rotational monitoring.

Additional variables may be added to the overall stream monitoring program based upon cause codes listed in the 303(d) list for the each affected water body segment and after consultation with other environmental agencies.



• Figure 2. **BUMP Rotating Stream Monitoring Stations.**

A database for information storage and retrieval was developed for the program using Microsoft Access. This database is compatible with state Geographic Information System (GIS) efforts. The developed database is used to store all data collected on lakes, streams, rivers, and groundwater as part of this monitoring program. In addition, the United States Environmental Protection Agency (USEPA) STORET program is being utilized to store some of the data collected in the BUMP.

In summary, the OWRB is performing routine sampling on approximately ninety-nine (99) stations annually with additional stations selected for rotational sampling as requested by other state environmental agencies. Purpose of the sampling is to document beneficial use impairments and trends in water quality (if possible Prioritization of stations and their exact location only occur after consultation with other state agencies. All monitoring activities are consistent with Oklahoma's Whole Basin Planning Approach, 305(b) guidance, and 303(d) listing procedures. State, federal, and tribal agencies are intimately involved in helping to locate sample stations and identifying variables to be monitored. Sampling activities are discussed at Water Quality Monitoring Council meetings to ensure the best possible use of money and manpower.

Task Goal - document beneficial use threats and impairments as specified in the OWQS and facilitate intensive investigations to remediate impairment.

2) **Fixed Station Load Monitoring** - The OWRB cooperates with the United States Geological Survey (USGS), or other agencies involved in collecting flow data, to establish monitoring stations. This effort focuses on collecting both water quality and quantity information in order to calculate pollutant loads. This initiative is facilitated through the OWRB's Cooperative Agreement Program with USGS and various Compact Commission activities. Parametric coverage tracks with Fixed Station Concentration Monitoring. Sample site coverages associated with this task are driven by the USGS cost share program, Oklahoma's 319 program, Oklahoma's 314 program and the 303(d) process.

Task Goal - assist in TMDL development, document OWQS beneficial use impairment, examine trends, and facilitate load calculations.

3) **Fixed Station Lakes Monitoring** - The OWRB samples approximately thirty (30) to thirty-five (35) lakes as part of the BUMP. It is the long-term goal of the OWRB to sample approximately one-hundred-sixteen (116) lakes as part of the monitoring program with fifty-eight (58) lakes sampled quarterly each calendar year. In this manner, quarterly sampling of 58 lakes would occur annually with repeat sampling occurring every two (2) years. Data collected consists primarily of nutrient and solids information. In general, sampling of three stations per reservoir representing the lacustrine zone (main body of the lake), transitional zone, and riverine zone (portion of the lake that is more river like in nature) occurs at all lakes. A greater number of sample sites are utilized on the larger United States Army Corps. of Engineers (USACOE) reservoirs. Vertical profiles for dissolved oxygen, % D.O. saturation, temperature, pH, salinity, oxidation-reduction potential, and specific conductance are taken at one meter intervals from the lake surface to the lake bottom. Readings for secchi disk depth and nephelometric turbidity are also taken at all sample stations. See Table 2 for a list of monitoring variables and Table 3 for a list of lakes sampled as part of the BUMP lakes component.

• Table 2. **Water quality variables monitored on Oklahoma lakes.**

LAKES SAMPLE VARIABLES		
General Water Quality Variables – Sampled Quarterly		
Dissolved Oxygen	pH	Specific Conductance
Temperature	Oxidation/Reduction Potential	% D.O. Saturation
Salinity	Nephelometric Turbidity	Chlorophyll-a
Total Dissolved Solids	Secchi Disk Depth	
Nutrients – Sampled Quarterly		
Kjeldahl Nitrogen	Ortho-Phosphorus	Total Phosphorus
Nitrate Nitrogen	Nitrite Nitrogen	Ammonia Nitrogen
Total Nitrogen – calculated from Kjeldahl Nitrogen, Nitrate Nitrogen, and Nitrite Nitrogen		

• Table 3. **Lakes Sampled by the OWRB as part of the BUMP.**

	Lake Name	Site #	County	Surface Area (Acres)	Volume (Acre Feet.)	Mean Depth (Feet)
1	Altus Lugert	4	Greer	6,260	132,830	21
2	American Horse	3	Blaine	100	2,200	22
3	Arbuckle	4	Murray	2,350	72,400	31
4	Arcadia	5	Oklahoma	1,820	27,520	15
5	Ardmore City	3	Carter	142	600	4
6	Atoka	5	Atoka	5,700	125,000	22
7	Bell Cow	3	Lincoln	1,153		
8	Birch	3	Osage	1,137	19,200	17
9	Bixhoma	3	Wagoner	110	3,130	28
10	Bluestem	4	Osage	762	17,000	22
11	Boomer	3	Payne	260	3,200	12
12	Broken Bow	8	McCurtain	14,200	918,070	65
13	Brushy Creek	3	Sequoyah	358	3,258	9
14	Burtschi, Louis	2	Grady	180	2,140	12
15	Canton	4	Blaine	7,910	111,310	14
16	Carl Albert	3	Latimer	183	2,739	15
17	Carl Blackwell	4	Payne	3,370	61,500	18
18	Carter	3	Marshall	108	990	9
19	Cedar (Mena)	3	LeFlore	78	1,000	13
20	Chandler	3	Lincoln	129	2,778	22
21	Chickasha	3	Caddo	820	41,080	50
22	Church, Lloyd	3	Latimer	160	3,060	19
23	Claremore	3	Rogers	470	7,900	17
24	Clear Creek	3	Stephens	722	7,710	11
25	Cleveland	3	Pawnee	159	2,200	14
26	Clinton	3	Washita	335	3,980	12
27	Coalgate	3	Coal	352	3,437	10
28	Comanche	3	Stephens	184	2,500	14
29	Copan	4	Washington	4,850	43,400	9
30	Crowder	3	Washita	158	2,094	13
31	Cushing	3	Payne	591	3,304	6
32	Dripping Springs	3	Okmulgee	1,150	16,200	14
33	Duncan	3	Stephens	500	7,200	14
34	El Reno	3	Canadian	170	709	4
35	Elk City	3	Beckham	240	2,583	11
36	Ellsworth	3	Comanche	5,600	95,200	17
37	Elmer Thomas	3	Comanche			
38	Etling, Carl	3	Cimarron	159	1,717	11
39	Eucha	3	Delaware	2,860	79,600	28
40	Eufaula	17	Haskell	105,500	2,314,600	22

(continued.)

	Lake Name	Site #	County	Surface Area	Volume	Mean Depth
41	Fairfax	3	Osage	111	1795	16
42	Fort Cobb	6	Caddo	4100	80010	20
43	Fort Gibson	8	Cherokee	14900	355200	24
44	Fort Supply	3	Woodward	1820	13900	8
45	Foss	4	Custer	8800	256220	29
46	Frederick	3	Tillman	925	9526	10
47	Fuqua	5	Stephens	1500	21100	14
48	Grand Lake	13	Mayes	46500	1672000	36
49	Great Salt Plains	3	Alfalfa	8690	31240	4
50	Greenleaf	3	Muskogee	920	14720	16
51	Guthrie	3	Logan	274	3875	14
52	Healdton	3	Carter	370	3766	10
53	Hefner	3	Oklahoma	2500	75000	30
54	Henryetta	3	Okmulgee	450	6600	15
55	Heyburn	3	Creek	880	7105	8
56	Holdenville	3	Hughes	550	11000	20
57	Hominy	3	Osage	165	5000	30
58	Hudson	3	Osage	250	4000	16
59	Hudson	8	Mayes	10900	200300	18
60	Hugo	5	Choctaw	13250	157600	12
61	Hulah	3	Osage	3570	31160	9
62	Humphreys	3	Stephens	882	14041	16
63	Jean Neustadt	3	Carter	462	6106	13
64	John Wells	3	Haskell	194	1352	7
65	Kaw	5	Osage	17040	428600	25
66	Kerr, Robert S.	6	Sequoyah	43380	525700	12
67	Keystone	12	Tulsa	23610	557600	24
68	Konawa '	4	Seminole	1350	23000	17
69	Langston	3	Logan	304	5792	19
70	Lawtonka	4	Comanche	2398	56574	24
71	Liberty	3	Logan	167	2740	16
72	Lone Chimney	3	Pawnee	550	6200	11
73	Longmire, R.C.	3	Garvin	918		0
74	Maysville (Wiley Post)	3	McClain	302	2082	7
75	McAlester	3	Pittsburg	1521	13398	9
76	McGee Creek	4	Atoka	3810	113930	30
77	McMurtry	3	Noble	1155	19733	17
78	Meeker	3	Lincoln	250	1818	7
79	Murray	5	Love	5728	153250	27
80	Nanih Waiya	1	Pushmataha	131	1064	8

(continued.)

	Lake Name	Site #	County	Surface Area	Volume	Mean Depth
81	Okemah	4	Okfuskee	761	13,100	17
82	Okmulgee	3	Okmulgee	668	14,170	21
83	Oologah	7	Rogers	29,460	553,400	19
84	Overholser	3	Oklahoma	1,500	15,000	10
85	Ozzie Cobb	3	Pushmataha	116	833	7
86	Pauls Valley	3	Garvin	750	8,730	12
87	Pawhuska	3	Osage	96	3,600	38
88	Pawnee	3	Pawnee	257	3,855	15
89	Perry	3	Noble	614	6,892	11
90	Pine Creek	4	McCurtain	3,750	53,750	14
91	Ponca	3	Kay	805	14,440	18
92	Prague	3	Lincoln	225	2,415	11
93	Purcell	3	McClain	150	2,600	17
94	Raymond Gary	3	Choctaw	263	1,681	6
95	Rock Creek	3	Carter	248	3,588	14
96	Rocky (Hobart)	3	Washita	347	4,210	12
97	Sahoma	3	Creek	312	4,850	16
98	Sardis	5	Pushmataha	13,610	274,330	20
99	Shawnee Twin No. 1	4	Pottawatomie	1,336	22,600	17
100	Shawnee Twin No. 2	3	Pottawatomie	1,100	11,400	10
101	Shell Creek	3	Osage	573	9,500	17
102	Skiatook	7	Osage	10,190	322,700	32
103	Sooner '	3	Pawnee	5,400	149,000	28
104	Spavinaw	3	Mayes	1,584	38,000	24
105	Spiro, New	3	LeFlore	254	2,160	9
106	Sportsmans	3	Seminole	354	5,349	15
107	Stanley Draper	4	Cleveland	2,900	100,000	34
108	Stilwell	3	Adair	188	3,110	17
109	Stroud	3	Creek	600	8,800	15
110	Talawanda No. 1	3	Pittsburg	91	1,200	13
111	Talawanda No. 2	2	Pittsburg	195	2,750	14
112	Taylor (Marlow)	3	Grady	227	1,877	8
113	Tecumseh	3	Pottawatomie	127	1,118	9
114	Tenkiller	6	Sequoyah	12,900	654,100	51
115	Texoma	13	Bryan	88,000	2,643,300	30
116	Thunderbird	7	Cleveland	6,070	119,600	20
117	Tom Steed	3	Kiowa	6,400	88,970	14
118	Vanderwork	3	Washita	135	1,578	12
119	Vincent, Loyd	3	Ellis	160	2,579	16
120	W.R. Holway	3	Mayes	712	48,000	67
121	Walters (Dave Boyer)	3	Cotton	148	861	6
122	Waurika	4	Jefferson	10,100	203,100	20
123	Waxhoma	3	Osage	197	2,100	11

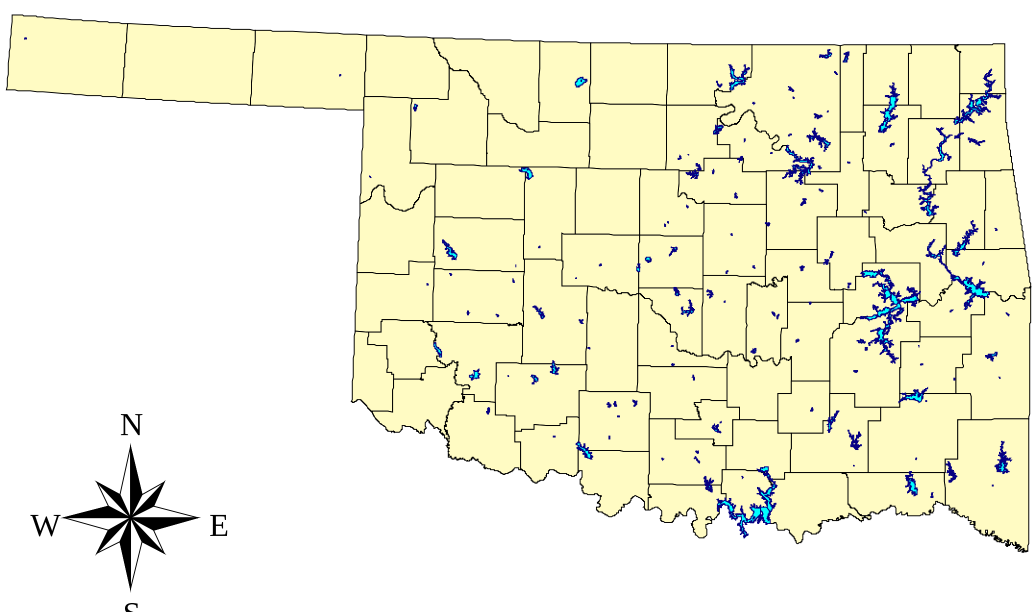
(continued.)

	Lake Name	Site #	County	Surface Area	Volume	Mean Depth
123	Waxhoma	3	Osage	197	2,100	11
124	Wayne Wallace	1	Latimer	94	1,746	19
125	Webbers Falls	6	Muskogee	11,600	170,100	15
126	Wes Watkins	3	Pottowatomie			
127	Wewoka	3	Seminole	371	3,301	9
128	Wister	3	LeFlore	7,333	62,360	9
129	Yahola	3	Tulsa	431	6,445	15

Bathymetric maps are generated as necessary to document sedimentation rates and determine reliable yield. Biological sampling is also conducted as required. Please see Figure 3 that shows the lakes monitored as part of the program. Currently, the OWRB is working closely with the USACOE to conduct lake sampling on USACOE lakes to benefit both parties. Cooperative efforts of this nature allow more lakes to be sampled annually and increase the amount of available data to use for use support determinations.

Task Goal - determine beneficial use impairment in Oklahoma's lakes and assess enrichment and sedimentation trends.

Lakes Currently Monitored by the Beneficial Use Monitoring Program



• Figure 3. **Lakes sampled as part of the lakes sampling program on the BUMP.**

3) **Fixed Station Groundwater Monitoring** – Monitoring of ground water resources as part of the BUMP has not occurred as of yet and without an increase in funding, it will be very difficult to conduct a comprehensive monitoring program on our abundant ground water resources. However, any monitoring initiated will consist of spatial stratified sampling of all unconfined major Class I and Class II (as identified in the OWQS) groundwater aquifers. Vulnerability may also be evaluated to prioritize those most vulnerable to contamination. Year one will consist of assembling and assessing available water quality data to document the current status of groundwater monitoring. The ODEQ, in cooperation with municipalities across the state, currently oversees a groundwater quality monitoring program as part of their Public Water Supply Program. Data collected as part of this program will be examined before additional monitoring is implemented. Proposed groundwater monitoring efforts will be coordinated with the current ODEQ program.

Task Goal - document beneficial use impairment, baseline water quality, trends, and groundwater contamination.

4) **Intensive Investigation Sampling** - If a beneficial use impairment is identified, all appropriate state agencies will be alerted and an intensive investigation will be initiated if warranted. The source of the impairment will be identified and the appropriate state agency with statutory oversight will pursue the matter as conditions dictate. Potential causes of use impairment include; improper beneficial use or criteria (Oklahoma Water Resources Board jurisdiction), point source problems (Oklahoma Department of Environmental Quality or Oklahoma Department of Agriculture), non-point source problems (Oklahoma Conservation Commission), oil and gas contamination (Corporation Commission), and mine activities (Oklahoma Department of Mines). All activities will be cooperative in nature. Activities conducted as part of this component will not, in general, be funded through the routine beneficial use attainment monitoring program described in this scope of work. Federal sources of funding will be utilized to conduct activities of an intensive nature.

Reporting

Critical to the success of any monitoring program is a data analysis, interpretation and distribution component. Results of all monitoring efforts are published annually in February/March to document results from the previous years sampling efforts. The report lists waters that possess threatened or impaired beneficial uses, and to the extent possible, the cause of that impairment is identified. The report also addresses such issues as documentation of baseline water quality values, analysis of water quality trends (will not truly be conducted until at least 5 years worth of data is available), and detail the results of quality assurance/quality control procedures as appropriate. Information is presented in a clear, concise and easily understood format. Graphics and illustrations are used extensively to aid the reader in understanding sampling results. The Final Report to the legislature is also posted on the Internet for public access and review. In addition, it is the intention of the OWRB to begin posting data on the Internet beginning in 2001 after all quality assurance protocols have been conducted to ensure collected data meets stated DQOs.

Conclusions

The Beneficial Use Monitoring Program represents a big step forward for Oklahoma’s water quality management process. Another “big step forward” in terms of water quality management has been the development of standardized Use Support Assessment Protocols (USAP). Through this effort and the subsequent rule making process to promulgate the USAP into the Oklahoma Administrative

Code, water quality is assessed following standardized procedures, which results in a better information available to make management decisions. It is vital that when making water quality management decisions, that we "compare apples to apples" to ensure that monies are spent in the most effective manner.

Clean Lakes & Technical Studies Program

The Oklahoma Water Resources Board has been designated by the Oklahoma legislature as the technical lead agency for Clean Lakes work. With this charge, the OWRB provides Lake Diagnostic, Feasibility and Restoration services across the State. The OWRB has conducted numerous Clean Lakes studies in the past with the express objective of diagnosing water quality problems, identifying sources of water quality problems, and conducting remediation activities to restore lake water quality.

The Oklahoma Water Resources Board was directed in 1997 by the Oklahoma Legislature to conduct a study on the impact of concentrated animal feeding operations on potable water to municipalities with a population over 250,000 (Enrolled House Bill No. 1522). Two municipalities, Oklahoma City and Tulsa met the stated criteria. Lakes Eucha and Spavinaw were monitored in a cooperative effort with the City of Tulsa to aid the city in the management of these critical water supply lakes. In addition, work was performed for Oklahoma City. Six reservoirs are utilized by Oklahoma City for their water supply needs. These reservoirs are Canton, Overholser, Hefner, Stanley Draper, Atoka and McGee Creek.

Oklahoma City Lakes Monitoring

The focus of the Oklahoma City project is the study of the six Oklahoma City water supply reservoirs and watersheds, including the North Canadian River extending westward from Oklahoma City through the panhandle mentioned above. The Oklahoma City project consists of three components:

1. compilation of all historical data on these water resources, including United States Geological
2. Survey (USGS) gauging stations and the Department of Environmental Quality Ambient Trend Monitoring Stations (ATMS),
3. development and implementation of baseline monitoring for the North Canadian River and the six reservoirs serving Oklahoma City as water supplies,
4. bathymetric mapping of Oklahoma City water supply lakes to determine current reservoir volume for future sedimentation surveys, and
5. report the compilation and evaluation of all collected data to Oklahoma City and the Oklahoma legislature.

The project will continue for a period of three years to determine the health and water quality trends of these water resources. The OWRB is in the final stages of the monitoring effort and will be working on a Draft Final Report documenting monitoring efforts in the very near future.

PROJECT OBJECTIVES

- ✔ Determine the trophic status of the six OKC water supply reservoirs.
- ✔ Estimate nutrient lake loading.
- ✔ Impact on biological community (based on historical record review only).
- ✔ Sedimentation rates in OKC water supply reservoirs, including reliable yield estimates.

The first step in the project was to compile existing water quality data from Oklahoma City water supply reservoirs and the North Canadian River. Potential sources of lake data include, but are not limited to, Oklahoma Water Resources Board, Oklahoma Department of Wildlife Conservation, Oklahoma Conservation Commission, USGS gauging stations, Department of Environmental Quality (ODEQ), and the City of Oklahoma City. USGS streamflow-monitoring stations are utilized extensively in this study (see Table 4). Historical benthic macro-invertebrate and fishery data has been investigated to address aquatic community health.

Historical data collection activities in Task 2 will be incorporated into trend analysis for Task 3 for the final report currently being written. Volunteer monitoring data was also investigated as a historical data source. Oklahoma Water Watch volunteers are currently monitoring Wolf Creek, a stream that drains into the North Canadian River near Ft. Supply.

• Table 4. **USGS Gauging Station and Ambient Trend Monitoring station locations.**

USGS STREAMFLOW MONITORING STATIONS 1997-1998	AMBIENT TREND MONITORING STATIONS
Beaver Creek at Beaver, OK.	North Canadian River near Seiling, OK.
North Canadian River at Woodward, OK.	North Canadian River below Canton Lake
North Canadian River near Seiling, OK.	North Canadian River near El Reno
*North Canadian River near Calumet, OK.	North Canadian River near NW 10th, below Overholser, OKC
North Canadian River near El Reno, OK.	

*Currently monitoring water quality

Research and review began in September 1997 and continued through early 1998 for data compilation as part of Task 3 of the Oklahoma City/CAFO project. Based on identified historical information, a baseline monitoring program was established. This program monitored parameters to determine the potential impacts of Concentrated Animal Feeding Operations (CAFO) on potable water for Oklahoma City. The baseline monitoring program is comprised of two components;

1) The North Canadian River sampling regime
2) Sampling of six reservoirs that are currently serving OKC as water supplies.

North Canadian River west of Oklahoma City extending through the panhandle of Oklahoma:
Data was collected by OWRB staff to determine water quality and the USGS was utilized to determine stream flow. All samples were collected for the parameters listed in Table 2. Additional parameters were monitored as necessary.

USGS streamflow monitoring stations at Beaver and Seiling (or Woodward), monitored flow in 1997-98, are sampled for water quality by OWRB staff. The BUMP assisted with stream and lake sampling for this project to maximize the use of OWRB resources (people and financial). OWRB staff collected the following data using a multi probe datasonde at both Beaver and Seiling streamflow monitoring stations. Parameters included; pH, dissolved oxygen, specific conductance, oxidation-reduction potential (redox), salinity, and temperature. Turbidity for each site was measured by OWRB staff using a HACH turbidimeter upon return to the Oklahoma City office. Observations including date, time, estimated air temperature, estimated wind speed and direction, estimated cloud cover, secchi disk depth (if adequate depth) and comments were made for each sample site. In addition to these parameters, samples were collected for laboratory analysis of the parameters listed in Table 2. This data was used in conjunction with the USGS collected flow data to estimate load values.

Samples were collected monthly from 6-9 stations in the watersheds of the Oklahoma City water supply lakes.

Oklahoma City Public Water Supply Reservoirs:
Lakes Canton, Overholser, Hefner, Stanley Draper, Atoka, and McGee Creek were sampled by OWRB staff to assess their water quality. Reservoir water quality samples were collected on a quarterly basis throughout the project period. Hefner, Overholser, and Atoka were sampled at two sites within the lake representing the lacustrine and riverine zones. Draper, McGee, and Canton were sampled at three sites representing the lacustrine, transition, and riverine zones.

Surface samples were collected at each site while bottom samples were collected at the lacustrine site only when thermal stratification is present. Each site had a vertical profile performed, including data recording at one-meter depth intervals from the lake bottom to the lake surface using a multi-probe datasonde. Parameters include: pH, dissolved oxygen, specific conductance, redox, salinity, and temperature. Turbidity for each site was measured upon return to the OWRB offices. Observations of site number, instrument type and number, date, time, estimated air temperature, estimated wind speed and direction, estimated cloud cover, reservoir conditions, secchi disk depth and comments were made at each sample site. In addition to these parameters, samples were collected for laboratory analysis of the parameters listed in Table 5. All sampling procedures follow accepted EPA protocols. Bathymetric maps were also developed to facilitate Task 3.

Reservoir sampling began in October 1997 and occurred quarterly through August 2000. USGS streamflow monitoring station data collection occurred monthly beginning in February 1998 through July 2000.

• Table 5. **Laboratory Parameters sampled for as part of the OKC/CAFO Project.**

Laboratory Analyzed Parameters	
Fecal Coliform	Fecal Streptococcus
Solids, Settleable (ml/L)	Solids, Suspended
Solids, Total Dissolved	Nitrate as N
Nitrite as N	Kjeldahl nitrogen
Ammonia as N	Chlorides
Sulfate	Ortho-phosphate
Total Phosphorus	

Bathymetric data collection was completed for the six reservoirs by July 2000. This allowed for an additional data collection, if needed, at the end of the project for identifying current volume for the lakes. Data is currently being analyzed to determine trophic status of the six reservoirs and average nutrient loads in the North Canadian River along monitoring sites.

Eucha/Spavinaw Lakes Monitoring

The monitoring program for the City of Tulsa was somewhat different then the monitoring being conducted for Oklahoma City. The Tulsa Metropolitan Utility Authority (TMUA) reported increased expenditures related to treating Lake Spavinaw raw water for human consumption. Consumer complaints of taste and odor in the finished water have also been reported. City staff determined that taste and odor problems attributable to blue-green algae has increased in frequency over time. Historical water quality data indicated that the phytoplankton community has caused TMUA problems and that specific solutions need to be developed. The City of Tulsa collaborated with the OWRB to perform an intensive study of the lake system. The OWRB was specifically asked to;

1) Establish the relationship between Spavinaw Lake nutrients and phytoplankton
2) Use the relationship to develop a target nutrient value to control algae
3) Examine methods of system management to achieve the target concentration
4) Recommend a long-term water quality monitoring plan for both lakes

The three (3) year project being conducted jointly by the OWRB and the City of Tulsa provided answers to these questions. To accomplish the goals outlined above, the OWRB and the City of Tulsa examined the Lake Spavinaw-Eucha-Yahola complex as one system. The OWRB assisted the TMUA in assembling a comprehensive database to facilitate phytoplankton prediction. The data base information was then available to the OWRB to satisfy the four objectives outlined in the problem statement. Parameters of this comprehensive database include the following:

- Complete weather information for the system
- Updated bathymetric maps of both reservoirs
- Indication of groundwater quality and flow
- Inventory of surrounding spring water quantity and quality
- Semi - quantitative and qualitative survey of aquatic macrophytes
- Quantity and quality of surface water entering and exiting the system
- Current data on lake water quality (chemical, physical and biological).

Historical Data: Historical data was examined using the software WQStat II (CSU, 1988) to help identify trends in lake water quality. Sources of the data include; pre-impoundment engineering plans, water treatment, raw water quality, treatment costs, taste & odor events, OCC Eucha Lake Phase I Study, TMUA contract reports, USGS streamflow monitoring stations, Oklahoma Department of and other sources to be identified. Historical water quality data was also used to construct an initial water quality model for the system. BATHTUB (Walker, 1990) and EUTROMOD (Reckow, 1993) were used to construct the initial model. The examination was completed by January 1, 1998.

Hydrologic Data: The collection of hydrologic data provided an estimate for the hydraulic budget of the lake. This hydraulic budget is the foundation of nutrient modeling/budgeting for the lake complex.

<u>Lake Bathymetry</u> - Current bathymetric maps have been produced for both lakes using a Raytheon fathometer and Trimble Global Positioning System (GPS) coordinated by a "rugged" laptop computer. Mapping software (HYPAK) was used to plot and create the bathymetric maps. Current lake volume will be examined to assess sedimentation for both reservoirs. The distribution of deposited sediment was discussed to indicate the source of the sediment. Lake volume was determined from morphometric data and then hydraulic residence times and nutrient budgets can be calculated.

<u>Tributary Water Quantity and Quality</u> - SIGMA remote storm water monitors were installed on major tributaries to quantify water quality and quantity. Field sampling of storm events augmented and completed tributary data. Field sampling consisted of collecting water, integrated both vertically (using a "bomb" type sampler) and horizontally (by compositing the "bomb" samples with a "churn" splitter) throughout the water column and across the storm hydrograph. Storm water sampling also occurred on Spavinaw Creek, Beaty Creek and Dry Creek. Water exiting Eucha Lake was sampled when spillway flow increased to compensate for the in-flow of storm water. Parameter analysis consisted of total alkalinity, total hardness, settleable solids, suspended solids, sulfate, ammonia-nitrogen, kjeldahl-nitrogen, nitrate-nitrogen, nitrite-nitrogen, total nitrogen, ortho-phosphorous, and total phosphorus. Sample frequency was be determined by rainfall events, but at least six events were anticipated to be sampled over a two year period. Attempts were made to capture integrated storm water samples encompassing the rise, peak and fall of a single storm event hydrograph. Water exiting each lake was estimated based on recorded spillway overflow observations and water use records by City of Tulsa staff on Eucha, Spavinaw and Yahola Lakes. Precipitation data was obtained from City of Tulsa records, Oklahoma Climatological Service and the National Weather Service (NWS). Evaporation data was retrieved from the NWS.

<u>Groundwater</u> - Significance of groundwater contribution was assessed through the construction of a potentiometric map and analysis of water quality. Specific analytical parameters for the sampled ground water are listed in Table 6. Cation and anion content were examined for both stream and groundwater sites to assess aquifer source. Aquifer source was examined by comparison of sampled ground water to known constituents of the local major aquifers. The potentiometric map showed the direction of groundwater movement in relation to topographic features. The range for the rates of groundwater movement was provided for a given type of groundwater. A potentiometric map with relative movement rates answered the question of relative contribution of groundwater to the hydraulic budget of the lake system.

Current Limnological Data: Two years of current limnological data were collected and used to establish a relationship between nutrients and phytoplankton response, recommend a target nutrient concentration and evaluate lake management options to reduce impacts of degraded water quality to Spavinaw Lake. Water quality sampling entailed the regular monitoring of Spavinaw and Eucha

• Table 6. **Analytical variables for sampled ground water.**

VARIABLES MONITORED		
Alkalinity – total	Potassium	Nitrite - nitrate Nitrogen
Alkalinity – bicarbonate	Sodium	Phosphorus - Total
Alkalinity – carbonate	Chloride	Ammonium Nitrogen
Total dissolved solids	Calcium	Dissolved Orthophosphorus
Total suspended solids	Sulfate	Dissolved Oxygen

Lakes as well as tributary inflow and regular monitoring of the holding basin (Lake Yahola) following diversion from Spavinaw Lake.

All water quality sampling was preformed between 08:00 hours and 14:00 hours to facilitate completion early enough for delivery of the samples to the analytical/QA lab. The sampling schedule was once a month on the second Tuesday from November through March and twice per month beginning April through October on the second and fourth Tuesday of the month. The sequence of sampling was conducted as follows; Lake Eucha (Tuesday), Lake Spavinaw (Wednesday) and all Tributaries (Thursday). For storm water runoff events the field personnel notified the lab that samples were to be delivered on the day of collection. Field personnel and the QA lab determined final details of weekend or special dates for runoff sampling. Table 7 indicates the sampling sites for the project. Sampling of Yahola Lake occurred at one site as close to the water treatment plant intake as practicable.

• Table 7. **Sample Sites for Spavinaw-Eucha-Yahola Lake Complex. Sample site for Yahola Lake not included.**

SAMPLE SITES			
Site Code	**Site**	**Site Code**	**Site**
EUC01	Lake Eucha Dam	EUC11	Beaty Creek
EUC02	Lake Eucha mid Lake	EUC12	Clouds Creek
EUC03	Lake Eucha Hw-10	EUC13	Lake Eucha Tailwater
EUC04	Rattlesnake Creek	EUC14	Lake Eucha Tailwater
EUC05	Brush Creek	EUC16	Lake Eucha (Dry Creek)
EUC06	Beaty Creek	SPA01	Spavinaw Lake
EUC07	Dry Creek	SPA03	Spavinaw Lake
EUC08	Spavinaw Creek	SPA05	Upper Spavinaw Lake
EUC09	Spavinaw Creek	SPA06	Black Hollow
EUC10	Spavinaw Creek	USGS01	USGS at Sycamore

Observations regarding site number, instrument type and number, date, time, estimated air temperature, estimated wind speed and direction, estimated cloud cover, reservoir conditions, and comments were made at each sample site. Field parameters collected included date, time, temperature, pH, specific conductance, salinity, dissolved oxygen, percent saturation of dissolved oxygen, redox potential, irradiance, depth, and secchi depth. Field parameters were monitored at each site with depth in one-meter intervals. Surface samples were analyzed for turbidity and chlorophyll-a concentration. Table 8 summarizes all the analytical parameters for lake samples. They included total alkalinity, total hardness, dissolved solids, settleable solids, suspended solids, sulfate, dissolved silica, ammonia-nitrogen, kjeldahl-nitrogen, nitrate-nitrogen, nitrite-nitrogen, ortho-phosphorous, and total phosphorus. Samples were collected from both 0.5 m below the surface and approximately 0.5 meters above the bottom at all stations except the dam. At the dam station five samples were taken evenly spaced from 0.5 m below the surface to approximately 0.5 meters above the bottom. When stratification was apparent five samples were collected; two samples from the epilimnion, one sample from the metalimnion, and two samples from the hypolimnion. Sample handling and analysis is described in detail in the Spavinaw-Eucha-Yahola Lake QAPP.

Characterization of the biological quality of this system was accomplished through enumeration of phytoplankton and zooplankton assemblage. Vertical tows using a Wisconsin net integrated zooplankton sampling throughout the water column and Lugol's solution (1ml/100ml sample) was used as the preservative. Grab samples of surface water were used to enumerate epilimnetic phytoplankton assemblage using glutaraldehyde (1ml/100ml sample) as the preservative. Zooplankton and phytoplankton sampling occurred concurrent with water quality sampling. An additional phytoplankton sample was taken when a concentration of algae was noted with depth. Monitoring of dissolved oxygen (the presence of a positive heterograde) served as an indicator of an algal concentration while fluorometry was used to confirm and indicate the width of the zone. The depth zone of algal concentration was noted in the field notebook.

• Table 8. **Analytical variables for lake water samples.**

VARIABLES MONITORED		
Total Hardness	Total Phosphorus	Total Suspended Solids
Total Alkalinity	Dissolved Orthophosphate	Total Dissolved Solids
Ammonia Nitrogen	Turbidity	Algal Composition
Nitrate-Nitrite Nitrogen	Dissolved Silica	Zooplankton Composition
Kjeldahl Nitrogen	Chlorophyll-a	
Sulfate	Total Settleable Solids	

Sampling of Lake Yahola followed Spavinaw-Eucha Lake sampling and consisted of secchi depth, chlorophyll-*a*, turbidity, and nutrients (nitrogen and phosphorus constituents) on a quarterly basis. When taste and odor problems attributable to blue-green algae were noted at the Mohawk Water Treatment plant, a grab sample was taken for algal enumeration. Sampling of Lake Yahola occurred more frequently when water from Spavinaw was retained in Yahola before treatment.

Additional examination of lake water quality, sediments, and aquatic macrophyte distribution occurred as necessary. Sediment was sampled for composition and nutrient content at the monitoring sites. Additional analysis of hypolimnetic water quality occurred infrequently following the initiation of stratification for the parameters of dissolved iron and sulfide. This documented bio-geochemical cycling (fate of phosphorus) within the hypolimnion. Aquatic macrophyte distribution was determined through either GPS mapping or from aerial photographs. Transects were run from shore to the end of aquatic macrophyte growth, three transects per lake zone to characterize the aquatic plant community surrounding each lake. Table 9 summarizes additional analytical parameters given in this section.

• Table 9. **Additional variables for analysis of water(w), sediment(s) and plant (p).**

VARIABLES MONITORED		
Total Nitrogen(s)	Total Phosphorus(s)	Total Iron(s)
Nitrate-Nitrite Nitrogen(s)	Orthophosphorus(s)	Sulfide(s)
Particle size(s)	Dry Weight (p)	Sulfate(s)
Dissolved Iron(w)	Total Iron(w)	Sulfide(w)

Oklahoma Water Watch/Public Outreach: Oklahoma Water Watch (OWW) efforts in the Eucha/Spavinaw basin focused on recruitment of volunteer monitors throughout the study area. Initial efforts were to identify and train the local volunteers to perform the functions necessary for a successful volunteer monitoring program. These functions were program coordination, data management, equipment coordination and quality control and assurance. Depending on location, commitment and ability, volunteers monitored for the parameters listed in Table 10. Volunteers using boats were supplied with Van Dorn samplers and electronic equipment enabling the characterization of the water column for the parameters of dissolved oxygen, specific conductance, temperature, pH, phosphate, nitrate and ammonia. Volunteers only performed monitoring in the Lake Eucha watershed.

Certification of volunteer monitors is a three phased approach to ensure the highest quality volunteer data. OWW conducts Quality Control Assessments twice a year for each volunteer group to maintain monitor quality following certification. As a member of OWW, each volunteer was added to the OWW newsletter, **Oklahoma Water Log**. Once a year, OWRB staff met with the volunteer monitors to discuss their data. Educational opportunities were available to the volunteer monitors to participate in and have a voice in environmental issues. OWRB staff also supported volunteer directed outreach to the community. OWW continues to support volunteer monitoring efforts in the study area beyond the project period.

• Table 10. **Variable suite for volunteer monitoring of water quality.**

VARIABLES MONITORED		
Air Temperature	Dissolved Oxygen	Specific Conductance
Water Temperature	Phosphate Phosphorus	Salinity
Secchi Disk Depth	Ammonia Nitrogen	Apparent Color
pH	Nitrate-Nitrite Nitrogen	Chlorophyll-*a*

Assessments:

Limnological Data Assessment of limnological data started with plotting of monitored data over time. Isopleths of dissolved oxygen, temperature and other parameters were constructed to characterize each reservoir. This phase of the project was completed in 2000.

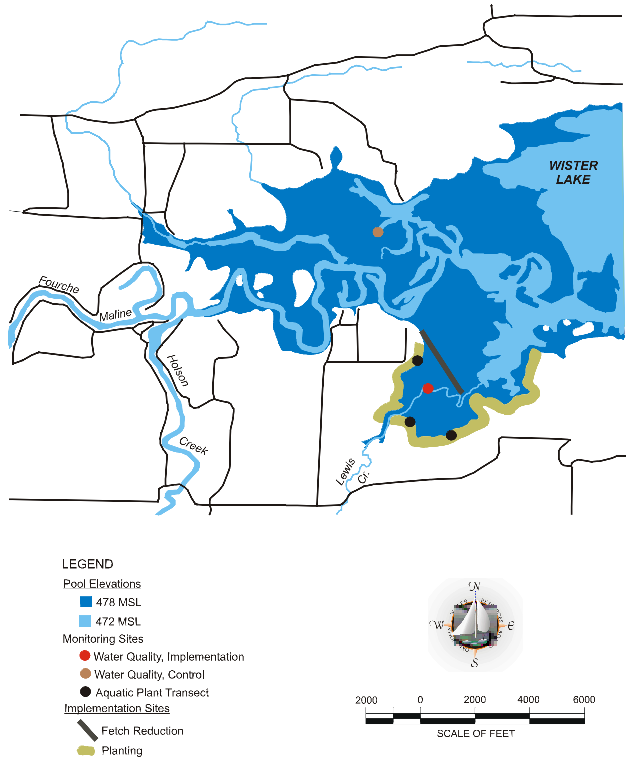
Trophic State Determination Carlson's trophic state index was applied to chlorophyll-a, secchi disk depth and total phosphorus data to define the monitored trophic status of each reservoir (Carlson, 1977). Phytoplankton data was also examined for seasonality and trophic state indicator species (Palmer, 1969). Zooplankton data was analyzed for trophic state indicator species and by size class to determine impact of predation (Wetzel, 1983). Hypolimnetic and sediment characteristics were also examined as a trophic state category (Wetzel, 1983).

Lake Water Quality Modeling Examination of the degree of eutrophication of the lake system started with a simple examination of the data for predictive fit (Vollenweider, 1968). Box and whisker plots of chemical and biological data to determine extent of reservoir zonation for further efforts were constructed. Conclusions drawn about the extent of reservoir zonation were used to recommend long-term monitoring sites and determine the number of sections needed to divide the lake for the lake water quality model BATHTUB (Walker, 1990). The model EUTROMOD was also applied to the monitored system (Reckhow, 1993). Predictions of the model were compared to monitored data to asses its predictive abilities. Regression analysis was examined to establish a reliable relationship between phytoplankton and phosphorus concentration. Regression analysis was also be used to establish a relationship between the presence of taste and odor causing phytoplankton and water quality. Lake Yahola data was compared to raw water intake data and lake water quality data to determine the influence of Lake Yahola on the quality of intake raw water to the treatment plant. A percentage nutrient reduction was developed to meet the predicted "natural" or background lake phosphorus concentration.

Determination of Target Nutrient Concentration Lake modeling results were coordinated with watershed modeling efforts by OSU Biosystems and Agricultural Engineering Department. This coordination served as a final check on model accuracy. The effect of varying lake management schemes was examined. Results will be presented to the City of Tulsa and TMUA in 2001 as a starting point to determine a target nutrient concentration for the lake.

Lake Wister Restoration

When the OWRB performed a §314 Clean Lakes Diagnostic and Feasibility Study of Wister Lake in 1991 little did the OWRB know that this would serve as the first effort to demonstrate low-cost lake remediation methods 9 years later. The Oklahoma Water Resources Board (OWRB) received a §319 grant to demonstrate the feasibility of reducing suspended sediment within the Fourche Maline Arm of Wister Lake. The OWRB study showed that the shallow areas in the Fourche Maline arm of Wister Lake are open mud flats with 100% of the plant growth as floating algae). The cost of treating this water as a drinking water supply for increases with high concentrations of floating algae and suspended sediment. A recommendation of the OWRB study was to shift the plant growth on these shallow mud flats from suspended algae to rooted vascular plants. Such an ecological shift would also result in reduced floating algae and suspended sediment; reducing water treatment costs as well as providing food and habitat to fish and wildlife. Challenges to this effort include periods of flooding and excessive oxygen depletion. Another recommendation of the OWRB Study was to reduce suspended sediment by reducing the effective fetch (and thus wave action). Challenges to this approach are limited federal funds.



• Figure 4. **Lake Wister Project Area.**

To maximize the effectiveness of the §319 grant dollars, the OWRB entered into agreements with the Corps of Engineers (COE) through the Planning Assistance to the States (PAS) program. The first agreement was to determine whether native aquatic plants that could be established in the Lake. Then additional work was performed to define specific plants and propagation methods. Another agreement was established to set the type and placement of materials to reduce wave action in the Fourche Maline arm. All of these agreement a have allowed the OWRB to call on COE expertise to plan the most effect method of demonstration. Specific recommendations are now being translated into the 319-demonstration project through the consensus of local lake stakeholders (COE Lake Wister project Office, ODWC regional fisheries supervisor, OWDC Lake Wister wildlife management Area, and Poteau Valley Improvement Authority).

A 2100-foot line of round hay bales were placed in the Lewis Creek arm of the lake to reduce wave action while a six man crew planted approximately. Monitoring of water quality in this area showed whether this method improves water quality. Plant establishment also targeted the Lewis Creek arm. Plants were harvested locally and transplanted into the lake. Seeds purchased and harvested across the state were also used to jumpstart the effort. Planting efforts began in May 1999, using a crew stationed out of Wister Lake. This crew, with the assistance of additional staff harvesting plants from Lake Murray and Spavinaw Lake, engaged in establishing plants with the intention to establish “founder populations” of aquatic plant species at strategic sites around Lake Wister. These colonies then served expanded to unvegetated areas of the lake. The purpose was to demonstrate that if re-vegetative efforts were to be performed over a five to ten year period, significant water quality benefits would be realized (See Figure 4).

Illinois River Monitoring

This project entailed monitoring water quality and water quantity to aid in documenting the effectiveness of nonpoint source pollution controls in Oklahoma and Arkansas, in conjunction with current TMDL and BMP implementation in the basin. This project also provided monitoring support for 319 projects in the basin, Oklahoma Scenic Rivers Commission (OSRC), US Geological Survey (USGS), and Environmental Protection Agency (EPA) studies currently being conducted in support of the Tenkiller Ferry TMDL. The goal of the project was to quantify loadings to Lake Tenkiller and assist in the bench marking process. The two areas of interest were Horseshoe Bend and Caney Creek.

Background:

The OWRB contracted with Oklahoma State University (OSU) to conduct a §314 Phase I Clean Lakes study on Tenkiller Ferry Lake in the early 1990s. A report was completed in June 1996, which outlined eutrophication problems in Tenkiller Lake due to nitrogen and phosphorus loads, which were especially excessive during periods of high flow. The noted water quality degradation included algal blooms and excessive algal growth, anoxia (low dissolved oxygen levels) during stratified periods of the year, and compromised water clarity. The OWRB, United States Army Corps of Engineers (USACOE), OSU and the Environmental Protection Agency (EPA), jointly recommended a 40% phosphorus load reduction to the lake be implemented to maintain water quality conditions at the quality present in the early to mid 90s. This recommendation was just a short-term goal. The Horseshoe Bend area of the lake was identified as the point where loadings be measured and a baseline number (approximately 228,000 kg P/year) was established based on historical data.

Project Activities:

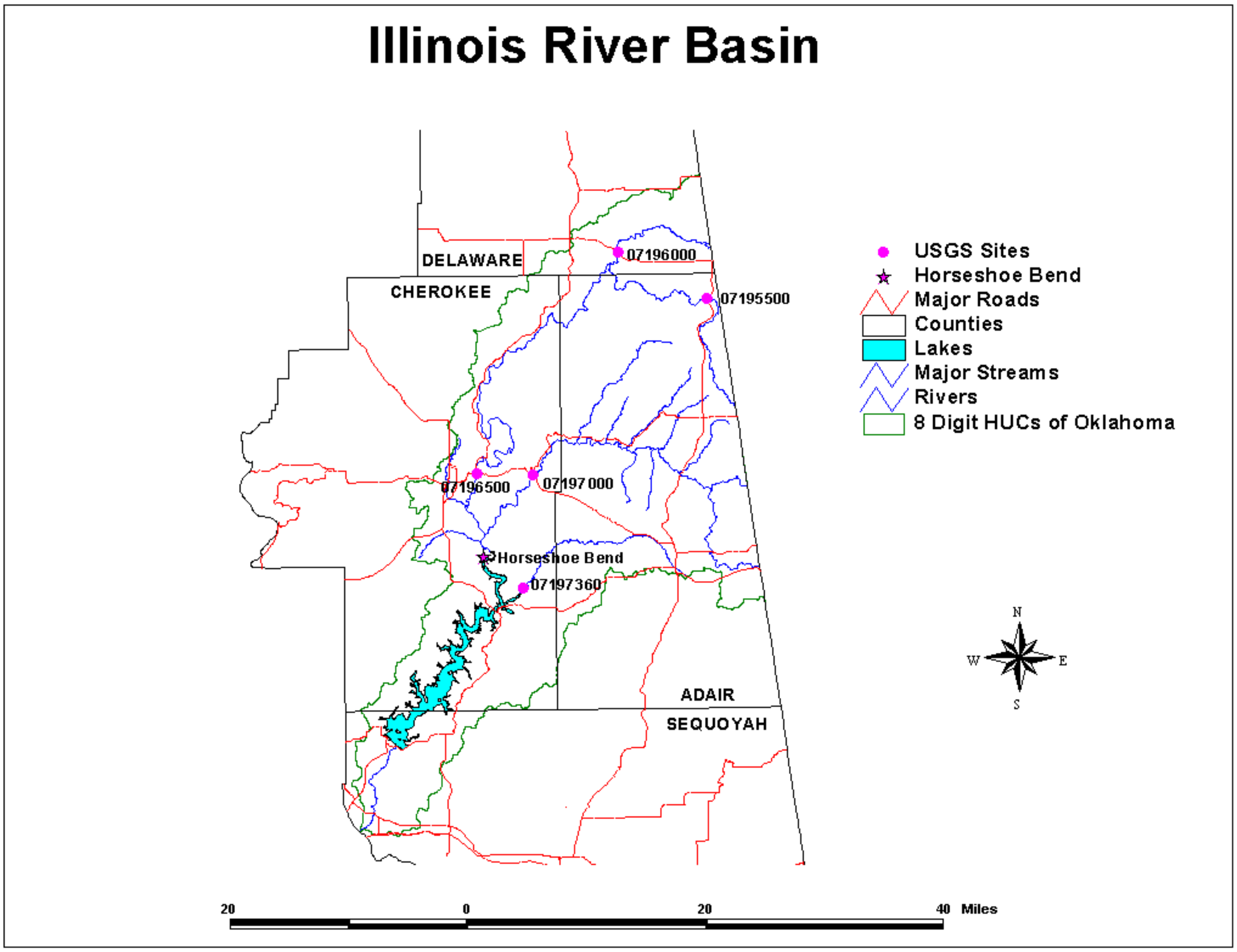
Monthly monitoring to document water quality and quantity in the Illinois River/Lake Tenkiller basin at Horseshoe Bend and Caney Creek and to establish and/or verify the benchmark number was conducted by the OWRB with assistance from the Oklahoma Scenic Rivers Commission (OSRC). The purpose of the monitoring was to determine nutrient loading estimates of identified parameters and assess the effectiveness of phosphorus load reduction activities in the basin and whether or not the 40% TMDL reduction goal is being met.

Collection of stormwater at three USGS streamflow monitoring stations (Baron Fork at Eldon, Illinois River at Tahlequah, and Caney Creek at Barber) was conducted. The OWRB worked with the OSRC and the United States Geological Survey (USGS) to accomplish this part of the project. By collecting stormwater, flow weighted mean loading values can be calculated to assess the amount of loading that occurs during high flow as opposed to low flow.

Baseline Monitoring Program:

Phosphorus concentrations and stream flow are currently being used to calculate loadings at Horseshoe Bend (07196500 + 07197000) and Caney Creek (07197360). Water quality monitoring commenced in May 1998 and continued through October 2000. Storm event samples were collected at three USGS streamflow monitoring stations, Illinois River near Tahlequah (07196500), Baron Fork at Eldon (07197000), and Caney Creek near Barber (07197360). See Figure 5 for a graphic depicting the monitoring sites for the Illinois River project.
Water quality parameters that were quantified in the field using a Hydrolab unit include: dissolved oxygen,

pH, specific conductance, salinity, temperature, oxidation-reduction potential and total dissolved solids (TDS). Turbidity values (NTUs), chlorophyll-a and pheophytin concentrations, and Secchi disk depths were also determined for the Horseshoe Bend and Caney Creek sites. Water quality samples are collected at each site at the surface and one (1) meter from the bottom at Horseshoe Bend. The samples are preserved for analysis of nitrate nitrogen, nitrite nitrogen, ammonia nitrogen, kjeldahl nitrogen, organic nitrogen, ortho-phosphorus, total phosphorus, settleable solids and suspended solids. The City County Health Department of Oklahoma County (CCHDOC) Water Quality Laboratory was utilized for the bulk of the project with the ODEQ laboratory used for the last few months of the sampling program. .



• Figure 5. **Map of OWRB and USGS monitoring sites for the Illinois River project.**

The same nutrients are analyzed for when stormwater samples are collected. The methods of collection are slightly different, in that an equal width increment and integrated depth sample is collected at the three USGS streamflow monitoring stations in the Illinois River Basin using a specialized sampler. The goal is to collect at least four storm events per year through the course of the project. By collecting water quality samples at different flow measurements, it is possible to assess whether or not monthly monitoring at base flow is an actual depiction of the annual loadings into Lake Tenkiller.

Data collected by the USGS, OWRB's Beneficial Use Monitoring Program (BUMP) and Oklahoma Water Watch (OWW), the OWRB sponsored citizen volunteer monitoring program, will be included as supplemental data for the Final Report, due to Region 6 EPA in April 2001.

Stream Studies for OWQS Support & Criteria Development

The OWRB conducts Use Attainability Analyses (UAAs) when required. A UAA is an intensive short-term data collection program with the objective of establishing the type of aquatic community present in a stream and what type of aquatic community the water body can support. This is vital in the OWQS setting process, so that the water body is assigned the correct beneficial use designation. The OWRB conducts sampling of numerous streams across Oklahoma under the auspices of the BUMP. Sampling conducted in conjunction with the BUMP is discussed elsewhere in this document. The OWRB is conducting stream sampling in support of our development of biocriteria for inclusion in the Oklahoma Water Quality Standards (OWQS).

One of the main components of Oklahoma's Water Quality Standards (OWQS) is beneficial use designation for the state's receiving waters. Beneficial uses are assigned to listed waters in OAC 785:45 Appendix A. Determining whether these uses are being supported has been a challenge, that staff of the Oklahoma Water Resources Board has endeavored to meet.

Beneficial uses for which Oklahoma has developed Use Support Assessment Protocols (USAP's) include Fish and Wildlife Propagation, Primary Body Contact Recreation, Public and Private Water Supply, Agriculture and Fish Consumption. EPA began several years ago urging states to develop biological water quality criteria (*biocriteria*), a methodology by which an organization could determine if the aquatic community found in a given stream was the best the stream could support under normal circumstances. Numerous guidance documents have been compiled in order to inform states of EPA's goals and objectives as well as assisting states in deciding the best course of action when developing their own biocriteria.

Over the past few decades, much energy has been dedicated to deriving some type of index or indicator that could be used to directly measure the "health" of the biological community. Several states have made forays into this arena with varying degrees of success. Ohio has extensive "biocriteria" contained in their WQS. North Carolina and Maine have also pursued biocriteria a well as other states. Oklahoma, by contrast, will address the problem from a slightly different perspective.

BIOCRITERIA DEVELOPMENT

Ouachita Mountain Ecoregion Project

Methodology:

In developing the biological assessment thresholds and associated methodology, other state environmental agencies were invited to participate and provided valuable input into the process. A ***universal biological assessment protocol*** was developed in order to provide guidance to agencies and individuals performing any assessment relating to biocriteria. A review by six state and federal agencies as well as a local university produced the final protocol document published by OWRB as Technical Report 99-3. Contained within the protocol are methods for physical, chemical and biological assessment of a given stream reach. These methods have been refined over the course of several years and are intended to provide a comparable level of effort for all assessments and collections relating to biocriteria. However, the Executive Summary of the document contains the following disclaimer.

> **"The intended application of this protocol is establishment of a uniform biological assessment through which aquatic communities of similar streams can be compared. Any section of the protocol (physical, chemical or biological) is capable of being used separately. However, a complete picture of the biological condition of any given stream necessitates that each section be applied in conjunction with the others. Agencies, universities, independent entities and individuals are not required to employ these protocols for their own projects unrelated to biological criteria. Separate, project-driven or agency-devised protocols are acceptable for other purposes. Only when results are to be used in biological criteria applications related to Oklahoma's Water Quality Standards will these protocols be required."**

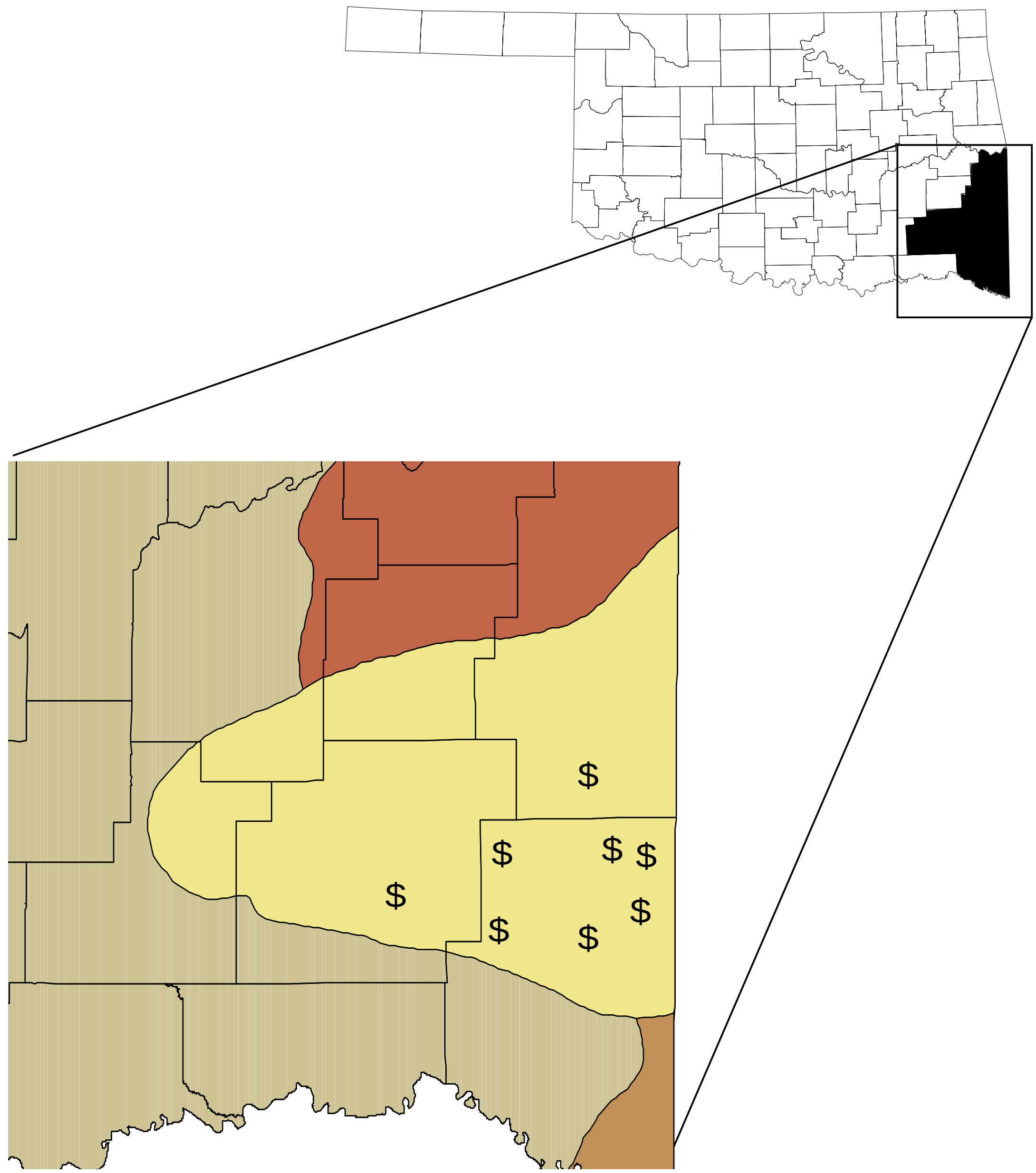
Development of the proposed biological assessment thresholds involved comparison of reference steams to streams of varying levels of impact. Development of the applicable USAP subchapter containing the proposed thresholds involved merging the approved biocriteria protocols with the proposed thresholds for the Ouachita Mountain ecoregion. This proposed USAP was put before the biocriteria working group, as well as other staff familiar with the development of previous USAP language, for review and comment prior to this public presentation.

Selection of the ecoregion to begin development of statewide biological thresholds was an unforeseen outcome of another project. In the process of examining the distribution of known faunal collections from across the state, it was noticed that the Ouachita Mountain ecoregion (as determined by Omernick, 1987) contained nearly twice the number of collections as almost any other area of the state. It was decided that, especially for the initial stages of "biocriteria" development, the larger the number of test streams to chose from the better.

One of the few existing references to biocriteria in the WQS (785:45-5-12(e)(5)(A)(1)) allows for comparison of test data to regional reference data from similar waters. This concept, that similar waters with similar habitats and ecological characteristics will contain similar aquatic communities, is a basic tenet of the ecoregion concept. At its most basic level, it suggests that environmental alterations, whether chemical, physical or biological, will be manifest in the aquatic community. Quantification of these aquatic community differences drives biocriteria and is dependent upon the establishment of the "reference condition". Oklahoma's Conservation Commission, a contributing party to this process, developed project-specific "reference streams" under separate grant support based upon chemical and biological factors. OWRB used these streams as the reference condition against which all test streams would be compared. The list and locations of reference streams used for this project are shown in Figure 6 and Table 11. Table 11 also shows the results of various standard metrics applied to faunal collections.

In order to create the matrix of support levels, it would first have to be determined what those support levels would "look like". In other words, what sort of fish community would be present in different stream types under different impact conditions? As part of OWRB responsibilities, Use Attainability

Analyses (UAA's) are performed on certain streams to determine the appropriate Fish & Wildlife Beneficial Use sub-category for the purposes of discharge permitting.



• Figure 6. **Location of Ouachita Mountains ecoregion reference stream sites validated by OWRB assessments.**

Results of these UAA's reveal different levels of impact ranging from nearly non-existent to severe depending upon the discharger and stream characteristics Impact zones were assigned based upon the widely accepted principle that the further downstream one proceeded from a point-source insult, the lesser the impact to the faunal community. Part of this relates to dilution and part to assimilation capacity of the stream.

Comparison of the reference streams to the UAA test streams required some technique to measure the faunal community. Eliminating subjectivity during the measurement process was imperative. An extensive search was begun in order to find some sort of index or set of metrics that would accurately and repetitively measure the pertinent parameters within the faunal community indicative of use support.

Ohio was found to have the most functional and well-supported biocriteria program employing fish taxa. Examination of their documentation revealed an extensive set of measurement parameters that had already been field tested and validated. Even though Ohio only has four ecoregions compared to our eleven, their work provided the best hope of not "re-inventing the wheel". After review by the multi-agency work group, the resulting set of parameters were felt to be most representative of Oklahoma conditions and fauna. Those particular metrics (total species, % tolerant species, # of intolerant species) were found to relate to drainage area.

• Table 11. **Results of various metrics applied to Ouachita Mountain reference streams by OWRB staff.**

Stream Name	County	OWRB Shannon's Diversity [1] (fish/inverts)	OCC Shannon's Diversity (fish/inverts)	Sorenson's Similarity [2] (fish only*)	OWRB Taxa richness (fish/inverts)	OCC Taxa richness (fish/inverts)	OWRB EPT	OCC EPT
Mine Ck.	McCurtain	2.14 / 1.76	na / 1.93	na	10 / 18	na / 19	9	7
Big Hudson Ck.	McCurtain	1.88 / 1.93	1.93 / 2.78	0.73	10 / 19	12 / 21	10	10
Cedar Ck.	McCurtain	1.30 / 1.93	1.76 / 0.94	0.70	7 / 20	13 / 25	10	9
Caney Ck.	Pushmataha	2.41 / 2.27	1.89 / 2.23	0.71	13 / 22	15 / 17	11	5
Cucumber Ck.	LeFlore	1.70 / 2.24	2.00 / 2.60	0.87	10 / 22	12 / 21	8	8
Terrapin Ck.	McCurtain	2.09 / 1.84	1.89 / 2.62	0.57	14 / 28	14 / 20	16	11
Dry Ck.	McCurtain	1.60 / 2.54	na / 2.40	na	10 / 27	na / 19	11	8
Silver Ck.	McCurtain	1.00 / 2.64	2.09 / 2.46	0.30	4 / 26	16 / 19	14	10
Buffalo Ck.	McCurtain	1.95 / 2.51	na / na	na	10 / 20	na / na	8	na

*between OCC and OWRB collections

1 $\bar{d} = -\sum_{1}^{n} \frac{n_i}{N} \ln \frac{n_i}{N}$ where n_I = # of individuals within given taxa and N= total # of individuals in the sample

2 $S = \frac{2C}{A+B}$ where A = taxa richness of site A, B = taxa richness of site B, C = taxa common to both sites

na = data not available from or collected by Oklahoma Conservation Commission

After collection information was gathered from as many sites as possible, the test sites were segregated into their respective Fish & Wildlife Beneficial Use sub-categories and impact classifications. Establishing breakpoints for support levels involved looking at range of values, their means and applying some best professional judgement to set category minimums.

Beneficial Use Support Assessment Protocols (USAP's) found in Oklahoma Administrative Code §785:46 do not directly address biological communities. In fact, USAP attempts to assess the support of Fish and Wildlife Beneficial Use (B.U.) through the indirect measurements of chemical parameters. If the water quality parameters are within guidelines, then the expected fauna should be present and the community should be diverse and healthy.

Some benefits to using this approach to biocriteria development are:

- The results are blind to source meaning that no consideration is given to whether these results are due to point- or non-point-source impacts,

- The biological USAP methodology is usable by any agency employing biocriteria protocols, and

- The results are directly correlative to 303(d) list making resource allocation (for subsequent work in the stream if necessary) and listing decisions easier.

The proposed biological thresholds will allow state agencies and others to analyze the biological community in terms of the Fish and Wildlife Beneficial Use.

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Proposed bio-assessment thresholds for the Ouachita Mountains will provide a method of directly measuring the faunal community against an index of "support levels". These proposed support levels (*fully supporting, supporting but stressed, and not supporting*) are separated according to different F&W sub-categories (WWAC and HLAC) which have their own support level indices.
Some benefits to using this approach to biocriteria development are:

- The results are blind to source meaning that no consideration is given to whether these results are due to point- or non-point-source impacts,

- The biological USAP methodology is usable by any agency employing biocriteria protocols, and

- The results are directly correlative to 303(d) list making resource allocation (for subsequent work in the stream if necessary) and listing decisions easier.

The proposed biological thresholds will allow state agencies and others to analyze the biological community in terms of the Fish and Wildlife Beneficial Use. These procedures will, for the first time, allow for consistent examination of biological communities with a minimum of subjectivity and judgement.

Establishment of reference streams and reference taxa for 3 ecoregions in Eastern Oklahoma

Justification and Background:

Previous work done through FY95 and FY96 604(b) grants established the reference streams and fish taxa for the Ouachita Mountain ecoregion in Oklahoma. This was considered the first step in formulating biological water quality criteria for the state.

An unexpected result of the FY95 604(b) work was the identification of gaps in the statewide collections of fish and invertebrates that could be used to determine the reference taxa for future reference streams. The on-going Biocriteria Technical Working Group (BTWG) meetings have provided necessary insight into the collections that exist at various institutions across the state. Oklahoma Conservation Commission (OCC) personnel have made preliminary stream assessments across several regions of Oklahoma. This will allow for elimination of many candidate reference-streams without involving field work.

This project will produce a list of reference streams for each of the three selected ecoregions and ecoregion-specific metrics that can be used to infer water quality. The continuing development of biocriteria for the Ouachita Mountain ecoregion will be used as the model for development of biocriteria for the remaining ecoregions. Metrics used in other states will be evaluated for appropriateness for use in Oklahoma.

Objectives:

The objective of this project is to establish the reference streams and associated metrics for each of 3 major ecoregions in eastern Oklahoma. Selection of these streams will proceed using previously determined selection criteria. Stream assessments will follow established procedures documented in existing biocriteria development QAPP and Use Attainability Analysis (UAA) protocols. All efforts will proceed with the expert support of BTWG members. Field validation of reference streams was and is followed by the determination of appropriate metrics for each ecoregion. Upon completion of stream assessments and collections, candidate metrics are applied to previous and existing collections to establish draft numeric biological water quality criteria for each ecoregion. Completion of this phase of biocriteria development will allow progress toward formalizing draft numeric biocriteria for the entire state.

Methods:

1) Consult BTWG on selection of appropriate candidate reference streams in each ecoregion.

2) Use appropriate survey methods established in previous workplans and QAPP documents to assess each candidate reference stream.

3) Create the necessary GIS coverage to establish the appropriate map layer. This will include reference streams, draft biocriteria and other pertinent information.

4) Evaluate metrics used in other states for appropriateness for use in Oklahoma and field-validate where appropriate.

Validation of reference streams and formulation of draft biological criteria for the Central Oklahoma/Texas Plains (COTP) ecoregion

JUSTIFICATION AND BACKGROUND:

Oklahoma Water Resources Board staff, with input from various state and federal agencies, are in the progress of developing statewide biological criteria for use in Beneficial Use (B.U.) support designations. Each Omernick ecoregion across the state will eventually have its own biocriteria and use support thresholds. These B.U. support designations and their associated protocols will eventually become part of the Beneficial Use Monitoring Program.

OBJECTIVES:

The objectives of this project are (1) to validate the selection of reference streams which are to be the basis for "fully supported" beneficial use support designations and (2) to create the draft biocriteria for the COTP ecoregion.

METHODS:

This project will allow for the collection of stream faunal data from those areas in Oklahoma that are incorporated into the COTP ecoregion. These data will be taken from and compared to the data from a selection of "reference streams" provided by Oklahoma's Conservation Commission. Validation of these reference streams (duplication of the assessment efforts and comparison of results) will be accomplished through a uniform biocriteria assessment protocol. The logic behind re-sampling the reference stream is part of the process of validation of the reference stream. Before OWRB can confidently use the OCC suggested reference stream, we re-sample and re-assess it using the same protocols and similar equipment. If our assessments and sampling results are comparable to those of OCC, we will concur with the selection of the stream as a reference stream. The stream and its assessment results will then become part of the biocriteria development process. If we cannot validate it, that stream isn't used as a reference stream. It may, however, be considered for other purposes. These reference steams will become examples of "fully-supporting" unimpacted streams.

Additional existing data from streams in the region, including habitat assessments and collection data taken from Use Attainability Analyses (UAA's) performed throughout the region, will be segregated into "impact categories" that will initially roughly equate to use-support categories. These impact categories are derived from the distance downstream from the point source located on the stream. The closer the collection is to the point source, the higher the presumed impact will be.

Fish collections are examined through the use of an Index of Biotic Integrity (IBI) originating in Ohio and modified for Oklahoma. In previous biocriteria work (FY95 604(b)), it was shown that distributions of stream insects in particular did not conform well to ecoregional boundaries. Additionally, it is an ecological axiom that if the fish are present, then the supporting levels of producers and consumers are also present in amounts and frequencies sufficient to support the fish community. If those supporting levels are not present, then the fish community reflects the absence of prey taxa and will not be as diverse or populace.

Aggregate clustering of these resulting data points will permit setting numeric thresholds between fully-, partially- and non-supporting designations. Inclusion of these data into existing historical databases maintained by the biocriteria project manager will additionally provide a better view of the distributions of native organisms across Oklahoma.

It is the goal of biocriteria development to incorporate numeric biological assessment values for stream types into the regulatory framework of the water quality standards. The results of this project were incorporated as part of the Use Support Assessment Protocol language that is contained within Oklahoma's water quality standards implementation language.

Volunteer Monitoring Program – *Oklahoma Water Watch*

The Oklahoma Water Resources Board conducts a volunteer monitoring program on numerous water resources across the state. The volunteer program, Oklahoma Water Watch, was initiated in 1992 and continues to thrive to this day.

As stated above, Oklahoma Water Watch (OWW), the citizen volunteer monitoring program begun by the Oklahoma Water Resources Board (OWRB) in 1992, has flourished since its inception. Starting with a single group, the Grand Lake Association, OWW now has twenty groups with a total membership of over 200 individuals. High schools, colleges, civic groups, and Lake Associations are all represented within its ranks, as are all parts of the state. From Lake Carl Etling in the panhandle to Broken Bow Lake in the southeast, OWW currently has groups on 16 lakes and 6 streams across the state (See Figure 7).

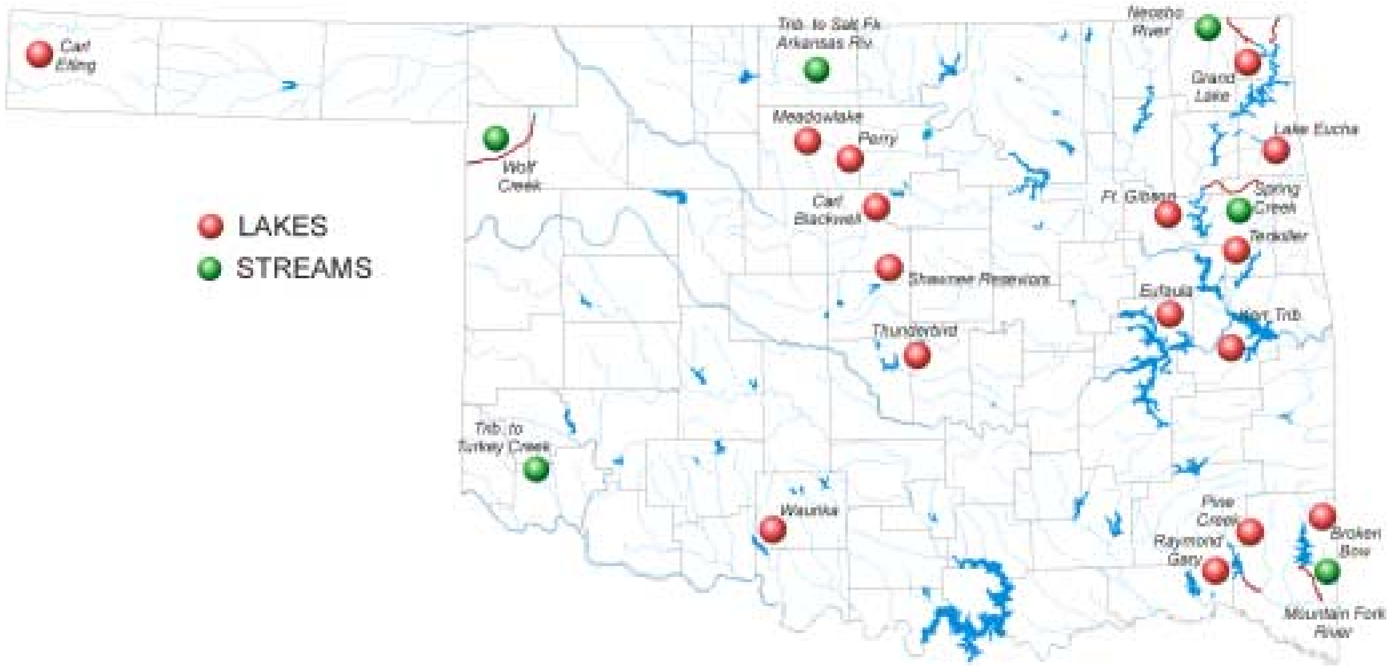
Oklahoma Water Watch established five primary goals at its foundation. They are as follows:

- Collect environmental data to determine baseline water quality conditions for Oklahoma's water resources.
- Identify current or potential water quality problems.
- Determine water quality trends.
- Promote citizen participation in protecting, managing, and restoring our water resources.
- Educate the public on basic ecological concepts associated with our water resources.

Sapulpa High School students and their teacher complete Phase III of OWW training.

These goals are currently being met. To date, OWW has accepted more than 3,000 data sheets. Several lakes including Grand, Eufaula, and Tenkiller have multiple years of data that can be analyzed for trends. Citizens have shown a genuine interest in learning the limnology behind their watershed and how they can help manage water resources.

Day-to-day management of the program includes scheduling training sessions with new groups and classes, setting up quality control sessions to ensure that quality data is being collected, updating monitors on new program information, handling data collected by volunteers, and making sure that grant obligations are fulfilled. Oklahoma Water Watch monitors are trained to collect physical as well as chemical data to supplement data collected by OWRB professionals. See Table 12 for a list of variables monitored. In addition to this routine management, OWW is always looking for ways to recognize and promote volunteers by nominating them for awards or sending them information on how to apply for grant money.



• Figure 7. **Sites monitored by Oklahoma Water Watch volunteers.**

• Table 12. **Variables monitored by Oklahoma Water Watch volunteers.**

Parameter	Units	Data Type
pH	Standard units	Chemical
Dissolved Oxygen	Milligrams/Liter	Chemical
Orthophosphate	parts per million	Chemical
Nitrate Nitrogen	parts per million	Chemical
Ammonia Nitrogen	parts per million	Chemical
Secchi Disk Depth	Centimeters	Physical
Temperature	°C	Physical
Water Color	Borger Color System	Physical
Cloud Cover	Range	Physical
Wind Speed	Range	Physical
Wind Direction	Range	Physical
Waves	Range	Physical
Aquatic Macrophytes	Range	Physical
Precipitation	Centimeters	Physical

Water Watch recently purchased volunteer monitoring recognition signs for all OWW groups to display at their locations throughout the state. These metal signs help bring recognition both to the program and to its dedicated volunteers. Posted at Lake Docks, park entrances, and other highly visible areas, these signs serve as a reminder to all Oklahomans that there is a way to become involved in watershed management in their community.

Attendance at public events is also important in gaining public support and participation. OWW routinely attends the H2Oklahoma Festival, Oklahoma Association for Environmental Education Exposition, and other statewide activities such as Earth Day. Oklahoma Water Watch also takes a lead role in promoting Oklahoma Lakes Appreciation Week and the Great American Secchi Dip-In each year.

A representative of the Seneca-Cayuga tribe receives a sign for display in conjunction with the Grand Lake Association Water Watch group.

One of the primary goals of OWW mentioned above is to determine baseline water quality conditions and trends in Oklahoma's water resources to supplement agency-collected data. In 1998-1999, OWW furthered this goal by giving dedicated in-lake volunteer monitors electronic water quality monitoring sample probes to facilitate lake profiling. Purchase of electronic instrumentation allows monitors to collect in-situ data throughout the lake profile. Data can now be collected for dissolved oxygen, pH, specific conductance and temperature without having to use the standard LaMotte testing procedures. Five Hydrolab® H20s and Scouts were purchased to help monitors collect data that is very much comparable to data collection procedures used by agency lake sampling personnel. Several groups have already begun putting their probes to good use and we expect that many more instruments will be distributed in the future.

At the present time, Oklahoma Water Watch is also involved in several EPA grants. The OWW obligations to these grants vary but generally involve establishing a group of volunteers at a lake that is known to be impacted by some type of pollutant. Volunteers collect data to help substantiate and supplement data collected by the agency, as well as bring water quality awareness to the community. Meadowlake (located in the City of Enid), was conducted as part of a §319 funded study, wrapped up this past year and is a sterling example of what professionals and volunteers can accomplish when working together. Though the federal funding for the project has ended, the high school group in Enid that participated in fulfilling this grant is continuing their monitoring indefinitely, demonstrating the unique opportunity that OWW provides for long-term monitoring beyond the conclusion of a specific study. The Meadowlake monitoring group also serves as a good example of how government working jointly with volunteers in the public sector, can achieve water quality improvements through good science and community awareness/education.

A representative of the Hydrolab Corporation demonstrates the use of a multi-parameter water quality monitoring instrument.

Oklahoma Water Watch serves as an integral bridge between our agency and local communities. It, along with numerous other citizen programs around the country, is proving that volunteers can collect vital and useful environmental information. It is hoped that OWW will continue to receive financial support into the future so that a quality program can be provided to the citizens of Oklahoma and that an educated and informed public can play a more key role in the management of our water resources for the good of us all. For more information on the OWRB volunteer monitoring program, please contact Crystal McLaren, Interim Program Coordinator at (405) 530-8800 or at her e-mail address clmclaren@owrb.state.ok.us.

CHAPTER

2

Water Quality Monitoring Programs at the Oklahoma Conservation Commission

Introduction

The Oklahoma Conservation Commission Water Quality (OCCWQ) Program has an extensive monitoring program. While OCCWQ conducts several distinct types of monitoring activities, the overall goal of the program is as follows:

To conserve and improve water resources of the State of Oklahoma through assessment, planning, education, and implementation.

The major types of monitoring performed by OCCWQ are listed below.

1. Ambient_Monitoring: Ambient monitoring is routine monitoring, either at fixed or randomly selected sites, conducted to identify potential problems, baseline or natural conditions, or high quality waters. It is the backbone of any statewide monitoring program because the data can be used for so many different purposes. Data can be used to track changes over time, to identify problems, to compare the severity of problems and thus prioritize efforts, and for many other uses. Ambient monitoring is critical for determining what the problems are and where they exist. Finally, this type of monitoring is the only way the State NPS Program can effectively address the Clean Water Act Section 319 mandate, "to monitor and assess the State's waters for the effects of NPS pollution."

2. Diagnostic_Monitoring: Diagnostic monitoring programs often result from ambient monitoring. In systems where ambient monitoring has identified potential NPS problems, a diagnostic monitoring program is established. Diagnostic monitoring involves more in-depth sampling to confirm or refute the suspected problem, identify and pinpoint sources, and more accurately document causes and effects of the specific problem. Monitoring may include land use

assessment, modeling, intensive water quality monitoring, and biological assessments to determine relative pollutant input.

3. Implementation Monitoring: Implementation monitoring is performed to determine the effects of best management practices (BMPs) on water quality. The Oklahoma Conservation Commission is heavily involved with the deployment of various types of BMPs designed to protect or improve water quality throughout the state. It is necessary to know whether these practices are successful, so changes can potentially be made to achieve the desired effect. Implementation monitoring often involves sampling before and after a management practice is installed.

4. Reference Condition Monitoring: Waterbodies differ in naturally occurring levels of compounds that are considered pollutants. Most of this naturally occurring variation is due to variability in native plant communities, geology and soils, slope, climate, and other factors related to geography. Likewise, the resident communities of aquatic organisms vary by region for similar reasons. In order to determine whether a stream is polluted or whether its aquatic community is healthy, it is necessary to know what the water quality of the stream and its biological communities should be like. Data collected from reference condition monitoring allows state and federal agencies to make this type of determination. As the database of potential reference streams becomes complete, less reference condition monitoring will be necessary. Data collected on potential reference streams will be used by the OWRB in their effort to establish biological criteria to support the water quality standards.

The OCCWQ conducts other specialized types of monitoring, although rather infrequently and generally at the request of other agencies. These types include monitoring to protect endangered species, total maximum daily load (TMDL) monitoring, and fluvial geomorphological monitoring. Monitoring to protect endangered or threatened species is specific to the particular species requiring protection and is not commonly done by the OCCWQ. It is normally done in response to a specific threat to the species of concern.

The TMDL process divides up the total amount of allowable pollutant loads among all activities in the watershed that generate a specific pollutant. To do so equitably, monitoring must first determine how much of the pollutant is currently being generated by all point and nonpoint sources. Then, the TMDL estimates what effect reductions will have on the waterbody.

Fluvial geomorphological monitoring is a non-traditional type of monitoring. Studying the form and relationship of streams to their watershed and to climate makes it possible to compile a reference database to determine what the physical dimensions of the stream should be, how much bank material erodes naturally, what the substrate materials should be, and how to repair channels that do not meet these expectations.

The OCCWQ collects numerous types of samples including water, soil, air, habitat, and biological samples (fish, benthic macroinvertebrates (aquatic insects), and algae). Water samples are used to determine whether pollutants exist in concentrations high enough to cause water quality problems. Soil samples suggest areas in a watershed where nutrients are likely to runoff the land surface or percolate into the shallow groundwater during storm events. Air deposition samples (samples of materials deposited from the atmosphere) allow for a differentiation between loadings due to activities on the land in a watershed and those from the atmosphere. Habitat surveys make sure that the stream contains adequate habitat for aquatic organisms. Biological samples, when compared to those from a reference stream, can show whether a pollutant is negatively impacting the aquatic community.

During 1999 and 2000, OCCWQ collected more than 2,944 water samples for conventional pollutants at over 265 sites and collected over 650 samples for pesticide analysis at 75 sites. Staff performed a detailed land survey on 78,000 acres of land, collected 849 soil samples, and 170 poultry litter samples. Biologists completed 122 fish collections, collected nearly 629 invertebrate samples, and performed over 125 aquatic habitat assessments. All OCCWQ monitoring is conducted following methods and sampling plans established in EPA approved Quality Assurance Project Plans (QAPPs). These QAPPs are subject to peer agency review and approval by the Office of the Secretary of Environment.

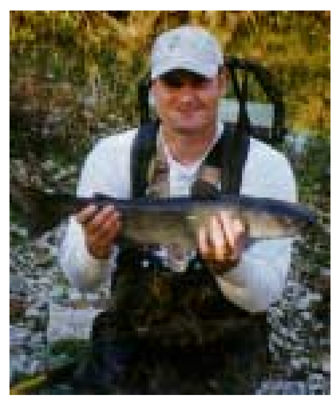
All OCCWQ collected data is stored electronically in a Microsoft Access® database, maintained by OCCWQ staff. The data is spatially referenced so it can be used in Geographic Information System's (GIS) analysis. Select data will soon be available for viewing and download from the OCCWQ website (www.okcc.state.ok.us). A data manager answers more extensive data requests. OCCWQ data will ultimately be entered into the STORET database and the State of Oklahoma Database being developed by the ODEQ.

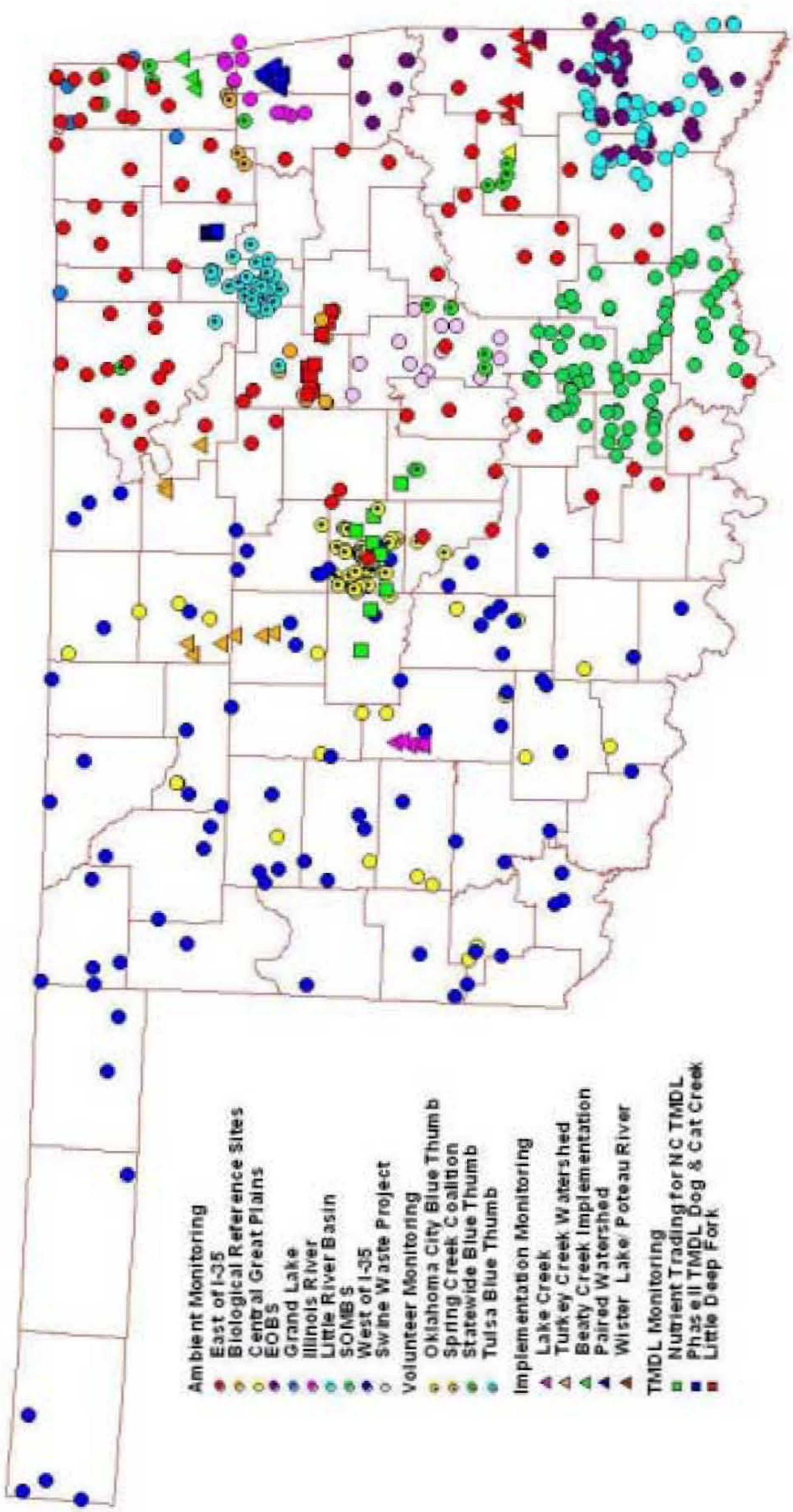
Various types of reference condition monitoring have comprised the bulk of the OCCWQ's monitoring efforts for the past several years. Significant projects that have added to the reference condition database include the Illinois River Basin Study, the Southern Oklahoma Multiple Basin Study (SOMBS), the Eastern Oklahoma Border Study (EOBS), the Little River Basin Study, the Central Great Plains Reference Condition Study, and the East and West of I-35 Data Gaps Projects (Figure 8).

Monitoring to fill Data Gaps- Ambient and Reference Condition Monitoring

East of I-35 Data Gaps Study- Eastern half of state

This project was designed to complete the database of potential reference streams for the eastern half of Oklahoma. Reference stream information is used to determine whether a stream is polluted and whether its biological communities are healthy. The determination of stream quality is accomplished by comparing water or biological data of the stream in question to reference stream data.



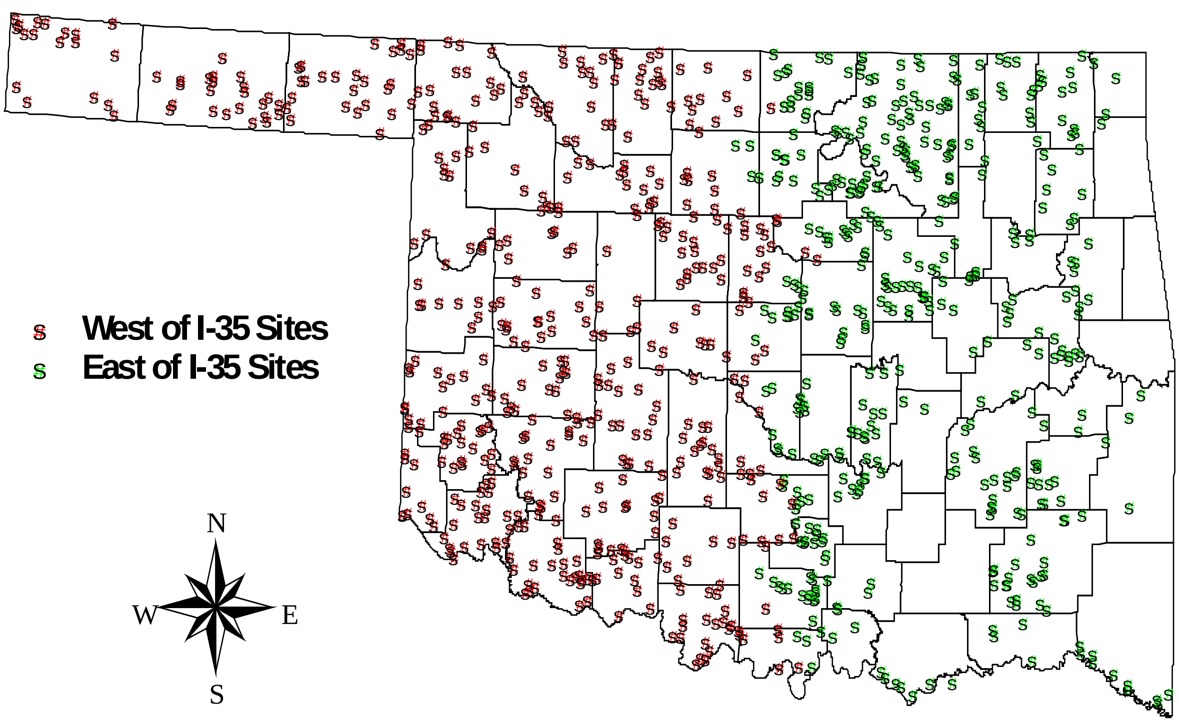


• Figure 8**. Recent and Current OCC Monitoring Sites.**

The OCCWQ has been collecting reference stream data for several years in eastern Oklahoma. When completed, this project will fill in the data gaps in the eastern half of the state that exist where streams have not yet been surveyed. To select sites for this study, OCCWQ first looked at streams in the state where little data existed. Short habitat assessments and basic water quality analysis were then completed on 430 streams (Figure 9). Habitat assessments on 100 of these streams were repeated for quality assurance purposes. Seventy-nine streams were selected for intensive monitoring based on the preliminary analysis (Figure 9, Table 1). Intensive monitoring included water, biological, full habitat assessments, and land use observations. Water samples were collected at evenly spaced time intervals to avoid bias against poor weather conditions.

• Table 13. **Intensive Monitoring Details for the East of I-35 Project.**

Sampling duration	2 years	Parameters Measured	
Number of sites	79	Nitrate-Nitrogen Nitrite-Nitrogen Ammonia-Nitrogen Kjeldahl-Nitrogen Orthophosphate Total-Phosphorus Chloride Sulfate Fecal-Coliform Bacteria E. Coli Enterococcus Total Suspended Solids Temperature, water & air	Total Hardness Alkalinity pH Instantaneous Discharge Specific Conductance Dissolved Oxygen, absolute & % saturation Turbidity Toxic Metals & Pesticides if Biotic Collections Indicate Potential Problems
Sampling frequency			
Water samples	10/year/site, evenly spaced		
Fish Collection	1/site		
Macroinvertebrate (aquatic insect) collection	2 summer and 2 winter collections/site		
Aquatic Habitat Assessment	1/site plus repeats for quality assurance purposes on selected streams		



• Figure 9. **Initial Short Habitat and Water Quality Assessment Sites for Data Gaps Projects.**

West of I-35 Data Gaps Study - Western half of the state

Based on a one-time site visit, initial habitat and water quality analyses have been completed on 605 streams in the western half of the state (Figure 9). From the results of that survey, 79 stream sites were selected for intensive monitoring that began in March of 2000 (Figure 8). This project is identical in design and rationale to the East of I-35 Data Gaps Study. This study will collect data to fill existing regional data gaps in the western half of the state. Sampling consists of water, biological, and habitat collections, along with land use observations (Table 14). Like the East of I-35 Project, preliminary short habitat assessments were completed on over 600 sites to select the 79 final sites intensively sampled in this project.

• Table 14. **Intensive Monitoring Details for West of I-35 Project.**

Sampling Duration	2 years	Parameters Measured	
Number of sites	79	Nitrate-Nitrogen	Alkalinity
Sampling Frequency		Nitrite-Nitrogen	Total Suspended Solids
Water samples	10/year/site, evenly spaced	Ammonia-Nitrogen	Temperature, water & air
		Kjeldahl-Nitrogen	pH
Fish Collection	1/site	Orthophosphate	Instantaneous Discharge
Macroinvertebrate collection	4/site	Total-Phosphorus	Specific Conductance
		Chloride	Dissolved Oxygen, absolute & % saturation
Aquatic Habitat Assessment	1/site plus repeats on selected streams for quality assurance	Sulfate	Turbidity
		Total-Hardness	Toxic metals & pesticides if biotic collections indicate potential problems
		Fecal-Coliform Bacteria	
		E. Coli	
		Enterococcus	

Other Ambient Monitoring

Honey Creek & Cave Springs Branch - Delaware County

The OCCWQ Division has also been conducting sampling in Honey Creek and Cave Springs Branch, at the request of the Cherokee Nation. The purpose of this monitoring is to obtain data on the health of this system. The Cherokee Nation is interested in not only water quality samples, but also biological and habitat information (Table 15).

• Table 15. **Sampling Details for Honey Creek & Cave Springs Branch Project.**

Sampling duration	once	Parameters Measured	
Number of sites	6	$CBOD_5$	Fecal-Coliform Bacteria
		Nitrate-Nitrogen	Total Suspended Solids
Sampling Frequency		Nitrite-Nitrogen	Temperature, water & air
Water samples		Ammonia-Nitrogen	Alkalinity
		Kjeldahl-Nitrogen	pH
		Orthophosphate	Instantaneous Discharge
		Total-Phosphorus	Specific Conductance
		Chloride	Dissolved Oxygen, absolute & % saturation
		Sulfate	
		Total-Hardness	Turbidity

Fish Collection	1/site		
Macroinvertebrate Collection	1/site		
Aquatic Habitat Assessment	1/site		

Grand Lake Watershed: Phase II Monitoring - Southeast Kansas & Southwest Missouri

The OCCWQ has been addressing the eutrophication of Grand Lake for several years. This project was a cooperative effort between the States of Kansas, Oklahoma, Arkansas, and Missouri, and EPA Regions VI and VII. The first stage of the program consisted of the development of a watershed model that was used to prioritize the major sub-basins of the reservoir for treatment. No new data were collected during this phase. During the next phase, data was collected in the priority sub-basins that were previously identified. This data (Table 16) will be used to predict relative contributions from the various basins. The primary water quality problem identified in the lake was excess nutrient loading. Data collection centered on nutrients and related compounds. The states of Kansas and Missouri requested analysis of samples for Atrazine and metals to help meet some of their data requirements.

- Table 16. **Sampling Details for Grand Lake Watershed Project.**

Sampling duration	2 yrs	Parameters Measured		
Number of sites (Figure 1)	28	Nitrate+Nitrite-Nitrogen Ammonia-Nitrogen Kjeldahl-Nitrogen Orthophosphate Total-Phosphorus Chloride Sulfate Total Hardness PH	Enterrococcus E. coli BOD_5 COD Atrazine Lead Copper Zinc Cadmium Alkalinity	Temperature, water & air Fecal-Coliform Bacteria Instantaneous Discharge Specific Conductance Dissolved Oxygen, absolute & % saturation Turbidity Total Suspended Solids Volatile Suspended Solids
Sampling Frequency				
Water samples	6/year/site, evenly spaced			

Fluvial Geomorphological Assessments - Statewide

Fluvial geomorphological monitoring measures the physical dimensions and hydraulics of a stream. By studying the form and relationship of streams to their watershed and climate, a reference database can be compiled that explains the physical dimensions of the stream, the amount of bank material eroding naturally, the nature of substrate materials, and how to repair channels that are not stable. Over 60 fluvial geomorphological assessments were performed in 1999 across the state.

National Study on Chemical Residue in Lake Fish - Tissue Collections

The OCCWQ collected data in 2000 to help the EPA monitor distribution of chemical residues in fish flesh. The OCCWQ collected fish tissue during the fall and winter of 2000 in two randomly selected ponds in McClain and Osage counties. Fish were collected, preserved, and sent to the EPA laboratory. This task was part of the EPA's "National Study of Chemical Residue in Lake Fish Tissue."

OCCWQ Volunteer Monitoring- Ambient Monitoring

Oklahoma City Blue Thumb - Oklahoma City Metropolitan Area

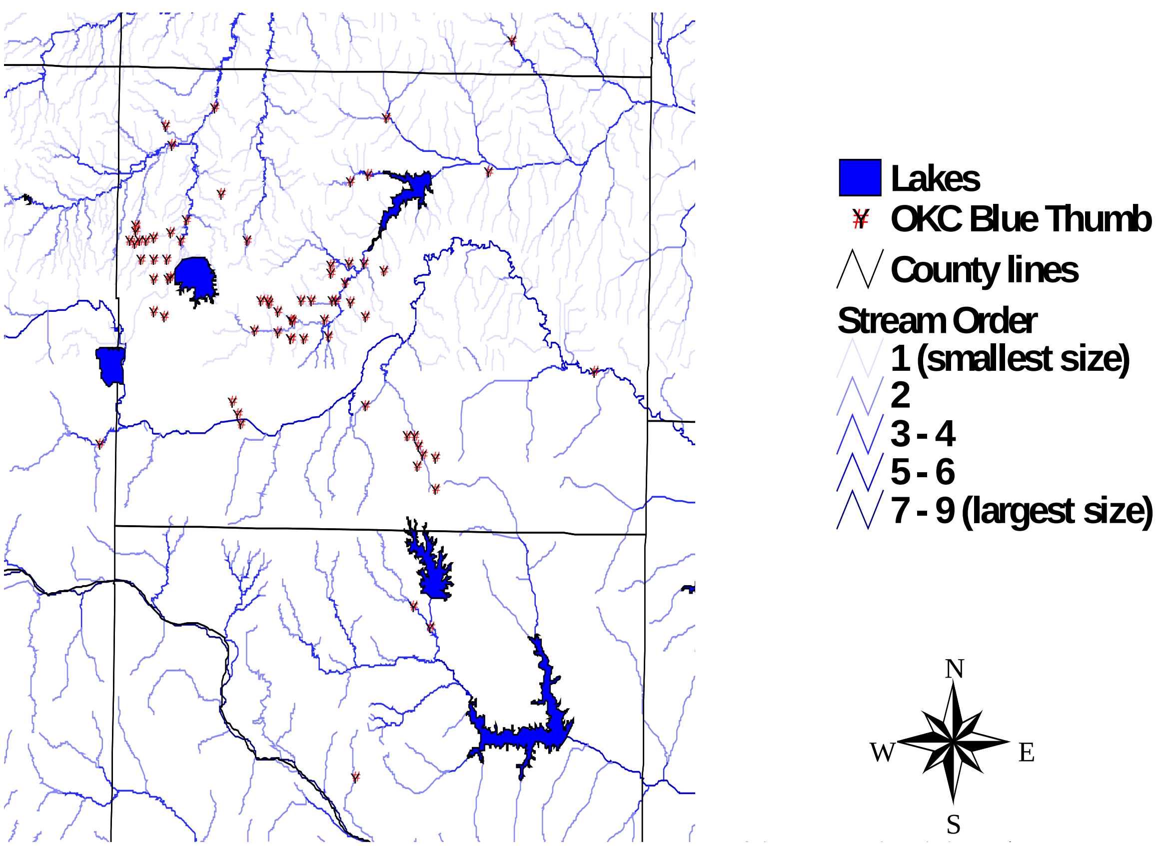
The mission of the Oklahoma City Blue Thumb Program is water quality education. OKC Blue Thumb conducts three major monitoring programs. In two programs, the Home-Assist Program and the Oklahoma City Sub-Watershed Inventory, trained professional staffs collect the samples. The third monitoring activity is the volunteer monitoring program where trained volunteers collect monthly water quality data and professional staff collects benthic invertebrates, fish and perform aquatic habitat evaluations (Figure 10 and Tables 17 & 18). The staff also collects samples for pesticide and Fecal Coliform bacterial analysis at the volunteer monitored sites. Data are then interpreted and given to the volunteers. The volunteers use this information, along with the knowledge they gain from monitoring, to educate landowners, businesses, school children, and other groups about water quality related issues.

• Table 17. **OKC Blue Thumb Monitoring Conducted by Staff.**

Home-a-Syst Wellhead Protection Program			
Sampling duration	indefinite	Parameters Measured	
Number of sites	Over 250	Nitrate-Nitrogen	Alkalinity
Water sampling frequency	once per home	Fecal-Coliform Bacteria Temperature, water	pH Specific Conductance
Oklahoma City Sub-Watershed Inventory			
Sampling duration	Indefinite	Parameters Measured	
Number of sites	79	Water Temperature Instantaneous Discharge	
Sampling frequency	Once/site		
Fish Collection	1/site		
Macroinvertebrate collection	1/site		
Aquatic Habitat Assessment	1/site		

• Table 18. **OKC Blue Thumb Oklahoma City Area Volunteer Monitoring Program.**

Sampling duration	Indefinite	Parameters Measured
Number of sites	8	Nitrate-Nitrogen Ammonia Nitrogen Orthophosphate Chloride Fecal-Coliform Bacteria Temperature, water & air pH Dissolved Oxygen, absolute & % saturation Secchi Disk Transparency Chlorpyrifos
Sampling Frequency		
Water samples	12/year/site, evenly spaced	
Fish Collection	1/site every 3rd year	
Macroinvertebrate collection	2/site yearly	
Aquatic Habitat Assessment	1/site every 3rd year	



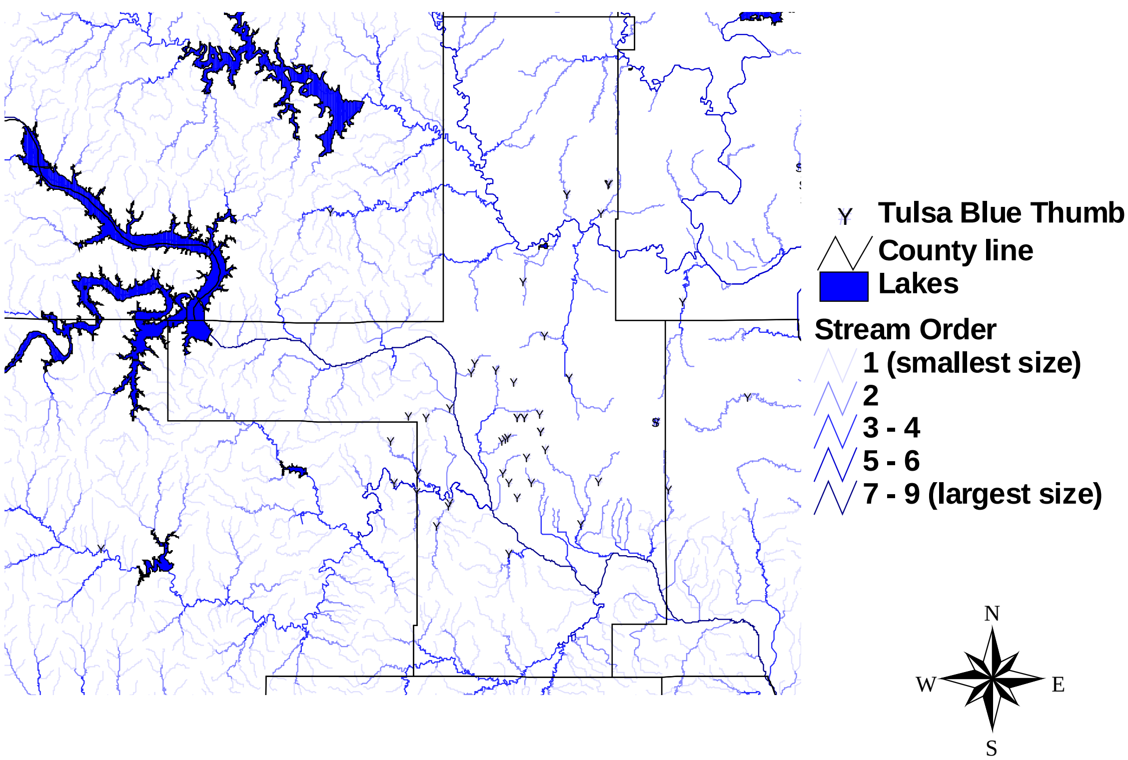
• Figure 10. **OKC Blue Thumb Program Monitoring Sites in the Oklahoma City Area.**

Tulsa Blue Thumb - Tulsa Metropolitan Area

The principle activity of the Tulsa Blue Thumb program is volunteer monitoring. Trained volunteers collect monthly water quality data. Professional staffs collect benthic invertebrates and fish and perform aquatic habitat evaluations with volunteer assistance. The staff also collects samples for pesticide and Fecal-Coliform bacterial analysis. Data are then interpreted and given to the volunteers who use it to give presentations to area schools and other groups on different aspects of water quality. Settleable solids samples are collected during runoff events for complaint investigation and for educational purposes. Current sites administered by the Tulsa Blue Thumb program are in Creek, Rogers, Osage and Tulsa Counties (Table 19 & Figure 11).

• Table 19. **Tulsa Blue Thumb Sampling Program.**

Duration of sampling	Indefinite	Parameters Measured	
Number of sites	27 active, 24 inactive	Nitrate-Nitrogen Ammonia-Nitrogen Orthophosphate Chloride Fecal-Coliform Bacteria pH Settleable Solids	Dissolved Oxygen, absolute & % saturation Secchi Disk Transparency Temperature, air & water Chlorpyrifos
Sampling frequency			
Water samples	12/year/site, evenly spaced		
Settleable Solids	during runoff events		
Fish Collection	1/site every 3rd year		
Macroinvertebrate collection	2/site yearly		
Habitat Assessment	1/site every 3rd year		



• Figure 11. **Tulsa Blue Thumb Volunteer Monitoring Sites in the Tulsa Vicinity.**

Statewide Blue Thumb

The monitoring activity of the Statewide Blue Thumb program is also volunteer monitoring. Data collection and educational activities are conducted as previously described for the Tulsa Blue Thumb Program. There are currently active programs in Cherokee, Delaware, Hughes, Latimer and Pottawatomie Counties (Table 20 and Figure 8). Programs in LeFlore and Okmulgee Counties began sampling early in 2000.

• Table 20. **Statewide Blue Thumb Sampling Program.**

Duration of sampling	Indefinite	Parameters Measured	
Number of sites	15	Nitrate-Nitrogen Ammonia-Nitrogen Orthophosphate Chloride Fecal-Coliform Bacteria pH Temperature, air & water	Dissolved Oxygen, absolute & % saturation Secchi Disk Transparency Chloropyrifos
Sampling frequency			
Water samples	12/year/site, evenly spaced		
Settleable Solids	during runoff events		
Fish Collection	1/site every 3rd year		
Macroinvertebrate collection	2/site yearly		
Habitat Assessment	1/site every 3rd year		

TMDL Monitoring

Dog Creek TMDL – Roger County

The Dog Creek TMDL study was initiated because of problems with low dissolved oxygen in Dog Creek below the City of Claremore's wastewater treatment plant discharge (Table 21). All sources of oxygen demanding pollutants must be identified before any one contributor can be asked to reduce their load to the stream to meet the allowable level defined in the TMDL. This project will identify all significant contributors and then Oklahoma Department of Environmental Quality (ODEQ) and the Indian Nations Council of Governments (INCOG) will proceed with completion of the TMDL.

• Table 21. **Sampling Details for Dog Creek TMDL Project.**

Sampling duration	2 years	Parameters Measured	
Number of sites	9 (Figure 1)	$CBOD_{20}$ $CBOD_5$ Nitrate-Nitrogen Nitrite-Nitrogen Ammonia-Nitrogen Kjeldahl-Nitrogen Orthophosphate Total-Phosphorus Chloride Sulfate Total-Hardness	Fecal-Coliform Bacteria Tot. Suspended Solids Temperature, water & air Alkalinity pH Instantaneous Discharge Specific Conductance Dissolved Oxygen, absolute & % saturation Turbidity Chlorophyll-a Periphyton Chlorophyll-a
Sampling Frequency			
Water samples	12/year/site, evenly spaced at 5 core sites and 4/year evenly spaced at remaining 4 sites		
Fish Collection	1/site		
Macroinvertebrate collection	4/site		
Habitat Assessment	1/site		

Poteau River Watershed Monitoring - LeFlore County

OCCWQ intensively monitored the Poteau River for two 24-hour periods at both high flow and summer low flow conditions. These activities occurred once in the summer of 1998 and once in the winter of 1999 (Figure 8). Data collected included physical and chemical water quality measurements related to excess nutrients and low dissolved oxygen in the Poteau River. Data were used to assist the Agricultural Research Service in developing water quality models. Monitoring is completed and the model is currently being tested. This model will be used by the ODEQ to develop the TMDL and by others to assist in planning implementation for the TMDL.

Little Deep Fork - Creek County

This project was initiated due to reported water quality problems by the Cities of Depew and Bristow. These problems were reported to be occurring upstream of their discharges. These towns are having trouble meeting their discharge permit requirements; therefore, a TMDL is necessary to determine whether treatment plant upgrades are necessary. The goal of monitoring was to determine if there were significant nutrient and BOD contributing areas upstream of the two towns. If these areas existed, then the economics of point source and nonpoint source treatments needed to be analyzed. Monitoring centered on monthly nutrient sampling at seven sites (Figure 8). A habitat assessment was completed for the entire length of the stream to determine the quality of the habitat and interpret whether the stream habitat could be contributing to water quality problems. Land use for the entire watershed was mapped in detail so that a model could be developed to estimate nutrient contribution to the stream from different fields.

Nutrient Trading for North Canadian River TMDL - Oklahoma, Pottawatomie, & Canadian Counties

The North Canadian River was monitored by the OCCWQ intensively for 24 hours (Figure 8) during the summer of 1998 to assist the Association of Central Oklahoma Governments (ACOG) in performing a TMDL for the Oklahoma City Metropolitan Area. The goal was to identify upstream nutrient contributors and then develop a scheme whereby cities can pay the cost of treating upstream sources. Treatment of upstream sources would allow cities to discharge more nutrients, which could reduce the cost of their wastewater treatment.

Implementation Monitoring

Beaty Creek Demonstration Project - Delaware County, Oklahoma & Benton County, Arkansas

The Beaty Creek Demonstration project was initiated in response to water quality problems in Lake Eucha. Landowners and agricultural producers in the watershed are being encouraged to adopt best management practices (BMP's) to control runoff of phosphorus into Beaty Creek and Lake Eucha. Monitoring is designed to show the effectiveness of BMP implementation (Table 22).

A site in the National Air Deposition Program (NADP) has been installed in the Lake Eucha watershed to account for air (or rain) deposition of nutrients. The NADP program is a nationwide network of precipitation monitoring sites. The network is a cooperative effort between many different groups including Agricultural Experiment Stations, U.S. Geological Survey, U.S. Department of Agriculture, and numerous other governmental and private entities. The NADP network currently has over 200 sites across the US. The Beaty Creek site is one of four in Oklahoma. The air deposition data from this site is used not only for the Beaty Creek study, but also in nation-wide studies of loadings due to air deposition.

• Table 22. **Sampling Details for Beaty Creek Project.**

<table>
<tr><td>Sampling duration</td><td>5 years</td><td>Parameters Measured</td></tr>
<tr><td>Number of stream sites</td><td>5 (Figure 1)</td><td rowspan="11">Nitrate-Nitrogen
Nitrite-Nitrogen
Ammonia-Nitrogen
Kjeldahl-Nitrogen
Orthophosphate
Total-Phosphorus
Chloride
Sulfate
Total-Hardness
Fecal-Coliform Bacteria
Enterrococcus
E. coli
Chlorophyll-a
Periphyton chlorophyll-a
Total Suspended Solids
Temperature, water & air
Alkalinity
pH
Instantaneous Discharge
Specific Conductance
Dissolved Oxygen, absolute & % saturation
Turbidity</td></tr>
<tr><td>Number of air sites</td><td>1</td></tr>
<tr><td colspan="2">Sampling Frequency</td></tr>
<tr><td>Water samples</td><td>Flow weighted, drawn every ½ hour, composited once/week at 2 core sites. 12/year spaced evenly at 3 sites</td></tr>
<tr><td>Fish Collection</td><td>2/site; once each in 1st & 5th years</td></tr>
<tr><td>Macroinvertebrate collection</td><td>2/year/site</td></tr>
<tr><td>Periphyton chlorophyll-a</td><td>3/year/site</td></tr>
<tr><td>Aquatic Habitat Assessment</td><td>2/site; once each in 1st & 5th years</td></tr>
<tr><td>Habitat & Riparian Assessment of Entire Stream</td><td>1st & 5th years</td></tr>
<tr><td>Bank Erosion Rates</td><td>1st, 3rd & 5th years at each site</td></tr>
<tr><td>Air Deposition Site</td><td>weekly</td><td></td></tr>
</table>

Turkey Creek - Kingfisher, Major, Alfalfa & Garfield Counties

Multiple state and federal agencies are cooperating to address water quality problems in the Turkey Creek Watershed in North-central Oklahoma. The Turkey Creek Basin was selected for monitoring and demonstration of best management practices due to concerns raised by OSU Cooperative Extension about excess nutrients in the watershed. The watershed receives no point source discharges, as all of the wastewater treatment plants are total retention facilities. Therefore, the majority of the contaminants stem from various nonpoint sources. Monitoring activities focused on nutrients and fecal bacteria. The OCCWQ monitored six surface water sites 1998-1999 (Figure 8). Implementation planning is currently underway by the OCCWQ, Conservation Districts, NRCS, and other relevant groups.

The US Geological Survey (USGS) and the Oklahoma Department of Environmental Quality (ODEQ) are also conducting substantial monitoring in the watershed. The USGS is monitoring surface waters and wells in the Turkey Creek Basin for nitrogen isotopes, bacteria, wastewater indicator organic compounds, and discharge measurements. The purpose of this monitoring is to pinpoint the sources of contaminants in the watershed. Monitoring for contaminants that are specific to sources (such using caffeine from human waste as an indicator of septic tank sources) is one of the best ways to verify and differentiate between different sources of pollution. The ODEQ is monitoring drinking water wells in the watershed as part of their wellhead and source water protection program. Not only is the water quality of the well water tested, but the integrity of the well casing is inspected, an inventory of the surrounding area for potential sources of contamination is completed, and well owners and users are educated about wellhead protection. Monitoring efforts in the Turkey Creek Watershed were coordinated to avoid duplication of efforts and optimize use of resources.

Lake Creek - Caddo County

Lake Creek and its surrounding watershed were monitored in 1998-1990 due to pesticide and toxicity concerns. The shallow groundwater in the area is believed to be highly susceptible to contamination. Toxicity was identified as an issue in an earlier project conducted by the OCCWQ. Lake Creek was monitored for approximately eighteen months to answer the following questions.

- → What are the ambient conditions of the surface and seep water?
- → Is there still toxicity in Lake Creek?
- → If so, what is the cause of the toxicity?
- → What is the source of the toxicity?

Monitoring was completed in October of 1999, and centered on pesticides. Five surface water sites were monitored for fourteen months (Figure 8). Twenty-four groundwater sites were monitored for ten months. Best management practices have been put into place including riparian corridor fencing, grade stabilization structure placement, pond construction, critical area plantings, diversion terraces, and management agreements (deferred grazing, rotational grazing, etc.).

Paired Watershed Project (Peacheater Creek) - Adair County

Peacheater Creek is one of twenty projects selected as a National Monitoring Demonstration Project. Serious nutrient problems were previously identified in this stream, and OCCWQ had committed funds to implement nutrient control BMP's in the watershed. The nutrient of concern is phosphorus. Nitrogen and bank erosion are secondary concerns. Due to financial and time constraints, it is often difficult to statistically prove the effectiveness of BMP implementation. However, for this project, the National Monitoring Project funded the extra monitoring necessary to achieve this end. Two primary sites were sampled weekly for four months a year and monthly for the rest of the year. Bank erosion rates and the nutrient contribution of soil in eroding banks were measured twice (10 sites -Figure 8). Landuse of the entire watershed was mapped in detail so that an overland flow model could be run to estimate nutrient contribution to the stream from different fields. The pre-implementation and calibration monitoring is completed and implementation of BMP's is underway. Monitoring will resume when BMP installation is complete.

Acid Mine Drainage Monitoring – Latimer and Pittsburg Counties

A cooperative effort between the Abandoned Mine Land Program and the Office of Surface Mining has been developed to address water quality impairment associated with Oklahoma's coal mining industry. The OCCWQ conducts significant monitoring to support demonstration of best management practices to control acid mine drainage. OCCWQ monitored several sites in eastern Oklahoma to assess the effectiveness of control measures. OCCWQ also monitored streams in the Lake Eufaula watershed to help pinpoint seeps and the impacts of those seeps on stream water quality. This monitoring will lay the groundwork for future remediation efforts.

Monitoring to Protect Endangered Species

Twin Cave – Delaware County

The Twin Cave project was initiated in conjunction with The Nature Conservancy to protect the environment of the Ozark Gray Bat, the Ozark Cave Fish, the cave crayfish, and several other sensitive species. Brominated hydrocarbons have been detected in the cave stream and it is believed that these chemicals or others associated with them may poison fauna living in the cave. Water in the project area has been tested for acute and chronic toxicity to aquatic organisms and for the presence of conventional pollutants (Table 23). Water in the cave and runoff water in the watershed are currently being tested for priority pollutants.

• Table 23. **Sampling Details for Twin Cave Project.**

<table>
<tr><td>Sampling duration</td><td>2 years</td><td colspan="2">Parameters Measured</td></tr>
<tr><td>Number of sites</td><td>3 in cave, up to 5 watershed sites</td><td rowspan="5">Nitrate-Nitrogen
Nitrite-Nitrogen
Ammonia-Nitrogen
Kjeldahl-Nitrogen
Orthophosphate
Total-Phosphorus
Chloride
Sulfate
Total-Hardness
Fecal-Coliform Bacteria</td><td rowspan="5">Total Suspended Solids
Temperature, water & air
Alkalinity
pH
Specific Conductance
Instantaneous Discharge
Dissolved Oxygen, absolute & % saturation
Turbidity
Priority pollutants- volatile and semi-volatile organics, pesticides, PCBs, and metals</td></tr>
<tr><td colspan="2">Sampling Frequency</td></tr>
<tr><td colspan="2">Cave Water samples</td></tr>
<tr><td>Cave water samples</td><td>5/year/site, evenly spaced</td></tr>
<tr><td>Watershed samples</td><td>up to 5/site depending on occurrence of rain</td></tr>
</table>

CHAPTER

3

Water Quality Monitoring Programs at the Oklahoma Department of Environmental Quality

Introduction

The Department of Environmental Quality (DEQ) conducts a number of surface and ground water quality monitoring activities through its Water Quality, Customer Services, and Land Protection Divisions:

Water Quality Division (WQD)

- Background Level Monitoring of Receiving Water for Certain Municipal and Industrial Point Source Discharges
- Total Maximum Daily Load (TMDL) Monitoring Activities
- Public Water Supply Monitoring Program for Drinking Water
- Honey Creek/Cave Springs Branch Water Quality Monitoring
- Fish Kill Investigations

Customer Services Division (CSD)

- Toxics and Reservoirs Program (Rotating Fish Flesh Toxics Sampling in Lakes)
- Fish Community Biotrend Monitoring

Land Protection Division (LPD)

- Solid Waste Groundwater Monitoring Program
- Hazardous Waste Permitting and Corrective Actions (RCRA)

- Underground Injection Control (UIC)
- Radiation Management Program
- Brownfields Voluntary Redevelopment and Superfund Program

The DEQ performs a portion of the monitoring related to these activities through the CSD's State Environmental Laboratory (SEL). Local councils of government, such as INCOG in the Tulsa area and ACOG in the Oklahoma City area, also perform some of this water quality monitoring related to their area of service (particularly that related to TMDL studies) and submit the information to the DEQ for review and further processing. On an as-needed basis, the WQD may conduct water quality monitoring related to complaint investigations, fish kill investigations, or in areas of special interest. The WQD and WMD also require surface and ground water quality monitoring to be performed by the regulated community through several of the above-listed regulatory programs.

Definitions and Abbreviations

- BOD_5 means five-day biochemical oxygen demand (a measure of oxygen-demanding organic matter in water).
- BTEX means benzene, toluene, ethyl benzene and xylene.
- CERCLA means the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (see also SARA).
- CWS means Community Water System, i.e., any public water supply system which serves at least 15 service connections used by year-round residents or regularly serves 25 year-round residents.
- COD means chemical oxygen demand (a measure of chemically-driven oxygen demand in water).
- CPP means the Continuing Planning Process document published by the DEQ.
- CWA means the Clean Water Act of 1972 and amendments thereto.
- FDA means the U.S. Food and Drug Administration.
- NPDES means the National Pollutant Discharge Elimination System, established under Section 402 of the CWA and implemented through 40 CFR 122 – 125.
- NCWS means Non-Community Water System, i.e., any public water supply system which serves an average of at least 25 individuals at least 60 days per year but is neither a CWS nor a NTNCWS.
- NTNCWS means Non-Transient Non-Community Water System, i.e., any public water supply system that is not a community water system and that regularly serves at least 25 of the same people over 6 months per year.
- OPDES Act means the Oklahoma Pollutant Discharge Elimination System Act, 27A O.S. §2-6-201 *et seq.*

- ODWC means the Oklahoma Department of Wildlife Conservation.
- OSDH means the Oklahoma State Department of Health.
- OWQS means the Oklahoma Water Quality Standards promulgated by the OWRB in OAC 785:45.
- OWQS Implementation Criteria means the various criteria promulgated by the OWRB in OAC 785:46 to implement the OWQS.
- OWRB means the Oklahoma Water Resources Board.
- POE means point of entry into a public water supply distribution system.
- RCRA means the Resource Conservation and Recovery Act.
- SARA means the Superfund Amendments and Reauthorization Act of 1986 (see also CERCLA).
- SEL means the DEQ's State Environmental Laboratory.
- SVOC means semi-volatile organic compounds.
- TMDL means Total Maximum Daily Load.
- TOC total organic carbon.
- TPH means total petroleum hydrocarbons.
- UIC means Underground Injection Control.
- VOC means volatile organic compounds.
- WWTP means wastewater treatment plant.

Background Level Monitoring of Receiving Water for Point Source Discharges

Introduction

The WQD's PDES Permitting Section monitors Ambient, or "background," pollutant levels in selected receiving waters through the permitting of municipal and industrial point source discharges. Point source discharge permits are issued in accordance with the NPDES permitting program. The NPDES permitting program for the State of Oklahoma (except for certain categories of agricultural facilities under the jurisdiction of the Oklahoma Department of Agriculture and certain oil and gas production, transport and storage facilities under the jurisdiction of the Oklahoma Corporation Commission) was delegated by EPA Region 6 to the DEQ in November, 1996. The program is administered by the WQD under the authority of the OPDES Act and DEQ promulgated rules.

For permitting purposes, background concentrations are caused by sources upstream of permitted discharges. The upstream sources may be either point or nonpoint. Nonpoint sources may be either natural or anthropogenic. OAC 785:46-5-9 requires that background levels be considered in the permitting of point source discharges, but not all discharge permitting situations will require background monitoring. Where reasonable potential is demonstrated for a discharge to exceed numerical water quality criteria, background levels must be accounted for in wasteload allocations because the receiving water's assimilation capacity decreases as the background level increases.

Program Objectives

- To provide current and defensible background level data.
- To provide representative pollutant background levels for determining whether there is reasonable potential for point source discharges to exceed applicable OWQS numerical criteria.
- To account for pollutant background levels in the wasteload allocation process where reasonable potential to exceed a numerical criterion is determined to exist.

Program Description

Background monitoring is performed by the regulated community, both municipalities and industries, through monitoring requirements established in their OPDES permits.

Monitoring Requirements

Background monitoring is most often required for priority pollutants with relatively low water quality numerical criteria (re: OWQS, Subchapter 5). Samples collected for the purpose of establishing background levels must be collected as close to low flow conditions in the receiving water as possible. At least twelve sample concentrations are required to determine the background concentration. Hardness and/or pH must be obtained along with background levels if the water quality criterion for any of the pollutants under observation is hardness- or pH-dependent. Unless the information is already available, permittees are also required to monitor and report effluent levels of the same pollutants for which background monitoring is required in their OPDES permits over the same period of time. The facilities that are currently required to perform background monitoring, their receiving waters and the pollutants which they are required to monitor are shown in Table 24.

Monitoring Locations

Background monitoring must be performed at a location that is representative of the receiving water, but unaffected by the discharge being permitted. For streams, this location is typically only a short distance upstream from the permitted discharge. For lakes, samples are collected at a point outside the regulatory mixing zone, which extends 100 feet in any direction from the source. Background monitoring is normally site-specific. Where several discharging facilities may be clustered together in a short segment of a receiving water, a single background monitoring site may apply to all the facilities since effluent values of the monitored parameters may be easily used to adjust the background level for the next downstream discharger.

Data Evaluation

When at least twelve data points are available, the background level for each pollutant under observation is determined by computing the geometric mean of all available data points. Hardness and/or pH data, if applicable, is determined in the same manner, so that the hardness or pH-dependent numerical criterion may be determined based on site-specific data.

Actions Taken or Prescribed

Once the background level of a pollutant at a specific location is obtained, the permit writer redetermines whether there is reasonable potential to exceed the numerical criteria for that pollutant for all applicable beneficial uses. If necessary, an OPDES permit is reopened to establish a new effluent limitation, or modify an existing one, based on the results of the background monitoring. In cases where background monitoring for a pollutant shows a background level to be equal to or higher than a numerical criterion, the wasteload allocation for that pollutant is set equal to the numerical criterion in accordance with OAC 785:46-5-4 or 785:46-7-4 and permit limitations are computed.

Time Lines

The time line for background monitoring at a specific location is normally tied to the effective date of an OPDES permit. Thus, background monitoring is an ongoing process rather than one performed statewide over a common period of time at all locations. In order to meet the requirement for at least twelve samples, facilities are normally required to sample monthly for a period of one year, although monitoring may be specified over a longer time period, e.g., quarterly for a period of three years.

Total Maximum Daily Load (TMDL) Monitoring Activities

Introduction

Section 303(d) of the CWA requires that waters of the state that are not currently achieving the beneficial use classification contained in the OWQS, after implementation of prescribed technology-based controls has been shown to be inadequate, be listed on the state's "303(d) list." As a result of this listing the CWA also requires that a TMDL be established for each pollutant category (cause) for each listed water. A TMDL, simply stated, is the amount of a specific pollutant that may be discharged into a waterbody and still meet numeric and narrative water quality criteria. Development of a TMDL consists generally of five activities:

- Selection of pollutant(s) or stressor(s) to be considered. This is generally derived from the listed cause(s) on the 303(d) list.
- Estimation of the waterbody's assimilative capacity.
- Estimation of the pollution load from all sources, both point and nonpoint.
- Analysis of the pollution.
- Establishing the allowable TMDL.

In order to complete a TMDL for a listed water, reliable water quality data are necessary to establish both the current and allowable pollutant loading. This usually requires that water quality monitoring be conducted because reliable historical water quality data in the state are very limited.

Program Objectives

- To obtain reliable water quality information on each waterbody selected for study via the priority-ranked 303(d) list.
- To develop a TMDL that will ensure the quality of listed waters will be protective of its designated beneficial use(s).

• Table 24. **OPDES Permit-Related Background Monitoring in Oklahoma**

County	Permitted Facility	Receiving Water Monitored	Pollutant Monitored																			
			Arsenic	Cadmium [a]	Chromium	Copper [a]	Lead [a]	Mercury	Nickel [a]	Selenium	Silver [a]	Thallium	Zinc [a]	Cyanide	Total Phenols	Dichlorobromomethane	Bis (2-ethylhexyl) phthalate	Di-n-butyl phthalate	alpha-Endosulfan	Lindane	Gamma-BHC	Heptachlor
Caddo	Public Svc. Co. of Oklahoma (Southwestern Stn-Anadarko)	Washita River	X				X						X									
Choctaw	Western Farmers Elec. Coop (Hugo)	Red River												X								
Garfield	Farmland Industries (Enid)	Skeleton Creek						X			X		X									
Garvin	Wynnewood Refining Co.	Washita River	X		X		X						X									
Grady	Chickasha Municipal Authority	Washita River	X	X	X	X	X	X	X	X	X		X	X								
Kay	City of Ponca City	Arkansas River	X											X							X	
	Conoco Refinery (Ponca City)	Arkansas River					X							X								
Muskogee	Fansteel (Muskogee)	Arkansas River	X	X	X	X	X		X				X									
	Ft. Gibson Util Auth.	Grand Neosho River					X						X		X							
	Ft. James Operating Co.	Arkansas River		X		X	X						X	X								
	Oklahoma Gas and Electric (Muskogee Stn.)	Arkansas River				X							X									
Oklahoma	City of Del City	North Canadian River	X	X	X					X	X	X	X						X	X		
	City of Oklahoma City - N. Canadian Plant	North Canadian River			X	X		X					X		X							
Pittsburg	City of McAlester - West Plant	Sandy Creek								X				X							X	X
	McAlester Army Ammunition Plant	Bull Creek				X	X						X									
Pottawatomie	Shawnee Municipal Authority - North Plant	North Canadian River		X	X	X	X	X			X	X	X									
	Shawnee Municipal Authority - South Plant	North Canadian River		X		X	X	X		X	X	X	X						X			
Seminole	Oklahoma Gas and Electric - Seminole Stn.	Lake Konawa				X																
Tulsa	Baker Performance Chem. (Sand Springs)	Arkansas River	X										X		X							
	City of Sand Springs (Main Plant)	Arkansas River		X					X			X	X									
	Tulsa MUA - (South Plant)	Arkansas River					X			X	X		X		X							
	Tulsa MUA (Lower Bird Creek Plant)	Bird Creek												X				X				
Washington	City of Bartlesville (Plant #1)	Caney River	X									X		X		X	X					

[a] Pollutant's aquatic toxicity numerical criteria are hardness-dependent.

Program Description

An initial site inspection is performed before initiation of data collection activities to address environmental and logistical problems likely to be encountered at the site. The problem to be addressed can be clearly identified at this stage, and relevant parameters determined. The prime objective of the initial site inspection is to collect as much information as possible about the site and the surrounding area that might impact the site. Any information that will help in better understanding the system being studied is considered. Other state agencies are notified, if necessary, depending on the nature of the individual project. Stream and lake data gathered through the OWRB's BUMP program (see Chapter 1), where available, is a valuable resource. In addition, local councils of government, such as INCOG in the Tulsa area and ACOG in the Oklahoma City area, sometimes participate in TMDL monitoring and analysis activities. The DEQ has scheduled the streams shown in Table 25 for monitoring activity and TMDL development.

Monitoring Requirements

Time of travel studies are conducted at the site to determine flow rates and velocities. Routine sampling is conducted at each monitoring location (see below) to determine a base flow condition. Routine sampling for most parameters is generally performed on a monthly basis. More intensive, short-term studies for dissolved oxygen problems may also be performed. Sampling in such cases is performed two to four times in a 24-hour period, the total sampling period lasting 24 hours. The parametric coverage includes the constituents causing the impairment of the waterbody's beneficial use(s) and grab samples for flow, dissolved oxygen, temperature, pH, and specific conductivity. Composite samples are generally collected for the 24-hour period from any stormdrains or tributaries known or seen to be discharging. Other parameters, including inorganics, organics and/or heavy metals, may require special sampling consideration. Habitat modification may also require assessment. Wet weather sampling is conducted after storm events, as necessary, to quantify the nonpoint source contribution to the waterbody's impairment. Parametric coverage is generally the same as for base flow monitoring.

Monitoring Locations

Site-specific sampling plans are developed jointly by the field personnel and the engineer responsible for modeling. Sample sites, by necessity, are selected considering accessibility to the sites, significance of data, and anything else gleaned from the initial site inspection that may be relevant to the outcome of the study. Sampling plans are developed which include the proposed sites and the analyses to be conducted for each site.

Data Evaluation

The monitoring data collected is evaluated to determine:

- The waterbody's assimilative capacity.
- The pollution load from all sources, both point and nonpoint.

Actions Taken or Prescribed

The allowable TMDL is established by summing point source loadings and nonpoint source loadings, allowing for a margin of safety, which will allow the waterbody to meet applicable water quality criteria.

Time Lines

TMDL studies are an ongoing process dictated by the priority-ranked 303(d) list. Duration of monitoring is project-specific and is generally determined by project logistics.

• Table 25. **Streams scheduled for TMDL activities.**

Waterbody	303(d) Cause Listing	Program Funding
Kiamichi River	Nutrients, noxious aquatic plants, pH and suspended solids	106 Grant
Little River	Pesticides	106 Grant
Blue River	Nutrients, noxious aquatic plants and suspended solids	106 Grant
Washita River	Pesticides, nutrients, siltation, salinity, and suspended	106 Grant

Public Water Supply Monitoring Program for Drinking Water

Introduction

The WQD's Public Water Supply (PWS) Section operates a monitoring program for public water supply systems which have surface or groundwater sources. These public water supply systems fall into three categories (as defined in the introduction to this chapter):

- Community water system (CWS)
- Non-community water system (NCWS)
- Non-Transient Non-Community Water System (NTNCWS)

The water sources, by category, are currently as follows:

System category	Total No. of Systems	Water Source		
		Surface	Groundwater	Purchased
CWS	1184	208	471	505
NCWS	367	10	204	153
NTNCWS	130	7	113	10

Currently there are nine ground water systems with active sources that exceed the nitrate standard and one system with a trichloroethylene exceedance. Approximately 40 other systems have had exceedances but have removed the wells from service until a correction is achieved. All of these systems are under consent orders or other enforcement actions.

Program Description

All vulnerable public water supply surface and groundwater sources are monitored. Sampling is performed by the regulated community, i.e., the water supply systems, and reported to the DEQ. The PWS Section evaluates the reported data for drinking water standards violations. Violations of drinking water standards are subject to enforcement action.

Monitoring Requirements

Routine monitoring requirements are shown in Table 26. Table 27 reflects contingent additional and/or reduced monitoring requirements.

Monitoring Locations

All vulnerable public water supply systems.

Data Evaluation

Evaluation criteria are reflected in Tables 26 and 27.

Time Lines

This is a permanent program.

• Table 26. **Routine monitoring requirements.**

Contaminant(s) monitored	Applicable to	Routine Monitoring	
		Frequency	Location
Inorganic Chemicals: Antimony, arsenic, barium, beryllium, cadmium, chromium, cyanide, fluoride, mercury, selenium, and thallium Re: 40 CFR 141.23(c)	CWS NTNCWS	**Surface water systems:** annually **Groundwater systems:** once each 3 years If system samples more frequently than annually, compliance determined on running annual average at any sampling point. If system samples on an annual or less frequent schedule, compliance determined on the average of an initial and confirmation sample.	Sample at each POE, representative of each source after treatment.
Inorganic Chemicals: Asbestos Re: 40 CFR 141.23(b)	CWS NTNCWS	**Vulnerable systems:** once each 9 years, during first 3 years of each 9-year compliance cycle. Vulnerability is determined by corrosion of asbestos-cement pipe or the presence of asbestos in source water.	Vulnerable systems must monitor at a tap served by asbestos-cement pipe under conditions most conducive to asbestos contamination.
Inorganic Chemicals: Nitrate and nitrite Re: 40 CFR 141.23(d) and (e)	CWS NTNCWS	**Surface water systems:** quarterly **Groundwater systems:** annually	Sample at each POE, representative of each source after treatment.
	NCWS	Annually	
Inorganic Chemicals: Sodium Re: 40 CFR 141.41	CWS	**Surface water systems:** annually **Groundwater systems:** once each 3 years	Sample at each POE.
Inorganic Chemicals: Sulfate Re: 40 CFR 141.40(n)	CWS NTNCWS	N/A	Sample at each POE, representative of each source after treatment.
VOCs (other than trihalomethanes): Re: 40 CFR 141.24	CWS NTNCWS	Four consecutive quarterly samples during each 3-year compliance period. All samples analyzed in a quarter must be used to average the quarter.	Sample at each POE, representative of each source after treatment.

Contaminant(s) monitored	Applicable to	Routine Monitoring	
		Frequency	Location
Synthetic Organics Re: 40 CFR 141.24(h)	CWS NTNCWS	Monitor quarterly for pesticides and other synthetic organic contaminants unless granted a waiver. These samples must be collected during the quarter that previously yielded the highest analytical results. If a system samples more frequently than annually, compliance shall be determined on the running annual average of all samples at each sampling point. If a system samples on an annual or less frequent schedule, compliance shall be determined on the average of an initial and confirmation sample.	Sample at each POE, representative of each source after treatment.
Radiochemical ***Re: 40 CFR 141.26***	CWS	Monitor every 4 years by analyzing 4 consecutive quarterly samples or a composite of 4 consecutive quarterly samples. Community systems using surface water sources and serving more than 100,000 persons must also analyze for man-made beta and photon emitters.	Sample at each POE.
Unregulated VOCs Re: 40 CFR 141.40 (e) and (j)	CWS NTNCWS	Sample each source at least once. The EPA requires data so they may determine whether to establish MCLs.	Sample at each POE.
Unregulated Organic chemicals: Aldicarb, Aldrin, Butachlor, Carbaryl, Dicamba, Dieldrin, 3-Hydroxycarbofuran, Methomyl, Metolachlor, Metribuzin, Propachlor Re: 40 CFR 141.40(n)	CWS NTNCWS	Four consecutive quarterly samples.	Sample at each POE, representative of each source after treatment. Each sample must be taken at same sampling point unless conditions make another sampling point more representative of each source or treatment plant.

- Table 27. **Contingent additional and/or reduced monitoring requirements.**

Contaminant(s) monitored	Applicable to	Additional Monitoring	Reduced Monitoring
Inorganic Chemicals: Antimony, arsenic, barium, beryllium, cadmium, chromium, cyanide, fluoride, mercury, selenium, and thallium Re: 40 CFR 141.23(c)	CWS NTNCWS	If a maximum allowable level is exceeded, sample quarterly, beginning with the next quarter. Surface water systems must sample for 4 consecutive quarters. Groundwater systems must sample for 2 consecutive quarters. If the results indicate that the sources are reliably and consistently below the applicable standard, a waiver may be requested to reduce sampling to the original frequency.	The monitoring frequency may be reduced to annually. Water systems may apply to the state for a waiver from initial and repeat sampling frequencies. If the results of 3 years of sampling have no detections, the system may apply for a waiver from monitoring. These waivers must be renewed every 9 years. Waivers are contaminant specific and must be based upon a vulnerability assessment based on lack of use of the chemicals in the area or physical condition of the well and the area surrounding it.
Inorganic Chemicals: **Asbestos** Re: 40 CFR 141.23(b)	CWS NTNCWS	N/A	Systems not vulnerable to asbestos may apply to the DEQ for a monitoring waiver.
Inorganic Chemicals: **Nitrate and nitrite** Re: 40 CFR 141.23(d) and (e)	CWS NCWS NTNCWS	If any sample is 50% or more of the maximum allowable level, sample quarterly for at least 1 year.	Surface water systems with less than 50% of the maximum allowable level and groundwater systems which are reliably and consistently below the maximum allowable level may be reduced to annual sampling. Annual sample must be collected during the quarter which yielded the highest results during initial monitoring. Systems that disinfect are exempt from nitrite monitoring.

Contaminant(s) monitored	Applicable to	Additional Monitoring	Reduced Monitoring
Inorganic Chemicals: **Sodium** Re: 40 CFR 141.41	CWS	N/A	N/A
Inorganic Chemicals: Sulfate Re: 40 CFR 141.40(n)	CWS NTNCWS	N/A	N/A
VOCs (other than trihalomethanes): Re: 40 CFR 141.24	CWS NTNCWS	If contaminants are detected (>0.5ppb), sample quarterly at each point with a detection, beginning with the next quarter. Groundwater systems must sample for 2 quarters and surface water systems must sample for 4 quarters to establish a baseline. If the results indicate that the sources are reliably and consistently below the applicable standard, the sampling frequency may be reduced to annually. These samples must be collected during the quarter which previously yielded the highest analytical results. If a system samples more frequently than annually, compliance is determined by either the running annual average of all samples at each sampling point or the average of an initial and confirmation sample.	After a minimum of three years of annual sampling, a groundwater system with no previous detections of any contaminant may collect one sample each compliance period. Water systems may apply to the state for a waiver from initial and repeat sampling frequencies. These waivers must be renewed for each compliance period. Waivers are contaminant-specific and must be based upon a vulnerability assessment. Waivers may be granted based on lack of use of the chemicals in the area or physical condition of the well and the area surrounding it. If the results of initial monitoring have no detections, the system may apply for a waiver from monitoring. A waiver shall be effective for no more than 6 years. If a waiver is granted, groundwater systems must take one sample at each sampling point during the period when the waiver is in effect (one sample each 6 years) and update its vulnerability assessment. Surface water systems which are granted a waiver shall monitor at a frequency determined by the state (if any) and update the system's vulnerability assessment each compliance period.
Synthetic Organics Re: 40 CFR 141.24(h)	CWS NTNCWS	N/A	The monitoring frequency may be reduced to annually. Water systems may apply to the state for a waiver from initial and repeat sampling frequencies. If the results of 3 years of sampling have no detections, the system may apply for a waiver from monitoring. These waivers must be renewed every 9 years. Waivers are contaminant-specific and must be based upon a vulnerability assessment based on lack of use of the chemicals in the area or physical condition of the well and the area surrounding it.
Radiochemical ***Re: 40 CFR 141.26***	CWS	If gross alpha exceeds 5 pCi/L, analyze for radium-226. Monitor annually if radium-226 exceeds 3 pCi/L.	If less than 50% of the MCL, a single sample may be approved instead of quarterly samples. If gross alpha is less than 5 pCi/L at the 95% confidence level, radium may be waived.
Unregulated VOCs Re: 40 CFR 141.40 (e) and (j)	CWS NTNCWS	Confirmation of the presence of any volatile organic chemical in any source will require quarterly monitoring of that source.	N/A
Unregulated Organic chemicals: Aldicarb, Aldrin, Butachlor, Carbaryl, Dicamba, Dieldrin, 3-Hydroxycarbofuran, Methomyl, Metolachlor, Metribuzin, Propachlor Re: 40 CFR 141.40(n)	CWS NTNCWS	N/A	Systems not vulnerable to potential contamination may obtain a waiver. A wavier may be granted if the contaminant has never been used in the area, or if previous analytical results indicate no detection of the chemical (<0.5 ug/L) and by considering environmental transport and persistence of the contaminant, number of persons served, and degree of wellhead or watershed protection.

Honey Creek / Cave Springs Branch Water Quality Monitoring

Introduction

Cave Springs Branch is a tributary to Honey Creek located in northeast Oklahoma near the City of Grove. Honey Creek flows into Grand Lake a few miles west of its confluence with Cave Springs Branch. There is a minimum of fifty-five residences positioned along Cave Springs Branch and Honey Creek in the approximately six-mile stream segment downstream from the Oklahoma-Missouri state line.

Pursuant to a Supreme Court Ruling, *Oklahoma v. Arkansas,* 503 U.S. 91 (1992), waters entering the state of Oklahoma must meet OWQS criteria at the state line. A significant portion of the existing flow in Cave Springs Branch is generated by the permitted discharges from a facility (a poultry-processing plant) located near Southwest City, Missouri. These discharges are introduced into Cave Springs Branch approximately one-half mile east of the state line. The largest discharge by far from this facility is its treated process wastewater discharge. Accordingly, discharges from this facility have the potential to significantly impact the water quality of these streams.

Treatment plant upsets at this facility occurred in the spring and early summer of 1996, and again in February 1998. These upsets significantly impaired the water quality and aquatic life in Cave Springs Branch. The plant was taken off line for a short time during the winter and spring of 1998, but has operated since this time without interruption.

Program Objectives

- To monitor the progress being made in the clean up of Honey Creek and Cave Springs Branch.
- To monitor compliance of the southwest Missouri poultry plant's discharge with OWQS criteria at the state line.

Monitoring Requirements

The monitoring program is managed by the WQD with assistance from the DEQ's Environmental Complaints and Local Services (ECLS) Division. ECLS staff collects samples and sends these samples to the SEL for analysis. WQD staff receives the results of the SEL's analyses and monitors the two streams for compliance with OWQS criteria.

Initially, samples were collected and analyzed on a weekly basis. Sampling frequency was reduced to twice per month prior to January 1, 2000, and is currently once per month on a continuing basis. The reduction in sampling frequency was necessitated by funding restrictions and is commensurate with the apparent improvement in the poultry processing plant's discharge and the water quality in the streams.

Monitoring Locations

The five sites in the Honey Creek/Cave Springs Branch watershed at and downstream of the state line which are monitored are shown in Figure 12.

Data Evaluation

The samples are analyzed for 5-day Biochemical Oxygen Demand (BOD_5), Total Suspended Solids (TSS), Ammonia, Nitrates, Nitrites, Phosphorus, Organic Nitrogen, Kjeldahl Nitrogen, Total Nitrogen, bacterial colonies, pH, Temperature, and Dissolved Oxygen. Monitoring data is analyzed by WQD personnel and compared to Discharge Monitoring Reports (DMRs) submitted monthly by the poultry processing facility to the Missouri Department of Natural Resources (MDNR) and the DEQ.

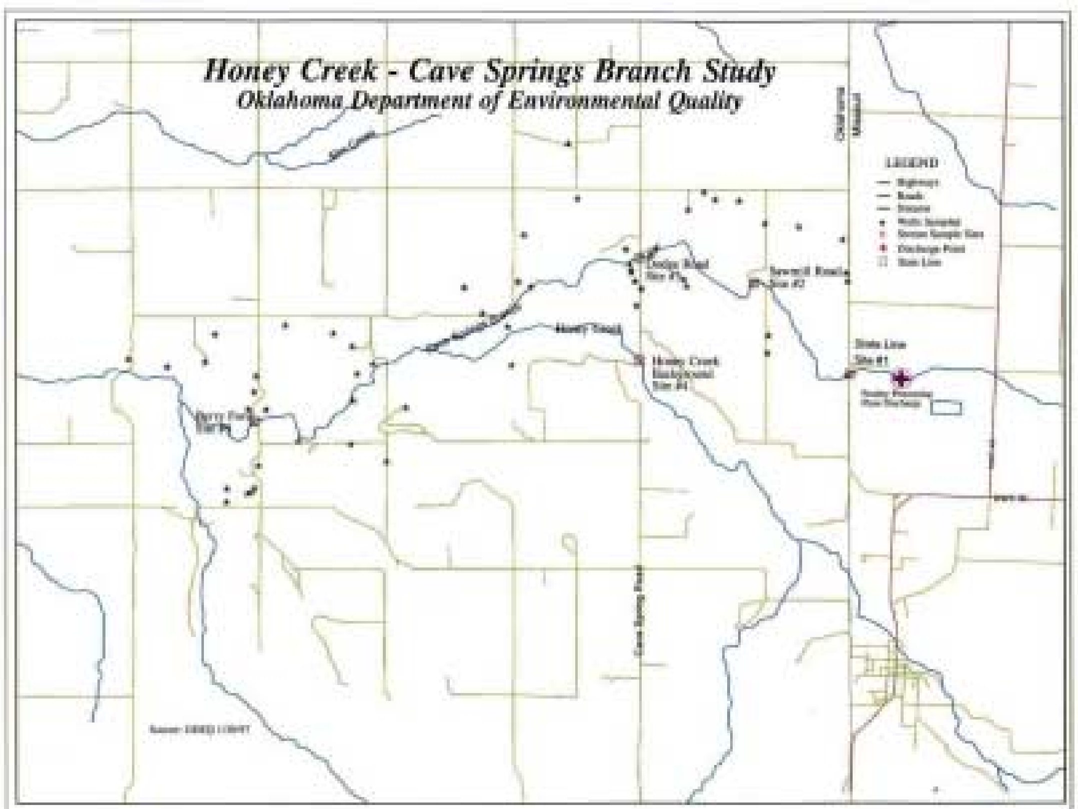
Actions Taken or Prescribed

Cave Springs Branch has showed continued improvement over the eighteen-month period before January 2000, and aquatic life continues to return to the stream. Based on this monitoring, the DEQ has made recommendations to the MDNR concerning the poultry processing plant's discharge permit. The DEQ has also had the capability through this monitoring program to respond quickly to citizen concerns about the water quality in these two streams.

Monitoring reports are sent periodically to members of the Oklahoma Legislature, as well as to the poultry processing facility, the MDNR, and other state agencies and environmental groups.

Time Lines

This is a program of indefinite duration.



• Figure 12. **ODEQ Honey Creek Monitoring Effort.**

Fish Kill Investigations

Introduction

When fish kills are reported, a quick and appropriate response is indicated. Unsafe drinking water and adverse effects on fish and wildlife are immediate concerns. Fish kills in ponds, lakes and lagoons are often associated with dissolved oxygen (DO) depletion resulting from dense algae blooms, which in turn are typically the result of eutrophic or hyper-eutrophic conditions (an overabundance of nutrients). Multiple non-point sources often account for excess nutrients, making it difficult oftentimes to attribute individual fish kill events to a specific non-point source, such as urban runoff or runoff of poultry litter applied to agricultural land. Water quality assessments and fish kills reported since 1997 are tracked by the WQD in a relational database as an adjunct to identifying stresses and impairments to waterbodies. WQD works closely with the Oklahoma Department of Wildlife Conservation (ODWC), which also collects and maintains information regarding fish kills.

Program Objectives

- To provide timely notification to public water supplies where there is reasonable potential for contamination of surface source water supplies.
- To gather accurate information regarding fish kill incidents and maintain historical data for use by citizens and government agencies.
- To discover, if possible, a specific cause for the fish kill, and the extent of its impact.
- To recommend management practices and provide technical assistance to citizens, businesses and government agencies in order to prevent additional fish kills.

Program Description

The fish kill investigation program is designed to respond to fish kill alerts, maintain an historical reference of fish kill sites, monitor fish kill sites as may be warranted, and provide assistance to the public and governmental agencies.

Monitoring Requirements

Conditions at a fish kill site, upstream as well as downstream, must be documented. If a fish kill is suspected to be of either natural or anthropogenic origin, field sampling and testing to document pH, DO, ammonia, nitrite-nitrates, phosphorus and temperature are warranted. Oftentimes, fish kills resulting from natural causes are determined only by upstream or adjacent stream monitoring. If pesticide toxicity is suspected, samples of affected fish, as well as apparently healthy fish, may be gathered for laboratory tissue bioassay. Sampling and analysis of water and/or fish tissue for other suspect toxicants may be determined on a case-by-case basis through consultation with the State Environmental Laboratory.

Monitoring Locations

Fish kill site locations are precisely established by onsite investigators using Global Positioning System (GPS) equipment and/or discharge outfall latitude and longitude from OPDES permits. Fish kill sites and select data from fish kills investigated since 1997 are shown in Table 28.

Data Evaluation

Evaluation of data gathered in fish kill investigations is, by its very nature, site-specific.

Actions Taken or Prescribed

Where possible, technical assistance is provided to citizens, businesses and government agencies in order to prevent additional fish kills. Data gathered via this program is entered into a relational database, which is available to the public, and is utilized in the process of identifying stresses and impairments to waterbodies.

Time Lines

This is a permanent program.

Maps/Graphs/Tables

- Table 28. **Fish Kills Reported Since 1997 and Related Data.**

Month and Year	County (and State if other than OK)	Affected Waterbody	Number and Type of Fish Killed	Probable Cause of Fish Kill	Other Relevant Information
Feb 1998	McDonald (MO)	Cave Springs Br, Honey Creek	Number and type not specified	Poultry processing facility	Facility closed until discharge compliant
Jun 1998	Payne	Scull Creek	20-30, type not specified	Industrial facility sludge discharge	High BOD_5 and COD
Aug 1998	Pottawatomie	Trib to Squirrel Creek	Unk no. of panfish, carp, catfish	Installation of new discharge pipe at POTW	Effluent-dominated receiving stream
Aug 1998	LeFlore	Morris Creek	Numerous, type not specified	Vandalism at industrial facility WWTP	Aerators disabled, sulfuric acid tank valve broken
Aug 1998	Oklahoma	Chisholm Lake	Numerous species	Hot dry conditions	
Oct 1998	McDonald (MO)	No. Fork, Cave Springs Br.	Stonerollers	Slug loading from line break at poultry processing facility	Downstream looked good
Dec 1998	Oklahoma	Kuhlman Creek	100-200, type not specified	Fire suppression foam release at Tinker AFB	Due to power outage - high COD
Jan 1999	Cleveland	OU Campus Duck Pond – Bishop Creek	100+ minnows & catfish, plus two ducks	Antifreeze spill caused by water heater pump failure	Spill originated from Physical Sci Bldg
Jan 1999	Oklahoma	Trib to Crutcho Creek, adjacent to Tinker AFB	Numerous, all types	Undeterminable	
May 1999	Oklahoma	Pond in NW portion of Tinker AFB	Numerous, type not specified	Debris from 5/3/99 tornado	Numerous tests conducted by Tinker AFB
Jul 1999	Tulsa	Metro storm water sediment control basin	Numerous bluegill, smallmouth and largemouth bass	Fertilizer in storm water runoff	Sediment control basin not intended to support fishery

Month and Year	County (and State if other than OK)	Affected Waterbody	Number and Type of Fish Killed	Probable Cause of Fish Kill	Other Relevant Information
Aug 1999	McDonald (MO)	Cave Springs Br	12 green sunfish	Undeterminable	
Sep 1999	Oklahoma	Metro storm drain to Deep Fork	6 sunfish	Undeterminable	
Sep 1999	Lincoln	Bell Cow Creek	10 carp, drum, carpsuckers	Undeterminable	Fish were in adv state of decomp when investigated
Feb 2000	Beckham	Timber Creek	6 perch + 1 frog	Crude oil/brine –open casing valve– estimate 1000 bbls spilled	Large scale cleanup operation
Feb 2000	Oklahoma	Trib to Deep Fork in far north OKC	Hundreds of minnows, perch, mudcats	Injection well site, estimate 2900 gal diesel fuel spilled	

Toxics & Reservoirs Program - Rotating Fish Flesh Toxics Sampling in Lakes

Introduction

Oklahoma's Toxics and Reservoirs program came about after the discovery of fish contaminated by PCBs from the Pryor Creek Arm of Ft. Gibson Reservoir in the late 1970s. It was realized by officials that little was known about the concentrations of toxic metals and organics in the fish of Oklahoma's reservoirs.

Beginning in 1979, 50 of the state's largest reservoirs were targeted for the sampling of fish flesh by the Oklahoma State Department of Health (now DEQ). Seven to nine reservoirs were sampled yearly with multiple sites sampled on the bigger water bodies. Composites of fish fillets were analyzed for mercury and seven common organic compounds known to be carcinogenic. Concentrations were compared to FDA recommended levels for the consumption of fish flesh. If levels consistently exceeded the FDA Action Level then a consumption advisory was issued relative to the affected area and species.

The program has developed and matured on its own without input of federal money or intervention. While federal 106 grant monies are eligible to be used for this type of monitoring (most other states use 106 monies), Oklahoma's program has always been funded by state appropriation. EPA did not issue guidance on fish sampling and analysis until 1993. By that time Oklahoma's program and procedures were well in place.

With the issuance of guidance by EPA and the emergence of mercury contamination issues throughout the southeastern U.S., there began to be a comparison of fish sampling programs across the nation. Because of EPA's late entry onto the scene, each state's program had developed independently, much like Oklahoma's. However, one common shortcoming was identified in most of the states' programs. There was a need for risk-based consumption advisories that would target vulnerable populations and allow some consumption instead of the blanket no-consumption-by-anyone advisories that were being issued. The SEL's Toxics and Reservoirs Program addresses that need and documents the methods and procedures used for the collection and analysis of samples, data reporting, and the issuance of fish consumption advisories.

It is noteworthy that DEQ will be participating in the National Fish Study, led by the Environmental Protection Agency, to study chemical residues of 87 persistent, bioaccumulative and toxic substances in lake fish tissue. This study began in 1999 and will continue through 2002, with the final report scheduled for completion in 2003.

Program Objectives

- To protect public health by evaluating levels of commonly found toxic compounds in fish flesh from Oklahoma reservoirs and, when necessary, issuing fish consumption advisories to the public in cooperation with other state agencies.

Program Description

Three general categories of fish are targeted for collection and analysis to ensure that the species analyzed are those most susceptible to bioaccumulation of toxics and most frequently consumed. The three categories of fish are:

- Predator species
- Bottom feeders
- Rough fish

Table 29 lists the preferred fish species and other acceptable species for each of the above three categories.

Monitoring Requirements

Sample Collection

Since the intent of the program is to measure toxics in fish flesh, any legal method of obtaining uncontaminated samples is acceptable. This includes gill nets, seines, trot line, electrofishing, rod and reel, and angler surveys. DEQ has a working agreement with the ODWC to collect fish in conjunction with their fish survey activities. ODWC generally uses electrofishing collection methods. DEQ supplements these collections, when necessary, with fish collected by gill net or seine.

Species Selection

Fish are composited according to size and species for analysis. A valid composite consists of 3 to 8 individuals of the same species with the smallest fish being at least 75% the length of the largest. Only valid composites are analyzed.

To provide the best screening tool for the evaluation of concentrations of toxics that could affect human health, it is desired that each category of fish be available for analysis. For screening purposes, it is necessary that only one composite be run for each category of fish. If the preferred species is available, that species is normally chosen for analysis. If the preferred species is not available for a given category, then one of the other acceptable species may be analyzed. If more than one composite of a selected species is available, the composite of the largest individual fish should be chosen for analysis.

Upon receipt in the laboratory, all fish are separated by species, weighed and measured. The data are recorded and the fish are composited according to length recommendations. Filets are collected from each fish and combined into the appropriate composites. The composited filets are wrapped in aluminum foil and labeled according to site, species and size. All composites are held frozen until sample analysis and data evaluation is complete. Composites selected for analysis are logged in and held in a separate plastic container. Composites not selected for analysis are combined according to site and held frozen in labeled plastic bags until the screening process is complete.

Monitoring Locations

Table 30 lists the water bodies routinely sampled on a rotating basis and the number of monitoring sites for each listed water body.

Data Evaluation

Sample Analysis

Samples chosen for analysis are logged into the SEL's ***Aquarius*** data management system. Data fields in the ***Aquarius*** system are completed as follows:

Project Code:	The appropriate project code - generally TS-XF.
Date Collected :	Date of collection.
Station ID:	The Aquarius station ID if available. This field is reserved if station ID has not yet been assigned.
Source:	The total number, number analyzed, and species of the sample, e.g., 5 of 7 Largemouth Bass.
Sampler's Comments:	The site name, collecting agency (if not DEQ), and other pertinent information.

Sample preparation, analytical methods, detection limits, and QA/QC procedures are spelled out in the ***SEL Quality Assurance Project Plan***.

Screening Levels

Screening levels are used to determine potential problems and if other samples and species need to be analyzed. Screening levels are set at 75% of the lowest level for which a consumption advisory would be issued.

If all analyzed values at a given site fall below the screening values, the other composites are not analyzed. If an analyzed value exceeds the screening value, all the held composites from that site are then logged in and analyzed.

If, during routine sampling, screening values are exceeded, samples are recollected as soon as practicable with emphasis on collecting the species and categories of fish that showed contamination. As long as sample results for a site remain above screening levels, that site is re-sampled annually for the species and categories showing contamination.

Actions Taken or Prescribed

Consumption Advisories

Consumption advisories may be issued for a particular species or a general category of fish, e.g.: predator species. Consumption advisories may also be issued within size ranges, e.g.: largemouth bass greater than 14” in length.

Consumption advisories are only issued after sampling indicates contaminant levels that are consistently above DEQ standards. Generally, this means at least two sampling events. Selective sampling techniques are used to determine if only certain species or categories of fish are affected.

Consumption advisories are only issued with the cooperation of the ODWC. In addition, other interested parties are notified and consulted before consumption advisories are issued. These may include other state and federal agencies, tribes, and municipalities.

Consumption advisories are rescinded only after sampling indicates contaminant levels that are consistently below DEQ standards. Generally, this means three consecutive sampling events.

If a site has a consumption advisory issued for it, that site is sampled annually for the species or category of fish for which the consumption advisory applies.

Program Results

DEQ has issued consumption advisories for four water bodies since 1978. Currently there are two active consumption advisories;

Largemouth bass at McGee Creek Reservoir
Catfish at Bitter Creek.

DEQ is also closely monitoring three other sites where screening values have been exceeded.

If increased funds were made available, DEQ could work with other agencies to target additional reservoirs, municipal lakes, and stream sites for sampling and analysis.

Time Lines

Reservoirs are routinely sampled once every seven years. Streams are sampled on a case-by-case basis at locations where contamination is known or suspected to exist. If sample results indicate elevated levels of contaminants, sampling frequency is increased to at least annually.

• Table 29. **Fish categories and preferred species for toxics determination.**

Category	Preferred Species	Acceptable Species
Predators	Largemouth Bass	Hybrid, White, Striped Bass, Walleye, or Flathead Catfish
Bottom Feeders	Channel Catfish or Blue Catfish	Black Bullhead
Rough Fish	Smallmouth Buffalo	Carp, River Carpsucker, Largemouth Buffalo

• Table 30. **Water bodies sampled as part of the Toxics & Reservoirs Program.**

Waterbody	No. of Sites	Year Scheduled
Lake Arcadia	1	2002
Altus-Lugert Reservoir	1	2003
Lake Arbuckle	2	2005
Lake Atoka	1	2005
Broken Bow Reservoir	2	2002
Boomer Lake	1	2000
Lake Carl Blackwell	1	2004
Canton Lake	1	1999
Copan Reservoir	1	2004
Draper Lake	3	2001
Lake Eufaula	4	2004
Lake Ellsworth	1	2004
Ft. Gibson Reservoir	4	2005
Foss Reservoir	2	2002
Fort Supply Reservoir	2	2004
Grand Lake	3	2001
Great Salt Plains Reservoir	2	2005
Greenleaf Lake	1	2000
Guthrie Lake	1	2001
Lake Hudson	3	2001
Lake Hefner	1	2001
Hugo Lake	2	2001
Hulah Reservoir	1	2005
Kaw Reservoir	3	2002
Lake Keystone	4	2005
Liberty Lake	1	2005
Lake Lawtonka	1	2003
McAlester City Lake	1	2003
McGee Creek Reservoir	1	2002
Lake McMurtry	1	2005
Lake Murray	3	2004
Newt-Graham Lock & Dam	1	2003
Pine Creek Reservoir	1	1999
R S Kerr Reservoir	2	2002
Sardis Lake	1	2004
Shawnee Lake	1	1999
Skiatook Lake	1	2004
Lake Thunderbird	1	1999
Lake Tenkiller	1	1999
Tom Steed Reservoir	2	2001

Waterbody	No. of Sites	Year Scheduled
Lake Texoma	4	2000
Lake Wister	1	1999
Waurika Lake	1	1999
Bitter Creek	2	Annual
Stinking Creek	2	Annual
Turkey Creek	1	Annual

Fish Community Biotrend Monitoring

Introduction

In 1976 the then OSDH (now DEQ) established the first long-term biotrend monitoring program in the state of Oklahoma. Initially the program consisted of 12 sampling sites that were sampled once a year. The program was expanded to 21 sites the following year. By 1998 the program had expanded to 72 sites sampled 2 to 3 times a year. In addition to these long-term sampling sites for the monitoring of fish communities, a number of intensive studies were conducted. The DEQ fish community database now contains information on 1361 sites across the state from 5538 collections.

In the beginning a wide range of biological and physical indicators were monitored: fish, macroinvertebrates, plankton, chlorophyll, aquatic plants and other aquatic vertebrates, as well as water chemistry and habitat evaluations. All elements but the fish community and habitat evaluations have been dropped due to personnel and fiscal constraints.

In 1998 DEQ revised the biotrend monitoring program with input from the ODWC, Oklahoma State University and the University of Oklahoma. After looking at the list of long-term sampling stations in association with the major watersheds, several gaps in areal coverage of the state were noticed. Several new stations (for a total of 96) were added to the biotrend monitoring program so that all major watersheds of the state were adequately covered. At the same time sampling at each site was reduced from 2-3 times a year to once every 3 years.

Program Objectives

- To evaluate the biotic integrity of Oklahoma streams and to provide information to public, state and federal agencies for the prudent use of this valuable resource.

Monitoring Requirements

Sampling is conducted using various combinations of nylon seines that range in length from 3.0 to 9.1 meters and in depth from 1.2 to 1.3 meters with mesh size from 4.8 to 6.3 mm as determined by the nature of each sampling locality. Each seine is equipped with extra floats and with extra heavy lead line to ensure a maximum capture rate. To ensure standardized sampling the following procedures are used:

- Collections are performed at the same location at each site during each sampling trip
- Sampling areas always cover 200 meters of the shoreline.
- The total sampling area always covers 2000 square meters.

- Thoroughly sampling all habitats in the 200 meter stretch of shoreline sampling area. Some habitats (riffles, pools, and raceways) are present at each station.
- An attempt is made to ensure a uniform effort per visit by sampling for a period of 1.5 hours.
- Attempts are made to perform approximately the same number of seine hauls at each site (20 with each covering approximately l0 m distance).
- Repeat seine hauls are done several times at each site to ensure that most of the fish are captured in a certain habitat.
- All specimens are preserved in the field with 10% formalin to insure a good complete sample from each site.
- Preserved samples are taken to the Sam Noble Museum of Natural History (SNMNH), as set forth in an agreement between DEQ and the University of Oklahoma, to ensure correct identification of species.
- All collections are permanently housed in the SNMNH for reference and further study.

Three basic types of seining techniques are used for data collection in the biotrend monitoring program:

- The "sweep" method is used along shorelines relatively free of obstructions. In shoreline seining the seine is worked (pulled) through the water, generally in the direction of the current, while the lead line is kept on the bottom and in front of the float line. The offshore end of the seine should be slightly ahead (downstream) of the near shore end, thereby forming a "J". The float line should not go under the water surface, and the lead line should always stay on the bottom. After a determined distance or time of seining the seine is hauled upon a smooth sand bar or swiftly lifting it out of the water and the fish are placed into the collection bottle. This method works best in a downstream direction.
- The "kick" method is very effective for species common in riffles and shallow raceways such as madtoms and darters. Two persons hold the seine in a vertical position in the water and perpendicular to the flow. The brails are allowed to slant downstream as the current forms a bag in the seine. A third person, upstream from the seine, disturbs or "kicks" the substrata working downstream toward the lead line. The bagged seine is then lifted out of the water to finish the haul.
- The "dip" method is used around undercut banks, brushpiles, and dense cover. The seine is swept into or around an obstruction keeping a wide bag and moving the lead line as close to the obstruction as possible. The bottom ends of the brails are used repeatedly to probe as far as possible into the brush working from the outside in until the brails meet and are overlapped. The seine is then swiftly stretched and lifted vertically from the water.

Monitoring Locations

Table 31 lists the stream sites designated for biotrend monitoring, ID numbers, number of sample collections for each site, and the next scheduled year for routine sampling. The geographical distribution of monitoring locations is shown in Figure 13.

Data Evaluation

An index of biotic integrity for Oklahoma fish communities was developed by DEQ to be used in assessment of the biotic integrity of Oklahoma streams. Sixteen attributes are used to determine this biotic integrity. These attributes, called metrics, fall into three categories:

- Species richness (diversity)

- Trophic composition
- Fish abundance and condition

Table 32 lists the sixteen biotic integrity metrics, their value range and point value (score) for each of the five biotic condition levels (excellent to very poor).

The total biotic integrity metrics score determines the biotic condition of the fish community, as follows:

Total Biotic Integrity Metrics	Biotic Condition
46 - 71	Excellent
72 – 122	Good
123 – 173	Fair
174 – 201	Poor
202 – 250	Very Poor

Stream habitat is one of the most important factors in determining fish communities. Prior to DEQ's inception, the OSDH developed a stream habitat index that consisted of fifteen metrics that fall into five categories:

- Watersheds
- Stream banks
- Stream bottom
- Stream morphology and flow
- Other habitat features

Table 33 lists the fifteen-stream habitat metrics, their value range and point value (score) for each of the five habitat condition levels (excellent to very poor).

The total stream habitat metrics score determines the suitability of the stream habitat to support a healthy fish population, as follows:

Total Stream Habitat Metrics	Stream Habitat Condition
66 – 119	Excellent
120 – 192	Good
193 – 254	Fair
255 – 328	Poor
>329	Very Poor

Actions Taken or Prescribed

The results of these collections are compared to DEQ's long-term database to see if they fall within historic ranges. If it is determined that a detrimental change has occurred, sample frequency is increased to more closely monitor that site. Also, sampling within a river system should be set up so that no adjacent sites are sampled in the same year. It is felt that, given the funding available, this is the most efficient method of determining trends in the fish communities as they relate to environmental disturbances.

Fish community data has shown improvements in the ecosystem of specific sites as water quality of the site has improved. Long-term fish community data shows tremendous improvements in Cow, East Cache, and Bird Creeks, as well as in the North Canadian and Deep Fork Rivers after a number of cities made major improvements to their wastewater treatment systems.

The DEQ biotrend monitoring program has provided assistance to many state and federal agencies as well as private citizens by supplying fish community data to help them in their decision making, standard setting, and rule making efforts.

Time Lines

Sampling at each site is conducted once every three years. If detrimental changes are determined to have occurred at a specific site, sampling frequency is increased to more closely monitor that site.

Maps/Graphs/Tables

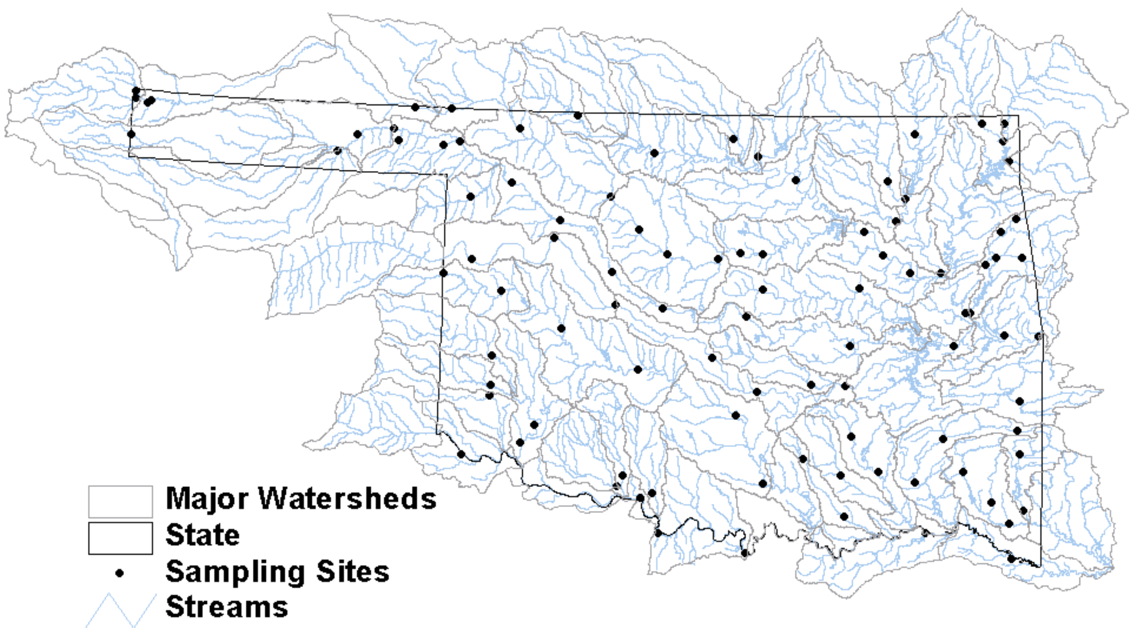
• Table 31. **Fish Community Biotrend Monitoring Sites.**

Site ID No.	Site Name / Location	No. of Times Collected	Year Scheduled
U07165520	Arkansas River at Bixby	35	1999
U07164400	Arkansas River at Sand Springs	58	2000
U07194600	Arkansas River below Webbers Falls Lock and Dam	47	1999
U07165570	Arkansas River near Haskell	58	2001
U07194500	Arkansas River near Muskogee	52	2000
U07148140	Arkansas River near Ponca City	50	1999
U07152500	Arkansas River near Ralston	58	2001
U07246400	Arkansas River near Sallisaw	45	2001
U07197000	Baron Fork near Eldon	32	1999
U07196540	Baron Fork at Baron on Hwy 59	2	2001
U07234000	Beaver River near Beaver	29	2001
U07234450	Beaver River near May	31	2000
U07233840	Beaver River near Turpin	31	1999
U07178400	Bird Creek at Catoosa	46	1999
U07332500	Blue River near Blue	34	1999
U07332390	Blue River near Connerville	49	2001
U07245000	Canadian River near Whitefield	42	1999
U07175500	Caney River near Ramona	0	2001
U07152000	Chick River near Blackwell	43	2000
U07156960	Cimarron River 7 mi North of Mocane	18	2000
U07154510	Cimarron River East of Kenton	33	2001
U07157950	Cimarron near Buffalo	62	2001
U07158585	Cimarron River near Cleo Springs	39	2000
U07160900	Cimarron River near Coyle	34	1999
U07159100	Cimarron River near Dover	43	2001
U07157580	Cimarron River near Englewood, KS Rost	31	1999
U07160000	Cimarron River near Guthrie	51	2000
U07154500	Cimarron River near Kenton	38	1999
U07158839	Cimarron River near Okeene	42	1999
U07161000	Cimarron River near Perkins	64	2001
U07232241	Corrumpa Creek 6S 2E Wheeless	1	2001
U07332941	Clear Boggy Creek 6E 1/8S Wapnuckahw7 168	1	2001
U07234125	Clear Creek 6S 4E Beaver	1	1999
U07313600	Cow Creek at Waurika	49	1999
U07243500	Deep Fork near Beggs	1	1999
U07242400	Deep Fork near Wellston, Fish Site	61	2000
U07311150	East Cache Creek 1S 2.5 W Temple	2	2000
U07189000	Elk River near Tiff City, MO	0	2000
U07303500	Elm Fork near Mangum	38	2001
U07195780	Flint Creek 3.5N 0.5E Hwy 412 near Mosely	1	2000
U07337910	Glover River W Broken Bow Hwy 3/7 (LR3078)	35	2000
U07198000	Illinois River near Gore	61	2000
U07196500	Illinois River near Tahlequah	63	2001
U07195520	Illinois River at Low Crossing (01)	3	1999
U07335700	Kiamichi River East of Big Cedar	62	1999
U07336200	Kiamichi River near Antlers	48	2000
U07335790	Kiamichi River near Clayton	43	2001
U07234140	Kiowa Creek 3 N Slapout	1	2001
U07337100	Little River near Cloudy	3	2001

(CONTINUED)

Site ID No.	Site Name / Location	No. of Times Collected	Year Scheduled
U07338500	Little River near Idabel	61	1999
U07321000	Little River near Sasakwa	0	2001
U07339000	Mountain Fork near Eagletown	39	2001
U07338840	Mountain Fork near Smithville	41	2000
U07333540	Muddy Boggy Creek 6N 0.5E Coalgate 145	1	1999
U07333900	Muddy Boggy near Lane	20	2000
U07185000	Neosho River near Commerce	9	2000
U07237500	North Canadian River at Woodward	54	1999
U07239500	North Canadian River near El Reno	63	1999
U07241550	North Canadian River near Harrah	65	2001
U07238000	North Canadian River near Seiling	26	2001
U07239200	North Canadian River near Watonga	42	2000
U07242000	North Canadian River near Wetumka	45	2000
U07154502	North Carrizozo Creek 1 E 8 N Kenton	5	2000
U07301500	North Fork Red River near Carter	57	1999
U07305000	North Fork Red River near Headrick	64	2001
U07306500	North Fork Red River W Tipton	17	2000
U07234180	Palo Duro Creek 9 E Hardesty Hwy 3	2	2000
U07249440	Poteau River near Fort Smith, AR	64	2000
U07247350	Poteau River near Heavener	50	1999
U07299775	Prairie Dog Branch at Eldorado	52	1999
U07335500	Red River near Arthur City, TX	47	2001
U07336820	Red River near De Kalb, TX	62	2000
U07316000	Red River near Gainsville	49	1999
U07315500	Red River near Terral	56	2000
U07312720	Red River near Waurika	52	2001
U07150520	Salt Fork Arkansas River at Nash	56	2001
U07300500	Salt Fork Red River near Mangum	56	2000
U07148350	Salt Fork Arkansas River near Winchester	1	1999
U07228210	South Canadian River N Taloga	2	2001
U07228800	South Canadian River S Norman at I-35	2	1999
U07231500	South Canadian River at Calvin	64	2000
U07228500	South Canadian River near Bridgeport	68	2000
U07229410	South Canadian River near Byars	42	2001
U07228200	South Canadian River near Roll	2	1999
U07154505	South Carrizo Creek at Dinosaur Mountain	4	2000
U07188450	Spring River at Twin Bridges	38	1999
U07188250	Spring River East of Miami	35	2001
U07176000	Verdigris River near Keetonville	1	2001
U07171000	Verdigris River near Lenepah	1	1999
U07320000	Washita River 1E 4 S Hwy 33 Texas Line WC1-92	1	1999
U07326503	Washita River 5 W Verdon on Hwy 9	1	1999
U07331000	Washita River near Durwood	53	2000
U07324200	Washita River near Hammon	0	2001
U07328500	Washita River near Pauls Valley	38	2001
U07311500	West Cache Creek 1N Taylor Hwy 58 2.5W 1S	1	2000
U07235500	Wolf Creek N of Gage on Hwy 46	0	2000

Biotrend Monitoring Stations



• Figure 13. **Distribution of Fish Community Biotrend Monitoring Stations.**

• Table 32. **Biotic Integrity Metrics.**

Metric No.	Biotic Integrity Metric Attribute	Value Range and Score	Level of Biotic Integrity				
			Excellent	**Good**	**Fair**	**Poor**	**Very Poor**
1	No. of species per collection	Range	>20	15 - 20	10 - 14	5 - 9	<5
		Score	0	3	6	9	12
2	Accumulated species per site	Range	>40	30 - 40	20 - 29	10 - 19	<10
		Score	0	6	12	18	24
3	Species diversity based on no. of fish	Range	>2.75	2.25 - 2.75	1.75 - 2.24	1.25 - 1.74	<1.25
		Score	4	8	12	16	20
4	Species diversity based on biomass	Range	>3.00	2.25-2.99	1.50-2.24	0.75-1.49	<0.75
		Score	6	9	12	15	18
5	Proportion biomass / no. of fish	Range	>1.0	0.75 - 0.99	0.50-0.74	0.26-0.49	<0.25
		Score	8	10	12	14	16
6	No. of Darter species	Range	>4	3	2	1	0
		Score	0	2	4	6	8
7	No. of Sunfish species	Range	>4	3	2	1	0
		Score	2	4	6	8	10

Metric No.	Biotic Integrity Metric Attribute	Value Range and Score	Level of Biotic Integrity				
			Excellent	Good	Fair	Poor	Very Poor
8	No. of Sucker species	Range	>4	3	2	1	0
		Score	0	2	4	6	8
9	No. of Intolerant species	Range	>4	3	2	1	0
		Score	0	4	8	12	16
10	Proportion green sunfish to other sunfish species	Range	<0.10	0.10 - 0.29	0.30 - 0.49	0.50 - 0.80	>0.80
		Score	4	8	12	16	20
11	Proportion of fish to no. of species	Range	<50	50 - 249	250 - 449	450 - 650	>650
		Score	6	9	12	15	18
12	Proportion of individuals as omnivores	Range	< 0.10	0.10 - 0.24	0.25 - 0.49	0.50 - 0.75	>0.75
		Score	4	8	12	16	20
13	Proportion of individuals as insectivores	Range	>0.75	0.50 - 0.75	0.25 - 0.49	0.10 - 0.24	<0.10
		Score	0	3	6	9	12
14	No. of top carnivore species	Range	> 10	8-10	5-7	3-4	< 3
		Score	0	3	6	9	12
15	Species making up 75% population	Range	>4	4	3	2	1
		Score	4	8	12	16	20
16	Percent of rough fish in population	Range	<5	5 - 9	10 - 14	15 - 25	>25
		Score	8	10	12	14	16

• Table 33. **Stream Habitat Metrics.**

Metric No.	Stream Habitat Metric Attribute	Value Range and Score	Stream Habitat Condition				
			Excellent	Good	Fair	Poor	Very Poor
1	Erosion	Range	None	Some	Moderate	Heavy	Very Heavy
		Score	8	10	14	16	18
2	Nonpoint Sources	Range	None	Some	Moderate	Heavy	Obvious
		Score	4	8	12	16	18
3	Bank Slope (Percent)	Range	<30 None	30 – 39 Some	40 - 49 Moderate	50 - 59 Heavy	>60 Many
		Score	6	9	12	15	18
4	Bank Vegetation	Range	High Diversity >90%	81 – 90%	Grasses/Shrubs 71 - 80%	Grasses 51 - 70%	None <50%
		Score	6	9	12	15	18
5	Channel Capacity Overflows W/O Ratio	Range	None <7	Rare 8 - 15	Some 16 - 23	Often 24 - 31	Many >31
		Score	8	10	12	14	16
6	Bank Deposition	Range	Little	Some	Moderate	Heavy	Very Heavy
		Score	3	6	9	12	15
7	Percent Bottom Scouring	Range	<10	10 – 39	40 – 49	50 – 59	>60
		Score	4	8	12	16	20
8	Bottom Substrate Percent Rubble	Range	>50	41 – 50	31 – 40	21 – 30	<21
		Score	2	4	6	8	10
9	Average Depth (feet)	Range	>24	12 – 23	7 - 11	3 – 6	<3
		Score	0	6	18	21	30
10	Flow (cfs)	Range	>5	2.0 – 4.9	0.5 – 1.9	0.2 – 0.49	<0.2

Metric No.	Stream Habitat Metric Attribute	Value Range and Score	Stream Habitat Condition				
			Excellent	Good	Fair	Poor	Very Poor
		Score	0	6	18	24	36
11	Pool/Riffle Run/Bend Ratio	Range	Highly diverse 5 – 7	Adequate 7 – 10	Few riffles 10 – 15	Bends only 15 – 25	Flatwater >25
		Score	4	9	16	28	36
12	Aesthetics	Range	Wilderness	Highly natural	Some development	Developed	Offensive
		Score	8	10	14	16	20
13	Percent Vegetative Disturbance	Range	None <10	Light 10 - 24	Moderate 25 – 49	High 50 – 74	Extreme >75
		Score	4	8	14	22	28
14	Canopy Shading	Range	Partial shade 50%	Partial shade 25%	Filtered sunlight	Full shade	Full sun
		Score	6	8	12	16	22
15	Diameter of Organic Matter (inches)	Range	Large logs >3.9	Branches 2.0 – 3.9	Twigs 0.4 – 1.9	Leaves 0.02 – 0.39	Dissolved <0.02
		Score	0	6	12	20	28

Solid Waste Groundwater Monitoring Program

Introduction

DEQ received authorization for the state program implementing Subpart D requirements of the federal RCRA. This is slightly different than traditional delegation of other federal programs. Under the authorization process, DEQ adopts rules and regulations for operating the state program. EPA then approves these as meeting federal requirements. However, unlike delegated programs, there is no subsequent federal oversight, nor does the DEQ receive federal funds to assist in implementing the state rules. Under the Subpart D program, municipal landfills must meet much stricter requirements. During FY 99, the state continued the process of implementing these new requirements, including the posting of financial assurance for closure and post-closure of landfills, a statutory requirement which took effect on April 9, 1997.

The Solid Waste Program is responsible for implementing the Oklahoma Solid Waste Management Act. Its principal regulatory mission is to permit, inspect and ensure compliance at solid waste disposal sites. Program staff also provide technical assistance, lead a county solid waste planning process, assist local governments' in planning recycling programs and provide public environmental education.

Program Objectives

- To ensure the protection of groundwater, and surface waters, as appropriate, from degradation by leachate from municipal solid waste, construction and demolition, and non-hazardous industrial waste landfills.

Program Description

The LPD's Solid Waste Permitting Section issues operating and post-closure permits to municipal solid waste landfills, construction and demolition landfills, non-hazardous industrial waste landfills, transfer stations, and waste processing facilities. Groundwater monitoring is required for permitted solid waste landfills. Important state regulatory references are as follows:

OAC 252:510-5-7:	Surface water monitoring program
OAC 252:510-11-7 and 252:520-9-9:	Groundwater monitoring program
OAC 252:510-11-8:	Detection monitoring program
OAC 252:510-11-9:	Assessment monitoring program
OAC 252:510-19-7:	Post-closure monitoring frequency
OAC 252:520-23-14(c):	Groundwater monitoring (closure)

Monitoring Requirements

Parameters Monitored

Municipal solid waste (MSW) landfills, regulated by OAC 252:510, must monitor groundwater. Minimum monitoring requirements are pH, Chemical Oxygen Demand (COD), Specific Conductivity, Chlorides, Sulfates, Calcium, Magnesium, Nitrates, Sodium, Carbonates, Potassium and, selectively, 15 metals and 47 volatile organic compounds listed in Appendix A to OAC 252:510. Surface water monitoring requirements, when required, are pH, COD, Specific Conductivity, Dissolved Oxygen and Turbidity. Construction and demolition (C&D) landfills, regulated by OAC 252:520, must monitor groundwater for pH, COD and specific conductivity.

Monitoring Frequency

Existing MSW landfills monitor groundwater quarterly for two full years and new MSW landfills monitor groundwater quarterly for one full year to determine background water quality. After determination of background, groundwater must be monitored every six months during the landfill's active life and post-closure. Surface water, if required, is monitored every six months. C&D landfills are sampled quarterly for one full year to determine background water quality, then quarterly thereafter. Post-closure monitoring is required every six months.

Monitoring Locations

Permitted landfills, sorted by county location, which participate in the groundwater monitoring program, are listed in Table 34. There are 44 active MSW and C&D landfills in operation under Solid Waste Section oversight, all of which participate in the groundwater monitoring program. There are also 21 non-hazardous industrial waste (NHIW) landfills under Solid Waste Section oversight.

Data Evaluation

MSW, C&D and NHIW landfills are required to statistically analyze the parameters monitored after each semi-annual detection monitoring event. Exceedances of criteria are assessed and, if significant, corrective measures are initiated.

Actions Taken or Prescribed

The presence of the following parameters have "triggered" additional investigations at various landfills and have resulted in the institution of corrective measures in the case of one facility currently.

Nitrates	Lead	Chlorides	Sulfates
Barium	Manganese	Tetrachloroethene	Trichloroethene
Cis-1,2-dichloroethene	Vinyl chloride	1,1-Dichloroethane	

Time Lines

This is a permanent program.

Maps/Graphs/Tables

• Table 34. **Solid Waste Landfill Groundwater Monitoring Requirements.**

County	Facility/Site Name	Type Facility [a]	Type Monitoring: Investigation	Type Monitoring: Detection	Type Monitoring: Compliance	Type Monitoring: Remediation	No of Wells	Parameters Monitored	Monitoring Frequency	Reporting Frequency
Adair	Cherokee Nation Sanitary LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
Beckham	Elk City Municipal LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
	Sayre Municipal LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
Bryan	City of Durant LF/Transfer Stn	C&D		X			3	Gen chem	Semi-annual	Semi-annual
Canadian	CCSWDA LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
Carter	Custom Land Fill Service Inc. LF	NHIW		X			4	Gen chem	Semi-annual	Semi-annual
	Southern Okla. Reg. Disposal LF	MSW		X			5	Gen chem, App A	Semi-annual	Semi-annual
	TPI Petroleum, Inc.	NHIW		X			7	Gen chem, App A	Semi-annual	Semi-annual
Cherokee	Ft. Gibson Fly Ash Monofill	NHIW		X			2	Barium	Semi-annual	Semi-annual
Choctaw	Hugo Plant Fly Ash Monofill	NHIW		X			11	Gen chem, App A	Semi-annual	Semi-annual
Cleveland	City of Norman Compost Facility	COM		X			3	Gen chem, App A	Semi-annual	Semi-annual
Comanche	City of Lawton LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
	Ft. Sill C/D LF	C&D		X			3	Gen chem	Semi-annual	Semi-annual
	Ft. Sill MSW LF	MSW		X			11	Gen chem, App A	Semi-annual	Semi-annual
Cotton	Temple Utilities Auth. LF	C&D		X			3	Gen chem	Semi-annual	Semi-annual
Creek	Creek County LF	C&D		X			3	Gen chem	Semi-annual	Semi-annual
Garfield	City of Enid LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
Garvin	Foster Waste Disposal Facility	MSW		X			3	Gen chem, App A	Semi-annual	Semi-annual
Grady	Great Plains LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
	Southern Plains LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual

County	Facility/Site Name	Type Facility [a]	Type Monitoring				No of Wells	Parameters Monitored	Monitoring Frequency	Reporting Frequency
			Investigation	Detection	Compliance	Remediation				
Jackson	City of Altus LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
Kay	Ponca City Vashi 4 Eyes Ph. ll LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
Lincoln	AMD, Inc. City of Prague LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
Major	Red Carpet LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
Mayes	Georgia Pacific Corp. LF	NHIW		X			4	Gen chem	Semi-annual	Semi-annual
	Grand River Dam Authority LF	NHIW		X			3	Gen chem	Semi-annual	Semi-annual
	Grand River Dam LF	NHIW		X			3	Gen chem	Semi-annual	Semi-annual
	Midwest Carbide Company	NHIW		X			4	Gen chem	Semi-annual	Semi-annual
	Norit Americas, Inc.	NHIW		X			4	Gen chem, App A	Semi-annual	Semi-annual
	Pryor Foundry Landfill	NHIW		X			4	Gen chem	Semi-annual	Semi-annual
McClain	Pinecrest LF	MSW		X			6	Gen chem, App A	Semi-annual	Semi-annual
McCurtain	City of Broken Bow LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
	Weyerhaeuser Company	NHIW		X			3	Gen chem, App A	Semi-annual	Semi-annual
Muskogee	Fort James Operating Company	NHIW		X			24	Gen chem	Semi-annual	Semi-annual
	Muskogee Community LF & Recyc	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
Noble	Evans & Assoc. Const. Co. Inc.	NHIW		X			3	Gen chem	Semi-annual	Semi-annual
	Grassy Point LF	NHIW		X			3	Gen chem, App A	Semi-annual	Semi-annual
	Northern Oklahoma Disposal	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
Oklahoma	BFI Oklahoma LF	MSW		X		X	8	Gen chem, App A	Semi-annual	Semi-annual
	East Oak Sanitary LF	MSW		X			6	Gen chem, App A	Semi-annual	Semi-annual
	Fill Sand LF	C&D		X			3	Gen chem	Semi-annual	Semi-annual
	Southeast OKC LF	MSW		X			24	Gen chem, App A	Semi-annual	Semi-annual
Okmulgee	Elliott Construction Co. LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
Osage	Osage LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
	Shell Creek LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
Payne	HEW Waste System LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
Pittsburg	City of McAlester LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
	Pittsburg County LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual

County	Facility/Site Name	Type Facility [a]	Type Monitoring: Investigation	Detection	Compliance	Remediation	No of Wells	Parameters Monitored	Monitoring Frequency	Reporting Frequency
	US Army McAlester Ammo Plant	NHIW		X			4	Gen chem, App A	Semi-annual	Semi-annual
Pontotoc	City of Ada Municipal LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
	Holnam Inc. - Webster facility	NHIW		X			5	Gen chem	Semi-annual	Semi-annual
Pottawatomie	Absolute Waste Soluutions LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
	Canadian Valley LF	MSW		X			5	Gen chem, App A	Semi-annual	Semi-annual
Pushmataha	Clinton Lewis Constr Co. LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
Seminole	Sooner Land Management LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
Texas	City of Guymon LF (Closed)	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
Tulsa	North Tulsa Sanitary LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
	Quarry LF	MSW		X			9	Gen chem, App A	Semi-annual	Semi-annual
Wagoner	51B LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
	Broken Arrow LF	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual
Woodward	NW Okla. SWDA	MSW		X			4	Gen chem, App A	Semi-annual	Semi-annual

[a]Type facility: MSW – Municipal and Solid Waste, NHIW – Non-Hazardous Industrial Waste, C&D – Construction and Demolition

Hazardous Waste Permitting and Corrective Actions (RCRA)

Introduction

The LPD's Hazardous Waste Permitting Section oversees corrective action activities at hazardous waste facilities. The permitting section also oversees remedial activities for certain voluntary clean up operations. These corrective action/remedial activities may include site characterization, remediation, and monitoring efforts.

Long term groundwater monitoring is conducted for detection, compliance and remediation and corrective action purposes. Groundwater monitoring is also used for site characterization; but site characterization does not typically require long term monitoring.

Program Objectives

- To detect contaminants in the groundwater in the assessment of the integrity of certain operations
- To assess compliance with regulatory standards
- To evaluate the effectiveness of remedial/corrective actions.

Program Description

The LPD's Hazardous Waste Permitting and Corrective Action section reviews permit applications and writes permits for hazardous and solid waste treatment, storage, disposal and recycling facilities. It also oversees corrective actions at various hazardous and solid waste sites.

Monitoring Requirements

Monitoring activities at RCRA facilities are sometimes done to assure that no hazardous constituents have contaminated groundwater and/or moved off-site. Monitoring parameters are usually dependent upon what types of wastes were used at a specific site. According to 40 CFR 264.90(a)(2) surface impoundments, waste piles, and land treatment unit or landfill that receives hazardous waste must participate in a groundwater monitoring program for the purposes of detecting, characterizing and responding to releases to the uppermost aquifer.

In 40 CFR 264.90(b) owner/operators regulated unit is not subject to a groundwater monitoring program if he operates a unit that is:

- An engineered structure; does not receive or contain liquid waste or waste containing free liquids;
- Is designed and operated to exclude liquid, precipitation, and other run-on and run-off;
- Has both inner and outer layers of containment enclosing the waste;
- Has a leak detection system built into each detection layer;
- The owner or operator will provide continuing operation and maintenance of these leak detection systems during the active life of the unit and the closure and post-closure care periods;
- To a reasonable degree of certainty, will not allow hazardous constituents to migrate beyond the outer containment layer prior to the end of the post-closure period.

If at any time these requirements are not met, a groundwater monitoring system shall be instituted. Monitoring requirements are shown in Table 35.

Monitoring Locations

Permitted RCRA facilities as well as Corrective Action cleanups are listed in Table 35. There are currently 49 RCRA facilities participating in a groundwater monitoring program.

Data Evaluation

Data evaluation is performed on a site-specific basis. Because the nature of groundwater contamination and fluid migration dynamics vary from site to site, it is not feasible to provide statewide trend analyses.

Actions Taken or Prescribed

Anytime a RCRA permitted facility has a statistically significant increase of a constituent in a downgradient monitoring well over the amount of the constituent found in an upgradient, background monitoring well, the facility must initiate either compliance monitoring or remediation.

Time Lines

Hazardous waste-related groundwater monitoring is an ongoing process.

Maps/Graphs/Tables

• Table 35. **RCRA Groundwater Monitoring Requirements.**

County	Project Name	Type Monitoring				No of Wells	Parameters Monitored	Monitoring Frequency	Reporting Frequency
		Investigation	Detection	Compliance	Remediation				
Canadian	El Reno Correctional Institution		X			5	VOC	Qtrly	Qtrly
	Gemini Coatings				X	10	VOC, SVOC	Qtrly	Qtrly
	Global Compression		X			9	VOC	Not estab	Not estab
	XEROX Corporation				X	46	VOC, SVOC	Semi-annual	Semi-annual
	Dowell				X	7	VOC	Semi-annual	Semi-annual
Carter	TPI Petroleum		X	X		28	Gen Chem	Qtrly	Qtrly
							Metals, VOC, SVOC	Semi-annual	Semi-annual
Comanche	Ferguson Dump		X			6	Metals, VOC	Annual	Annual
Creek	Kwikset Corporation	X				9	VOC, SVOC	N/A	N/A
Garfield	Vance AFB			X		80	VOC, SVOC	Semi-annual	Semi-annual
	Union Pacific Resources		X			7	Metals, VOC	Semi-annual	Semi-annual
	Advanced Food			X		5	VOC, SVOC	Semi-annual	Semi-annual
	Clean Clothes Rental				X	15	VOC, SVOC	Semi-annual	Semi-annual
Garvin	Wynnewood Refining Company		X			8	Gen chem, Metals, VOC, SVOC	Semi-annual	Semi-annual
Grady	Halliburton			X		7	Beta, Alpha, Radium, Nitrate, Fluoride	Semi-annual	Semi-annual
Jackson	Altus AFB		X			200	Metals, VOC	Semi-annual	Semi-annual
Kay	Conoco Ponca City Refinery				X	400	Gen chem, Metals, VOC, SVOC	Semi-annual	Semi-annual
Major	Safety-Kleen, Inc. Lone Mountain		X	X	X	63	Gen chem, Metals, VOC, SVOC	Semi-annual	Semi-annual
Mayes	Terra Nitrogen			X		2	Nitrates, VOC	Semi-annual	Annual
	Norit Americas		X			5	Gen chem, Metals, VOC, SVOC	Qtrly	Qtrly
McClain	Newcastle Land Co.				X	4	Metals, VOC, SVOC	Annual	Annual
McCurtain	Huffman Wood Preserving		X			7	N/A	None	None

County	Project Name	Type Monitoring				No of Wells	Parameters Monitored	Monitoring Frequency	Reporting Frequency
		Investigation	Detection	Compliance	Remediation				
	Mixon Brothers Wood Preserving		X			3	VOC, SVOC	Semi-annual	
	Thomason Lumber and Timber Co.		X			4	VOC, SVOC	Semi-annual	Semi-annual
Oklahoma	Lucent Technologies		X			64	VOC	Semi-annual	Semi-annual
	Unit Parts Corporation		X			36	VOC	Not estab.	Not estab.
	Tinker AFB		X		X	400	Metals, VOC	Semi-annual	Semi-annual
	Seagate Technology				X	18	VOC	Semi-annual	Semi-annual
	Madewell & Madewell, Inc.		X			8	Gen chem, Lead	Semi-annual	Semi-annual
	Safety-Kleen Systems Lindley St.				X	7	Gen chem, VOC, SVOC	Semi-annual	Semi-annual
	Chemical Products Devel. Corp.			X		6	VOC, SVOC	Semi-annual	Semi-annual
Ottawa	Eagle-Picher Electro-Optics Matls			X	X	14	Gen chem, Metals, VOC, SVOC	Qtrly	Qtrly
Payne	Moore Business Forms			X		11	VOC, SVOC	Semi-annual	Semi-annual
Pontotoc	Exxon Chemicals				X	1	Metals	Qtrly	Qtrly
	Texaco Group, Inc.				X	11	VOC, SVOC	Semi-annual	Qtrly
	J.P. Emco				X	21	VOC	Semi-annual	Semi-annual
Rogers	Centrilift				X	31	VOC, SVOC	Qtrly	Qtrly
Sequoyah	Cavenham Forest Industries		X			8	Gen chem, Metals, VOC, SVOC	Semi-annual	Semi-annual
Tulsa	Norris/O'Bannon			X		2	Metals	Qtrly	Qtrly
	U.S. Air Force Plant #3				X	19	VOC	Annual	Annual
	Perma-Fix Treatment Services				X	17	Gen chem, Metals, VOC, SVOC	Semi-annual	Semi-annual
	Crosby-McKissick			X		41	Gen chem, VOC, SVOC	Qtrly	Qtrly
	American Airlines				X	5	VOC	Semi-annual	Semi-annual
	Safety-Kleen, Inc.				X	37	VOC	Semi-annual	Semi-annual
Tulsa	Sunoco, Inc.		X			21	Gen chem, Metals, VOC, SVOC	Semi-annual	Semi-annual
	Ozark-Mahoning Co.				X	11	Gen chem, Metals, VOC, SVOC	Qtrly	Qtrly
	Sinclair Oil Corp.		X			22	Gen chem, Metals, VOC, SVOC	Semi-annual	Semi-annual
Washington	Zinc Corporation of America		X	X		25	Gen chem, Metals	Semi-annual	Semi-annual

County	Project Name	Type Monitoring				No of Wells	Parameters Monitored	Monitoring Frequency	Reporting Frequency
		Investigation	Detection	Compliance	Remediation				
Woods	Texaco Group, Inc. - Alva Site				X	3	VOC, SVOC	Qtrly	Qtrly
Woodward	Texaco Group, Inc. - Woodward Site				X	5	VOC, SVOC	Semi-annual	Semi-annual

Underground Injection Control (UIC)

Introduction

To increase groundwater protection, a federal Underground Injection Control (UIC) program was established under the provisions of the Safe Drinking Water Act of 1974. Since then, state and federal regulatory agencies have modified existing programs or developed new strategies to protect groundwater by establishing even more effective regulations to control permitting, construction, operation, monitoring and closure of injection wells. Delegation of the federal program to the State of Oklahoma can be found in 40 CFR 147, Subpart LL. Federal regulations for the UIC program can be found in 40 CFR 144-148. State Rules can be found in OAC 252:652.

Program Objectives

- To assess the impact of deep well-injection operations on the integrity of underground sources of drinking water.

Program Description

The UIC program at DEQ issues operating permits to Class I, Class III and Class V injection wells. They are as follows:

- Class I: Wells used to inject liquid hazardous and non-hazardous wastes beneath the lower-most Underground Source of Drinking Water (USDW).
- Class III: Wells used to inject fluids for the extraction of minerals.
- Class V: Wells not included in the other classes, generally injecting non-hazardous fluid into or above a USDW.

The two classes of wells not mentioned are Class II and Class IV. Class II wells are used to dispose of fluids associated with the production of oil and natural gas, enhanced oil recovery, and storage of liquid hydrocarbons, and are under the jurisdiction of the Oklahoma Corporation Commission. Class IV wells were historically used to dispose of hazardous or radioactive wastes into or above USDW. Class IV wells are now banned.

Monitoring Requirements

Monitoring requirements are shown in Table 35.

Monitoring Locations

OAC 252:652-7-1(4) states that at least one monitoring well shall be installed and maintained by the owner of a Class I injection facility. The wells must monitor the lowest underground source of drinking water beneath the site. The well(s) must also be located so that one or more wells are placed hydraulically downgradient from the site. OAC 252:652-9-1(3) states that the groundwater from monitoring wells must be analyzed for parameters specified in the permit at least once each month. The analyses and water levels must be submitted as part of the quarterly report. Class III and Class V well monitoring requirements are determined on a case-by-case basis (See Table 36).

Data Evaluation

Data evaluation is performed on a site-specific basis. Because the nature of groundwater contamination and fluid migration dynamics vary from site to site, it is not feasible to provide statewide trend analyses.

Actions Taken or Prescribed

If any constituents are detected in the monitoring well(s), specifically the well located in the USDW, injection would be stopped and an investigation conducted to determine how the constituent appeared in the monitoring well. After a determination, remediation would follow.

Time Lines

UIC groundwater monitoring is an ongoing process.

Maps/Graphs/Tables

• Table 36. **UIC Groundwater Monitoring Requirements.**

County	Project Name	Type Monitoring: Investigation	Detection	Compliance	Remediation	No of Wells	Parameters Monitored	Monitoring Frequency	Reporting Frequency
Beckham	Sayre Brine Station		X			22	Specific Electrical Conductance	Monthly Annual	Qtrly Qtrly
Creek	IMCO Recycling		X			1	Gen chem, Metals	Monthly	Qtrly
Mayes	Kaiser		X			5	NH_3, NO_3, Chlorides	Monthly	Qtrly
	Wil-Gro		X			28	NH_3, NO_3	Monthly Qtrly	Qtrly Qtrly
Oklahoma	Macklanburg-Duncan		X			1	Metals, Diss Solids, Specific Conductance	Monthly	Qtrly
Tulsa	American Airlines					18	Gen chem, Metals, VOC	Monthly Semi-annual	Qtrly Qtrly
	Boeing		X			1	Gen chem, Metals	Monthly	Qtrly
	Perma-Fix		X			1	VOC Metals, SVOC	Monthly Annual	Qtrly Qtrly
Washington	Zinc Corporation of America		X			1	Metals	Monthly	Qtrly

Radiation Management Program

Introduction

The Radiation Management Program implements state law and works closely with the Nuclear Regulatory Commission (NRC) to supervise the use of atomic energy and other sources of ionizing and non-ionizing radiation, exclusive of medical diagnostic X-ray.

Program Objectives

- To protect groundwater and surface water from degradation from activities past and present involving any processes associated with radioactive materials or devices.

Program Description

The Radiation Management Program is directly assisting OSU in groundwater monitoring where radioactive waste was buried in the past. The Radiation Management Program also assists the NRC in reviewing data for facilities under NRC jurisdiction in Oklahoma.

Monitoring Requirements

Currently this program conducts water quality monitoring at only one facility in Oklahoma. Monitoring requirements are shown in Table 37.

Monitoring Locations

Currently, this program conducts water quality monitoring at only one facility in Oklahoma, as shown in Table 37.

Data Evaluation

The parameters monitored during each semi-annual sampling event are being evaluated against applicable standards. Exceedances of the criteria are being assessed to determine the extent of contamination and appropriate corrective measures to be taken. The future sampling data will then be utilized to determine effectiveness of the corrective measures.

Actions Taken or Prescribed

Certain parameters have triggered additional investigation in evaluating the extent of contamination.

Time Lines

This will be a permanent program until the site(s) are deemed closed or remediated.

Maps/Graphs/Tables

- Table 37. **Radiation Management Monitoring Requirements.**

County	Project Name	Type Monitoring				No of Wells	Parameters Monitored	Monitoring Frequency	Reporting Frequency
		Investigation	Detection	Compliance	Remediation				
Payne	Oklahoma State University		X	X		1	Radionuclides, Gen chem, Metals, VOC, SVOC	Semi-annual	Semi-annual

Brownfields Voluntary Redevelopment and Superfund Program

Introduction

Superfund

CERCLA was enacted in 1980, creating a large-scale national program to identify and clean up sites contaminated from previous hazardous waste management practices. This effort is now known as

Superfund because CERCLA established a national revolving fund to pay for cleanup at sites whose owners were no longer available or financially solvent. CERCLA also established a mechanism to recover cleanup costs from potentially responsible parties (PRPs). CERCLA was amended by SARA in 1986.

The DEQ conducts and oversees site assessment and remediation activities at many sites that fall under CERCLA/SARA in Oklahoma. Twelve sites in Oklahoma are on EPA's National Priorities List (NPL), which ranks sites for cleanup, based on the actual or potential risks posed to human health and the environment.

Brownfields

Brownfields are abandoned, idled or underused industrial or commercial facilities or other real property where expansion or redevelopment of the real property is complicated by environmental contamination caused by regulated substances. Abandonment of these properties has largely been attributed to CERCLA/Superfund, which was designed to clean up contaminated property. CERCLA provides for strict, joint and severable liability for any environmental contamination at a site. This means that anyone who deposited hazardous waste at a site, owned or leased the site, acquired title to the site via foreclosure, and certain other persons could be held accountable for the entire cost of cleanup. Lenders, purchasers, and developers, unwilling to become PRPs at existing sites, have turned to building new industrial facilities in "greenfields" (undeveloped natural areas and farmland). The desertion of brownfield areas for greenfields has contributed to unemployment, a depressed tax base, underuse of existing infrastructure, environmental degradation, urban blight and urban sprawl.

The Oklahoma Brownfields Voluntary Redevelopment Act (27A O.S. §2-15-101 *et seq.*) was signed into law on June 14, 1996, establishing a voluntary cleanup program to foster the voluntary redevelopment and reuse of brownfields by limiting liability. The law provides prospective purchasers, lenders, insurers, and other future owners some assurance that the environmental issues at these sites have been properly addressed and, therefore, the liability issues also. The limited liability protection provided by the law may be dependent upon successful completion of a risk-based environmental cleanup. The law does not negate the rights of any other person from pursuing other legal action. The DEQ has been given the responsibility of implementing this program. Implementing rules were adopted by the Environmental Quality Board on January 28, 1997, and were signed by Governor Keating on March 18, 1997.

Program Objectives

- To determine the nature and extent of groundwater and, in certain instances, surface water pollution.
- To monitor natural attenuation of groundwater pollutant plumes.
- As a site progresses from investigation to cleanup, to monitor the effectiveness of cleanup activities and remediation efforts.
- To pursue active remediation to remove pollution source and reuse groundwater where feasible.

Program Description

Most Superfund sites have had releases to groundwater. Many of the groundwater wells at a site are installed to identify and quantify the nature and extent of the pollution. As these sites proceed toward cleanup, the wells are used to monitor the effectiveness of remedial activities, to monitor natural attenuation of pollutants in the groundwater, and to actively remediate the groundwater, such as a series of pump-and-treat wells. Monitoring activities at Brownfield sites is very similar to that for Superfund sites.

Monitoring Requirements

Monitoring requirements for Superfund and Brownfield sites are shown in Table 38.

Monitoring Locations

Monitoring locations for Superfund and Brownfield sites are shown in Table 38.

Data Evaluation

Data evaluation is performed individually on each Superfund and Brownfield site. For Superfund sites, because of the typical long-term nature of the investigation and remediation process, it is generally too early to determine long term trends at each site. Each site typically establishes a baseline to use in trend analysis as remediation progresses. For Brownfield sites, groundwater monitoring is continued as long as data shows an increase, no decrease, or migration of contaminants.

Actions Taken or Prescribed

At Superfund sites, groundwater monitoring requirements are terminated only when analysis demonstrates there is no longer a problem. For Brownfield sites that show improved groundwater quality and/or have demonstrated that there is not a problem, monitoring requirements may be terminated and wells plugged.

Time Lines

Many Superfund and Brownfield sites require long term monitoring of five years or more. The DEQ relies heavily on federal money, awarded as cooperative agreements, to implement pre-remedial and remedial activities at the Superfund sites. The state must contribute a 10% match on all remediation activities, unless they are funded by private parties. The DEQ's Brownfield program relies on reimbursement from PRPs for the state's oversight costs. The EPA provides limited funding for continued program development.

Maps/Graphs/Tables

• Table 38. **Brownfields/Superfund Surface Water and Groundwater Monitoring Requirements.**

County	Facility/Site Name	Media [a]	Type Monitoring				No. of Sources	Parameters Monitored	Monitoring Frequency	Reporting Frequency	Other Remarks
			Investigation	Detection	Compliance	Remediation					
Beaver	Colorado Interstate Gas	GW			X		4	BTEX	Semi-annual	Semi-annual	
	Warren Petroleum	GW			X		5	BTEX	Semi-annual	Semi-annual	
Caddo	Oklahoma Refining Co.	GW				X	19	Metals, VOC, SVOC	Annual	Annual	Rush Springs Sandstone
		GW				X	56	Free phase	Qtrly	Qtrly	For presence of LNAPL
		SW				X	10	Metals, VOC, SVOC	As needed	As needed	Gladys Creek plus north and south tributaries
		SED				X	10	Metals, VOC, SVOC	As needed	As needed	
Canadian	Altec Lansing	GW			X		10	Chlor solvents	Qtrly	Qtrly	
Carter	Mobil – Bumpass	GW		X			14	BTEX, TPH	Semi-annual	Annual	
		GW				X	4	BTEX, TPH	Semi-annual	Annual	
	Mobil – E. Hewitt	GW		X			10	BTEX, TPH	Annual	Annual	
	Mobil - Fox	GW		X			33	BTEX, TPH	Semi-annual	Annual	
		GW				X	12	BTEX, TPH	Semi-annual	Annual	
Comanche	Fort Sill	GW				X	44	Metals, VOC	Semi-annual	Semi-annual	
Creek	Quaker Chemical	GW			X		8	Chlor solvents	Qtrly	Qtrly	
Garfield	David Allen Ballpark	GW			X		3	TPH	Qtrly	Qtrly	
	Dowell-Schlumberger	GW				X	16	Metals, VOC, SVOC	Qtrly	Semi-annual	
	Farmland Industries	GW				X	14	VOC	Qtrly	Qtrly	
Garvin	Mobil – Bradley	GW		X			53	BTEX, TPH	Semi-annual	Annual	
		GW				X	20	BTEX, TPH	Semi-annual	Annual	

[a] Water media: Groundwater (GW), Surface water (SW) and sediment (SED).

(continued)

County	Facility/Site Name	Media [a]	Type Monitoring: Investigation	Detection	Compliance	Remediation	No. of Sources	Parameters Monitored	Monitoring Frequency	Reporting Frequency	Other Remarks
Grady	Mobil – Hughes	GW		X			17	BTEX, TPH	Annual	Annual	
	Mobil – W. Chitwood	GW		X			2	BTEX, TPH	Annual	Annual	
	Mobil - Chitwood	GW		X			47	BTEX, TPH	Semi-annual	Annual	
		GW				X	20	BTEX, TPH	Semi-annual	Annual	
Jackson	Clinton-Sherman Industrial Park	GW				X	138	Metals, VOC	As needed	As needed	
Kay	Blackwell Zinc	GW		X			34	Metals	Monthly	Qtrly	18 onsite, 16 offsite, Chicaskia River aquifer
		SW		X			6	Metals	Qtrly	Qtrly	5 on Ferguson Ave trib, 1 on Chicaskia River
Kingfisher	UPRR	GW				X	13 of 17	VOC, Carbon Tetrachloride	Once/4 mo.	Once/4 mo.	Cimarron River alluvium (13 of 17 wells monitored)
		SW				X	1	VOC, Carbon Tetrachloride	Once/4 mo.	Once/4 mo.	Cimarron River
LeFlore	Rab Valley Wood Preserving	GW	X				16	Metals, VOC, SVOC	As needed	As needed	
		SW	X				11	Metals, VOC, SVOC	As needed	As needed	
Major	Mesa Willey	GW				X	8	Chlorides	Qtrly	Qtrly	
McClain	Hardage/Criner NPL	GW				X	30	VOC	Annual	Annual	Shallow unnamed
		GW				X	41	Water level	Daily	Annual	Shallow unnamed
		GW				X	77	Water level	Qtrly	Annual	Shallow unnamed
		GW				X	2	Water level	Monthly	Annual	Shallow unnamed
McCurtain	Weyerhauser Wright City Mill	GW		X			10	Gen chem, Iron, Chlorides, Pentachlorophenol	Semi-annual	Semi-annual	Quarternary terrace deposits
		SW	X				1	Gen chem, Iron, Chlorides, Pentachlorophenol	As needed	As needed	Little River
Murray	Halliburton	GW			X		24	Chlor solvents	Qtrly	Qtrly	

[A] WATER MEDIA: GROUNDWATER (GW), SURFACE WATER (SW) AND SEDIMENT (SED).

(CONTINUED)

County	Facility/Site Name	Media [a]	Type Monitoring: Investigation	Detection	Compliance	Remediation	No. of Sources	Parameters Monitored	Monitoring Frequency	Reporting Frequency	Other Remarks
Oklahoma	Casady Square	c			X		4	Chlor solvents	Qtrly	Qtrly	
	COTPA	GW	X				11	BTEX, VOC, chlor solvents	One-time	One-time	Alluvium (additional wells to be installed as site progresses)
	Double Eagle Superfund Site	GW				X	7	Gen chem, Metals, VOC	Qtrly	Qtrly	Garber-Wellington Monitor semi-annual after 3/2000
	Fourth Street Superfund Site	GW				X	6	Gen chem, Metals, VOC	Qtrly	Qtrly	Garber-Wellington Monitor semi-annual after 3/2000
	FAA Monroney Aeronautical Ctr	GW				X	17	Gen chem, VOC	Semi-annual	Semi-annual	Bison shale Natural attenuation
	KM Tech	GW				X	12	Inorganics, VOC,	Annual	Annual	Henessey residium
	LD Rhodes	GW				X	3	BTEX, TPH, VOC, SVOC	Qtrly	Qtrly	N Canadian alluvium
	Mid American Chem	GW	X				1 of 2	BTEX, TPH, VOC, SVOC	Annual	Annual	N Canadian alluvium (1 of 2 wells being monitored)
	Mosley Road	GW		X			14	Gen chem, VOC, SVOC,	Semi-annual	Semi-annual	Garber-Wellington alluvium
		SW		X			1	Gen chem, VOC, SVOC,	Annual	Annual	Pond (former borrow pit)
	Sooner State Ford Truck Sales	GW			X		3	TPH	Un decided	Un decided	
	Summit Tool	GW			X		4	VOC	Un decided	Un decided	
	Tenth Street	GW				X	5	Polychlor biphenyls	Annual	5-yr review	
	Tinker AFB NPL	GW				X	175	Metals, VOC	Semi-annual	Annual	Garber-Wellington
	Tinker AFB RCRA	GW				X	865	VOC	Annual	Annual	Garber-Wellington
	Tinker AFB	GW				X	60	VOC	Semi-annual	Annual	Garber-Wellington
Okmulgee	Okmulgee Refinery	GW				X	15	Metals, VOC, SVOC	As needed	As needed	
Osage	Cleveland	GW				X	119	Metals, VOC, SVOC	As needed	As needed	

[A] WATER MEDIA: GROUNDWATER (GW), SURFACE WATER (SW) AND SEDIMENT (SED).

(CONTINUED)

County	Facility/Site Name	Media [a]	Type Monitoring				No. of Sources	Parameters Monitored	Monitoring Frequency	Reporting Frequency	Other Remarks
			Investigation	Detection	Compliance	Remediation					
Ottawa	BF Goodrich – Michelin	GW				X	24	VOC, SVOC	As needed	As needed	
	Tar Creek	GW				X	5 of 6	Gen chem, Metals	Qtrly	Qtrly	Roubidoux (5 of 6 wells being monitored, more to be installed)
		SW				X	0 of 49	Gen chem, Metals	N/A	N/A	Tar Creek
Pawnee	BNSF	GW				X	8	Metals, VOC, SVOC	As needed	As needed	
Payne	Kerr-McGee Cushing Refinery	GW	X				70	Gen chem, Metals, VOC, SVOC, Th, U, Ra	As needed	As needed	Vanoss group
		SW	X				9	Gen chem, Metals, VOC, SVOC, Th, U, Ra	As needed	As needed	Skull Creek and tributaries
Pottawatomie	Mobil Chem Midwest Films	GW				X	19	VOC	Semi-annual	Semi-annual	
Sequoyah	Coltec	GW				X	9	Metals, VOC, SVOC	Qtrly	Semi-annual	
Stephens	Duncan Refinery	GW	X				20	Metals, VOC, SVOC	As needed	As needed	Garber-Wellington and alluvium
		SW	X				4	Metals, VOC, SVOC	As needed	As needed	Claridy Crk and north trib to creek
	Mobil – Doyle	GW		X			36	BTEX, TPH	Semi-annual	Annual	
		GW				X	15	BTEX, TPH	Semi-annual	Annual	
	Mobil – Sholem - Alochem	GW		X			44	BTEX, TPH	Semi-annual	Annual	
		GW				X	24	BTEX, TPH	Semi-annual	Annual	
Tulsa	BNSF – Tulsa	GW				X	22	Metals, VOC, SVOC	As needed	As needed	
	Facet International	GW				X	26	Chlor solvents	Qtrly	Qtrly	
	Kerr Glass	GW				X	5	Gen chem, Metals	Semi-annual	Semi-annual	
	Labarge Electronics	GW				X	10	VOC	Semi-annual	Semi-annual	
	Nalco/Exxon	GW				X	8	Metals, VOC, SVOC	Semi-annual	Semi-annual	

[A] WATER MEDIA: GROUNDWATER (GW), SURFACE WATER (SW) AND SEDIMENT (SED).

(CONTINUED)

County	Facility/Site Name	Media [a]	Type Monitoring: Investigation	Detection	Compliance	Remediation	No. of Sources	Parameters Monitored	Monitoring Frequency	Reporting Frequency	Other Remarks
Tulsa	Norris Sucker Rod	GW				X	39	VOC	Semi-annual	Semi-annual	
	Sand Springs Petrochemical	GW				X	9	Metals, VOC	Annual	Annual	
Wagoner	UNARCO	GW			X		26	Chromium	Qtrly	Qtrly	
Washita	Clinton Sherman Industrial Park	GW	X				125	Gen chem, Metals, VOC, SVOC, TOC, TPH, Herbicides	As needed	As needed	Elk City Sandstone and Doxy Shale
		SW	X				15	Gen chem, Metals, VOC, SVOC, TOC, TPH, Herbicides	As needed	As needed	

[a] Water media: Groundwater

CHAPTER

4

WATER QUALITY MONITORING DONE BY THE OKLAHOMA CORPORATION COMMISSION

General Information

The Corporation Commission does four types of environmental monitoring:

1. Soil sampling at spill and other potential pollution case sites;
2. Well water sampling near spill and other potential pollution case sites;
3. Stream water sampling near spill and other potential pollution case sites; and
4. Spring, stream, and other surface water sampling in historic oilfield areas, to determine the overall impact of historical oilfield activity on the waters of the state.

Petroleum Storage Tank Division

The Commission's Petroleum Storage Tank Division (PST) has handled thousands of spill and leaking tank cases. A case is only opened when there is soil and likely ground or surface water petroleum contamination outside of the tank pit. 1156 cases are currently active, with 107 underground storage tank and three aboveground storage tank new cases initiated in 1999; 1916 cases have been closed since the program began in 1987.

Monitoring in each case is usually done by consultants hired by the tank owner or other responsible party (RP). Almost all of the cases have had 4 to 15 monitoring wells installed to delineate the extent of any groundwater pollution plume, the amount/concentrations of pollutants present, and to determine the best remedial option(s). No database with the total number of samples or their results has been made. Most of the water samples collected are analyzed for pollutants typically found in gasoline and diesel spills, including benzene, toluene, ethyl-benzene, xylenes, and naphthalene. Each monitoring well has usually been sampled quarterly for at least one year; surface water sampling is done only if there is a nearby stream likely to be impacted. During 1999, seventeen (17) streams were identified as being threatened or impaired by leaking underground storage tanks.

Oil & Gas Conservation Division

Since November 1995 Commission Oil & Gas Conservation Division (Oil &Gas) staff have taken 921 water samples from possibly impacted wells and borings, 277 of which were taken in 1999, and (with help from cooperators) 1150 samples from springs and streams. During 1999 this current and historic data was compiled into two databases, one for subsurface water sampling and one for surface water sampling, containing both water sampling locations and field and/or analytical results.

Until late 1998 all of the surface water sampling done was associated with specific oilfield and pipeline pollution cases. Since 1998 the Commission has undertaken an active program, in association with the Oklahoma Water Resources Board (OWRB), to evaluate possible oilfield impacts on the waters of the state.

Monitoring Program Statistics

Of the 826 non-PST surface water samples taken for field or laboratory analysis during 1999 (up to 12 samples per water body over one calendar year, to determine seasonal changes):

- 338 samples were taken to evaluate 43 streams on the 1996 federal Environmental Protection Agency's (EPA's) 303d list of allegedly threatened and impaired water bodies, to determine if they were actually affected. These streams were alleged to have an oil & gas related source;

- 256 samples were taken to evaluate 34 streams on the 1998 (and 1996) 303d list, to determine whether or not they are actually impaired. These streams were also alleged to have an oil & gas related source;

- 53 samples were taken to evaluate six streams in the Lake Oolagah watershed identified as Priority I in the 1998 Unified Watershed Assessment (UWA) report;

- 116 samples (typically, one to four samples per stream and tributaries) were taken in suspect streams in oilfield areas; and

- 77 samples (again, one to four samples per pond or stream and tributaries) were taken to evaluate water bodies that may have been impacted by known spill site cases.

- 594 of the 826 samples were taken by OWRB, mainly for the UWA and 303d streams; the rest were taken by Commission staff. OWRB is continuing to sample their streams for a few more months, to complete 12 months of sampling, before starting to sample different streams for the year 2000 program (see below).

In addition,

- Eight (8) samples were taken by responsible parties' (RP's) consulting companies to evaluate streams near their possibly oilfield related pollution sites, and

- Dr. Harris at the University of Tulsa made the data his group collected for the Seminole Nation of Oklahoma from 45 stream and lake locations in Seminole County available to us.

Approximately 278 different stream, pond, and lake surface water segments have been sampled for the various Commission projects and by the University of Tulsa, including the 17 PST identified streams (but not other non-impacted streams sampled by RPs for the PST division). A water body segment extends for up to 25 miles along a stream, and includes tributaries that are not themselves large enough to qualify for a separate OWRB segment number. Larger streams and rivers are thus divided into several different segments. When tributaries to a particular stream segment or lake are sampled, they are counted as being in the same water body segment as the main stream.

Altogether:

- 178 different surface water bodies have been sampled by the Commission (Oil & Gas), the University of Tulsa, and a few by OWRB as suspects in historic problem areas or as part of case investigations. 85 of these segments had at least one sample taken during1999;
- Six streams were sampled by the Commission and OWRB during 1999 as part of the UWA watershed investigation;
- 43 streams on the 1996 federal Environmental Protection Agency's (EPA's) 303d list were sampled by the Commission and OWRB during 1999;
- 34 streams on the 1998 (and 1996) 303d list, were sampled by the Commission and OWRB during 1999; and
- 17 streams were identified as threatened (13) or impaired (4) by the PST division during 1999.

Conclusions

These evaluations have demonstrated that:

- 21 of the evaluated EPA 1998 listed 303d streams are fully (16) or partially (5) supporting their designated beneficial uses as defined in OWRB's state water quality standards, and can be removed from future federal 303d lists of impaired streams.
- 39 of the 1996 listed 303d streams are also fully (32) or partially (7) supporting their designated beneficial uses, confirming that they were correctly removed from the 1998 303d list.
- Six of the 1996 listed streams will have to be put back on the (year 2000) 303d list, several for problems not known in the original 1996 listing.
- Five of the six Oolagah UWA streams were found to have salinity problems requiring placement on the year 2000 303d list, and another stream in this area already on the 303d list for other reasons was also found to have salinity problems.
- Four of the 17 streams identified by PST will be placed on the year 2000 303d list; the other 13 will be put on the threatened/partially impaired list for two years and will then be re-evaluated.
- 68 of the streams evaluated as part of the suspect stream investigation project or case investigations, or 38%, were found to have pollution problems exceeding state water quality standards in at least one sample. Since these water bodies were selected for sampling on the basis of known pollution problems nearby, a significant percent was expected to be impacted.

- 13 of these impacted suspect/case water bodies sampled have had sufficient seasonal sampling to determine actual impairment (greater than 25% of 10 samples exceeding state water quality standards, or at least three samples if fewer than 10 samples were taken), and will be placed on the year 2000 303d impaired list.

- Another 55 of the impacted suspect/case water bodies sampled had one or two samples exceeding state water quality standards, and will be placed on the partially supporting/threatened list for two years.

- These 55 streams will be nominated for the year 2000 water monitoring program, to be done by the Commission and OWRB, in order to obtain enough data to determine whether or not they are impaired.

Plans for 2000

During 2000, the Commission expects to continue its routine case-related PST and Oil & Gas monitoring programs. Additional suspect streams in historic oil and gas producing areas will be targeted for a few rounds of sampling, to identify those likely to be exceeding water quality standards. The OWRB will be asked to monitor streams on the 1996 and 1998 303d list alleged to have an oil & gas related source that have not been sufficiently monitored to date, and streams which have been identified during 1999 as likely exceeding standards where there is not enough data as yet to determine actual impairment.

Chapter

5

WATER QUALITY MONITORING PROGRAMS AT THE OKLAHOMA DEPARTMENT OF AGRICULTURE (ODA)

Water Quality Monitoring by ODA Plant Industry and Consumer Services

The Oklahoma Department of Agriculture Plant Industry and Consumer Services have been delegate the responsibility of monitoring the uses of pesticides and fertilizers and their threat to the contamination the waters of the State.

At the present time we have the Illinois River Irrigation Tailwater Project and sampling water that is suspected to be contaminated from a pesticide spill or misuse.

The Illinois River Irrigation Tailwater Project involves the sampling of irrigation tailwater return flow, surface water and groundwater at three nurseries on the Illinois River and one near Lake Fort Gibson in Cherokee County. This project has been ongoing since 1989.

The Plant Industry and Consumer Services is responsible for the investigation of fertilizer spills and pesticide misuse. Often these investigations involve the monitoring of both surface and groundwater to determine if contamination has occurred. These investigations are performed when a complaint or inquiry is made to our office.

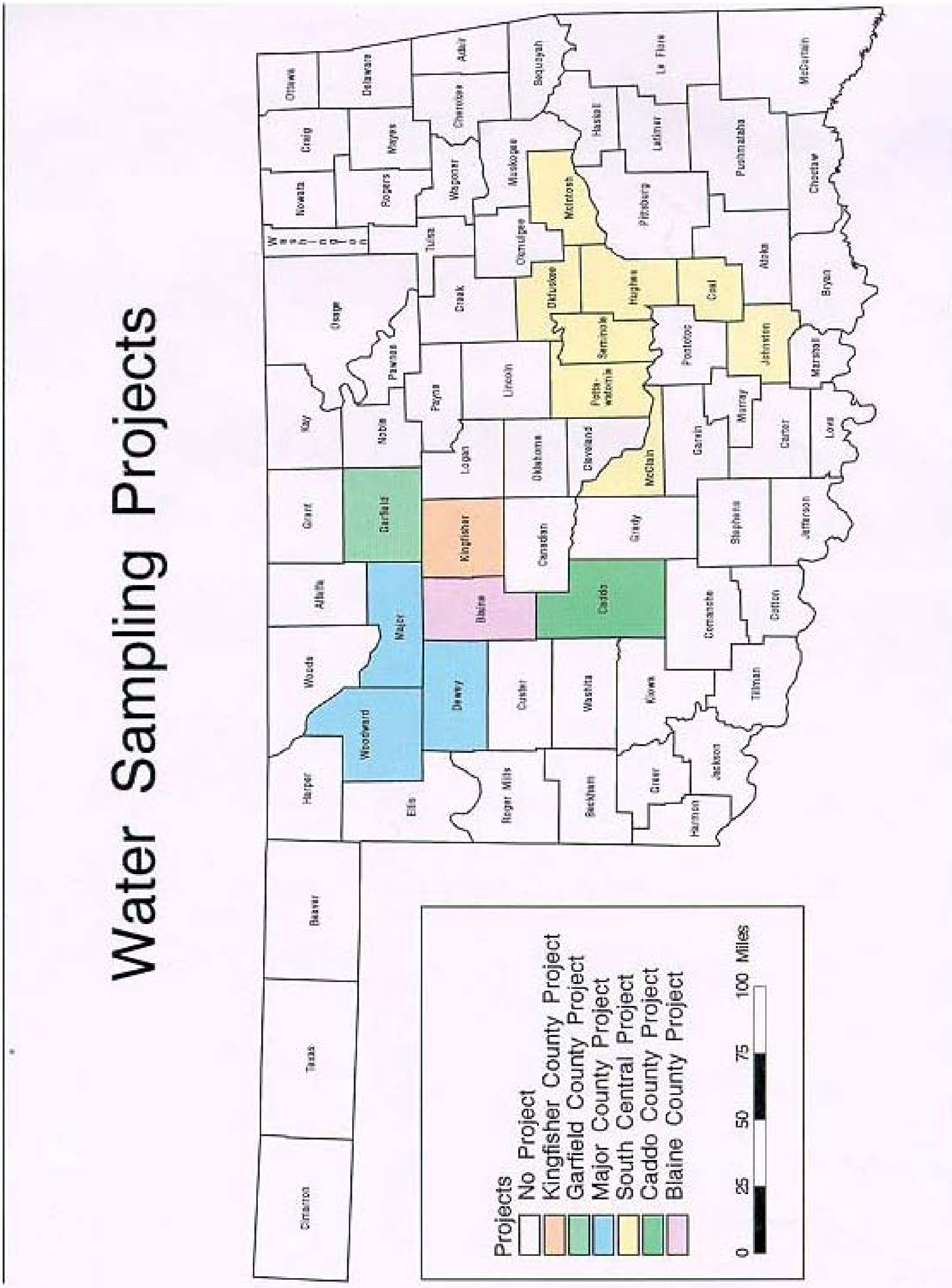
Water Quality Services Monitoring Well Project

Senate Bill 1175 of 1998 requires all Licensed Managed Feeding Operations (LMFOs) to install monitoring wells or leak detection systems around all waste retention structures. An LMFO is any facility using a liquid waste management system and housing more than 1,000 animal units of swine in a roof covered structure. Monitoring wells were required to be installed by September 1, 1999. The initial sampling of those wells should be completed by July 1, 2000. At that time, the Department's Water Quality Services Division will have new data on each LMFO site.

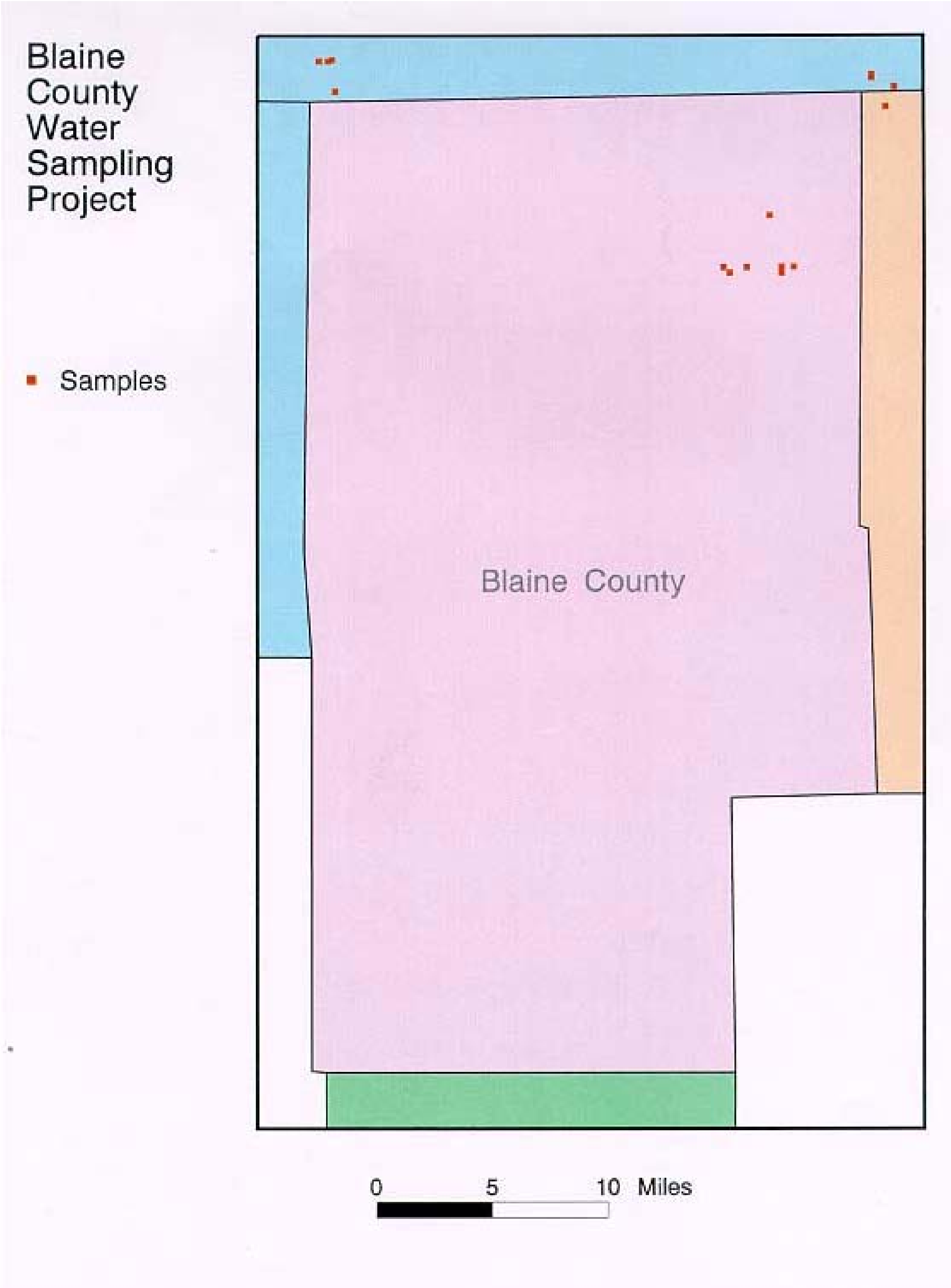
Water Quality Division - Routine Area/County Water Monitoring Projects

Due to the concerns arising from an increasing number of concentrated animal feeding operations being located in the state, the Oklahoma Department of Agriculture began two water monitoring projects in 1991 adjacent to several animal feeding/operation sites. By 1995, the number of projects had grown to eight, involving sites in 19 counties. Currently there are 138 active sites (129 ground water and II surface water). Twenty-two of these sites are located on the premises of animal feeding operations and five are rural water district or municipality wells.

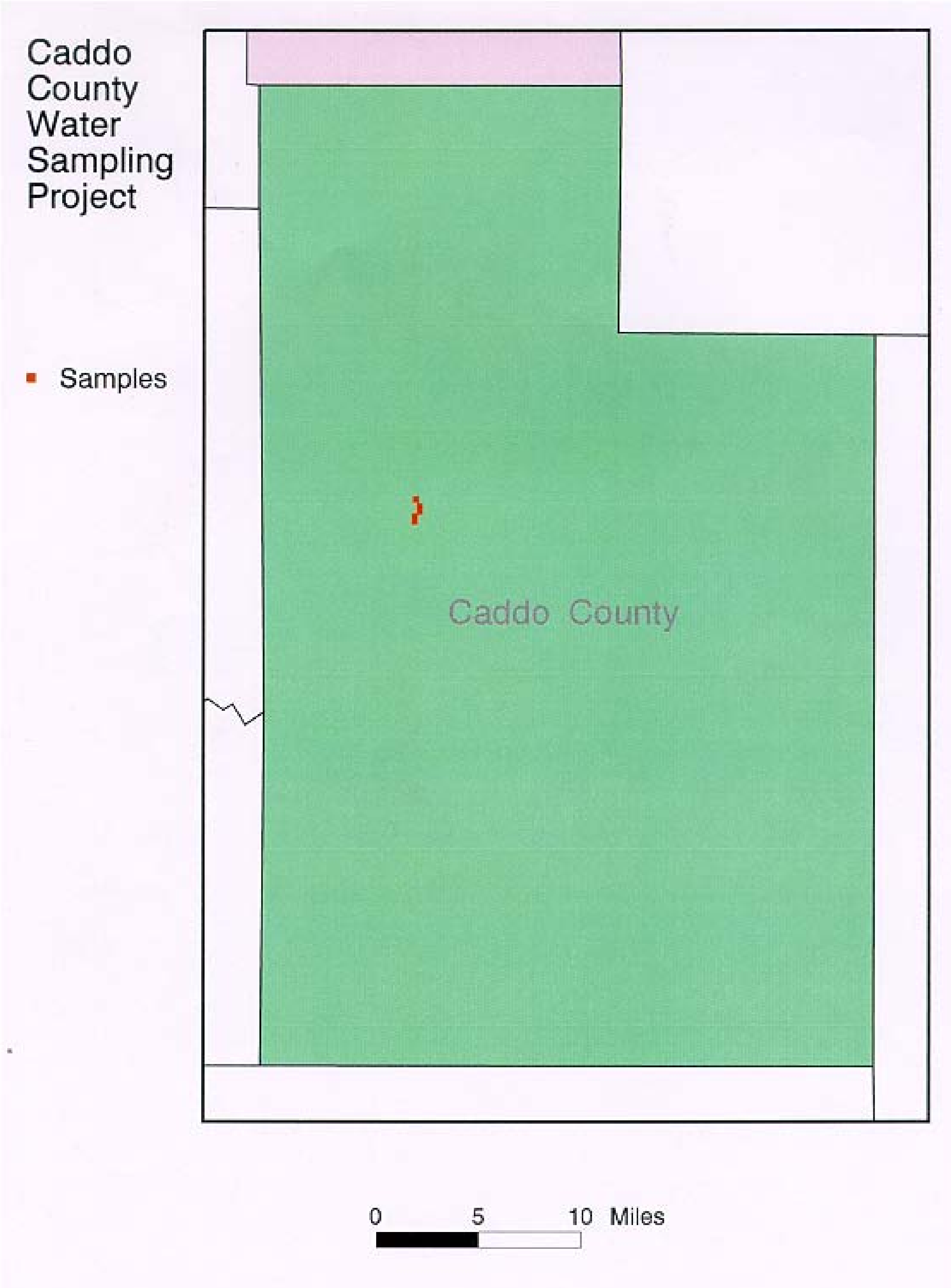
Samples are collected from the sites three to four times per year. The collections are carried out with the assistance of other divisions within the Department because of the man-hour requirements of the process. Due to the concern of potential contamination by nutrients related to these facilities, the primary parameters tested are nitrate-nitrogen and total phosphorus. Sites which have tested high for either nutrient are generally investigated more thoroughly, including the testing of additional parameters. Sites with historically high nitrate levels are occasionally tested for Kjeldahl nitrogen to ensure the levels are not the result of introduction of nitrates by organic sources.



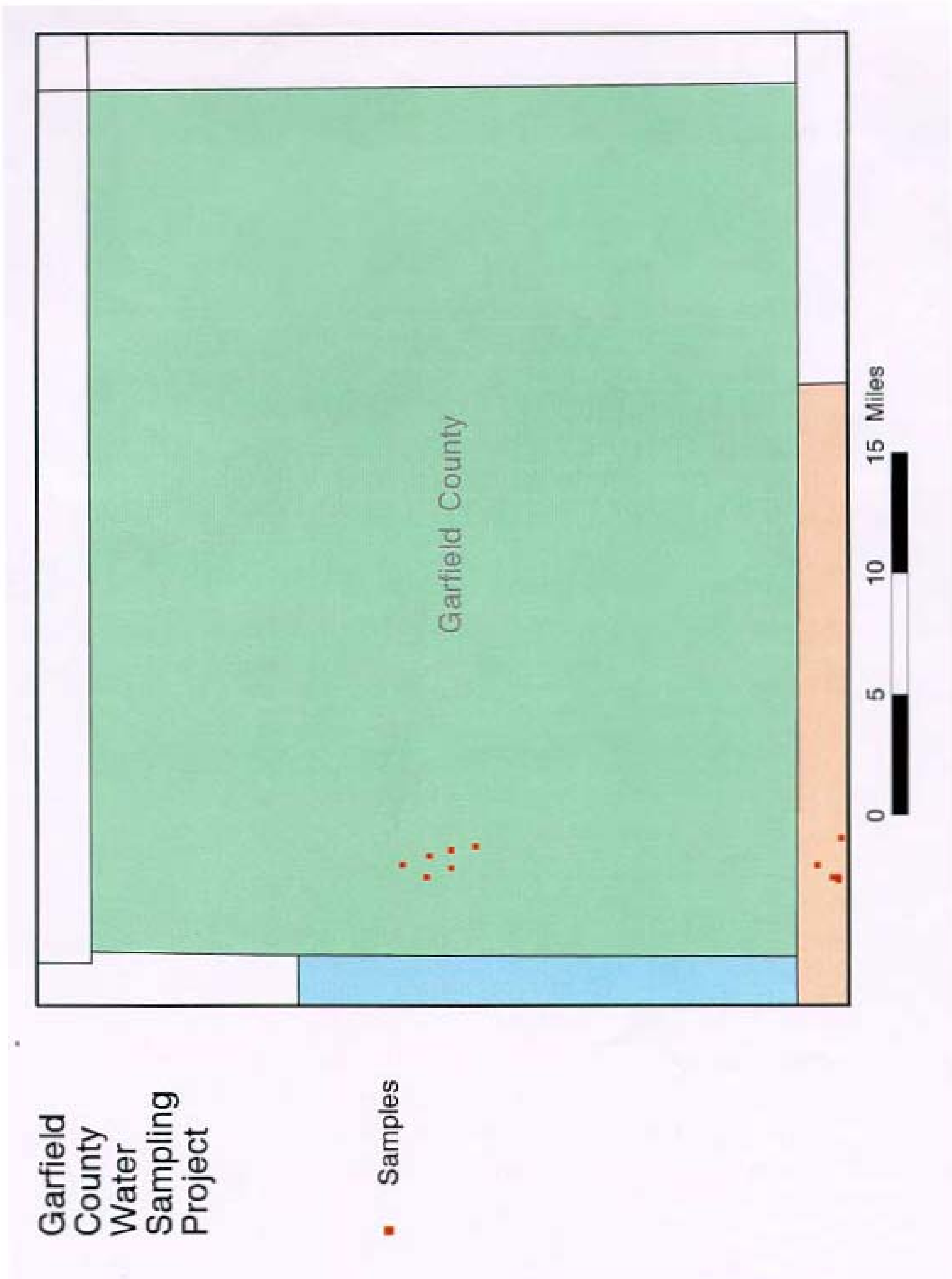
• Figure 14. **Water Sampling Projects of the Oklahoma Department of Agriculture.**



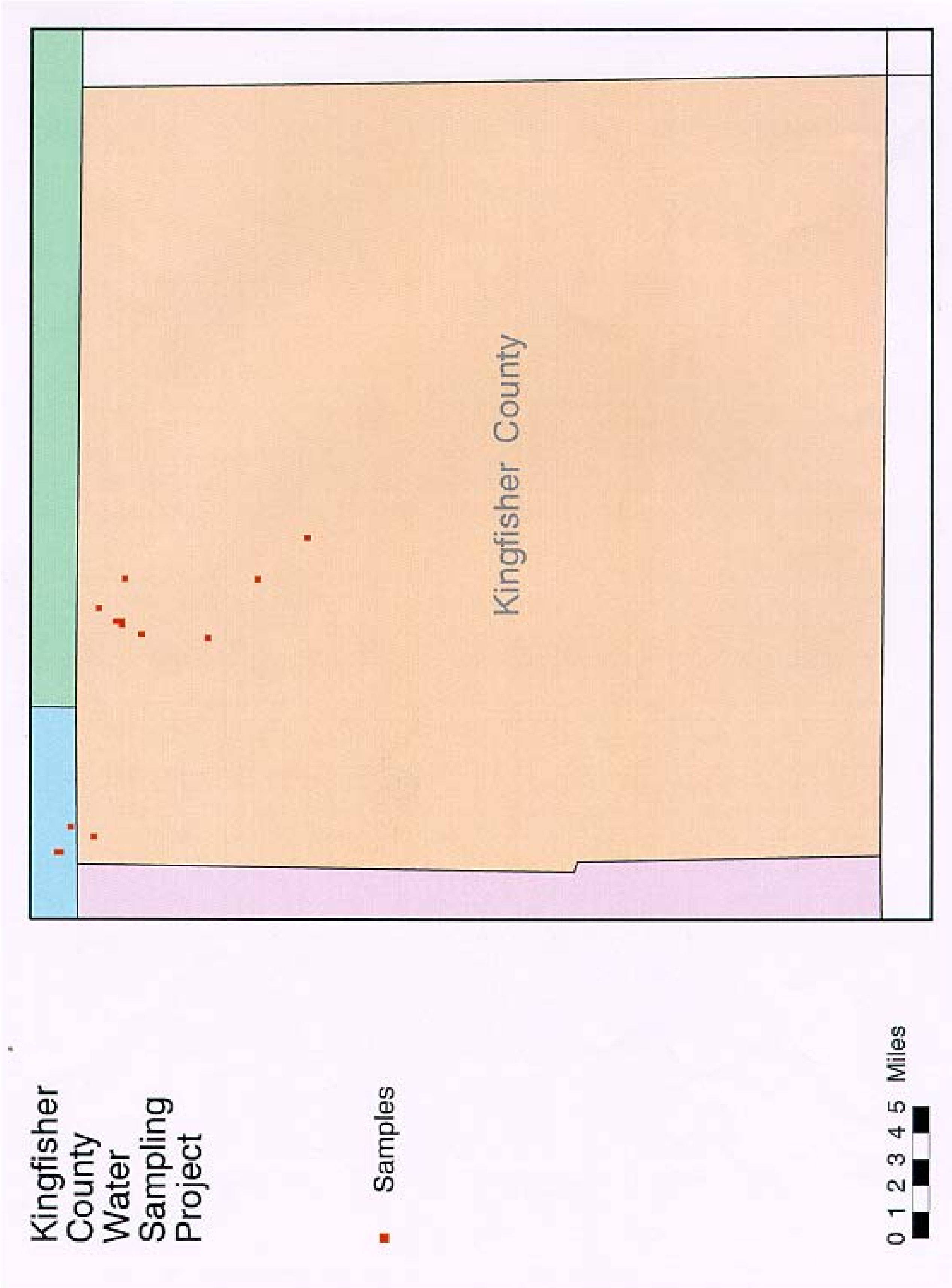
• Figure 15. **Blaine County Water Sampling Project.**



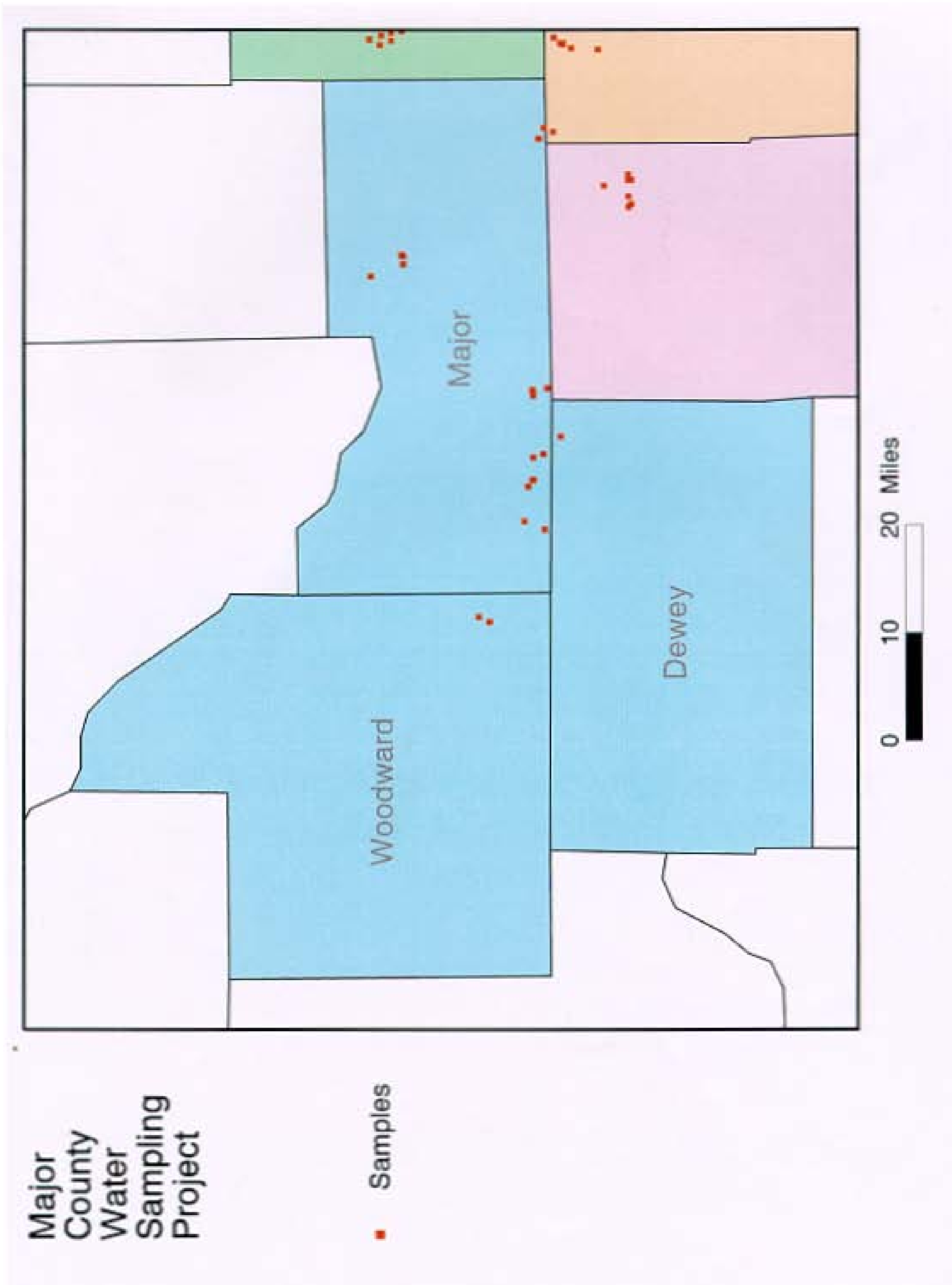
•Figure 16. **Caddo County Water Sampling Project.**



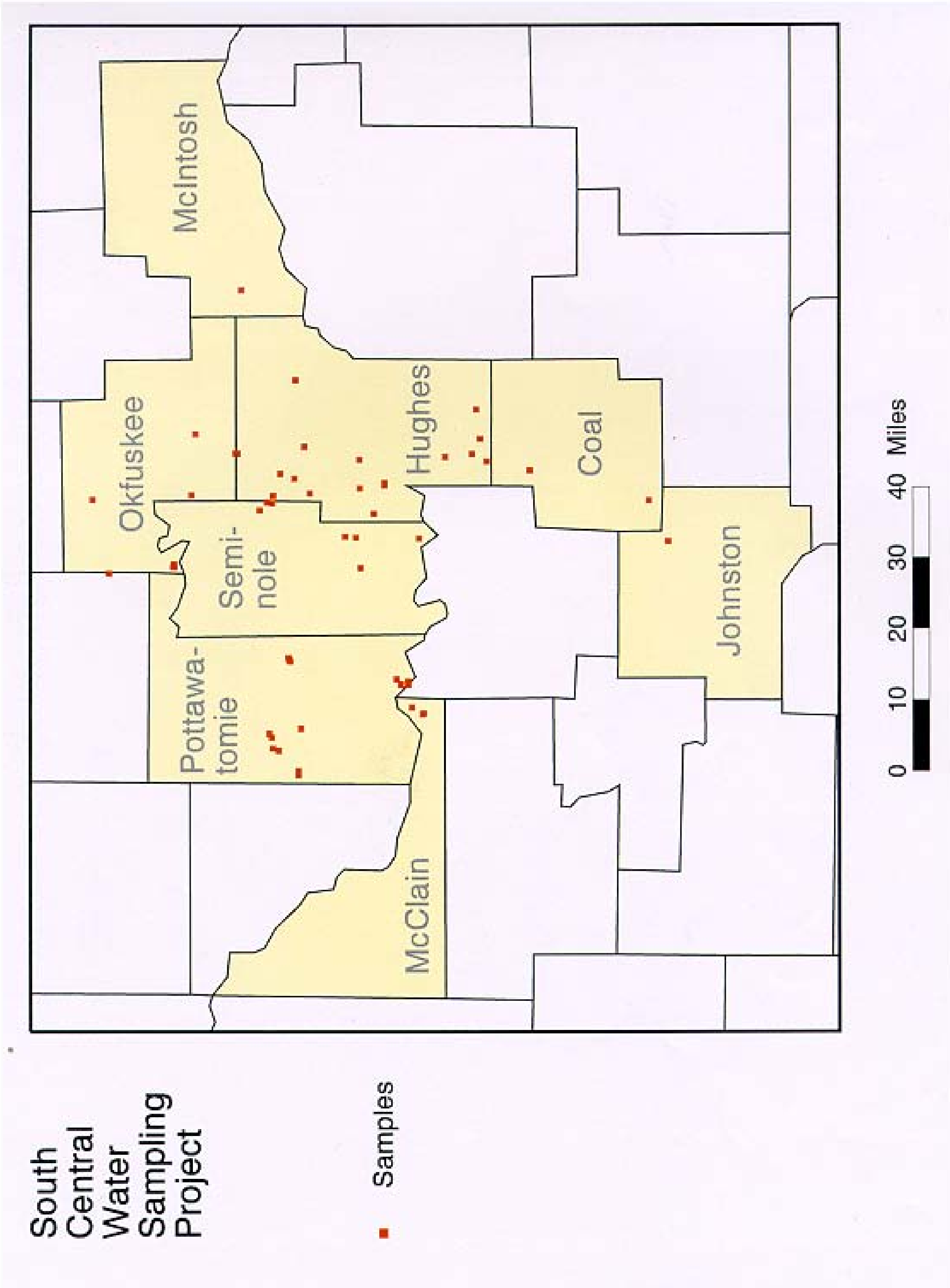
•Figure 17. **Garfield County Water Sampling Project.**



• Figure 18. **Kingfisher County Water Sampling Project.**



• Figure 19. **Major County Water Sampling Project.**



• Figure 20. **South-Central Water Sampling Project.**

Chapter

6

WATER QUALITY MONITORING PROGRAMS AT THE UNITED STATES GEOLOGICAL SURVEY

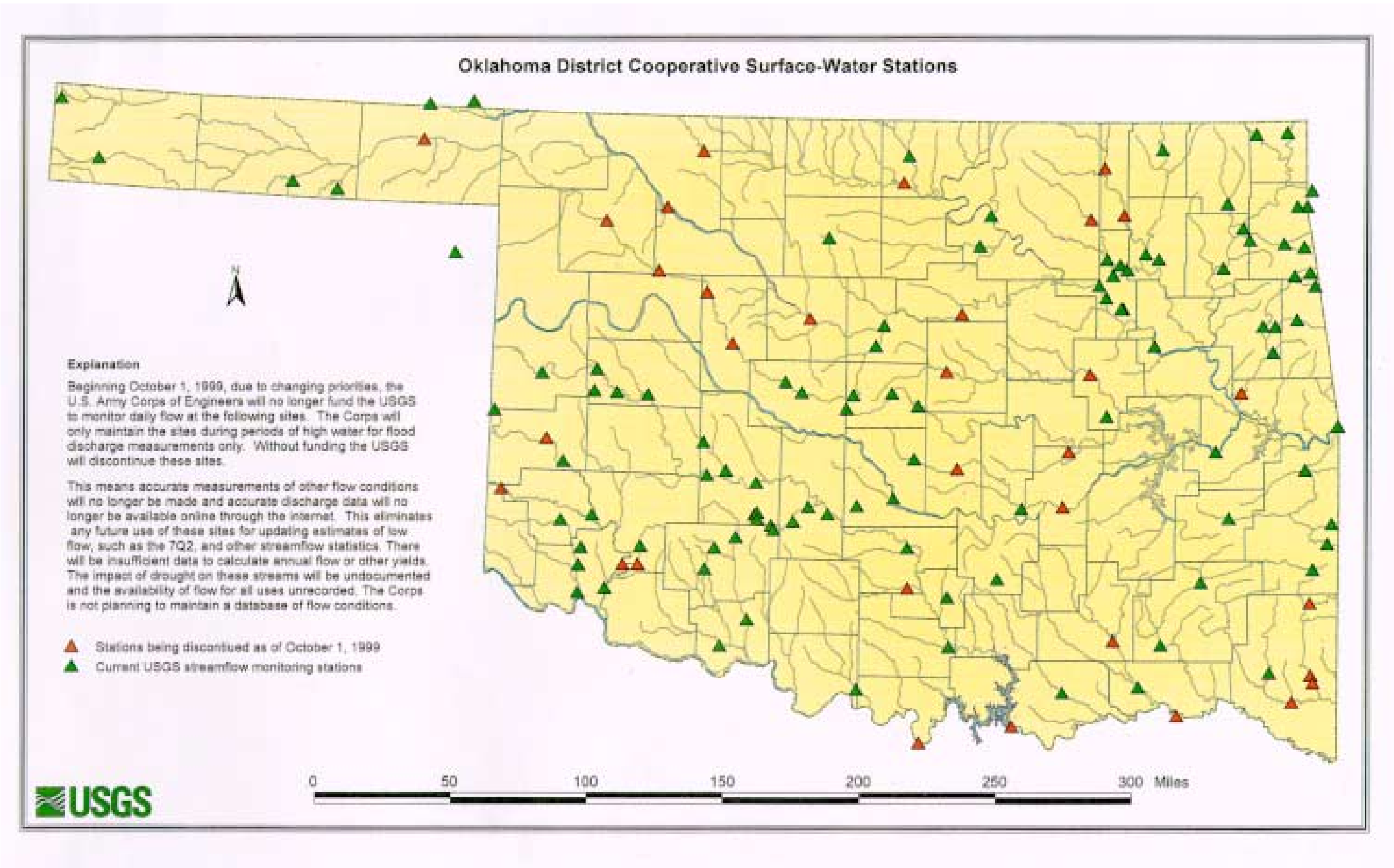
The United States Geological Survey (USGS) is without a doubt the most active federal agency in Oklahoma in terms of water quality monitoring. The USGS operates and maintains and extensive stream monitoring network for multiple purposes. The streamflow-monitoring network is used for forecasting flood events, for determining base flow, for calculating pollutant loadings (based upon flow data), and the USGS also conducts routine water quality monitoring at numerous stations across the state. The USGS has a very extensive historical record on many streams across the state. The existence of this historical record is very useful in the management of our water resources and the continuation of the network in its present form should be preserved if possible.

The USGS streamflow-monitoring program provides hydrologic information needed to help define, use, and manage the State's water resources (See Table 39). The program provides a continuous, well-documented, well-archived, unbiased, and broad-based source of reliable and consistent water data. Because of the nationally consistent, prescribed standards by which the data are collected and processed, the data from individual stations are commonly used for purposes beyond the original purpose for an individual station. Those possible uses include, but are not limited to, the following:

- Characterizing current water-quality conditions
- Providing data for forecasting and managing floods
- Monitoring compliance with minimum flow requirements
- Setting permit requirements for discharge of treated wastewater
- Delineating and managing flood plains
- Magnitude and frequency of floods and droughts
- Operating and designing multipurpose reservoirs
- Scheduling power production
- Designing highway bridges and culverts

- Designing, operating, and maintaining navigation and recreational facilities
- Allocating water for municipal, industrial, and irrigation uses
- Administering compacts or resolving conflicts on interstate rivers
- Defining and apportioning the water resources at our international boarders
- Undertaking scientific studies of long-term changes in the hydrologic-cycle

Data for one or more of these purposes are needed at some point in time on virtually every stream in the country, and a data-collection system must be in place to provide the required information. The general objective of the streamflow-monitoring program is to provide information on stream-flow characteristics at any point on any stream. Stream-flow data are needed for immediate decision making and future planning and planning and project design. Data, such as that needed to issue and update flood or drought forecasts are referred to as "data for current needs". Other data, such as needed for the design of a future bridge or reservoir, are referred to as "data for future or long-term needs". Some data, of course, fit into both classifications; a station that supplies data for flood forecasting also can provide data to define long-term trends clearly fits both classifications.



• Figure 21. **USGS cooperative agreement surface water quality monitoring stations.**

•Table 39. **Water quality monitoring conducted by the USGS in Oklahoma, 01/01/2000 (*SUBJECT TO CHANGE*)**

STATION NO.	STATION NAME
CONTINOUS STREAMFLOW STATIONS	
7148400	SALT FORK OF THE ARKANSAS RIVER NEAR ALVA
7151000	SALT FORK OF THE ARKANSAS NEAR TONKAWA
7152000	CHIKASKIA RIVER AT BLACKWELL
7152500	ARKANSAS RIVER AT RALSTON
7153000	BLACK BEAR CREEK AT PAWNEE
7154500	CIMARRON RIVER NEAR KENTON
7156900	CIMARRON RIVER NEAR FORGAN
7158000	CIMARRON RIVER NEAR WAYNOKA
7159100	CIMARRON RIVER NEAR DOVER
7159750	COTTONWOOD CREEK NEAR SEWARD
7160000	CIMARRON RIVER AT GUTHRIE
7160350	SKELETON CREEK AT ENID
7161450	CIMARRON RIVER NEAR RIPLEY
7164500	ARKANSAS RIVER AT TULSA
7164600	JOE CREEK AT 61ST STREET IN TULSA
7165562	HAIKEY CREEK AT 101ST STREET
7165565	LITTLE HAIKEY CREEK AT 101ST STREET
7165570	ARKANSAS RIVER NEAR HASKELL
7171000	VERDIGRIS RIVER NEAR LENAPAH
7174400	CANEY RIVER ABOVE COON CREEK AT BARTLESVILLE
7175500	CANEY RIVER NEAR RAMONA
7176000	VERDIGRIS RIVER NEAR CLAREMORE
7176500	BIRD CREEK AT AVANT
7177500	BIRD CREEK NEAR SPERRY
7177650	FLAT ROCK CREEK AT CINCINNATI STREET
7177800	COAL CREEK AT OK HIGHWAY 11
7178000	BIRD CREEK NEAR OWASSO
7178200	BIRD CREEK AT HIGHWAY 266 NEAR CATOOSA
7178520	DOG CREEK AT CLAREMORE
7185000	NEOSHO RIVER NEAR COMMERCE
7188000	SPRING RIVER NEAR QUAPAW
7189000	ELK RIVER NEAR TIFF CITY
7189540	CAVE SPRINGS BRANCH NEAR SW CITY, MO
7189542	HONEY CREEK NEAR SW CITY
7190500	NEOSHO RIVER NEAR LANGLEY
7191000	BIG CABIN CREEK NEAR BIG CABIN

STATION NO.	STATION NAME
7191220	SPAVINAW CREEK NEAR SYCAMORE
7191222	BEATY CREEK NEAR JAY
7191227	BLACK HOLLOW CREEK NEAR SPAVINAW
7191500	NEOSHO RIVER NEAR CHOUTEAU (TW)
7195500	ILLINOIS RIVER NEAR WATTS
7195855	FLINT CREEK NEAR W. SILOAM SPRINGS, OK
7195865	SAGER CREEK WEST SILOAM SPRINGS, OK
7196000	FLINT CREEK NEAR KANSAS, OK
7196500	ILLINOIS RIVER NEAR TAHLEQUAH
7196973	PEACHEATER CREEK AT CHRISTIE
7197000	BARON FORK AT ELDON
7197360	CANEY CREEK NEAR BARBER
7198000	ILLINOIS RIVER NEAR GORE
7228500	CANADIAN RIVER NEAR BRIDGEPORT
7229200	CANADIAN RIVER AT PURCELL
7230000	LITTLE RIVER BELOW LAKE THUNDERBIRD IN NORMAN
7230500	LITTLE RIVER NEAR TECUMSEH
7231000	LITTLE RIVER NEAR SASAKWA
7231500	CANADIAN RIVER AT CALVIN
7232250	BEAVER RIVER NEAR FELT
7232900	COLDWATER CREEK NEAR GUYMON
7233650	PALO DURO CREEK NEAR RANGE
7234000	BEAVER RIVER AT BEAVER
7237500	NORTH CANADIAN RIVER AT WOODWARD
7238000	NORTH CANADIAN RIVER NEAR SEILING
7239000	NORTH CANADIAN RIVER NEAR CANTON
7239300	NORTH CANADIAN RIVER NEAR WATONGA
7239450	NORTH CANADIAN RIVER NEAR CALUMET
7239500	NORTH CANADIAN RIVER NEAR EL RENO
7239700	NORTH CANADIAN RIVER NEAR YUKON
7240000	LAKE HEFNER CANAL NEAR OKLAHOMA CITY
7241000	NORTH CANADIAN RIVER BELOW LAKE OVERHOLSER
7241520	NORTH CANADIAN RIVER AT BRITTON ROAD
7241550	NORTH CANADIAN RIVER NEAR HARRAH
7242000	NORTH CANADIAN RIVER NEAR WETUMKA
7242380	DEEP FORK AT WARWICK
7243500	DEEP FORK NEAR BEGGS
7244100	COAL CREEK NEAR HENRYETTA
7245000	CANADIAN RIVER NEAR WHITEFIELD
7247015	POTEAU RIVER AT LOVING

STATION NO.	STATION NAME
7247250	BLACK FORK BELOW BIG CREEK NEAR PAGE
7247500	FOURCHE MALINE NEAR RED OAK
7249413	POTEAU RIVER NEAR PANAMA
7249455	ARKANSAS RIVER NEAR FT. SMITH, AR.
7300500	SALT FORK OF THE RED RIVER AT MANGUM
7300530	BITTER CREEK NEAR MARTHA
7300580	BITTER CREEK WEST OF ALTUS
7301110	SALT FORK OF THE RED RIVER NEAR ELMER
7301420	SWEETWATER CREEK NEAR SWEETWATER
7301500	NORTH FORK OF THE RED RIVER NEAR CARTER
7303000	NORTH FORK OF THE RED RIVER BELOW ALTUS NEAR LUGERT
7303400	ELM FORK NEAR CARL
7305000	NORTH FORK OF THE RED RIVER NEAR HEADRICK
7305500	WEST OTTER CREEK SNYDER LAKE NEAR MT. PARK
7307010	OTTER CREEK NEAR SNYDER
7307028	NORTH FORK OF THE RED RIVER NEAR TIPTON
7311000	EAST CACHE CREEK NEAR WALTERS
7311200	BLUE BEAVER CREEK NEAR CACHE
7311500	DEEP RED CREEK NEAR RANDLETT
7315700	MUD CREEK NEAR COURTNEY
7316000	RED RIVER NEAR GAINESVILLE, TX.
7316500	WASHITA RIVER NEAR CHEYENNE
7324200	WASHITA RIVER NEAR HAMMON
7324400	WASHITA RIVER NEAR FOSS
7325000	WASHITA RIVER NEAR CLINTON
7325500	WASHITA RIVER NEAR CARNEGIE
7325800	COBB CREEK NEAR EAKLY
7326000	COBB CREEK NEAR FT. COBB
7326500	WASHITA RIVER AT ANADARKO
73274408	LITTLE WASHITA RIVER TRIBUTARY NEAR CYRIL
7327442	LITTLE WASHITA RIVER NEAR CYRIL
73274455	LITTLE WASHITA RIVER TRIBUTARY
7327447	LITTLE WASHITA RIVER NEAR CEMENT
7327483	BOGGY CREEK AT NINNEKAH
7327550	LITTLE WASHITA RIVER EAST OF E. NINNEKAH
7328100	WASHITA RIVER AT ALEX
7328180	NORTH CRINER CREEK NEAR CRINER
7328500	WASHITA RIVER NEAR PAULS VALLEY
7329700	WILDHORSE CREEK NEAR HOOVER
7329852	ROCK CREEK AT SULPHUR

Station No.	Station Name
7331000	Washita River Near Dickson
7331600	Red River Near Denison
7332500	Blue River Near Blue
7334000	Muddy Boggy Creek near Farris
7334200	Byrds Mill Spring Near Fittstown
7334200	Byrds Mill Spring Near Fittstown (pipelines)
7335300	Muddy Boggy near Unger
7335500	Red River at Arthur City, TX
7335700	Kiamichi River Near Big Cedar
7335790	Kiamichi River Near Clayton
7336200	Kiamichi River near Antlers
7337900	Glover Creek Near Glover
7338500	Little River Below Lukfata Creek Near Idabel
7338750	Mountain Fork River at Smithville
7339000	Mountain Fork River near Eagletown
7164500	Arkansas River at Tulsa
Miscellaneous Streamflow Stations	
7159639	Bluff Creek Above Treatment Plant
7159643	Deer Creek below Bluff Creek at Oklahoma City
7159650	Deer Creek at Oklahoma City
7159735	Chisholm Creek near Edmond
7194830	Illinois River at Arkansas Near Pedro, AR.
7195400	Illinois River at Siloam Springs, AR.
7196040	Illinois River Below Flint Creek Near Flint
7196090	Illinois River at Chewey, OK.
7196190	Illinois River Near Scraper, OK.
7196320	Illinois River Near Moodys
7196400	Illinois River at No Head Hollow
7196490	Illinois River Near Briggs, OK.
7196520	Illinois River near Park Hill, OK
7197080	Baron Fork at Welling, OK.
7247345	Black Fork near Hodgens
7247650	Fourche Maline Near Leflore
7247800	Holson Creek at Summerfield
Slope Stations	
7190500	Neosho River Near Langley(slope gage 1)
7190500	Neosho River Near Langley(slope gage 2)
Crest-Stage Gage	
7178007	Bell Creek at Tulsa

Station No.	Station Name
7178018	Mill Creek at Tulsa
7178025	Cooley Creek Above 115 East Avenue
7178025	Cooley Creek at Highway 169
Staff Gage	
7185080	Neosho River at Highway 125 at Miami
7229053	Canadian River Tributary at Norman
7240200	North Canadian River at Highway 66
7327446	SCS Pond No. 31 near Cement
Monitoring for the U.S. Army Corps of Engineers	
7248500	Poteau River Near Wister
7301481	North Fork of the Red River Near Sayre
7339000	Mountain Fork River Near Eagletown
Lake Storage	
7191400	Lake Hudson Near Locust Grove
7229900	Lake Thunderbird near Norman
7325900	Ft. Cobb Reservoir Near Ft. Cobb
Lake Levels	
7159550	Lake Hefner at Oklahoma City
7190000	Grand Lake at Langley
7191300	Spavinaw Lake Near Spavinaw
7229445	Draper Lake near Oklahoma City
7240500	Lake Overholser Near Oklahoma City
7302500	Lake Altus near Lugert
7308990	Lake Ellsworth Near Elgin
7309500	Lake Lawtonka near Medicine Park
7324300	Foss Reservoirs near Foss
73274406	L. Washita River Above Pond 26
7327441	SCS Pond No. 26
7327484	SCS Pond No. 11
7333010	Atoka Reservoir Near Stringtown
7333900	McGee Creek Lake Near Farris
Instrumentation Support for the National Weather Service	
7239500	North Canadian River near El Reno
Continuous Temperature	
7164500	Arkansas River at Tulsa
7178520	Dog Creek at Claremore
7198000	Illinois River Near Gore
7244100	Coal Creek Near Henryetta

Station No.	Station Name
7338905	Mountain Fork River at Highway 259a Broken Bow
7338960	Mountain Fork River at Presbyterian Falls at Eagletown
7339000	Mountain Fork River near Eagletown
Continuous Temperature and Conductivity	
7239500	North Canadian River Near El Reno
7239700	North Canadian River Near Yukon
7316000	Red River Near Gainesville, TX.
7331000	Washita River Near Dickson
7331600	Red River Near Denison
Continuous Temperature, Conductivity, and Dissolved Oxygen	
7241000	North Canadian River Below Lake Overholser
7241520	North Canadian River at Britton Road
Continuous Temperature, Conductivity, Dissolved Oxygen, and pH	
7177500	Bird Creek near Sperry
7178000	Bird Creek Near Owasso
7178200	Bird Creek at Highway 266 Near Catoosa
7239450	North Canadian River Near Calumet
7241550	North Canadian River Near Harrah
7338920	Broken Bow Lake at the Regulation Dam
Stations Where Water-quality Samples are Collected	
7159639	Bluff Creek Above the Treatment Plant
7159643	Deer Creek Below Bluff Creek at Oklahoma City
7159650	Deer Creek at Oklahoma City
7159730	Chisholm Creek at Edmond
7189540	Cave Springs Branch Near SW City, MO.
7189542	Honey Creek Near SW City
7195500	Illinois River near Watts
7195855	Flint Creek Near West Siloam Springs, OK.
7195865	Sager Creek at West Siloam Springs, OK.
7196000	Flint Creek Near Kansas, OK.
7196090	Illinois River at Chewey, OK.
7196320	Illinois River near Moodys
7196500	Illinois River near Tahlequah
7196520	Illinois River Near Park Hill, OK.
7197000	Baron Fork at Eldon
7197360	Caney Creek Near Barber
7239450	North Canadian River near Calumet
7241000	North Canadian River Below Lake Overholser

Station No.	Station Name
7241520	North Canadian River at Britton Road
7241550	North Canadian River Near Harrah
7247015	Poteau River at Loving
7247250	Black Fork Below Big Creek Near Page
7247345	Black Fork Near Hodgens
7247650	Fourche Maline Near Leflore
7247800	Holson Creek at Summerfield
7249455	Arkansas River Near West FT. Smith, AR.
7316000	Red River Near Gainesville, TX.
7331000	Washita River Near dickson
7331600	Red River Near Denison
Rain Gage	
7148400	Salt Fork of the Arkansas River Near Alva
7151000	Salt Fork of the Arkansas River Near Tonkawa
7152000	Chickaskia River at Blackwell
7152500	Arkansas River at Ralston
7153000	Black Bear Creek at Pawnee
7158000	Cimarron River near Waynoka
7159100	Cimarron River near Dover
7159750	Cottonwood Creek near Seward
7160000	Cimarron River at Guthrie
7161450	Cimarron River Near Ripley
7164500	Arkansas River at Tulsa
7165570	Arkansas River Near Haskell
7171000	Verdigris River near Lenapah
7174400	Caney River Above Coon Creek at Bartlesville
7175500	Caney River Near Ramona
7176000	Verdigris River Near Claremore
7177500	Bird Creek Near Sperry
7185000	Neosho River Near Commerce
7188000	Spring River Near Quapaw
7189000	Elk River Near Tiff City
7190000	Grand Lake at Langley
7191000	Big Cabin Creek Near Big Cabin
7191220	Spavinaw Creek Near Sycamore
7191400	Lake Hudson Near Locust Grove
7195500	Illinois River near Watts
7196000	Flint Creek near Kansas
7196500	Illinois River Near Tahlequah
7197000	Baron Fork at Eldon

STATION NO.	STATION NAME
7198000	ILLINOIS RIVER NEAR GORE
7229053	CANADIAN RIVER TRIBUTARY AT NORMAN
7229200	CANADIAN RIVER AT PURCELL
7229900	LAKE THUNDERBIRD NEAR NORMAN
7230500	LITTLE RIVER NEAR TECUMSEH
7231500	CANADIAN RIVER AT CALVIN
7234000	BEAVER RIVER AT BEAVER
7237500	NORTH CANADIAN RIVER AT WOODWARD
7238000	NORTH CANADIAN RIVER NEAR SEILING
7239300	NORTH CANADIAN RIVER NEAR WATONGA
7241000	NORTH CANADIAN RIVER BELOW LAKE OVERHOLSER
7241550	NORTH CANADIAN RIVER NEAR HARRAH
7242000	NORTH CANADIAN RIVER NEAR WETUMKA
7242380	DEEP FORK AT WARWICK
7243500	DEEP FORK NEAR BEGGS
7245000	CANADIAN RIVER NEAR WHITEFIELD
7247500	FOURCHE MALINE NEAR RED OAK
7249413	POTEAU RIVER NEAR PANAMA
7301420	SWEETWATER CREEK NEAR SWEETWATER
7301481	NORTH FORK OF THE RED RIVER NEAR SAYRE
7301500	NORTH FORK OF THE RED RIVER NEAR CARTER
7302500	LAKE ALTUS NEAR LUGERT
7303400	ELM FORK NEAR CARL
7305000	NORTH FORK OF THE RED RIVER NEAR HEADRICK
7307010	OTTER CREEK NEAR SNYDER
7311000	EAST CACHE CREEK NEAR WALTERS
7316000	RED RIVER NEAR GAINESVILLE, TX.
7316500	WASHITA RIVER NEAR CHEYENNE
7324300	FOSS RESERVOIR NEAR FOSS
7325000	WASHITA RIVER NEAR CLINTON
7325500	WASHITA RIVER NEAR CARNEGIE
7325800	COBB CREEK NEAR EAKLY
7325900	FT. COBB RESERVOIR NEAR FT. COBB
7326500	WASHITA RIVER AT ANADARKO
7327442	LITTLE WASHITA RIVER NEAR CYRIL
7327447	LITTLE WASHITA RIVER NEAR CEMENT
7327550	LITTLE WASHITA RIVER EAST OF EAST NINNEKAH
7328100	WASHITA RIVER AT ALEX
7328500	WASHITA RIVER NEAR PAULS VALLEY
7331000	WASHITA RIVER NEAR DICKSON

Station No.	Station Name
7331600	Red River Near Denison
7334000	Muddy Boggy Creek Near Farris
7335300	Muddy Boggy Creek Near Unger
7335500	Red River at Arthur City, TX.
7335700	Kiamichi River Near Big Cedar
7335790	Kiamichi River Near Clayton
7336200	Kiamichi River Near Antlers
7337900	Glover River Near Glover
7338500	Little River Below Lukfata Creek Near Idabel
7338750	Mountain Fork River at Smithville
7338920	Broken Bow Lake at the Regulation Dam
7339000	Mountain Fork Near Eagletown
Sediment	
7195500	Illinois River Near Watts
7195855	Flint Creek Near West Siloam Springs, OK.
7195865	Sager Creek West Siloam Springs, OK.
7196000	Flint Creek Near Kansas, OK.
7196090	Illinois River at Chewey, OK.
7196500	Illinois River Near Tahlequah
7196520	Illinois River Near Park Hill, OK.
7197000	Baron Fork at Eldon
7247015	Poteau River at Loving
7247250	Black Fork Below Big Creek Near Page
7247345	Black Fork Near Hodgens
7247500	Fourche Maline Near Red Oak
7247650	Fourche Maline Near Leflore
7247800	Holson Creek at Summerfield
7249455	Arkansas River Near West Ft. Smith, AR.
Groundwater Well - Continuous Water Levels	
01N13W04	Cache, Comanche County
01N16E04	Fittstown, Pontotoc County
21N22W23	Sharon, Woodward County
Atmospheric Deposition	
	Goodwell Res. Site
	Great Salt Plains national Wildlife Refuge

CHAPTER
7

OTHER MONITORING PROGRAMS

Numerous other state agencies are involved to a lesser degree in water quality monitoring in Oklahoma, predominantly on a project specific basis. For the purposes of this report, they will not be discussed. The point the reader should glean from this is that this report should not be construed as a comprehensive document of **all** water quality monitoring efforts occurring in Oklahoma, just a brief discussion of the major state-wide efforts currently being conducted. Some examples of project specific work would include work conducted by several state and federal agencies.

The Oklahoma Department of Wildlife Conservation (ODWC) conducts monitoring activities related to water quality on an individual project basis when wildlife issues are involved, such as the work being conducted in the Canton Lake area. In addition, ODWC conducts numerous wildlife surveys and sampling initiatives that are related to water quality issues without being water quality monitoring. The United States Army Corps of Engineers (COE) also conducts monitoring activities on several COE lakes in Oklahoma each year. In some instances the monitoring may be very extensive such as work currently being conducted on Broken Bow Lake or may just involve a years worth of monitoring that occurs every ten (10) years or so. The United States Environmental Protection Agency is also spending several million dollars looking extensively at Lake Texoma and water quality impacts. There is certainly additional monitoring occurring on a project by project basis. For the purposes of brevity, only the agencies actively engaged in comprehensive state-wide water quality monitoring programs were included in this document. It is hoped that future reports may be able to address other monitoring activities that have some bearing upon water quality.