TOPICS IN WATER USE: EASTERN MISSOURI

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1.

Introduction

According to the Missouri Water Resources Law (sections 640.400 to 640.435, RSMo), the Missouri State Water Resources Plan is to address water needs for drinking, agriculture, industry, recreation and environmental protection. Addressing water "needs" requires us to first establish why such needs exist. 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, adequate quantity and, at the same time, source water quality. This report takes a step toward addressing the water needs of eastern Missouri by identifying problems faced in this area.

As noted in the legislation, there are many aspects of water use problems. Missouri water law is concerned with protecting private individual water rights and protecting public health and welfare. In addition to social and economic needs, there are the environmental needs of the forests, fish and wildlife of Missouri. There are the facets of quantity and quality of the water resources, themselves. And there are the political jurisdictions that administer public water supplies under Missouri statutes. It is within this matrix of considerations that the Missouri Department of Natural Resources has approached these regional water use problems and opportunities as well as the broader topic of state water planning.

To ensure equal consideration for all uses, emphasis was placed on identifying water use problems in each topical area identified in the Water Resources Law. Similar topics sometimes are addressed in more than one category, reflecting the different viewpoints of those who raised these topics as water use problems.

When reading this report on the water use problems identified in eastern Missouri, it will become apparent that many of them are, in fact, very closely related. In addition, because of the diverse perspectives the various contributors bring to this effort, what, from one standpoint, may appear to be a "serious problem," may not seem so, from another. For these reasons, the following problems underscore the importance of working cooperatively in addressing the water use problems facing eastern Missouri.

The Regional Approach

Water resource professionals commonly subdivide the state into physiographic units, such as watersheds or groundwater provinces. While the water supply side is chiefly focused on where the water resource is located, its quantity and quality, the water use side is focused primarily upon administering demands, needs, and the purposes the water serves. In this series of reports, we have chosen to address the subject using the broad geographic similarities of the six field service areas of the Missouri Department of Natural Resources. This volume is the fifth and final report in the series and finishes the entire state. As of June 2003, the Missouri Department of Natural Resources has reduced its field offices from six to five. This has resulted in an increase in the number of counties that each remaining field office services. For the purpose of these State Water Plan (SWP) reports the traditional Department of Natural Resources service areas are used. This approach provides continuity with past SWP Phase II reports (figure 1). Each of these regions has distinctive physiographic features and socio-economic characteristics, as well as being composed of counties, 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 Phase 2 of the State Water Plan.

The area formerly (pre-June 2003) served by the department's St. Louis Regional Office is the focus of this report. Staff members of this office and other state agencies dealing with water resources were the primary sources of information for this effort. This enables us to draw upon the insights and experiences of field staff, who, by virtue of their work, deal with the many water use problems that face residents of eastern Missouri on a daily basis.

Figure 1. Counties covered by each regional report.

The Watershed-Based Approach

The watercourses of the eastern Missouri region drain either directly or indirectly into the Mississippi River. Some drain into the Missouri River, which joins with the Mississippi just north of St. Louis.

Watersheds may be defined as the areas of land that drain surface water runoff into a central watercourse. The watershed usually is named after its stream, such as the Cuivre River Watershed. In the 1990s, federal and state environmental planners began to put a greater emphasis on consideration of water resources and water problems within a watershed context. In this manner, they hoped to take into consideration all the factors that affect water quality from a geographic perspective. Comprehensive watershed assessment, planning, and management of water resources makes sense, but political boundaries (cities, counties, states) rarely follow watershed boundaries. Indeed, boundaries often follow watercourses, effectively dividing any watershed where this occurs, therefore, cooperation and coordination among all the jurisdictions within any watershed is critical to taking a watershed approach to the solving of problems like nonpoint source pollution.

Concerning this watershed-based approach, segments of the separate watersheds are further subdivided into increasingly smaller "hydrologic units" so that distinct watersheds may be broken into more manageable sizes for study. Watersheds (or hydrologic units) have been assigned identification numbers so that the several agencies working with them can be in agreement on the piece of land they are studying. There are 2-digit, 4-digit, 6-digit, 8-digit, 10-digit, and 12-digit watersheds. The more digits, the smaller the watershed identified. The watershed approach has been endorsed by leading federal agencies like the United States Environmental Protection Agency (USEPA) and the United States Department of Agriculture (USDA). It should be remembered that these watersheds define surface water drainage areas only, and while interacting with groundwater areas and political boundaries, they are but pieces of the bigger picture of the interrelationships of water supply and water use.

Temporal Aspect of Water Use

Times change, and styles change. Per capita, more water is used today than ever before. Those folks who are self-supplied (mostly rural dwellers on their own wells) use much less water per capita than those on public water supply systems. Hydropower use has evolved from water wheels that turned the stones of gristmills of early Missourians to the large power generating plants of today. Bathing, clothes washing, and other occasional uses of water by Missouri's previous generations was nothing compared to the water use demands of today's large population of Missourians. Greater demands, in each generation, have resulted in efforts to supply ever-greater quantities of water to our population from finite supplies. Not only is it just more people using more water, but rather more people using greater quantities of water in a greater variety of ways. This pattern is likely to continue.

Acknowledgments

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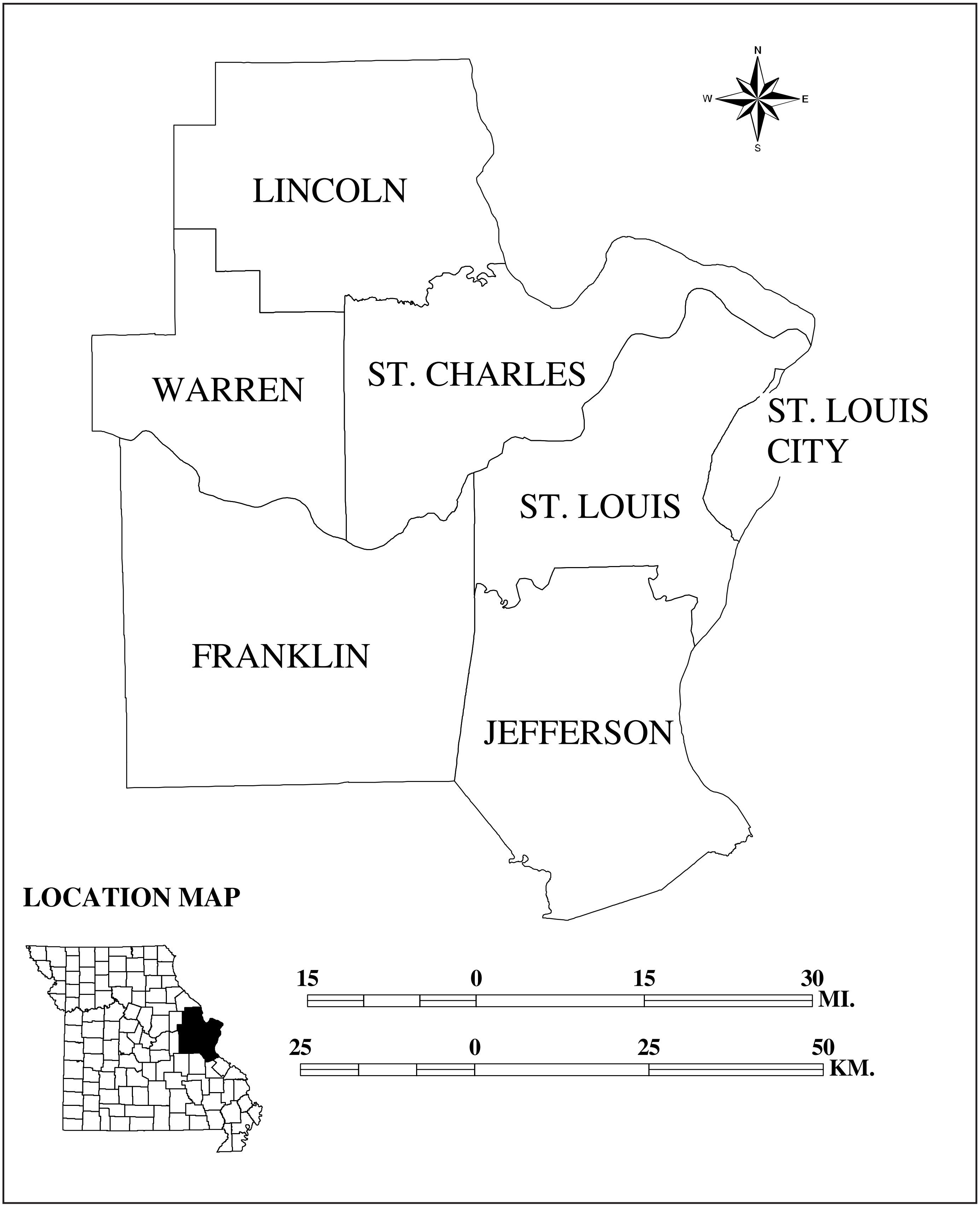

Figure 2. Map showing counties of the eastern Missouri region covered by this report.

3.

Regional Description

The eastern region covers six counties and one independent city. These counties are Franklin, Jefferson, Lincoln, St. Charles, St. Louis, and Warren counties, and St. Louis City (figure 2).

The Mississippi River forms the eastern boundary of the region. Four of the six counties in the eastern region front on the Mississippi River, a path of commerce since early times. Similarly, four of the six counties front on the Missouri River. The confluence of these two rivers in this region of the state has made the alluvial soils of the region very rich and productive, and the Greater St. Louis Area a hub of commerce, the third largest railroad center (after Chicago and Kansas City).

Colleges and Universities

There are 24 colleges situated in the counties of the eastern region. The list includes, alphabetically, Concordia Seminary (St. Louis City); East Central Missouri College (Franklin Co.); Florissant Valley Community College (St. Louis Co.); Fontbonne College (St. Louis Co.); Forest Park Community College (St. Louis City); Greenleaf College (St. Louis Co.); Harris-Stowe State College (St. Louis City); Jefferson College (Jefferson Co.); Keller Graduate School of Management (St. Louis City); Lindenwood University (St. Charles Co.); Logan College of Chiropractic (St. Louis Co.); Maryville College (St. Louis Co.); Meramec Community College (St. Louis Co.); Missouri Baptist College (St. Louis Co.); Missouri Technical College (St. Louis Co.); Patricia Stevens College (St. Louis City); Ranken Technical College (St. Louis City); St. Charles Community College (St. Charles Co.); St. Louis College of Pharmacy (St. Louis City); St. Louis University (St. Louis City); Sanford Brown College (St. Louis Co.); University of Missouri-St. Louis (St. Louis Co.); Washington University (St. Louis Co.), and Webster University (St. Louis Co.) (figure 3). There also are branches of other colleges that offer courses in the region.

Regional Transportation

Navigation

Commercial river navigation in the eastern region of Missouri is entirely by way of the Mississippi and Missouri rivers. The Mississippi River has a year-round commercial navigation season and the Missouri River's commercial navigation season typically is from April 1 to December 1 annually. A nine-foot navigation channel depth, and a 300-foot width, is maintained on these reaches of the Missouri and Mississippi rivers (Bacon, 2002). Port authorities in the region are the Jefferson County Port Authority, St. Louis County Port Authority, Port of Metropolitan St. Louis and the City of St. Louis Port Authority's Port District (figure 4).

The Jefferson County Port is located on the Mississippi River at river mile 150, south of metropolitan St. Louis. It has underground storage and access to the Union Pacific and the Burlington Northern-Santa Fe railroads (Missouri Ports, 2002).

The St. Louis County Port, also south of metropolitan St. Louis, is on the Mississippi River at the mouth of the River Des Peres at Mississippi River mile 171. A riverboat casino is located at the port and barge ties are available (Missouri Ports, 2002).

The largest and most active port in the state, the Port of Metropolitan St. Louis, also known as the City of St. Louis Port, is located on the Mississippi River and extends 70 miles, from Mississippi River mile 138.8 to river mile 208.8 (Missouri Ports, 2002). Encompassing both

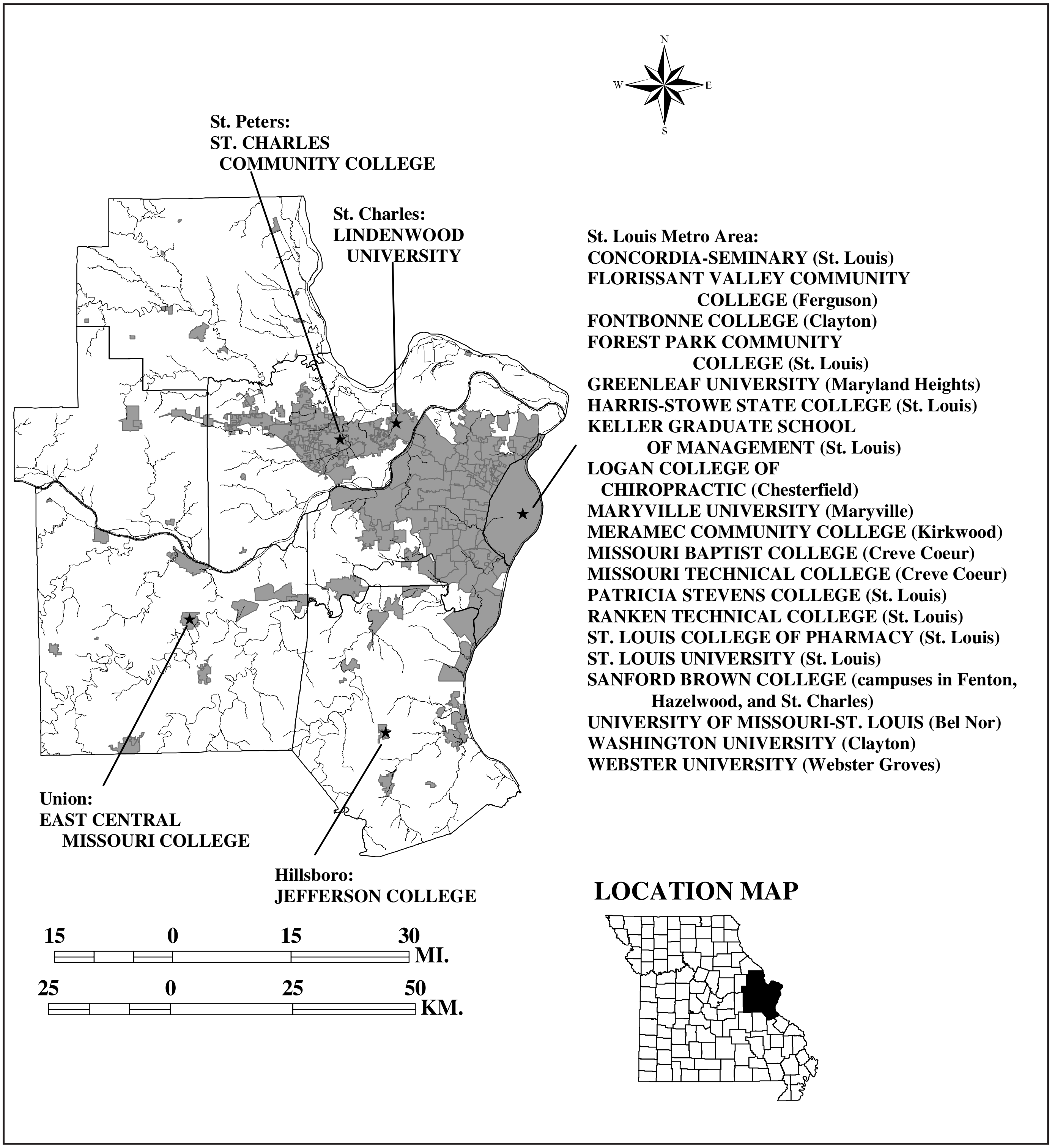

Figure 3. Locations of colleges and universities in eastern Missouri.

banks of the Mississippi River and at 33.3 million tons annually, it is the third largest inland port in the U.S. and ranks 23rd in the nation (USACE, 2002). The port has 76 piers, wharves and docks on the Missouri side and 58 on the Illinois side for a total of 134. The port has over 55 fleeting areas that allow barges to be held awaiting movement. Petroleum, chemicals, grain and coal are the chief commodities moving through the port, representing approximately 80 percent of the cargo handled. The Port of Metropolitan St. Louis is the northernmost point on the Mississippi River that normally remains ice-free and open during the winter months, and is the northernmost point on the river with lock-free navigation to the Gulf of Mexico (SLRC&GA, 2002).

The City of St. Louis Port Authority's Port District (CSLPAPD) lies between river mile 171.9 and 191.2. Lying within the city limits and encompassed within the boundaries of the Port of Metropolitan St. Louis, these 19.3 miles of riverfront include 30 docks handling specific products, commodities and services, warehousing, manufacturing, barge switching, fleeting and barge cleaning and repair services. The CSLPAPD coordinates city-owned riverfront property with river users to encourage capital investment and increased commercial volume. There are two general-public dock facilities (Missouri Ports, 2002).

Railroads

Passenger rail transportation via Amtrak has one trunk line from St. Louis across the southeastern Missouri region, stopping in Poplar Bluff, Missouri, and Little Rock, Arkansas, and ending in San Antonio, Texas. Another line crosses the state to Jefferson City and Kansas City, with a third line heading to Chicago. All of these trains have other stops too numerous to mention here. There are three Class 1 rail freight service companies in the east central region of Missouri: Burlington Northern–Santa Fé (BNSF), Norfolk Southern (NS), and Union Pacific (UP) (see figure 4).

Rails to Trails

The roadbed of the former Missouri, Kansas, and Texas (MKT or the "Katy") Railroad has been conserved by the State of Missouri, Department of Natural Resources, Division of State Parks, to form the Katy Trail State Park, running more or less parallel to the Missouri River from St. Charles County westward to near Boonville, where it crosses the river and heads southwestward. This major hiking-biking trail is a popular state park with many major and minor trailheads for access. Those interested in following the Lewis and Clark Trail in Missouri on foot or by bicycle find this trail attractive.

Aviation

St. Louis' Lambert International Airfield is the only airport in the region with commercial airline service. Currently under expansion, it is the busiest airport in Missouri, having passenger, air freight, and military flights daily. There are numerous major air carriers providing service from Lambert Field. Numerous smaller airports serve the region as well.

Highways

U.S. Interstate Highway transportation routes include I-44, which heads southwestward toward Springfield, Oklahoma, and Texas; I-55, which roughly parallels the Mississippi River southbound; I-70, which heads towards Kansas City and Indianapolis; and I-170 and I-270, which are St. Louis by-pass routes.

Other major U.S. numbered highways include Route 40, which sometimes runs parallel and sometime concurrent with I-70; Route 50, which heads westward to Kansas City through Jefferson City; and Routes 61 and 67, which run north-south (figure 5).

The Great River Road (State Highway 79 in Lincoln County, and U.S. Highways 61 and 67, Jefferson County) run parallel to the Mississippi River, and is marked with signs showing a

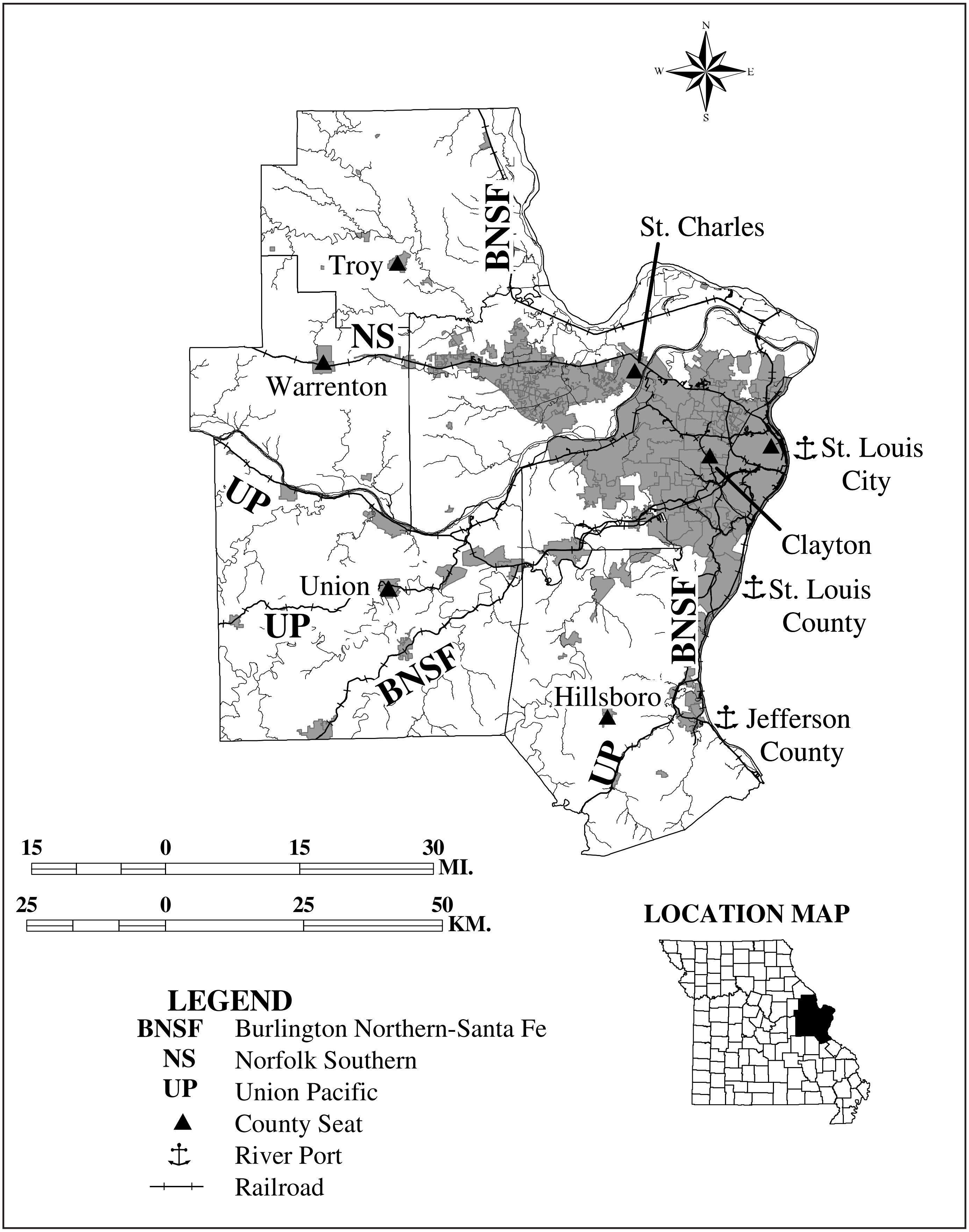

Figure 4. Railways and river ports in eastern Missouri.

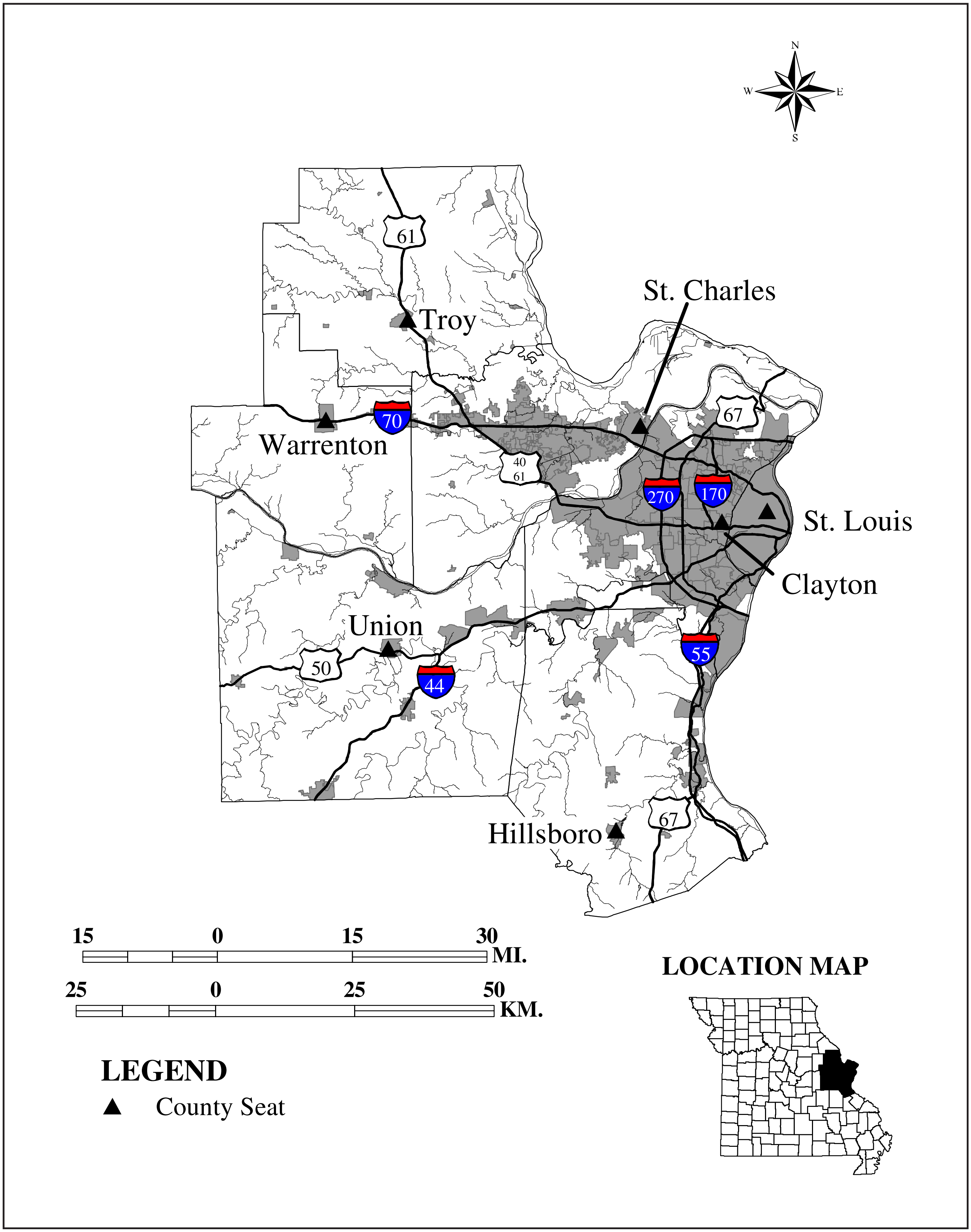

Figure 5. Major roads and cities in eastern Missouri.

riverboat helm. The Lewis and Clark Trail (State Highway 94 in St. Charles and Warren counties, and State Highway 100 in St. Louis and Franklin counties) runs parallel to and along both sides of the Missouri River, the route traveled by the Lewis and Clark Expedition in 1804-1806. Forest Park in St. Louis was the site of the fair, and several buildings from the fair still stand, including the Missouri Historical Society and the St. Louis Art Gallery. U.S. Route 40 and I-64 run along the south side of Forest Park. The Bicentennial Commemoration of the Louisiana Purchase and the Lewis and Clark Expedition will be observed in 2003 – 2006.

Population Characteristics

All of the counties in the region grew in population between the 1990 and 2000 censuses, with the increase ranging from 4,000 to 71,000 people (2-35 percent increases). The City of St. Louis however, lost nearly 50,000 people, continuing a downward trend. The population growth since 1990 in the St. Louis Metro Region was 5.1 percent compared to 9.1 percent for the state. The region is becoming increasingly urban and suburban, with rapid growth and development in the counties outside of the City of St. Louis.

The largest city in the region is St. Louis, with almost 350,000 people; St. Charles follows at nearly 60,000. Total population for the region, according to the 2000 census, was 2,003,762 (table 1). This represents an average of 531.2 persons per square mile. Fifty-two percent of the population in the 7-county region is female, with 48.0 percent male. Eleven percent of the total population were rural residents in 1990. By age groups, 26.3 percent of the population is less than 18 years old, 8.7 percent is 18-24, 30.2 percent is 25-44, 22.3 percent is

County Name	**County Seat**	**Major Town(s)***	**River Port(s)**
Franklin-93,807	Union-7,784	Pacific-5,561	New Haven-1,909
		Washington-13,092	
Jefferson-198,099	Hillsboro-1,729	Arnold-20,080	
		De Soto-6,364	
		Festus-9,956	
Lincoln-38,944	Troy-6,647	Elsberry- 1,898	
St. Charles-283,883	St. Charles-59,997	Lake St. Louis-10,059	
		O'Fallon-45,888	
		St. Peters-51,332	
		Wentzville-7,058	
St. Louis-1,016,315	Clayton-12,826	Ballwin-31,223	Florissant-50,229
		Chesterfield-46,973	
		Ferguson-22,090	
		Hazelwood-26,174	
		Kirkwood-27,270	
		Maryland Heights-25,937	
		University City-37,462	
		Webster Groves-23,064	
		Wildwood-33,445	
Warren-24,525	Warrenton-5,209		
St. Louis City-348,189			

(Regional Population: 2,003,762. per Census Bureau Website: www.census.gov, June 2001).
*for St. Louis County, only cities over 20,000 people were included in the list.

Table 1. Eastern Missouri region counties and their populations.

45-64, and 12.6 percent is 65 or older. The median age is 36 years. The 2000 census identified 846,055 housing units and 782,531 households within the region (U.S. Census Bureau, 2002).

Education statistics list 7.1 percent of the region's residents 25 and older with less than a 9th grade education, 14.1 percent had greater than 9th grade but less than 12th, 35.8 percent had graduated from high school, 30.0 percent were college degreed and 12.9 percent held graduate degrees. Employment and income data show 33.6 percent of the available workforce were managers/professionals, 26.8 percent held technical/sales/administrative positions, 13.5 percent were employed in a service industry, 0.1 percent farming and farm related, and 20.5 percent in "other" employment sectors. The average annual household income was $46,042 and the average home value was $105,102. The unemployment rate for the region was at 5.5 percent. Approximately 9.4 percent of the region's residents were at or below the poverty level. This compares with 11.8 percent for the state as a whole. However, the poverty rate in the urban core is much higher, at 24.7 percent. The unemployment rate during 2001 for the St. Louis Metro Region was 4.6 percent, slightly lower than the state's rate of 4.7 percent. Again, the rate in the urban core is higher, at 8.2 percent. The growth in personal income and per capita income in the St. Louis Metro Region over the past decade is slightly less than the growth of the state as a whole. Per capita income in the region was an extremely high $33,102 during 2000, slightly more than the $27,271 for the state (MERIC, 2003).

Industry, Commerce and Agriculture

More than 2.5 million people live in the St. Louis region (including those in Illinois), making it the 18th largest metropolitan area in the United States. The region's main industries include aviation, biotechnology, chemicals, electric utilities, food and beverage manufacturing, refining, research, telecommunications, and transportation (MDED, 2003).

The economy of the St. Louis Metro Region is generally trailing the economy of Missouri as a whole. However, there has been an extremely varied amount of economic growth in this region during the last ten years. St. Louis is home to a wide variety of high tech and high value-added manufacturing processes. Local firms like GKN Aerospace, Mallinckrodt, and Boeing are profitable companies because of their ability to incorporate new technologies with traditional manufacturing products.

St. Louis is a regional center for both information technology (IT) and the application of IT in businesses ranging from finance, manufacturing and distribution. St. Louis has a particularly high concentration of jobs in the IT fields of communications services, and computer-integrated design services. The region also boasts rapid growth in other IT sectors, including programming services, prepackaged software and computer- related services.

The St. Louis Regional Commerce and Growth Association (RCGA) is the chamber of commerce and economic development organization for the bi-state St. Louis region. Formed in 1973, RCGA is the result of the merger of three separate organizations: the Chamber of Commerce of Metropolitan St. Louis, the St. Louis Regional Industrial Development Corporation, and the St. Louis Research Council (MDED, 2003).

Some of the top employers in the St. Louis region include A.G. Edwards and Sons, Anheuser-Busch Brewing Co., Edward D. Jones & Co., and Schnuck's Markets. The Greater St. Louis Area ranks sixth in the United States as a headquarters location for Fortune 500 companies. Anheuser-Busch, Emerson Electric, May Department Stores, Premcor, Graybar Electric, Express Scripts, and AmerenUE are all Fortune 500 companies headquartered in the St. Louis metro area (MDED, 2003).

Other major firms in the eastern Missouri region include McDonnell-Douglas Branch of Boeing, the TWA branch of American Airlines, research and technical firms like Mallinkrodt; automobile manufacturers like GM at Wentzville, Chrysler at Fenton, and Ford at Hazelwood, and so on. Even the St. Louis Cardinals, the St. Louis Rams, and the St. Louis Blues are commercial professional teams that have fans in a wide area and make St. Louis stand out, economically.

In addition to these major corporations, many entrepreneurial businesses flourish in the St. Louis area. In fact, St. Louis ranked second in the U.S. in *Entrepreneur* magazine's listing of the top places for small business, marking four straight years on that publication's Top 10 list. *Inc.* magazine placed St. Louis among the Top 10 areas for growing firms. *Black Enterprise* magazine also named St. Louis as one of six new business meccas for African Americans (MDED, 2003).

For the most part, agriculture in the six-county region no longer plays a major role in the economy of Missouri. One segment of the farm economy that is outstanding is the nursery business. Shrub and tree nurseries of this region comprise 2,517 acres and generate more than $100 million, 42 percent of the state's cash receipts in nursery products (Schlegel, 2003).

In the eastern region, another outstanding segment of the agricultural sector is the emerging winemaking, grape-raising business. The number of small wineries in the region is growing, and the number of growers of wine grapes also is growing in the region. Tourists are also attracted to the vineyards of the region for wine-tasting visits.

As a matter of fact, the first federally designated viticulture area in the United States is the region around Augusta, in St. Charles County. This area has been nicknamed the "Rhineland of Missouri." Of the 41 listed wineries in the 2002 list from the Missouri Department of Agriculture, Market Development Division, Grape and Wine Program, 12 are located in the eastern Missouri Region. Six are in St. Charles County, four are in Franklin County, one is in Warren County, and one is in Jefferson County.

Indeed, the awareness of the place of agriculture in the economy is growing among the largely urban population, and the popularity of farmers' markets and of organically grown produce is rising.

Another important agricultural crop in the urban region is lawn sod, grown for installation at new home and office building sites. Much of the agricultural irrigation water use in the region is for the growing of sod. Sod farms in the St. Louis metropolitan area include: Lincoln County has 9 sod farms, with 804 acres; St. Charles County has 5 sod farms, with 797 acres, and St. Louis County has 6 sod farms, with 800 acres (Schlegel, 2003).

Among the major agricultural goods of the state, the six counties of the eastern region do not rank among the high producers, except that Franklin County ranks 9th among the 114 counties of Missouri in hog and pig production. Alphabetically, in other agricultural goods, Franklin County ranks 16th in hay production, and 19th in milk cows; Jefferson County ranks 41st in milk cows; Lincoln county ranks 17th in corn production, 19th in hogs and pigs, and 20th in wheat production; St. Charles County ranks 20th in corn production; St. Louis County ranks 57th in wheat production, and Warren County ranks 27th in hogs and pigs (MASS, 1999).

Physical Characteristics

Eastern Missouri has a humid, continental climate with average annual temperatures from about 54° F to 56° F. Long term annual precipitation averages from 36 to 42 inches throughout the region (figure 6). Rainfall amounts are generally highest in the spring and lowest in the fall and winter months. Evapotranspiration, the process of precipitation being returned to the air through direct evaporation or transpiration of plants, consumes from 28 to 30 inches of annual rainfall. Surface runoff of precipitation averages from 9 to 12 inches annually.

About half of eastern Missouri lies in the dissected till plains of the Central Lowland Region (northern Missouri), and the other half lies in the northern part of the Salem Plateau of the Ozarks physiographic region common to most of southern Missouri (figure 7). During the last period of glaciation, called the Wisconsin glaciation, the exposed rocks of northern Missouri, eroded by earlier glacial advances, were scoured again by advancing ice sheets. The farthest reach of the ice is shown in Figure 8. The result of the glacial scouring is a combination of preglacial and postglacial eroded surfaces, best characterized by being called "almost flat".

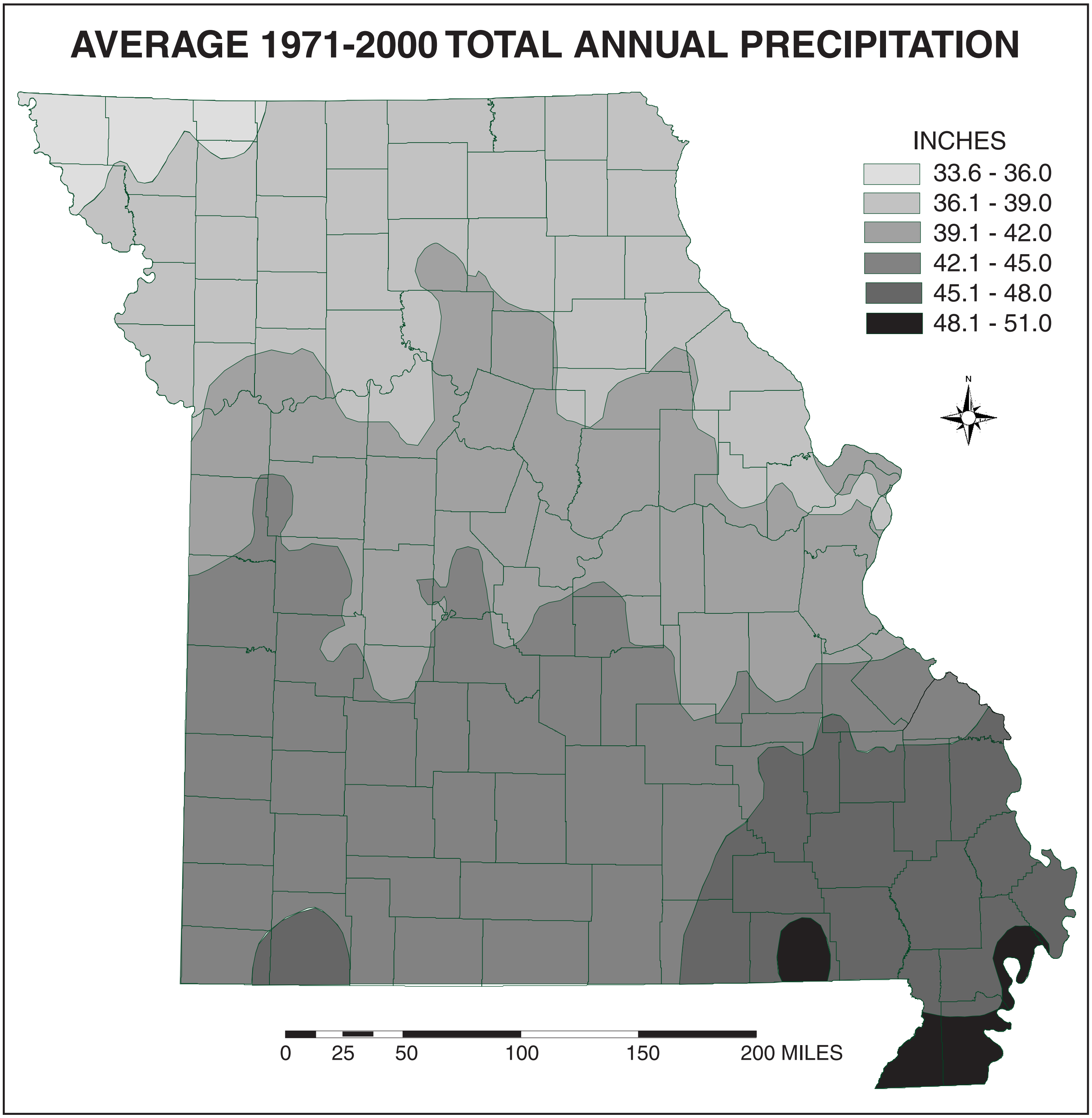

Figure 6. Missouri average annual precipitation from 1971-2000. Source: Office of State Climatologist, University of Missouri-Columbia.

Glacial till or drift, composed of sand, clay, silt, gravel, cobbles, and boulders, deposited on the surface and in valleys that were eroded earlier, can be quite thick, up to several hundred feet in the dissected till plains (Brookshire, 1997). These glaciated plains and glacial till are constantly being eroded by rainfall and dissected by runoff, gradually destroying the formerly nearly level topography. In the glaciated area, particularly near the Missouri and Mississippi rivers, post-glacial winds carried large quantities of fine

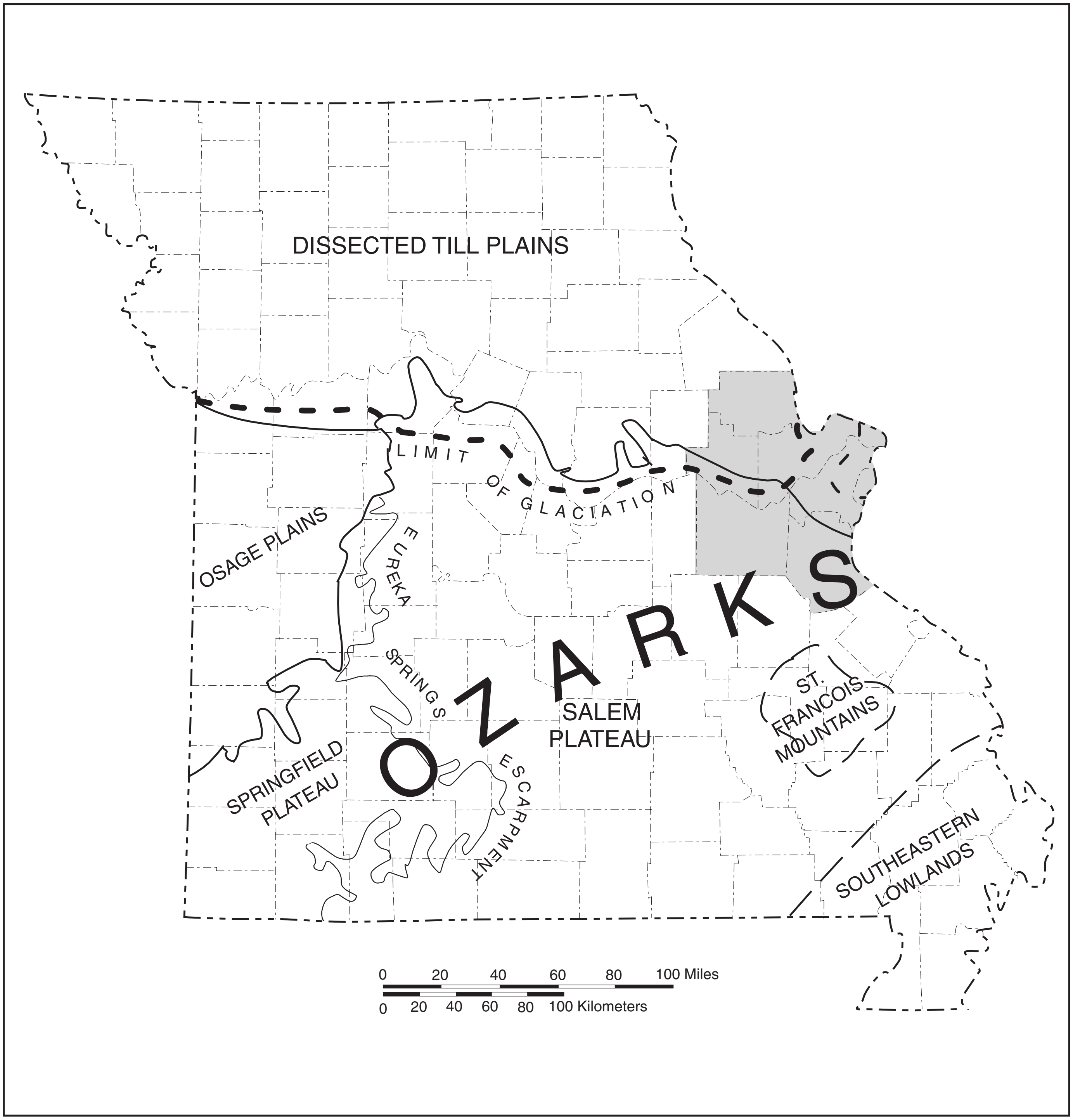

Figure 7. Physiographic provinces of Missouri. Source: Missouri Department of Natural Resources' Geological Survey and Resource Assessment Division.

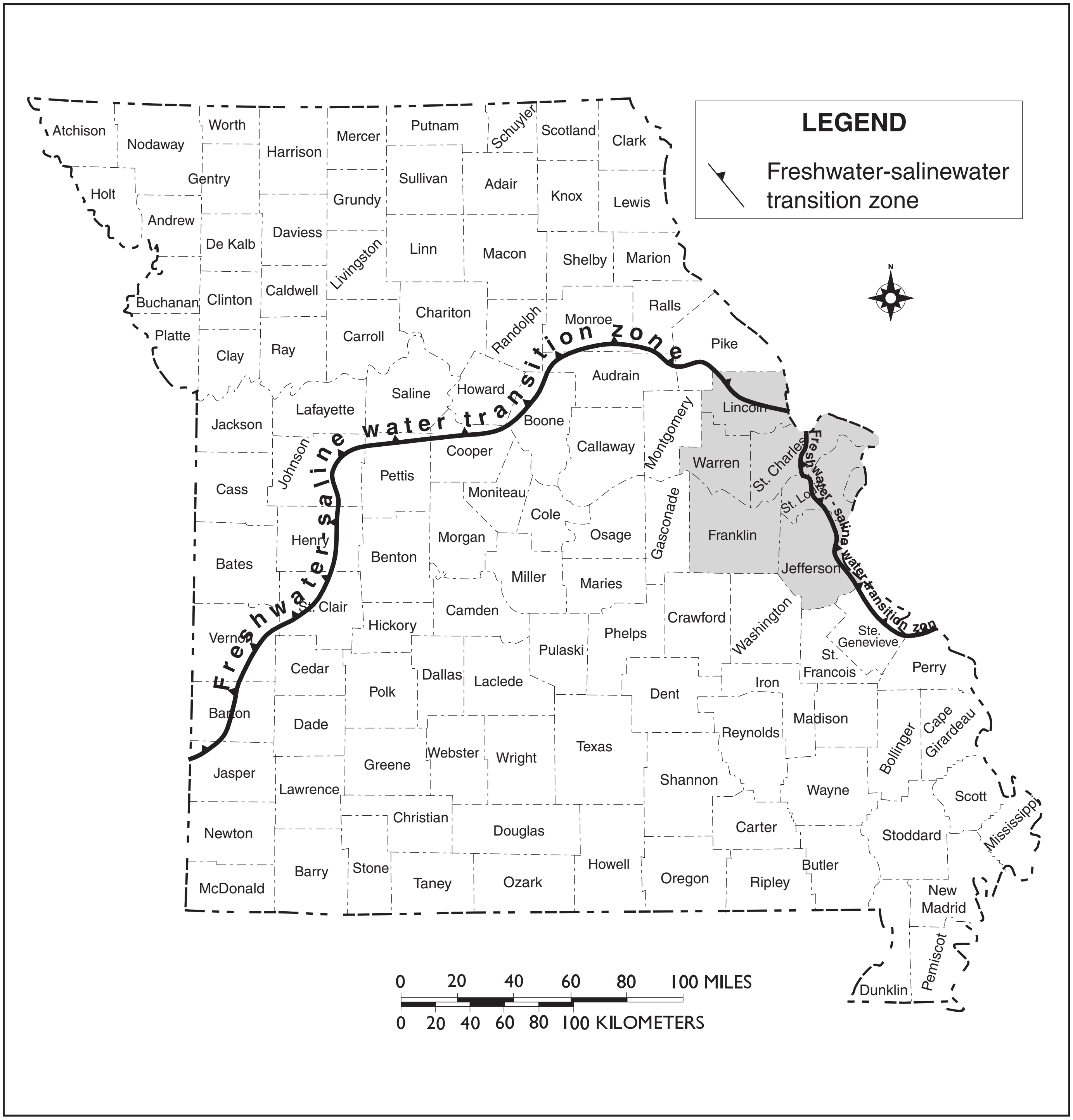

Figure 8. Approximate extent of glacial ice in Missouri.

silt into the air, subsequently depositing it in the "river hills." The silty material, deposited in wind-blown drifts (like sand dunes, but finer-grained), is called loess. Except for the alluvial groundwater along the major rivers, the northern part of Lincoln and the eastern parts of St. Charles and St. Louis counties have saline groundwater that requires extensive treatment to make it potable. The rest of the region in the dissected till plains has the Cambrian-Ordovician aquifer underlying it, which can provide significant quantities of groundwater. The shallow aquifer can, however, be adversely impacted by drought conditions.

The remainder of the eastern region is included in the Salem Plateau of the Ozark Plateau physiographic region. This area is composed of mostly Ordovician- and Cambrian-age sedimentary rocks. The landscape is maturely dissected with steep-sided valleys separated by more gently rolling uplands. Modern soils are typically thin except for the upland areas. In those areas, bedrock is overlain by thick deposits of unconsolidated residuum (weathered rock), typically permeable, allowing high rates of groundwater recharge. Karst topography here is typical and widespread. Caves in St. Louis were used as warehouses and wine cellars in the early history of the city. The aquifer in this area is known as the Ozark Aquifer, and is unconfined. It receives recharge primarily from precipitation and lateral movement of groundwater from outcropping bedrock, and can produce large quantities of good-quality groundwater.

Water stored in the flood plain deposits of the Missouri and Mississippi rivers is called alluvial groundwater. These deposits generally are very good sources of drinking water and alluvial wells generally yield large quantities of water (figure 9).

Recreation

The gentle hills, rivers and lakes in eastern Missouri provide a scenic backdrop for twelve state parks and historic sites, and numerous conservation and wildlife areas (table 2), even though the area is heavily urbanized. All types of water recreation, including fishing, sailing, swimming, canoeing, water-skiing, and motorboating are available on the area's streams and small lakes, although not as many choices exist as in the southern part of the state.

Other notable waterfront, excursion, commercial, gaming, historical, and water-borne navigation sites include the downtown waterfront areas of the cities of St. Louis and St. Charles. There are also numerous Missouri Department of Conservation (MDC) recreational river accesses on the Big, Bourbeuse, Cuivre, Mississippi, Missouri, and Meramec rivers, to name but a few (MDC, 2002).

County	State Parks[1]	MDC[2]	Federal[3]
Franklin	2	7	0
Jefferson	3	4	0
Lincoln	1	9	0
St. Charles	2	7	1
St. Louis	3	5	1
Warren	0	3	0
St. Louis City	1	0	1

Sources: [1]www.dnr.state.mo.us/dsp/index.html; [2]www.conservation.state.mo.us; [3]www.fws.gov; [3]www.usace.army.mil; [3]www.nps.gov; [3]www.af.mil; [3]www.fs.fed.us

Table 2. Number of state and federal recreational facilities in Eastern Missouri.

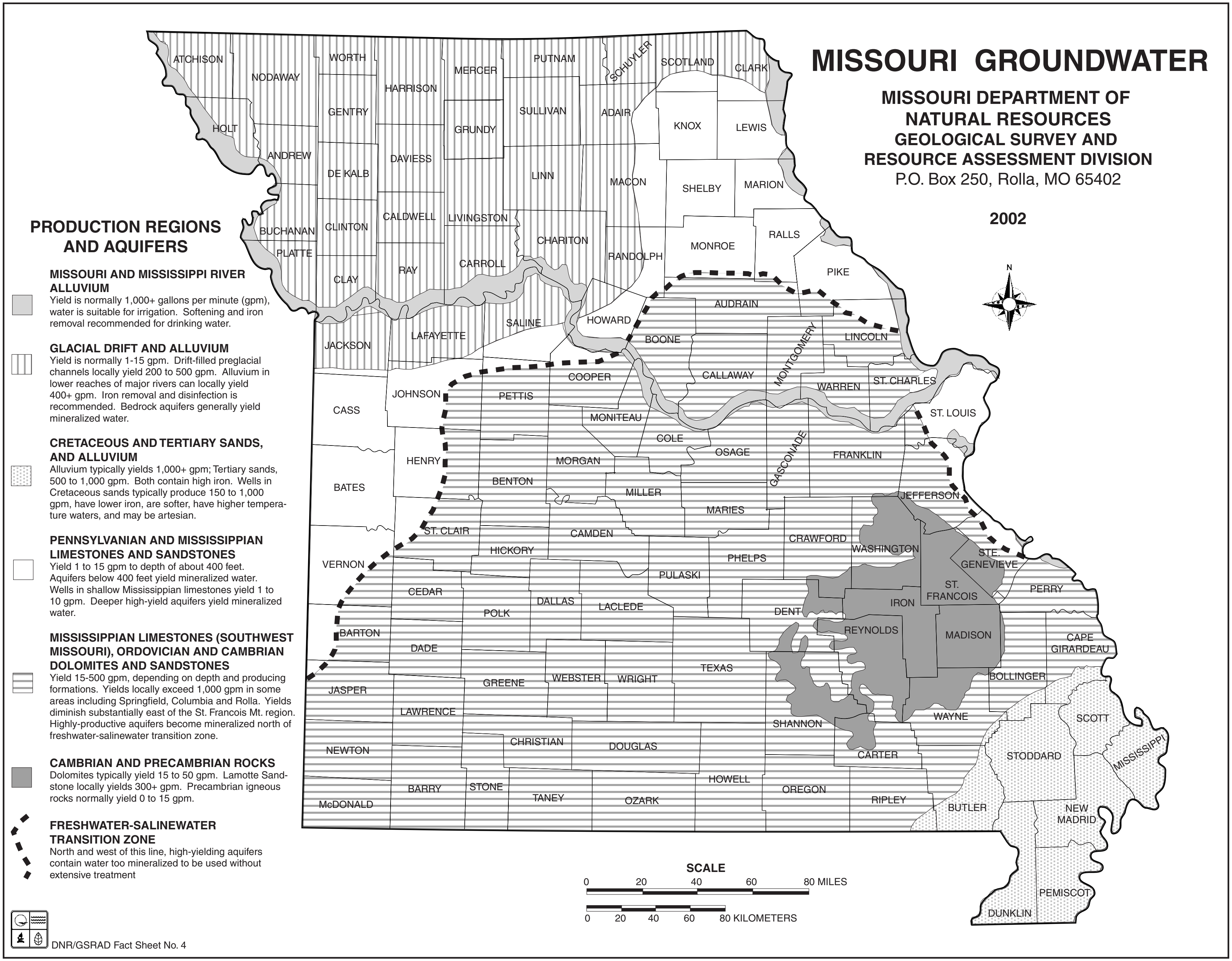

Figure 9. Generalized groundwater quality map.

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Regional Water Use Overview

Water Resources Management

There are many issues that confront and hinder water resource managers. Watershed management has now become the preferred method for evaluating water resources and identifying problems and solutions. A watershed may be defined as the natural or disturbed unit of land on which all the water that falls (or emanates from springs or snowmelt), collects by gravity, and fails to evaporate, runs off via a common outlet (Gaffney and Hays, 2000). While these units are natural and logical boundaries, they seldom follow political boundaries. This creates a problem for planners who must now coordinate many agencies, municipalities, and varied interests. Cooperation among all stakeholders is usually needed to implement and manage an effective watershed management plan. This cooperation is often difficult, if not impossible. On the local level, municipalities may not have the funding, expertise, or political will to become involved in a regional or state plan.

On many water topics, there are organizational challenges to address. For example, the protection of wetlands involves many state and federal agencies. Some wetland manipulations require federal permits while others do not, and this situation appears to change frequently in the wake of federal court decisions. There are federal and state guidance and executive orders, all of which back the concept of stopping the loss of wetlands. However, there are few formal means to prevent wetland losses when many activities that destroy wetlands are beyond regulation. An understanding of the missions of each agency involved in the discussion, as well as what assistance each can lend, would be useful in solving the larger problem (Madras, 2001).

The state is working with the U.S. Army Corps of Engineers (USACE) districts to unify the approaches to Section 404 permits and their corresponding Section 401 water quality certifications. Similarly, the state is working with parties that frequently obtain certifications so that the requirements of certifications can be accommodated within the design of the projects. A major initiative is to make these requirements known at an early stage of the process so the design can anticipate them (Madras, 2001). Continued state budget constraints exacerbate the difficulties.

Jurisdictional issues also arise in water resources planning and management. Many river basins are interstate and therefore, fall under jurisdiction of the federal government. This is implicit in the United States Constitution, in which the federal government reserves the right to "regulate commerce with foreign nations, and among the several states, and with the Indian tribes." In the early years of our country, commerce was carried out via waterways and navigation was a critical issue. A stream is navigable if it can float a boat that can be involved in commerce. It was also deemed that the defense of our country was dependent in large part on the protection of navigable waters.

The USACE is now involved with issuing wetland permits, granting permits for dredge and fill in navigable waters, flood control, water supply, dam safety, floodplain management, and more recently, environmental protection and restoration. The United States Environmental Protection Agency (USEPA) is charged with the administration of the Clean Water Act (CWA). It is involved in water resource planning, research, and enforcement. In most cases, the USEPA has delegated much authority to the states in regards to water resources protection and management. Recent court rulings may have both clouded and clarified the role of the USACE in determining what wetland areas are and are not within their administrative jurisdiction to regulate under the CWA and other federal laws.

The following description of water use in eastern Missouri is included to provide context for the water use problems identified in this report. The categories used below are the same as those used by the United States Geological Survey (USGS) in the National Water-Use Information Program. In addition, most of the water use data provided in this section was collected through this program.

Public Water Supply

The percentage of publicly supplied water in eastern Missouri allocated to commercial, domestic, and industrial uses are higher than statewide averages. The percentage of water withdrawn for public supply delivered for domestic use in 2000 was approximately 57 percent compared to 50 percent for Missouri statewide (USGS, 2003).

Public water use is often defined as community-wide applications of water, such as firefighting and filling public swimming pools. Public water use also includes transmission losses (water lost from leaking pipes and joints while being delivered to domestic, commercial and industrial users). Approximately 21.7 percent of eastern Missouri's publicly supplied water went to public uses in 2000 compared to 27.7 percent statewide (USGS, 2003).

Similarly, 2000 commercial use of public water supplies was slightly higher in eastern Missouri than for the state overall. Commercial water use is defined by the USGS as "water for motels, hotels, restaurants, office buildings, other commercial facilities, and institutions" (Solley, et. al., 1993). In 2000, approximately 9 percent of eastern Missouri's publicly supplied water was delivered to commercial water users compared to 8 percent statewide (USGS, 2003). Similarly, public water supply deliveries for industrial use in eastern Missouri were low in 2000. Compared to the statewide figure of 14 percent, industrial water users in eastern Missouri accounted for over 24 percent of total public water supply usage (USGS, 2003).

Twenty-eight percent of the population of eastern Missouri receiving water from public water systems is supplied by groundwater wells compared with a state average of 43 percent. In eastern Missouri, 94 percent of citizens are connected to a public water supply compared to 85 percent statewide.

Domestic Water Use

Domestic water use is often defined as "water used for household purposes", such as drinking, cooking, bathing, and washing clothes and dishes. Excluding thermoelectric and hydroelectric power generation, domestic water use is the predominant use of water in eastern Missouri. The National Water-Use Information Program of the United States Geological Survey (USGS) estimated 2000 domestic water use in eastern Missouri at 62.9 billion gallons of water. USGS figures indicate that per capita usage was approximately 86 gallons/day for domestic usage. While 96 percent of eastern Missouri's domestic water requirements are supplied by public water systems, private water supplies serve some of the area's population. Approximately 112,000 people in eastern Missouri withdrew water from private supplies in 2000 (USGS, 2003). USGS data from 2000 indicates that 100 percent of self-supplied domestic water withdrawals came from groundwater sources, although it is likely that a small percentage of users obtained water from surface water sources. In the 1990 U.S. Census of Population and Housing, approximately 2,400 housing units in eastern Missouri reported using "some other source" for water, a catch-all category which the United States Census Bureau (USCB) defines as "water obtained from springs, creeks, rivers, lakes, cisterns, etc."

Industrial and Commercial Water Use

Industrial water use in eastern Missouri is high, and accounts for 24 percent of public water supply deliveries. The USGS estimated 2000 industrial water withdrawals at 2.3 billion gallons throughout the year. Industrial water users across Missouri typically rely on public supplies rather than self-supplied water. In 2000, industrial water users in eastern Missouri received 32.8 billion gallons of water from public water systems, approximately 94 percent of their total water use (USGS, 2003). In 2000, 55 percent of total self-supplied withdrawals for industrial use came from groundwater sources. USGS data indicates varying levels of industrial water use throughout eastern Missouri, with all but one county showing little or no industrial water use at all.

In eastern Missouri, commercial water use is less than industrial water use. Commercial water use in eastern Missouri totaled nearly 12.3 billion gallons in 2000. Commercial water use in eastern Missouri depends mostly on public water supply deliveries supplying approximately 98 percent of the region's commercial water requirements (USGS, 2003).

Agricultural Water Use

Farmers in eastern Missouri withdraw water both to irrigate farmlands and to water their livestock. Groundwater sources account for most of eastern Missouri's agricultural water withdrawals. In 2000, over two-thirds of the 1.8 billion gallons of water withdrawn for agricultural operations in eastern Missouri was taken from the region's aquifers (USGS, 2003).

Irrigation water withdrawal in eastern Missouri surpassed livestock water withdrawals in 2000, exceeding 1 billion gallons of water. Three-fourths of livestock water withdrawals were from surface water sources, consistent with the state as a whole. Livestock production is evenly distributed across eastern Missouri (other than St. Louis City and County having essentially no livestock production), with individual counties withdrawing up to 321 million gallons per year (USGS, 2003). A variety of livestock is raised in eastern Missouri, each of which must have access to water throughout the year. Farmers in eastern Missouri withdrew slightly more than 780 million gallons of water for their livestock in 2000. Irrigation water withdrawals are somewhat spread out in eastern Missouri, with two counties (Jefferson County and St. Louis City) having virtually no irrigation.

Less than 1 percent of irrigation withdrawals in eastern Missouri came from surface water sources in 2000, as compared to the statewide value of 4 percent (USGS, 2003).

Water Use in Power Production

The Major Water Users Database of the Missouri Department of Natural Resources reported total thermoelectric power generation withdrawals in eastern Missouri at approximately 950 billion gallons of water in 2000 (Missouri Department of Natural Resources, 2001). Withdrawals for thermoelectric power generation are used primarily for power plant cooling and come mainly from surface water sources. Although thermoelectric power generation requires vast amounts of water, very little of it is actually consumed. Statewide, more than 99 percent of all thermoelectric power withdrawals were returned to their source waters. In eastern Missouri, five facilities (Ashley Plant, St. Louis City; Labadie Plant, Franklin Co.; Meramec Plant, St. Louis Co.; Rush Island Plant, Jefferson Co; and Sioux Plant, St. Charles Co.) account for the region's thermoelectric power generation. All of the plants get their water from the Mississippi River, except Labadie, which uses Missouri River water. There are no hydroelectric power plants in the region.

Other Instream Flow Uses

Fish and other aquatic organisms in eastern Missouri's lakes and streams depend upon flowing water for survival and aquatic habitat preservation. Many municipalities in eastern Missouri rely upon flowing water to safely release wastewater back into the environment.

Swimming areas and boat launches found on nearly every body of water within the region accommodate recreational activities throughout much of the year. Although no water is withdrawn, each of these is a "use" of water as well. Collectively, these are often referred to as "instream" uses.

Eastern Missouri has many opportunities for water-based recreation. There are showboats, floating restaurants, excursion steamboats, and gambling boats based in St. Charles and St. Louis. In addition, there are marinas on the two big rivers, the Missouri and the Mississippi. There are several state parks, such as Castlewood, Confluence Point, Cuivre River, and Meramec that are connected to local rivers. Canoeing and boating is a favorite pastime on some of the rivers and lakes of the region.

Preservation of aquatic wildlife and habitat is another important "instream" use of water. Numerous conservation areas maintained by the Missouri Department of Conservation are located in eastern Missouri. Although some upland drainages may become dry during drought conditions, many rivers and streams in eastern Missouri have permanent streamflow that supports fish and wildlife throughout the year, particularly the large rivers. Fishing in these streams is another flow-dependent use.

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Water Use Problems

Drinking Water Use

The City of St. Louis Lacks Residential Water Metering

Problem:

Lack of water metering can result in water wastage. Non-metered water service can also skew the true cost to produce and the price charged for drinking water.

Discussion:

The City of St. Louis is relatively "water rich" with the Missouri and Mississippi rivers being the sources for the city's drinking water. The city's two water treatment plants, Howard Bend Facility located on the Missouri River, and Chain of Rocks Plant on the Mississippi River, process an average of 150 million gallons a day. Together, they have a combined capacity of 686 million gallons per day; 450 million gallons at the Chain of Rocks Plant and 236 million gallons at the Howard Bend Facility. The city's public water supply system was created in 1831, the City of St. Louis becoming the owner in 1835. The Chain of Rocks Plant began operating in 1894, and the Howard Bend Facility in 1929 (City of St. Louis, 2003).

Individual residential water meters were extremely uncommon 172 years ago, which partly explains why the City of St. Louis, with its long history of public water supply, does not have universal residential metering. A second explanation is that water is normally not a commodity in short supply in St. Louis, hence historically, conservation has not been a major driving factor. The cost for the city to produce and the price paid by consumers for drinking water is very reasonable, this being a third factor. A fourth factor is that water meters are an additional piece of equipment that, while not absolutely necessary for water service delivery, adds an additional cost to the final price of water delivered to the home.

Water meters are an excellent way to encourage water conservation. Water meters increase the knowledge and control that individual residents have over their personal water usage and their water bill. Typically, metered customers use water more carefully since they pay for what they use. It calls attention to things like leaking fixtures. Problems are usually fixed quickly, especially if you have to pay for the wasted water. Lawn and garden watering is scrutinized more carefully, again monetary savings being the driving factor. A side benefit of decreased lawn and garden watering is less potential surface water pollution from runoff. Excessive lawn and garden watering can wash fertilizers and insecticides into stormwater drains, causing aquatic and downstream pollution problems. Meters are also a useful tool for the city for determining present water consumption, quantities lost in transmission, and future growth and consumption planning, however, the economic costs of installing meters can be fairly substantial. The question then centers on whether or not the economic benefits, which are primarily savings in long term expansion costs, outweigh the initial capital costs of installing meters.

Wastewater management is also a factor. Less water coming out of the tap means less water going down the drain, therefore, less quantities of wastewater that must be treated at the wastewater treatment plants. Less electricity is used in both wastewater and drinking water treatment because less water is being managed at both ends. With a decrease in the demand for drinking water there is a proportional decrease in the quantity of filters and chemicals used to produce it, which can lead to lower production costs. All these conservation factors, prompted by metered water conservation, can lead to a more secure supply during times of severe drought and an economic savings for both the consumer and the city, especially during times of economic downturns.

Sources:

City of St. Louis, February 3, 2003, Water Department web pages on: ***History, Customer Service,*** and ***Water Quality***; www.stlwater.com

Water Wastage

Problem:

Water is a precious natural resource with many uses, however, humans often waste it in many ways, which can lead to a wide range of problems.

Discussion:

Water is essential to life. We often think it is unlimited, in part because we pay so little for drinking water, which can lead to our wasting it. This waste takes on many forms: overwatering of lawns (as evidenced by water flowing off of lawns into the street), use of high volume flush toilets, etc. It can also be considered wasting when high quality water is used when that of lower quality could be used in its place (such as for irrigation, flushing toilets, etc.). Water wastage becomes a problem felt most strongly during times of drought, but there are also other times when it is felt (i.e. the gradual growth of per capita use, combined with an increasing population, can exceed the supply in a region).

During times of drought, the need for water is felt more strongly. In part, this is because there is less of it and people are encouraged to conserve water so that a supply will last longer for everybody. The need for water is often exacerbated because precipitation rates are lower during the time of year (late summer) when people want their lawns and gardens to grow, which requires more watering. Heat plus lack of precipitation often makes people crave water more (for swimming, drinking, etc.).

Water supplies can be taxed even during times of abundant rainfall. Water use increases for two reasons: 1) increasing population (more people using water means more water is used), and 2) per capita consumption tends to increase over time (USGS, 2002). This can be a rather insidious phenomenon as it happens gradually over years or perhaps decades (in contrast to a drought scenario, the effects of which may appear more rapidly, and are clear to see). It may appear that there is abundant water if there has been abundant precipitation, which may make it seem less important to conserve water. Developing more water supplies is often expensive, and the amount of water available from a new reservoir is often significantly more expensive than the amount of water saved via conservation practices (Gleick, 2000).

As water supplies become stressed, many problems can occur. If a source runs out, it may need to be replaced, usually at a very high cost. If the source is from a reservoir, the quality may go down dramatically as the reservoir falls. This is due to water at the bottom often being turbid (muddy). If the source is from wells, the groundwater table may drop, which can make wells go dry, produce less water, or require the wells to be redeveloped. If the supply is from a stream, creatures can have problems (i.e. low dissolved oxygen, habitat loss, etc.) because they are considered less important than using water for drinking and other uses when humans choose how to allocate water.

Wastage of water adversely affects energy and economics: it takes energy (pumping, treating, etc.), which costs money and natural resources, to get the water to a consumer. Thus, when water is wasted energy and money are also wasted.

Wastage of water can take on many forms. North Americans use many appliances that consume more water than the same appliance doing the same job in other parts of the world. For example, an average European washing machine and dishwasher use considerably less water and energy than ours do. One of the biggest uses of water in the average home is the flush toilet. Many of the older models of toilet use much more water than necessary; in some places (i.e. Australia), toilets have the option for a full flush or ½ flush. Some of water wastage is nothing more than habit. Leaks and drips are another surprising waste of water: what may seem like a slow drip can add up to 10,000 gallons a year.

The way people landscape around buildings affects the amount of water they use. Pretty green lawns require much more water than xeriscaped lawns or lawns that employ good rainwater capture/use, such as rain gardens.

High quality groundwater can be found in about two-thirds of the eastern Missouri region, however there are some areas with naturally occurring high-salinity groundwater unsuitable for use as drinking water (see figure 10, freshwater-saline groundwater transition zone). The high quality groundwater is an excellent source of drinking water but it does need treatment for human consumption. There are many uses where water of lower quality could replace high quality groundwater. For example, greywater (household wastewater not coming from a toilet) can be used as irrigation or for flushing toilets (see Chapter 6). This is similar to water reuse (a.k.a. water reclamation), which uses treated wastewater for certain applications. Thermoelectric plants use large volumes of water, and some of them are considered "single-pass" (which means that fresh water is used once before being released into the environment). This water could easily be reused for many purposes other than drinking.

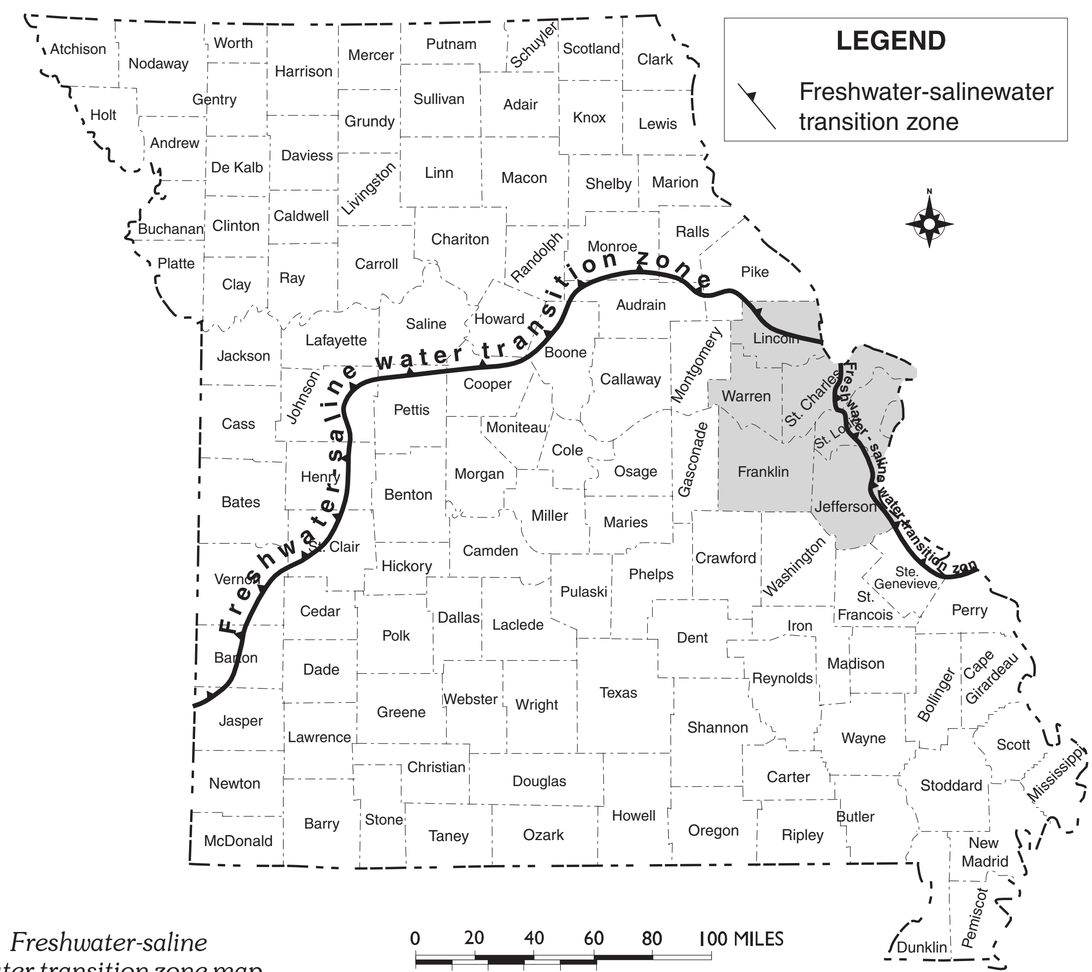

Figure 10. Freshwater-saline groundwater transition zone map.

Sources:

Gleick, P. H., 2000, ***The Changing Water Paradigm: A Look at Twenty-first Century Water Resources Development***, *Water International*, Vol. 25, Number 1, pp.127-138, March, 2000.

United States Geological Survey (USGS), 2002, www.water.usgs.gov/watuse

Aging Infrastructure of Public Water Supply Systems

Problem:

The basic equipment, structures and installations public water suppliers use to provide services can become less efficient or break with age and become undersized with increasing demand. It is difficult for many communities to find the money to adequately update their systems. Since much of the population of eastern Missouri is served by public water supplies, this problem is especially relevant.

Discussion:

The National Water Use Information Program of the USGS estimated in 2000 that 95 percent of the population of eastern Missouri was served by public water supplies. The ages of municipal water supply systems and public water supply districts in eastern Missouri range between 8 and 172 years. Forty-four percent of them are between 31 and 50 years old, and 18 percent of them are 51 years old or more.

The problems caused by aging water supply infrastructures are many. Aging water lines that are made of materials inferior to those allowed by current technology become fractured and begin to leak. Leakage, also called "transmission loss," reduces system efficiency and can have a negative impact on the system's revenue generation. This, in turn, may make it more difficult for the water supply system to finance much needed improvements in the future. A more common problem is rupture of these old water lines, which means that customers are without water until it is fixed, and there can be significant disturbance above-ground since workers have to tear up the surface (often a road) to get to the pipes (Ryser, 2001).

Aging water supply infrastructures may also impact water quality. Outward leaking pipes can also leak inward if there is a sudden loss of pressure, allowing the system to become contaminated. In addition, some very old service connections may have lead joints, which may leach lead into drinking water. In the human body, accumulations of lead as well as prolonged exposure to even very small amounts of lead can result in serious health effects. Older systems may also have "dead-end" lines in which water may become stagnant and undrinkable. Some rural water districts laid water lines with an older form of PVC piping, which now leaches vinyl chloride (a known human carcinogen) into the water when it is at a dead end for a while (Timmons, 2001).

Quite often, lines and facilities that were adequate when they were first constructed, are undersized when it comes to present service requirements. With age, systems may no longer be able to convey the amount of water that system users need. Present household, industrial and public uses, such as firefighting, may be limited. Without viable alternatives, future development may also be restricted as potential users are discouraged from locating their facilities in a service region unable to support their needs for water.

Sources:

Ryser, E., Manager of Systems Engineering Division, Kansas City Water Department. Personal communication, February 2001.

Timmons, T., Missouri Department of Natural Resources, Water Protection and Soil Conservation Division, Public Drinking Water Program. Personal communication, February 2001.

MTBE Contamination of Wells

Problem:

Methyl Tertiary Butyl Ether (MTBE) has been found in trace amounts in several wells in the Eastern Missouri region. Other contaminants also have been detected, including benzene.

Discussion:

Reformulated gasoline is required in the City of St. Louis, Franklin, Jefferson, St. Charles, and St. Louis Counties, in order to help the area's air quality "non-attainment" status. MTBE is sometimes added to reformulated gasoline to help it burn more cleanly and completely. The compound is added to conventional gasoline to reduce engine knocking. MTBE has been used as a gasoline additive since 1979. The USEPA has placed MTBE on its Drinking Water Contaminant Candidate List (CCL) for additional research and possible regulation (USEPA, 2004). The department monitors all community and non-transient non-community public water supplies for MTBE contamination. Seven private wells and one public drinking water well in the region have been found to have trace amounts of MTBE, as of June 2001.

Regular gasoline may contain up to 15 percent by volume of MTBE. Higher percentages are typically found in premium grades and reformulated gasoline. MTBE can enter water supplies through gasoline spills, storage tank leaks, or discharges from two-cycle engines. MTBE also can enter the atmosphere from airborne emissions from vehicles. It can travel through groundwater faster than other components of gasoline, and its chemical composition does not readily degrade.

Public water supply systems are routinely tested for MTBE contamination. Private wells are rarely tested. MTBE has a turpentine-like odor and unpleasant taste, both of which are detectable at quantities less than that considered harmful. MTBE use has been reduced significantly recently, with plans in progress to further curtail its use. Benzene, a component of all gasoline, is a more serious health risk than MTBE. It is a known cancer-causing agent at levels much lower than the likely exposure to MTBE.

Source:

Missouri Department of Natural Resources, on-line at www.dnr.state.mo.us/mtbe/cntwlmap.htm and www.dnr.state.mo.us/mtbe/homemtbe.htm

United States Environmental Protection Agency (USEPA), 2004, on-line at www.epa.gov/safewater/ccl/cclfs.html and www.epa.gov/safewater/ccl/cclfs.html#table1 and www.epa.gov/safewater/mtbe.html

Alluvial Groundwater Pollution in St. Charles County

Problem:

The alluvial groundwater in parts of St. Charles County has petroleum contamination. Due to the characteristics of the alluvial deposits, other types of contamination may make it into the shallow groundwater or contamination already in the groundwater may come to the surface during a flood and pollute the surface water.

Discussion:

People living on the floodplain between the Mississippi and Missouri rivers near West Alton, Missouri have historically used the shallow alluvial groundwater. In fact, the water table can be within several meters of the surface, and the supply is quite abundant. However, this proximity to the surface means that there is less filtration of the water as it seeps through the soil and unconsolidated sands and gravel of the river's alluvium, thereby creating the potential for easy pollution.

In the vicinity of West Alton, St. Charles County, there is an underground petroleum pipeline system that was reported to have a leak in the late 60s or early 70s. During the summer of 2002, a citizen noticed a petroleum-based odor. This was reported to the department and investigated. Preliminary results showed high concentration of contamination in certain soil horizons. Some of the water wells that were sampled also contained Methyl Tertiary Butyl Ether (MTBE) and benzene, which are typically associated with petroleum products. Further testing in the pipeline trench detected extensive contamination. Four inches of petroleum was found in one temporary monitoring well and 30 inches in another.

The company responsible for the pipeline has been cooperative and is cleaning up the leak. Although the responsible party is willing to supply bottled water to the local citizens effected by the petroleum contamination, some of the surrounding citizens (not immediately effected) want to retain their own water supplies. West Alton's residents have their own private water supply and private sewage treatment system (septic tanks). These water wells are "sand point" wells. They are easy to construct because the unconsolidated material is sand and gravel alluvial deposits and the water table is close to the surface. All that is needed to get water is to pound or push a 2-inch pipe, with a drive point on the bottom, into the ground to a certain depth. A screened interval just above the drive point lets in the water and it is pumped to the surface. Although, this type of well may produce adequate water quantity for private use purposes, it does not provide any protection from surface-derived contamination, and therefore, any future potential contamination events (pipeline leaks, tanker truck accidents, septic tank effluent, etc.) have a high probability of causing a pollution problem similar to the one currently being addressed.

In addition, since this area is in the flood plain between two large rivers, when floods occur, septic tank effluent and petroleum products that are lighter than water and have filtered into the ground, will be forced to the surface due to rise of the groundwater table. Increased development of this area will only increase the potential of future pollution incidents effecting citizens. It is important to note that the location of the sand point water well be up hill and, as far away from the land owner's septic tank and field as the property will allow. It is also important to be aware of the neighbor's septic field. Contamination of a private water well from a nearby septic tank is all too possible.

Sources:

Missouri Department of Natural Resources, 2002, ***Department Hosts Public Availability Session and Meeting on Sept. 25 for West Alton***, News Release No. 095, September 16, 2002.

Freshwater-Salinewater Interface near St. Louis, Missouri

Problem:

The groundwater in the Eastern Missouri Region is not potable in certain areas due to naturally occurring high salinity.

Discussion:

Groundwater is water beneath the earth's surface within a zone of saturation.

Water supplies in the St. Louis area are available from surface sources such as streams and rivers, and underground sources such as bedrock and alluvial (unconsolidated materials deposited by streams and rivers such as sand and gravel) aquifers that underlie the region. Aquifers are layers of rock and other geologic materials capable of transmitting and storing usable quantities of water. The bedrock aquifers in this region are primarily comprised of dolomite and limestone.

The principal factors affecting groundwater quality in the area involve the complex interrelations imposed by the lithology (type of rock) of the rock units; the permeability of the rock units; the controls on water movement exerted by the geologic structure; the length of time water has been in the aquifer and the distance it has moved from the recharge area; and the degree of flushing of entrapped saline water (connate water) from the rock units. Connate water is the ancient water that was included within the sediments as they were being deposited. These sediments later became the rocks (dolomite and limestone) that underlie this region today.

The quality of groundwater in the area varies greatly, ranging from 122 mg/l dissolved solids to 17,500 mg/l dissolved solids. As a general rule, 500 mg/l dissolved solids is the upper limit for a public water supply. For comparison purposes, seawater on average has 34,000 mg/l dissolved solids.

Water from the alluvial deposits generally is a very hard calcium-magnesium-bicarbonate type with iron and manganese content commonly high. Saline water has moved upward from the underlying bedrock into the alluvial aquifers at Valley Park and Times Beach (now Route 66 State Park) in the Meramec River valley and in the Mississippi River valley north of St. Peters. This upward leakage may be a natural occurrence, but part of it is probably through boreholes of improperly constructed old wells or the casing has deteriorated in these old wells. Improperly abandoned deep wells could also be contributing to this problem. Where head pressure differences permit, some water is undoubtedly moving from the shallow aquifers into deeper ones through these wells (Miller *et al.*, 1974).

The usability of the groundwater contained in bedrock is related to its geographic location and depth beneath the land's surface. The water contained in all bedrock aquifers in the Northeast part of the region is non-potable. Proceeding to the southwest, across the region, the top of the non-potable groundwater aquifer becomes deeper, with a potable groundwater zone lying above the non-potable aquifer. The exception is the area around Eureka, which has non-potable groundwater in all bedrock aquifers. The reason for this natural occurrence is under study and may be related to the geologic structure and type of rock underlying that area.

Sources:

Miller, Don, et.al., 1974, Water Resources Report Number 30, ***Water Resources of the St. Louis Area***, Missouri Geological Survey and Water Resources, 114 p.

Miller, Don, and Vandike, James E., 1997, Water Resources Report Number 46, ***Groundwater Resources of Missouri***, Missouri State Water Plan Series Volume II, Missouri Department of Natural Resources, Division of Geology and Land Survey, 210 p.

Missouri Department of Natural Resources, 2002, Water Resources Report Number 60, ***Topics In Water Use: Central Missouri***, Missouri Department of Natural Resources, Geological Survey and Resource Assessment Division, 60 p.

Recreational Water Use

Designated Uses of Water Bodies

Problem:

Most of the rivers and streams in the Mississippi River Basin fail to fully support all of their "designated uses" due primarily to health and safety concerns, and contaminated runoff.

Discussion:

The Mississippi River is one of the world's major river systems in size, habitat diversity, and biological productivity. It is the largest and second longest river in North America, flowing 3,705 kilometers from its source at Lake Itasca in the Minnesota North Woods, through the midcontinental United States, the Gulf of Mexico Coastal Plain, and its subtropical Louisiana Delta. Commercially, the Mississippi is one of the world's most important and intensively regulated rivers; the term 'regulated' applies to rivers that are impounded and leveed. The river is navigable by ocean vessels upstream as far as Baton Rouge, Louisiana, and by commercial craft with a 9-foot (2.7-meters) draft as far as Minneapolis (USGS, 2003).

"Designated uses" are water body uses as determined by the state agency that administers the Clean Water Act. Every water body in the state must have at least one designated use, per the USEPA, based on water quality standards. The Missouri Clean Water Commission (CWC) designated both the Missouri and the Mississippi rivers with the following beneficial uses of water: irrigation, livestock and wildlife watering, protection of warm water aquatic life and human health-fish consumption, boating and canoeing, drinking water supply, industrial process water and industrial cooling water. In addition, part of the Mississippi River was designated for whole body contact (Clean Water Commission, 2003).

There has been a significant increase in recreational boating and angling activity on the Lower Missouri and Mississippi rivers. This is due in part to increased awareness of the possibilities due to new boat ramps and publicity stemming from commemoration of the Lewis and Clark Expedition. Boaters frequently gather on the natural sandbars and islands that form along the rivers. Above the Melvin Price Lock and Dam, at Pool 26, there are marinas at Alton, Ill., and Portage des Sioux, Mo. Many recreational uses occur in this area. The Missouri River is too swift for swimming, however, some small craft can be used here and Washington, Missouri has a marina. Recreational craft on the lower Missouri River range in size from kayaks to large speedboats (MSWP IATF, 2003). There could be problems because there is not currently (2003) the capacity to absorb the increased tourism. The Meramec River is a favored canoeing river.

Sources:

Clean Water Commission, 2003, available at www.sos.mo.gov/adrules/csr/current/10csr/10c20-7b.pdf

Missouri State Water Plan, Inter Agency Task Force (MSWP IATF), public meeting 24 Sept. 2003.

United States Geological Survey (USGS), 2003, available at www.biology.usgs.gov/s+t/SNT/noframe/ms137.htm

Bilge Water and Barge Cleaning Operations Can Pollute Waterways

Problem:

Release of bilge or ballast water and the improper cleaning and maintenance of barges and tows can cause pollutants to enter Missouri's waterways. This can have a detrimental impact on human health and the environment and is also contrary to the terms of the Clean Water Act, Missouri Water Quality Standards, and other environmental and water laws.

Discussion:

In 1997, a St. Louis-based shipyard and four of its employees pled guilty to pumping bilge water and dumping petroleum wastes into the Meramec River. The USEPA and Missouri Department of Natural Resources jointly investigated the case (USEPA, 2003).

St. Louis is a major inland port and waterborne navigation center for the Mississippi and Missouri rivers. The Port of St. Louis handles approximately 33 million tons of commodities annually. It is the largest port in the region, the second busiest inland port in the country, and the 23rd largest overall in the nation based on tonnage. Around eighty percent of the cargo handled includes petroleum, chemicals, grain and coal. U.S. Army, Corps of Engineers, records indicate that over 4.3 million tons of petroleum and petroleum products, and over 1.2 million tons of chemicals and related products were handled at the Port of St. Louis in the year 2000. These figures do not include tonnage that just moved through the port in transit to other destinations (USACE, 2003). The Port of St. Louis has over 130 piers, wharves and docks and more than 50 fleeting areas, including special areas for services that include barge cleaning and vessel repair. Looking only at these numbers, one quickly realizes that there is substantial potential for a contaminant release in the St. Louis area that is related to commercial navigation.

The bilge is the lowest internal part of the outer hull of a vessel. Bilge water is water and other fluids that seep or leak into the bilge, collecting there, and becoming stagnant, dirty and contaminated. There is no intention on the part of the vessel operator to increase the volume of bilge water, but rather to prevent the bilge water from escaping the ship and entering the environment. Bilge water is significantly different than ballast water. Ballast water is water that is intentionally pumped into and out of specially designed holding tanks on a vessel to improve its stability and control its draft. Ballast water, typically taken directly from the waterbody that the vessel is floating in at the time, can ultimately be transported hundreds, or even thousands of miles to a new location before being released into a different environment.

Contaminated bilge and ballast water and, improper barge and tow cleaning can cause bio liquids and solids, petroleum, chemicals, trash, and exotic species to be released into waterways. Substances that are categorized as corrosive, flammable, reactive or toxic are classified as hazardous wastes under federal laws. A release can be intentional and occur when a substance is knowingly released directly into the waterway. It can result from unintentional mishandling, when it is not properly managed and contained during cleaning process, or as runoff from inadequately protected and maintained cleaning sites. Contamination from mishandling can occur when bilge water that is evacuated from the ship to shore is not placed in proper containment. Contamination can be short-term acute point source or long-term chronic nonpoint source and it can flow either directly into the waterway or as accumulated leachate from a shore area.

Overseen by the U.S. Environmental Protection Agency and the Missouri Department of Natural Resources, Section 312 of the federal Clean Water Act (CWA) helps protect human health and the aquatic environment from hazardous compounds and disease-causing microorganisms that can be present in discharges from vessels. The CWA provides for laws, regulations, monitoring, enforcement and penalties that are incentives to keep people from polluting and penalizes them when they do. The discharge of constituents from vessels can introduce, into waterways, disease-causing pathogens that pose a public health concern. It can also adversely affect the recreational use of those waterbodies. The discharge of chemical compounds such as oil and gasoline in bilge water, as well as the by-products from their decomposition, can poison plants, fish and wildlife. The discharge of foreign ballast water can also introduce hazardous substances and harmful exotic species into native waters (USEPA, 2003). It is surmised that at least two exotic species, the zebra mussel and the round goby, were transported to this country in ballast water, and released into the environment when the water was pumped out of the ship.

In addition to the CWA, other federal and state laws and regulations protect waterways by establishing a comprehensive framework for environmental protection. These laws include: the National Environmental Policy Act (NEPA), the Oil Pollution Act (OPA), the Federal Water Pollution Control Act (FWPCA), the Pollution Prevention Act (PPA), the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Toxic Substance Control Act (TSCA), the Federal Facility Compliance Act (FFCA), and the Revised Statutes of Missouri Chapters 260, 319 and 644.

Developed jointly by the USEPA and the U.S. Department of Defense (USDOD), Section 325 of the 1996 National Defense Authorization Act – Uniform National Discharge Standards (UNDS) addresses liquid discharges from Armed Forces vessels. From time to time, military vessels discharge toxic or hazardous substances. The UNDS helps to ensure that when discharges occur, it is in a manner that is as environmentally benign as possible.

The U.S. Coast Guard (USCG), in addition to USEPA, USACE, USDOD and the department monitor vessels and enforce regulations for vessels transporting oil, noxious liquids, garbage, waste and ballast water on our nation's navigable waters. The USCG's main area of emphasis is in making sure that these substances are transported properly, and that each commercial vessel transporting these substances has an approved vessel response plan (VRP) should a mishap or spill occur.

Sources:

United States Army, Corps of Engineers (USACE), ***Waterborne Commerce of the United States, part 2***, www.iwr.usace.army.mil/ndc/wcsc/pdf/wcusmvgc00.pdf, January 30, 2003.

United States Coast Guard, www.uscg.mil/d14/units/msohono/references/cfrs/sub%20o/part%20159.htm, and www.uscg.mil/vrp/faq/planreq.shtml, January 30, 2003.

United States Environmental Protection Agency (USEPA): Headquarters; Office of Water; and Office of Wetlands, Oceans, and Watersheds, www.epa.gov/owow/oceans/lets_help/foghorn.html#Debris, and yosemite.epa.gov/opa/admpress.nsf/b1ab9f485b098972852562e7004dc686/c042dad347b5c47a852564d10070006f?OpenDocument, January 30, 2003.

Industrial Water Use

Missouri River

Problem:

Competition with interstate interests for Missouri River water may reduce Missouri's future beneficial uses of the Missouri River.

Background:

The Missouri River main stem reservoir system (System) is the largest in the United States. The storage capacity of the Missouri River main stem reservoirs is over 73 million acre-feet (MAF) (USACE, 1979). In contrast, Harry S Truman Reservoir has a capacity of approximately 5 MAF (USACE, 1981). The System was designed to provide flood control, water supply, power generation, navigation, water quality, recreation, and fish and wildlife enhancements. The System is managed and operated by the U.S. Army Corps of Engineers. Water released from the lowest Missouri River reservoir, at Gavins Point Dam, accounts for a significant proportion of the river's water flowing to its confluence with the Mississippi River.

Missouri River water is used by Missourians in several ways. Intakes in the river draw water for both public drinking water supplies and for cooling use in power plants. In addition, barges navigate the river, moving agricultural commodities, such as grain and fertilizer, and construction materials, such as asphalt, and cement, up and down the river. Water provides habitat for fish and wildlife, and for river-based recreation. Water from the Missouri River also benefits Missourians as it continues down the Mississippi River by supporting instream flow, Mississippi River navigation, and a myriad of uses.

Since the System was completed in the early 1960s, the reservoirs have remained at relatively constant levels, refilled by runoff from the annual mountain snowmelt. In the late 1980s, the System experienced its first substantial drought that lasted for 5 years. In 1988, the first year of the drought, runoff was only about one half of normal. When this occurred, upstream states saw reservoir levels begin to decline into the large carryover multiple use pool (storage designed to provide water for downstream use during prolonged drought). They became extremely concerned about possible impacts to a reservoir recreation industry that had developed and the stocked, cold-water fish that drives that industry. To address these concerns, the USACE entered into a revision process of the Master Water Control Manual (Master Manual), the document that provides the rules for operation of the System. Changing Missouri River reservoir operations for endangered species is also part of the Missouri River Master Manual revision process.

After 14 years, the USACE is likely nearing the end of their review and update of the Missouri River Master Manual. Almost every plan studied by the USACE provides less usable water to the state of Missouri. A Preferred Plan will likely be selected by the USACE in the near future.

Another related issue is water depletion and out-of-basin diversion or transfer of water. The upper Missouri River basin lies in the western

United States where water demand often outpaces water availability and it is treated as a commodity that is bought and sold. Water depletion is water that is consumed or lost due to some activity and is no longer available for use (figure 11). Currently, the U.S. Bureau of Reclamation estimates that there are approximately 13.7 Million acre-feet of depletions occurring annually within the basin. This amounts to approximately 22 percent of the annual average volume that flows past Hermann, Missouri (1958-2002). Out-of-basin transfer of water physically removes water from the basin where it originated for use in a different river basin. For example, in North Dakota the Garrison Diversion Project will transfer water from the Missouri River basin into the Red River of the North that drains into Canada's Hudson Bay. This project has massive pumps capable of pumping approximately 1 million acre-feet of water per year (enough water to supply a city of approximately 2 million people) from the USACE lake behind Garrison Dam (Garrison Diversion, 2000). Tribal water rights could influence future water availability in the Missouri River. The Mni Sose Intertribal Water Rights Coalition, an organization representing many of the basins 28 Tribes on water issues, have estimated tribal water rights at over 21 MAF, of which approximately 11 MAF could be depleted (presented in a draft document submitted to the Missouri River Basin Association). Out-of-basin diversions and depletions mean less water flowing downstream, thereby decreasing the amount available for use by Missouri.

Although the USACE's decision will likely be made in the near future, water management of the Missouri River main stem system and upstream out-of-basin transfers of water will continue to be a potential problem and important issue for Missouri.

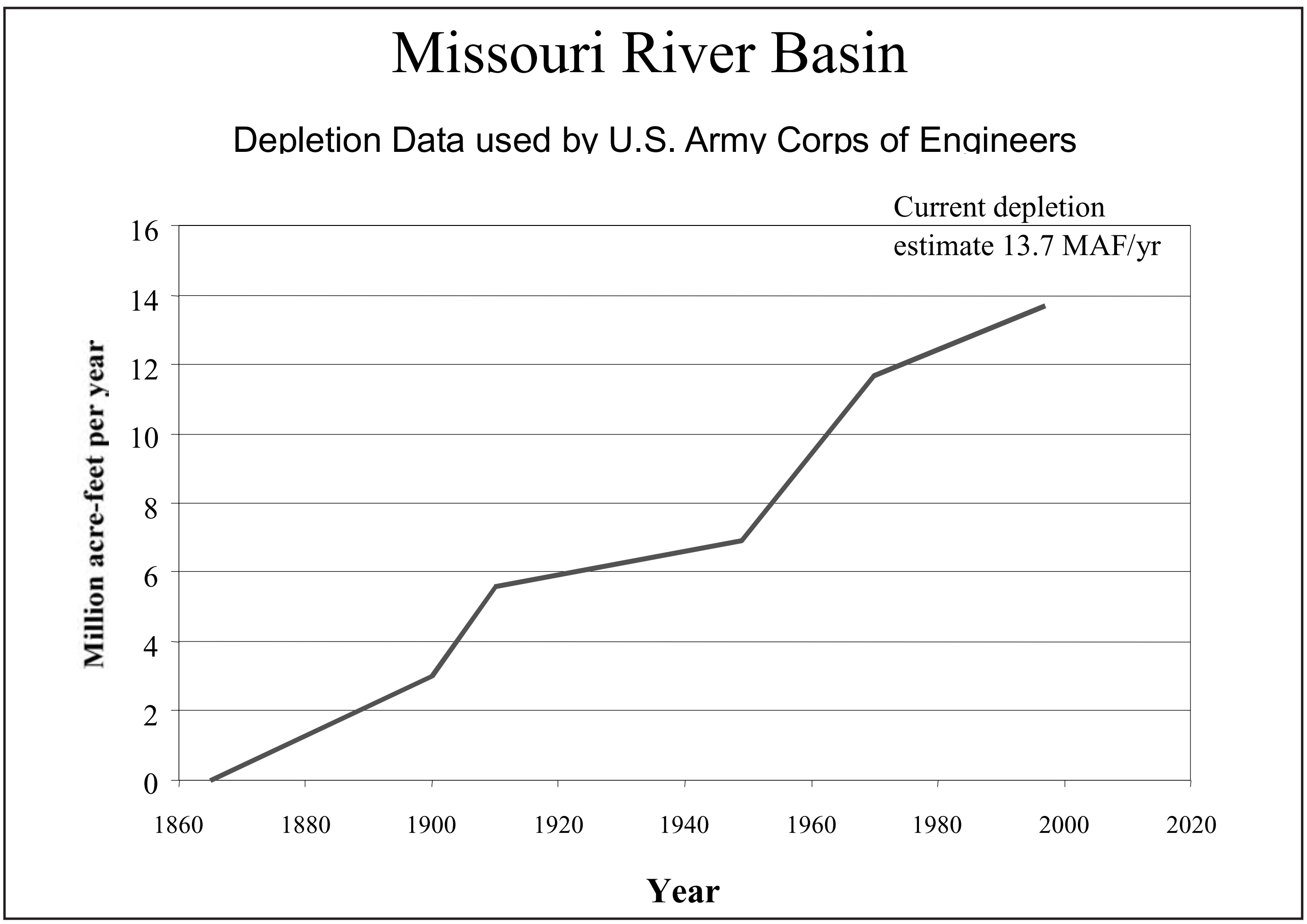

Figure 11. Depletions of Missouri River water.

Sources:

Garrison Diversion, 2000, website: www.garrisondiv.org/complete.htm

United States Army Corps of Engineers, (USACE), 1979, ***Missouri River Main Stem Reservoir System Reservoir Regulation Manual –Master Manual***, Omaha, Nebraska.

United States Army Corps of Engineers, (USACE), 1981, ***Lake Regulation Manual – Harry S. Truman Reservoir***, Kansas City, Missouri.

United States Army Corps of Engineers, (USACE), 2001, ***Revised Draft Environmental Impact Statement: Master Water Control Manual-Missouri River***, Omaha, Nebraska.

United States Army Corps of Engineers, (USACE), 2003, ***Missouri River Mainstem System 2002-2003 Annual Operating Plan***, Omaha, Nebraska.

Environmental Water Use

Combined Sewer Systems

Problem:

The St. Louis Metropolitan Sewer District (MSD) mixes sanitary sewage and stormwater runoff in combined sewer systems (CSSs). During heavy rains, the large volume of runoff overwhelms the system, and flushes untreated sewage into surface waters, thereby polluting those waters. The economic costs to rehabilitate sewer systems are large. In addition, CSSs increase operational costs for wastewater treatment facilities (WWTF).

Discussion:

Before clean water regulations, municipalities sometimes sent untreated sewage directly into receiving bodies of water. Thus, it was convenient to design systems that combined the sanitary sewage and the stormwater runoff (known as a combined sewer system, CSS) since they were directed to the same place. Passage of the Clean Water Act (CWA) mandated that all sanitary sewage be treated before being released into the environment, and that stopped construction of CSSs.

Since passage of the CWA, all of the flows in a CSS have been redirected to a WWTF for treatment. This extra volume of water causes higher treatment plant operational costs than if the stormwater did not come to the facility. This is especially true considering that the first part of stormwater runoff has a lot of extra pollutants carried with it, such as litter, waste oil, lawn fertilizer, etc. When there is excessive flow caused by a rainstorm or snowmelt (sometimes there is over 10 times the amount of water flowing in the system due to a storm than during normal flows), it can exceed the capacity of the treatment facility and/or the CSS. This excess flow is then directed to surface waters without treatment, (termed a combined sewer overflow, CSO). This overflow of untreated sanitary sewage is a pollution discharge (violating the CWA), and can cause health and environmental problems.

Municipalities are in the process of implementing a CSO Control Plan initiated by USEPA. They must characterize their CSOs (i.e. frequency, flow, pollution levels, etc.) and start using minimum technology-based controls to minimize the impact of these on the environment. Finally, they must develop a long-term control plan (LTCP) which should ensure that all their discharges comply with the CWA. There are three basic LTCP abatement options: eliminate the overflow by separating stormwater and sanitary sewage, provide treatment of the overflow, or maintain and monitor the overflow to ensure that what comes out is sufficiently diluted as to not pollute significantly (USEPA, 2001). The latter could eventually become a problem as minimum contaminant levels are lowered; thus, what was once acceptable may no longer be so.

The only known CSOs that exist in eastern Missouri are in the St. Louis Metropolitan region. St. Louis has approximately 208 they know of, and are still finding ones they didn't know about. Their main effort has been focused on keeping the system free of blockages through regular inspections, and installing equipment that properly directs the flow. A big obstacle to this is finding the money for the abatement measures. For example, the city of Cape Girardeau spent $23 million and 5 years rehabilitating their CSOs (Cook, 2001), and that system was but a fraction the size of the St. Louis system. There is also the question of the outfalls that they don't know about, and it has been difficult to locate them all.

Sources:

Cook, Steve, Environmental Services Coordinator, City of Cape Girardeau. Personal communication, May 2001.

United States Environmental Protection Agency (USEPA) / CSO homepage, 2001: www.epa.gov/owm/cso/htm

Section 303(d) List and TMDL's

Problem:

Within the region are a number of streams and lakes that have been identified as polluted as a direct result of human activities. The pollutants include lead, ammonia, chlordane, zinc, nonvolatile suspended solids, and excessive sediment. Two rivers are also listed due to habitat loss, which is considered as a "condition" by USEPA and the department. These pollutants and conditions affect the usability of the water, adversely impact aquatic life, and can be costly to clean up.

Discussion:

The Clean Water Act (CWA) is the cornerstone of surface water quality protection in the United States. While the CWA does not deal directly with groundwater nor with water quantity issues, it does employ a variety of regulatory and non-regulatory tools to sharply reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters. Initially, states' enforcement of the CWA focused mainly on the chemical aspects of the "integrity" goal. However, during the last decade, more effort has been given to physical and biological integrity. In the early decades of the Act's implementation, efforts were also focused on regulating discharges from traditional "point source" facilities, such as municipal sewage treatment plants and industrial facilities, with less effort given to non-point sources (runoff from streets, construction sites, farms, and other "wet-weather" sources) (USEPA, 2003).

Starting in the late 1980s, efforts to address polluted runoff have increased significantly, primarily through voluntary programs, including cost sharing with landowners who must manage runoff. There has been a shift from a pollutant-by-pollutant and source-by-source approach to holistic watershed-based strategies (USEPA, 2003).

The Section 303(d) List, mandated as part of the federal Clean Water Act, is a compilation of waterbodies that do not meet Missouri's water quality standards. The Missouri Section 303(d) List identifies the stream, river or lake, the county, the number of miles or acres impacted, the specific pollutant(s) or condition(s), the source of the pollutants, priority, and remediation schedule. TMDL's (total maximum daily loads) is the measure of the amount of a specific pollutant that a waterbody can assimilate and still meet minimum water quality standards. The TMDL program and Section 303(d) list also provides a framework for cleaning up impaired waters (Missouri Department of Natural Resources, 2003).

Two lakes and six streams and rivers in the region have been placed on the 1998 Section 303(d) List as impaired waterbodies (at the time of writing the 2002 list had not been finalized). These waterbodies include: Creve Coeur Lake and Lake St. Louis, Big River, Rock Creek, Saline Creek, Indian Camp Creek, and the Missouri and Mississippi rivers. The sources for the pollutants and the conditions include urban non-point source runoff, channelization, lead mine tailings, and point source runoff (Missouri Department of Natural Resources, 2003).

Several of the pollutants and sites can be labeled near-term, in that changes in management, operations or engineered solutions could address them almost immediately, such as upgrading sewage treatment plants. Others might be considered intermediate-term. These would require all the improvements specified for near term but would require it for a longer time and greater extent, such as clean up of a closed landfill. The remainder could be called extended-term. These would require an extensive long-term social, economic and environmental commitment, and include old lead mining tailings, channelized rivers and non-point urban runoff.

Cost and commitment to the community, city, business and industry, and the public, in both amount of dollars and duration of effort, to adequately address the near-term, intermediate-term and extended-term issues associated with these 303(d) sites could vary considerably. Commitment is important because sometimes projects get started but there is not sufficient commitment (money and effort) to finish them. What ultimately occurs is the pollution problem is not fully taken care of, but a lot of money and resources have gone into it. Upgrading a waste-water treatment plant is costly, but is much less costly than un-doing river channelization, creating wetlands in suburban areas, and removing heavy metals from miles of river water and sediment. The human health impacts could very well be even more costly for not committing adequate funds and efforts than for doing it. Many times, these long-term societal health costs are not incorporated when talking about how much it costs to continue polluting versus cleaning it up and taking the necessary steps to prevent future pollution.

There is concern for two other streams, the Peruque and the Dardenne. While these are not currently on the Section 303(d) list, without preventive action they could be listed in the future. Besides the environmental and human benefits from keeping these two streams off the 303(d) list there is economic motivation.

It is less costly, economically, to prevent environmental pollution than to let it occur and then invest the funds to clean it up after the fact. Besides the concern for human health impacts, there are aesthetic impacts, recreational boating considerations, direct impacts on fish and other wildlife as well as the aquatic and adjoining terrestrial habitat concerns. To each of these pollution concerns there are detrimental economic, social and environmental impacts.

Sources:

Missouri Department of Natural Resources, January 21, 2003, www.dnr.state.mo.us/wpscd/wpcp/wpc-tmdl.htm

Missouri Department of Health and Senior Services, January 30, 2003, ***Health Department Advises Missourians on Fish Safety***, www.health.state.mo.us/NewsReleases/02FishAdvisory.htm

United States Environmental Protection Agency (USEPA), February 13, 2003, ***Introduction to the Clean Water Act***, www.epa.gov/watertrain/cwa

Stormwater Infrastructure

Problem:

Many cities in the region are struggling to find cost-effective approaches to manage and upgrade their storm water infrastructure. After March 2003, cities have to meet the minimum control measures required by National Pollutant Discharge Elimination System (NPDES) Phase II Storm Water Rule. With no federal monies allocated to help cities to comply, the cost of achieving compliance will be steep. The consequences of noncompliance and the impact of the NPDES Phase II Storm Water Rule will be far reaching.

Discussion:

Many cities have grown exponentially in the last two decades, which has led to more impervious surfaces and greater amounts of storm water runoff. Unfortunately, the old creeks couldn't keep up with it, and some of the older homes in the older parts of town felt the brunt of the expansion by the erosion in their creeks. Unless it is raining, stormwater management is not as visible of a priority to communities as the construction and repair of streets and roads, or the enhancement of police and fire protection. As a result, stormwater systems in the city jurisdictions are many times old and in need of repair. Additionally, rapid development in many areas has increased runoff problems and caused existing systems to be inadequate. To make matters worse, local flooding problems can be chronic when affected by runoff from adjacent cities and towns.

The USEPA has passed the National Pollutant Discharge Elimination System (NPDES) Phase II Stormwater regulations to improve water quality by reducing non-point source pollution carried by stormwater. Many cities in the region fall under the NPDES Phase II Stormwater requirements. These cities are facing difficulties in approaching the minimum control measures required by the NPDES Phase II Stormwater rule. It requires permits for construction activities disturbing one or more acres of land area. Phase II also requires regulated small local governments systems, called municipal separate storm sewer systems or MS4s, be permitted and implement comprehensive storm water management programs. The Phase II rule is an extension of NPDES Phase I Stormwater rule. The Phase I rule was issued in 1990 and covered medium and large municipal separate storm sewer systems and construction activities disturbing more than 5 acres (USEPA 2002).

Phase II stormwater permit applications must address six minimum control measures: public education and outreach, public involvement and participation, illicit discharge detection and elimination, runoff from construction sites, runoff from new development and redevelopment, and pollution prevention during municipal operations.

The USEPA is consciously attempting to make the NPDES Phase II Stormwater Regulations accomplish its statutory objectives in the least burdensome and most cost-effective fashion. It is estimated that for a city of 50,000 people, it will cost between $70,000 and $390,000 to achieve compliance (Reese, 2002). Under Phase II, each regulated community will need to develop a set of Best Management Practices (BMPs) under each of six specific program minimums. These BMPs can be any combination of programs, structures and other controls that, in the agreed opinion of the permit writer and the regulated community, meet the standard of reducing pollution discharge to waters of the state to the Maximum Extent Practicable (MEP). In this process, permittees and permit writers would evaluate the proposed stormwater management controls to determine whether reduction of pollutants to the MEP could be achieved with the identified BMPs (Reese, 2002).

Sources:

United States Environmental Protection Agency (USEPA), 2002, Phase II NPDES Storm Water Program, available at cfpub.epa.gov/npdes/stormwater/swphase2.cfm

Reese, Andrew J., 2002, ***NPDES Phase II Cost Estimates***, Ogden Environmental and Energy Services, Inc., 3800 Ezell Rd., Suite 100, Nashville, TN.

Water Use Opportunities and Regional Observations

New Recreational Opportunities for Lakes

Entities that manage a lake, or that are intending on building a lake, could create a niche market by prohibiting motor craft on the lake. They could have a swimming area at one end and non-motorized boating in others. There would be added benefits if it were a water supply lake, for the water quality could be increased by not having the petroleum-related products in the water. For example, Quabbin Reservoir in Massachusetts is used for non-motorized craft and water supply only. There are still numerous opportunities throughout the region for people with motorized craft to recreate on area lakes.

There are many small lakes in the eastern Missouri region that provide recreational opportunities. However, many people dislike recreating there because motorized craft (motorboats, jet skis, etc.) can be used on them. These people like to canoe, swim, fish, sail, or bird watch, among other quiet activities, away from the disruption that motorized watercraft cause. Some people feel safer when there are not fast motor boats zipping by them, and are more comfortable swimming in water that does not smell like gasoline and combustion by-products. Large portions of the boundary waters area in northern Minnesota are an example of a very popular water recreation area whose draw, in part, is having areas without motor craft; large numbers of people go there to fish and boat, infusing the local economy with money.

Opportunities for Improved Floodplain Management

A “floodplain” is the lowland adjacent to a river that gets flooded when the river rises above its banks. The largest and most notable floodplain in the eastern Missouri Region is the Missouri River floodplain in St. Louis, St. Charles, Franklin, and Warren counties. Floodplains are designated by the frequency of the flood that is large enough to cover them. For example, the 10-year floodplain will be covered by the 10-year flood and the 100-year floodplain by the 100-year flood. Another way of expressing the flood frequency is the chance of occurrence in a given year, which is the percentage of the probability of flooding each year. For example, the 100-year flood has a 1 percent chance of occurring in any given year (FMA, 2003).

While dams, levees, channels and other protective works provide some measure of protection against some specific level of flooding, the very nature of flooding often shows this to be a false sense of security. Levee failures are usually due to a flow greater than their design flow, poor maintenance, erosion and undercutting of the levee by high flow, or a combination of these factors (FMA, 2003). When the levee breaks, the area it was protecting gets flooded.

While there is a wide range of measures that can be used to protect against flooding probably the smartest is to do the obvious: follow floodplain management recommendations – don’t develop and build in the floodplain and flood prone areas in ways that are inconsistent with potential future flooding (FMA, 2003). Common sense says that the use function of the land should be compatible with the location. Wise property management says you don't use the floodplain for incompatible purposes (Gaffney, 2003). Areas that are prone to flooding can be used for agricultural purposes, forested or open areas, wetlands, hunting preserves, parks, ball fields, or other compatible purposes. Compatible uses not only protect property but protect the water as well. When a paint factory, a dry cleaner or a sewer plant, for example, is built in a floodplain and a flood occurs, the floodwater has the potential to become contaminated by everything that it washes away. This in-turn can cause water pollution problems downstream and, after the flood has subsided, land and soil contamination.

There are very real negative aspects associated with non-compatible flood plain development. These negative aspects include a greater chance of loss of personal property due to floodwaters, increased pollution of water and land, valuable agricultural land taken out of production, added cost to replace damaged infrastructure-roads, sidewalks, pipelines after flooding has passed, and, most important, a greater chance for the loss of human life. This last point not only includes those who drive through floodwater, those who refuse to leave, and those who go back into a flooded area and get themselves stranded, but also the emergency responders who have to put their lives on the line to rescue a person.

Sources:

Federal Emergency Management Agency, March 26, 2003, Floodplain Management, www.fema.gov/fima/floodplain.shtm

Floodplain Management Association (FMA), March 26, 2003, Floodplain Management: www.floodplain.org/flood_basics.htm

Gaffney, Richard M., Water Resources Report Number 54, ***Flood Report Analysis***, Missouri Department of Natural Resources, Division of Geology and Land Survey, 1996.

Gaffney, Richard M., Planner, Geological Survey and Resource Assessment Division, Missouri Department of Natural Resources, personal communication, March 31, 2003.

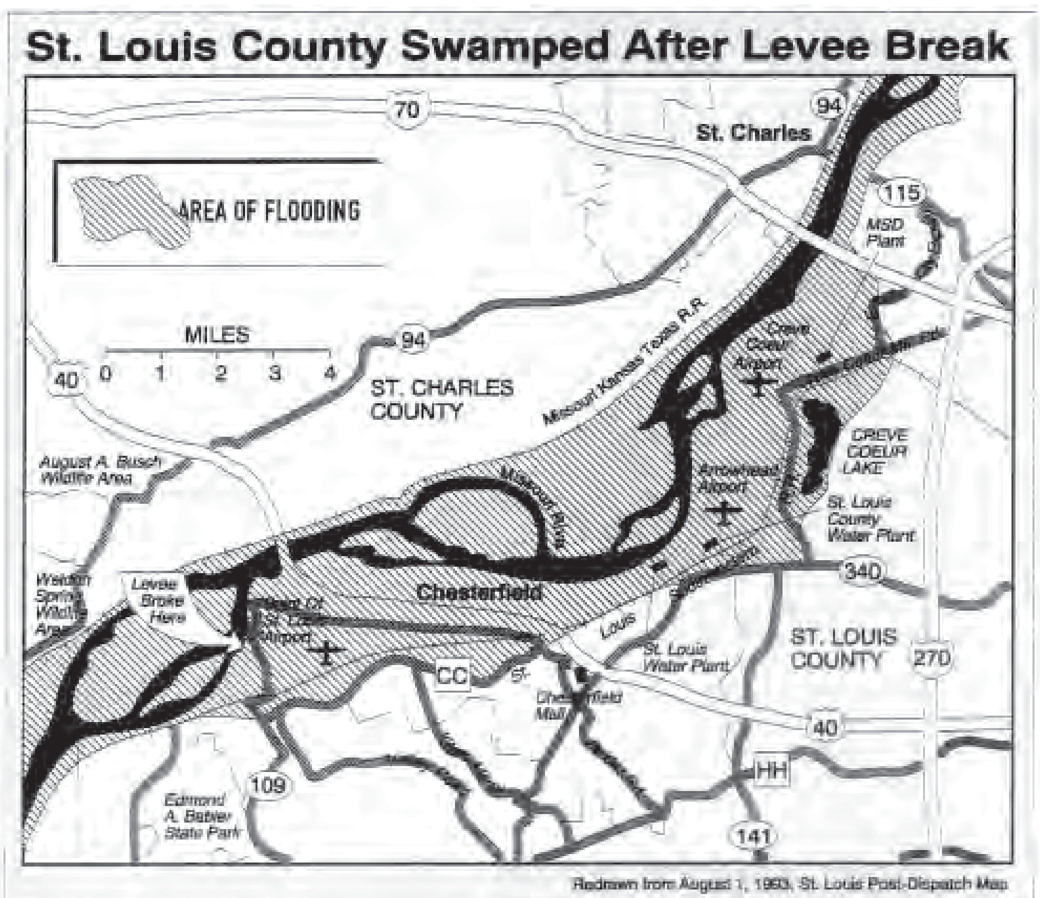

Figure 12. St. Louis County swamped after levee break.

Alternative Wastewater Systems

In many rural settings, residences use septic systems to take care of their wastewater. These are time-tested systems, and their mass-production is refined. However, they do not work adequately in all scenarios. If the local soil conditions are poor, wastewater may not be adequately treated, and it may leak pollution to either surface or groundwater. Space can also be a limiting factor in choosing such a system. In addition, the wastewater is not used, it is only 'discarded'.

Some residences separate greywater from blackwater (the former does not include wastewater from a toilet). Blackwater can either be treated more intensely to take care of pathogens, or not created in the first place. If one uses current composting toilet technology, no blackwater is created, and no pathogenic pollution is emitted to the environment since pathogens are killed in the composting process. There are many models of composting toilets sold on the market, in addition to the owner-built ones. Blackwater can also be put into a lagoon system for treatment (something that is commonly done, and therefore the technology is refined).

In greywater systems, the water is usually run through a filter, then stored temporarily, used, or released to the environment. If one is careful about what they put down the drain, the greywater can be used for irrigation (either through a leach field or sub-surface drip irrigation) or for flushing a toilet. This concept is sometimes called water recycling since the water is used twice. The Uniform Plumbing Code even has an appendix for greywater systems' design and installation. Using greywater also cuts back on using higher quality freshwater (see topic, Water Wastage), and plants thrive on the added nutrients when the system is operated properly in the right context. Greywater can be put into a septic system, knowing that it is pathogen-free, and therefore will not contaminate local water bodies; however, in this situation, the water is not put directly to any beneficial use and does not conserve freshwater.

Low Impact Development

Urban development can cause numerous problems for local waterways, such as water quality impairment, increased flooding, and streambank erosion. However, there are some new approaches in designing new and redesigning existing development that help to minimize stormwater runoff's impacts to the aquatic environment by mimicking the pre-development hydrology as closely as possible.

One such approach, called low impact development (LID), is gaining momentum. LID is a real paradigm shift: instead of moving the water away as quickly as possible and treating the stormwater with expensive treatment options (now considered the conventional approach), LID aims to slow the water down and let the environment treat and infiltrate the water, as close as possible to where precipitation falls. It uses site-specific, lot-level stormwater management to decrease stormwater runoff impacts, by integrating environmental aspects into all phases of planning and construction. These lot-level measures include rain barrels, swales, porous paving and other measures that slow down the water and help it absorb into the ground instead of only running off. In addition to the increased groundwater recharge, fewer pollutants are added to waterways due to the filtering and biotreating of pollutants on-site. Less downstream erosion occurs because of the lower peak flows. There are also opportunities for increased retention and conservation of water, thereby decreasing demands on water supply systems. Although not a panacea nor without drawbacks, LID, in concert with other approaches such as brownfield redevelopment (see next Opportunity), can have positive impacts on stormwater, and water quality and quantity.

LID also has economic advantages. It costs less for both construction and maintenance of development, in large part because of the low infrastructure costs. Sometimes, more lots can be placed in a given area, thereby increasing the profitability for the developer. Enhanced aesthetics combined with the environmental benefits help to improve property values when compared with conventional development.

A new subdivision in Fredrick County, Maryland used LID in the entire development process. There were many measures that increased the profitability of the project (replacing curbs with grassed swales, increasing the number of lots from 68 to 70, etc.). Extensive modeling helped designers determine which features to use to mimic as closely as possible the pre-development hydrology in a cost-effective manner (NRDC, 2001).

Sources:

Low Impact Development Center, www.low impact development\Low Impact Development Center - Home.htm

Natural Resource Defence Council (NRDC), 2001, ***Stormwater Strategies***, www.nrdc.org/water/pollution/storm/stoinx.asp

Improved Brownfield Management

Brownfields are former industrial and commercial properties, in many instances abandoned tracts of land and buildings, where redevelopment is complicated by real or perceived contamination. In many, if not most instances, the major concern with brownfields is contaminants or toxics found on the site polluting adjacent surface and groundwaters. Redeveloping brownfields means transforming those sites contaminated with hazardous or toxic substances into safe, productive properties and eliminating or minimizing water pollution concerns. Redevelopment of brownfields transforms unproductive (due to potential liability from contamination) real estate into useable property, creating jobs, allowing expansion of businesses, and enhancing tax bases. However, prospective purchasers, real estate developers, and lenders are often reluctant to acquire brownfields because of the inherent cleanup liability of not only known contaminants but also others that may be discovered after the property has been acquired. The environmental and monetary liability resulting from the purchase of a brownfield can be very daunting, even though the location might be otherwise desirable.

The United States Environmental Protection Agency's (USEPA) Resource Conservation and Recovery Act (RCRA) Brownfields Prevention Initiative (BPI) encourages the reuse of potential RCRA brownfields so that the land better serves the needs of the community either through more productive commercial or residential development or as greenspace. It seeks to capitalize on the redevelopment of potential RCRA brownfields to achieve successful cleanup and long-term sustainable reuse of these sites. Through the brownfields programs, the USEPA seeks to promote the reuse of industrial sites instead of development of valuable farmland or other open "greenfields" for industrial or commercial use. The benefits of the BPI include the preservation of these greenfields, the cleanup of contamination, the revitalization of communities blighted by brownfields and protection of existing greenspace in communities.

Socially, redevelopment of brownfields helps to slow urban sprawl – and thereby, minimizes stormwater runoff and prevents inefficient utilization of water and land resources in urban areas. Environmentally, brownfield redevelopment aids in preventing the spread of surface and groundwater pollution not only to new areas by keeping industry in areas that are historically industrial, but also provides a mechanism for cleaning up existing sites or at least containing the contaminants to that site. In addition, some stormwater runoff problems can be avoided or minimized by using and improving upon the existing stormwater infrastructure, and not causing problems over a widespread area due to urban sprawl. Redevelopment slows the industrial development and paving of green areas where groundwater recharge takes place. Economically, the upside of brownfield redevelopment includes utilizing a tract of land for commercial or industrial purposes that is already zoned for commercial or industrial use and has an existing water infrastructure. New water and wastewater infrastructure does not need to be constructed to meet these demands.

Sources:

United States Environmental Protection Agency, February 25, 2003, Brownfields Cleanup: www.epa.gov/ebtpages/cleabrownfields.html

Price and Non-Price Water Conservation Programs

Water conservation is not a new idea in the United States. In fact, more than 40 states now have some type of water conservation program. Nationwide surveys already indicate more than 80 percent of water utility customers support some form of water conservation measures (Kranzer, 1988). Water suppliers and consumers can choose from a wide variety of available water conservation practices, programs, and strategies proven capable of significantly reducing water consumption.

In a review of 24 residential water demand articles, Espey (1997) found almost all estimated demand to be price unresponsive regardless of demand model specification and geographic location. When demand is price unresponsive, the quantity of water demanded is not relatively sensitive to changes in price, and increases in price to encourage water conservation result in less than proportional reductions in water demand. When demand is not price sensitive, increases in price will also result in increases in utility revenue. Although consumers respond to price, the price increases necessary to obtain significant reduction in demand and associated increases in revenue are problematic for public water providers, because of the lack of public support, and because of political acceptance of increases in rates and regulatory constraints. Water demand that is relatively unresponsive to price and institutional and political constraints on the ability to use price incentives to reduce demand have contributed to water provider interest in using non-price conservation measures.

Non-price water conservation measures such as public information programs, distribution of retrofit devices, appliance rebates, and water use ordinances are designed to reduce water demand by influencing consumer behavior and preferences. Water providers nationwide are implementing non-price conservation measures as a substitute or in addition to price incentive programs to reduce residential water demand. Water conservation can have major environmental and economic benefits.

Reducing drinking water demand through conservation helps improve water quality, protect drinking water resources and maintains aquatic ecosystems. The efficient use of drinking water can also prevent pollution by reducing wastewater flows and using less energy. Water conservation can be an effective approach to reducing the adverse effects of all types and sources of non-point source pollution most commonly associated with urban uses of water. Water conservation can lessen the need to withdraw ground or surface water supplies for municipal or industrial demands.

Water conservation measures become extra important during times of drought, when a limited supply of water has more demands placed on it. The department has a Missouri Drought Plan that was widely used in the most recent drought by communities to help them deal with decreased water supplies. In addition, there is a multi-agency Drought Assessment Committee that meets during times of drought to coordinate local, state and federal planning and response.

Sources:

Kranzer, B. S., 1988, ***Determinants of Residential Water Conservation Behavior: an Investigation of Socio-Economic and Psycho-Dynamic Factors***, Ph.D. dissertation, Southern Illinois University, Carbondale.

Espey, M., J. Espey, and W.D. Show, 1997, ***Price Elasticity of Residential Demand for Water: A Meta-Analysis***, Water Resources Research 33(6):1369-1374.

Comments Received

Topics in Water Use: Eastern Missouri was reviewed at several stages of preparation. On March 8, 2004, the draft report was placed on the Department of Natural Resources' Geological Survey and Resource Assessment Division's internet web page for a 30-day review and comment by the public. This request for public comment was also publicized statewide by issuing a departmental newsrelease (Department of Natural Resources NEWS Vol. 32, No. 060). The draft report was available in electronic format at the departmental website or, upon request, as a paper-copy version.

During the comment period the public notice and news release were electronically accessed 144 times and the draft report 24 times. There was one telephone request for a paper-copy of the draft report. There was one news report interview requested by and given to a St. Louis radio station.

Two individuals submitted written comments on the draft report on April 7, 2004. These comments can be viewed upon request to the Missouri Department of Natural Resources, Geologic Survey and Resource Assessment Division's custodian of records, Deputy Director Bill Duley. This report incorporates, as appropriately, the suggestions and recommendations that were received from public comments.

The department extends its sincere thanks to those individuals who took the time and effort to review a draft of this document and especially to those who provided comments.