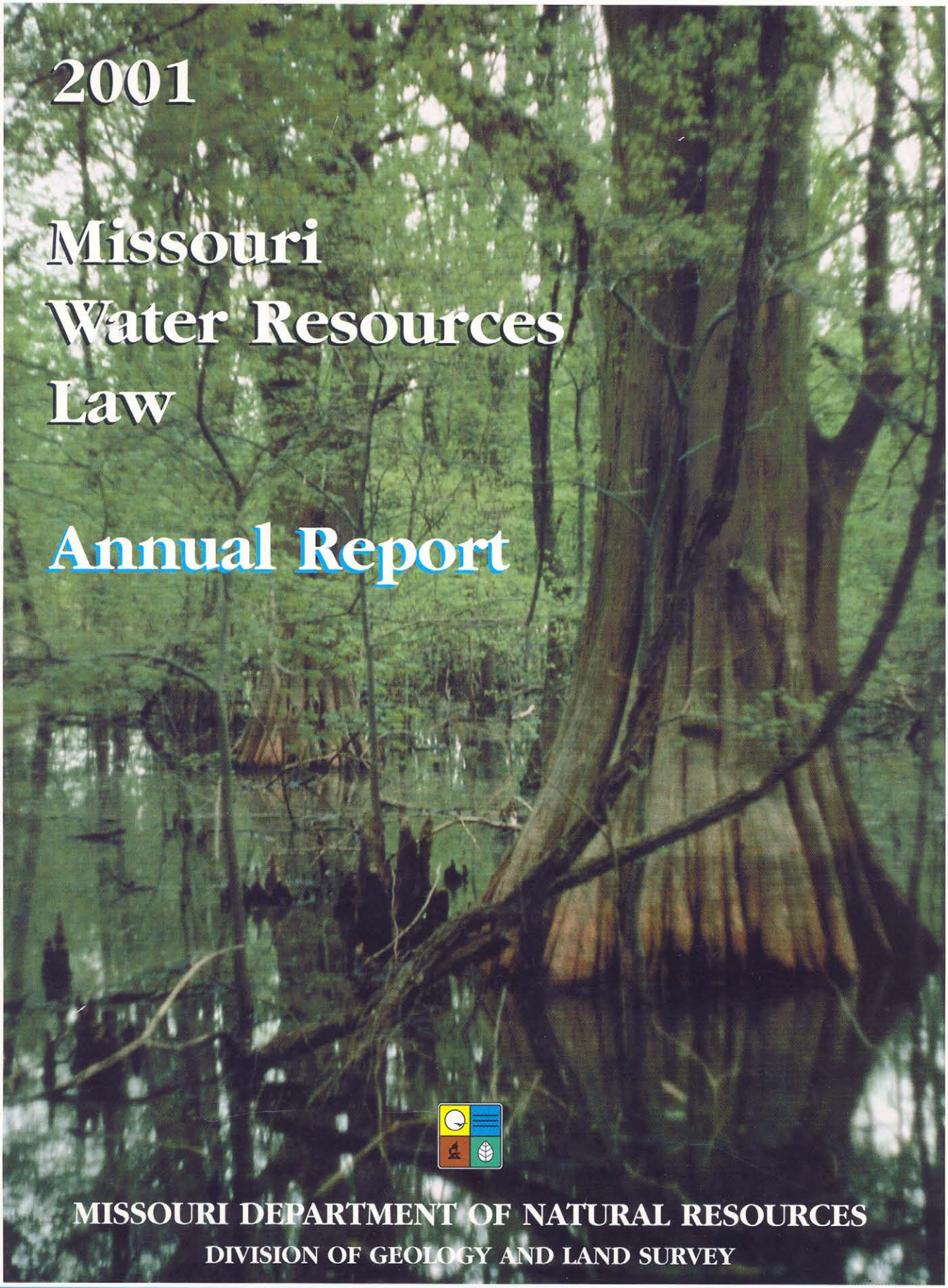
Water Resources Report Number 67



2001 Missouri Water Resources Law Annual Report

MISSOURI DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY AND LAND SURVEY

Water Resources Report Number 67

Missouri Water Resources Law

2001

Annual Report

Missouri Department of Natural Resources
Division of Geology and Land Survey
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Cypress trees in Big Oak Tree State Park. Photo by Jerry D. Vineyard.

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MISSOURI WATER RESOURCE LAW

Sections 640.400 to 640.435 shall be known and may be cited as the "Missouri Water Resources Law," in recognition of the significance of the conservation, development and appropriate use of water resources of Missouri. The law, in its entirety, is located in Appendix 1.

2001 MISSOURI WATER LAW ANNUAL REPORT

CONTENTS

Page

INTRODUCTION 1
WATER QUALITY AND QUANTITY 3
- Public Drinking Water Systems 3
- Delineating Source Water Areas of Water Wells 6
- Wastewater Treatment Systems 8
- Water Quality Coordinating Committee 8
- Nonpoint Source Pollution 8
- Impaired Waters 9
- Water Pollution Control Tools 10
- Soil and Water Conservation 11
- Soil and Water Conservation Programs Available in the State 12
- Hazardous Wastes 15
- Storage Tanks 17
- Solid Wastes 17
- Wells for Water, Heat Pumps, Monitoring and Mineral Testing 18
- Abandoned Well Plugging 20
- Wells for Oil, Gas and Underground Injection 24
- Reclamation of Mined Lands 24
- Environmental Emergency Response 26

INTERSTATE USE OF WATER 29
- Upper Mississippi River Basin Association 29
- Missouri River Basin Association 29
- Arkansas-White-Red Basins Inter-Agency Committee 30
- Lower Mississippi River Conservation Committee 31
- Interstate Council on Water Policy 31
- Mississippi River Parkway Commission 31
- Mississippi River Basin Alliance 32

MONITORING WATER QUALITY 33
- Vulnerability 34
- Groundwater 35
- Surface Water Quality Monitoring 37
- Monitoring Program Evaluation 38

INVENTORY OF WATER USE AND AVAILABILTY 39
Water Use 39
Groundwater Availability 40
Groundwater-Level Observation Well Network 45
Surface Water Availability 49
Dam Safety 51
STATE WATER PLAN 53
Background 53
Phase 1 - State Water Plan Volumes 54
Volume VII - A Summary of Missouri Water Laws 54
Phase 2 - Regional Reports 55
Topics in Water Use - Northeastern Missouri, Water Resources Report No. 59 56
Topics in Water Use - Central Missouri 57
Topics in Water Use - Northwest Missouri 57
Other Regional Reports 57
SPECIAL WATER QUALITY PROTECTION REPORTS 59
INTERAGENCY TASK FORCE 61
Central Missouri 61
RECOMMENDATIONS 63
APPENDICES 65
Appendix 1 - Missouri Water Resources Law 65
Appendix 2 - Division of Environmental Quality Regional Office Boundaries 69

2001 MISSOURI WATER LAW ANNUAL REPORT

INTRODUCTION

In this first year of the new millennium, the department presents the *2001 Annual Report* for the Missouri Water Resources Law, as required in Section 640.426, RSMo. This report provides an overview of the activities that the Missouri Department of Natural Resources performed to meet the objectives of the law in the 2000 calendar year.

The report focuses upon the accomplishments of individual programs and relates program activities to those sections of the law that are addressed. The report follows the same organizational structure as the law, beginning with Water Quality and Quantity. Each section begins with text from the law, followed by a brief discussion of how the department satisfied the requirements of the law. Through an accumulation of information from different programs throughout the department, each section emphasizes the progress that has been made in implementing the Water Resources Law.

TYPES OF WATER SYSTEMS

Public Water System *– Provides water to at least 25 people at least 60 days a year or has at least 15 service connections. Public water systems can be publicly owned or privately owned. There are two types of public water systems, community and non-community.*

Community Water System *– Has at least 15 service connections used by year-around residents or regularly serves at least 25 residents year-around.*

Non-Community Water System *– Serves an average of at least 25 persons at least 60 days a year.*

WATER QUALITY AND QUANTITY

RSMo 640.400.2 - The department shall ensure that the quality and quantity of the water resources of the state are maintained at the highest level practicable to support present and future beneficial uses. The department shall inventory, monitor and protect the available water resources in order to maintain water quality, protect the public health, safety and general economic welfare.

PUBLIC DRINKING WATER SYSTEMS

The Department of Natural Resources (the department) regulates more than 2,700 public water systems in Missouri to ensure the safe quality and adequate quantity of drinking water provided throughout the state. More than 90% of Missouri's population is served by public water systems.

A public water system provides water through pipes or other constructed conveyances, for human consumption, to at least 15 service connections or serves an average of at least 25 people for at least 60 days each year. There are three types of public water systems: Community (such as towns, subdivisions, or mobile home parks), nontransient noncommunity (such as schools or factories), and transient noncommunity systems (such as rest stops or parks). The requirements for construction, operation, and water quality monitoring vary among systems, based on their type, size, and source of water. Regulation is carried out under the authority of sections 640.100 through 640.140, RSMo.

Since drinking water can be a principal agent in the transmission of communicable diseases, these systems must be routinely inspected and samples from each system must be frequently analyzed. The department, in cooperation with the Department of Health, routinely monitors drinking water quality. The results provide early detection of potential health problems. Without this protection, the incidence of waterborne illnesses in the state could increase. The "Monitoring Water Quality" section of this report contains additional information about the department's drinking water monitoring efforts.

In addition to monitoring, the department is involved in other initiatives to protect water quality. The State of Missouri and the U.S. Department of Agriculture signed an agreement on September 15, 2000, that will form a federal/state partnership to reduce contamination of public drinking water reservoirs. The Conservation Reserve Enhancement Program (CREP) compensates farmers for voluntarily removing cropland from production. This reduces pesticides excess nutrients and sediment flowing into drinking water reservoirs. The department's

Public Drinking Water Program (PDWP) and Soil and Water Conservation Program are jointly implementing the program with the U.S. Department of Agriculture. Eighty percent of the funding to compensate the farmers will come from federal funds and twenty percent will come from state and local funds. An additional state incentive payment to farmers is planned from the Rural Water and Sewer Grant fund. Once in place, these agreements will protect drinking water sources and provide wildlife habitat for fifteen years.

The department also offers low-interest loans to eligible public water systems. Most of the funding for the loan program comes from the U.S. Environmental Protection Agency (EPA), with a 20% match from state funds required. The loan program provides a mechanism for the department to assist public systems in meeting water quality needs.

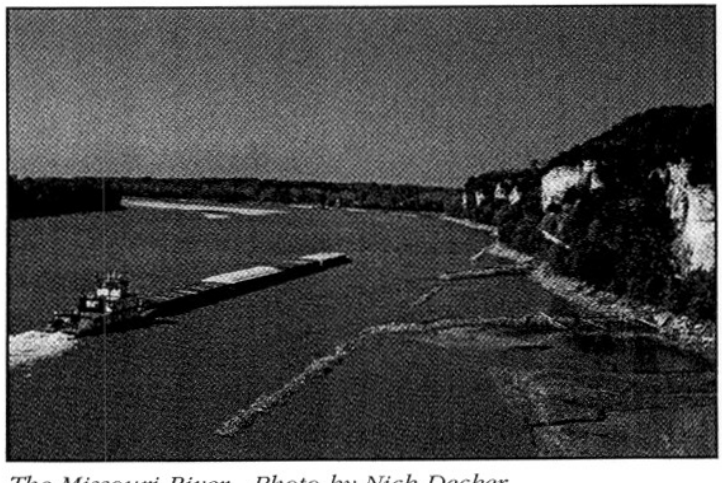
Since the program began in 1997, the department has loaned over $66 million to 14 water systems. In 2001, the department will offer over $155 million in loans to 47 water systems.

The department continues to be actively involved in assisting public water systems to provide an annual report to their customers on the quality of their drinking water. The PDWP provided over 1400 water systems with nearly complete "skeleton" Consumer Confidence Reports (CCR) so they could meet this requirement with a minimum of effort. These reports included data from the department's environmental laboratory and the Department of Health laboratory concerning drinking water sample results, violation information from PDWP files and standard language required in each CCR. Many small systems were able to use these reports as their official CCR without any modifications. For those who wanted to customize the report, the PDWP made the report available as an electronic file for use in any word processor.

There is generally plenty of good quality water in Missouri. By far the largest source of water for Missourians is the Missouri and Mississippi River systems. The abundant supply of water in these rivers, and their proximity to the state's major population centers, makes them popular as a water source.

Groundwater is the next most used source for drinking water for Missouri's community supplies. This is especially true in southern Missouri where good quality groundwater is easy to obtain and requires very little treatment to be used as a drinking water source.

Raw water sources vary in quality and quantity from one area of the state to another. To produce finished water of satisfactory quality and quantity on a consistent basis, treatment plants must be designed specifically for the raw water sources. Department staff review engineering plans and reports for the construction or renovation of public drinking water systems to ensure that essential sanitary standards are met. Construction permits are issued as appropriate.



The Missouri River. Photo by Nick Decker.

MISSOURI GROUND WATER

MISSOURI DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY AND LAND SURVEY
P.O. Box 250, Rolla, MO 65401

1990

PRODUCTION REGIONS AND AQUIFERS

GLACIAL DRIFT AND ALLUVIUM

Yield is normally 5-15 gpm (gallons per minute). Range 0-500 gpm. Bedrock aquifers generally yield mineralized water. Water should be treated for iron removal and chlorinated.

PENNSYLVANIAN AND MISSISSIPPIAN LIMESTONE AND SANDSTONES

Yield 1-15 gpm to depth of 400 ± ft. Aquifers below 400 ft yield mineralized water.

Yield localized 1-10 gpm to depth of 450 ± ft. Aquifers below 450 ± ft yield mineralized water.

CRETACEOUS SANDSTONES AND ALLUVIUM

Yield normally 1000 + gpm. Some wells flow. Cretaceous waters generally softer, lower temperature, and contain less iron than alluvial waters.

ORDOVICIAN AND CAMBRIAN DOLOMITES AND SANDSTONES

Yield 15-500 gpm, depending on depth and formations penetrated. Local yields of as much as 1000 gpm in Springfield and Rolla areas. Yields of wells east of St. Francois Mt. region usually about 15 gpm. Water in deeper aquifers locally mineralized.

CAMBRIAN AND PRECAMBRIAN ROCKS

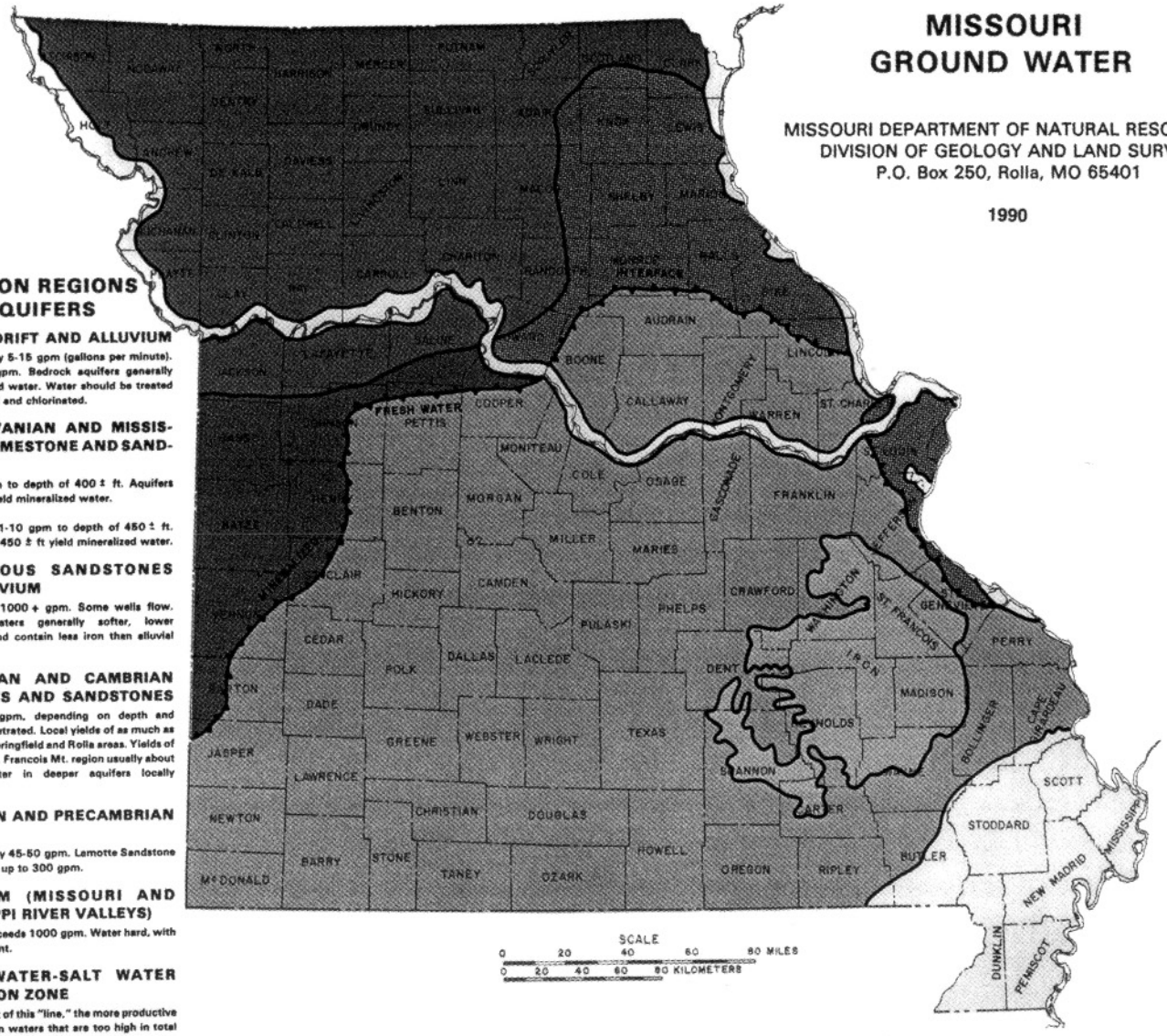
Yield is normally 45-50 gpm. Lamotte Sandstone in Potosi yields up to 300 gpm.

ALLUVIUM (MISSOURI AND MISSISSIPPI RIVER VALLEYS)

Yield locally exceeds 1000 gpm. Water hard, with high iron content.

FRESH WATER-SALT WATER TRANSITION ZONE

North and west of this "line," the more productive aquifers contain waters that are too high in total dissolved solids to be considered potable.



Department staff members assure that all public water systems are properly operated and maintained and that they operate under a state permit to dispense water. The public water systems must be operated in compliance with the law and regulations.

DELINEATING SOURCE WATER AREAS OF WATER WELLS

Groundwater is constantly on the move. The direction of flow is from source areas (or recharge areas) to discharge areas. At source areas, groundwater is replenished by precipitation that percolates downward through unsaturated overburden on its vertical descent to the water table, which constitutes the top of the groundwater system. Within the system, groundwater flows along hydraulic gradient through interconnected pores and fractures in rock materials. The pathways and patterns of flow may be simple or complex. Eventually, old groundwater leaves the system at discharge areas, which include perennial streams, springs, and water wells. The amount of time required for groundwater to travel from source areas to discharge areas can vary from days to millennia, depending on distance traveled, steepness of hydraulic gradient, and the nature of geologic materials. To summarize, groundwater systems, in addition to being dynamic systems, are most definitely open systems. New water continually enters, existing water continually flows within, and old water continually exits.

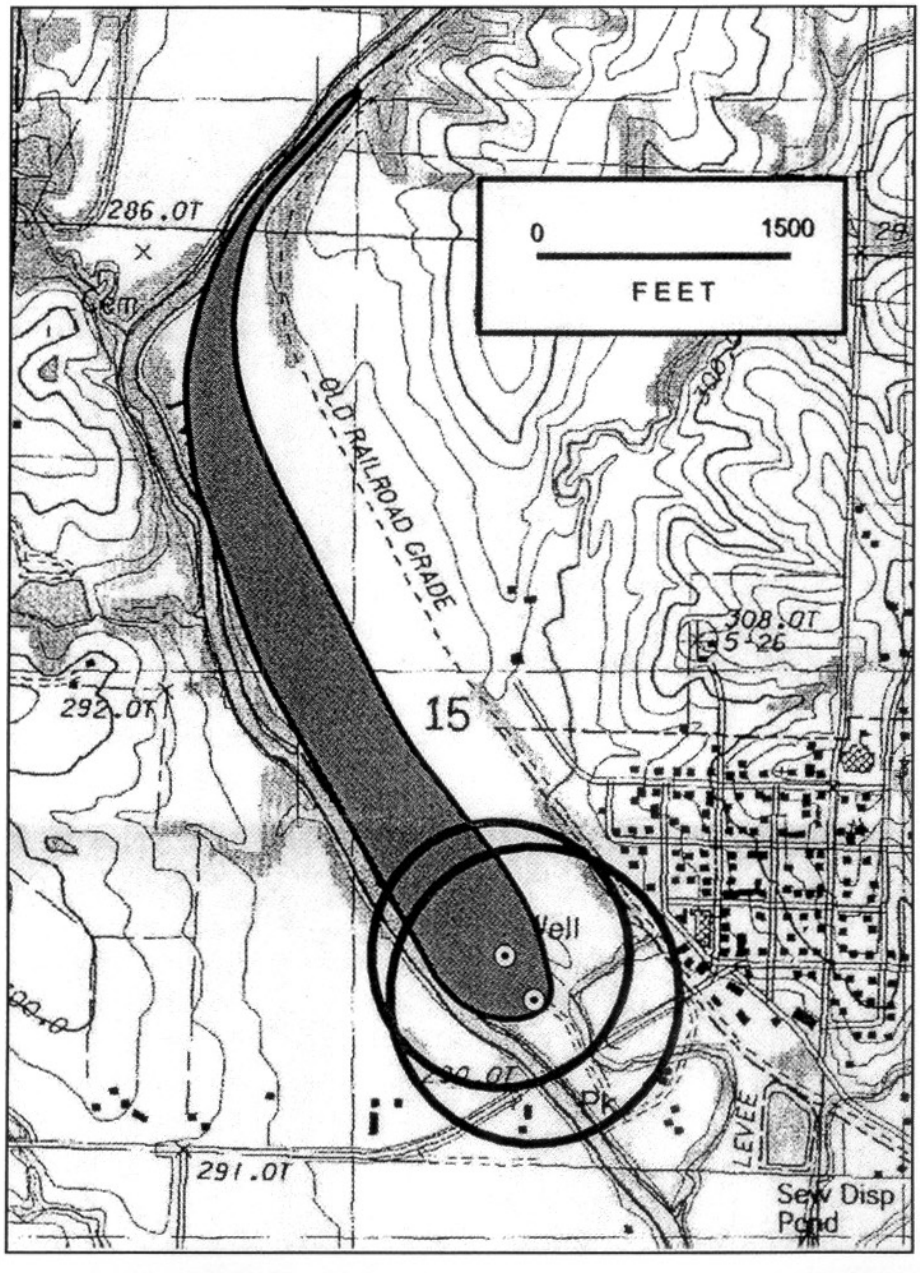
Because of their openness, groundwater systems are, to varying degrees, susceptible to contamination by a variety of chemical and biological substances. Contaminants, when they are present in source areas, may migrate downward on their own accord or otherwise be carried down by infiltrating surface waters to the groundwater system. Having entered the system, contaminants may travel along with groundwater to discharge areas. When the point of discharge happens to be a water well, the consequences can be dire.

The Division of Geology and Land Survey (DGLS), Water Resources Program (WRP), is engaged in delineating source water areas for public water supply wells. The work is being done as part of Missouri's Source Water Assessment Program (SWAP). Source water area is defined as the tract of land around a well that supplies recharge to the well within a specified time interval. Accordingly, source water areas are being delineated for one-, five-, ten-, and twenty-year times-of-travel (TOT). These areas serve to predict when a well is most likely to receive water from a recharge event (such as rain) that occurs at some given distance from the well. For example, a recharge event involving contaminants that occurs at the outer edge of the ten-year TOT source water area would be expected to arrive at the well in ten years. Source water areas can also serve as templates for planning land use around water wells.

Two methods are being used to delineate source water areas. The first is the cylindrical displacement method (CDM), in which (a) aquifer effective porosity, (b) saturated thickness of the aquifer above the well bottom, (c) pumping rate, and (d) time-of-travel are used to calculate the radius of a cylindrical volume of aquifer that surrounds the well. The radius of the cylinder is the radius of the source water area. Consequently, CDM source water areas are perfect circles that are centered on the wells. CDM source water areas have been delineated for all the approximately 4,000 active public water supply wells that reside in Missouri. Recently, a computer program was completed that automates the recurrent task of revising CDM source water areas to accu-

rately reflect additions, deletions, and changes of information in well databases. Strengths of CDM include simplicity and speed. Its major weakness is that it does not take into account the hydraulic gradients that are always present in groundwater systems. In the real world, gradients profoundly affect the sizes, shapes, and orientations of source water areas.

Groundwater modeling is the second approach that is being taken to delineate source water areas. Modeling is being achieved with computer software marketed under the name, *Groundwater Modeling System* (GMS 3.1). The software features windows-based pre-processing /post-processing that facilitates construction and display of complex three-dimensional conceptual models that realistically display actual hydrogeological conditions. The venerable MODFLOW and MODPATH modeling routines are at the heart of the software. When done correctly, groundwater modeling delineates source water areas at a high level of accuracy. The areas are characteristically elongated shapes that pull out considerably in the up-gradient direction from wells.



Comparison of ten-year time-of-travel source water areas delineated by two different methods. The perfectly circular areas are drawn via the cylindrical displacement method. The greatly elongated (eel-like) source water area is drawn via computer groundwater modeling. The modeled area more accurately depicts the actual source water area. The two wells produce from shallow tributary alluvium in which groundwater flows primarily to the southeastward. This map was produced by the Groundwater Section, Water Resources Program, DGLS, Rolla.

WASTEWATER TREATMENT SYSTEMS

Many agencies and organizations are closely associated with water quality issues, however, the Department of Natural Resources is the agency responsible for maintaining and improving water quality in Missouri's streams, lakes and groundwater. It is also the agency responsible for enforcing the Missouri Clean Water Law.

Missouri water quality standards are rules made by the Missouri Clean Water Commission. The standards list the classified waters of the state, their beneficial uses, and the allowable concentrations of various pollutants.

The department requires all point source discharges of contaminants (other than from single-family residences and certain stormwater discharges) to obtain a water pollution control permit and comply with its terms.

Permits cover point-source discharges such as treated sewage from towns, subdivisions or businesses, industrial wastewater discharges, and runoff from large concentrated animal feeding operations (CAFOs), mines, quarries, large construction sites, and chemical storage areas. The permits limit the amount of pollutants that can be discharged so those water quality standards set for streams, lakes, and groundwater are not violated.

The State of Missouri issues permits that are recognized by the federal government as equivalent to federal permits (commonly referred to as National Pollutant Discharge Elimination System or NPDES permits under the federal Clean Water Act). This delegation of authority means that the state has the primary responsibility for permitting, inspection and enforcement activities on regulated facilities.

Water Quality Coordinating Committee

There is an ad hoc assembly of roughly 30 organizations meeting under the aegis of the Water Pollution Control Program, called the Water Quality Coordinating Committee. This group is an informal interagency and public committee dealing with water quality issues. It meets on the third Tuesday of each month at 10:00 A.M. in Jefferson City or Columbia. Nonprofit organizations, business representatives, agency employees and citizens attend to discuss water quality issues. This is a partnering effort that has been going on for several years, and is designed to keep everyone informed so that those with an interest can interact with each other efficiently.

NONPOINT SOURCE POLLUTION

Nonpoint source pollution (NPS) is defined as contamination caused by diffuse sources that are not regulated as point sources. This type of pollution is normally associated with agricultural, silvicultural and urban runoff. It results in human-made or human-induced alteration of the chemical, physical, biological or radiological integrity of the water. In practical terms, nonpoint source pollution does not result from a discharge at a specific single location (such as a pipe), but generally results from land runoff, precipitation, atmospheric deposition or percolation. In simpler terms, it is pollution that enters waterways by overland flow or infiltration, as opposed to through conveyances such as pipes or channels.

By the early 1970s, many streams and lakes across the land had become open conduits for the nation's sewage and industrial wastes. With passage of the federal Water

Pollution Control Act of 1972 (P.L. 92-500), Congress set in motion a massive clean up. Throughout the following decades, hundreds of waste treatment facilities were constructed. Previously polluted streams and lakes became cleaner and aquatic life began to reappear. However, 29 years and billions of dollars later, we have not completely achieved the goal of having water that is clean enough for swimming, recreational uses, and protection of aquatic life. Only about half of today's pollutants come from pipes or point sources. The remainder is from nonpoint sources.

The Missouri Nonpoint Source Management Plan was developed to address these nonpoint sources. The plan focuses state and federal activities and funds related to nonpoint source pollution. The stated mission and goals of the plan are as follows-

Mission:

- Preserve and protect the quality of the water resources of the state from nonpoint source impairments.

Goals:

- Continue and enhance statewide water quality assessment processes to evaluate water quality and prioritize watersheds affected by nonpoint source pollution;
- Improve water quality by implementing nonpoint source-related projects and other activities;
- Maintain a viable, relevant, and effective Nonpoint Source Management Program with the flexibility necessary to meet changing environmental conditions and regulations.

Specific, quantifiable objectives have been developed to help achieve these goals, accompanied by methods to be used in evaluating success in meeting the goals and objectives.

IMPAIRED WATERS

There has been heightened interest at both the state and national level in sections of the Clean Water Act pertaining to the identification and restoration of impaired waters. The 1972 federal Clean Water Act requires states to list all waters that do not meet established water quality standards. This listing of impaired waters is referred to as the 303(d) list, referencing the section of the law that contains the listing requirement. The 303(d) list must be revised every four years. The department is currently working from the EPA-approved list of impaired waters developed in 1998. The list must be revised every four years and the next revision must be submitted to EPA in 2002. There are 174 impaired lakes, streams or stream segments on Missouri's 1998 303(d) list.

Once the 303(d) list is made final, the state is obligated to develop a plan that will result in the water body coming into compliance with water quality standards. These plans are referred to as Total Maximum Daily Loads (TMDLs). Based on existing data, calculations are performed to determine the maximum pollutant load a water body can receive without becoming impaired. This load is then divided up, or allocated, to all existing sources of the pollutant. Implementation plans are also part of the TMDL document and will identify the load reduction needed from all sources of the impairment. This includes point and nonpoint sources. Nonpoint sources of pollution have traditionally not been addressed in the implementation of the Clean Water Act. Addressing nonpoint source pollution to resolve water quality problems is controversial. The goal is to use existing regulations to address point source concerns and promote voluntary actions on the part of nonpoint sources through

the provision of funding for the installation of best management practices. The recent emphasis on this part of the Clean Water Act has resulted in increases in federal funding to address both point and nonpoint sources of pollution.

There have been 40 legal actions in 38 states related to TMDLs. The policies regarding TMDLs and the process for the development of restoration plans are constantly evolving. All agency actions related to this issue require public involvement and the opportunity for public comment. For more information, visit the department's TMDL web site at http://www.dnr.state.mo.us/deq/wpcp/wpc-tmdl.htm or contact the Water Pollution Control Program at 573-751-1300.

Water Pollution Control Tools

There are many methods the state uses to protect its waters or repair damaged waters. These include monitoring water quality and the status of pollution control facilities, permitting, financial and technical assistance and enforcement.

Monitoring water quality is fully described in a separate chapter. Monitoring information is compiled into several reports, the most notable being the "305(b) report," which is required by the federal Clean Water Act, Section 305(b). This report documents how water in the wells of each state meet that state's water quality standards. For example, it identifies the mileage of waters that provide for safe swimming, and those that are expected to be safe, but are not. These reports also provide the basis for establishing impaired waters lists and other management activities. The 305(b) reports are prepared every two years and the data are reported to Congress.

In addition to monitoring water quality throughout the state, the department compiles lists of water pollution control needs, which support the state's requests for federal grant and loan assistance. The Needs Survey, as it is known, documents the work that must be done to bring water quality related facilities into compliance with design standards or other conditions where they will not damage water quality. Federal grant and loan funds are apportioned to the states in relation to their needs.

In addition to permits described under Wastewater Treatment Systems, permits are required for concentrated animal feeding operations (CAFOs). The permits ensure that properly designed facilities are constructed for holding animal wastes. Letters of Approval (LOA) are offered for animal feeding operations smaller than 1,000 animal units. An animal unit is the equivalent of one beef steer. This voluntary program was developed two decades ago, and has been operated by the department as a free service to agricultural producers.

The Department of Natural Resources administers a program that distributes grants or low-interest loans for the construction of wastewater treatment and drinking water treatment facilities. The funds for this program come from the state and the U.S. Environmental Protection Agency. In 1998, this loan program dispensed loans valued at $68 million.

The loan program has been in effect since 1990 and requires that most of the burden of funding falls on cities. From 1972 to 1992, a state-federal grant program funded up to 90 percent of the construction costs of wastewater treatment facilities, which helped meet the needs of both expanding populations and replacement of aging facilities. Today, there is concern about the ability of the present funding system to continue to meet construction needs.

In 1995, the department entered into an agreement with the Department of Agri-

culture to operate an agricultural loan program. Under this program, the department will loan funds to the Agricultural and Small Business Development Authority (ASBDA). The ASBDA will use the funds to finance, at subsidized interest rates, animal waste facilities for producers. The loans are limited to animal feeding operations of less than 1,000 animal units. Producers' repayments are used by ASBDA to repay the loan. The department has committed $10,000,000 to these loans. Another $10,000,000 is available if the program is successful.

Enforcement actions related to water pollution are sometimes necessary. During 1998, there were about 258 active cases involving violations of the Clean Water Law or regulations. Of these, 83 cases were resolved, and the facilities returned to compliance during the year. These settlements included collection by the department and the attorney general's office of more than $1,200,000 for environmental damages and penalties.

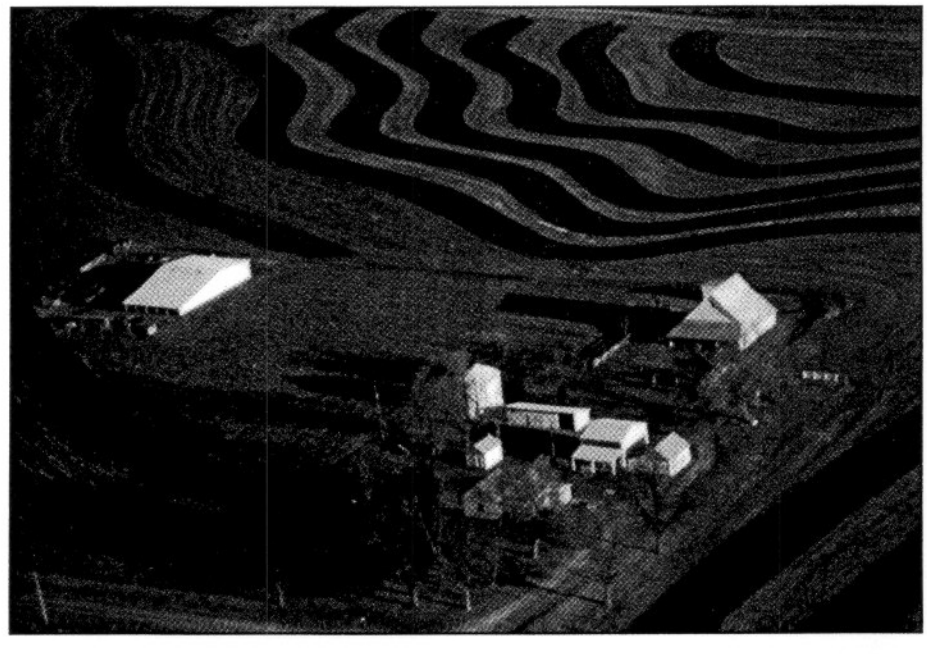
SOIL AND WATER CONSERVATION

Soil is a fragile natural resource capable of sustaining human life. All living things depend on the soil for food. Everything we eat, and most of what we wear comes from the soil.

Today, farmers work soils intensively to produce food for a growing population. In Missouri, agriculture is one of the largest industries. Of the 44 million acres in the state, more than half (26 million) are devoted to agricultural production. Sometimes, however, agricultural production can contribute to erosion.

Erosion is a process where wind and water move crop-producing soil off the land. This topsoil often collects in ditches, along roadsides or ends up in our lakes, rivers and streams. To prevent this, many landowners employ various soil conservation practices on their farms. Controlling and preventing erosion on Missouri's farms helps ensure production and keeps food plentiful and prices reasonable for future generations.

Missouri is now a leader in soil conservation, but in the past the state had the second highest rate of soil erosion in the nation. In 1984, 1988, and again in 1996, Missourians voted for a one-tenth-of-one-percent sales tax to support soil and water conservation efforts and state parks. The tax money added a unique twist to an already strong mix of federal, state and local players working to save our soil.



A typical Missouri farm demonstrating an erosion control technique called contour plowing. Photo from DEQ/SWCP.

Each county has a soil and water conservation district formed by a vote of eligible landowners in the county. These landowners also elect the board of supervisors to oversee the operations of the district. The supervisors work with the landowners and encourage them to participate in the district's voluntary programs. They work together to make decisions on the best treatments for the land.

The local districts work with the Missouri Soil and Water Districts Commission and the federal Natural Resources Conservation Service (NRCS) to administer the state soil and water conservation programs. The Commission sets the policy for use of the tax money and administers it through the department's Soil and Water Conservation Program. More than 75 percent of expenditures have gone back on the land. NRCS offers technical expertise to landowners on the best treatment or preventive measures for their land. Other partners include the University of Missouri-Outreach & Extension, and the Missouri departments of Agriculture and Conservation.

Missouri is now first in the nation in the rate of reducing soil erosion. But more than 4 million acres of agricultural land still need treatment. The Commission's work and goal for the coming years is outlined in its "Plan for the Future."

The goal is to treat 95 percent of all agricultural land in the state by the year 2006. Through the programs that have been set up to do that, participants also will address agricultural runoff and water quality issues, thus providing the state with a second benefit on its investment.

One way to do that is through the Special Area Land Treatment (SALT) Program. This program brings landowners in watersheds together to help solve soil erosion and water quality problems. Keeping soil and agricultural chemicals out of rivers and streams and on the land contributes to agricultural productivity and good water quality.

SOIL AND WATER CONSERVATION PROGRAMS AVAILABLE IN THE STATE

Currently, the Special Area Land Treatment (SALT) program is being expanded to address agricultural nonpoint source pollution (AgNPS) issues associated with runoff from production agriculture. The SALT program is a voluntary approach to natural resource management and conservation. A project grant is made available to local soil and water conservation districts to provide general support for the project, technical assistance, and information and education activities in the watershed. Financial assistance is available to landowners to encourage the adoption and implementation of best management practices. SALT projects are coordinated with the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture (USDA) for planning and technical support. AgNPS SALT projects can be combined with other programs to achieve maximum results from the resources provided to treat associated water quality problems. The Environmental Quality Incentive Program (EQIP) is a federal watershed program administered by the NRCS that may fit with an AgNPS project to address water quality problems. Other state and federal programs available that support AgNPS SALTs include the Water Pollution Control Program's 319s, the Missouri Department of Conservation's (MDC) Wildlife Incentive Programs, and the Missouri Department of Agriculture's Animal Waste Treatment System Loan Program. Partnerships between programs are extremely important to accomplish environmental goals because they can bring together the resources needed to help

ensure a successful project. Missouri is fortunate to have these partnerships coming together to address the water quality issues in the state.

The intent of the AgNPS SALT Program is to provide a basic level of resources to make significant contributions to the control and reduction of nonpoint source water pollution from agricultural runoff. The concept is based on numerous partners contributing to the project and various tools utilized to accomplish project goals. Through joint efforts, limited resources and funding can be used in a cost-effective manner.

There are currently seventeen pilot AgNPS SALT projects across the state. Six of these projects address waters listed on Missouri's Clean Water Act Section 303(d) list. Thirteen new projects have been proposed by Soil and Water Conservation Districts to start July 1, 2001, pending Commission approval. The seventeen current projects are depicted on the map on this page.

Some of the water quality issues being addressed in the pilot projects include: Sedimentation, excess nutrient loading (by nitrogen and phosphorus), chemical contamination from pesticides and herbicides, loss of aquatic habitat, streambank erosion, fecal coliform bacteria from animal wastes, and karst groundwater contamination. Often AgNPS SALT projects provide a springboard for landowners to address additional natural resource problems. Landowners working together in this way can address additional resource goals, such as improved water quality and improved pasture management, along with erosion treatment and control. The AgNPS SALT projects provide cost-share and reimbursement of interest paid on loan incentives to install and maintain conservation practices. To ensure the effectiveness of the practices used on the farm and to be eligible, practices have to be installed and certified as completed according to NRCS or MDC technical specifications.

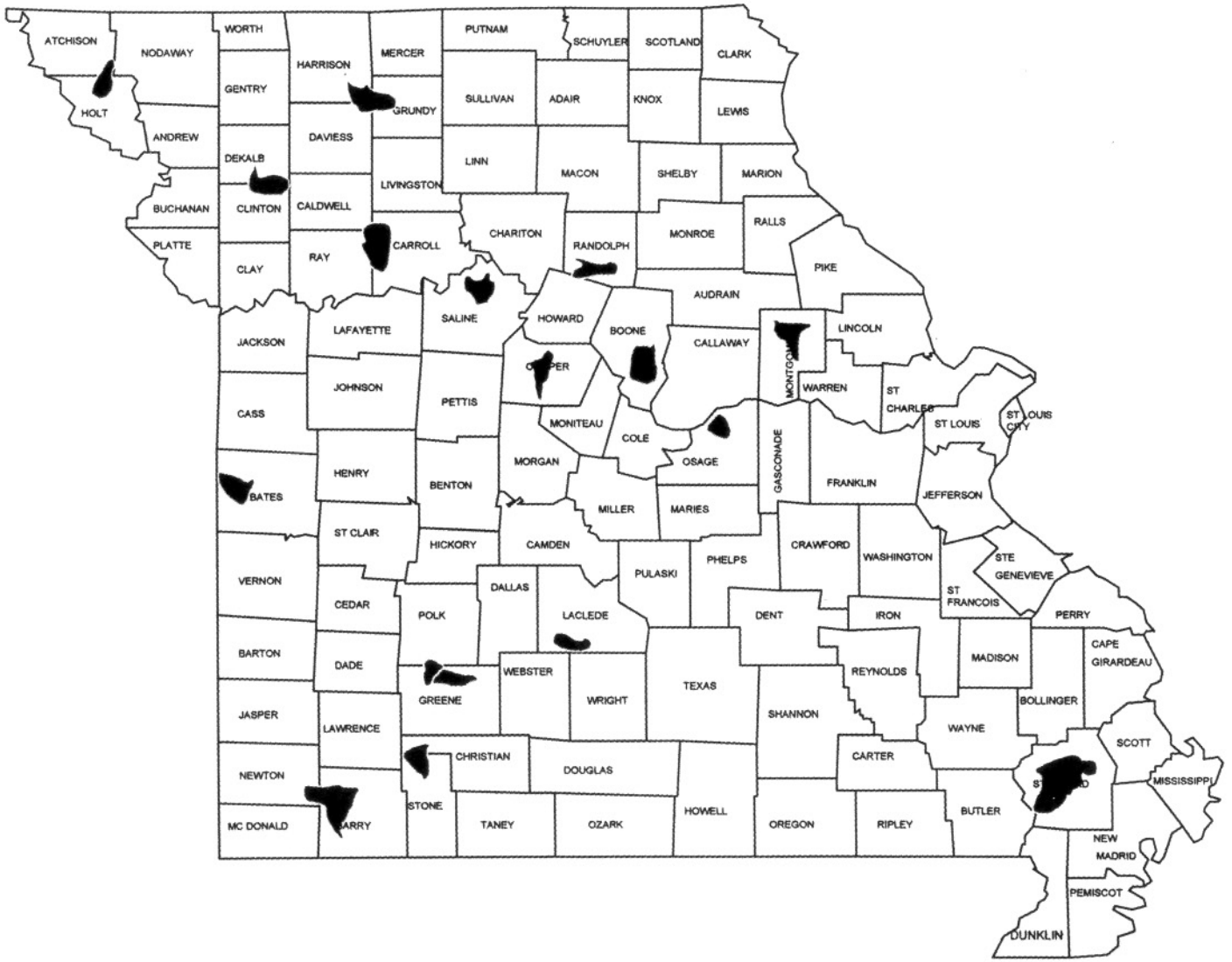
Two other programs administered by the Soil and Water Conservation Program are the Cost-Share and Loan Interest-Share Programs. These programs help landowners carry out conservation plans and the goals established in the Soil and Water Districts Commission's "Plan for the Future." The Cost-Share Program funds up to 75 percent of the cost of installing conservation practices on agricultural land. Through this program, the state has installed some 121,000 conservation practices, saving over 157 million tons of topsoil on about 2 million acres of cropland and pastureland. The Loan Interest-Share Program refunds a portion of the interest on loans for purchasing conservation equipment.

The Soil and Water Districts Commission considers local soil and water conservation districts to be the delivery system for its conservation programs. As such, a major point of the "Plan for the Future" is to strengthen the role of the local districts. Districts receive grants to provide technical assistance for landowners and other operational costs.

Finally, the commission plans to assist in the completion of the initial inventory of Missouri's soil resources by the end of state fiscal year 2002. The soil survey is used by a number of different occupations to provide valuable soils information to the citizens of the state. The soil survey information is highly useful to many entities working on soils and related water quality issues.

Missouri is a leader in soil conservation as a result of soil and water conservation districts' work and the voluntary commitment of Missouri farmers. These soil conservation successes contribute to improving the state's water quality as well.

Current AgNPS SALT Projects



HAZARDOUS WASTES

The department regulates hazardous waste to protect human health and the environment and to ensure that any contamination is remediated as quickly as possible. The department oversees groundwater and surface water monitoring at hazardous waste sites within the state. As part of the department's oversight, hazardous waste facilities are required to determine the impact of past and present waste management practices on water quality. This includes determining the extent of contamination, the distribution of contamination and the potential impact on other waters or water users. If contamination is found to pose a threat, the department will ensure that remedial actions are taken.

Groundwater and surface water monitoring activities, and any subsequent remediation, can occur at five different types of sites:

1) Resource Conservation and Recovery Act (RCRA) treatment, storage and disposal facilities (TSDs);
2) Superfund cleanup sites, including Federal Facility sites;
3) Voluntary cleanup sites;
4) Enforcement directed cleanup sites; and
5) Leaking storage tank facilities.

As of December 15, 2000, there were 3,123 of Missouri's hazardous waste generators considered "small quantity generators" and 536 considered "large quantity generators." There presently are 99 TSD's in Missouri.

The department may require RCRA TSD facilities whose practices might affect large bodies of surface water in Missouri to implement a surface water-monitoring program. Currently, nine RCRA TSD facilities in Missouri are monitoring surface water for various contaminants. These facilities are required to report to the department at least once per year. The results of the monitoring are examined and tracked by the department.

In accordance with state regulation, a TSD facility that is subject to federal groundwater monitoring requirements must conduct groundwater monitoring on a regular basis until released from such obligation by the department. Currently, 47 TSD sites are conducting groundwater monitoring in Missouri. Of these 47 sites, 21 are actively remediating groundwater contamination to improve the quality of water that may ultimately migrate to surface water bodies or drinking water sources.

Each TSD facility must submit an annual groundwater monitoring report to the

Department field investigators use drilling equipment to collect subsurface soil samples at a hazardous waste site. Photo from DEQ/ESP.

department for an official evaluation. The evaluation includes determination of contamination data trends and the extent of contamination resulting from TSD facility operation. All groundwater monitoring data from RCRA TSDs in Missouri are entered into a database where they can be tracked and evaluated. The department periodically conducts groundwater monitoring field audits at TSD facilities to help ensure that their samples are collected and analyzed in accordance with accepted standard operating procedures and that the sampling data generated by TSDs are reliable.

The Hazardous Waste Program's Federal Facilities Section provides oversight of 34 sites for which the Department of Defense (DOD) has the responsibility for environmental remediation, and three sites for which the Department of Energy (DOE) has the responsibility for environmental remediation. Of the 37 sites, four sites are on the National Priorities List (NPL), three are DOD sites and one is a DOE site. At the four NPL sites, the U.S. EPA has the lead regulatory role, leaving 33 sites for which the Hazardous Waste Program has the lead regulatory role. An additional 39 DOD Formerly Used Defense Sites are currently being investigated by the Federal Facilities Section. Groundwater remediation is continuing at two federal facilities. One of these is a DOD site and another is a DOE site. Nearly all of the remaining sites are undergoing surface and groundwater investigation for characterization of contamination and migration.

Additional hazardous waste sites fall under the "Superfund" law and its amendments. Superfund includes the authority to initiate and remediate actions when contamination is determined to present a threat to human health and the environment. The Department of Natural Resources performs site assessments on potential Superfund sites and from these assessments, determines the degree of surface water and groundwater investigations that will be required.

Currently, 69 Superfund sites are undergoing some type of groundwater investigation. An additional 47 sites are undergoing regular groundwater and surface water monitoring. Of the 69 sites, 37 have initiated some form of groundwater remediation. Available alternatives utilized in the past for groundwater remediation include, but are not limited to, providing an alternative drinking water source, and natural attenuation. The department requires periodic reporting concerning these sites. Contamination concentrations and trends are tracked in order to recommend future actions.

In 1994, a state law was passed allowing responsible parties to voluntarily initiate a cleanup of their sites under the oversight of the department. These cleanups are supervised by the department's Voluntary Cleanup Program (VCP). These VCP sites must be qualified first by virtue of not fitting into the RCRA TSD category and cannot be on the Superfund National Priority List (NPL). If a site is determined to be eligible, the responsible party must formally agree to remediate their site by entering into an agreement with the department. Currently, 119 sites are undergoing voluntary cleanup, and 62 sites have completed cleanup and received certificates of completion. Of the 119 sites undergoing cleanup, 70 sites either involve active groundwater monitoring or remediation, or groundwater monitoring or remediation is expected to become part of the site cleanup.

The Hazardous Waste Enforcement Section also directs and provides oversight on sites with hazardous waste contamination and requires testing and remediation, where appropriate, to protect surface water and groundwater. The section also coordinates with the Water Pollution Control Program to

assure that necessary permits are obtained at sites under Hazardous Waste Enforcement action.

Storage Tanks

The department regulates the operation and maintenance of underground storage tanks (USTs), because leaking USTs pose a significant threat to Missouri's water resources. Tanks containing petroleum products and some hazardous substances compose the regulated tanks in Missouri.

Most releases from underground storage tanks are gasoline releases. Gasoline poses a threat to groundwater because it contains benzene, a known carcinogen, and other chemical constituents, such as methyl tertiary butyl ether (MTBE). EPA has tentatively classified MTBE as a possible human carcinogen. MTBE is an additive to fuel to help the gasoline burn more completely.

Federal and state requirements are in place to reduce the potential of a release from a UST. Upgraded standards took affect December 22, 1998, requiring USTs to be equipped with spill, overfill and corrosion protection. Another requirement for UST owners is to have leak detection monitoring installed on their systems. Leak detection methods are designed to alert the owner of a release occurring in their tank system.

Despite these requirements, releases from tanks will continue to occur. Owners and operators are required to report a release from a tank to the department. Project managers are assigned to specific release sites to oversee the cleanup and remediation of tank releases. Over the past eleven years, over 5,400 releases from USTs have occurred and more than 3,900 of those have been remediated to department standards.

The department also investigates sites where aquifers have been impacted from petroleum but where the source of contamination is not known. Investigative techniques such as dye tracing, monitoring well installation, soil drilling/probing, soil gas surveys and geophysical surveys all provide valuable insight to understanding the potential migration pathways in the subsurface. This can lead to identifying the responsible party and eventual restoration of the aquifer.

Tank Facts as of January 22, 2001

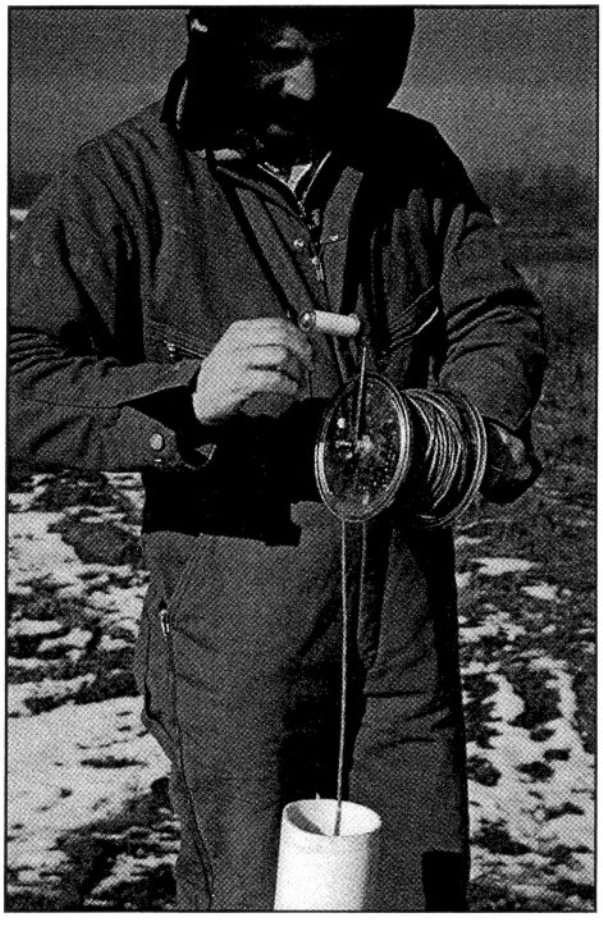
Underground Storage Tank (UST) Releases	5,422
UST Cleanups Completed	4,096
Ongoing UST Cleanups	1,326
Aboveground Storage Tank (AST) Releases in Remedial Oversight,	284
AST Cleanups Completed	31
Ongoing AST Cleanups	253
Total USTs (active and closed)	36,457
Total Closed USTs	25,571
Total Active and Temporarily Closed USTs	10,886
In-Use Active USTs Meeting Upgraded Requirements (98.1%)	9,587
In-Use Active USTs Meeting Leak Detection Requirements (98.4%)	9,617

SOLID WASTES

Historically, some landfills have been a source of surface and groundwater contamination. As of April, 1994, stricter federal subtitle D (of RCRA) design and operational requirements affected all operating landfills in Missouri. Some of the new requirements are related to establishing, developing and maintaining surface and groundwater monitoring. These include: Detailed hydro-geo-

logic investigations; installation of groundwater monitoring wells capable of detecting any contaminants that could leave the site; and installation of a composite liner and leachate collection system on areas that were not covered by waste as of April, 1994.

Another change that should help protect water quality in Missouri relates to the final "cover cap" requirements. Areas already landfilled but not properly closed will require a final cover cap of at least two feet of compacted clay and one foot of soil. All areas with a geomembrane liner (an impermeable material that does not allow liquids to pass through it) require cap designs that include a geomembrane, even if the areas were previously permitted for another final cover cap design.



A department field investigator measures the static water level in a landfill groundwater monitoring well. Photo from DEQ/ESP.

There are more than 150 closed or abandoned landfills scattered throughout Missouri. These older landfills were not constructed or operated like the modern subtitle D sanitary landfills we have today. The presence of these older landfills poses an unknown impact to the water resources of Missouri. No statewide assessment has been conducted; however, it is very possible that they are contributing leachate contamination to both surface and subsurface waters. Currently, such an assessment is in the planning stages. If implemented, information obtained over the several year study could confirm impacts or eliminate them on a site by site basis.

In 2000, the Solid Waste Management Program completed the design and installation of an artificial wetland to address a leachate discharge from an abandoned landfill in Warren County known to be impacting a nearby stream. The wetland will be used as a research tool to determine the effectiveness of such a treatment process in landfill leachate. If it is able to provide an acceptable level of treatment, it could be utilized at similar sites around the state and nation as an effective, low-cost solution.

WELLS FOR WATER, HEAT PUMPS, MONITORING AND MINERAL TESTING

If wells are not constructed or plugged properly, they most likely will allow surface water, with its contaminant load, to bypass the earth's natural filtering system and enter directly into drinking water aquifers. The "Water Well Drillers' Act" (section 256.600 to 256.640 RSMo) was passed into law in 1985. By the fall of 1987, rules were in place gov-

erning the construction of domestic water wells, pump installations, and the plugging of abandoned wells. The drilling contractors and pump installation contractors were required to be permitted (licensed), and their drill rigs were required to be registered.

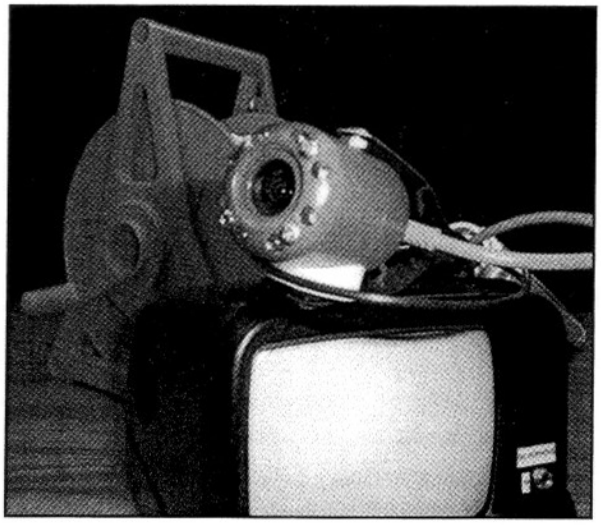
This law was passed to ensure that the quality of Missouri's groundwater is maintained at the highest level practical to support present and future use. The importance of this law and its enforcement plays a pivotal role in the protection of our groundwater.

An important amendment to this law was passed in 1991. The amendment brought the heat pump, monitoring well, and mineral test hole drilling industries under regulation. It also created the Well Installation Board. The department's Division of Geology and Land Survey (DGLS), with the oversight of the Well Installation Board, is responsible for implementation of the Water Well Drillers' Act. The Geological Survey Program within DGLS has been given the day to day tasks of implementation.

The preceding chart shows the number of wells reported since the "Water Well Drillers' Act" was created. This chart shows the number of completed certified wells drilled in Missouri during any given year. The numbers for water wells reflect wells in the private category as well as the public well category. It is extremely hard to estimate how many wells are drilled each year that are never reported. Geological Survey Program (GSP) personnel have been very diligent with their limited staff in the enforcement of the rules but a certain number of wells still are not reported each year. The rules state that the permitted contractors do not have to report that a new well has been drilled until 60 days after they have completed the job.

It is important to note that after the 1991 amendment to the law was passed, rules had to be written and approved before reporting on monitoring wells and heat pump wells

Date Completed	TYPE OF WELLS			
	Water	Monitoring	Heat Pump	Plugged Wells
1986	130	0	0	0
1987	4,390	0	12	4
1988	5,612	2	18	7
1989	5,451	14	9	13
1990	5,503	0	0	1
1991	5,246	0	2	4
1992	5,913	0	2	5
1993	5,732	1	4	4
1994	6,628	1,186	509	742
1995	6,653	1,125	488	1,174
1996	6,964	811	288	1,125
1997	6,787	1,058	250	1,298
1998	6,927	1,103	200	1,426
1999	8.063	1,553	143	1,553
2000	8,177	1,324	100	1,443
TOTAL	88,176	8,177	2,025	8.799



Waterproof downhole camera. Camera head is less than 2 inches in diameter. Photo by Bruce Netzler.

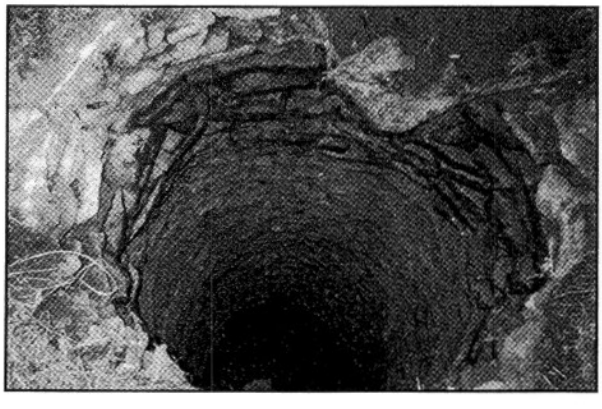
was required. These rules became effective December 13, 1993; therefore, the increase in numbers of heat pump wells and monitoring wells in 1994 reflects this regulatory change. Also, some contractors submitted records for heat pump and monitoring wells before they were required and these numbers are reflected in the chart. Typically, a mineral test hole is drilled, information obtained and the hole is plugged within 30 days; therefore, these types of wells are recorded only after they are plugged.

As a tool to aid in proper well construction and well plugging, the department purchased a black and white, waterproof, downhole camera in 1994. At the time the department purchased this camera, it was almost at the "cutting edge" of technology. The downhole camera is less than two inches in diameter and, when lowered into a well, can send back a video image that shows in detail underground features that few have seen. This single piece of equipment has revolutionized the division's ability to diagnose construction and contamination problems with water wells and provides the details needed to properly plug wells. Due to the large demand placed on the first downhole camera, a second one was purchased in the spring of 2000 to aid staff in their mission.

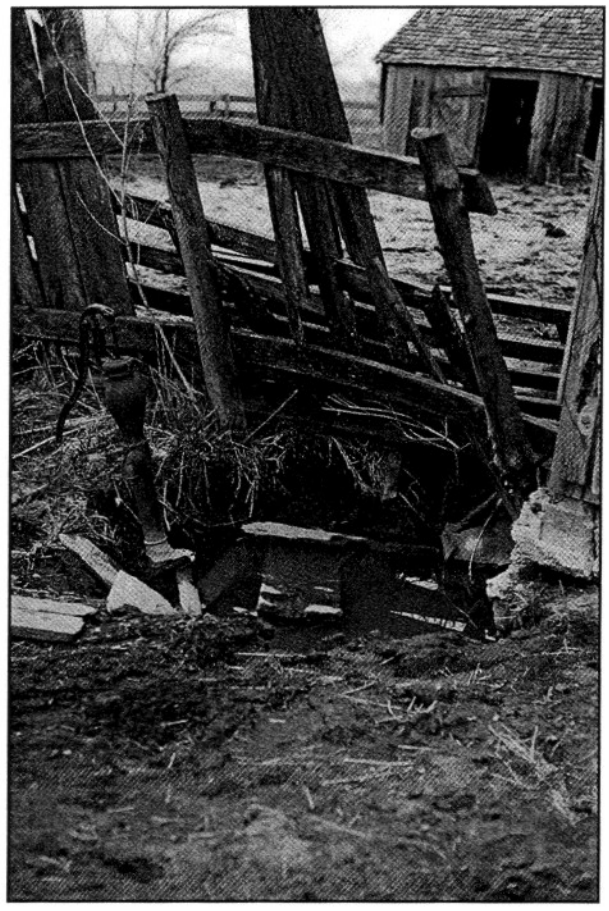
ABANDONED WELL PLUGGING

It has been estimated that Missouri has from 150,000 to 300,000 unplugged abandoned wells. However, this may be a conservative estimate. More recent estimates place the number in excess of 500,000 unplugged wells and cisterns scattered across Missouri. Each one of these unplugged wells or cisterns is a danger either to the health, welfare and safety of Missourians or to the groundwater that we rely on so heavily for our water resources.

Whenever surface contamination (pesticides, septic tank effluent, animal waste, chemicals, oil and grease, solvents, etc.) finds an unplugged well, it can quickly bypass the natural filtering system of soil, unconsolidated material and rock and directly contaminate the underground aquifers. Once an underground aquifer is contaminated, it is very difficult and very expensive to clean up. Prevention is always cheaper and better than remediation.



Looking into an old hand-dug well with cover removed. The well is approximately 4 to 5 feet in diameter and 30 feet deep. It is lined with field stone. Photo by Bruce Netzler.



Abandoned and forgotten hand-dug well in farm lot. Notice rotted cover and old hand pump. Photo by Jim Vandike.

Many things have changed since Missouri's early settlement days more than 150 years ago, but one thing that has not changed is the need for a dependable supply of water. If early settlers did not live near a river, spring, lake or stream they had to dig a well or cistern. The first wells were hand-dug and many of them are still in existence today but are rarely used and often forgotten. A hand-dug well is typically 5 to 10 feet in diameter and up to 50 feet deep. These wells were lined with rock or brick and were covered with a concrete or wooden cap. (The biggest hand-dug well in the U.S. is located in southwestern Kansas in the town of Greensburg and is 32 feet in diameter and 109 feet deep.) These types of wells are considered a major danger to life and limb. People have died across Missouri by accidentally falling into one of these wells. These types of tragedies can be avoided with a little preventive action.

Unplugged abandoned drilled wells are also a danger to personal safety and a potential conduit for surface derived pollutants. The size of Missouri's drilled wells range from the normal 6-inch diameter of a private domestic well, upwards to 36 inches in diameter. Many people do not realize that a well as small as 8 inches in diameter can be a death trap to young children. Some people still remember the drama that played out on television years ago about a little girl named Jessica McClure who was trapped in a well in Texas. The well was just 8 inches in diameter. She was very lucky to have been rescued.

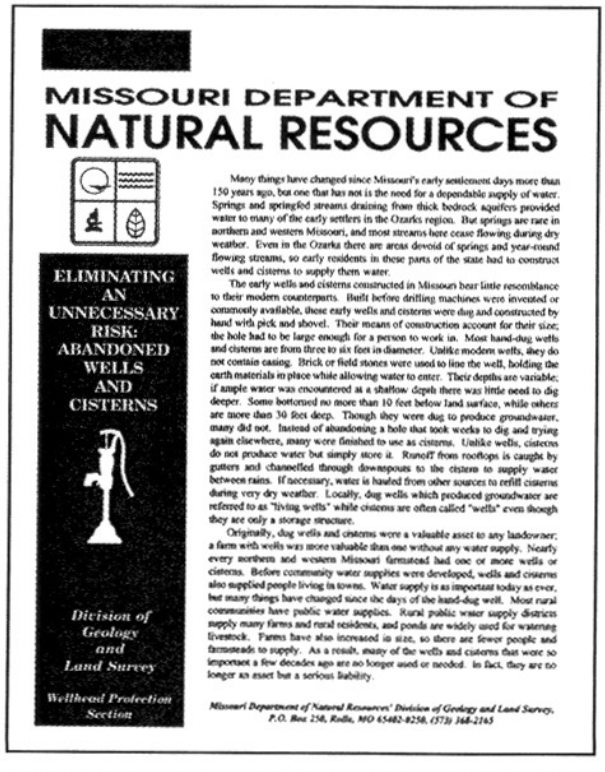
It may surprise many that the first and only law requiring abandoned wells to be plugged was enacted in 1991 and was an amendment to the Water Well Drillers Act (section 256.600 to 256.640 RSMo). This law states that wells abandoned after August 28, 1991, must be plugged according to approved standards. Therefore, wells abandoned before this date are not required to be plugged. That leaves a huge number of wells that have been abandoned before 1991 scattered across the countryside.

There are some exceptions to this general rule. When a person hooks up to a water district and is using a well for water supply, that well must be plugged, unless the landowner wishes to use it for other purposes. The law also states that if a landowner permits hazardous or potentially hazardous conditions to exist on owned property that may cause deterioration of the groundwater, the landowner can be held liable. This does give some enforcement ability but would require a

Notice of Violation and enforcement follow-up. It is important to note that if the landowner does not comply, the only recourse is referral to the Attorney General's Office and litigation. This is not the best way to achieve the goal of plugging abandoned wells and protecting groundwater.

Generally speaking, an educational effort has been in progress since 1991. It is felt that if people understand the dangers of leaving abandoned wells open, they will want to plug them in an approved manner. To accomplish this, several educational aids have been developed. These aids are described in the following paragraphs.

In the spring of 1992, a brochure entitled, "Eliminating An Unnecessary Risk: Abandoned Wells And Cisterns," was made available. The brochure focuses on the risk to human safety, livestock, and groundwater that exists when wells are left unplugged. The brochure begins with a history of Missouri's early settlement days and the types of wells that were dug, and finishes with the modern drilled wells of today. It is written in layman's terms and, with the use of diagrams, sets out easy to understand approved methods for plugging all types of wells. The brochure is geared to private landowners who have the right to plug wells located on their property. When the well plugging regulations were developed, the least expensive and easiest methods were developed as options for the private landowner. This brochure has been reprinted numerous times and is distributed free of charge to anyone requesting it. The brochure has been used extensively as part of well plugging demonstrations that have been carried out cooperatively between the University Extension System and the department's Division of Geology and Land Survey (DGLS).



MISSOURI DEPARTMENT OF
NATURAL RESOURCES

ELIMINATING AN UNNECESSARY RISK: ABANDONED WELLS AND CISTERNS

Division of Geology and Land Survey

Wellhead Protection Section

Many things have changed since Missouri's early settlement days more than 150 years ago, but one that has not is the need for a dependable supply of water. Springs and springfed streams draining from thick bedrock aquifers provided water to many of the early settlers in the Ozarks region. But springs are rare in northern and western Missouri, and most streams here cease flowing during dry weather. Even in the Ozarks there are areas devoid of springs and year-round flowing streams, so early residents in these parts of the state had to construct wells and cisterns to supply them water.

The early wells and cisterns constructed in Missouri bear little resemblance to their modern counterparts. Built before drilling machines were invented or commonly available, these early wells and cisterns were dug and constructed by hand with pick and shovel. Their means of construction account for their size; the hole had to be large enough for a person to work in. Most hand-dug wells and cisterns are from three to six feet in diameter. Unlike modern wells, they do not contain casing. Brick or field stones were used to line the well, holding the earth materials in place while allowing water to enter. Their depths are variable; if ample water was encountered at a shallow depth there was little need to dig deeper. Some bottomed no more than 10 feet below land surface, while others are more than 30 feet deep. Though they were dug to produce groundwater, many did not. Instead of abandoning a hole that took weeks to dig and trying again elsewhere, many were finished to use as cisterns. Unlike wells, cisterns do not produce water but simply store it. Runoff from rooftops is caught by gutters and channelled through downspouts to the cistern to supply water between rains. If necessary, water is hauled from other sources to refill cisterns during very dry weather. Locally, dug wells which produced groundwater are referred to as "living wells" while cisterns are often called "wells" even though they are only a storage structure.

Originally, dug wells and cisterns were a valuable asset to any landowner; a farm with wells was more valuable than one without any water supply. Nearly every northern and western Missouri farmstead had one or more wells or cisterns. Before community water supplies were developed, wells and cisterns also supplied people living in towns. Water supply is as important today as ever, but many things have changed since the days of the hand-dug well. Most rural communities have public water supplies. Rural public water supply districts supply many farms and rural residents, and ponds are widely used for watering livestock. Farms have also increased in size, so there are fewer people and farmsteads to supply. As a result, many of the wells and cisterns that were so important a few decades ago are no longer used or needed. In fact, they are no longer an asset but a serious liability.

Missouri Department of Natural Resources' Division of Geology and Land Survey, P.O. Box 250, Rolla, MO 65402-0250, (573) 368-2165

To further enhance the department's ability to get peoples' attention, and to educate them on the importance of plugging abandoned wells, a traveling display was developed in early 1995. The display consists of six 4' by 8' carpeted panels held together by Velcro. This allows the display to be constructed in many shapes from flat to chevron to a six-sided circular structure. Department personnel made the display by using one-inch blue foam insulation board to which carpet was glued. This made a lightweight, attractive, strong and portable display. It was also inexpensive. Each panel has a strong message. Below is a summary of each panel.

Panel 1 - Help Protect Your Community

- Organize A Well Plugging Demonstration
- Contact your local University Extension Office
- Contact the Division of Geology and Land Survey
- Cost-share money may be available from Farm Service Agency
- *Why Plug Unused Wells?*
  - Prevent loss of human life
  - Protect your livestock and pets

Limit landowner liability
Increase property value
Protect groundwater from potential pollution
Lending institutions may require it

Panel 2 - Unplugged Abandoned Wells Can Be Deadly

This panel has reproductions of actual newspaper articles from Missouri and Kansas documenting cases where people and animals have fallen into abandoned wells.

Panel 3 - The Dangers of Unplugged (Open) Wells

This panel features the "Jessica McClure" tragedy that many people remember. Jessica McClure was the little girl who fell into an "eight inch" diameter abandoned well in Texas. Fifty-two and one half-hours later she was rescued from a well that could have become her grave. She survived and became one of the lucky ones - many are not so lucky. This section of the panel also includes a series of sized rings designed to show people exactly what size wells can be found in Missouri. The rings are on hooks so that they can be taken off the display and placed over the heads of people to see if they could fit inside an abandoned well of that size. The rings come in the following sizes: 6, 8, 10, 16 and 34 inches in diameter. These rings correlate to standard sized well casings used in Missouri. On the floor in front of this panel is a five foot diameter rug that shows an average size hand-dug well or cistern. People usually stand on this rug to view the exhibit. It helps to drive home the point that they could have just fallen into a well.

Panel 4 - How to Plug Hand-Dug Wells, Bored Wells and Cisterns

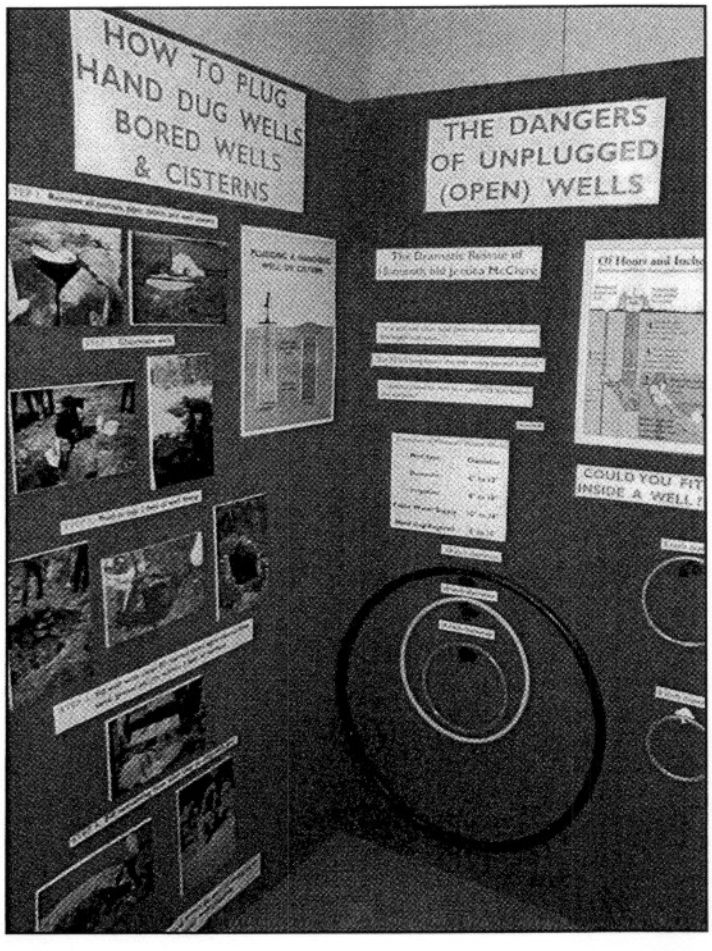
This panel shows a diagram of a hand-dug well before plugging and after plugging. It goes on to show the six steps required to plug hand-dug wells with photographs illustrating these steps.

Panel 5 - How Pollutants Enter the Groundwater through Unplugged Wells

This panel shows, through diagrams and pictures, how pollutants can enter the groundwater via the annulus of poorly constructed wells or by deliberate disposal into abandoned wells. For a normal domestic well, the annulus is the space between the drilled hole (usually 8 5/8 inches in diameter) and the outside diameter of the 6 5/8 inch diameter well casing. This annulus must be sealed with cement slurry or bentonite (swelling clay) to prevent surface contamination from entering the well bore.

Panel 6 - How To Plug Drilled Wells Used For Domestic Water Supply

This panel shows a diagram of how to plug a domestic well in bedrock and a dia-



gram of how to plug a domestic well in unconsolidated materials. Also, an illustrated, step-by-step approach is shown below each type of well.

In an effort to reach even more people and to embrace the computer age, DGLS personnel are in the process of developing a computer-generated well plugging demonstration using Power Point software. These well plugging modules will have excellent computer graphics and sound effects. Presentations will be developed for each different type of well, hand-dug well or cistern, drilled well in bedrock and drilled well in unconsolidated material. The plan is to place this on the Division of Geology and Land Survey's web page (http://www.dnr.state.mo.us/geology.htm) so that it can be viewed and downloaded by anyone.

This will be an extremely important and pivotal accomplishment to further the message of how and why to plug abandoned wells. When this is placed on the Internet it will be instantly accessible to the entire world. Teachers will be able to incorporate this information into their teaching units on environmental issues.

WELLS FOR OIL, GAS AND UNDERGROUND INJECTION

The Oil and Gas Law was passed in 1965. This law requires wells used for oil and gas production, water disposal, enhanced oil recovery, gas storage and geologic information to be constructed in a manner that does not contaminate surface and groundwater resources. Approximately 9,809 wells have been permitted since 1966. In 2000, 34 wells were permitted.

In addition to ensuring proper well construction, the oil and gas law requires a plugging bond to be placed on all permitted wells. This bond is required to be maintained until the wells are properly plugged. In the event an operator improperly abandons a well, the plugging bond is forfeited and the state, working through the Missouri Oil and Gas Council, has the authority to plug the well.

The Underground Injection Control Program is an EPA-delegated program for which Missouri has primacy. Injection wells have been divided into five classes by EPA, based upon the type of fluid injected and where it is injected in relation to underground sources of drinking water. Missouri has wells that fit into two of these classes - Class II and Class V.

Class II wells are oil- and gas-related injection wells. These wells may be used for the disposal of other fluids produced during oil extractions (mostly water) back into the producing horizon, or for enhanced recovery methods to increase production. These wells are subject to regulation under the Missouri Oil and Gas Law.

Class V wells (also called shallow injection wells) include a variety of well types that inject fluid into or above an underground source of drinking water. In Missouri, this well category includes mine backfill wells, septic systems (tank and lateral field), sinkholes improved for drainage purposes, heat pump systems, and injection wells used in groundwater cleanup projects. Septic systems are regulated by the Department of Health. Most other types of Class V injection wells are regulated through the Clean Water Law. The department administers the program and maintains an inventory of Class II and Class V wells.

RECLAMATION OF MINED LANDS

The mission of the Missouri Land Reclamation Commission and the department's Land Reclamation Program is to assure the

beneficial restoration of mined lands and to protect public health, safety and the environment from the adverse effects of mining within Missouri. Active mining regulation includes permitting, inspection and enforcement activities. The minerals regulated include coal, industrial minerals (clay, barite, limestone, sandstone, sand and gravel, traprock and tar sands) and metallic minerals (lead, iron, zinc, copper, gold and silver). While the Land Reclamation Commission is responsible for overseeing coal and industrial mineral laws, the responsibility for carrying out the duties associated with metallic minerals regulations rests solely upon the Land Reclamation Program and the director of the Department of Natural Resources.

At active coal mines, surface water quality is protected through National Pollutant Discharge Elimination System (NPDES) permitting. NPDES monitoring ensures that acid-forming spoils are being properly managed and adequate soil erosion control measures are being taken to prevent sedimentation or acid mine drainage from entering downstream tributaries. As for the protection of groundwater, coal-mining companies are required, under land reclamation permits, to conduct hydrogeologic assessment prior to, during, and after mining. They evaluate any impacts to groundwater quantity or quality in the vicinity of mine sites. Mine operators are further required to mitigate adverse effects stemming from mining activities.

For industrial mineral sites, the hydrogeologic evaluations are not required. Measures to control erosion and sediment movement off-site are required. Under the Metallic Minerals Law, the two lead mining companies and the one iron ore mining company in Missouri are required to provide plans and financial assurance for the continued maintenance of the mine waste sites after mining ceases. The objective is to ensure that the sites are stable and not subject to wind or water erosion of the waste materials (tailings). This primarily involves a coordination role to ensure that dam safety, water pollution control, air pollution control, and hazardous waste management regulatory requirements are met.

An estimated 19,650 acres at approximately 800 industrial mineral mine sites in Missouri are permitted for mining. Nearly 17,000 acres at 14 coal mine sites are permitted and are either actively being mined or are in various stages of reclamation. In addition, there are 15 coal mine bond forfeiture sites with approximately 5,100 acres that the department now has responsibility to reclaim. Seven of these projects have been completed and eight are in various stages of reclamation design or construction. The 10 lead mine sites and one iron ore mine site permitted under the Metallic Minerals Law comprises approximately 4,600 acres. The mining companies are responsible for the reclamation of these sites once mining has ceased.

Significant health, safety, and environmental problems are often associated with coal mine lands that were abandoned or inadequately reclaimed prior to passage of state and federal coal mining statutes in 1972 and 1977, respectively. There are more than 67,000 acres of abandoned coal mine lands in Missouri. Although nature has stabilized much of this land over the years, an estimated 19,650 acres at approximately 800 industrial mineral mine sites, more than 10,000 acres have been identified that require reclamation work to correct a wide range of public health, safety and environmental problems. The worst ones of these problems are being addressed by the department's Land Reclamation Program. Federal funds for abandoned mine land projects are collected by fees charged for each ton of coal mined in the U.S. These funds are distributed to Missouri and other states by the U.S. De-

partment of the Interior's Office of Surface Mining Reclamation and Enforcement.

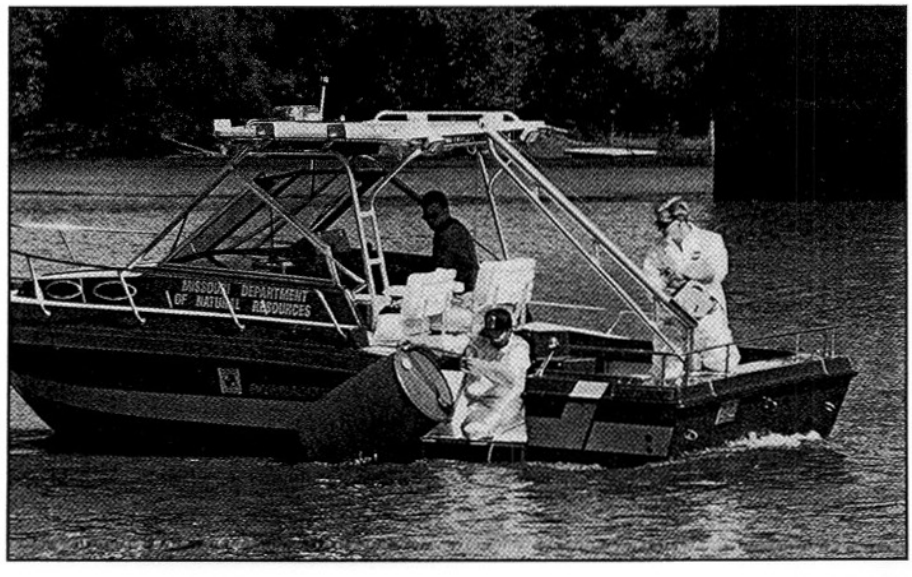
Since 1982, 90 abandoned mine land projects have been completed, reclaiming 3,796 acres. Acid mine drainage from abandoned coal mine lands severely degraded several streams, most notably Cedar Creek in Boone and Callaway counties, Manacle Creek in Callaway County and Middle Fork of Tebo Creek in Henry County, resulting in massive fish kills in the past. Reclamation projects completed from 1988-1994 in these watersheds successfully alleviated most of the acid mine drainage problems of these streams. Negative impacts on aquatic resources have been greatly reduced.

During 2001, additional reclamation work will be conducted in Cedar Creek to further lessen the effects of mine drainage on the creek. The Land Reclamation Program has received funds from the Office of Surface Mining's Clean Stream Initiative. Clean Stream Initiative funds address acid mine drainage problems. The department's Water Pollution Control Program has provided additional funds through an EPA 319 grant to the Land Reclamation Program to address Cedar Creek water quality problems. This work began in the fall of 2000 and will continue until 2002.

ENVIRONMENTAL EMERGENCY RESPONSE

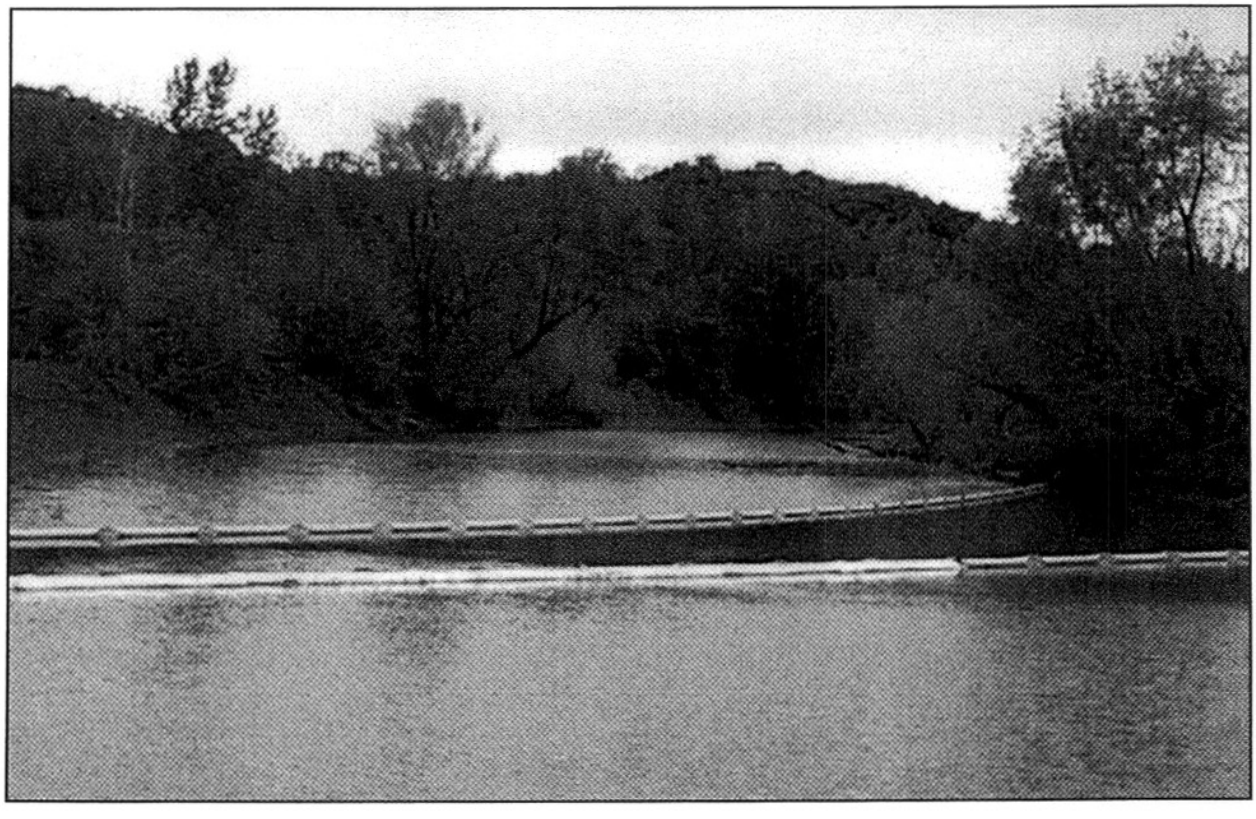
The department has Environmental Emergency Response (EER) personnel that are specially trained and equipped to provide technical assistance in the event of a hazardous chemical or petroleum spill. Based in Jefferson City within the Environmental Services Program, the EER staff operates a 24-hour emergency telephone line established for taking reports of hazardous substance spills and provides on-scene response to environmental emergencies. In addition to the central office, regional EER staff are located in Poplar Bluff, Macon, Springfield, St. Louis, and Kansas City to provide timely on-scene response throughout the state. Rapid and effective emergency response to hazardous substance spills is critical in protecting the public and preventing or minimizing adverse impacts to the environment. Water resources in particular are often threatened or impacted by spills from petroleum pipelines, barges or other vessels, chemical and petroleum bulk storage tanks, train derailments, and highway accidents.

In FY 2000, EER staff documented 2,590 incident reports received on the 24-hour



The department's environmental emergency response boat equipped for responding to petroleum and other chemical spills on major waterways. Photo from DEQ/ESP.

emergency telephone line. When a call is answered on the hotline relating to a chemical or petroleum spill, a duty officer documents the incident in a written report and takes appropriate action. Such action may include providing technical advice on spill cleanup over the telephone and may involve subsequent notification to other agencies that would have an interest. When warranted, EER staff will respond on-scene to provide technical advice and oversight, work to ensure the protection and safety of the public and the environment, and assess and document any environmental damages. The EER staff maintains a fleet of specially-equipped response trucks and a 24-foot response boat that are used for on-scene response as needed. In FY 2000, EER staff responded on-scene to 470 incidents throughout the state. The 24-hour telephone number for reporting environmental emergencies to the department is (573) 634-2436.



Floating booms are placed in a creek to contain diesel fuel released from a pipeline. Photo by DEQ/ESP.

One of seven specially-equipped EER (environmental Emergency Response) trucks used by the department for on-scene responses to environmental emergencies. Photo from DEQ/ESP.

INTERSTATE USE OF WATER

RSMo 640.405 - The department shall represent and protect the interests of the state of Missouri in all matters pertaining to interstate use of water, including the negotiation of interstate compacts and agreements, subject to the approval of the general assembly. Any department of state government affected by any compact or agreement shall be consulted prior to any final agreement.

Missouri shares the waters of its major rivers with 19 other states. Upstream states and Indian tribes can use water from these rivers before the streams reach Missouri. Federal agencies also manage much of this water. To make sure that Missouri's interests are considered, the department represents the State of Missouri in the following interstate river associations:

UPPER MISSISSIPPI RIVER BASIN ASSOCIATION

The Upper Mississippi River Basin Association (UMRBA) is made up of representatives of Missouri, Wisconsin, Minnesota, Iowa and Illinois. Steve Mahfood, director of the Department of Natural Resources, is Missouri's UMRBA representative.

The Association developed a master plan to balance economic development with environmental improvement on the upper Mississippi River. UMRBA works through Congress and the states to carry out provisions in the master plan, and pursues a legislative agenda as agreed upon by the state members. The Association also serves in an oversight or review capacity for the ongoing Mississippi River Navigation Study, scheduled for completion in 2002, to improve river transportation and the river environment. The Association has been very successful in attracting private and federal funding to enhance the Mississippi River.

MISSOURI RIVER BASIN ASSOCIATION

Membership of the Missouri River Basin Association (MRBA) includes Missouri, Kansas, Iowa, Nebraska, North Dakota, South Dakota, Montana, and Wyoming, plus one member representing the basin's Indian tribes. Steve Mahfood, director of the Department of Natural Resources, is Missouri's MRBA representative. The Association is currently working with the U.S. Army, Corps of Engineers, on revising the Master Water Control Manual for the Missouri River. It also pursues a legislative agenda as agreed upon by its Board of Directors, and provides a forum for the discussion of contemporary water resource issues in the basin, such as tribal water rights, flow management, diver-

sions, agricultural issues, and endangered species.

For the past 13 years, the states of the Missouri River basin have been embroiled in controversy over how the river should be managed. The disagreement, brought on by severe and persistent drought that began about 1986 and ended with the Great Flood of '93, focuses on the requirements embodied in the Missouri River Master Water Control Manual. This document, familiarly called the "Master Manual," guides the Corps' Reservoir Control Center in Omaha. The Control Center operates the system of dams and reservoirs that enable management of the river's flow.

As long as rainfall in the basin was normal or above, there was little disagreement between the states of the upper basin and those of the lower river. However, the system was not severely tested by drought until reservoirs began to be drawn down in response to the six-year drought from 1986 through 1992.

The crux of the disagreement is fundamental. Upper basin states contend that reservoir levels ought to be held at high levels - even in drought - to protect the recreational industry that has developed around the six large lakes on the upper river. Missouri views this position with considerable alarm, because it would deny our state the use of a significant share of the water stored in the reservoirs.

In effect, if the upstream states were successful in changing the management strategy to meet their demands, it would completely compromise the purposes for which the system was designed and built. The design objectives for the system were to store water in wet seasons, releasing it in dry seasons to provide flood control, navigation, water supply, power generation, irrigation water, and fish and wildlife benefits throughout even the most severe droughts.

Since 1998, the MRBA has been working on a consensus management plan for the Missouri River to recommend to the Corps of Engineers. The plan MRBA eventually adopted was not supported by Missouri because it placed too much emphasis on retaining water in upstream reservoirs for recreational purposes, and placed Missourians at greater risk of catastrophic flooding. During 2001, the U.S. Army, Corps of Engineers, plans to hold public workshops and hearings on the management strategy it will recommend, and Missouri will develop formal responses in an effort to reach eventual concurrence on a plan that will respect and protect Missouri's interests.

ARKANSAS-WHITE-RED BASINS INTER-AGENCY COMMITTEE

The Arkansas-White-Red Basins Inter-Agency Committee (AWRBIAC) includes representatives from the states of Missouri, Arkansas, Louisiana, Texas, Oklahoma, Kansas and New Mexico. Steve Mahfood, director of the Department of Natural Resources is Missouri's AWRBIAC representative. Federal agencies in AWRBIAC include the Dept. of the Interior, U.S. Geological Survey, Bureau of Reclamation, National Oceanic and Atmospheric Administration, Federal Emergency Management Agency, U.S. Army Corps of Engineers, Southwestern Power Administration and the Natural Resources Conservation Service, USDA.

The committee exists primarily for coordination and communication purposes. Administration and hosting of meetings are rotated among both state and federal members. The primary activity of interest to Missouri is the development of operating plans for the White River, which includes Table Rock Dam, Clearwater Dam, and part of Lake Norfork in Missouri. Also of interest is the

development of abatement measures and methodology to improve dissolved oxygen content of the tailwaters of White River dams. A revised operating plan for the White River has been developed that improves economic return while addressing issues related to low dissolved oxygen in the tailwaters that flow from hydropower dams.

In 2001, the Corps of Engineers will begin a comprehensive study of water allocation in the White River Basin, with the intent of developing an equitable sharing of water among various users.

LOWER MISSISSIPPI RIVER CONSERVATION COMMITTEE

The Lower Mississippi River Conservation Committee (LMRCC) has membership that includes the states of Missouri, Tennessee, Kentucky, Arkansas, Mississippi, and Louisiana. Federal agencies represented (as non-voting associates) include the U.S. Army Corps of Engineers, Environmental Protection Agency, U. S. Geological Survey, Natural Resources Conservation Service and U.S. Fish & Wildlife Service.

The LMRCC differs from other basin associations by including fish and wildlife agencies as well as environmental regulatory agencies. The LMRCC has several standing subcommittees that deal with specific subsets of lower Mississippi interests, such as fish and wildlife and water quality.

The LMRCC is addressing several water quality issues, including Gulf hypoxia (low dissolved oxygen). Hypoxia is thought to be caused by excessive nutrients in Mississippi River water flowing into the Gulf of Mexico. High nutrient levels ultimately result in oxygen depletion in the water and the development of a widespread "dead zone" in the Gulf that has been characterized as the marine equivalent of the "ozone hole" over Antarctica. This is an issue for Missouri because some of the nitrogen and phosphorous nutrient sources have been identified as coming from grain-producing states in the Midwest, from both urban and rural areas including point and nonpoint sources, e.g. effluent from wastewater treatment plants, and stormwater runoff from golf courses, parks, and farmlands.

INTERSTATE COUNCIL ON WATER POLICY

The Interstate Council on Water Policy (ICWP) is a national organization, with members representing state water resource agencies, that strives to promote the interests of states in dealing with the federal government on issues related to water. ICWP has a Washington office and a board of directors elected from among state members. The organization sponsors annual forums addressing water resource issues of interest to states, and an annual conference in Washington to bring together federal agency officials and Congressional staff with state representatives to discuss water resource concerns of states. Missouri is an active participant in ICWP activities.

The ICWP has a standing committee to coordinate the activities of interstate river basin organizations toward a more effective national input.

MISSISSIPPI RIVER PARKWAY COMMISSION

The membership of the Mississippi River Parkway Commission (MRPC) includes all ten states bordering on the Mississippi River. The MRPC's major thrust is toward improving opportunities for tourism growth along the Mississippi River from New Orleans to St. Paul.

Missouri's Mississippi River Parkway Commission has five members appointed by the governor, plus two senators and two representatives appointed by the State Legislature. The department participates in a technical advisory capacity, with the Missouri departments of Transportation and Conservation, and the Division of Tourism.

Missouri's participation in the MRPC has focused on improving the environmental quality of the river corridor as a way to increase the region's attractiveness to tourism and economic development.

MISSISSIPPI RIVER BASIN ALLIANCE

The Mississippi River Basin Alliance (MRBA) includes both individual and agency/corporate memberships. The Alliance focuses on environmental issues throughout the Mississippi River basin. Various committees address issues of current importance, such as environmental justice, nonpoint source pollution, legislative agenda, and monitoring federal initiatives.

The MRBA meets annually for technical sessions and training activities.

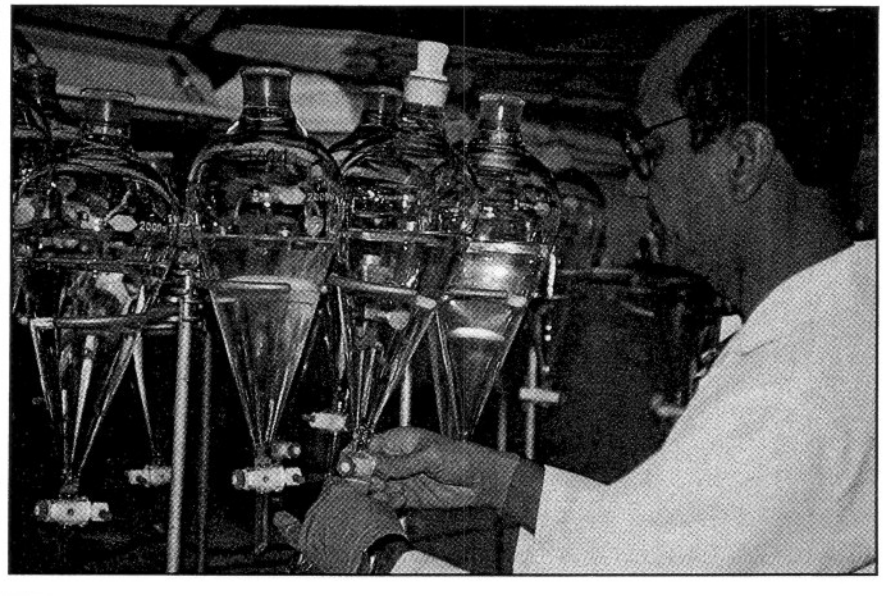
MONITORING WATER QUALITY

RSMo 640.409 calls for the department to establish, develop and maintain an ongoing statewide surface and groundwater monitoring program, the purposes of which are the following: 1) determination of ambient surface and groundwater quality for use as background or baseline water quality data; 2) detection of trends in the character and concentration of contaminants in surface and groundwater resources; and 3) identification of areas highly vulnerable to contamination.

The Department of Natural Resources (the department) conducts an extensive monitoring program for chemicals and microbial contaminants in public drinking water systems. In FY '00, more than 2,700 public water supplies were tested, with over 127,000 samples analyzed. This effort covers both surface and groundwater sources.

Most of the tests are performed on tap water, the "finished" water that people drink or use for cooking; this is water after treatment. Some "raw" water monitoring also is done to provide operational data to water system operators, and to help them in their treatment processes. For example, well water is tested to help the water companies know what is entering their water works. This helps them know what treatment to provide and to prepare in advance for potential problems with future regulations.

The vast majority of water quality violations are for failure to meet the requirements of the Total Coliform Rule. Total coliform bacteria serve as an indicator that disease-causing organisms may be present, and all public water systems in the state must test for this type of bacteria every month



Chemists go through many steps to analyze a sample of drinking water. Photo from DEQ/ESP.

they dispense water to the public. The department's Public Drinking Water Program (PDWP) provides an annual compliance report that lists all of Missouri's public water systems with maximum contaminant level (MCL) violations and those with chronic monitoring violation problems. The most recent reports are available on the PDWP's home page at www.dnr.state.mo.us/deq/pdwp/homepdwp.htm.

Public water systems with serious water quality violations potentially affecting public health or multiple monitoring violations are placed on a Significant Non-Complier (SNC) list. The department works closely with violators to return them to compliance in a timely manner. During 1999, only 93 of the more than 2,700 public water systems were on the SNC list.

For all violations, public water systems are required to notify the customers they serve. The method of notification varies by the violation and system type. Some water quality violations, such as the confirmed detection of fecal coliform bacteria or E. coli, warrant more immediate action due to the threat to public health. For such acute violations, the department requires systems to immediately notify their customers to boil their water before consumption. Boil water orders remain in effect until the problem has been corrected, and the water is safe to consume.

In addition to compliance monitoring, the department also provides monitoring that assists public water systems to anticipate the impact of future regulations. For example, in 2000, the Public Drinking Water Program initiated quarterly monitoring for disinfection by-products in 120 potentially vulnerable secondary water systems to determine the level of disinfection by-products. Secondary systems do not have their own water source, but instead purchase their water from another water system.

Disinfection by-products are formed in drinking water when a disinfectant (usually chlorine) is added to the water to inactivate bacteria and other potentially harmful microbes. The disinfectant reacts with natural organic matter in the water to form disinfection by-products, some of which can have serious health effects.

The purpose of the special monitoring was to see if any of the systems would have problems with the maximum contaminant level (MCL) limits anticipated to be required by federal regulations in 2002 for large systems and 2004 for small systems. The monitoring revealed a number of systems that will need to work together with their water suppliers to try to reduce disinfection by-product levels before the rules apply. Because of the PDWP's special monitoring effort, these systems now have more time to prepare for the regulations that are coming.

Vulnerability

The department first became aware of methyl tertiary butyl ether (MTBE) as a potential threat to Missouri's drinking water in 1994 and added it to the list of volatile organic chemicals routinely tested for. Public water systems served by surface water are routinely tested once a year and groundwater systems, once every three years. The end of 2000 marked a milestone as the PDWP completed two rounds of MTBE testing for all public water systems. In addition to the routine testing, MTBE results are also provided when other volatile chemical tests are run. The larger public water systems (serving 10,000 or more people), all surface water systems and some groundwater systems are tested every three months. Missouri has been fortunate in that over the years only five public water systems have been impacted by MTBE contamination. In all cases, the

source of contamination was leaking underground petroleum storage tanks.

A part of the monitoring plan is a vulnerability assessment performed to support the "waiver of monitoring" requirements. This indicates various threats to specific public water supplies and allows that information to be considered in establishing monitoring requirements.

The Public Drinking Water Program uses a vulnerability assessment to determine which sources of drinking water need to be tested for certain chemicals. If certain chemicals are located in a geographic area and may potentially affect a drinking water source, that source is monitored for the presence of those chemicals in the water. This allows the cost of analysis to be focused on the vulnerable sources. Without these assessments, the department would have to test every drinking water source for every chemical listed by the U.S. Environmental Protection Agency (EPA) as a drinking water contaminant.

The department is implementing a source water assessment plan to identify areas highly vulnerable to contaminants. The source water assessment plan describes how Missouri will delineate geographic areas that may influence the quality of drinking water and identify potential contaminant sources within the areas. The department is delineating source water protection areas for 4800 wells. The goal is to protect public drinking water sources from contamination and provide safe drinking water. The department's plan was approved by the U.S. EPA in June, 2000, and has verified the locations of over 9700 potential drinking water contaminant sites. The source water assessments will be completed in 2003.

The PDWP contracted with the University of Missouri to acquire accurate locations of potential drinking water contaminants in the vicinity of public drinking water sources. During 2000, the PDWP and the university located 6,470 potential drinking water contaminant sources, bringing the total number of inventoried sites to 9,770. All information is being collected, stored, and used in a geographic information system (GIS). These assessments increase awareness of the threats to drinking water, but do not mean the public water systems have been contaminated. The assessments are being provided to water systems and the public to inform them of the potential threats to their drinking water source and to encourage local source water protection.

The PDWP and the University of Missouri's Center for Agricultural, Resource, and Environmental Systems (CARES) have made maps and other information on all public water system wells available to the public on the Internet at http://www.cares.missouri.edu. In addition, detailed land use maps have been completed and are available from the PDWP for 66 public drinking water watersheds.

Outreach activities have been conducted to educate the public about the importance of protecting their drinking water sources from contamination. The department strongly encourages voluntary source water protection efforts to protect water quality, and hopes that communities will take advantage of the source water assessment results as a starting point for local source water protection efforts.

Groundwater

The department studies the recharge areas of springs, and delineates losing streams and sinkholes to determine areas where groundwater is particularly prone to contamination. Harmless fluorescent dyes are used to trace the movement of groundwater from its recharge area to its discharge point.

Since 1989, the department has performed numerous water traces in karst areas where groundwater resources can easily become contaminated by surface activities. In karst areas, much surface water is channeled underground in losing streams and sinkholes. The water lost to the subsurface typically resurfaces, sometimes as far as 40 miles away, at a spring or springs. Water wells between the recharge point and the receiving spring can be affected by contaminants entering losing streams and sinkholes.

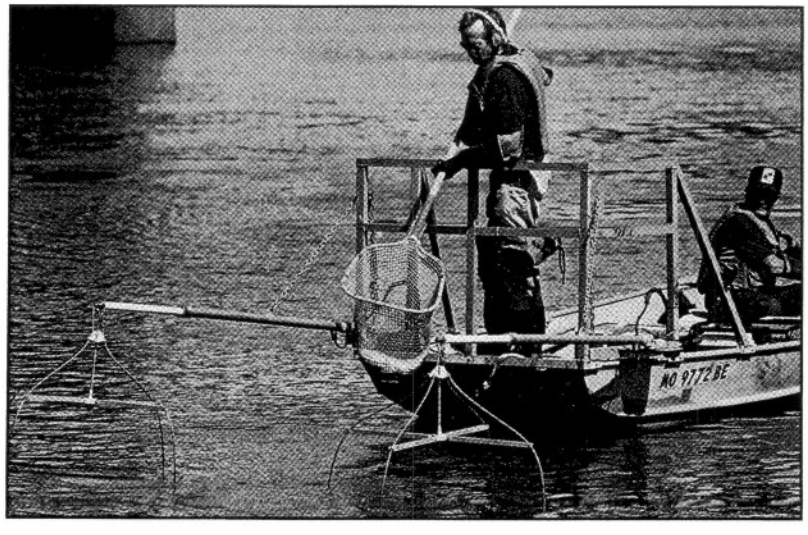
The results of individual dye traces are stored in the department's Dye Trace Data Base. Since 1989, several reports have been published that describe in-depth studies of several major spring systems *(Hydrogeology of the Bennett Spring Area, Laclede, Dallas, Webster, and Wright Counties, Missouri,* Water Resources Report No. 38; and *Hydrogeology of the Maramec Spring Area,* Water Resources Report No. 55) are examples.

The Water Well Drillers law requires that all persons engaged in water tracing register with the department and renew the registration annually. All proposed injections must be reported to the department's Division of Geology and Land Survey prior to injection of dye, and written and graphical documentation of traces is provided to the department within 30 days after completion of each trace. The information will be provided to interested parties upon request at cost of reproduction. For the trace to be included in the department's dye trace database, the data must be examined by a three-member Dye Trace Committee. If the data quality and documentation are satisfactory, then the results are entered into the department dye trace database.

Compliance monitoring is performed to test wastewater from facilities with National Pollutant Discharge Elimination System (NPDES) state operating permits.

The department performs a variety of water- and sediment-quality investigations each year in the form of complaint investigations, wasteload allocations, ecological risk assessments, and fish tissue contaminant monitoring. Department biologists are currently developing aquatic macroinvertebrate-based "biocriteria" for assessing stream quality in each eco-region of the state. These criteria will eventually be incorporated into the state water quality standards.

Due to the Flood of 1993, a federally funded sanitary landfill monitoring project for flood-damaged sanitary landfills was implemented. Effects of the flood included periods of surface ponding, soil saturation, and elevated groundwater table and increased velocity in the subsurface movement of water. The department received equipment and training to monitor landfills that operated before and after the flood to determine if any surface or groundwater contamination occurred.



Staff collect fish for analyses of pollutants that may accumulate in fish tissues. Photo from DEQ/ESP.

The results of the study indicated that landfills contributed no measurable contamination of surface water off-site. Also, no impact to groundwater could be determined to have taken place. However, many of the landfills studied did experience a significant increase in the migration of landfill gas (methane) through the soil away from their facilities.

Some of these migrations present a potential public safety problem due to the dangers associated with explosion or asphyxiation should the gas accumulate in nearby structures. For example, in the spring of 1998, a fire started in the basement of a private home situated next to a closed landfill. A field investigation conducted by the department confirmed that the fire was caused by methane gas migrating from the landfill into cracks in the floor, and igniting from the water heater. No one was injured; however, within weeks of the investigation, the landfill owner purchased the home and property from the citizen, and bought another home that was threatened. Both homes were vacated due to the ongoing threat of explosion. Through an extension of the original project, further study is underway to gain a better understanding of what can be done to evaluate and address these methane gas migrations that may occur at landfills throughout the state.

SURFACE WATER QUALITY MONITORING

The major purposes of the water quality monitoring program are to:

1) characterize "background" or "reference" water quality conditions;
2) better understand flow events, and diurnal and seasonal water quality variation and its underlying processes;
3) characterize aquatic biological communities and habitats, and distinguish between the impacts of water and habitat quality;
4) assess time trends in water quality;
5) characterize specific and regional impacts of point and nonpoint source discharges on water quality and;
6) check for compliance with water quality standards or wastewater permit limits.

All of these objectives are statewide in scope. Reference conditions of water chemistry and of aquatic macroinverte-brates have been or are being used to develop water quality standards. Due to the cost of environmental monitoring, the department routinely coordinates its monitoring activities with other state and federal agencies.

The strategy for monitoring varies by the waters being sampled. Many water quality monitoring strategies exist including monitoring effluent discharges, monitoring the impacts of discharges upon localized surface waters, monitoring extended impacts from effluent sources, and conducting surveys of "background" conditions. The monitoring activities through which these strategies are implemented take several forms:

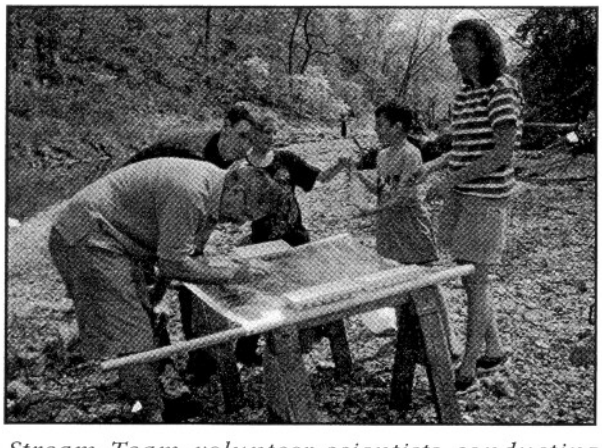
1) Fixed station chemical monitoring networks. The department maintains 63 fixed stations through cooperative agreements with the U.S. Geological Survey and 56 sites maintained by the department's lab, and routinely tracks data from about 60 other sites monitored by other agencies.
2) Intensive surveys
3) Special topic monitoring (fish kill investigations, bacterial monitoring, contaminant transport studies, etc.)
4) Toxics monitoring
5) Biological monitoring (of aquatic macroinvertebrates). The department presently is monitoring 60 streams annually.
6) Fish tissue, sediment, and shellfish monitoring. The Missouri Department of Conservation monitors about 30 sites and the

department/USEPA monitors about 20 sites annually for toxicants, primarily pesticides and metals, in fish tissue.

7) Monitoring by volunteers - A cooperative program sponsored by the Department of Natural Resources, the Department of Conservation, and the Conservation Federation of Missouri, known as Stream Teams, has trained and equipped volunteers around the state to conduct both chemical and biological monitoring of streams. At present, there are approximately 1,200 active volunteers monitoring 1,015 different sites. Most of the data collected by these volunteers are reported back to the department's Water Pollution Control Program.

MONITORING PROGRAM EVALUATION

The water quality monitoring program within the department evolved as a program to characterize and cope with point source wastewater discharges. This program, which has stressed chemical monitoring, appears to have been successful.



Stream Team volunteer scientists conducting biological water quality monitoring. Photo from DEQ/WPCP.

In 1998, the department shifted emphasis of monitoring programs in the following ways:

1) maintain the size of the fixed station flow and chemistry network, and include chemical analysis of sediments in some streams;
2) increase the amount of intensive chemical and biological water quality studies; and
3) increase the amount of aquatic invertebrate sampling statewide toward the development of biological criteria within the water quality standards.

The major reasons for these changes are the perception that:

1) more large municipal or industrial wastewater discharges need substantial water quality study to fully understand their impacts on receiving waters than the department is presently able to conduct;
2) biological criteria may be better than conventional chemical monitoring for characterizing many nonpoint pollution sources;
3) many problems in streams are not due to water chemistry problems, but to physical problems in the stream channel, in the riparian zone, or farther up in the watershed.

The biggest challenge will be to find a way to assess the water quality impact of thousands of confined animal feeding operations across the state. To date, the Department of Natural Resources and the Department of Conservation have been able to investigate and document at least a portion of all discharges that have caused fish kills, but no monitoring program has ever tried to assess the day-to-day subacute impacts of these pollution sources, which may be significant.

INVENTORY OF WATER USE AND AVAILABILITY

RSMo 640.412 - The department shall maintain an inventory of ground and surface water uses, quantity and users. - The department shall inventory the following: 1) existing surface and groundwater uses; 2) quantity of surface and groundwater available for uses in the future; and 3) water extraction and use patterns.

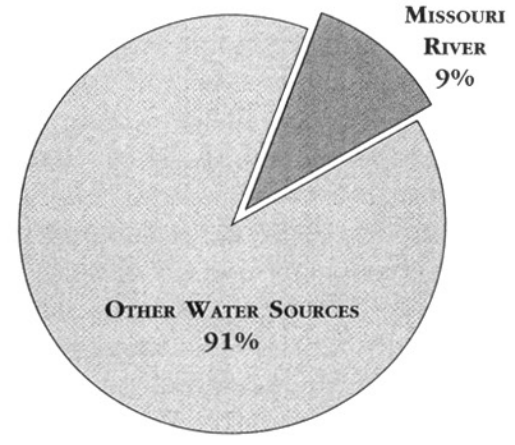
WATER USE

As part of the Major Water Users Law (RSMo 256.400), the department compiles water use information. Major water users are defined as those users that are capable of pumping greater than 100,000 gallons per day from either groundwater or surface water. There are 1,966 users registered. There is no penalty for failing to report. Most likely, there are many major water users that do not report. The Major Water User Database includes information about location, amount of water used and type of use (domestic, municipal, irrigation, recreation, industrial, electrical generation, fish and wildlife, and drainage.)

The department is updating the water user registration forms for Internet compatibility. Currently, the water user registration forms are mailed via the U.S. Postal Service to the major water users in the state. Users type in or print in the information and then mail the completed form back to the department. The first stage of the programming is finished and allows Internet access to the registration forms. Adobe Public Document Format (PDF) computer files of the registration forms are now available. These PDF files are linked to the Water Resources Program-Major Water Users Unit Internet web page (http://www. dnr.state.mo.us/dgls/wrp/waterusestatutes.html).

The second stage will allow users to complete their annual reporting obligation by filling out the forms on their home computers, and sending them to the department

1999 MISSOURI RIVER USE AS A PERCENTAGE OF TOTAL REGISTERED MAJOR WATER USE



for registration. The registration forms will be able to be filled out on the computer screen and then submitted via e-mail (mowaters@mail.dnr.state. mo.us) to the department, or (nrbarnj@mail.dnr.state. mo.us).

The final stage, some time away, will allow interactive communication between the users' computers and the department's computers, so that the public can view their own water usage and anyone can view and study water use trends by area and source. The department's Internet firewall and other safeguards must be in place before public sharing of the Major Water Users database will be allowed. The data may be copied or "downloaded" to individual computers so that people can study them. The original, master database will be write-protected and in read-only mode so that the data are not altered. During the last several years, the data have been geographically referenced so data users can develop data layers on geographic-based data platforms. Water withdrawal information is now in both the latitude-longitude format and the township-range format.

Public drinking water systems are significant users of both surface and groundwater. The PDWP and the Water Resources Program (WRP) have entered into a joint funding agreement with the U.S. Geological Survey for monitoring and mitigating the 1999-2000 drought. Physical (bathometric) surveys were performed jointly with the department, USGS, and the Natural Resources Conservation Service (NRCS) to determine the firm yield of the supply lakes. Based on the data available from historic droughts of record and the bathometric survey data, an analysis was performed on these lakes to show if the lakes are capable of sustaining capacity through the worst-case drought of history (the 1950s drought). A report of these lake studies will be available in 2001. This information will be beneficial to water systems in evaluating the quantity of water available for use, and the need for additional sources of water supply.

The Census of Missouri Public Water Systems, published by the department, provides many details about water use by public water systems. It includes the water source, the production capacity and average daily consumption, the location of surface water intakes, and the number of customers served. Currently, there are 2,760 public water systems serving cities, water districts, subdivisions, trailer parks, and institutions. Almost five million citizens of Missouri use public water systems as their source of water. The total production capacity of Missouri's community water systems is 1,840 million gallons daily (MGD), with an average consumption of 807 MGD. (Cities and water districts are examples of community water systems.)

GROUNDWATER AVAILABILITY

The importance of groundwater to Missouri cannot be overstressed. Based on statistics in the 2000 Census of Missouri Public Water Supplies, of the 1,444 community public water supplies in Missouri, 1,205, or about 83.4 percent, use groundwater as their water source. If only primary supplies are considered, 92.6 percent of the 1,191 primary water supplies use groundwater. Only 88 primary water supply systems use surface water. Secondary water supply systems are public water systems that purchase water from a primary system. Nearly all of the 1,296 noncommunity public water supplies use groundwater. There are about 3,800 active public water supply wells in use in Missouri, and another 600 public water supply wells that are inactive.

In terms of population served by public water supplies, surface water systems sup-

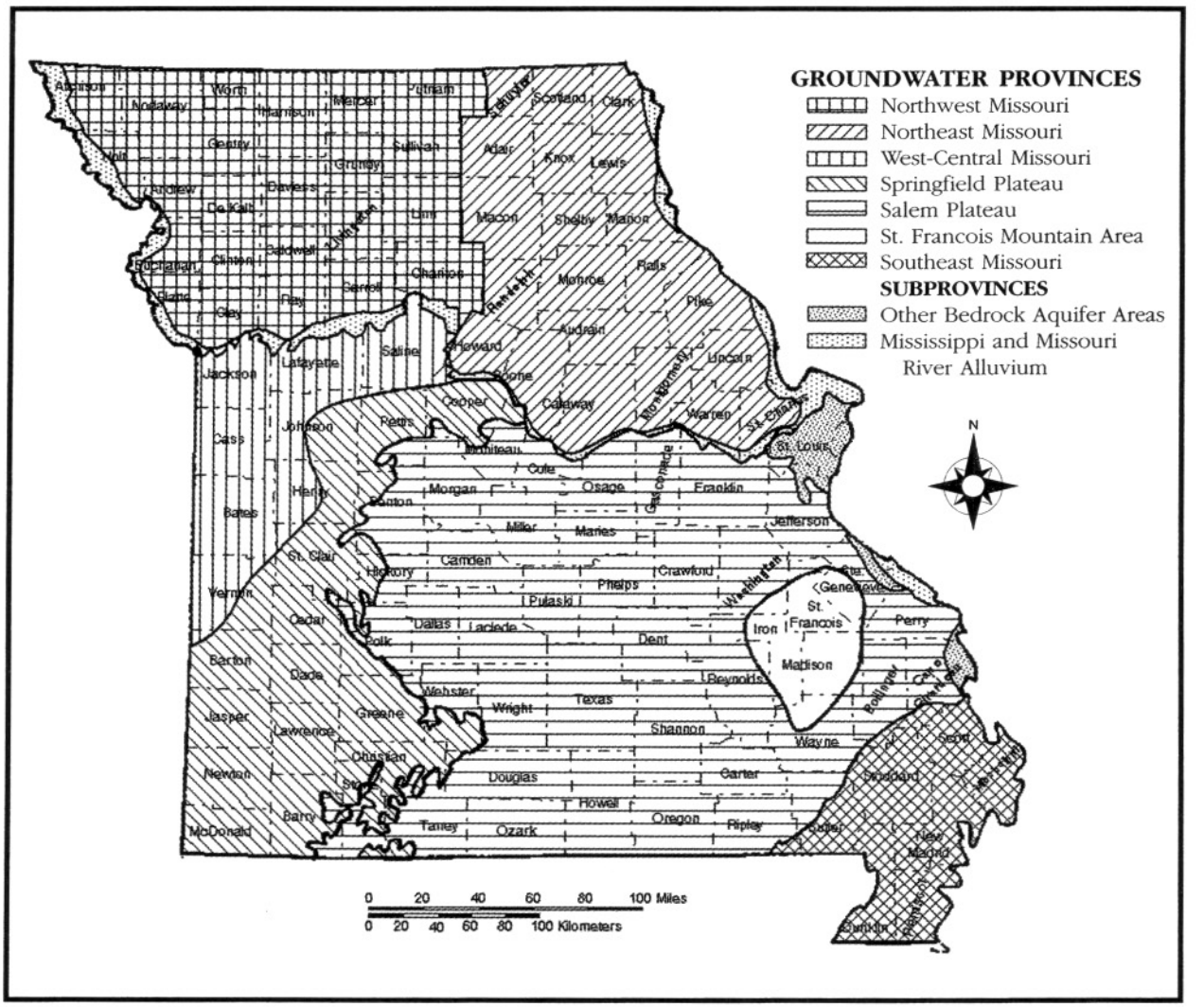
ply a greater percentage of Missouri residents than groundwater systems. Approximately 84.5 percent of Missouri's 5,595,200 residents, or 4,731,438 people, are served by community public water supplies. About 34 percent of these, 1,607,649 people, use groundwater. Surface water supplies about 3,123,789 people or 66 percent of the state's population.

An estimated 864,000 Missouri residents, or about 15 percent of the state's population, use private water supplies. Since small-scale private surface-water supplies suitable for providing safe drinking water to single families or farms are both complicated and expensive to construct and maintain, it is safe to say that most of these residents use groundwater. Approximately 7,000 private water supply wells are drilled yearly in Missouri, mostly in the southern part of the state.

Missouri's groundwater resources are not evenly distributed across the state. Potable groundwater, water that is essentially usable as it is produced and requires no elaborate treatment to remove undesirable constituents, is much more common in southern Missouri than in the northern part of the state. This is mostly due to the geologic variations across Missouri. Estimates made as parts of the Missouri State Water Plan Series indicate that potable groundwater in storage in Missouri may be as great as 500 trillion gallons. Only about 13.3 percent of this is in northern Missouri north of the Missouri River. The remainder is south of the Missouri River, principally in the Ozark region and in the Southeastern Lowlands.

The state can be divided into seven groundwater provinces, each having distinct groundwater and aquifer characteristics. The St. Francois Mountains groundwater province of southeastern Missouri contains the oldest rocks in the state that are exposed at land surface. Precambrian igneous rocks are found at or near the surface throughout much of this region. Upper Cambrian-age sedimentary rocks consisting of thin shales and siltstones and much thicker dolomite and sandstone units overlie them. The igneous rocks are nearly impermeable except where fractured. Thus, yields of wells drilled into the Precambrian igneous rock are generally only a few gallons per minute or less. The younger sedimentary rocks overlying the igneous rocks comprise the St. Francois aquifer. Where it is very thin, the St. Francois aquifer may only supply a few gallons of water per minute. Where it is the thickest and contains the greatest amount of sandstone it can produce more than 300 gallons of water per minute. The St. Francois Mountains area is one of the most difficult areas in Missouri in which to obtain a reliable groundwater supply for private domestic use. In most places, it is not possible to develop a groundwater supply capable of meeting even modest municipal or irrigation demands. Groundwater storage estimates indicate this region contains only about 0.92 trillion gallons of potable groundwater, which represents only about 0.2 percent of Missouri's groundwater resources.

The Salem Plateau groundwater province surrounds the St. Francois Mountains. The Salem Plateau is most extensive to the north, west, and south of the St. Francois Mountains, and relatively small on the east side. Thick Ordovician- and Cambrian-age dolomite and sandstone units comprising the Ozark aquifer overlie the St. Francis aquifer in this region. Groundwater resources in the Salem Plateau groundwater province are the most extensive in the state. About 46.6 percent of Missouri's potable groundwater is in this region, a volume of about 233 trillion gallons. All but a very few communities and essentially all of the rural residents in this province rely on groundwater. Depending on well depth and location, private domestic wells a few hundred feet deep can



Groundwater provinces and subprovinces of Missouri. Source: WR-46 -- Groundwater Resources of Missouri.

easily produce water ample for domestic purposes, while larger-diameter wells 1,200 to 1,500 feet deep typically can produce from 300 to more than 1,000 gallons of water per minute.

Although this region contains abundant groundwater resources, the geology here makes groundwater particularly prone to contamination. Permeable residual soils and karst features such as sinkholes and losing streams allow rapid groundwater recharge to occur. In some areas, most of the normal flows of streams are channeled underground in losing streams. Proper land use and waste disposal practices are paramount to protecting the wells and springs of this region.

The Springfield Plateau groundwater province occupies the southwestern part of the state and a small region of central Missouri south of the Missouri River. Thick Mississippian-age limestones and cherty limestones form the bedrock surface in the region and overlie the same Ordovician and Cambrian strata found in the Salem Plateau. The Mississippian strata comprise the Springfield Plateau aquifer that is widely used as a

private water supply source in this province. Yields of wells producing from the Springfield Plateau aquifer are typically less than about 20 gallons per minute. Wells fully penetrating the deeper Ozark and St. Francois aquifers can yield more than 1,000 gallons per minute. Groundwater in storage in this province is estimated to be about 122.5 trillion gallons, or about 24.5 percent of the usable groundwater in Missouri.

Like in the Salem Plateau, weathering of the limestone bedrock in the Springfield Plateau has created pathways for rapid groundwater recharge such as losing streams and sinkholes. These features are particularly well developed in parts of Greene and Christian counties, so much so that wells constructed in Greene and northern Christian counties since 1987 must be constructed to exclude production from the Springfield Plateau aquifer. A low-permeability shale unit between the shallow Springfield Plateau aquifer and the deeper Ozark aquifer greatly limits the vertical interchange of water between the two units and helps to protect the Ozark aquifer from contamination.

The West-Central Missouri groundwater province lies northwest of the Salem Plateau. The boundary between the two is the fresh water-saline water transition zone. South and west of the transition zone, groundwater in the Springfield Plateau, Ozark, and St. Francois aquifers is of good chemical quality. North and west of the transition zone these same aquifers yield water that is too mineralized for domestic use. The transition zone coincides with where the aquifers yield water containing 1,000 mg/L total dissolved solids. Water with less than 1,000 mg/L total dissolve solids is generally considered fresh water while that containing between 1,000 and 10,000 mg/L total dissolved solids is termed brackish. Water quality in deep aquifers further deteriorates to the north and west.

Potable groundwater in the West-Central Missouri groundwater province is typically difficult to obtain. Relatively shallow Pennsylvanian-age limestones and sandstones can produce marginal quality water but yields are generally low. In some areas it is impractical to develop a suitable groundwater source that will even supply a private residence. This province contains an estimated 1.2 trillion gallons of potable groundwater, or about 0.24 percent of the state's resource.

Many of the bedrock formations found throughout southern Missouri are also found north of the Missouri River. The southern part of the Northeast Missouri groundwater province lies to the south of the fresh water-saline water transition zone. Mississippian-, Ordovician-, and Cambrian-age strata in this area can supply from 10 to more than 1,000 gallons per minute of potable water, depending on depth. North of the transition zone water from deeper bedrock aquifers is generally too highly mineralized for most uses. Modest quantities of marginally potable groundwater are locally available in some of the shallow Mississippian strata where it is not overlain by Pennsylvanian strata. The Pennsylvanian strata have an overall low permeability and generally yield small quantities of marginal to poor quality water.

Glacial drift overlies the bedrock throughout much of this region. It is generally thickest in the northwestern counties of the province and thins toward the Missouri and Mississippi rivers. Thousands of shallow, large-diameter, hand-dug glacial drift wells once supplied many of the rural residents, but the development of rural public water supply districts has rendered most of these wells obsolete. The shallow glacial drift wells generally yielded less than 3 gallons per minute and relied on their large diameters for storage. Their shallow depths and poor construction made them very vul-

nerable to contamination from bacteria, animal wastes, and agricultural chemicals.

In most places, the glacial drift in this part of the state is not capable of supplying a volume of water suitable for public water supply. Alluvial deposits consisting of sand and gravel underlying the floodplains of major rivers in this area can yield large quantities of good-quality water. Yields as high as 2,000 gallons per minute are possible from properly constructed wells in favorable areas of the major alluvial aquifers. Groundwater storage in the Northeast Missouri groundwater province is estimated at 55.8 trillion gallons, or about 11.2 percent of the state's usable groundwater.

The Northwest Missouri groundwater province has geologic characteristics similar to those in the northeastern part of the state. However, in northwest Missouri there are no high-yield, potable bedrock aquifers available, and the glacial drift is typically more water productive than to the east. A test drilling program conducted in northwestern Missouri in the 1950s delineated the axes of numerous drift-filled preglacial channels, most of which are covered with younger glacial drift. The channels were the preglacial stream valleys, and were filled with waterborne coarse sediments during glacial periods. Properly constructed wells producing from favorable locations in the drift-filled channels can produce several hundred gallons of water per minute, and are locally used for irrigation as well as public water supply.

Like in northeastern Missouri, thick alluvial deposits underlying the floodplains of the major rivers are a significant source of water for agriculture as well as public water supply. Yields of 2,000 gallons of water per minute or more are possible from properly constructed wells in favorable areas of the Missouri River alluvium. Alluvial deposits along lesser streams generally yield substantially less water.

The Northwest Missouri groundwater province is estimated to contain about 11.2 percent of Missouri's potable groundwater, about 55.8 trillion gallons.

Groundwater, like all natural resources, is finite. Groundwater use in parts of the state has caused significant water-level declines in some aquifers. This is particularly true where groundwater is or was heavily depended upon to supply larger towns and cities. Water-level decline in the Ozark aquifer in the Springfield area, for example, has been well documented, and is partly responsible for the city seeking alternative supplies from surface-water sources.

Water-use conflicts occur on almost a yearly basis in numerous areas of the state. Often the conflicts stem from competing uses of the water. For example, an aquifer that has historically been used to supply private domestic wells for households and farms is suddenly tapped to supply water for irrigation, a rural water district, or a large industry. The result of the increase in groundwater demand commonly is a decline in groundwater level in the area in and adjacent to the major withdrawal. Many of these declines occur in aquifers that are more than 1,200 feet thick. A decline of, say, 100 to 200 feet, may seem reasonably minor compared to the total saturated thickness of such an aquifer, but it may completely de-water older, shallower private wells, or at least substantially decrease their yields. Such conflicts are further amplified during drought periods when groundwater use is above normal and lack of rainfall precludes any groundwater recharge, even to relatively shallow unconfined aquifers.

Unlike surface water, groundwater typically requires little or no treatment to make it suitable for most purposes. Assuming the resource is available, the cost of developing a groundwater supply is a small fraction of that of developing a similar volume surface-

water supply. Thus, where groundwater is available, it is most commonly used. Historically, most industries using large quantities of water typically developed near urban areas where there were established water supplies. However, in recent years there seems to be an increasing trend of developing water-intensive industries, especially those related to agri-business, in rural areas, and supplying them with groundwater. New developments such as these, coupled with existing demands placed on groundwater from irrigation, municipal and domestic water supply, and other uses will likely continue to fuel water controversies for the foreseeable future.

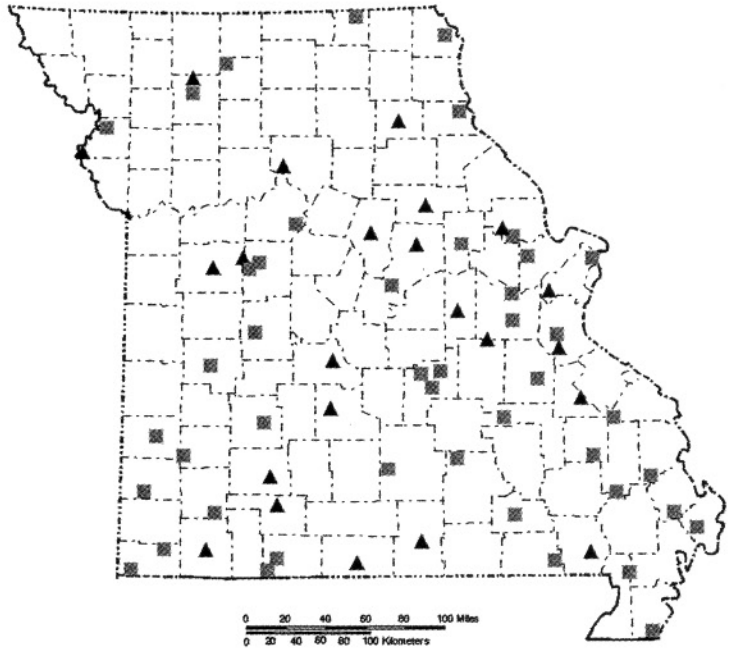
water from shallower aquifers, or from water moving laterally down-gradient from areas where the deeper aquifers are near land surface.

Most of Missouri's aquifers are dynamic groundwater flow systems. Water that is stored in the aquifers is actually in motion, slowly moving from areas of higher hydraulic head or water level to areas of lower hydraulic head or water level. Water in some karst aquifers that supply the major Ozark springs can move a mile per day or more, but most groundwater movement is measured in feet per year. Groundwater levels in unconfined aquifers directly relate to the volume of water in storage. In confined or

GROUNDWATER-LEVEL OBSERVATION WELL NETWORK

The Department of Natural Resources, Water Resources Program, operates and maintains a network of groundwater-level observation wells throughout Missouri. This work began during the 1950s when extended drought conditions were causing serious water-supply deficiencies. Drought affects surface-water resources almost immediately, but because groundwater is ultimately replenished by precipitation, it, too, is adversely affected by prolonged dry weather. Shallow aquifers are typically replenished faster than deeper aquifers, and likewise are more readily affected by drought conditions. Deeper aquifers are typically recharged by downward movement of

2000 GROUNDWATER LEVEL OBSERVATION WELL NETWORK
67 WELLS



LEGEND

■ Existing installations

▲ Additional Installations

artesian aquifers, the levels depict the head pressure in the aquifer. In both cases, an observation well is analogous to a dipstick in an automobile engine's crankcase. It allows the fluid level to be monitored accurately.

Water-level changes in aquifers can be due to many factors, both natural and man-induced. Tidal effects caused by the position of the Sun and Moon relative to the Earth can cause small fluctuations in groundwater levels in some aquifers. Barometric pressure changes can likewise cause significant temporary changes in water levels of confined aquifers when high and low pressure systems pass through Missouri. Earthquakes in different parts of the world can cause rapid fluctuations of groundwater levels in some wells up to several feet in magnitude. Water levels in some aquifers can be affected briefly by the passing of nearby trains or heavy trucks. However, the most major changes in water levels stem from the removal of large quantities of groundwater through wells.

Prior to man's construction of water wells, groundwater flow systems were, for the most part, under steady-state conditions. The volume of water exiting the aquifers through seeps, springs, diffuse groundwater movement into streams, and other natural means was essentially equal to the volume of recharge the aquifer received. During dry years, when recharge was low, spring flows and inflow of groundwater into streams would likewise decrease. During wet years, the reverse took place; there was additional recharge and a greater volume of groundwater exiting the system. What water-level changes occurred in the aquifers were relatively minor. This began to change with the development of water wells.

There were very few water wells in Missouri prior to 1900, other than shallow, hand-dug wells in the glacial drift area of northern Missouri. Streams and springs were mostly relied upon in the southern part of the state where shallow bedrock greatly hampers the construction of hand-dug wells. Early wells were mostly drilled for towns and cities. As drilling machines improved and drilling companies became more common, there was an increase in the development of private wells. Today, there are probably several hundred thousand wells in use in the state. Each year, some 7,000 new wells are drilled in Missouri, which are probably more than were drilled in a decade or more in the early part of the 1900s.

The total volume of groundwater removed each year from Missouri aquifers is not precisely known. Major water users, those entities capable of producing 100,000 gallons of water per day or more, reported using a total of about 267 billion gallons of groundwater during 1999, the latest year for which statistics have been compiled. This does not include the groundwater that is used by smaller suppliers, so it is safe to assume that actual groundwater use is substantially greater than 267 billion gallons. In 1995, the U.S. Geological Survey estimated that groundwater use in Missouri was about 890 million gallons per day, or about 325 billion gallons per year. If it were assumed that current groundwater use in Missouri is 350 billion gallons of water per year, this would be equal to an average yearly use of 62,554 gallons per resident, or a daily per capita use of 171 gallons, which is not an unreasonable value. If groundwater use per unit area is considered, then Missouri uses an estimated 5,020,872 gallons of groundwater per square miles each year. This is equal to 9.55 gallons of water per minute, per square mile, throughout the state.

A groundwater usage of less than 10 gallons of water per minute for each square mile of the state hardly seems excessive, and certainly would not be if the usage were evenly distributed. However, it is not. Large-scale groundwater use is generally localized.

A town of 12,000 residents in the Ozarks will likely use more groundwater within an area of a few square miles than is used throughout the remainder of the county. A single industry in a rural area can use as much groundwater as a town of 15,000. Agricultural irrigation is widely practiced in only a few areas of the state, including the southeast lowlands, west-central Missouri in Jasper, Barton, Vernon, and Dade counties, northeast Missouri in Audrain, Montgomery, and Callaway counties, and along the Missouri River. In these areas, irrigation can have a pronounced impact on groundwater conditions.

Groundwater-level observation wells measure the effects of groundwater usage on aquifers. Observation well installations in relatively isolated rural settings have measured very modest groundwater-level changes during the last 45 years. Most of the fluctuations in groundwater levels have been due to natural phenomena. However, in other areas of the state, observation wells have documented groundwater-level declines in excess of 400 feet since the 1950s.

Prior to 2000, the observation well network consisted of about 45 to 50 observation wells that were mostly in the area south of the Missouri River. All were equipped with instruments to measure and record water-level changes. Data were collected from the wells every few weeks or months, depending on their location. The data collected by newer digital recorders were stored on paper punch tape that could be read by a tape reader and directly fed into a computer for processing. Older mechanical recorders recorded data using a pen and chart paper. The charts had to be processed by hand to obtain the data, a time- consuming task. In both cases there was typically a several week to several month delay between when data were collected and when they were available for use.

All of this changed in 1999, when the Missouri Legislature approved of an expansion to increase the number of observation wells and replace the recording instruments with state-of-the-art equipment. During 2000, equipment was purchased to equip 70 groundwater-level observation wells with data collection platforms that not only measure and record groundwater levels, but also transmit the data from the field to the office using the GOES weather satellite system. Data are collected at each installation at 30-minute intervals. Every 4 hours, the GOES satellite listens for data from only one station, and that station has a 1 minute time window in which to send the data. Within a few moments, the data are routed from the well, to the GOES satellite 22,000 miles in space, and back to a receiving station in Little Rock, Arkansas, operated by the U.S. Geological Survey. From there, it is transmitted by phone line to the U. S. Geological Survey office in Rolla, and posted on an Internet web site that is being developed as part of this project.

As part of this work, the department contracted for the construction of eight new observation wells in areas where information is needed and no existing unused wells could be located. Another 16 unused wells were donated or loaned to the department for use as observation wells by cities or other interested parties. New observation wells are now on line at or near Columbia, Mexico, Shelbina, West Plains, Ozark, Springfield, Eureka, Camdenton, Qulin, Farmington, Lebanon, Cassville, Theodosia, Dresden, Coffey, and Troy. Equipment will soon be installed on a well at Warrensburg. Additional wells are being sought near Jefferson City, Fulton, California, and Festus.

When the expansion is completed, there will be approximately 70 groundwater level observation wells equipped with satellite-

linked data recorders. As of January 30, 2001, 54 installations have been completed. The remaining installations will be completed by the end of June, 2001.

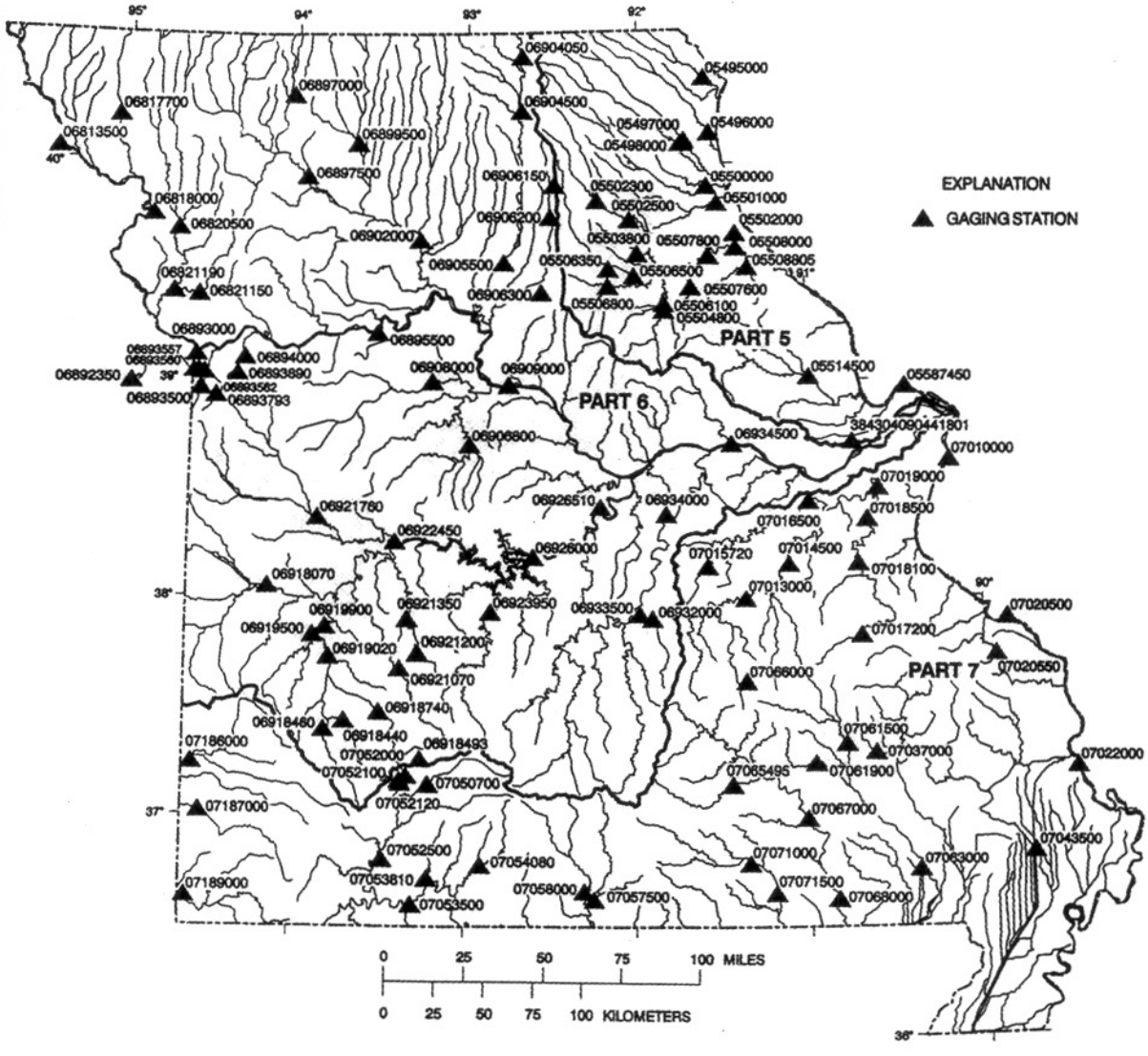
This expansion is allowing groundwater data to be used in ways that were previously not possible. Towns with observation wells can directly view the effects that their producing wells are having on groundwater levels. This information has been especially welcome during the past year because of widespread drought conditions. Residents with private wells in areas of high groundwater use can monitor changes in water levels. Additional observation wells in specific locations are not planned at this time, but the network will likely grow one to two wells per year in response to water-use conflicts, or where information is needed for other purposes. Real-time groundwater data can be obtained from the department's web site, www.dnr.state.mo.us/water.htm.

Wave of the future -- new observation well recorders. These new data collection platforms consist of electronic data recorders and digital encoders. Water level information from each observation well is transmitted via satellite every four hours, allowing almost instantaneous access to important data. Photo by Susan Dunn.

SURFACE WATER AVAILABILITY

The department is a cooperator in the U.S. Geological Survey program that collects and publishes water data for Missouri's surface and groundwater resources. Substantial amounts of surface and groundwater information have been collected through this effort, and published annually in a report series titled Water Resources Data-Missouri. Records have been collected in this manner for nearly 75 years. The scope of data collection efforts has widened to include surface and ground-

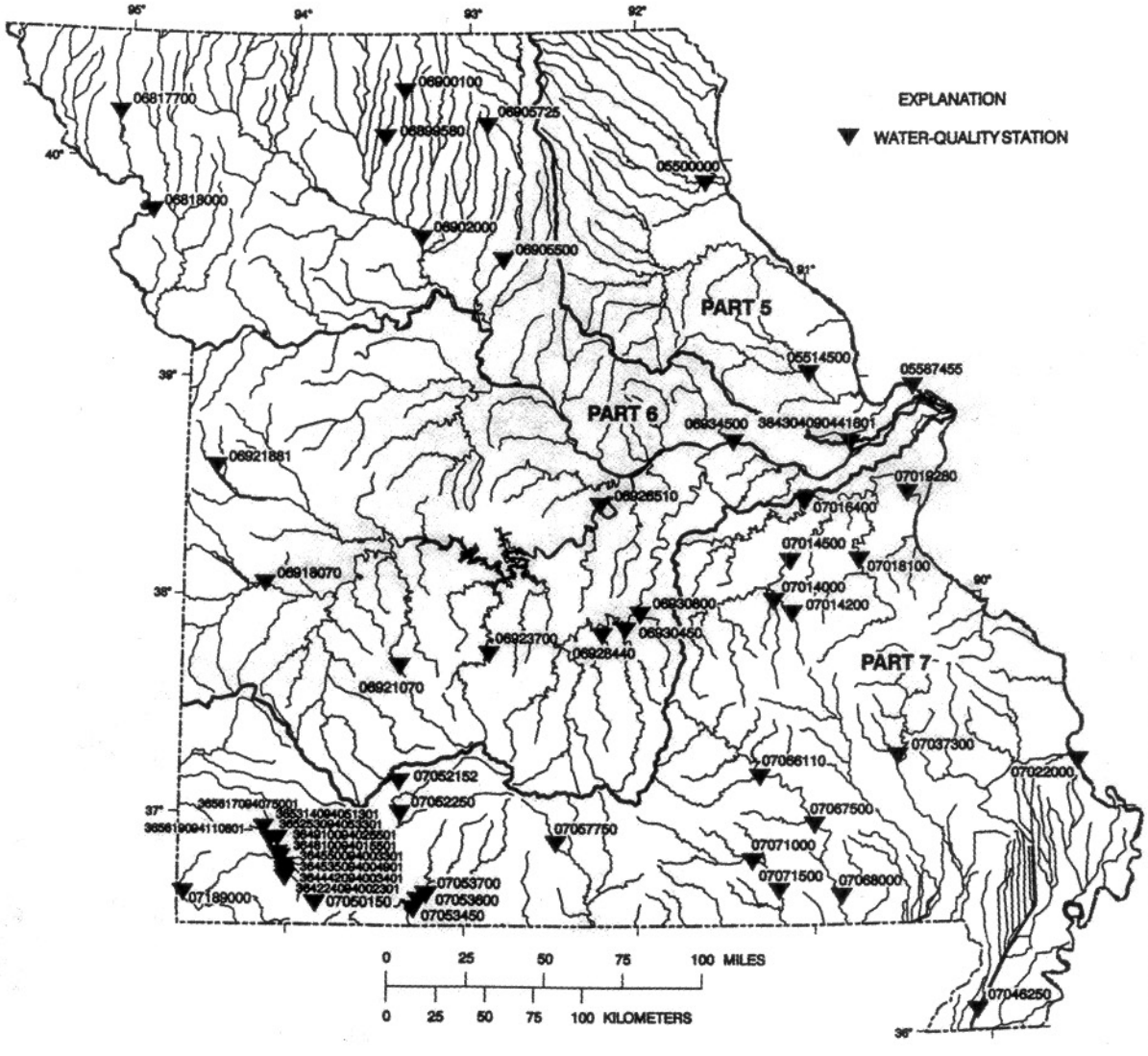
SURFACE WATER GAGING STATIONS IN MISSOURI



Source: USGS, "Water Resources Data - Missouri, Water Year 1999"

water quality information. Presently, the stream-gaging network monitors flow and stage at 138 stations, the stage at 12 lakes and reservoirs, and surface water quality at 53 sites statewide (including 2 lakes and reservoirs). Water quality stations include physical, chemical, and biological parameters such as water temperatures, specific conductance, dissolved oxygen, pH, carbonate, bicarbonate, alkalinity, inorganic constituents, nutrients, trace elements, indicator bacteria, sediment, and pesticides.

SURFACE WATER-QUALITY STATIONS IN MISSOURI

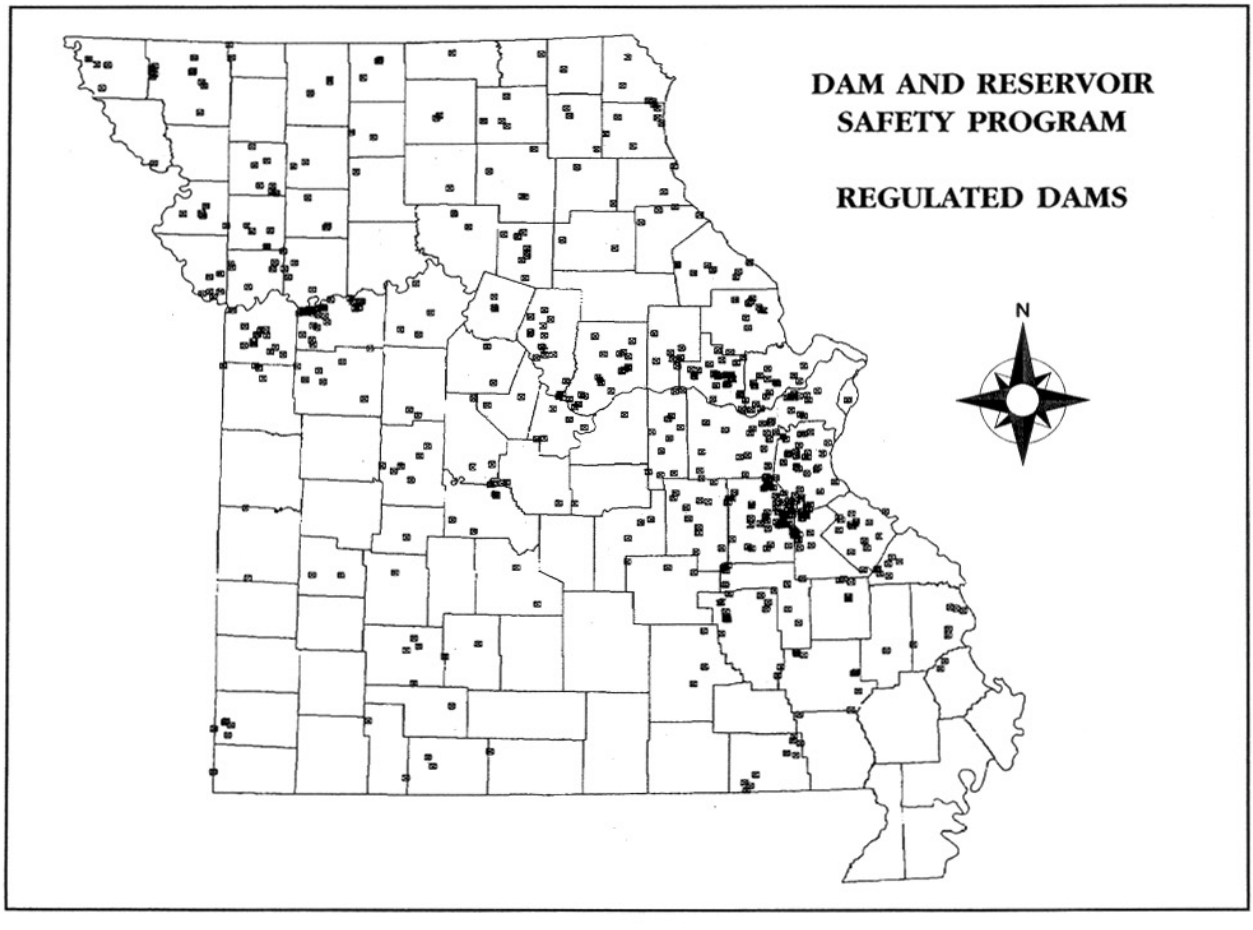


Source: USGS, "Water Resources Data - Missouri, Water Year 1999"

DAM SAFETY

The department maintains two databases on dams in the state. The STATUS database contains only those dams that are regulated in accordance with Chapter 236 of the Revised Statutes of Missouri. This includes dams that are 35 feet or more in height as measured from the crest to the downstream toe of the dam. The number of dams currently included in this database is 629. The database includes spatial and physical data, downstream hazard classifications, ownership information, water use, and the current regulatory status of each dam.

The NATDAM database is maintained through a continuing contract with the Federal Emergency Management Agency (FEMA) and the Association of State Dam Safety Officials. This database includes dams that meet the height and storage criteria established by FEMA and are identical to the criteria established by the U.S. Army Corps of Engineers for the original national inventory compiled in the 1970s. Dams which are 25 feet or more in height with a storage volume of at least 15 acre-feet, or which are 6 feet or more in height with a storage volume of at least 50 acre-feet, are included in this inventory. The number of dams currently inventoried in this database is 4,088. The database includes spatial and physical data, downstream hazard rating, water use, ownership information and purpose of the dam.



STATE WATER PLAN

640.415—1. The department shall develop, maintain and periodically update a state water plan for a long-range, comprehensive statewide program for the use of surface water and groundwater resources of the state, including existing and future need for drinking water supplies, agriculture, industry, recreation, environmental protection and related needs. This plan shall be known as the "State Water Resources Plan."

2. The department shall establish procedures to ensure public participation in the development and revision of the state water plan.

3. The department shall submit a report to the general assembly at least one year prior to the submission of the state water resources plan, and may recommend any statutory revision which may be necessary to implement the requirements of this section. The plan shall be submitted to the general assembly for approval or disapproval by concurrent resolution.

BACKGROUND

Since 1989, when the Water Resources Law was passed by the Legislature, the Department of Natural Resources (the department) has undertaken activities to address and fulfill the requirements set forth in RSMo 640.415. Specifically, these activities include public participation, issue identification, needs assessment, resource inventory, and multi-level planning and coordination.

The department has sought public input through the use of various forums that have included statewide public meetings and conferences, regional meetings and stakeholder meetings. This effort has included the Missouri Rural Opportunities Council (which is composed of various private groups as well as state and federal agencies), Regional Planning commissions, the Water Quality Coordinating Committee, the Missouri Irrigators Association, Missouri Association of Counties, the Clean Water Commission, Distributive Educational Clubs of America, the department sponsored "Open Houses," the Small Watershed Program Conference, Ozark Scenic Riverways Association, and the Missouri Municipal League. These public input forums serve to support, enrich, and further define the water resource issues first defined in 1990, identify new issues, and inform and educate the public on the broader, and often interrelated, water resource planning issues.

A three phase approach is well underway to create a thorough, well thought-out water plan. Phase 1 is the completion of a series of technical documents referred to as the State Water Plan Volumes described in

the next section. Phase 2 of the plan is the identification and description of water use problems and opportunities by region. See Phase 2-Regional Reports' section for description of regions. Six regional reports will be completed in this Phase. Phase 3 of the plan will identify the many potential solutions or suggestions to solving Missouri's water use problems or challenges.

PHASE 1 - STATE WATER PLAN VOLUMES

The department has completed a series of seven technical documents to provide basic information about Missouri's surface water, groundwater, water use, water quality, interstate issues, hydrologic extremes and water law. These volumes will assist in focusing the development of the Missouri State Water Plan. They will serve to support and complement public participation, issue identification, needs assessment, and multi-level planning coordination. Now that these volumes are completed, the department will work with groups and individuals across the state to gather input on a regional and watershed basis for the development of the State Water Plan. The Interagency Task Force will also have input into the State Water Plan before it is finalized and submitted to the governor and General Assembly.

The seven basic information volumes have been published serially. Completed volumes include *Volume I - Surface Water Resources of Missouri, Water Resources Report No. 45,* by James E. Vandike; *Volume II - Groundwater Resources of Missouri, Water Resources Report No. 46,* by Don E. Miller and James E. Vandike; *Volume III - Missouri Water Quality Assessment, Water Resources Report No 47,* by Cynthia N. Brookshire; *Volume IV - Water Use of Missouri, Water Resources Report No. 48,* by Charles B. DuCharme and Todd M. Miller; *Volume V - Hydrologic Extremes in Missouri: Flood and Drought, Water Resources Report No. 49,* by John D. Drew and Sherry Chen; *Volume VI - Water Resource Sharing: The Realities of Interstate Rivers, Water Resources Report No. 50,* by Jerry D. Vineyard, and the last in the series, *Volume VII- A Summary of Missouri Water Laws,* Water Resources Report No. 51, by Richard M. Gaffney and Charles R. Hays, with help from William J. Bryan, IV, and Amy E. Randles, of the Missouri Attorney General's Office, was recently published. A review of what this last important volume contains follows:

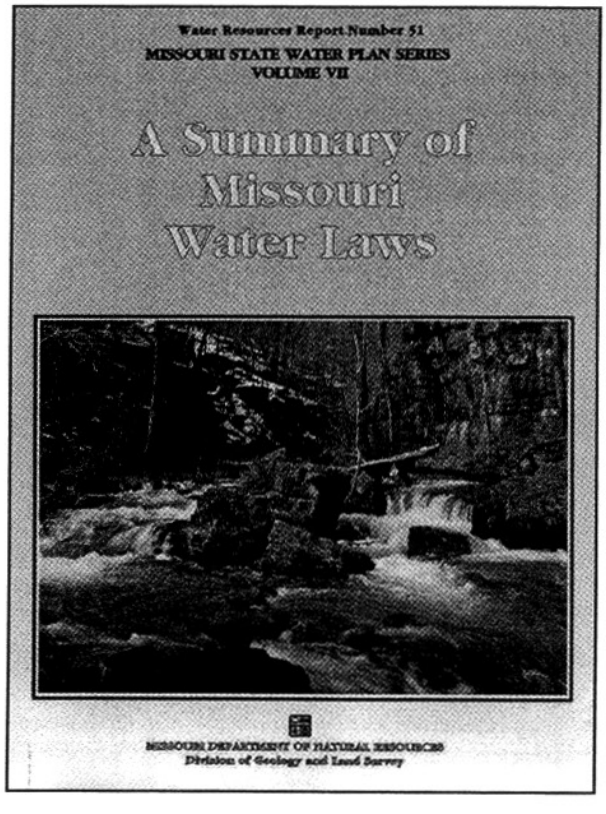
VOLUME VII - A SUMMARY OF MISSOURI WATER LAWS

The seventh volume in the first phase of the State Water Plan publications addresses statutory law, case law, and common law dealing with many aspects of water use, supply, and resources. Like the other volumes in Phase 1, this document is an inventory and technical assessment book. It is written to be as useful as possible to the widest audience. It can be used as a base source of information, as a reference work, or in conjunction with other State Water Plan volumes to provide comprehensive, factual information on the status of water law and water issues in the late 1990s.

The major emphasis of this volume is on contemporary water law— water use, water supply, and water quality— from both judicial (case law) and legislative (statutory law) perspectives. The document is a review of Missouri water law from an historical inventory approach. For the most part, statutory water law addresses forward looking, generalized, broad scope issues that have gained widespread attention of the public, or represent high priorities of our elected officials.

The focal points of statutory laws tend to be on the needs and well being of society as a whole. This differs from case law in that much of its emphasis centers on dispute resolution between individuals, and is of a highly detailed and limited nature. Generally, case law's focal points are on ownership and property, natural water, protection from water, water quality, water supply, and water use.

The most recent publications on water law before Volume VII of the State Water Plan were prepared by Theodore E. Lauer in 1964 and 1969. They were updated in 1977 by Peter N. Davis and James Cunningham with the assistance of Donald Anderson. Dramatic changes have occurred in the field of environmental law, especially in Missouri water law since that time, and such a volume was warranted in the State Water Plan. Of particular note in this regard was the Missouri Supreme Court's departure in 1993 from the "modified common enemy doctrine" to the law of "comparative reasonable use."



Water law is aimed at defining our use of water resources in a fair and equitable manner so as to serve the best interests of all citizens and their needs. With the passage of time, needs and priorities change, new questions arise, and historical facts are re-evaluated. These factors drive the evolution of water law. Legal restrictions and requirements on how we use and protect our water resources serve to balance individual needs with the needs of society. Public health, public safety, and the economic well being of the state and its citizens depend on the adequate availability of usable water. The value of our water resources continues to increase in proportion to demand and the recognition of its significance to our quality of life.

For these reasons, *A Summary of Missouri Water Laws* will be of immeasurable value to its readers, and to the continuing State Water Planning process. The largest of the seven volumes of Phase 1, this book will be of immense importance to students, various government agency personnel, property owners, concerned citizens, and anyone who uses water in daily life.

PHASE 2 - REGIONAL REPORTS

The seven technical volumes have been prepared in Phase 1 of the State Water Planning effort. Publication of the final volume concluded the first phase. Meanwhile, Phase 2 of the effort has commenced, and the first of several regional reports, *Topics in Water Use - Northeastern Missouri,* Water Resources Report No. 59, was received from the printers in 1999 and is available from the Publications Desk of the Division of Geology and Land Survey, Rolla.

Beginning with Northeast Missouri, the department is preparing a series of six regional reports, identifying water use problems and opportunities. The six regions are congruent with the six regional office territories of the department's Division of Environmental Quality (DEQ). See Appendix 2 for a map showing regional outlines. The staff of the Water Resources Program is preparing the reports, with the help of DEQ Regional Office personnel and other agency staffs.

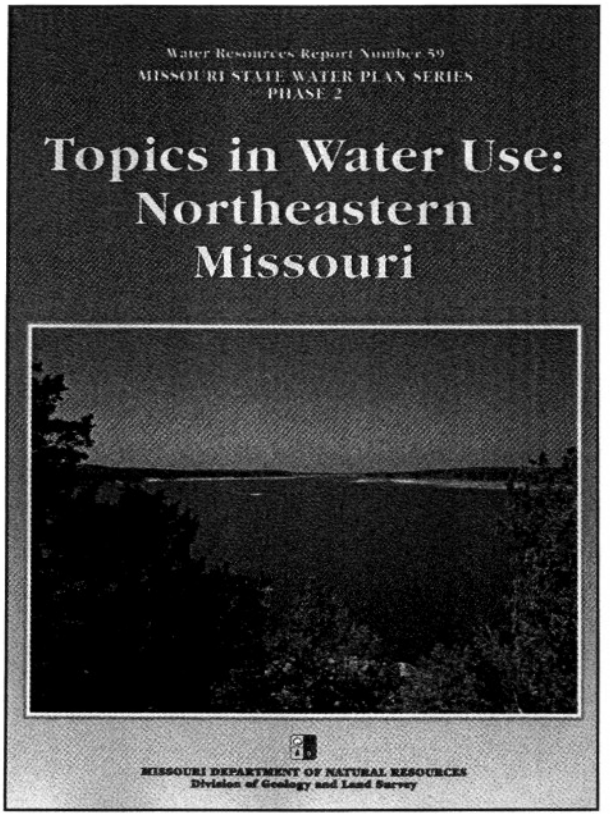
The Interagency Task Force (see Section 640.430, RSMo, below) met in 1998 to review the Phase 2 planning process and the Northeast Missouri Report and the department is following the Task Force's recommendations in continuing the planning process. A summary of the contents of this report is shown next.

Topics In Water Use - Northeastern Missouri,
Water Resources Report No. 59

According to the Missouri Water Resources Law, the state water resources plan is to address water needs for the following uses: drinking, agriculture, industry, recreation and environmental protection. Addressing water "needs" requires us to establish why these needs exist in the first place. In some cases, an existing water need is tied to one or more unresolved water problems. For example, communities "need" clean water. To meet this need, communities may have to address problems with water supply infrastructure and source water quality. This report explores the current issues facing the water resources of the northeastern Missouri region. Also included is a section addressing recent successes various water-related programs have enjoyed, and how they have affected the water resources of the region.

Although considered individually in this report, water use problems are not truly independent of each other. When reading through the water use problems identified in northeastern Missouri, it will quickly become apparent that many of them are, in fact, very closely related.

Water resource professionals commonly subdivide the state into physiographic units, such as watersheds or aquifers. While this approach is important for resource-based discussions, it may not adequately address water use problems or solutions. This series of reports addresses the subject using the broad geographic similarities of the six field service areas of the department's Division of Environmental Quality (DEQ)



(Appendix 2). Each of these regions has distinctive physiographic features and socio-economic characteristics, and therefore was chosen for the ease of referencing water use problems. This approach allows us to recognize Missouri's diversity, and lends itself well to the second phase of the State Water Plan.

The area served by the Division of Environmental Quality's Northeast Regional Office is the focus of this report. To this point, staff from this office and other state agencies dealing with water resources have served as the primary sources of input. This has enabled us to draw upon the insight and experience of field staff who, by virtue of their work, deal with many water use issues facing northeastern Missouri on a daily basis.

Topics In Water Use - Central Missouri

Work is well underway on the second report in Phase 2 of the State Water Planning process. It will cover the 15-county area surrounding Jefferson City, which is the service area for the Jefferson City Regional Office of DEQ (Appendix 2). The final working draft is being prepared to present to the Interagency Task Force for review and comment and is planned to be printed by the summer of 2001.

Topics in Water Use - Northwestern Missouri

Initial work has also begun on the third report in Phase 2 of the State Water Planning process. It will cover the 21-county area surrounding Kansas City, which is the service area for the Kansas City Regional Office of DEQ (Appendix 2).

Other Regional Reports

The southwestern Missouri region, the southeastern Missouri region, and the east central Missouri region will have their turns in the preparation of reports identifying water use problems and opportunities.

SPECIAL WATER QUALITY PROTECTION AREAS

640.418-Special water protection area, procedure to establish.

1. The department may establish special water quality protection areas where it finds a contaminant in a public water system in concentration which exceeds a maximum contaminant level established by the environmental protection agency pursuant to the Safe Drinking Water Act, as amended, or a maximum contaminant level established by the department pursuant to this chapter or sections 640.400 to 640.435 or a contaminant in surface or groundwater which exceeds water quality standards established pursuant to chapter 644, RSMo, which presents a threat to public health or the environment. In making such a determination, the department shall consider the probable effect of the contaminant or contaminants on human health and the environment, the probable duration of the elevated levels of the contaminant, the quality, quantity and probable uses of surface or groundwater within the area, and whether protective measures are likely to prevent, mitigate or minimize the level of the contaminant in the surface of groundwater.

2. If the department determines that a special water quality protection area should be established, it shall consult with the interagency task force and with the public water system or systems affected and determine the boundaries of such area. When the boundaries of any such areas have been determined, the department shall, after a public hearing, issue an order designating the area as a special water quality protection area. Such an order shall include a geographic, hydrologic and stratigraphic definition of the area.

3. The department shall hold a public hearing or a public meeting within the area under consideration for designation as a special water quality protection area. The department shall notify every city and county within the proposed area and shall notify the public by press release and by publication of a notice in a newspaper of general circulation in the region.

640.420-Special water protection area, information program to be established, purpose, duties. -When a special water quality protection area has been established, the department shall implement an area informational program to help prevent, eliminate,

mitigate or minimize the continued introduction of the contaminant or contaminants into the surface or groundwater.

640.423-Designation as protection area removed, when. -The department shall determine when the level of a contaminant or contaminants in a special water quality protection area does not exceed, and are not likely to exceed, the water quality standards established pursuant to sections 640.400 to 640.435 and this chapter, and chapter 644, RSMo. Upon such determination, the designation of an area as a special water quality protection area pursuant to section 192.300, RSMo, sections 640.100, 640.120, and 640.400 to 640.435 shall be removed.

No special water quality protection areas have been formed under this statute.

INTERAGENCY TASK FORCE

640.430-Interagency task force established, members, meetings.1. The department shall establish an interagency task force consisting of the departments of health, conservation, agriculture, the University of Missouri College of Agriculture, and other such departments and agencies as may be necessary to effectuate the purposes and provisions of sections 640.400 to 640.435.

2. The interagency task force shall meet at least semi-annually. The department shall be the lead agency in matters related to surface and groundwater protection.

Central Missouri

The department and the IATF are concurrently developing the regional water resource problems and opportunities of central and northwest Missouri. The geographic areas being considered are fixed upon the Division of Environmental Quality regional office in Jefferson City (JCRO) and in Kansas City (KCRO). JCRO problems and opportunities are being developed and initial work has begun on KCRO problems and opportunities. Water Resources Program staff members are developing topics contributed by field staff and others in the department. The IATF members will also be developing problem and opportunity statements for program staff to develop.

RECOMMENDATIONS

640.426-The department shall prepare and submit to the general assembly and the governor an annual report which details the progress it has made in meeting the objectives of sections 640.400 to 640.435 and which contains recommendations in furtherance of the purpose and provisions of sections 640.000 to 640.435.

This *2001 Annual Report* explains how the staff of the Missouri Department of Natural Resources carries out the legislative mandates of the Missouri Water Resources Law. It demonstrates the breadth of activities that the department conducts and the progress that has been made in meeting the objectives of the Water Resources law. This report is not a comprehensive listing of the department's water related activities.

As the State Water Plan volumes and reports continue to be published, the state's water quantity and quality needs will become more apparent. The goal of the State Water Plan is to produce a set of recommendations for local, regional, and statewide implementation, both short-range and long-range.

APPENDIX 1

2001 MISSOURI WATER LAW ANNUAL REPORT

MISSOURI WATER RESOURCES LAW

640.400. Citation of law.—1. Sections 640.400 to 640.435 shall be known and may be cited as the "Missouri Water Resource Law", in recognition of the significance of the conservation, development and appropriate use of water resources in Missouri.

2. The department shall ensure that the quality and quantity of the water resources of the state are maintained at the highest level practicable to support present and future beneficial uses. The department shall inventory, monitor and protect the available water resources in order to maintain water quality, protect the public health, safety and general and economic welfare.

(L. 1989 S.B. 112, et al. § 1)

Definitions.

640.403. As used in sections 640.400 to 640.435, the following terms mean:

(1) "Aquifer", a consolidated or unconsolidated subsurface water-bearing geologic formation, group of formations, or part of a formation, or other geologic deposits, capable of yielding a usable or potentially usable amount of water;

(2) "Contaminant", any physical, chemical, biological or radiological substance in water, including but not limited to, those substances for which maximum contaminant levels are established by the department pursuant to sections 640.400 to 640.435, this chapter and chapter 644, RSMo;

(3) "Department", the department of natural resources;

(4) "Groundwater", water occurring beneath the surface of the ground, including underground watercourses, artesian basins, underground reservoirs and lakes, aquifers, other bodies of water located below the surface of the ground, and water in the saturated zone;

(5) "Maximum contaminant level", the maximum permissible level established pursuant to this chapter of a contaminant in any water delivered to any user of a public water system;

(6) "Special water quality protection area", a geographic area meeting specified criteria established after public hearing by the department;

(7) "Surface water", water in lakes and wetlands, and water in rivers, streams and their tributaries in which water flows for substantial periods of the year;

(8) "Watershed", the area that drains into a river, stream or its tributaries;

(9) "Water resources", water in rivers, streams and their tributaries and water present in aquifers.

(L. 1989 S.B. 112, et al. § 2)

Interstate use of water, negotiation of interstate compacts, duties of department—general assembly and other agencies to be consulted.

640.405. The department shall represent and protect the interests of the state of Missouri in all matters pertaining to interstate use of water, including the negotiation of interstate compacts and agreements, subject to the approval of the general assembly. Any department of state government affected by any compact or agreement shall be consulted prior to any final agreement.
(L. 1989 S.B. 112, et al. § 3)

Surface and ground water monitoring program, duties of department, purpose.

640.409. The department shall establish, develop and maintain an ongoing statewide surface and groundwater monitoring program, the purposes of which are:

(1) Determination of ambient surface and groundwater quality for use as background or baseline water quality data;

(2) Detection of trends in the character and concentration of contaminants in surface and groundwater resources; and

(3) Identification of areas highly vulnerable to contamination.

(L. 1989 S.B. 112, et al. § 4)

Inventory to be maintained on ground and surface water uses, quantity and users.

640.412. The department shall inventory:

(1) Existing surface water and groundwater uses;

(2) The quantity of surface water and groundwater available for uses in the future; and

(3) Water extraction and use patterns, including regulated and unregulated users.
(L. 1989 S.B. 112, et al. § 5)

State water resource plan to be established for use of surface and ground water—annual report, contents—powers of department.

640.415. 1. The department shall develop, maintain and periodically update a state water plan for a long-range, comprehensive statewide program for the use of surface water and groundwater resources of the state, including existing and future need for drinking water supplies, agriculture, industry, recreation, environmental protection and related needs. This plan shall be known as the "State Water Resources Plan". The department shall collect data, make surveys, investigations and recommendations concerning the water resources of the state as related to its social, economic and environmental needs.

2. The department shall establish procedures to ensure public participation in the development and revision of the state water plan.

3. The department shall submit a report to the general assembly at least one year prior to the submission of the state water resources plan. The report shall specify the major components of the plan, and may recommend any statutory revision which may be necessary to implement the requirements of this section. The plan shall be submitted to the general assembly for approval or disapproval by concurrent resolution.

4. The department may:

(1) Require such reports from groundwater and surface water users and other state agencies as may be necessary; and

(2) Conduct investigations and cooperate or contract with agencies of the United States, agencies or political

subdivisions of this state, public or private corporations, associations or individuals on any matter relevant to the administration of section 192.300, RSMo, sections 640.100, 640.120, and 640.400 to 640.435.

(L. 1989 S.B. 112, et al. § 6)

Special water protection area, procedure to establish.

640.418. 1. The department may establish special water quality protection areas where it finds a contaminant in a public water system in concentration which exceeds a maximum contaminant level established by the environmental protection agency pursuant to the Safe Drinking Water Act, as amended, or a maximum contaminant level established by the department pursuant to this chapter or sections 640.400 to 640.435 or a contaminant in surface or groundwater which exceeds water quality standards established pursuant to chapter 644, RSMo, which presents a threat to public health or the environment. In making such a determination, the department shall consider the probable effect of the contaminant or contaminants on human health and the environment, the probable duration of the elevated levels of the contaminant, the quality, quantity and probable uses of surface or groundwater within the area, and whether protective measures are likely to prevent, mitigate or minimize the level of the contaminant in the surface or groundwater.

2. If the department determines that a special water quality protection area should be established, it shall consult with the interagency task force and with the public water system or systems affected and determine the boundaries of such area. When the boundaries of any such areas have been determined, the department shall, after a public hearing, issue an order designating the area as a special water quality protection area. Such an order shall include a geographic, hydrologic and stratigraphic definition of the area.

3. The department shall hold a public hearing or a public meeting within the area under consideration for designation as a special water quality protection area. The department shall notify every city and county within the proposed area and shall notify the public by press release and by publication of a notice in a newspaper of general circulation in the region.

(L. 1989 S.B. 112, et al. § 7)

Special water protection area, information program to be established, purpose, duties.

640.420. When a special water quality protection area has been established, the department shall implement an area informational program to help prevent, eliminate, mitigate or minimize the continued introduction of the contaminant or contaminants into the surface or groundwater.

(L. 1989 S.B. 112, et al. § 8)

Designation as protection area removed, when.

640.423. The department shall determine when the level of a contaminant or contaminants in a special water quality protection area does not exceed, and are not likely to exceed, the water quality standards established pursuant to sections 640.400 to 640.435 and this chapter and chapter 644, RSMo. Upon such determination, the designation of an area as a special water quality protection area pursuant to section 192.300, RSMo, sections 640.100, 640.120, and 640.400 to 640.435 shall be removed.

(L. 1989 S.B. 112, et al. § 9)

Report by department annually, content.

640.426. The department shall prepare and submit to the general assembly and the governor an annual report which details the progress it has made in meeting the objectives of sections 640.400 to 640.435 and which contains recommendations in furtherance of the purposes and provisions of sections 640.400 to 640.435.

(L. 1989 S.B. 112, et al. § 10)

Interagency task force established, members, meetings.

640.430. 1. The department shall establish an interagency task force consisting of the departments of health, conservation, agriculture, the University of Missouri, college of agriculture and such other departments and agencies as may be necessary to effectuate the purposes and provisions of sections 640.400 to 640.435.

2. The interagency task force shall meet at least semiannually. The department shall be the lead agency in matters related to surface and groundwater protection.

(L. 1989 S.B. 112, et al. § 11)

Judicial review from final orders of department, procedure—duties of department not to conflict.

640.435. 1. Any person aggrieved by a final order of the department issued pursuant to sections 640.400 to 640.435 may seek judicial review in the manner provided by chapter 536, RSMo.

2. The provisions of sections 640.400 to 640.435 shall not supersede the duties imposed under this chapter and chapter 644, RSMo.

(L. 1989 S.B. 112, et al. §§ 12, 13)

APPENDIX 2

2001 MISSOURI WATER LAW ANNUAL REPORT

DIVISION OF ENVIRONMENTAL QUALITY REGIONAL OFFICE BOUNDARIES

Kansas City Regional Office
500 NE Colbern Rd.
Lee's Summit, MO 64086-4710
(816) 544-4100
FAX: (816) 554-4142

Northeast Regional Office
1709 Prospect Drive
Macon, MO 63552-2602
(606) 385-6398
FAX: (606) 385-6398

Mississippi River Project Office
Wakonda State Park
Rt. 1, Box 242
LaGrange, MO 63448
(573) 655-4178

Jefferson City Regional Office
210 Hoover Road
P.O. Box 176
Jefferson City, MO 65102-0176
(573) 751-2729
FAX: (573) 751-0014

Lake of the Ozarks Satellite Office
Lake of the Ozarks State Park
Highway 134
Kaiser, MO 65047
(573) 348-2442

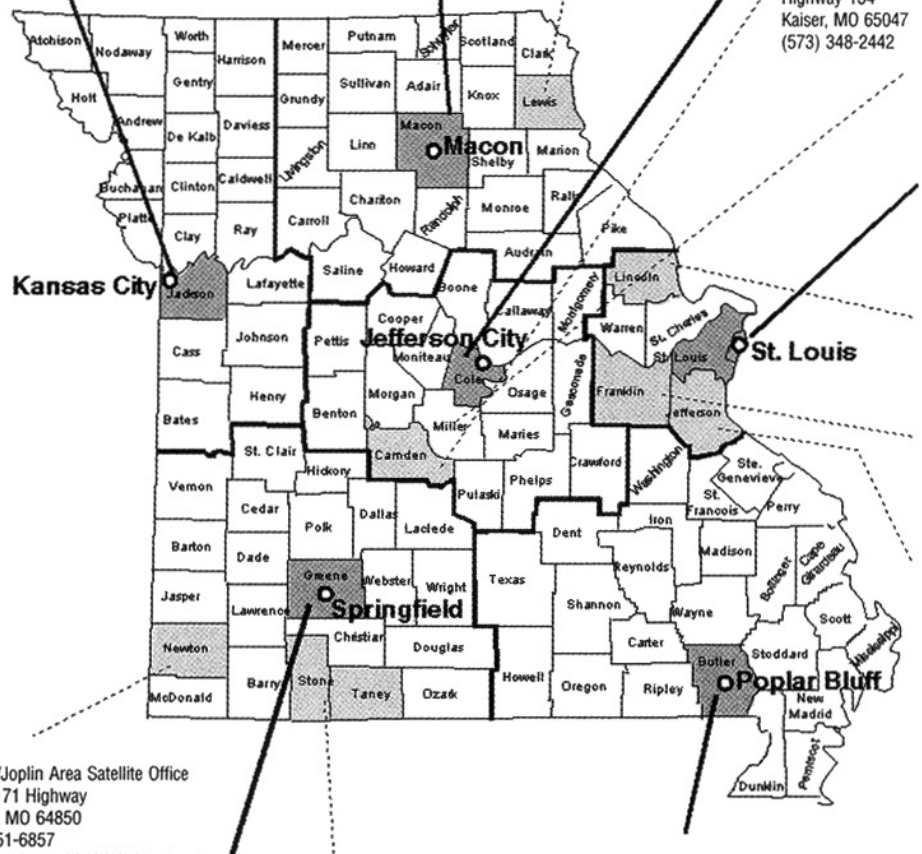
Lake of the Ozarks Satellite Office
Camden County
5568 A. Highway 54
Osage Beach, MO 65065

St. Louis Regional Office
10805 Sunset Office Drive
St. Louis, MO 63127-1017
(314) 301-7100
FAX: (314) 301-7101

Lincoln County Satellite Office
Cuivre River State Park
Highway 47 E.
Troy, MO 63379
(636) 528-4779

Franklin County Satellite Office
Meramec State Park
Highway 185 S.
Sullivan, MO 63080

Jefferson County Satellite Office
Eastern District Parks Office
Highway 61
Festus, MO 63028
(636) 937-3697



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1900 S. 71 Highway
Neosho, MO 64850
(417) 451-6857
Mailing address: 2040 W. Woodland
Springfield, MO 65807-5912

Southwest Regional Office
2040 W. Woodlamd
Springfield, MO 65807-5912
(417) 891-4300
FAX: (471) 891-4399

Taney/Stone Counties Satellite Office
Table Rock State Park
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Branson, MO 65616

Southeast Regional Office
948 Lester Street
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Poplar Bluff, MO 63901-1420
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FAX: (573) 840-9754