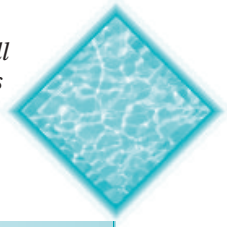
Chapter 5

Water Supply and Water Quality

"Not only is the level of the water in the global well getting low, the water is also polluted, sometimes to the point where it is no longer drinkable."

— Julie Stauffer, The Water Crisis, 1998, p. xi



"Although water is part of a global system, how it is used and managed locally and regionally is what really counts. Unlike oil, wheat and most other important commodities, water is needed in quantities too large to make it practical to transport long distances."

— Sandra Postel, Last Oasis, 1992, p. 23

KEY IDEAS

- Florida's future depends on a continued supply of adequate amounts of clean fresh water for human consumption and for natural systems.
- The amount of water changed by human activity is far greater than the amount of water directly used by humans.
- In some places in Florida, the demand for fresh water is greater than supply.
- Florida's water management districts are committed to finding new ways to meet the demand for water.
- Pollution is anything that causes an imbalance in or harms the natural environment.
- Scientists use a number of tests and measures to determine water quality.
- Pollution takes two main forms: point source pollution and non-point source pollution.

VOCABULARY

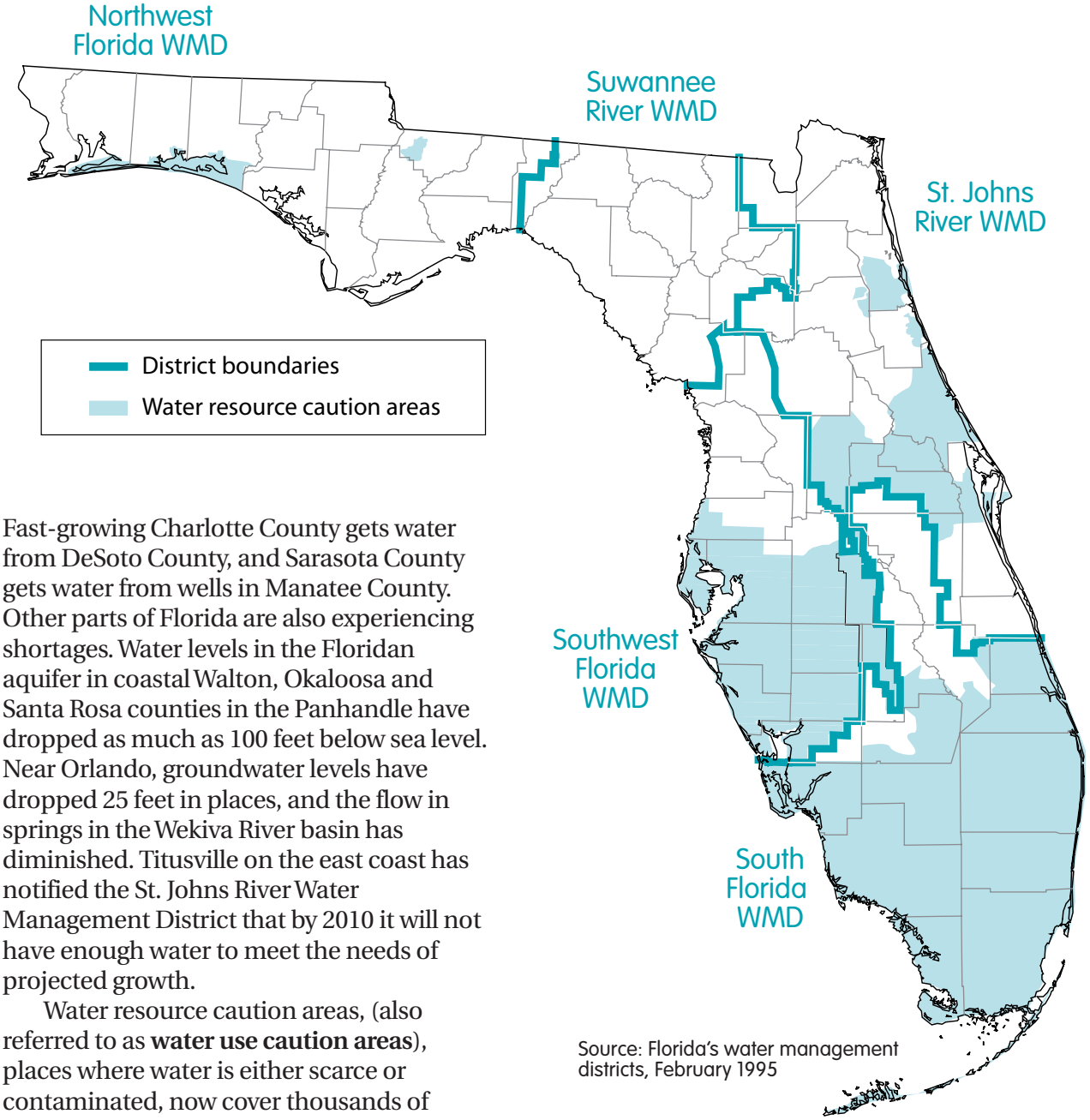
Aquifer storage and recovery
Best management practices
Conductivity
Desalination
Detention pond
Dissolved oxygen
Drip irrigation
Environmental pollution
Filtration
Impervious surface
Irrigation
Non-point source pollution
Nutrients
pH
Point source pollution
Pollution
Public supply
Reclaimed water
Retention pond
Reuse
Turbidity
Wastewater
Water Use Caution Areas
Xeriscaping

Florida's future depends on a continued supply of adequate clean fresh water. Water quality and water quantity are both important: it does little good to have vast amounts of polluted water. Plants, fish and other animals, as well as humans, all require adequate amounts of clean water.

The quantity of water changed by human activity is far greater than the amount of water directly used by humans (Betz 1984). Each time humans withdraw ground water or surface water for a particular purpose, waste is generated. Household use generates **wastewater** from toilets, sinks, showers, bathtubs, dishwashers and washing machines; phosphate mining generates phosphate slime; manufacturing generates chemical waste; irrigation generates runoff containing nutrients from fertilizers, as well as from pesticides and herbicides. Even rain contains impurities generated by burning of fossil fuels, dust and ash. It's not enough to be careful about the amount of water we use. We must also do our best to return it to the environment as pure as possible.

Some places in Florida, such as the Florida Keys and St. Petersburg, never had enough fresh water to support large-scale development. Each day, 16 million gallons of water flow from wells near Homestead, on the mainland of Florida, to the Florida Keys. Water travels through a 130-mile-long pipeline supplying water all the way to Key West. St. Petersburg, "a peninsula on a peninsula" with the highest population density in Florida (3,100 persons per square mile), ran out of water in the 1920s and now relies on well fields in Hillsborough and Pasco counties. In other places, water use is rapidly surpassing inexpensive water supply.

Water Resource Caution Areas (WRCAs) in Florida



Source: Florida's water management districts, February 1995

Fast-growing Charlotte County gets water from DeSoto County, and Sarasota County gets water from wells in Manatee County. Other parts of Florida are also experiencing shortages. Water levels in the Floridan aquifer in coastal Walton, Okaloosa and Santa Rosa counties in the Panhandle have dropped as much as 100 feet below sea level. Near Orlando, groundwater levels have dropped 25 feet in places, and the flow in springs in the Wekiva River basin has diminished. Titusville on the east coast has notified the St. Johns River Water Management District that by 2010 it will not have enough water to meet the needs of projected growth.

Water resource caution areas, (also referred to as **water use caution areas**), places where water is either scarce or contaminated, now cover thousands of square miles throughout the state. The most extensive water resource caution areas are in southwest Florida in all or parts of Pasco, Pinellas, Hillsborough, Sarasota, Charlotte, DeSoto, Polk and Highlands counties.

Florida's water management districts are committed to finding new ways of meeting the demand for water. Providing high-quality drinking water is expensive, and using that water to meet all water needs is unnecessary. Floridians will increasingly use alternative supplies of water to meet nonpotable demands, instead of seeking new, often far-away and more pristine sources. **Reclaimed water**, for example, can be used to irrigate golf courses and landscaping, as well as in industrial processes and power generation. The use of **desalination**, particularly of brackish ground water, is increasing in Florida's populated areas. Another

way to increase water supply is conservation and increased efficiency. Household fixtures, such as toilets and showers, that save water are now available. Landscaping with native, drought-tolerant plants (**Xeriscaping**) also helps conserve water. Agriculture and industry have begun to implement new and more efficient ways of using water. Water management districts have begun to explore the option of storing water in aquifers during times of abundant rainfall and withdrawing it during times when rainfall is scarce, a process known as **aquifer storage and recovery** (see illustration, page 90).

Water Use

DEFINITIONS

Agencies, such as the U.S. Geological Survey (USGS) that keep track of how much water is used for various purposes, distinguish between withdrawal uses, consumptive uses and nonwithdrawal uses. Withdrawal is the act of taking water from a source for storage or use. In many cases, water is withdrawn from its source and returned to its original source within a short period of time. Water withdrawn from a river to cool power plant equipment and then returned to the river is an example. Some of the withdrawn water is consumed; that means the water is no longer available for immediate reuse. Evaporation, plant transpiration and incorporation into a product are all consumptive uses. When water is withdrawn for irrigation, for example, some evaporates, some transpires and some is incorporated into plants. The remainder may return to the surface water or groundwater source from which it originated. Nonwithdrawal uses include use by natural systems, recreation use and use for transportation.

TYPES OF USES

The USGS collects and compiles water withdrawal data in Florida and throughout the United States. USGS distinguishes between saline water and freshwater use and between surface water and groundwater use. Data are collected in the following water use categories: public supply, domestic self-supplied, commercial-industrial self-supplied (including mining), agricultural self-supplied (including livestock), recreational irrigation and power generation (cooling of thermoelectric power plants).

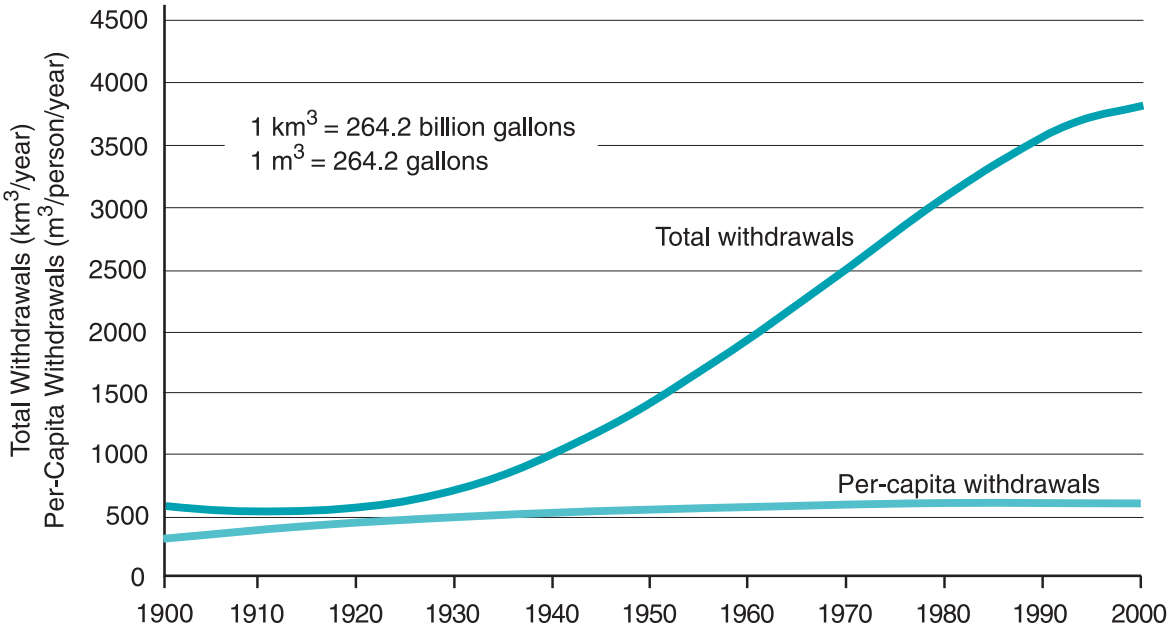
Public supply includes systems that serve more than 400 people or use more than 10,000 gallons of water each day. Public-supply systems provide water to households, businesses and industries. Domestic self-supplied is water withdrawn by the user for household use, usually from individual wells. Agricultural self-supplied includes **irrigation**, the process of supplying water to areas of land to make them suitable for growing crops, sod and landscaping plants, as well as water for livestock.

Recreational irrigation was a new water use category in 1995. It includes withdrawals for the irrigation of land used for recreational purposes. Golf courses are the largest users in this category. Before 1995, recreational irrigation was included under agricultural self-supplied.

HOW MUCH IS A MILLION GALLONS OF WATER?

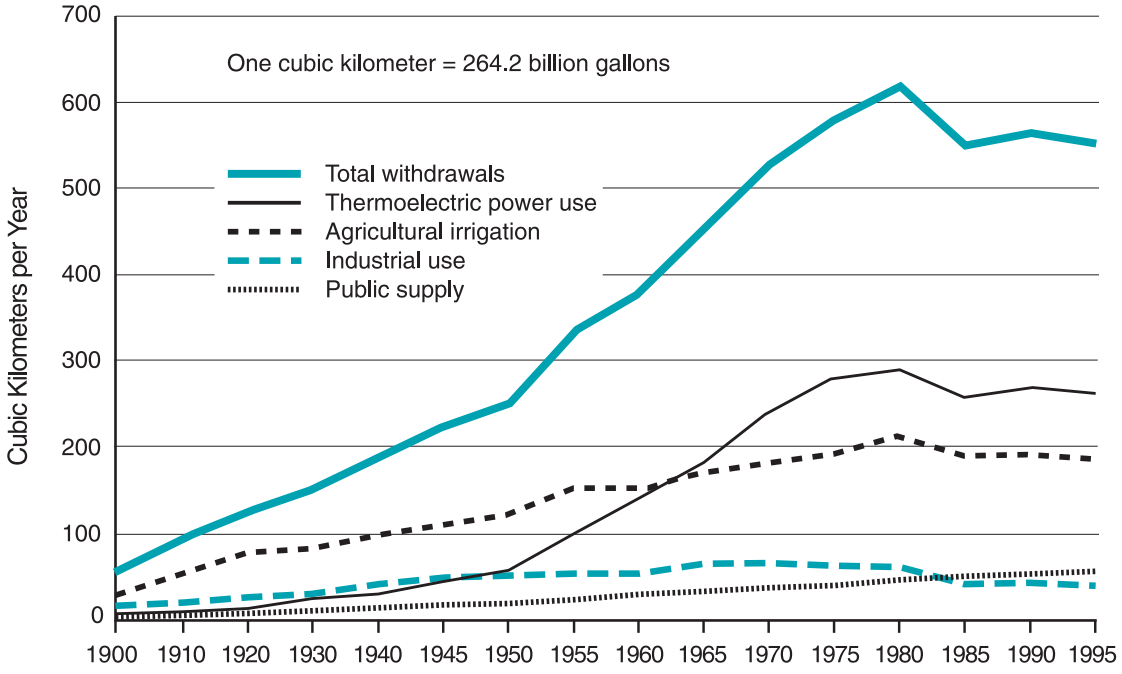
Agencies that keep track of water use usually do so in million of gallons used each day (mgd). Visualizing such a large number is difficult. Think about a bathtub or a swimming pool. A bathtub can hold about 50 gallons of water. You would have to take 20,000 baths before you used a million gallons of water! How big do you think a swimming pool would have to be to hold a million gallons of water? It would have to be 10 feet deep, 50 feet wide and 267 feet long! (USGS 2001)

Total and Per-Capita Global Water Withdrawals



Source: Gleick 1998

Water Withdrawals in the United States



Source: Gleick 1998

WORLDWIDE WATER USE AND TRENDS

Agriculture is the single largest user of water in Florida and in the world. Two-thirds of all the water withdrawn worldwide from surface water and groundwater sources is used for agriculture (Postel 1992). Many of the world's farmers irrigate in the same ways their ancestors did thousands of years ago: by flooding or channeling water across the land. Postel (1992) estimates the overall efficiency of agricultural water use worldwide is only 40 percent, meaning that over half of all water diverted for agriculture never produces food.

Industry also uses vast amounts of water. Even if water is not part of the final product, it is likely to have been used in the industrial process that created the product. For example, paper is manufactured from wood that is washed and soaked in vats of water and chemicals to form pulp. The pulp is rinsed, squeezed dry and then pressed into paper (Prentice Hall 2000). Many industries, such as power plants and steel mills, use high volumes of water to cool down hot machinery.

Worldwide household use is a third leading use of water. Most of us take safe, plentiful water for granted, but in many parts of the world women and children still spend hours every day walking to shallow wells, collecting water in jugs and carrying it home.

Most people in Florida and in other parts of the United States get their water from public-supply systems. When you have hundreds of people living in a square kilometer, it is much more efficient and safer to have the county or city water department deliver water to households than to have each household drill its own well or build its own water tank. Public water systems supply water to schools, businesses and industries, as well as to homes.

In the past century, population growth, industrial development and expansion of irrigated agriculture have resulted in an enormous increase in the amount of water used throughout the world. Throughout the first 75 years of the twentieth century, absolute and per capita demand for water throughout the world

Liters of Water Typically Used to Produce Products in the United States

1 automobile	400,000
900 kg of paper for bags	32,800
1 kg of cotton	8,800
1 kg of aluminum	8,800
1 kg of beef	7,000
1 kg of rice	5,000
1 kg of steel	2,200
1 liter of gasoline	75

Domestic Water Use (liters)

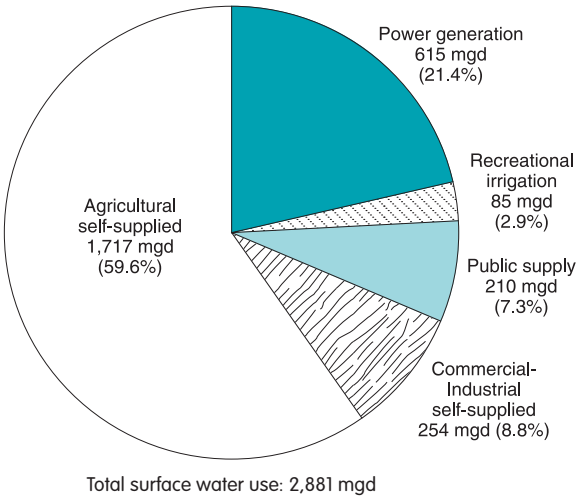
showering 5 minutes	95
brushing teeth	10
washing hands	7.5
flushing standard toilet	23
flushing low-flow toilet	6
washing one load of laundry	151
running dishwasher	19
washing dishes by hand	114

increased. Beginning in the mid-1980s and early 1990s, however, these trends reversed in the United States and water use began to decrease despite continued increases in population and economic wealth. Between 1980 and 1995, water use in the United States declined by nearly 10 percent. The two largest components of United States water use — thermoelectric cooling and agricultural irrigation — declined by about 10 percent. Industrial use dropped even more than thermoelectric cooling and agriculture (40 percent), as industrial water use efficiency improved and as the mix of United States industry changed. Part of the decline in agricultural use is a consequence of the availability of more efficient methods of irrigation. **Drip irrigation** is a process whereby water is applied directly to the roots. It was first developed in Israel and has expanded worldwide.

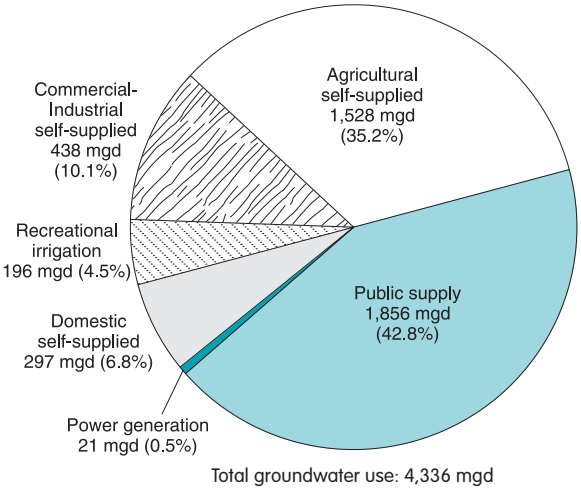
FLORIDA WATER USE AND TRENDS

In 1995, ground water accounted for 60 percent of the water withdrawn in Florida. Nearly 93 percent of the state's population relied on ground water for their drinking water needs, far more than any other state in the nation (Solley et al. 1998). The majority of ground water is withdrawn from the Floridan aquifer, although the Biscayne aquifer is the primary source of potable water in south Florida and the sand and gravel aquifer is the main source of potable water in portions of west Florida. Groundwater withdrawals steadily increased between 1950 and 1990, but decreased 7 percent between 1990 and 1995, even though the population increased 9 percent, from 12.94 to 14.15 million. Following trends in the United States as a whole, use of water for agricultural irrigation, industry and thermoelectric cooling has also decreased in Florida, due to more efficient use.

Florida Freshwater Use
1995

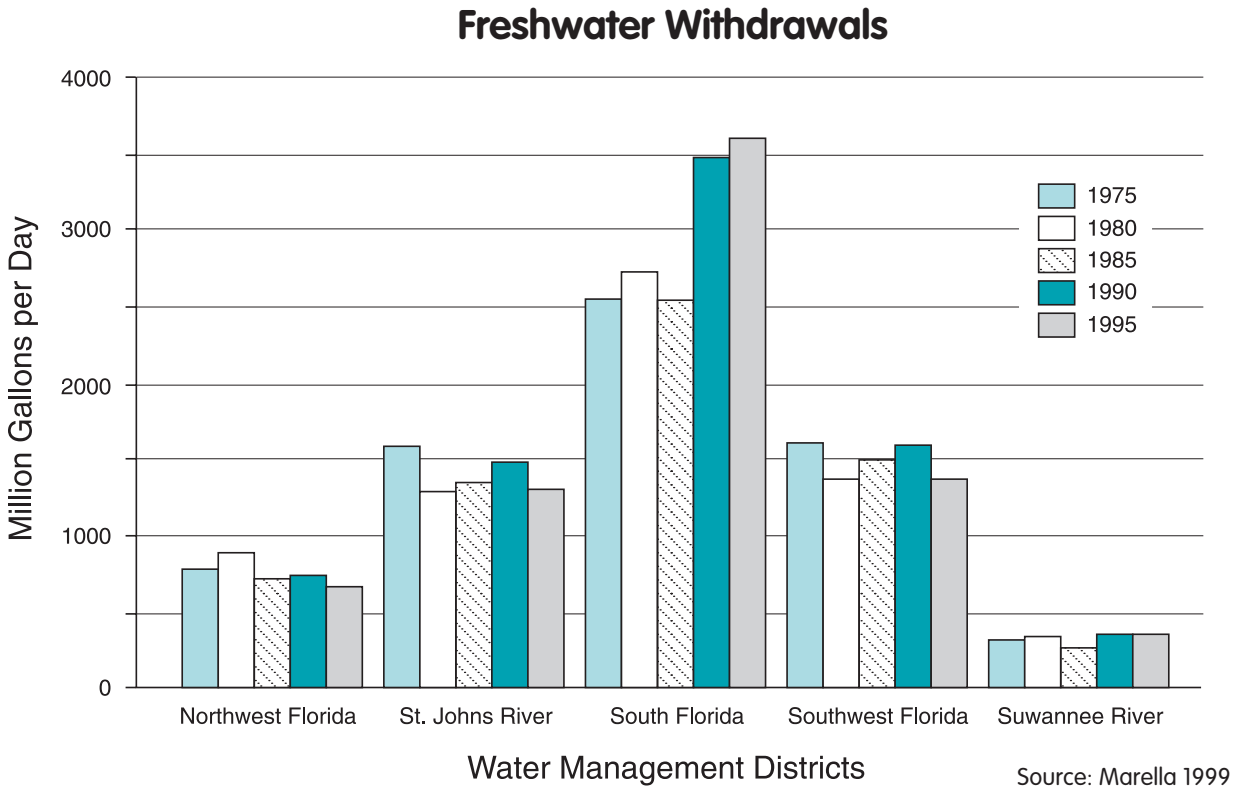


Surface Water



Ground Water

Source: Marella 1999



Source: Marella 1999

Statewide per capita residential use of water has decreased from an average of 144 gallons per day in 1980 to 103 gallons per day in 1995. This decrease has resulted from conservation efforts, including the use of more efficient toilets and showers, use of reclaimed water for lawn irrigation, and use of water-saving landscape techniques (Marella 1999). Florida households still use one-half of their water for landscape irrigation.

Florida ranks low (30th in the nation) in withdrawals of fresh surface water. Between 1990 and 1995, withdrawals of surface water increased by less than 1 percent. The primary uses of fresh surface water are for agricultural irrigation and as cooling water for power plants. Major sources of fresh surface water for irrigation are Lake Okeechobeee, Lake Apopka, the Caloosahatchee River and the marshlands associated with the headwaters of the St. Johns River. In some parts of the state, surface water is a significant component of public supply. Hillsborough River and the Tampa Bypass Canal supply Hillsborough County, and Deer Point Lake Reservoir supplies Bay County.

Water Reuse

Florida has become a leader among states in the **reuse** of water. Every day, 60 gallons of wastewater for each person flows out of homes and into sewers. As this wastewater travels miles through the collection system, it is diluted by ground water that infiltrates joints and defects in the sewers. By the time wastewater reaches the treatment facility, its volume has increased to about 100 gallons per person per day. Wastewater is now about 99.9 percent water and 0.1 percent pollutants. After treatment, wastewater can be safely used for many purposes.

State law requires reuse within water resource caution areas. In 1999, the total capacity of all reuse systems in Florida was about 1.04 billion gallons per day, nearly half of the total permitted capacity of all domestic wastewater treatment facilities in the state. A total of 523 million gallons per day of reclaimed water was reused in 1999.

Reclaimed water is being used for landscape irrigation (including golf courses, parks, highway medians, playgrounds and residential properties), agricultural irrigation (including irrigation of edible crops), aesthetic uses (decorative ponds, pools and fountains), groundwater recharge, industrial uses (for cooling, process or wash waters), wetlands creation, restoration and enhancement and fire protection (use in hydrants and sprinklers).

Water Quality

Good quality water in adequate amounts is indispensable for the water we drink, but it is also essential for many other uses. We cannot safely swim or fish in polluted waters nor can Florida's natural systems survive without adequate water of good quality.

The recreational and ecological values of good quality water and other natural resources are frequently acknowledged but are rarely considered in management decisions because we don't buy and sell them as we do other commodities. An article published in 1997 (Costanza et al.) in the journal *Nature* summarizes and synthesizes studies aimed at estimating the value of ecological functions and services. The authors conclude that the economic value of Earth's natural systems averages $33 trillion per year, which is 1.2 times as much economic value created by humans and measured by the combined gross national product of all the countries in the world.

Scientists use a number of tests and measures to help them determine water quality. These include turbidity, nutrient levels, pH, dissolved oxygen, conductivity and temperature.

Turbidity is characterized by a cloudy or muddy appearance caused by suspended solids that decrease the ability of the sunlight to penetrate the water. The most common suspended solids are soil particles and algae. Water may sometimes be naturally turbid because of high amounts of organic debris, erosion, or waves or floods that suspend sediments.

High turbidity reduces underwater plant growth by limiting sunlight penetration and photosynthesis. A decrease in plant growth results in a decrease in the number of organisms that depend on plants for food and shelter. Soil particles also affect the health of fish by clogging and irritating their gills. Turbid waters may suffocate some aquatic plants and animals and impair reproduction and development of eggs and larvae.

Nutrients in the proper amount are necessary for healthy aquatic systems, but in excess, nutrients, primarily nitrogen and phosphorus, can be harmful. Nutrients come from runoff containing fertilizer, waste from leaking septic tanks, decaying lawn debris and animal wastes. When too many nutrients are present, certain plants grow explosively and crowd out other plants, creating a monoculture. Increases in nutrients may result in algal blooms in lakes and rivers. When algae multiplies rapidly, it uses up dissolved oxygen, leaving less available for other forms of aquatic life. Excess nutrients also frequently increase nonnative nuisance plants, such as water hyacinth and hydrilla.

The measure of the amount of hydrogen ions (H+) and hydroxide ions (OH-) in a solution is **pH** (potential of hydrogen). The more acidic a solution, the greater the amount of hydrogen ions. The more basic or alkaline the solution, the greater the amount of hydroxide ions. The pH scale ranges from 0 to 14.

The lower the pH, the more acidic the solution is; the higher the pH, the more basic the solution is. A solution with a pH of 7 is neutral, neither basic nor acidic. Pure water has a pH of 7. Orange juice has a pH of 4 and battery acid has a pH of 0.5. Milk of Magnesia has a pH of 10 and lye has a pH of 14. Most aquatic organisms prefer water with a pH ranging from 6.5 to 8.5. As acidity rises (pH falls), other compounds in contact with the water or the soil may release toxic elements (for example, aluminum and mercury). Stormwater runoff containing leakage from faulty sewer lines or septic tanks, runoff from agricultural areas and acid rain can all decrease pH in lakes, rivers and estuaries, threatening aquatic organisms and releasing potentially harmful elements.

Dissolved oxygen in water is essential for the survival of nearly all aquatic plants and animals. Aquatic organisms, including most fish, generally thrive when dissolved oxygen levels are 5 parts per million (ppm) or greater. Oxygen in the water comes from the air and as a byproduct of photosynthesis. The cooler the water, the more dissolved oxygen it will hold. However, at night when photosynthesis stops, animals continue to use oxygen and the dissolved oxygen content of water drops.

Conductivity refers to how well the water conducts or transmits an electrical current. Pure distilled water does not conduct a current. As the concentration of minerals and salts in the water increases, however, conductivity rises. Conductivity is therefore an indirect measure of the mineral content of water. Sediments from stormwater runoff and intrusion of seawater increase the mineral content of water. Increases in conductivity may indicate water quality problems from increased salinity or increased sediment. Both of these make water less useful to humans and to natural systems.

Temperature affects the growth and life cycles of many aquatic organisms. Nearly all organisms have a temperature range they prefer or even require. Sediments can absorb heat and increase water temperature. Stormwater runoff from heated impervious surfaces and power plant outfalls also increases water temperature. As water temperature increases, the life cycles of aquatic insects may accelerate. The growth of algae generally increases, whereas the growth of other plants such as aquatic grasses may decrease. Other aquatic organisms may become more sensitive and vulnerable to disease and their reproductive cycles may be disrupted with increased temperatures.

CAUSES AND SOURCES OF WATER POLLUTION

Although **pollution** is often defined as contamination by harmful chemicals or waste materials, **environmental pollution** can be *anything* that harms or causes an imbalance in plants and animals in their natural habitat — even though the substance may not be harmful to humans. For example, phosphorus and nitrogen are common elements of most fertilizers. They are not harmful to humans. However, nitrogen runoff can be a pollutant in saltwater bays and estuaries, such as Tampa Bay and the Indian River Lagoon, and phosphorus runoff can be a pollutant in freshwater habitats such as the Everglades and Lake Apopka and other freshwater lakes because it causes an imbalance in the natural system.

Pollution is usually caused by human activities. Pollutants aren't always detectable by smell, sight or taste. Water may look and smell clean and even taste fine, but it may still be contaminated and unsafe for drinking.

Despite successes in cleaning up some water pollution, many modern pollutants are very difficult to remove, and it is obviously better not to pollute in the first place. Heavy metals and synthetic chemicals pose particular hazards to humans and other forms of life.

Heavy metals, such as lead and mercury,

can interfere with production of hormones and with reproduction. Lead can further result in physical and mental developmental problems in children. Other metals, such as copper and zinc, are less dangerous to humans but are toxic to aquatic life (Stauffer 1998).

More than 10 million chemicals are manufactured today. Most are used in agriculture and industry. Some break down quickly, whereas others, like heavy metals, remain in the environment for decades. Fewer than 2 percent of these chemicals have been fully tested with regard to human health risks, and no health information is available for more than 70 percent of them (Stauffer 1998).

Water may be polluted in two general ways: by **point source pollution** and by **non-point source pollution**. With point source pollution, the cause of the problem can be traced to a single source, for example, a pipe discharging waste from a factory. Non-point source pollution is more diffuse and originates from diverse sources over a wider area.

In the past, pollution from industrial and domestic point sources was common. Stronger regulations, new technologies and more advanced treatment of wastes have reduced point source pollution. Today most water quality problems result from non-point source pollution, including stormwater runoff, septic tanks, runoff from croplands, dairies, feedlots and farms, and erosion from construction sites and unpaved roads. Non-point source pollution carries pesticides and fertilizers from lawns and fields, oil and greases from roads and parking lots, sediments from construction sites and clear-cutting of trees, and wastes from improperly functioning septic tanks.

In 1982, the state of Florida implemented a rule to reduce stormwater runoff. Since 1982, all new developments have been required to use **best management practices** (BMPs) to minimize runoff during construction and to treat stormwater after construction. These BMPs include requiring swales, **retention ponds, detention ponds** and detention ponds with **filtration**.

FLORIDA WATER QUALITY AND TRENDS

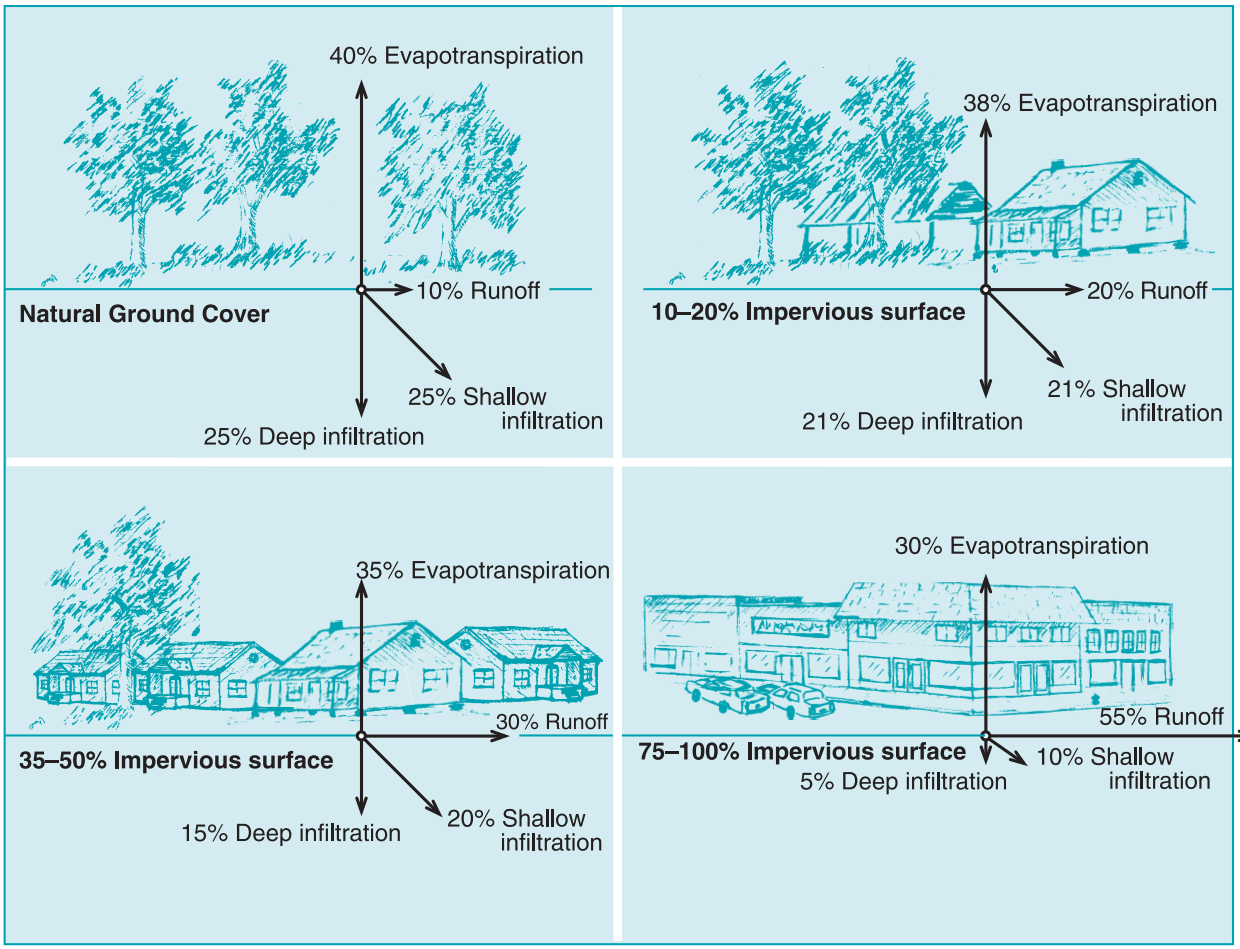
Because Florida is so populous and has grown so rapidly, an important source of pollution, particularly of surface water, is urban storm water. Surface water quality problems occur with the greatest frequency in heavily populated areas — the southeast, in the central region near Orlando, in the St. Johns River basin particularly around Jacksonville, in Pensacola Bay and its tributaries, in the Peace River basin and along the west coast between Tampa and Naples. Water bodies whose watersheds include large urban areas and intensive industry and agriculture have the poorest water quality.

Developed areas have a much higher proportion of **impervious surface** than rural areas. Impervious surfaces are covered with buildings or asphalt, concrete and other materials that prevent water from seeping into the ground. As a consequence, the volume of storm water increases, carrying pollutants with it.

The Florida Department of Environmental Protection monitors water quality in over 600 surface water bodies throughout the state. Between 1986 and 1995, the water quality in 71 percent of these water bodies was unchanged, the water quality of 20 percent improved, and the water quality of 9 percent declined. In general, improvements were related to better control of point source pollution, particularly discharges from wastewater treatment plants. Declines in water quality generally resulted from increases in stormwater runoff.

Florida's ground water, as well as its surface water, is vulnerable to contamination. Large portions of the state are covered with well-drained sandy soils overlying porous limestone. High

The Effect of Covered Surfaces on Runoff

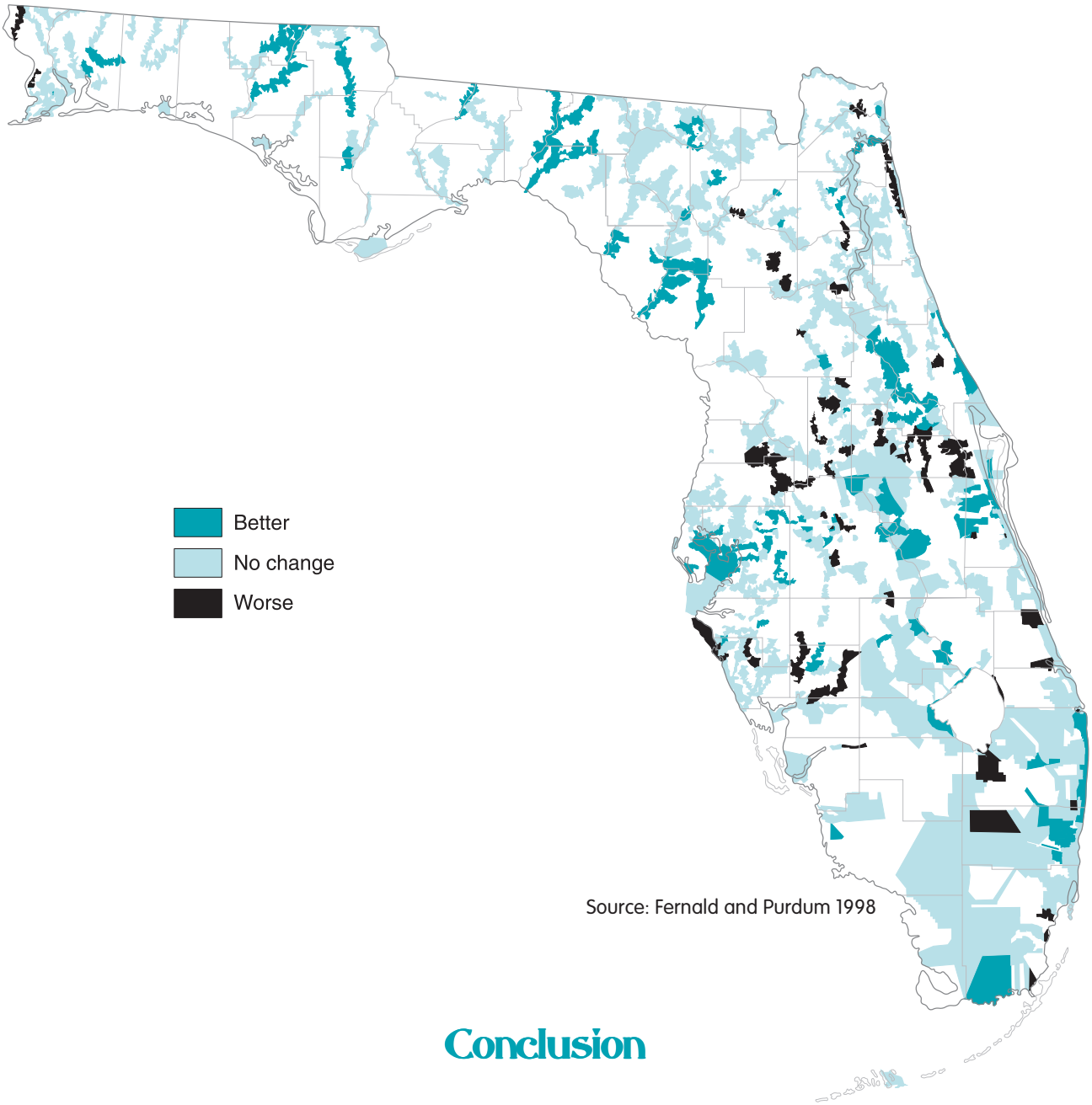


Source: Fernald and Purdum 1998

amounts of rainfall contribute to the potential for contamination of ground water: in many places, anything on the surface is likely to percolate through to the ground water. Connection between ground water and surface water also means that anything found in surface water is likely to find its way into ground water and vice versa.

In the 1980s, hundreds of wells in Florida were found to be contaminated with the soil fumigant ethylene dibromide (EDB). Other wells were found to be contaminated with dry-cleaning solvent and gasoline from leaking underground storage tanks. This resulted in standards for water well construction and water testing within areas of known groundwater contamination. Ground water in Florida has also been found to be contaminated with nitrate from fertilizers or leachate from septic tanks. Nitrate contamination of ground water may cause "blue baby syndrome," a condition affecting human infants under 6 months of age. High levels of nitrates decrease the amount of oxygen carried in the baby's blood. The skin around the eyes, mouth and feet appear blue. The syndrome may also cause difficulty breathing, loss of consciousness, convulsions and even death.

Monitored Surface Water Quality Trends
1986–1995



Source: Fernald and Purdum 1998

Conclusion

Although the analysis of water quality and water pollution is complex, the need for adequate amounts of clean water is clear. Some major water quality problems of the past, particularly waterborne epidemics, are now well controlled. We must face new challenges resulting from a fast-growing population, industry and intensive agriculture.

As water becomes scarcer, it will undoubtedly become more expensive, not just in Florida but throughout the world.

"In most countries, water is priced at only a fraction of its real cost. The working assumption is that it's an unlimited public resource, and the result is that few consumers have any incentive to use it sparingly. Yet the time is coming when water must be treated as [a] valuable [resource], like oil, not free, like air" (Voyage Publishing 1996).