Water and Health in Kansas

August 2003

KHI/R 03-4

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The Kansas Health Institute is an independent, nonprofit health policy and research organization based in Topeka, Kansas. Established in 1995 with a multi-year grant from the Kansas Health Foundation, the Kansas Health Institute conducts research and policy analysis on issues that affect the health of Kansans.

ACKNOWLEDGEMENTS

The authors wish to thank Lea Steele, Ph.D., for her sizable contribution to this report. Dr. Steele conducted much of the research upon which the report is based and contributed most of pages 26 to 40 of the report. It truly could not have been done without her. We also wish to acknowledge the contribution of Charles Betley to the finished product.

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EXECUTIVE SUMMARY

Essential to the life of plants and animals, water is also basic to the economy, spiritual well-being, recreation, and health of Kansans. How to allocate limited quantities of fresh, clean water across uses, across the current population, and across generations is the heart of water policy.

A reliable supply of water (i.e., not from precipitation) comes from two sources, ground water stored in underground aquifers, and surface water in lakes and streams. Ground water use predominates in the western and south central parts of the state, and surface water use predominates in the rest of Kansas. Agriculture accounts for more than 80 percent of all the water used in Kansas on an annual basis, while municipal use, which includes domestic use, accounts for less than ten percent of water use.

The area of the state that relies most on irrigation is the dry western third of the state. There the primary source of water is the section of the High Plains aquifer known as the Ogallala formation or the Ogallala aquifer. Because the amounts of water withdrawn from the Ogallala aquifer exceed the natural rate of recharge from precipitation, the aquifer is shrinking. Depending on the initial thickness of the aquifer that underlies a section of land, excessive use of water for irrigation could deplete the water in the aquifer to such a degree that it is no longer hydrologically or economically possible to use it further. However, the physics of high volume pumping that make the aquifer unusable for irrigation does not mean that it is dry—it means only that it is unusable for some purposes. Even after the supply of ground water in western Kansas is no longer useful for agriculture, for example, it could still be used for municipal purposes at a rate that would allow the aquifer to recharge.

In the eastern two-thirds of the state, where the reach of the High Plains aquifer is not as great, Kansans rely more on surface water than ground water. Surface water is exposed to a number of natural and man-made assaults that compromise its quality for drinking and recreation. Because there are more streams and lakes and greater population density in the eastern two-thirds of the state, the opportunities for polluting surface waters increase. (Rivers that flow into Kansas from other states may also be subject to up-stream pollution.) Most point source pollutants, such as an industrial plant that discharges chemical waste into a river, have been controlled in the 30 years since the passage of the Clean Water Act. But sources of pollution that do not come from a single point of origin (non-point sources) still persist. These non-point sources include run-off from streets, parking lots and residential lawns in urban areas. The greatest sources of non-point source pollution are agricultural: run off from farms fields (fertilizer, herbicides, insecticides) and animal waste. These non-point sources of pollution are the greatest regulatory challenge facing water policymakers in Kansas.

On the whole, the quality of drinking water in Kansas is good. The majority of the population is served by larger, well-managed water systems. The state has, however, many very small water systems that face a variety of resource constraints. As a result, there sometimes are violations of drinking water quality standards. Fortunately for the health of Kansans, these lapses are not frequent; the consequences are relatively minor; and the problems are quickly remedied.

The security of water processing plants and the need for emergency plans were highlighted by the events of September 11, 2001. Many water systems in Kansas have begun to improve security and establish procedures for emergency preparedness. Once again, the smallest of the water systems are least prepared, and because they have such limited resources, they are unable to make maximum use of the technical assistance presently available.

INTRODUCTION

Water is the most widely used and, perhaps, most thoroughly managed of our natural resources. Where water comes from, for what purposes it is used, how much of it is used, and how safe it is for certain uses is dizzyingly complex. By law, water in Kansas is considered a public asset dedicated to use by the people of the state, and subject to control and regulation by state government. Two prime aspects of water, its quality and quantity, are managed by more than 20 separate federal, state, and local government agencies, including agencies as diverse as the U.S. Environmental Protection Agency, the Army Corps of Engineers, the Kansas Water Office, the Kansas Department of Health and Environment, the Kansas Department of Agriculture, and local conservation and ground water management districts (KSU Agricultural Experiment Station and Cooperative Extension Service, 2001). Agricultural, livestock, industrial, and environmental interests compete to influence the water policies and regulations of these various agencies and the legislatures and boards that oversee them. Legal agreements with neighboring states regarding access to water in shared rivers also play a role in determining water policy in Kansas.

This paper is organized into five parts. The section following the introduction sets the context for water policy in Kansas. It begins with a discussion of the sources and uses of water and then outlines the major water policy issues. The section continues with a description of the agencies responsible for water regulation and control in Kansas. The next three sections expand upon the water policy issues of quantity, quality, and security.

THE POLICY CONTEXT OF WATER IN KANSAS

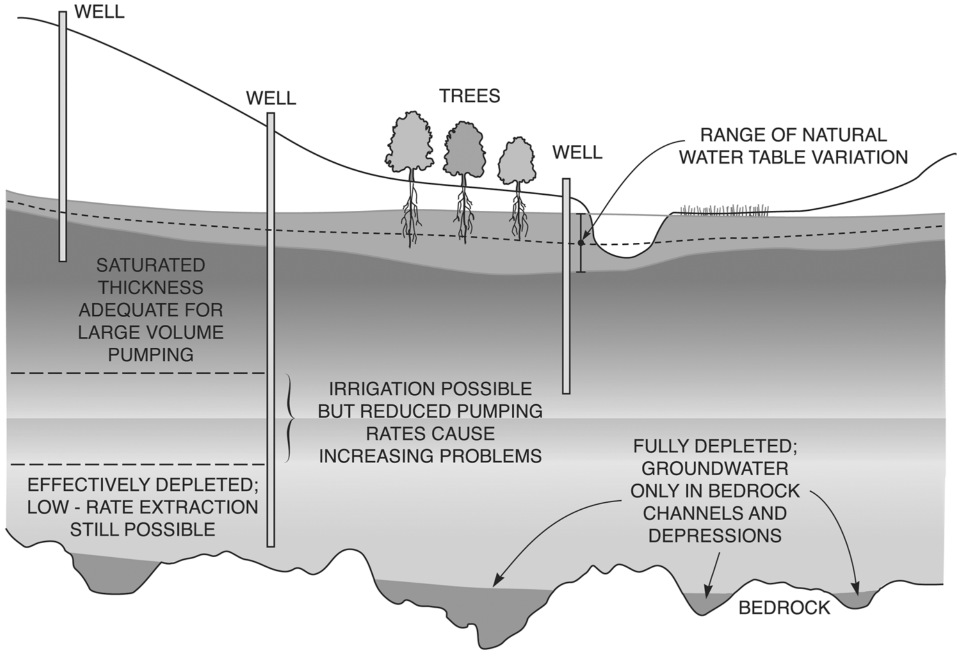
To fully grasp the complexity of water policy, it is necessary first to understand the sources and uses of water in Kansas.

SOURCES OF WATER IN KANSAS

Water issues are generally considered according to two sources of water on which we rely, ground water and surface water. The primary ground water resource in Kansas is the High Plains aquifer, a vast natural reservoir that underlies large portions of the central plains of the United States, including much of western Kansas. The Ogallala aquifer, Great Bend Prairie aquifer, and the Equus Beds aquifer are parts of the larger High Plains aquifer.

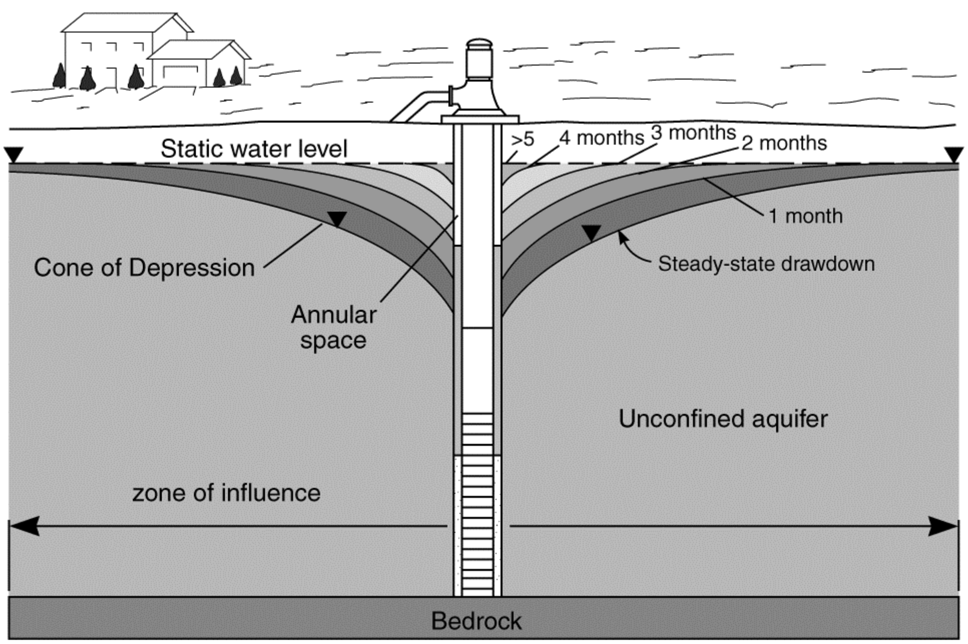
An aquifer is an underground rock or sediment formation that is saturated with water and is sufficiently permeable to transmit economic quantities of water to wells or springs. The amount of water available at a particular point in the aquifer is measured by its saturated thickness. Saturated thickness is the height of the pore spaces in the formation that are filled, or saturated, with water. The upper surface of the saturated thickness is called “the water table.” Saturated thickness is measured by the difference between the bedrock surface, the bottom of the aquifer, and the water table (Water Plan, 2003; Equus Beds Information Resource, 2003). At different points, the saturated thickness of an aquifer may vary substantially. (See Figure 1.)

Figure 1
Stages of Aquifer Depletion



Source: Buddemeier, 2000

Figure 2
Water-Table Drawdown and Recovery After Pumping

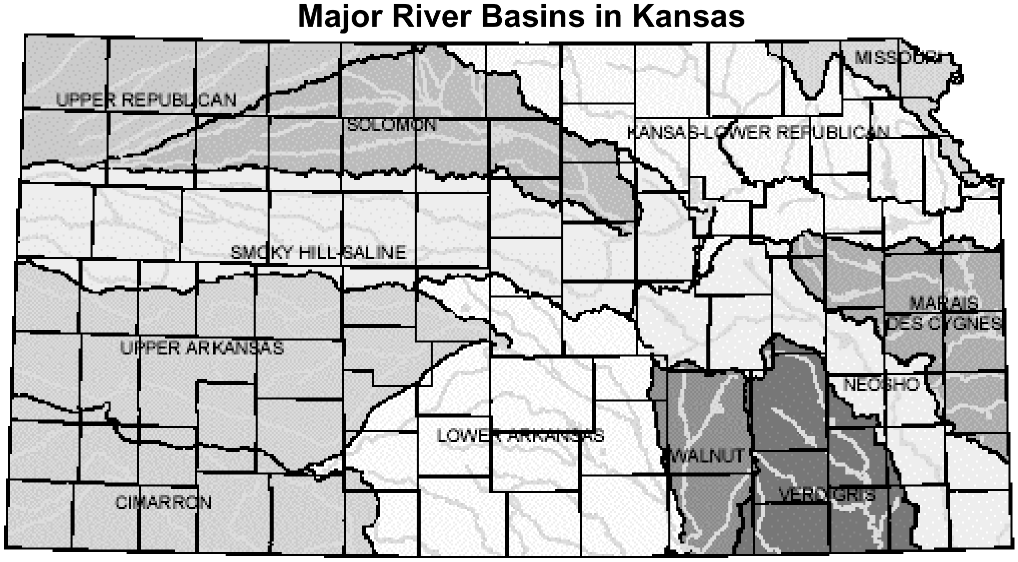


Source: Buddemeier, 2000

Thinly saturated zones of an aquifer may be unsuitable for high volume pumping even if substantial quantities of water are present. Pumping water creates a cone of depression, a conical dip in the water table, best illustrated by the common practice of vigorously sucking a thick milk shake through a soda straw. A depression on the top surface of the milk shake occurs around the straw, because the milk shake is being withdrawn more quickly than it can be replaced. Where the cone of depression for a milk shake can be measured in millimeters, that caused by a high-volume pump in an aquifer can be tens of feet deep. The broad base of the cone of depression is called the "zone of influence" of the pump (or well) and can have a diameter of a mile or more. The lowering of the water table by pumping is known as "drawdown." To be suitable for high-volume pumping, the saturated thickness of an aquifer must be great enough so that the pump can remain submerged at maximum drawdown. (See Figure 2.) Less powerful pumps than those used commonly for agricultural purposes may still be able to pump useable water from an aquifer that is unsuitable for agriculture (Buddemeier, 2000).

Surface water is water found on the Earth's surface, usually in rivers and lakes. Just as ground water is categorized by hydrologically linked aquifers, surface water in Kansas is classified by water flowing into one of twelve major river basins (See Figure 3). In addition to regulating the quantity and quality of surface water, state agencies manage streams to optimize their use by fish and wildlife and to promote their general aesthetics.

Figure 3
Major River Basins in Kansas



Source: Kansas Water Office, July 1999

USES OF WATER

Water issues must also be considered in the context of the purposes for which the water is used. For purposes of monitoring and regulation, Kansas has adopted the following designated use categories: agricultural water supply, aquatic life support, domestic water supply, food procurement, industrial water supply, and recreation. Water use, as reported by the Division of Water Resources (Kansas Department of Agriculture), falls into similar categories: industrial uses, irrigation, municipal water, recreation, stock water (water for animals), and other. Table 1 summarizes the overall uses of water in Kansas. Table 2 lists uses of water by source of supply.

Table 1
Water Use in Kansas, 2001

Uses	Percent
Irrigation	83.21
Stock water	0.98
Industrial	3.02
Municipal	9.91
Recreation	1.77
Other	1.11
Total	100.00

Source: Division of Water Resources, Kansas Department of Agriculture, 2003

Table 2
Water Use in Kansas by Source of Supply, 2001

Uses	Ground Water Percent	Surface Water Percent	Total Percent
Irrigation	98.72	1.28	100.00
Stock water	98.48	1.52	100.00
Industrial	54.28	45.72	100.00
Municipal	43.32	56.66	100.00
Recreation	15.57	84.43	100.00
Other	62.78	37.22	100.00

Source: Division of Water Resources, Kansas Department of Agriculture, 2003

Agriculture consumes the largest share of water usage. Between irrigation of cropland and stock watering, farming and ranching consumes 84 percent of all the water used in Kansas per year. Some of the water attributed to industrial uses may also have agricultural or food production uses. For examples, meat-processing plants are considered industrial and not agricultural uses. Not surprisingly, agricultural use of water is the largest issue in water quantity. Agricultural uses (irrigation and stock water) account for 92 percent of all ground water used. Clearly, agricultural practices are linked to the long-term survival of the High Plains aquifer. Agricultural practices also account for a sizeable amount of non-point source pollution in the state.

Both ground and surface water supply public drinking water systems: 32 percent of *Kansans using public water systems* rely on ground water, 26 percent rely on surface water, and 42 percent use a combination of both. Responsibility for assuring a ready supply of quality drinking water is shared between public and private enterprises. The 1,099 public water supply systems that exist in Kansas are owned and managed by public entities such as municipalities and rural water districts or by investor-owned utilities.

Municipal water use accounts for less than 10 percent of total water usage in the state. In addition to water for drinking, municipal water is used for bathing, laundry, car washing, lawn and garden watering, and thousands of other domestic uses.

Aside from drinking water and water for household uses, most Kansans encounter water in recreational settings. People use the state's lakes and rivers for fishing, swimming, boating, and other water-based recreation activities. The water in lakes and streams has not been treated by a public water system or filtered by leaching, and it may be impaired from point and non-point source pollution. Accordingly, surface water used for recreation is a potential cause of illness for humans who come into contact with contaminated waterways.

MAJOR WATER POLICY ISSUES IN KANSAS

Controversy over public water systems in Kansas is not a recent phenomenon. For many years, the debate has centered around two general types of water issues: (1) concerns regarding the *quantity* of available water, that is, the adequacy of the water supply to meet current and future needs, and (2) concerns regarding water *quality*, that is, how clean the water is and how suitable it is for public use. Since September 11, 2001, a third issue, water security, has received considerable attention.

The issue of the availability of adequate supplies of fresh water is one of the most pressing global issues of our time. Worldwide, large numbers of people in developing countries do not have regular access to adequate amounts of water. In Kansas, however, no concerns have been raised about the availability of adequate water for human consumption, either now or in the foreseeable future. Nevertheless, depletion of the aquifers in the more arid parts of the state may limit adequate supplies of water for both personal and agricultural use.

Clean water may be contaminated by point sources of pollution and non-point sources. Point sources of pollution are those that are linked to a specific, single point, such as an outflow pipe from a factory, wastewater treatment plant, or livestock feeding operation. Point sources of pollution are subject to regulatory control. Non-point sources of pollution originate from unregulated sources over a widespread area, such as agricultural use of chemicals and livestock waste, and from urban sources such as post-rainfall runoff of sediment, oils, fuels, and road salt. Non-point sources of pollution are the most prominent source of water contamination statewide (Water Plan, 2003 and Equus Beds, 2003).

Monitoring of water quality is an essential public health function. The water quality-monitoring network for surface water is more comprehensive than that for ground water. Water is monitored at its source, that is, in the river or the well, but it is also monitored at the point at which it is supplied for public use, that is, when it leaves the water treatment plant. The water provided to homes for drinking and showering is subject to different standards than water used for irrigation or swimming. The next section discusses the agencies responsible for water monitoring and management.

Those charged with protecting the community from terrorist activities are making protection of the water supply a top priority. The importance of water as a security issue was underscored by recent media reports that documents outlining plans to poison public water supplies had been found on captured Al Qaeda suspects (Shannon, 2002). President Bush toured a Kansas City Water Works plant last June to highlight the importance of water security (Krasky, 2002). Less publicized were recommendations issued jointly by the Centers for Disease Control and Prevention (CDC) and the Environmental Protection Agency (EPA) regarding alert measures to be implemented to protect water supplies when the U.S. Department of Homeland Security recently upgraded their security advisory level to orange (indicating a high risk of terrorist attack) (U.S. EPA, 2003b). While reports differ on the likelihood that terrorist efforts to undermine public water supplies could succeed in harming a large number of people, water systems around the country are performing mandated vulnerability assessments and taking steps to address identified shortcomings (U.S. EPA, no date, b). As with other segments of the public health sector, the heightened awareness and surveillance measures implemented to protect the public from terrorism are also expected to benefit detection and response capacity for other, unintentional, water contamination problems.

WATER REGULATION IN KANSAS

The state of the environment—in Kansas and in the rest of the United States—has undergone dramatic changes in the last half century. As the number and variety of chemicals used in our everyday lives has increased, so have government regulations regarding allowable levels of contaminants in the water, soil, and air. Passage of the 1972 Federal Water Pollution Control Act, commonly known as the Clean Water Act, was a landmark legal event that introduced sweeping measures to protect and restore America's streams, rivers, and lakes.

Evidence from extensive monitoring and enforcement activities conducted by the Kansas Department of Health and Environment indicates that Kansas water has benefited substantially from measures mandated by the Clean Water Act (KDHE, 1997). While population and industrial activities have increased in the state over the past 30 years, statewide levels of water pollutants have significantly decreased. There are many dramatic examples of these successes. The Arkansas River is no longer dark with inadequately treated sewage as it passes through Wichita. A diverse biosystem has been restored in Big Creek near Hays, once contaminated with high ammonia levels and bacteria. And, while the beef packing industry now produces about five times as much product as in 1972, the amount of related pollutants discharged into Kansas rivers has been dramatically reduced.

Improvements in water quality stemming from the Clean Water Act have been largely due to clean-up of larger, individually-identifiable sources of water pollution. As these point sources of pollution, such as wastewater treatment and industrial plant effluents, are reduced, attention has turned increasingly to problems associated with non-point sources of pollution such as pesticides and animal waste carried from fields into streams, or surface run-off from roadways, households, and parking lots. Logistic, economic, and political challenges associated with regulating these non-point source pollutants abound.

The Clean Water Act marks a sea change in water regulation, but it was not the first public policy to touch on water regulation in Kansas. The Kansas Legislature created the Division of Water Resources (in the Department of Agriculture) in 1927, and it has, over the years, gone on to administer 28 water laws, perhaps most notably, the Kansas Water Appropriations Act, passed in 1978.

The Kansas Water Appropriations Act makes it illegal to use water for any purpose other than domestic use without holding a vested right or having a permit from the Division of Water Resources (DWR) to appropriate water. The Act applies to ground water and surface water on public and private property. Violators of the law are subject to up to six months in jail and a $500 fine.

All water users from farmers and ranchers to industrial concerns to municipalities must possess the right to use the waters of Kansas. Vested rights are those “beneficial uses of water” begun before June 28, 1945. More than 2,000 vested rights exist. Additionally, since 1945, DWR has approved more than 43,000 applications to appropriate water. Water users are required to make annual reports of water use and the chief engineer of DWR has the power to regulate the volume of water used to protect the state’s supplies of ground and surface water for the future.
DWR also administers laws concerning the construction of dams across rivers and streams, changes in course or current of streams, construction of levees, and floodplain management,

among others. For the purpose of this paper, only DWR's role in regulating water quantity is of interest.

While DWR is primarily responsible for assuring the quantity of water is appropriate both now and in the future, the Bureau of Water (BOW) in the Kansas Department of Health and Environment is responsible for regulating the quality of ground water and surface water in Kansas. BOW assures compliance with state and federal laws and regulations such as the Clean Water Act and the Safe Drinking Water Act, administering programs related to public water supplies, wastewater treatment systems, sewage disposal, and non-point sources of pollution. The purpose of BOW is to assure safe drinking water and prevent water pollution.

Although BOW does not regulate well water quality, it is responsible for licensing and regulating water well contractors in Kansas. To obtain a license, applicants must complete a written examination. Licensed water well contractors agree to comply with state standards for the construction, reconstruction, treatment, and plugging of wells. Licensed contractors are required to renew their license annually and are obligated to satisfy the continuing education requirements of licensure. The primary purpose of the water well program is to protect ground water from pollution and contamination. Secondary purposes include the protection of "the health and general welfare of the citizens of Kansas." BOW has the authority to request that the well contractor of newly constructed and reconstructed water wells provide a sample of water from the well for chemical analysis. Water well construction standards include items such as the location of the well and the lining and grouting of the well. Using data from well construction records, state officials estimate the potential supplies of water in Kansas.

The various agencies responsible for water policy in Kansas—as well as the various users of water—come together in a single organization to coordinate their disparate activities and to share information. That organization is the Kansas Water Authority, and its chief objective is to approve an annual *Kansas Water Plan* developed by the Kansas Water Office. The Water Authority is composed of 23 members, eleven appointed by the Governor, one by the President of the Senate, and one by the Speaker of the House. Agency representatives (identified in K.S.A.

74-2622) serve as *ex officio* members. The state and local agencies responsible for the various parts of the plan are charged with its implementation, operation, and evaluation.

Kansas Water Authority Representative Membership

1. Representative of the Governor
2. Director of the Kansas Water Office
3. Representative of Central Kansas Groundwater Management Districts
4. Representative of western Kansas Groundwater Management Districts
5. Representative for Conservation and Environmental Issues
6. Secretary of Kansas Department of Agriculture
7. Representative of the President of the Senate
8. Representative of the State Association of Kansas Watersheds
9. Director of the Division of Environment (KDHE)
10. Secretary of the Kansas Department of Wildlife and Parks
11. Director of the Agricultural Experiment Station (KSU)
12. Representative Small Municipal Water Users
13. Representative of the Speaker of the House of Representatives
14. Representative of the Kansas Association of Conservation Districts
15. Representative Large Municipal Water Users
16. Chief Engineer, Division of Water Resources (Department of Agriculture)
17. Representative of the General Public
18. Representative of the General Public
19. Secretary of the Kansas Department of Commerce and Housing
20. Administrative Officer of the State Conservation Commission
21. Representative of Industrial Water Users
22. Chairperson of Kansas Corporations Commission
23. State Geologist (Kansas Geological Survey)

Created in the early 1980s (K.S.A. 82a-901a), the Kansas Water Office is the water planning agency for the state. The Director of the Water Office reports to the Governor. The Water Office is charged with formulating the *Water Plan* with input from other water-related agencies. Using the framework of the twelve major river basins as planning areas, the *Water Plan* organizes its planning into the following policy categories:

- Water Management
- Water Conservation
- Public Water Supply
- Water Quality
- Flood Management
- Wetland and Riparian Management
- Water-Based Recreation
- Data and Research
- Public Information and Education

Water management and quality assurance is also the responsibility of local arms of government. Five ground water management districts (GMD) have formed voluntarily in central and western

Kansas, under authority granted by the Legislature in 1972. GMDs are formed by the majority vote of voters in the designated (usually multi-county) district. GMDs generate revenues to finance their operations by water use fees and a per acre levy on land owners. The mission of a typical GMD (#4) is as follows.

> The purpose of this district is the proper conservation and management of the ground water resources. It is also to provide local land owners and water users with the ability to be directly involved in the process by establishing their own regulations regarding the resource. Moreover, all necessary research and education are to be conducted under local direction. Finally, the district is to cooperate with other local, state, and federal agencies in their endeavors.

By statute, GMDs have the power to install gages and meters to monitor the amount of water withdrawn; enter private property to determine compliance with state laws and regulations and district rules; recommend rules and regulations to the chief engineer (Department of Agriculture) which relate to the conservation and management of ground water within the district; and recommend rules and regulations to the Kansas Department of Health and Environment, the Corporations Commission, and other state agencies.[1]

Municipal water systems, rural water districts (a water supplier distinct from GMDs), and private water systems bear the responsibility of providing adequate quantities of water at a level of quality defined by the federal Safe Drinking Water Act. Counties and municipalities are also charged with responsibilities for controlling their own wastewater and other point sources of pollution to surface waters that fall within their jurisdiction.

Water is a highly regulated commodity. The federal government sets the framework for much of the quality standards that are enforced at the state and local levels. The courts also play a role in water quality and quantity disputes, primarily in interstate conflicts but also with respect to intrastate issues. (For example, see the discussion of Senate Bill 204 below.) Regional compacts between and among states establish rules for water use. A variety of state agencies monitor and

[1] Rules and regulations proposed to the chief engineer or other state agencies must be approved or rejected. All approved rules and regulations are effective only within the specified district.

regulate water use and its quality, establishing state guidelines where they are needed. The Kansas Water Office attempts to be a clearinghouse—or a lightning rod—where all of these disparate regulatory and legal issues meet. The size of the topic, its scientific, economic, and social complexity, and the values of competing interests make the rational management of water extremely difficult.

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When asked "What is the single most important issue related to water in Kansas?" one key informant responded that there was no single issue. "In the western third of the state, " he said, "it's water quantity, and in the eastern two-thirds, it's water quality." Despite half a century of water policy to improve water quantity and water quality—and substantial improvements have been made in both arenas—there still remains much to do. The ground waters in the Ogallala formation are being used faster than they can be recharged. Non-point sources of pollution have proven a more intractable problem to water quality than point source pollution. And in the aftermath of September 11, 2001, we have all become aware how vulnerable we are to attack and sabotage. In the next three sections, we expand our discussion of water quantity, quality, and security.

WATER QUANTITY

> We must save the Ogallala aquifer and show future generations that the Ogallala aquifer is about a lot more than the water. It's a way of life.
>
> *Senator Sam Brownback*
> *Hydrogram, Summer 2002, Kansas Water Office*

> In some parts of the state there's enough water—they can irrigate another 200 years. But in other parts, they may be down to 25 years or less.
>
> *Clark Duffy, Assistant Director of the Kansas Water Office*
> *Lawrence Journal-World, July 22, 2002*

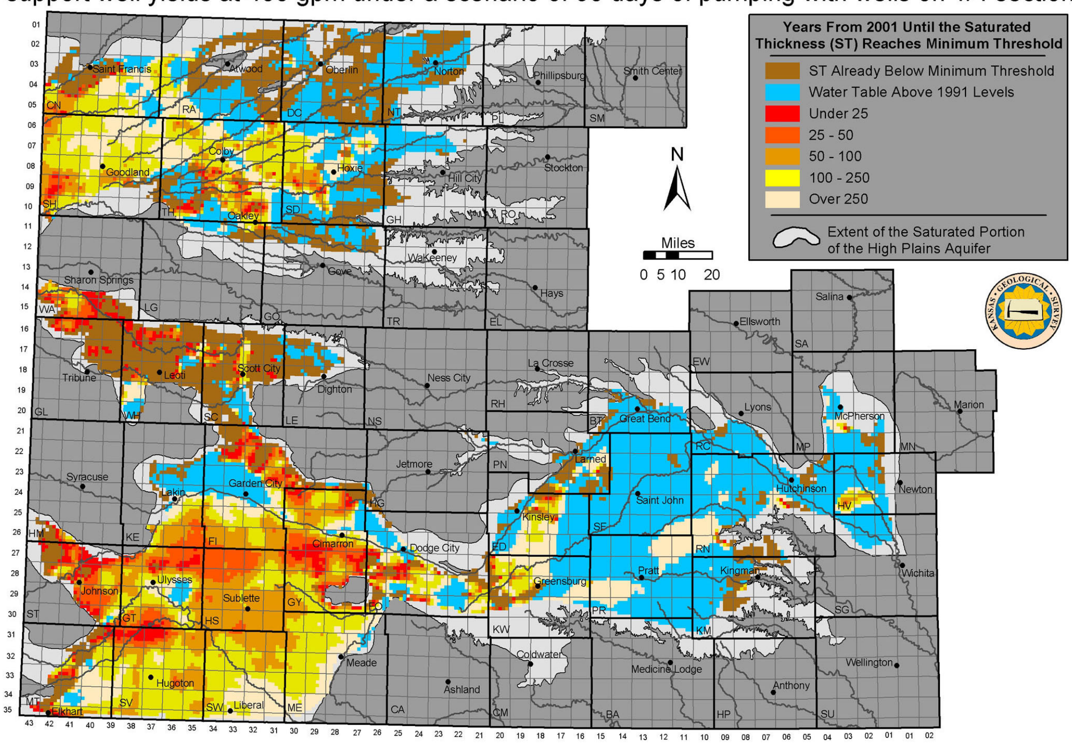
The Ogallala formation, part of the High Plains Aquifer, is the primary source for nearly all water in western Kansas. Senator Sam Brownback said the Ogallala aquifer must be saved to maintain the current way of life in western Kansas. Why does the aquifer need saving? The basic problem is that water in the aquifer is being depleted at a rate faster then it is being replenished, or recharged, by nature. Water levels that had been maintained in more or less a steady state for millennia have rapidly declined since large capacity pumping wells were first introduced into the area in the 1940s. The overall rate of decline across the Ogallala formation decreased approximately 1.4 feet per year between 1969 and 1979; between 1989 and 1999, the rate of depletion dropped to just over 0.5 feet per year. Reasons given for the decline in rates include the passage of the 1978 Water Appropriations Act, use of more efficient sprinkler irrigation systems, and agronomic advances allowing greater crop yields with less water (Kansas Water Office, 2003). Even though the *rate* of ground water depletion was somewhat less in the 1990s than in prior decades, water usage continues to outpace recharge rates.

In western Kansas, aquifer thickness and rates of decline vary substantially from area to area. The most seriously affected area lies in Kansas Groundwater Management District (No. 1), which passes from Lane through Wallace and Greeley counties in the far western part of the state. The Kansas Water Office reports that half of the area in the district has experienced a 50 percent or more decline in the water table in the years since high-volume pumping was introduced. Water Office projections indicate that, if water is depleted at the rate observed in the 1990s, high volume water pumping will no longer be feasible in 43 percent of the district within 50 years. If the rate is more similar to that seen in the drier 1980s, nearly 60 percent of the district will experience water levels too low to pump within 50 years. A February 2003 report from University of Kansas scientists suggests that the latter scenario may be more likely, with measures from hundreds of wells indicating that the water table has, in the last several years, declined at rates exceeding those observed in the 1990s. (See Figure 4 for a depiction of the estimated useful life of the High Plains Aquifer in Kansas.)

An additional problem regarding aquifer depletion is the effect that it can have on surface water supplies, or the level of water in streams and rivers. Some streams are partially fed by seepage from underground aquifers. Excess depletion of ground water in such areas lowers the water table, resulting in a “reverse flow” of water from streams to aquifers, and a net loss of water in the streams (Sophocleous, 2000). In western Kansas, where surface water is already in short supply, the depletion of ground water resources has already resulted in stream flow reductions. According to a report from the Kansas Geological Survey, such trends “are most dramatic in the upper Arkansas, Cimarron, and Smoky Hill River basins, where a shift toward irrigated crop production has contributed to the lowering of the water table and significantly reduced baseflow contributions to streams from shallow aquifers." The concern is that, as aquifers fail to recharge, rivers and streams in the areas most affected also are drying up.

Figure 4
Estimated Usable Lifetime for the High Plains Aquifer in Kansas

(Based on ground water trends from 1991 to 2001 and the minimum saturated thickness required to support well yields at 400 gpm under a scenario of 90 days of pumping with wells on 1/4 section)



The Kansas Geological Survey compiled this map according to specific cartographic standards, using what is thought to be the most reliable information available. The Kansas Geological Survey does not guarantee freedom from errors or inaccuracies and disclaims any legal responsibility or liability for interpretations made from the map, or decisions based thereon.

Source: Kansas Geological Survey

Only a small fraction, less than five percent, of the ground water used in Kansas provides water for public water systems, and an even smaller fraction, 0.7 percent, is used to supply water for individual household use. Nearly all ground water used from the Ogallala aquifer in Kansas is used for agricultural purposes—over 95 percent, according to the Kansas Department of Agriculture.

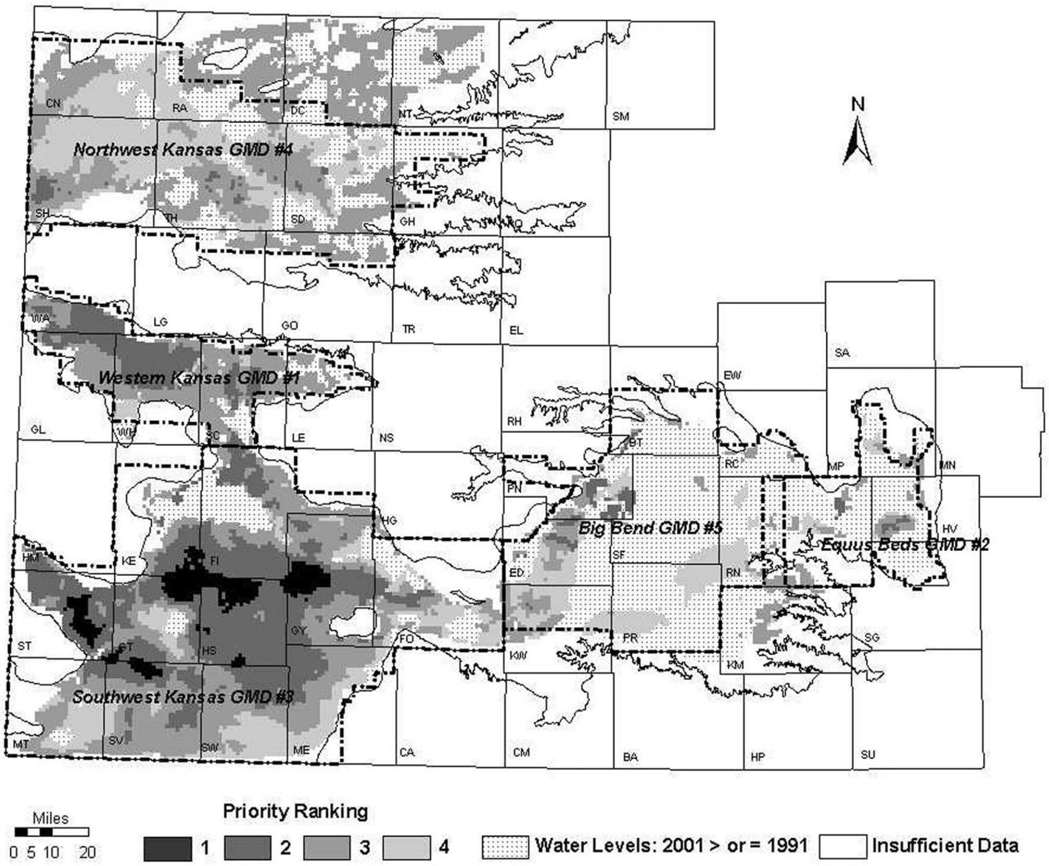
Municipal, industrial, and other relatively large volume uses of water are not as demanding on the ground water of the Ogallala aquifer as is agriculture, because they are intermittent users and spread their demand for water more uniformly throughout the year. Recharge rates in most of the High Plains aquifer are such that domestic, municipal, and infrastructure needs (e.g., power generation, construction) can be sustained indefinitely if there is adequate water in storage to manage variations in demand and recharge (Buddemeier, 2002).

In 2001, Governor Bill Graves called for zero depletion of the Ogallala aquifer in Kansas by 2020, a position that was strongly opposed by agricultural interests and some state legislators. This call to action has been included in the current working copy of the *2005 Kansas Water Plan.* Based in part on a study by the Kansas Geological Survey (Wilson, Young and Buddemeier, 2002), the *Water Plan* proposes to "Reduce water level declines within the Ogallala aquifer and implement enhance[d] water management in targeted areas by 2010."

The current focus of management of the Ogallala aquifer is to divide it into sub-units that share common characteristics so that decisions can be made for areas that share common problems rather than those that simply share geographical space. Specific water use goals will be established for each of the sub-unit types. This is a relatively new concept in water management of the Ogallala aquifer and moves away from the one-size-fits-all policies of the past by recognizing that all areas of the aquifer are not alike. The sub-units are intended to serve as management tools to sustain the aquifer. A map indicating priority ground water decline areas will be used to guide decisions on water conservation until the sub-units are delineated (see Figure 5).

The Water Authority hopes that voluntary, incentive-based water use reduction approaches can be used to halt aquifer depletion instead of regulatory actions. Emphasis will be placed on programs that inform individual water users about cost-savings that can be achieved through water conservation. To do so requires the effective communication of current information about specific areas of the aquifer to the people who depend upon it for their livelihoods.

Figure 5
Priority Ground Water Decline Areas



Areas are created by combining data on estimated usable lifetime and density of ground water use. Rank 1 indicates areas with a shorter estimated unable lifetime to support 400 gpm well yields and a history of higher ground water usage. Higher ranks represent longer estimated lifetimes and lower densities of water usage.

Source: Kansas Water Office

Throughout history, the availability of adequate water resources has determined where communities locate and what types of activities they pursue. The economy in western Kansas currently relies heavily on wheat and livestock production, both of which require large quantities of water to maintain. Declining water levels pose a threat to the economy and way of life in the region. Where ground water supplies are extremely low, government officials have publicly stated that it will be necessary to take steps to move to a “non-irrigated” economy in the near future. While the situation is less immediate in other locations, all parties agree that most areas of the Ogallala aquifer cannot support current patterns of water use, and well-planned management steps are immediately required to preserve this resource and the way of life it provides for Kansans in the western part of the state.

ECONOMIC IMPACT OF THE DEPLETION OF THE OGALLALA AQUIFER

The Ogallala aquifer is the major source of water for agriculture in western Kansas. Commodity production is the foundation upon which the infrastructure supporting agribusiness rests. This infrastructure includes grain elevators, cattle feedlots, farm machinery and equipment dealers, trucking firms, production input suppliers such as seed, fertilizer, and chemical dealers, meat packing plants, and so on (Terrell and Johnson, 1999). By one, possibly low, estimate, approximately nine percent of the economic activity of western Kansas is attributable to irrigated farming[2] (Gilson, Aistrup, Heinrichs, and Zollinger, 2001). According to the Western Kansas Irrigation Research Project at Kansas State University (1998), irrigated acres in western Kansas is expected to decline between 40 and 85 percent by 2020 due to declines in the water table and higher energy costs for pumping.

Can western Kansas sustain such a blow? Are the residents of that section of the country hostage to the inevitability of aquifer depletion and economic ruin? A variety of researchers have attempted to answer these questions. The alternative futures for western Kansas they forecast are predicated on a number of assumptions of future behavior, economic conditions, and environmental circumstances. Whether these conditions will occur or whether new, currently unforeseen, events will take place to alter circumstances is, of course, not known. These studies, therefore, are "informed guesses" about the impact of the depletion of the Ogallala aquifer on the economy of western Kansas.

Because water, seemingly free for the taking, is actually a significant cost of agricultural production, producers will adapt as water becomes more expensive to extract from the ground. Farmers must invest capital in large volume wells and pumps and in expensive sprinkler technology. The variable cost of pumping water as the saturated thickness declines requires more energy to lift the water to the surface. Declining market prices for grain, higher energy prices,

[2] This estimate uses an economic multiplier for irrigated agriculture of 3.5. It is not clear from the report if the value of all of the infrastructure industries were included in the estimate of the multiplier.

and the lowering of the water table could combine to make irrigated grain production unprofitable (High Plains Study, 1982; Buller and Williams, 1990; Kromm and White, 1992; Terrell and Johnson, 1999). At this point, the farmer will stop or greatly reduce irrigation of crops even though the aquifer is not technically depleted. Some researchers suggest that farmers will shift cropping patterns to water-efficient crops or dryland farming, or convert their fields to grazing land. The alternative crops the farmer will shift to may not be as lucrative as irrigated crops; regional economic activity, therefore, may be adversely affected.

The Docking Institute of Public Affairs at Fort Hays State University undertook a project for Southwest Kansas Groundwater Management District (No. 3) in 2001 to develop an integrated model that would estimate water utilization, depletion rates, cash flows, and economic impact in southwestern Kansas over twenty years (Gilson, et al., 2001). The Institute analyzed water utilization and economic impact under five scenarios.

- **Scenario 1** models the current farming and water utilization practices (two-thirds of irrigation by center-pivot methods and one-third by flood irrigation), assuming no changes to current conditions in water management policies and no significant regional economic changes. The results of this scenario were compared to those of the other scenarios.
- **Scenario 2** assumed that all irrigation would be by more efficient center-pivot methods, eliminating flood irrigation.
- **Scenario 3** is based upon the center-pivot assumptions of scenario 2, but it also assumes that the amount of water applied to crops is 50 percent less than scenarios 1 and 2.
- **Scenario 4**, like scenario 3, is based upon the center-pivot assumptions of scenario 2, but it assumes that crop yields are reduced by 10 percent of the fully irrigated level (scenario 2).
- **Scenario 5** combines elements of the three previous scenarios. It assumes that all irrigation will be by center-pivot methods, water will be reduced by 50 percent on a single crop, corn, and the 50 percent reduction in water applied to corn will result in a 10 percent reduction in yield.

Table 3
Summary of Docking Institute Findings

Scenario	Average NPV[1] per Square Mile	Average Depletion Rate	Average Change in Saturated Depth
Scenario 1: Current practice	- $150,000	30.6%	-53.9 feet
Scenario 2: All center pivot	- $206,000	19.3%	-33.1 feet
Scenario 3: Water reduced 50%	- $337,000	-8.8 %	11.9 feet
Scenario 4: Crop yield reduced 10 %	- $268,000	-2.1%	2.2 feet
Scenario 5: Water for corn reduced 50%	- $234,000	1.7%	-3.8 feet

[1] Net present value
Source: Gilson, et al., 2001

Under the first scenario, the average depletion rate would be 30.6 percent for the twenty-year period, and the average saturated depth would drop by 54 feet. In this scenario (current practice), corn accounts for 45 percent of total irrigated acres.[3] Table 3 summarizes the findings for the five scenarios. Current practice has the smallest impact on the economy,[4] but it has the greatest impact on the aquifer. Continuing business as usual is sometimes called "planned depletion," although there is precious little planning involved. Planned depletion is the explicit admission that at some future point it will no longer be economically viable or hydrologically possible to pump large volumes of water for irrigation (SWKGMD, 1999). When the aquifer is depleted, of course, depends on the saturated thickness of the aquifer under a particular piece of land.

Scenarios 1, 2, and 5 reduce the average saturated thickness of the aquifer, although scenario 5 achieves near-zero depletion. Scenarios 3 and 4 actually halt depletion, withdrawing so little water from the aquifer that the saturated thickness grows. Allowing the aquifer to recharge, however, has the greatest economic costs of the five scenarios. There is, in these five scenarios, a

[3] Only two irrigated crops, milo and alfalfa, are currently profitable for farmers in the region. Noting that, the researchers comment, It is hard to see how water can have a positive economic impact on the region (p. 36). Dryland farming, confined feeding, and livestock might subsidize irrigated crops for the farmer, but the primary reason irrigated agriculture is profitable is due to public policies that support agriculture: favorable tax policies and government subsidies. The Docking Institute estimated these government subsidies to be 88 percent of the value of crop revenues. In other words, for every dollar a farmer earns selling irrigated crops, he receives 88 cents in tax breaks or subsidies from the federal and state governments. The policy implications of this finding will be discussed below.

[4] The study used a time frame of twenty years, beginning in 1998. At its simplest, net present value is a technique for estimating future expected cash flows (revenues minus expenses) in terms of current dollars. The discount rate used in the study was 12 percent, an amount equal to the average long-term rate of return from equity investments in the United States. Due to the recent history of equity markets, the discount rate may be somewhat overstated. A smaller discount rate would make the average net present value of water used for irrigation per square mile substantially lower.

clear trade-off between preserving the aquifer and the economy of the area. However, a planned depletion strategy merely forestalls the economic consequences to a later date when all of the water is effectively used up.

Scenario 5 suggests that changing to center-pivot irrigation and reducing the water for corn irrigation by 50 percent can achieve near-zero depletion. The researchers assume a 50 percent reduction in water would result in a 10 percent decline in corn yields, an assumption that is questioned by some in the Kansas Department of Agriculture who think it is too low (personal communication, 2003). Nevertheless if the assumptions of Scenario 5 are accepted, the average net present value per square mile of land would decline by $84,000 or 56 percent from current practice (i.e., the difference between -$150,000 and -$234,000). The cost of saving the Ogallala aquifer could be transferred to the residents of the region in terms of diminished economic activity, or public subsidies could be increased to recoup some or all of the losses.

Using a different economic impact model and focusing on another section of the Ogallala aquifer, Terrell and Johnson (1999) estimated the impact of depletion on the southern high plains of Texas. Their model used a 25-year planning horizon and a dynamic optimization model, which suggests that producers will change their behavior to optimize net income in the face of changing circumstances. One of the inputs to the model was the unit cost of pumping water as a function of pumping lift and well yield. The costs of pumping increase as the aquifer is depleted.

The average decrease in saturated thickness for this portion of the Ogallala was estimated at 18.1 percent over the 25-year period, while the costs of pumping increased by 8.2 percent (in constant dollars) across the region. The researchers concluded:

> The results of this study support the conclusion that as the saturated thickness of the Ogallala aquifer diminishes and pumping lifts of irrigation wells increase, the regional cropping patterns will begin to shift toward more dryland agriculture. As water availability decreases, farmers will reevaluate their traditional cropping patterns. When faced with reduced water availability, the results indicate that the optimal solution for producers will be to shift their focus to those crops that utilize

> less water during the growing season, and to adopt the most efficient irrigation technologies (pp.10-11).

Because the preferred crop of the future in this analysis was cotton, the researchers noted that the reduction in feed grain production would result in declines and possible closures of regional feedlots and meat processing plants. The researchers also observed that even at optimal levels of production, alternative crops (predominantly cotton) would produce a lower level of regional economic activity, affecting employment and household consumption patterns.

The Docking Institute study proposed that producers change their water use patterns to save the Ogallala aquifer; the Terrell and Johnson study suggested that the costs of pumping water as the saturated thickness declines would force producers to select more water-efficient crops. Both studies imply that water use can be reduced to levels that allow the aquifer to recharge sufficiently to support agriculture on the Great Plains for many years into the future. But any change in water use, they say, will come at a price.

An Alternative View

Being forced to choose between saving the Ogallala aquifer and, for a time, maintaining economic activity in the region may be a Hobson's choice, where no alternative is satisfactory. Some however—let us call them the market optimists—believe that the invisible hand of the market will provide the solution. Some producers will shift to crops that demand less water as the costs of production and profits shrink. In response to demand, seed producers, and the geneticists they employ, will create new genetically modified organisms that are more drought resistant than current varieties of seed crops. More efficient irrigation technologies will be developed that lower lift costs and reduce the amount of water that evaporates into the air before it ever touches the ground.

Others—we will call them the post-agricultural pioneers—believe that there can be economic and social life after agriculture ceases to be the primary engine of human activity in the Great Plains. Water for domestic purposes is far below the amount needed to recharge the Ogallala aquifer. The population of most counties in western Kansas has declined in every Census year since the 1930s. The Great Plains, of which Western Kansas is a part, have become so depopulated that Frank Popper, a demographer from Rutgers University has, with only the slightest amount of irony, suggested that the region be turned into a giant theme park called Buffalo Commons.

Popper's view of returning the Great Plains to nature is popular among a group of conservationists, but it is short-sighted in that it simply extrapolates forward current population trends and speculates that at some future point there will be no sustainable communities left in the region. But, this does not account for the dynamic effect of changing incentives.

At the same time the Great Plains have been emptying out of people, the "teeming masses" who live in the coastal areas of the country have become more teeming. By 2000, approximately 50 percent of the population of the United States lived within 50 miles of an oceanic beach (including the Gulf of Mexico). This concentration of population has implications for the health of the environment and the health of people. One example is housing. Housing is becoming increasingly unaffordable for low- and middle-income families in cities. For example, families with median incomes can afford only 51.3 percent of homes in Boston, 42.1 percent in New York, 40.2 percent in Los Angles, and only 10.3 percent in San Francisco (Lind, 2003). The post-agricultural pioneers say, "The heartland needs people and many Americans on the coasts need affordable housing. Why not bring them together?"

The post-agricultural pioneers suggest financing the relocation, or homesteading of families, in part by phasing out the $2 billion in annual irrigation subsidies to western farmers. What would the "homesteaders" do to support themselves if agriculture is not practical? The predominant model for the future of the Great Plains is not a continuation of its 19th Century agricultural past, but a high-tech industrial future:

> Rural Kansas will never be as scenic as San Francisco or as crowded with libraries as Boston. But a post-agrarian heartland would be a nice place to live for the children and grandchildren of many of today's struggling costal families. Fortunately, most jobs in the service industry can be performed anywhere. By the middle of the twenty-first century the archetypal Plains dweller might be a telecommuting professional (Lind, p. 88).

Citing the U.S. Geological Survey, one of the pioneers writes that the same amount of water that supports a sixty-acre alfalfa farm with only two workers could support a semiconductor factory with 2,000 workers (Lind, 2003). A view held by some others is that the economic shortfalls that come from water depletion will be so devastating to the economies of rural areas that the federal government will have no choice but to intercede with greater agricultural subsidies. Federal dollars will replace lost revenues and underwrite additional costs associated with agricultural practices that conserve water. More than an economic issue, this is a political one. Will the other parts of the country agree to transfer wealth to Kansas to maintain a way of life that is in decline?

On March 12, 2003, Senator Sam Brownback introduced the New Homestead Economic Opportunity Act (S.602). Twelve Senators, half of them from Great Plains states, joined Senator Brownback as co-sponsors of the bill. The legislation provides:

- Repayment of up to 50 percent (up to $10,000) of college loans for recent graduates who live and work in a qualifying county (non-metropolitan area which has lost population of at least ten percent in the last 20 years).
- Tax credits of $5,000 of the purchase price of a qualified residence in a qualifying county.
- Creation of tax-exempt individual homestead accounts for higher education or medical expenses, first-time homebuyer or business capitalization costs, and rollovers.
- Offers new incentives for businesses to expand or locate in high out-migration areas, such as rural investment tax credits and micro-enterprise tax credits.
- Establishes a new $3 billion Homestead Capital Fund to promote business development in high out-migration areas.

In addition, Senator Brownback is an original co-sponsor of the High Plains Aquifer Hydrogeologic Characterization Mapping, Modeling, and Monitoring Act (S.212). The purpose of the act is to provide scientific data that can be used by policymakers in “assessing issues relating to ground water depletion and resource assessment of the aquifer.” In a March 6, 2003 press release, Senator Brownback said, “S.212 is another in a series of steps that I have been involved with in the preservation of the Ogallala aquifer. This kind of scientific data has not been collected comprehensively across the aquifer in over 20 years. This type of data is important so that we can accurately aim our efforts at preserving the Ogallala.” Clearly, Senator Brownback is interested in “preserving the way of life dependent on the Ogallala,” but when it is completed in 2011, the news from the project enabled by S.212 may not be good for agricultural interests in western Kansas. Accordingly, he is taking the beginning steps to create an economy in western Kansas that is not as dependent on water for its survival.

•••

Is ground water depletion a health concern? If health is considered in its broadest sense, to include economic, social, and aesthetic well-being, then certainly, depletion of water resources in the western part of the state poses a serious threat to the well-being of those who depend on the agriculture and livestock-based economy of western Kansas. Reduction of ground water levels also generates additional environmental consequences, such as increased concentration of water contaminants and loss of surface water.

If health is considered more narrowly, however, to include only issues directly related to physical well-being, the importance of ground water depletion as a public health concern is less obvious. The most onerous health consequence of diminished water resources, of course, would be a scenario in which people are expected to have insufficient water for drinking and other personal uses, which is not the case in western Kansas. Only a tiny fraction of the millions of gallons pumped daily from the Ogallala provides water for human use, an amount that should continue to be available for many years to come. Another direct health concern would relate to whether the increased concentration of pollutants that can result from diminished quantities of ground water might generate health risks due to human or animal consumption of specific contaminants. As discussed later in this report, a number of contaminants that can pose a risk to human health do, at times, exceed allowable levels in public drinking water obtained from the Ogallala. These problems are infrequent, however, and can generally be managed with improved treatment procedures.

Thus, depletion of ground water resources in western Kansas does not appear to pose a *direct* health threat of great magnitude to people in the area. Answering the larger question of whether aquifer depletion is fundamentally a health issue, therefore, depends on the extent to which maintaining an agricultural economy and way of life in western Kansas is considered a health concern in its broadest sense, or, more narrowly, as primarily a social and economic concern.

WATER QUALITY[5]

> "Ever since the fort's [Fort Riley's] foundation, the efforts of its occupants have constantly been to find some other source of water supply than the Kaw. It is one of the nastiest rivers that I know of, being the natural sewer of an immense agricultural district… and draining innumerable pig farms."
>
> *Captain George Pond*
> *U.S. Army quartermaster, Fort Riley, Kansas, 1886* (Dobak)

> "After a while my cows will wander over there and stand in the shade and crap in that stream bed. And when we get a good rain it'll wash in to the Solomon, and in a few days it'll reach you in Kansas City."
>
> *Jim Scharplaz, Central Kansas rancher*
> *"The Kansas Ag Industry Dumps All Over Efforts to Clean Up the State's Water." Pitch Weekly, August 9, 2001*

There are a number of different issues to consider in assessing the quality of water in Kansas and its potential to affect the health of Kansans. Most pressing is the question of whether there are contaminants that may pose a threat to human health in the water with which we have direct contact—our public water supply. Other important questions can be posed concerning the extent to which our streams, lakes, and ground water may be polluted with substances that pose a threat to health. The most immediate health threats posed by contamination of "source water," or the sources that provide water for human use, would be contaminants that are not effectively removed in plants that treat our public drinking water, those present at levels high enough to cause diseases through surface contact during recreational activities, and those that contaminate fish that will be consumed by humans. Other areas of concern relate to contaminants that may disrupt the ecological balance in source water, but are not thought to pose any direct threat to human health.

Despite the clean-up successes resulting from the Clean Water Act, contamination of Kansas rivers and streams has fostered controversy and acrimonious debate in recent years. In its 2002 annual report, the nonprofit American Rivers Foundation identified the ten most endangered

[5] Pages 26 to 40, with the exception of the discussion on Senate Bill 204 and the section on children and vulnerable populations, were written by Lea Steele and were contained in the interim report, March 3, 2003.

rivers in America (American Rivers, 2002). Two of the top four endangered rivers identified—the Kansas and the Missouri Rivers—flow through Kansas. The report stated that the Kansas River is "festering under a load of livestock manure" and that "documents filed by the state with EPA indicate that 81 percent of the state's surface waters are impaired by pollution." Press coverage of this announcement included a dispute of the report's accuracy by KDHE's Director of the Division of Environment, who noted that the levels of fecal contamination in the river have steadily decreased in recent years.

SENATE BILL 204

The debate over agricultural sources of water contamination in Kansas became contentious in 2001, with the introduction and passage of Senate Bill 204. Governor Graves signed the bill over the public opposition of the sitting Secretary of Health and Environment. The bill was a response to a lawsuit brought by the Kansas Natural Resource Council and the Sierra Club against EPA for failing to enforce state water quality standards mandated by the Clean Water Act. On May 19, 2000, Judge John W. Lungstrum entered a consent decree in which EPA agreed to publish proposed regulations to correct Kansas's remaining deficient water quality standards. The proposed rules were published on July 3, 2000. Consistent with the Clean Water Act, EPA should have promulgated final rules within 90 days of their proposal. EPA did not.

The 2001 state bill reclassified 1,456 water bodies in the state from "primary contact recreation" bodies to "secondary contact recreation" bodies, which are exempt from the standards of the Clean Water Act. Citing more than 2,000 written comments on its proposed water quality rules for Kansas—most of which were critical of EPA's proposed primary contact recreation use designation for the 1,456 bodies of water—EPA stated that many of the bodies of water may have been improperly designated. However, because Kansas failed to perform the necessary analyses supporting the lower designation, EPA was unwilling to change—or implement—its proposed rule.

On March 26, 2001, KDHE and EPA developed a memorandum of understanding that set a schedule for the state to perform use attainability analyses for the 1,456 bodies of water. The analyses and resulting modification proposals were subject to annual deadlines ending on July

14, 2006. The lawsuit filed by the Kansas Natural Resource Council and the Sierra Club against EPA was decided in federal district court on March 31, 2003, and preempted the KDHE-EPA agreement. Judge G. Thomas VanBebber ordered EPA to issue final rules in response to the comments it received on the proposed July 3, 2000 rule on or before June 30, 2003. As a consequence of the decision, the law created by Senate Bill 204 is void. The court stated that it "realizes that this order may result in bodies of water being given a primary contact recreation designation when a use attainability analysis might rebut such a designation," but that the plain language of the Clean Water Act limits the options of the court. For Kansas to remove the primary contact designations, KDHE must conduct the use attainability analyses and resubmit water quality standards to EPA.

The first step in that process has already been completed. The U.S. Geological Survey completed an assessment of median flow rates in all 2,232 Kansas stream segments on the Kansas Surface Water Register in January 2003 (Perry, Wolock, and Artman, 2003). The assessment determined that, depending on the years for which flow records were used, 30-40 percent of Kansas stream segments would no longer be regulated (average flow rates of less than one cubic foot of water flow per second), and thus not subject to Clean Water Act standards. An interactive map documenting this study can be found at: http://ks.water.usgs.gov/Kansas/studies/strmstats/index.shtml. The red stream segments are those with average flow rates of less than one cubic foot of water flow per second. One can obtain a county map by clicking on a county; the county map shows all streams occurring in the county. By placing the cursor on a stream in a county, the viewer can obtain statistics about the stream. Note that most of the red stream segments on the state map appear in the western half of the state. Some of the smaller streams are dry for portions of the year.

WHAT ARE THE MAJOR CONTAMINANTS OF CONCERN IN KANSAS WATER?

Every two years, the Kansas Department of Health and Environment provides a summary of the state's surface water monitoring activities and water standards violations, the Kansas Water Quality Assessment Report (305(b) report) (KDHE, 2002b). In 2002, 19,827 miles of streams and 188,487 lake acres were monitored. According to the 2002 report, 76 percent of the stream miles monitored did not meet standards for all uses for which they had been designated, and 77 percent of total lake acres were impaired for at least one designated use. This means that, between 1998 and 2001, about three quarters of the surface water in Kansas was in violation of at least one water quality standard applicable to each specific stream or lake. The proportion of streams that did not meet required standards established for sources of domestic water supplies was much lower, where 38 percent were reported to have identified violations. However, 68 percent of lake acres used for domestic water supplies were found to have water quality problems indicating “nonsupport” or only partial support of their use for public water systems. According to the 2002 report, these findings reflect improvements in surface water quality brought about by stringent permit limits and improved wastewater treatment facilities.

In streams, the majority of standards violations were due to sulfates, fecal coliform, organic pollutants, and chlorides. The primary sources identified for these pollutants were agriculture (both crop production and livestock operations), natural sources, municipal point sources, and ground water withdrawal. In lakes, the most frequently identified problems included sedimentation, turbidity, excess nutrients (nitrogen and phosphorous), and taste and odor problems. Excess levels of nutrients in lakes produce a problem called eutrophication, the enhanced growth of plants and algae. About 12 percent of lake acreage in Kansas was found to be undergoing measurable eutrophication. Among lakes used for domestic water supplies, the major problems identified were eutrophication, and contamination by atrazine, chloride, and sulfates. The main sources of lake pollution identified in the report included agriculture and municipal point sources.

High levels of nitrates accounted for about 85 percent of the identified drinking water standards violations identified in ground water. Additional isolated areas of concern in ground water quality included volatile organic compounds, heavy metals, petroleum products, and bacteria. The major sources identified for these contaminants were industrial facilities, spills, leaking storage tanks, mining, and agricultural activities (KDHE, 2002b).

CONTAMINANTS IN KANSAS PUBLIC DRINKING WATER SYSTEMS

Although most Kansas streams and lakes do not meet federal water quality standards, the most direct threat posed to the health of Kansans comes from water contaminants in the water we drink and in which we bathe. Most Kansans obtain their water from public water supplies and drink water that has been processed in water treatment plants, which remove the majority of water contaminants before they reach our homes and offices. The majority of public water systems in Kansas are very small, with fewer than eight percent serving 1,000 or more people.

According to KDHE's 2001 Annual Public Water Supply Compliance Report, of the 1,099 public water systems operating in Kansas, 259 (24 percent) incurred one violation or more during 2001 (KDHE, 2002c). This is similar to the 25 percent of public water systems nationwide reported by EPA to have had one or more drinking water violations in 2000 (U.S. EPA, 2002). Conversely, 76 percent of all public water systems in Kansas, serving 87 percent of Kansans, had no violations at all. The majority of drinking water quality violations cited in the 2001 Kansas report included problems associated with excess levels of fecal bacteria, nitrates, lead, copper, and disinfection byproducts.

Microbiological Contaminants

Although we generally think of human disease due to waterborne pathogens in the context of problems such as cholera epidemics in developing countries, studies conducted over the past decade have indicated that gastrointestinal conditions due to contamination of U.S. drinking water systems may occur far more commonly than had previously been believed (Lee, Levy, Craun, et al., 2002). Bacterial and viral contamination of water can come from a number of sources, but primarily comes from human and animal wastes. Most human waste in Kansas is processed by municipal wastewater treatment facilities. Although wastewater treatment problems have been greatly reduced in recent decades, water contamination by human sewage still occurs in some areas, due largely to improperly functioning wastewater treatment and septic systems and poor treatment during storm periods (KDHE, 2002).

However, there is still a great deal of concern in Kansas regarding contamination of water resources by animal waste, and excess levels of fecal bacteria is the most common violation of drinking water standards in Kansas. These excesses are not known to be associated with identified disease outbreaks, such as the much-publicized drinking water-related cryptosporidium epidemic that occurred in Milwaukee in 1993. But the extent to which microbial contaminants produce health problems in Kansas may be more difficult to determine precisely.

Despite regular monitoring for bacterial contaminants, it appears that some disease-causing pathogens can remain in drinking water even after chlorination and may be associated with endemic (as opposed to epidemic) levels of gastrointestinal illness. For example, a 1991 Canadian study of households using municipal tap water that met all water quality criteria found that residents of households randomly assigned to have filters installed which eliminated microbial and chemical contaminants had significantly lower rates of gastrointestinal illnesses than residents of households without such filters (Payment, 1991). The results indicated that as much as 35 percent of gastrointestinal illnesses were due to water contaminants in treated municipal systems. Recognizing infectious disease cases due to water contamination can be difficult and typically requires an outbreak large enough that health care providers recognize the problem and report it to authorities. However, most cases of waterborne infection are thought to occur sporadically and remain unidentified.

The only pathogens that are routinely monitored in Kansas public water supplies are total coliform and fecal coliform bacteria. During 2001, 40 public water systems (four percent) reported exceeding allowable levels of coliform and/or fecal coliform.

Nitrates

Nitrogen compounds occur naturally in the environment and can find their way to ground and surface water from decaying plants and organic matter. However, the main sources of excess nitrates in water are livestock wastes and fertilizers applied to crop and grazing lands. High levels of nitrates in water pose an immediate threat to young children, causing methemoglobinemia, or “blue baby” syndrome, which can be fatal if untreated. In a number of studies, nitrates also have been associated with increased risk of different types of cancer (Barrett, 1998; Weyer, 2001). However, the epidemiological data for a nitrate/cancer connection is not conclusive, with increased rates shown in some areas and subpopulations, but not in others.

In Kansas, 28 (three percent) of the 722 water systems required to monitor for nitrates reported levels in excess of allowable standards in 2001. These violations were found only in smaller communities, with the largest town reporting excess nitrate levels being Hiawatha, Kansas, with a population of 3,417.

Lead and Copper

Exposure to heavy metals such as lead and copper has long been linked to adverse health effects in humans, particularly in children and infants. Both lead and copper can leach into drinking water from water pipes and solder joints. Lead exposure is associated with behavioral problems and decreased intelligence in children, and with impairment in red blood cell formation, anemia, kidney damage and hypertension in adults. Copper exposure is associated with gastrointestinal problems (Pizarro, 2001).

In Kansas, eleven of the 153 water systems required to monitor for lead and copper levels did not do so in 2001, and eight (six percent) of those that did monitor for these metals exceeded the maximum allowable levels for copper or lead. Additional levels of lead and copper, not measured by public utilities, can be introduced into water where it is used, for example, at drinking fountains or by household plumbing.

Chlorination Byproducts

In most municipal water systems, water is disinfected with chlorine or chlorine derivatives before it is released for public distribution. Chemical disinfection of drinking water has prevented countless cases of water-related death and disease, but it does not come without a price. The chlorination process can introduce unwanted chemical byproducts into treated water, the best known and studied of which are the trihalomethanes (THMs). EPA standards for THM levels were developed after consumption of chlorinated water was found to be associated with increased rates of bladder cancer in humans (Cantor, 1997). Studies also have found that chlorination byproducts may be associated with increased rates of rectal and colon cancer (Morris, 1995).

In Kansas, water systems that serve 10,000 or more people are required to monitor for THMs. According to KDHE's 2001 drinking water compliance report, of the 42 systems monitoring for THMs, three (seven percent) reported THM violations. No information is available concerning levels of THMs in smaller public systems.

Pesticides

Pesticides are used widely in Kansas and are routinely detected in Kansas streams, lakes, and ground water, although not usually at levels that exceed government standards. For example, Atrazine, a pesticide widely used for row crops such as corn and sorghum, is frequently detected in Kansas ground water, and it also has been found to exceed allowable levels during certain seasons in streams and lake water. In a recent report from the U.S. Geological Survey, 73 percent of shallow wells sampled in residential and commercial areas of Wichita were found to contain detectable levels of one or more of 47 pesticide compounds tested, and 50 percent of wells showed nitrate enrichment (Pope, 2002). Atrazine was the pesticide detected most often, found in 70 percent of the sampled wells. Although no compounds were found in concentrations that exceeded allowable levels, the presence of these pesticides was significant, since the areas studied had not been used for agricultural purposes for years.

The most urgent question, of course, is whether pesticides contaminate our drinking water. EPA currently has drinking water standards for 54 synthetic organic chemicals. From 1993 to 1995, KDHE required public water systems to monitor for a large number of pesticide and herbicide-related compounds. Only two compounds, atrazine and ethylene dibromide, were detected in any system during that period. As a result, public water systems in Kansas were required to test for only these two compounds at specified intervals between 1999 and 2001. None of the 272 water systems tested for atrazine or ethylene dibromide in 2001 exceeded allowable levels. However, 59 percent of samples taken did find detectable levels of atrazine. Levels of other pesticides in public drinking water systems have not been routinely reported since 1995 and are presumed by KDHE to be of little concern.

CHILDREN AND OTHER VULNERABLE POPULATIONS

It has long been known that some segments of the population are more vulnerable than most of us to the effects of biological and chemical water contamination. Although some drinking water standards and regulations have been established to allow for these special vulnerabilities, the degree to which specific populations are uniquely affected by different contaminants is not always precisely known (Howd, 2002).

Water contamination by biological pathogens is of particular concern for the elderly and people with impaired immune systems, such as those with acquired immunodeficiency syndrome (AIDS), cancer, or other chronic diseases. Infectious agents that are not adequately destroyed by water treatment methods would generally be expected to pose a greater risk for these groups. For example, a recent study found that AIDS patients who regularly consume tap water had nearly a 700 percent higher risk of diarrheal disease due to infection by cryptosporidium than patients who used other sources of drinking water (Aragon, 2003). The study covered a period of more than two years, during which time no cryptosporidium outbreaks had occurred in connection with the public water system. The organism apparently was present at levels high enough to cause infection in this susceptible population, however, and study results led investigators to recommend that persons with AIDS not consume tap water. Similarly, a recent report found that the elderly were particularly vulnerable to more severe disease during the 1993 cryptosporidium outbreak in the Milwaukee public water system (Naumova, 2003). Numerous studies have documented serious infections resulting from tap water exposure in hospital and surgical patients (Sniadack, 1993; Lowry, 1993).

The special vulnerability of children to chemical and biological water contaminants is a global health concern, especially in developing countries where water-borne pathogens cause widespread disease and death. Worldwide, children are the most common victims of diarrheal diseases, which account for 17 percent of all childhood deaths (United Nations Environment Programme, 2002). For example, children are more susceptible to cholera than adults, and untreated cholera-induced diarrheal disease is often fatal. According to a 2002 United Nations report, contaminated food and water lead to the death of 5,500 children each day (UNEP, 2002).

Water contamination by chemical pollutants also can have a more severe affect on children than on adults. The U.S. EPA's drinking water standards for lead, nitrates, and nitrites were all established based on the risks posed by these substances to children. Children's exposure to chemicals can begin before they are born, as substances are passed from the mother to the developing fetus (Whyatt, 2000). Several studies have found an association between drinking tap water during the first trimester of pregnancy and an increased risk of spontaneous abortion (Swan, 1998; Deane, 1992).

Biologically and environmentally speaking, children are susceptible to chemicals in ways that adults are not, that is, they are not just "little adults." Very young children consume substantially more food and water, on a pound per pound basis, than adults. Children under six months of age, for example, consume about seven times as much water as a proportion of their own body weight as the average adult (National Environmental Health Association, 1997). Children are also uniquely susceptible to the effects of toxic chemicals on growth and development. Biological systems such as the nervous and respiratory systems undergo rapid growth and development in the first years of life, and are particularly sensitive to the adverse effects of toxic chemicals (U.S. Agency for Toxic Substances and Disease Registry, 2002).

As with adults, some chemicals that contaminate water supplies are known to cause cancer in children. Studies have suggested links between childhood pesticide exposure and leukemia, neuroblastoma, lymphoma, and cancers of the brain, colorectum, and testicles (Zahm SH, 1998). Under recently proposed EPA guidelines, children aged two and younger are considered to have 10 times the risk of adults to carcinogenic chemicals, and children aged two through 15 are considered to be three times as vulnerable as adults (EPA, 2003a). Table 4 lists the possible effects of long-term pesticide exposure on children identified by the United Nations Environment Program, based on current epidemiological and animal research.

Table 4
Possible Health Effects of Pesticide Exposures on Children

- Abnormal growth and development, failure to develop normal organ function.
- Hormone disruption by chemicals that mimic, block, or abnormally stimulate hormone production.
- Impaired neurological development, resulting in reduced intelligence and behavioral abnormalities.
- Cancers, including leukemia, and tumors of the brain and kidney.
- Compromised immune systems and impaired response to infectious agents.

Adapted from United Nations Environment Programme (2002), *Children in the New Millennium: Environmental Impact on Health*, page 57.

Water contamination by lead is also of particular concern for children. Lead exposure during pregnancy, for example, can result in premature birth, low birth weight, or miscarriage (UNEP, 2002). Even at relatively low levels in the blood, lead can interfere with normal physical and mental growth and result in long-term reductions in intelligence (UNEP, 2002).

Water contamination by nitrates is a serious problem worldwide, and a frequent problem in Kansas rivers and streams. Excess nitrate levels also occur in some public drinking water systems in Kansas and are thought to be a common problem in private wells. As previously mentioned, the most serious hazard of excess nitrate levels is a condition called methemoglobinemia, or "blue baby syndrome." Children less than six months of age are most susceptible to this condition, associated with a reduced oxygen-carrying capacity in the blood.

Overall, the effects of water pollution—both chemical and biological—can generally be considered a more pressing problem for children than for the general population, since children are more likely to suffer adverse effects at lower concentrations of many water contaminants. It is not unreasonable to speculate that the risks posed by toxicants about which relatively little is known, such as newly emerging concerns regarding pharmaceuticals and endocrine disruptors in water sources, may also disproportionately affect children and other vulnerable populations.

HEALTH RISKS OF WATER FROM PRIVATE WELLS

Roughly 110,000 households in Kansas get their water from private wells (KSU Agricultural Experiment Station and Cooperative Extension Service, 1998). In rural areas, particular contaminants of concern are bacterial pathogens, nitrates, and pesticides. Septic tanks, farm chemicals, and livestock runoff all pose serious threats to private wells that are not structurally sound or are improperly located (U.S. General Accounting Office, 1997). Although Kansas has specific regulations regarding new well construction, private well owners are not required to test their wells or their drinking water. Studies indicate that a high proportion of private wells contain contaminants at levels much higher than those allowed in public water systems. For example, a 1994 study of domestic wells in nine Midwest states found that, on average, 60 percent of all wells sampled in Kansas did not meet safe drinking water standards (U.S. CDC, 1998). Forty-three percent of wells across the region contained coliform bacteria, 65 percent contained nitrates, and 14 percent contained the pesticide Atrazine. The Kansas Farmstead Well Survey found that wells containing high nitrate levels also were most likely to contain pesticides (Grosh, 1986; Powell, 1990).

WATER QUALITY CONCERNS IN LOCAL AREAS

In addition to statewide water quality issues, Kansas, like other states, is home to local areas of environmental contamination and accidents that can result in serious human health risks. In Kansas, these issues are handled by KDHE's Bureau of Environmental Remediation, which is responsible for evaluating the contaminated site and taking appropriate actions to protect public health (KDHE, 2002a). A specific area of concern for the Bureau are releases from underground petroleum storage tanks. In Kansas, about 2,000 such tanks have been investigated since 1990, requiring KDHE to improve water treatment or provide alternate water supplies for more than 124,000 Kansas residents (KDHE, 2002a). Mining activities—past and present—have also resulted in water contamination problems in some areas that can pose a threat to human health and safety. And solvents used by dry cleaners have produced serious water contamination problems in some areas and are now targeted for specific remediation measures by the state.

Superfund Sites in Kansas

In 1980, EPA developed the Superfund Program to identify toxic waste sites of serious environmental concern, and to prioritize them for cleanup and remediation. Under this program, sites determined to be of highest priority for cleanup are entered on the National Priority List. Seventeen Kansas sites have been put on the National Priorities List, five of which have subsequently been deleted (U.S. EPA, no date, a). All active National Priority sites in Kansas have been determined to pose a risk to local surface or ground water, with the type of water contamination and magnitude of risk differing from site to site. For example, a toxic metal, chromium, is known to have leaked into the Ogallala aquifer from the site of a now-closed chrome plating plant in Colby, Kansas. Toxic chemicals flow into the Kansas River in Johnson County from the former site of a private landfill. And heavy metals have contaminated surface waters near an abandoned mining area in Cherokee County near the Oklahoma border, resulting in the need to provide alternate water sources in some towns, and the permanent relocation of eleven families.

Perhaps the highest profile Superfund site in Kansas is the Sunflower Army Ammunition Plant site near DeSoto (U.S. EPA, 1995). The site covers nearly 10,000 acres, where the Army once manufactured powder and propellants for small weapons systems, as well as nitric and sulfuric acids. Investigations have identified 89 separate chemicals of concern in soil and water at the site, including hazardous substances such as mercury, ammonia, and arsenic in Kill Creek and local ground water. Future use and specific cleanup activities for the site are still being debated and negotiated among federal, state, local, and commercial interests.

LOCAL WATER CONTAMINATION PROBLEMS IN THE NEWS

Algae in Cheney Reservoir

From October 2002 through January 2003, Wichita residents were aware of an unpleasant smell and taste in their city water (Hays, 2003b). The problems were the result of an overgrowth of blue-green algae in Cheney Reservoir, which was, in turn, caused by high levels of phosphorous from agricultural run-off in the Cheney watershed (Pope, 2001). Algae blooms cause occasional problems at several state reservoirs, and typically last for a few days during warm summer months. The recent bloom at Cheney was uncharacteristically long, and it was the first to occur there in the winter.

Wichita officials said that, although the water smelled and tasted bad, it was safe to drink. City officials had tried to address the problem since 1994 by working with area farmers to reduce the amount of farm chemicals that wash into the lake. The city is now planning more direct (and costly) actions to minimize similar problems in the future by making plumbing changes at the water treatment plant and initiating testing of an ozone water treatment system, which has been useful in reducing taste and odor problems in other cities, including Emporia (Hays, 2003a).

Wells Contaminated at Former Missile Site

In October 2002, 26 private wells near a former military site northwest of Wamego, Kansas, were found by KDHE investigators to be contaminated with a toxic solvent, trichloroethylene, or TCE (KDHE, 2003). The site had housed intercontinental ballistic missiles in the 1960s, and TCE was used as a degreaser. Although wells at the missile site were known to be contaminated, the 2002 tests were the first to show contamination outside the property boundaries of the former military base. The current drinking water standard for TCE is five parts per billion, but samples from contaminated wells at the former base contained 247 parts per billion TCE. TCE is classified as a possible carcinogen and has been linked to liver damage and gastrointestinal problems. The area is currently being evaluated by KDHE's Superfund Unit to develop a cleanup plan.

EMERGING WATER AND HEALTH ISSUES

A number of water contaminants that are not routinely monitored for or removed from public drinking water supplies have begun to emerge as issues of concern in Kansas and around the country. These include the growing number and concentration of pharmaceuticals, hormones, and other organic chemicals that are finding their way into public water supplies. Such chemicals are rarely tested for and are often not readily removed by standard water treatment measures.

In 2002, the U.S. Geological Survey released a report that examined 95 such chemicals, which enter the water supply from wastewater and industrial sources (Kolpin, 2002). Tested compounds included substances such as antibiotics, natural and synthetic hormones, detergents, and insecticides. Eighty-one of the 95 chemicals examined do not currently have established standards for drinking water. Further, it is not known whether there are long-term health effects from repeated low-dose exposure to these substances. The report stated that steroids, non-prescription drugs, and a chemical found in insect repellants were most often detected in stream samples. Samples frequently contained mixtures of various chemicals, with seven or more of the compounds identified in half of the streams tested. While a great deal of additional information is needed to understand whether these substances may give rise to either short or long-term health problems, immediate questions have been raised concerning issues such as the growing problem of endocrine disruptors in animals and possible connections with antibiotic resistance in humans and animals.

Water quality issues in Kansas can be summarized as including both good news and not-so-good news. The majority of streams and lakes in the state contain, at least at times, levels of microbiological or chemical substances that exceed federal standards. Despite steady improvements in the decades since the Clean Water Act, there is still concern about the state of our rivers, lakes, and ground water. The sources of water pollutants are increasingly attributable to non-point sources—those not associated with individual locations and identifiable effluent pipes.

Although nitrates, chlorination byproducts, and bacterial pathogens continue to exceed allowable levels in some public drinking water supplies in Kansas, there is little evidence of widespread violations for chemicals that are routinely monitored. This suggests that, for the most part, Kansans served by public water systems can have confidence that their water does not pose risks to their immediate or long-term health. Identified health threats due to water quality are largely limited to problems found in specific locations resulting from specific contamination problems. Still, a number of unanswered questions regarding water quality and health remain. These questions relate largely to contaminants that are not currently tested for or for which health effects are currently unknown.

The “big unknown” in water quality and its effects on human health is whether water from private wells, used by one in ten Kansas households, poses a health risk. This water is not monitored or regulated, and studies show that a large proportion of these wells may contain bacterial and chemical contaminants at levels that can far exceed those allowed in public drinking water systems. Another area of potential concern relates to contaminants such as THMs that can pose serious health risks, but are not currently monitored in smaller public water systems, which serve the majority of Kansas communities (but not the majority of the population). It is also unknown whether the large number of chemical compounds such as hormones and pharmaceuticals, which are increasingly identified in water sources but are not specifically tested for or filtered out by public water systems, may pose additional health risks. And very little is known about the extent to which mixtures of contaminants can affect human health.

WATER SECURITY

Water security has always been an issue for suppliers of public drinking water. Efforts to protect the public against contamination through vandalism, sabotage, and criminal mischief, however, have become a greater concern since the events of September 11, 2001. Water security is intrinsically linked to the campaign against bioterrorism. The Bioterrorism Preparedness and Response Act of 2002 requires water systems serving more than 3,300 persons to:

- Conduct vulnerability assessments
- Certify and submit a copy of the assessments to EPA
- Prepare or revise emergency response plans that incorporate the results of the vulnerability assessment
- Certify to EPA, within 6 months of the assessment completion, that the emergency response plan has been created or revised.

Ninety-three percent of the public water systems in Kansas serve fewer than 3,300 people, and therefore, are exempt from the Bioterrorism Preparedness and Response Act of 2002. However, KDHE has prepared a simplified assessment tool for these small suppliers to help them perform vulnerability assessments on a voluntary basis. Fortunately, the vast majority of Kansans are served by larger systems. The six largest water systems in the state serve approximately 70 percent of the population. Water systems that serve larger populations are on a more accelerated implementation schedule for the Bioterrorism Preparedness and Response Act of 2002. Table 5 shows the timetable for the required items.

Table 5
Emergency Response Planning Timetable

Systems serving a population of:	Certify and submit vulnerability assessment by:	Certify emergency response plan no later than:
100,000 or greater	March 31, 2003	September 30, 2003
50,000 - 99,999	December 31, 2003	June 30, 2004
3,301 - 49,999	June 30, 2004	December 31, 2004

Source : www.epa.gov, Water Infrastructure Security section, 2003

Vulnerability assessments are intended to help water systems evaluate their susceptibility to threats and to identify ways to reduce or mitigate the risk of serious consequences of untoward actions. Assessments are designed to take into account water supply, transmission, treatment and distribution systems, as well as risks to the surrounding community. The basic elements of the vulnerability assessments are:

- Characterization of the water system, including organizational mission and objectives
- Identification and rating of adverse consequences to avoid
- Determination of critical assets that might be subject to malevolent acts that could result in undesired consequences
- Assessment of the likelihood (qualitative probability) of such malevolent acts
- Evaluation of existing countermeasures
- Analysis of current risk and development of an organized plan for risk reduction

To date, KDHE has focused its efforts on assisting all suppliers to update their emergency plans. It is important to have emergency plans in place regardless of whether a utility is vulnerable to a terrorist attack. The Water Bureau notes that emergency plans are virtually the same for all types of emergencies whether they are intentional (e.g., terrorist attack) or natural (e.g., tornado). For instance, both an explosives attack and a tornado could disable a water supply system, which could affect water availability both for drinking and fighting fires.

The costs associated with preparing and implementing the emergency response plans can be considerable. According to the *Boston Globe* (March 6, 2003) the estimated cost for the vulnerability assessment alone for towns under 100,000 is about $1,000 per 1,000 people. This estimate will vary significantly depending on location and system characteristics. EPA has made money available to systems serving over 100,000 people (there are four of them in Kansas out of 1,099 water systems) to do assessments. Larger systems often hire professional consultants and engineers to help them with their assessments.

Federal money has not yet been appropriated in the form of grants to smaller systems, although a bill (H.R. 866) is wending its way through Congress to do just that. Although EPA has not given grants to smaller water systems, it is working with the National Rural Water Association and other organizations to provide training, assessment tools, and technical assistance to allow smaller water systems to assess vulnerabilities and identify steps to address them. EPA regional offices are holding local workshops and providing information to small systems.

A survey conducted of its members by the Kansas Rural Water Association in October 2002 asked the question, “What has your water system done to improve security?” Responses were as follows: 33 percent said they did not know where to start; 66 percent had completed an assessment and have started to make changes. The response rate for the survey is unknown; readers, therefore, should be cautioned that generalizations from the survey may be misleading.

In addition to completing their vulnerability assessments and emergency plans, water systems are undertaking a variety of activities to address vulnerabilities and to prepare for emergencies. Understandably, KDHE and local water suppliers are reluctant to give out specific details of their preparedness activities. Nevertheless, they are preparing for a variety of threats: biological, chemical, and destructive (i.e., explosions that disable a plant). The following is a list of steps that plants have taken or are considering taking.

- Installing locks on doors, gates and other access points
- Installing security systems and cameras and hiring security guards
- Limiting access to facilities and controlling access to water supply reservoirs
- Communicating and coordinating with local law enforcement to increase surveillance and patrolling of utility property
- Securing access points to the distribution system, such as hatches, meter boxes, hydrants, and manholes

- Increasing lighting in limited staffing areas
- Controlling access to computer networks and control systems
- Requiring advance notification of deliveries with specific information about materials being delivered and personnel doing the deliveries
- Training employees in all security measures, including those answering the phones, so they know how to handle a threat if one is called in
- Developing strict access, parking, and delivery procedures for contracted and service people
- Developing access requirements for cellular phone companies
- Conducting background checks on new hires
- Developing neighborhood watch groups for facilities located in residential areas
- Varying timing of operational procedures
- Practicing emergency procedures
- Reporting any illness in customers that might be associated with water supplies
- Reporting any threats, suspicious behavior, or attacks to law enforcement immediately

To aid in reporting tasks, a new resource is available for those in the industry to communicate with each other about threats and activities and to obtain information from law enforcement, public health, and environment agencies. A Water Information Sharing and Analysis Center (Water ISAC) has been established under an EPA grant. It functions as an information clearinghouse for suppliers and water treatment facilities. The Water ISAC is a highly secure Internet portal that provides the best source for sensitive security-related information and alerts for providers. It is the single centralized resource that gathers, analyzes, and disseminates threat information that is specific to the drinking water and wastewater community.

In a relatively short period of time, most water systems in Kansas have begun to take steps to assure the safety of drinking water. This level of preparedness may never be tested by a bioterrorist, but the procedures that are put in place as a result of the plans will improve the response of water systems to natural disasters and acts of domestic sabotage.

CONCLUSION

Water in Kansas is a large, complex, and divisive issue. Despite the thousands of people in the state with a profound interest in water, very few make an explicit link between health and water. Certainly the chief administrators of water quality regulations within KDHE acknowledge the link, but they are trained as civil engineers and are not health experts. Environmental groups understand the linkage too, but a different sensibility informs their understanding; to them, poor health is a symptom of poor water quality, not the reason for improving it.

The shortage of water for agricultural purposes may have a profound effect on the economy of western Kansas in the coming decades. While there is a direct relationship between socio-economic status and health, the impact on health of the declining agricultural economy in the west is not entirely certain. One post-agricultural scenario for western Kansas has farmlands and economically undiversified communities emptied of people and returned to their natural state. Another scenario suggests that as agriculture declines in economic importance to the region, another economic sector will take it place. Under the first scenario, the would-be poor migrate to other places where jobs and services are available, possibly to regional communities where the economic base is more diverse.[6] This migration reverses any downturn in socio-economic status that may have occurred. Under the second scenario, the replacement of agriculture as the primary economic engine of the region will help maintain or improve the overall economic status of its residents.

Water quality is likely to have a more pronounced impact on the health of Kansans than water quantity. Nevertheless, the potential impact of water quality on health is not widespread, but is local and episodic. The aim of the vigorous water quality inspection system in place in Kansas is to protect the public by early detection and remediation of quality problems with the public water supply. Most water quality violations occur in small water systems serving small numbers of

[6] A period of transition will accompany this process of emptying out. During it, a tipping point will be reached when it is no longer possible to sustain locally available health services for those remaining in the area. The loss of health services may serve to accelerate flight from the area, exacerbating the problem of providing health services to those left behind, the elderly, the disabled, and those unable to move for other reasons.

users. None of these violations have resulted recently in reported episodes of serious illness or disease.

The greatest risk of contaminated drinking water comes from three sources. The first is danger from new contaminants in the water supply that are outside of the current regulatory umbrella and, consequently, remain undetected and uncorrected. The list of these, largely chemical, contaminants grows annually. Regulation and science seldom move forward in lockstep. The lag between them is a potential source of risk to the population.

The second risk to the health of Kansans comes from contaminated water in private wells. Although construction of modern wells in Kansas is regulated to reduce or eliminate contamination, a substantial number of wells were dug before the current regulations were enacted. These wells are a potential threat to the health of families who consume water from them. Wells—whether new or old—that tap contaminated ground water are potential sources of illness and disease. A system of continuous monitoring of private well water quality may greatly mitigate this health risk.

The third, and final, risk to drinking water contamination comes from a variety of sources: terrorism, accident, vandalism, and sabotage. Each of these sources introduces potentially harmful chemicals or biological agents into the water system that could harm the public's health. These are low-probability events, but because of their high cost in lives, health, and finance, they must be continuously guarded against. Enhancements to water security systems motivated by bioterrorism preparedness represent a substantial step forward in protecting the public's health. These efforts must be maintained and expanded to meet future threats, foreign or domestic.

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