Valuing Pennsylvania's Water Resources

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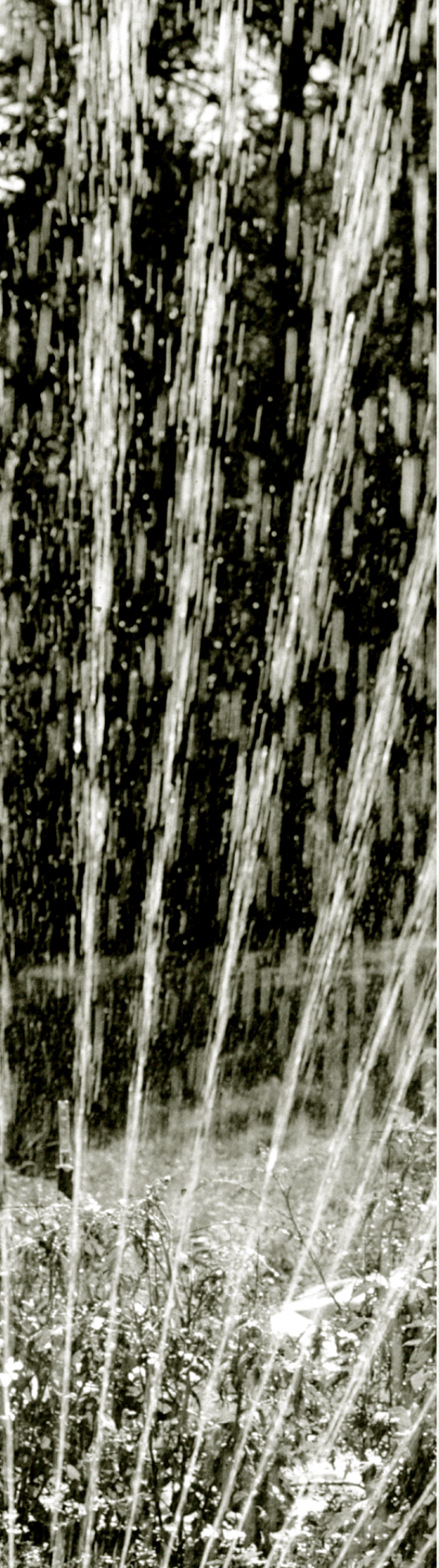


Table of Contents

Water's many uses

Children of a culture born in a water-rich environment, we have never really learned how important water is to us. We understand it, but we do not respect it.

William Ashworth, *Nor Any Drop to Drink*, 1982

Jennifer switched on the light in her dining room, picked up the evening newspaper, and sat down to eat her dinner of steak, potatoes, stewed tomatoes, and an orange. What do all these things have in common? They all require lots and lots of water—water to cool the equipment at a thermoelectric power generating station, water to grow trees and process the wood into newspaper, water for the cow and the meat processing, and water to grow the vegetables and the fruit. Did you realize the essential role played by water in many of the things you do and many of the products you use every day? In fact, about 2,500 gallons of water may have gone into growing and preparing Jennifer's meal. Water has many uses that go unnoticed and often are not truly appreciated.

Tap water in our country is almost always safe to drink; however, many people around the world don't have that luxury. Most people in the undeveloped world still lack running water in their houses. The generally high quality of drinking water in the United States is an important reason that Americans have lower medical costs and a longer average life span than residents of most nations.

The value of clean water as a community asset is not always considered in local or regional planning decisions. We usually think of an item's value in terms of money. But some things such as clean water are very difficult to put a price tag on. This is because the value of water stems from, among other things, ecological benefits such as wildlife habitat; aesthetic beauty; transportation services such as barge shipping; and recreational opportunities.

The quantity of water available to meet society's needs is another factor

in its value. Having too much or too little water often causes economic hardship, which indicates that the true value of water can be revealed in extreme situations. For example, although Pennsylvania is generally thought of as a water-rich state, seasonal droughts are quite common. Regional droughts were recorded in 1998 and 1999, and most parts of the state started the new millennium with a water deficit. Droughts could become more common with increased demands placed on our water supplies.

The opposite problem, flooding, has long been a serious environmental hazard in Pennsylvania. The statewide flooding in January 1996 and regional flooding in September 1999 from Hurricane Floyd are two recent examples of the severe damage that can be caused by floods. The 1996 storm cost the state and federal government $320 million (1996 dollars) in aid, and Floyd cost more than $26 million (1999 dollars) in aid.

Drought and flooding are extreme examples of how quantity, as well as quality, can affect the value of water. The issues of water quality and quantity promise to play an important role in Pennsylvania and world politics in the next millennium, and they are discussed in greater detail throughout this publication.

Objectives and organization of this publication

This publication is designed to educate members of watershed groups, public officials, businesspeople, water supply managers, and interested citizens about the many uses of water and the value of these uses and services to individuals and society. It begins with an overview of national and Pennsylvania water resources and a discussion of how these resources are managed in Pennsylvania. A second section, focusing on water valuation, discusses ways that water is valued and why the price of water is low relative to its value in different functions and uses. This section attempts to convey a greater appreciation for the generally high water quality in Pennsylvania and describes the true costs of some typical water pollution incidents. Final sections cover water quantity issues—including drought and flooding—and global water concerns. The overall goal of this publication is to motivate citizens, public officials, and businesspeople to make better decisions about water use and to express their preferences about water management to government officials.

1. Water Resources and Management

National water resources and uses

Most Americans are accustomed to having a safe and virtually endless supply of water at their fingertips. In 1993, daily water use in the United States averaged 370 gallons per person—more than 500 times the dietary need. This includes each person's share of water used to generate power and produce goods.

Although we consume a lot of water, our average usage on a national basis is decreasing. According to the United States Geological Survey, water withdrawals from surface and underground sources in 1995 declined by two percent from the amount withdrawn in 1990 and by 10 percent from that withdrawn in 1980. These reductions are attributed to more efficient water use, economic savings, regulatory requirements, and greater awareness about water conservation. The declines occurred despite a 16 percent increase in the country's population between 1980 and 1995.

Globally, however, fresh water is becoming increasingly scarce as needs, driven by an increasing population and an economic boom in many industrialized countries, grow faster than precipitation can replenish our supplies. The total amount of fresh water available is limited by its location relative to population centers, by Earth's climate, and by the costs of developing new sources.

Table 1. Percentages of Total Surface and Ground Water Withdrawn in Pennsylvania (1995) for Various Uses

Water Use	Total Surface and Ground Water Withdrawal in Pennsylvania (1995) (Billion Gallons per Day)	Percent of Total*
Thermoelectric power generators	5.9	61
Industrial/commercial	1.74	18
Public supply	1.55	16
Mining	0.29	3
Domestic customers	0.19	2
Agricultural	0.097	1

** Numbers do not sum to 100 because of rounding.*

Pennsylvania's water resources and uses

Pennsylvania is endowed with plentiful supplies of surface water and ground water, which is stored below ground between soil and rock particles. The state's surface water resources include 65,000 miles of streams and more than 2,400 lakes, reservoirs, and ponds. Approximately 47 trillion gallons of ground water lie in the soil and rock of our state. In an average year, 42 inches of precipitation fall to replenish our supplies.

However, there are many demands on Pennsylvania's water supply. In 1995, the total withdrawal of surface and ground water in Pennsylvania (Table 1) was about 9.68 billion gallons per day—although much of the water used by some industries such as power generators is

Pennsylvania's surface water resources include 65,000 miles of streams.

returned to the source directly after use. This is called a *nonconsumptive use.* The relative proportion of water devoted to different uses varies across the state and throughout the year. Domestic uses are largest in the crowded southeast corner of Pennsylvania. Mining requires disproportionately more water in the western part of the state. Demand for water tends to be greatest in the summer months when people water gardens and lawns and fill swimming pools.

Water management in Pennsylvania

The federal government, in partnership with the watershed states, created the Delaware River Basin Commission (DRBC) and the Susquehanna River Basin Commission (SRBC) to manage water interests in the eastern two-thirds of Pennsylvania and neighboring states. Although these interstate river basin commissions do not charge for surface or groundwater withdrawals, they do restrict the amount of water that can be removed without a permit or review.

In Pennsylvania, a lack of uniform and definitive water management laws hampers regional water planning and fails to encourage conservation. Private well owners pay nothing and do not have to meet any stipulations (such as a replacement requirement) for private groundwater withdrawals. A permit must be obtained for very large daily withdrawals; requirements differ depending on the region of the state. The Pennsylvania Department of Environmental Protection has guidelines for how private wells should be constructed (http://www.dep.state.pa.us/dep/deputate/watermgt/wsm/facts/fs2450.htm), but their implementation is not mandatory. A few counties, including Chester and Montgomery, have adopted their own standards for private well construction. Throughout the state, well drillers are supposed to provide the state Bureau of Topographic and Geologic Survey and the homeowner with a copy of the Water Well Completion report, but enforcement of the law is lax.

Pennsylvania's system of local government impedes regional water planning. The Commonwealth has more than 2,500 municipalities, all looking after their own interests. Some Pennsylvania counties have dozens of separate water authorities. Although water fails to obey political boundaries and constantly crosses jurisdictional lines, most water management decisions in Pennsylvania are made at the municipal level. Cooperation and resource sharing for water management are rare. Therefore, the impacts of development or regulation in one municipality can dramatically affect the quality of water in neighboring areas.

Increasingly strict water quality monitoring regulations are resulting in increased costs for water suppliers. Monitoring costs per customer are high for small water systems. If more municipalities and water authorities would work together, they could manage pollution and land use in their watersheds more effectively and reduce monitoring, personnel, and billing costs per customer. But many local officials are hesitant to cooperate because they fear a loss of autonomy or that their constituents' interests would be overshadowed by larger or wealthier municipalities. Despite these difficulties, increased cooperation among water managers could help them leverage limited resources, benefiting both consumers and the environment. The next section examines the many factors that affect how water is valued and explores why water is often underpriced despite its many uses and benefits.

2. Water Valuation

Water price vs. value: A paradox

Most U.S. households pay more per month for satellite or cable TV than they do for water. The average cost for water supplied to American homes by municipal water authorities is about $1.30 for 1,000 gallons. That's more than 7 gallons per penny. If you buy a gallon of bottled water at the grocery store, you'll pay about 75 cents in Pennsylvania, far less than for a gallon of milk. When the price of water is so low, people have little reason to conserve.

The prices of products sold in markets are a function of the interaction of supply (reflecting producers' costs) and demand (what consumers are willing to pay). Under certain conditions, these market forces work to determine a product's true value and allocate resources efficiently in an economy. Unfortunately, for products such as water and many other natural resources, the market does not reveal the true value of these goods. When actual monetary values are not available, decision makers often are forced to use available indicators of the use and value of the products. This is the case in water pricing. Economists have been developing and refining methods to estimate, for example, the value of water-based recreation, or the value added to industrial products by the use of water in processing.

Because of imperfect or nonexistent markets for water in much of the United States, its price does not account for all of its values to society. This is the paradox of water pricing. The price of water generally is based only on the costs incurred to provide drinking water to customers—the costs of pumping, treatment, and delivery, and the annual depreciation of the transmission and distribution equipment. But because water is essential for life, its real value to us is much higher.

The longer we ignore or distort ground water's value, the more overused, degraded, and misallocated the resource becomes. Without price signals or other indicators of value to help guide policy, we tend to devote too little attention and funding for resource management and protection of ground water.

National Research Council, *Valuing Ground Water: Economic Concepts and Approaches*, 1997.

Other factors affecting water valuation

Several other factors can affect the valuation of water. *Scarcity* imparts value to a commodity. Consider the value of a diamond versus the value of a one-gallon jug of tap water—several hundreds or thousands of dollars versus less than one penny. The world has a finite supply of diamonds, but here in Pennsylvania it may seem as though we could never run out of clean water. Where water is scarce, however, such as in the desert, its value increases because it is necessary for life. A person lost in the desert surely would choose a gallon of water over a diamond.

This relates to the next concept, *intrinsic value.* Intrinsic value represents the usefulness of a product. The intrinsic value of water is high because it can be used for many purposes. The intrinsic value of a diamond is low since it is useful only for its beauty and as a cutting tool. Because of other factors, however, intrinsic value does not always affect *market value*—the price paid by consumers—which is low for water and high for a diamond.

Of course, water *quality* affects its value. Ground water, which tends to be of higher quality than surface water, often is more useful for that reason. Also, the *use* to which water is put can create value. The same 1,000 tons of water can be used to produce 1 ton of wheat worth about $200, or it can be used in the computer industry to produce processors worth thousands of dollars. Although both uses are important, the latter use clearly creates greater market value.

Finally, *location* and *timing* can affect the value of water. In the eastern United States, groundwater tends to be available almost anywhere people want to use it, which keeps its value low. And water must be available *when* it is needed—we know from our experience with floods and droughts that too much water is as great a problem as too little.

Problems with water valuation

Water valuation is a complex process, and several problems arise when it is undertaken. First, people have different relationships with water that cause them to assign it different values. Many Americans feel that it is their birthright to use as much water as they choose. Others see it as a finite resource in need of protection. Some people experience almost a spiritual relationship with water and feel calmed by its presence. Native Americans value water for religious reasons, as the "lifeblood" of Mother Earth. Other people ask: why should we have to pay for something that falls from the sky? Each of these people probably would be willing to pay different amounts of money for clean drinking water or a pristine lakefront lot.

A second problem involves inefficient uses of water because of improper pricing. We know that we gain many benefits from clean water, including improved health and productivity, increased recreational opportunities and tourism expenditures, higher property values, and greater natural productivity of fish and wildlife. But because water often is priced well below its true value, it is sometimes used unwisely. For example, where water is very inexpensive (some of its values not accounted for), homeowners might wash their driveways with water from a hose. But if the price of water reflected all of its values, people might choose instead to use a broom to clean their driveways.

Another problem arises because the often irreversible nature of groundwater pollution, depletion, and land subsidence usually is neglected when people make decisions that affect groundwater. Many municipalities don't factor the costs of potential water quality degradation into decisions about where to allow new commercial development. For instance, a municipality might not take into account how the runoff from a new strip mall may affect the quality of water from a nearby well or a neighboring municipality's reservoir. The value of these natural resource losses would be considered only if all of the development's true costs to society were included in the developer's construction costs.

Quantifying the value of water

Access to water is so convenient in the U.S. that we seldom stop to think about the many services and benefits water provides every day. Table 2 lists some examples of benefits provided by clean water. This section discusses

Table 2. Some Benefits Provided by Clean Water

Benefit	Impact
Healthier consumers	Reduced medical costs Improved school and work attendance and productivity
Increased recreational use	Increased tourism expenditures More opportunities for outdoor recreation
Aesthetics	Higher property values Peace of mind More recreational use
Improved wildlife habitat	More sustainable ecosystem Greater natural productivity of fish and wildlife
Nutrient removal	Lower regulatory scrutiny Lower monitoring costs Reduced treatment costs
Enhanced community supply	Less susceptibility to droughts and floods Greater customer satisfaction

Adapted from National Water Research Institute, 1999

Pittston giardiasis outbreak: A case study

In 1983, an outbreak of the waterborne disease giardiasis occurred in the Pittston area northeast of Wilkes-Barre, Pennsylvania. According to a study conducted by Resources for the Future, a think tank in Washington, D.C., the outbreak cost the area between $23 million and $55 million. (All costs for this case study are in 1984 dollars.)

Giardiasis is caused by infection with *Giardia lamblia*, a waterborne microorganism usually transmitted by consuming water contaminated with fecal matter from infected humans or animals. Giardiasis causes prolonged, recurring diarrhea. In a few rare cases, hospitalization for dehydration may be necessary.

The presence of *Giardia* in Pittston's municipal water caused the Pennsylvania Department of Environmental Resources (DER, now the Department of Environmental Protection) to issue a boil-water advisory in December 1983 for about 25,000 households. Boiling water for a certain time kills the disease-causing microorganisms and makes the water safe to drink. By late winter, 370 confirmed cases of giardiasis had been reported to the state Department of Health. This made the incident one of the largest recorded outbreaks in the country at the time. By March 30, 1984, the boil-water advisory was lifted and the water for about half the affected houses was deemed safe to drink. In some areas, the advisory lasted almost 9 months. The exact source of contamination was never pinpointed, although the most likely cause was inadequate sewage treatment or infected animals such as beavers living in the reservoirs.

"The biggest problem was people always took for granted that when you turned on the tap, you were going to have safe water," said Mark Carmon, community relations coordinator for DER in Wilkes-Barre, in an area newspaper. "Nursing homes, hospitals, restaurants and bars, the average homeowner having to boil or buy water—it had a tremendous impact on the average citizen, businesses, and institutions . . . . It hit everybody. People were hopping mad, for good reason."

By surveying the 370 people with confirmed cases of giardiasis, researchers from Resources for the Future estimated medical costs for all residents covered by the boil-water advisory. About 6,000 people in the Pittston area experienced giardiasis-related economic losses. The median length of illness among the survey respondents was 30 days. Medical costs, including doctor, hospital, and emergency room visits; lab tests, medication, time and travel losses associated with medical treatment; and lost work time, work productivity, and leisure time amounted to about $5.6 million for the community.

The Resources for the Future study also assessed costs related to actions taken by area citizens to avoid drinking contaminated water. Citizens incurred these costs, called *averting expenditures,* while trying to avoid the illness. Averting expenditures were calculated from random telephone interviews of 50 people in the boil-water advisory area. Forty-six percent of the households either hauled or boiled water, so averting expenditures included costs such as gasoline and the value of lost work and leisure time spent securing water from other sources. The best estimate for these expenses was $518 per household throughout the episode, not including the aggravation and inconvenience of transporting water. Therefore, assuming that the responses given in the 50 random phone surveys were representative of the 25,000 households in the affected area, the total cost of averting expenditures for the area was $12.9 million during the outbreak.

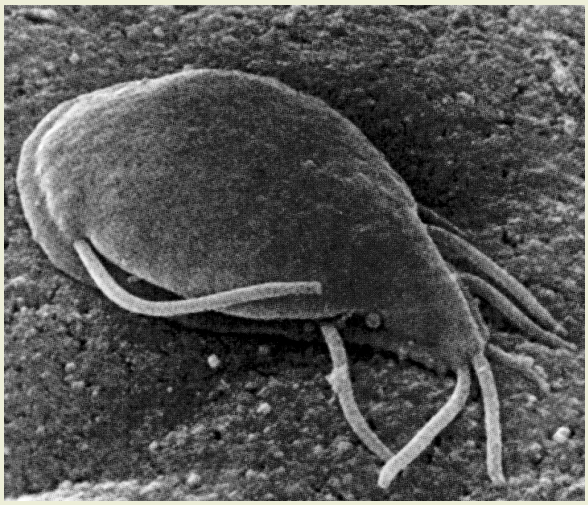


PHOTO: *MICROBIOLOGY*, PRESCOTT, ET AL. 1999. REPRODUCED WITH PERMISSION OF THE McGRAW-HILL COMPANIES.

A scanning electron micrograph of *Giardia lamblia.*

Business and utility costs of the Pittston giardiasis outbreak

Losses to businesses such as taverns and restaurants from the Pittston giardiasis outbreak were estimated at $3.6 million. This includes the costs of purchasing, hauling, and/or boiling water, and declines in sales during the period.

Direct losses to the water utility itself were estimated at $1.8 million. The utility paid an additional $45 million for three new water filtration plants for the contaminated source and other reservoirs in the supply system. The utility company was subject to extra monitoring requirements after the outbreak, adding costs in the form of lab materials and employee wages. The company also spent years trying to win back the public trust.

various types of water uses, the approximate monetary values of those uses, and how the values are determined.

Human health values

The generally high quality of drinking water in the United States means that Americans spend very little on medical costs related to waterborne diseases. Reliable potable water supplies help contribute to the long average life span in America and the high standard of personal health and productivity enjoyed by the average citizen. The case study discussed on page 9 provides a dramatic example of the tremendous costs involved with treating, avoiding, and rectifying an outbreak of a rather mild form of waterborne illness.

Consumptive use values

Off-stream or *consumptive use* removes water from a surface or underground source and does not return it directly to the source. Irrigation and industrial uses are two examples of consumptive uses of water.

IRRIGATION. Irrigation of farm crops accounts for two-thirds of global freshwater use. Irrigated lands cover almost 630 million acres of the planet and supply 40 percent of the world's food, although they account for only 17 percent of the world's cropland. Irrigation is essential to the food supply of most developing countries. About 40 percent of U.S. water withdrawals are for irrigation.

In 1992, less than 1 percent of Pennsylvania's farm land was irrigated. Still, irrigation consumed 16 million gallons of water per day in the Commonwealth in 1995. Irrigation in our area is most often used for high-value crops such as fruits. Little is known about the value added to these crops by irrigation; however, the value of water used for irrigation rises when it is applied during critical periods of plant growth such as germination, or during drought.

INDUSTRY. Water is essential to most industries (see Table 3 for a few examples). In 1995, Pennsylvania industries used 1.7 billion gallons of water per day, the fourth highest state total in the country. This large amount is influenced heavily by the kinds of industry common in the state. The paper industry, for ex-

The paper industry relies heavily on water, using an average of 14,000 gallons of water per ton of finished paper.

Table 3. Gallons of Water Needed to Produce Various Foods and Products

Product	Water Needed for Production (Gallons)
1 pound of sugar	14
1 pound of potatoes	23
1 pound of plastic	24
1 pound of oranges	47
1 pound of cotton or wool	101
1 pound of meat	5,000
1 gallon of gasoline	70
1 barrel of crude oil	1,851
1 new automobile (with 4 tires)	39,090
1 ton of steel	62,600

ample, relies heavily on water, using an average of 14,000 gallons of water per ton of finished paper.

Water is used heavily in Pennsylvania's large farming and food processing sector (Table 3). Producing one gallon of milk, including the water used in processing, sanitizing, and packaging it before it reaches your dinner table, requires about 900 gallons of water. It takes about 140 gallons of water to grow, process, cook, and package the grains required for one loaf of bread. Most fruits and vegetables have very high water contents. Cucumbers are 97 percent water; strawberries are 90 percent water. One tomato requires 8 gallons of water to grow and ripen.

The use of water in mining is tracked separately from other industrial uses. In 1995, mining companies in Pennsylvania used 252 million gallons of water per day. Much of this water was later returned to the source, although rarely was it as clean as when it was removed.

In-stream values

Water does not always have to be removed from its source to generate value. Recreation, transportation, aesthetics, and ecological services increase when water is left in place. These are known as *in-stream* or *nonconsumptive use* values.

RECREATION. The presence of a recreational water body can expand a region's economy and job base. The amount of money brought into Pennsylvania by water-based recreational opportunities is difficult to quantify and thus often overlooked in resource management decisions.

Whitewater rafting is an example of a water-based recreational activity that can generate income for a local economy.

The economies of Pennsylvania and several other states depend on the operation of the Port of Philadelphia complex, the largest freshwater port in the world.

Whitewater rafting is a kind of water-based recreation that stimulates local economies. In a ranking of the major eastern whitewater rivers by annual user days, the top two, the Lehigh and the Youghiogheny, are located in Pennsylvania. A research study by the U.S. Forest Service showed that for every 1,000 rafters on the Youghiogheny River in Maryland, more than $139,000 (1990 dollars) were pumped into the state's economy.

Another research study published in 1990 examined the use of the Upper Delaware Scenic and Recreational River in northeast Pennsylvania and the Delaware Water Gap National Recreation Area between Pennsylvania and New Jersey. The study showed that in 1986, river recreation generated total annual income of $5.6 million for the Upper Delaware and $3.2 million (1986 dollars) for the Delaware Water Gap. River recreation in these places generated 292 and 156 jobs, respectively.

TRANSPORTATION. In many parts of the country, water provides the least expensive way to ship freight. The Port of Philadelphia complex, which includes Philadelphia and four other cities along the Delaware River, is the largest freshwater port in the world and moves the second largest volume of international freight. The port complex transferred more than 7 million tons of cargo in 1997. The economies of Pennsylvania, the mid-Atlantic region, and the United States depend on the operation of the port and the products that pass through it.

ECOLOGICAL SERVICES. Aquatic ecosystems often support diverse populations of plants and animals. Besides the aesthetic value of these resources, this biodiversity provides people with many kinds of food. According to recent research led by scientists at the Center for Environmental Studies at the University of Maryland, estuaries—the coastal zones in which salt water mixes with fresh water—provide the most value of all the world's ecosystems, almost $23,000 per acre. According to an article in *Bay Journal,* published by the Alliance for the Chesapeake Bay, the Chesapeake Bay and the tidal portions of its major tributary rivers

provide services (including food production, flood control, recreational opportunities, etc.) worth about $29 billion per year. Most of that value comes from processes such as photosynthesis, in which plants transform raw nutrients into new growth. This new plant biomass then serves as food for fish and other aquatic life, creating value in human uses such as commercial and recreational fishing.

Commercial fishing enterprises rely completely on adequate water quality. The Great Lakes, the Gulf of Mexico, and other coastal areas annually produce 10 billion pounds of fish and shellfish. On the retail market, this is worth $42 billion in annual sales. Commercial fishing employs 250,000 people in the United States.

Ground water performs many important functions, even though it is hidden from view. Ground water sources supply about 40% of Pennsylvanians with drinking water; the percentage is even higher in rural areas where more people have private wells. Ground water also serves as a buffer against drought. Ponds and streams may dry up during a drought, but ground water levels are affected more slowly. Some municipalities may draw more heavily on ground water for drinking water during droughts.

The presence of ground water helps to support the land and the structures people build. Subsidence is the sinking of land caused by excessive weight on the surface, the removal of ground water that helped to support the soil, or inherent characteristics of the soil itself. Dramatic instances of subsidence due to ground water removal can be cited from around the world, although the problem tends to be most common and severe in arid areas. In Las Vegas, for example, whole housing developments have been condemned because of subsidence caused by the withdrawal of ground water faster than it can be replaced by rainfall and snowmelt.

The presence of ground water can stop intrusion of salty ocean water into ground water pumps. Saltwater intrusion can occur in coastal areas where ground water is withdrawn in excess of the rate that it is recharged by precipitation. Intrusion into a water supply makes the water undrinkable without extensive

Water holds a special attraction for many people. More than half of the U.S. population lives within 50 miles of an ocean, Great Lake, or major river. People spend millions of dollars to build houses with sweeping water views, even at the risk of periodic destruction from flooding and coastal storms.

Acidic drainage from abandoned coal mines can harm or kill fish and other aquatic life.

treatment. The Delaware River Basin Commission, a regional agency that represents the federal government and the states that share the basin, closely monitors the level of salinity in regional groundwater to guard against saltwater intrusion. During droughts, as water is drawn to wells from farther and farther away, the Commission occasionally has ordered the release of water from upstream reservoirs to drive salty ground water back towards the ocean and away from wells and water intakes. The Commission is studying the possible impacts on the salinity line of significant sea level rise due to global warming.

AESTHETICS. Land with a water view is nearly always more valuable, although the exact value of this amenity is difficult to quantify. According to the National Association of Home Builders, proximity to water raises the value of a home by an average of 28 percent. The 1991 American Housing Survey found that when other factors are equal, the price of a house located within 300 feet of a water body is up to 28 percent higher than more distant houses. An earlier study conducted at Penn State found that water quality improvements significantly lifted the price of riverfront and streamfront land in Pennsylvania. A one-point increase in the water's pH (one indicator of the health of a stream) brought the average sale price of a waterfront home up by nearly 6 percent. This was equal to $654 (1979 dollars).

Public awareness of the value of water

The average American citizen is not well informed about water quality issues. A 1990 poll of Ohio and West Virginia residents found that 21 to 30 percent of respondents could not name a single important water quality issue in their state. However, many environmentalists and scientists rank the assurance of adequate clean water supplies as one of the country's most important environmental problems.

Penn State research concluded in 1994 showed that public concern for water quality is high in comparison to other environmental problems, but of lesser importance when considered along with other social and economic problems. Although the public consistently expresses support for tough

water quality standards and enforcement, the research showed that most people express little willingness to modify their behavior (such as by driving less to reduce water pollution from roadways) or to incur costs to help solve water quality problems. There is a disconnect between expressions of concern and motivation to make changes in personal behavior and public and business decisions. Threats to water quality are viewed as serious, but not as likely or threatening as other kinds of problems. As high-quality water becomes more scarce, or in the wake of a high-profile water contamination incident, people are more likely to take an interest in water. Readers should consider taking proactive approaches to protecting their surface and ground water supplies before serious contamination occurs.

Watershed management vs. pollution cleanup

Evidence is mounting that pollution prevention can be less costly than cleaning up environmental contaminants. Besides being expensive, disruptive, and time-consuming, many pollution cleanup methods are unproven or unperfected. Following are two examples of how costly solving water pollution problems can be.

Acidic drainage from abandoned coal mines affects the water quality in more than 2,400 miles of Pennsylvania streams. This drainage can harm or kill some kinds of fish and other aquatic life. The Pennsylvania Department of Environmental Protection estimated in 1996 that it would cost $5 billion to eliminate acidic mine drainage in the state. Many of the previously mined lands in the state have been abandoned by the companies that mined them, so cleanup probably would be at taxpayer expense.

A ground water contamination incident in Beaver County provides another illustration of how expensive pollution cleanup can be. In 1988, toxic trichloroethylene (TCE) contamination was first discovered in Vanport Township's (Beaver County) groundwater supply. The source of the contamination soon was identified as a nearby industrial facility. Vanport Township was lucky—the company agreed to pay all the water treatment costs and to reimburse the township for employee time spent on the problem. The costs for the first year, including researching, designing, building, and operating the treatment equipment, came to about $3 million (1989 dollars). The company also agreed to pay for the maintenance and operation of the facility for 25 years and possibly longer if the problem persists. Operating costs are about $0.75 per one thousand gallons of water treated.

Wellhead protection efforts are often cost-effective in preventing or reducing ground water pollution in the long run. Wellhead protection involves studying land use and land features around a water supply well to determine how various land uses might affect the well's water quality. This preplanning can allow rapid identification of the contaminant source in the case of a spill or leakage. Wellhead protection planning often includes a program of public education.

Let's compare two case studies of water pollution planning and incidence from southern Pennsylvania. Four communities in Lancaster County have developed a regional wellhead protection plan. The municipalities began by delineating protection zones around each of the community's wells. Potential contamination sources were cataloged, and the communities worked together to develop a comprehensive zoning ordinance to be followed by each community for approved land uses within the protection zones. The cost of these activities in 1995, including the delineation and mapping of protection zones and some costs of developing the zoning ordinance, totaled $66,000, much of which was paid by federal and state grants. A detailed facility inspection plan that may run through 2005 may bring the cost to about $350,000, split among the four communities.

Contrast that situation to the cost of a single pollution incident in Gettysburg that occurred when no water supply protection zones were in place. The municipality discovered volatile organic chemical contamination of a water supply well in the mid-1980s. The source was determined to be a nearby dry cleaning operation. Since 1987, the municipality has used an air stripper to treat the water at the well. The cost of the contamination incident as of late 1995 was $1.7 million (1995 dollars), including $349,000 incurred by the municipality. Costs through 2025 are expected to reach about $3.9 million, many times the cost of wellhead protection planning for the four Lancaster County communities previously mentioned. Operating costs will continue until the concentration of the chemical decreases enough that treatment can be stopped. These comparisons dramatically reveal the cost of not investing in measures to protect water supplies.

3. Water Quantity Management

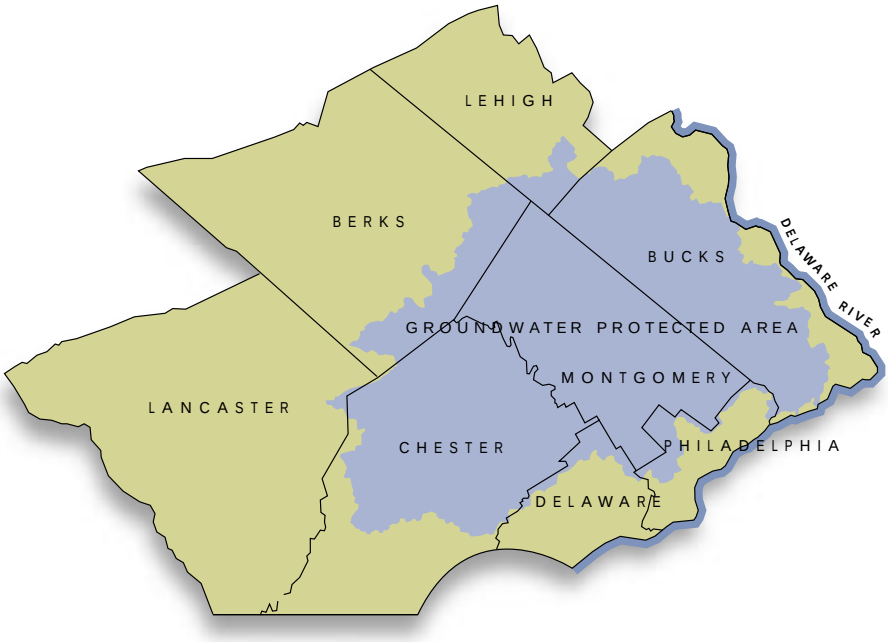
Water availability

The availability and quality of water help to determine its value. Large amounts of contaminated water are not valuable, nor are large quantities of clean water where and when nobody can use them.

Many people have the notion that we have an endless supply of easily extractable, high-quality ground water. This is untrue. Overdrafting occurs when ground water is pumped faster than rainwater and snow melt can replenish aquifers. The water table drops gradually, and some wells may have to be deepened. Albuquerque, New Mexico and Phoenix and Tucson, Arizona are among the larger U.S. cities that are withdrawing water from their aquifers faster than nature replaces it. California is overdrafting ground water at a rate equal to 15 percent of the state's annual usage, mainly for irrigation in the Central Valley.

The water table of the High Plains, or Ogallala Aquifer, which extends for 174,000 square miles beneath the Great Plains from Texas to Wyoming and South Dakota, has dropped 10 to 100 feet in the last 30 years because of pumping for irrigation. The aquifer, which is the largest freshwater body in the world, is experiencing pumping rates two to 100 times the recharge rate in some areas. This presents not only a water quantity problem, but a quality problem as well, since water quality tends to decline in deeper rock formations from which some water is now being drawn.

Even in traditionally water-rich Pennsylvania, there are regions where water quantity management is already a concern. The Delaware River Basin Commission created the Groundwater Protected Area of Southeastern Pennsylvania in response to development pressures on the water supply. All or parts of Bucks, Chester, Lehigh, Montgomery, and Berks counties are subject to the regulations, which require permits for all ground water withdrawals larger than 10,000 gallons per day on a 30-day basis. The Protected Area regulations prevent "depletion of groundwater and protect the interests and rights of lawful users of the same water source, as well as balance and reconcile alternative and conflicting uses of limited water resources in the region" (DRBC Web page, http://www.state.nj.us/drbc/pagwpa.htm).The regulations were amended in 1999 to establish numerical withdrawal limits for most of the sub-basins entirely or



The Groundwater Protected Area of Southeastern Pennsylvania (shaded area) was created in response to development pressures on the water supply in this region. Permits are required for large, sustained ground water withdrawals in the GWPA.

Because water is a "fugitive" resource—naturally flowing from one location . . . to another—individuals, [states], and countries have incentives to capture and use the resource before it moves beyond their control, but little, if any, incentive to conserve and protect supplies for downstream users.

—K. D. Frederick, Water as a Source of International Conflict, Resources for the Future, *Resources 123*, Spring 1996.

partially within the Protected Area. With the potential for future droughts and economic growth, regions of Pennsylvania requiring special water use planning and regulation are likely to expand.

Drought

Pennsylvania has seen its share of droughts in recent years. Regional droughts were recorded in 1998, especially in the northwest part of the state. Severe to extreme droughts occurred in 1999 throughout much of the state; eastern Pennsylvania was particularly hard hit. Parts of Pennsylvania and the Northeast began the year 2000 with a precipitation deficit.

Many people think about water availability only during droughts. Short-term voluntary water conservation measures are effective and agreeable to most people during droughts. Many people, however, resist the suggestion that these measures be made permanent or compulsory. Many consumers also resist increased water fees designed to encourage water conservation.

Despite plentiful supplies of water, Pennsylvania has had its share of drought problems.

Flooding

Flood control is an important concern in Pennsylvania. Many rivers and streams have been diverted and channeled to protect cities and towns from floodwaters. Unfortunately, these engineering techniques don't always work. The January 1996 floods, which were caused by rapid snow melt and heavy rain, triggered federal disaster declarations in 63 of the state's 67 counties. Federal and state aid totaling $320 million was paid to residents, businesses, and local governments for cleanup, repairs, and reconstruction. Between 1978 and 1995, Pennsylvania had more than 3,500 flood insurance claims, for a total cost of $38 million. The Commonwealth is combating these expenditures by removing houses and other structures from flood-prone areas, using zoning to restrict new building in floodplains, and improving dam safety.

Flood control is an important concern in Pennsylvania. The state had more than 3,500 flood insurance claims from 1978 to 1995.

4. Emerging Global Water Issues

Population pressure and water wars

Both the United Nations and the World Bank have listed safe drinking water as one of the most serious issues facing the world in the 21st century. Since water does not stop flowing at political boundaries, all the world's citizens should be concerned about international water conditions. A neighboring country's water problems quickly can become a problem for one's own country.

A vivid example of this interdependency was provided by the devastating flooding in Mozambique in February and March 2000, which killed at least 500 people and left more than 300,000 homeless. Some experts have suggested that extensive deforestation and efforts to channelize and straighten rivers in Mozambique and neighboring South Africa and Zimbabwe may have exacerbated the flooding.

The United Nations estimates that in 1997, one-third of the world's people still lacked access to safe drinking water. Most cities in developing countries discharge 80 to 90 percent of their untreated sewage directly into streams and rivers, damaging water quality downstream. According to the United States Agency for International Development, 8 percent of the world's citizens face chronic water shortages. By 2025, this number is expected to skyrocket to 35 percent of the world's population. This is because two of every three people live in areas that receive only one-quarter of the planet's total rainfall. To make matters worse, current per-person water consumption rates are rising twice as fast as the world's population rate, thanks mainly to expanding industrial and energy needs. The Worldwatch Institute estimates that due to population growth, in 2050, there will be only one-fourth as much water per person in the world as there was in 1950.

International affairs experts agree that contested access to water likely will ignite wars in the coming century. Many countries' borders were

The Middle East, India, Pakistan, and the former Soviet Union as hot spots where water could develop into an explosive international issue.

established with no regard for water resources or watersheds. Conflicts are inevitable because citizens have little incentive to conserve water for their downstream neighbors, especially if they are perceived as enemies. A report by Resources for the Future named the Middle East, India, Pakistan, and the former Soviet Union as hot spots where water could develop into an explosive international issue. Water rights were an important theme in negotiations between Syria and Israel in Shepherdstown, West Virginia in January 2000 and between Israel and Palestine in Maryland in March 2000.

The Resources for the Future report found several common causes for international conflicts over water. These include "the variability and uncertainty of supplies, the interdependencies of users, and the increasing scarcity and rising costs of fresh water." Also contributing to water difficulties are the "vulnerability of water quality . . . to human activities, the failure to treat water as an economic resource, the desire for food security and self-sufficiency in arid . . . regions of the world, and the importance of water to public health and economic development." Most of the reasons behind international water tensions apply to community, state, and regional water conflicts as well.

At least 300 million people live in regions of severe water shortages. By the year 2025, it will be three billion.

—Paul Simon, *Tapped Out: The Coming World Crisis in Water and What We Can Do About It*, 1998.

The report also identified a few ways to ease tensions over water. Countries should be encouraged to increase their water efficiency through cooperative watershed-based management and to develop water markets so that the price of water reflects its true value in people's lives.

Food security

More and more often, we hear about countries that need help feeding their citizens: North Korea, China, and Russia, for instance. Food security increasingly is tied to water availability, as high rates of ground water pumping send water tables plummeting. Citizens in the developing world are heavily dependent on irrigated crops; this places significant stress on ground water levels. In northern China, the water table dropped about 5 feet every year between 1991 and 1996. This area provides nearly 40 percent of China's grain, so Chinese

leaders and human and environmental rights advocates are concerned about the long-term stability of China's food supply. Some areas of India are pumping water twice as quickly as it recharges the aquifers, causing the water table to fall 3 to 10 feet each year. Severe food shortages in these densely populated countries would stress international food stores and distribution channels.

The competition for water in the Middle East is so intense that lasting peace in the region is unlikely in the absence of an agreement over shared water use.

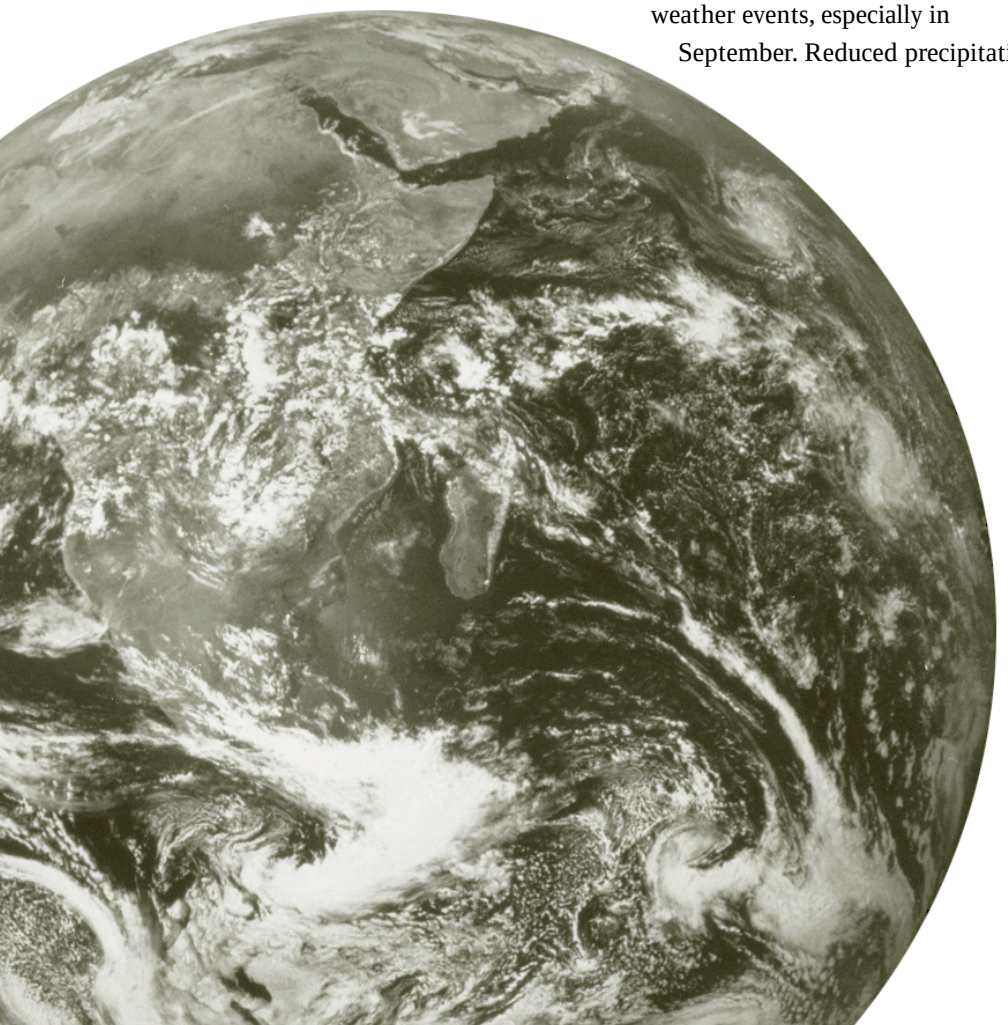
—K. D. Frederick, Water as a Source of International Conflict, Resources for the Future, *Resources 123*, Spring 1996.

Global climate change

Some scientists are concerned about the potential effects of projected global climate change on temperatures and the distribution of future rain and snowfall. Most computer models predict that global climate change is likely to be disproportionately harmful to agricultural productivity in the world's poorest regions. Decreased water supplies in these areas could intensify international water conflicts.

Climatologists working with the U.S. Environmental Protection Agency predict that in North America, warmer temperatures accompanying global climate change may bring increased precipitation and streamflow in the winter, decreased precipitation in the summer months, and increased frequency of extreme weather events, especially in September. Reduced precipitation during the growing season would be troublesome in Pennsylvania because most of our farms do not have irrigation equipment. A higher number of extreme weather events such as hurricanes and tropical storms in early autumn could interfere with crop harvests. Increased winter precipitation could raise the likelihood of severe winter storms, floods, and ice jams.

Floods tend to reduce drinking water quality temporarily because wastewater treatment plants can not adequately treat all of the water rushing into them from streets and sewers. Some wastewater may have to be released to rivers or streams with little or no treatment, and if a down-



Cancer-causing water in Bangladesh

We turn on the kitchen faucet, assuming that the water is drinkable. Many of the world's people can't make this assumption. For example, at least 6 million people in Bangladesh have developed cancer because of high arsenic concentrations in their ground water supplies. Ironically, the exposure of Bangladeshi citizens to arsenic results from efforts in the 1970s to discourage citizens from drinking from contaminated ponds. During that time, the government and international aid organizations helped residents sink tube wells to reach groundwater. Little did they know that the bedrock in much of the country has naturally high levels of arsenic. The Bangladeshi government is now working with international aid groups to test every tube well in the country, replace contaminated supplies, and educate residents about the health risks of drinking arsenic-laden water.

stream town draws its drinking water from the river, the incoming water quality will suffer. A research team from Johns Hopkins University and the University of South Florida found that 20 to 40 percent of drinking-water-related disease outbreaks in the last 20 years have occurred during floods.

A group of Penn State researchers has estimated the costs associated with a projected increased incidence of the waterborne disease cryptosporidiosis due to climate-change-induced flooding. Cryptosporidiosis normally causes diarrhea lasting 1 to 2 weeks, but can be deadly to people whose immune systems are already compromised. Using data gathered in Lancaster County, Pennsylvania, the scientists found that the current cost to society (including medical costs, lost work time, money spent securing alternative water sources to avoid getting sick, etc.) of a cryptosporidiosis outbreak totals about $211 (1998 dollars) per person (assuming the affected person does not die). These costs could increase if flooding becomes more frequent in our region because of global climate change. This is just one of the potential hidden costs of climate change.

Conclusions

We are fortunate to live in a water-rich country and state, but managing our water resources wisely is a constant challenge. Because water continually crosses political boundaries, government officials can manage shared water resources most efficiently through cooperation. A basinwide approach to management recognizes that the actions of towns, regions, states, or nations very often affect their neighbors, and sometimes distant areas as well.

We know that market forces have not set the price of water to include all of the costs and benefits of its use. In addition to providing many human health benefits, clean water is irreplaceable for irrigation, industrial production, transportation, and recreation. The cost of water also does not include intangible benefits from leaving water in the stream or ground such as aesthetics, physical support of the land and structures, and wildlife habitat. This incomplete pricing has resulted in some problems. Developers are rarely charged for the costs of potential ground water contamination and depletion caused by their construction projects. Also, water sometimes is misallocated to less efficient uses. If water were priced to include all benefits and costs, we would expect that the most valuable uses of water would be fully supplied, and less valuable uses would be reduced or perhaps not undertaken.

The bottom line is that if we are facing a future of water scarcity, we are also facing a future of food scarcity. . . . Restructuring the world water economy holds the key to eliminating hunger.

—L. R. Brown, *State of the World 1999*. W. W. Norton and Co. 1999.

Availability is also an important factor in water's value. Regional droughts and flooding call attention to this issue, as do many international situations in which water is in scarce supply. We live in a world with a steadily increasing population, and recent estimates indicate that as many as one-third of the world's people still lack access to safe drinking water. Chronic water shortages now affect 8 percent of the world's citizens and could affect 35 percent of the population by 2025. Many believe that access to water will be an explosive international issue in the coming decades.

After reading this publication, you should be more aware of the importance of water in your life and why water should be protected before contamination occurs. Individuals and businesspeople can possibly affect water resources by using water conservatively, by becoming informed about local water issues, and by getting involved in local water awareness or action groups. Every person on the planet uses water every day, so each person has an opportunity every day to make a difference in water resources in his or her area. Local officials can play an important role by sponsoring effective water-related policies and by encouraging cooperative regional management of water resources and related land areas. Citizen groups can have an impact by educating other citizens and local officials about wise water decisions.

As we begin the 21st century and the new millennium, the importance of water resources issues will only grow. As a society, we must learn from past mistakes and factor in the complexity of water resources and their diverse values to make better decisions about water in the future.

For more information

Abdalla, C. W., J. Becker, and J. R. Drohan. 1997. *A Primer on Access and Allocation of Water in Pennsylvania.* Penn State College of Agricultural Sciences, University Park, PA.

Brown, L. R., G. Gardner, and B. Halweil. 1998. Beyond Malthus: Sixteen dimensions of the population problem. Worldwatch Paper 143. Worldwatch Institute, Washington, DC. pp. 16–18.

Brown, L. R., M. Renner, and C. Flavin. 1998. *Vital Signs 1998: The Environmental Trends That Are Shaping Our Future.* W.W. Norton & Co., New York.

Cordell, H. K., J. C. Bergstrom, G. A. Ashley, and J. Karish. 1990. Economic impacts of river recreation on local economies. *Water Resources Bulletin* 26(1): 53–60.

Durlin, R. R. and W. P. Schaffstall. 1997. Water resources data, Pennsylvania, water year 1995, v. 2, Susquehanna and Potomac River Basins. U.S. Geological Survey Water-Data Report PA-95-2, 518 pp.

Environmental Protection Agency. 1999. *Global Warming.* Chapter 8, North America. http://www.epa.gov/globalwarming/reports/pubs/ipcc/chp8/america9.html

Fox, R. G. 1998. Water use in the U.S. and Pennsylvania. Environmental synopsis. PA General Assembly, Joint Legislative Air and Water Pollution Control and Conservation Committee. Nov. pp. 2–3.

Frederick, K. D. 1996. Water as a source of international conflict. Resources for the Future, *Resources 123,* Washington, DC. abstract p. 1.

Frederick, K. D., T. VandenBerg, and J. Hanson. 1996. Economic values of freshwater in the United States. Resources for the Future, Discussion Paper 97-03, Washington, DC.

Harrington, W., A. J. Krupnick, and W. O. Spofford, Jr. 1991. Economics and episodic disease: The benefits of preventing a giardiasis outbreak. Resources for the Future. Washington, D.C.

McClure, S. 1986. Giardiasis cost Pittston area up to $55 million in 1983. *The Globe-Times.* Bethlehem, PA. Oct. 15. p. A-3.

National Water Research Institute. 1999. *The Value of Water.* Fountain Valley, CA.

National Research Council. 1997. *Valuing Ground Water.* National Academy Press, Washington, DC.

O'Connor, R. E., R. J. Bord, and A. Fisher. 1994. Perceptions of fresh water. *National Geographic Research & Exploration* 10(3):318-341.

Pennsylvania Department of Environmental Regulation. 1996. Commonwealth of Pennsylvania 1996 water quality assessment. 305(b) report. R.F. Frey, ed. Bureau of Water Quality Management. Harrisburg, PA.

Postel, S. 1999. When the world's wells run dry. *World Watch,* Sept./Oct. pp. 30–38.

Solley, W. B., R. R. Pierce, and H. A. Perlman. 1998. Estimated use of water in the United States in 1995. U.S. Geological Survey, Circular 1200.

U.S. Environmental Protection Agency. Office of Ground Water and Drinking Water. 1995. Benefits and cost of prevention: Case studies of community wellhead protection. Vol. I. Source water protection business and economics series, Report no. 2.

U.S. Environmental Protection Agency and Delaware River Basin Commission. 1986. *Greenhouse Effect, Sea Level Rise, and Salinity in the Delaware Estuary.* Ch. 3. Salinity in the Delaware estuary. http://www.epa.gov:80/oppeoee1/globalwarming/reports/pubs/sealevel/delaware/chap3.pdf

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