UF UNIVERSITY of FLORIDA
IFAS Extension

Florida's Water Resources [1]

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Introduction

Water is important to Floridians for household uses, to industry for cooling and processing, to agriculture for irrigation, and to recreationists for boating and swimming. Water sustains wildlife, and is an integral part of Florida's environment.

Rates of water use, especially freshwater resources, have increased steadily over the years (Leach, 1978). Due to increases in the use of Florida's freshwater, Floridians are paying closer attention to plans to further develop water supplies. A better understanding of Florida's water resources is the first step toward assuring adequate freshwater supplies.

The Hydrologic Cycle

Where does water come from? How much water is available? These questions are pertinent to the fundamental nature of water as it "cycles" through the environment.

The continual circulation and distribution of water on the surface of the land, in the ground, and in the atmosphere is referred to as the "hydrologic cycle" or "water cycle" (Ackermann, 1955). There are five basic phases in the hydrologic cycle: condensation, precipitation, infiltration, runoff, and evapotranspiration (Figure 1). These phases, with the exception of precipitation, may occur at the same time and continuously.

The first phase of the hydrologic cycle is *condensation*, which occurs as moist air cools. The cooling water vapor forms into tiny droplets that cling to dust particles in the air, creating clouds or fog (Ackermann, 1955). As the droplets increase in size, they gain weight, causing them to fall as rain or snow, depending on weather conditions.

When raindrops or snowflakes fall from the atmosphere, the second phase, *precipitation*, occurs. Rainfall varies in amount and intensity from one season to another and from one region to another (Erwin, 1964). Differences in rainfall patterns result from general differences in climate over time and space.

When rainfall reaches the earth's surface, it may do one of three things: enter the ground (infiltration), collect into surface streams and lakes (runoff), or

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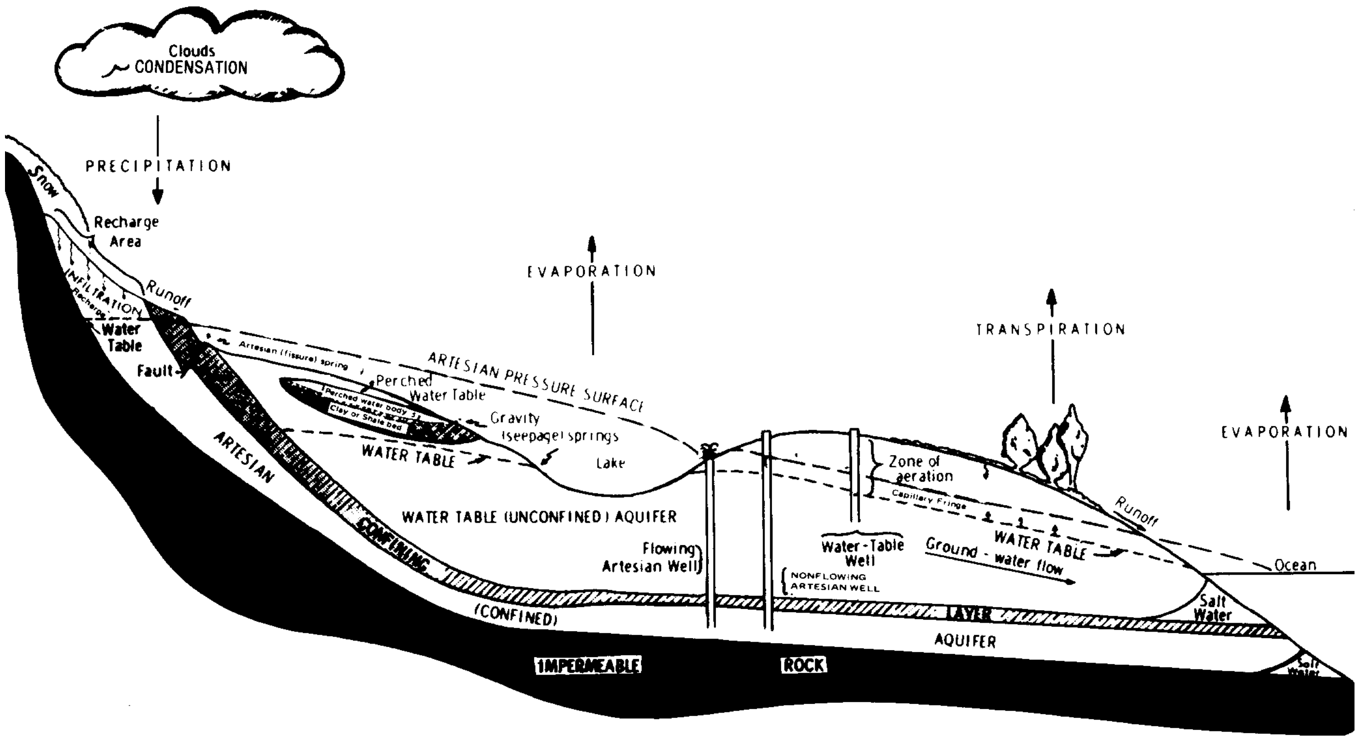

Figure 1. The Hydrologic Cycle.

return to the atmosphere as water vapor (evapotranspiration) (Erwin, 1964).

The third and fourth phases, *infiltration* and *runoff*, are highly interrelated and are influenced by the form of precipitation, the type and amount of vegetation on which the precipitation falls, and the permeability of the soil.

When water infiltrates the soil, it first enters the soil zone where plants may absorb water with their roots. Some soils do not readily retain water, which causes the water to quickly percolate (seep) downward until it encounters a stratum (zone) where the pores in the soil or rocks are saturated. Water in saturated stratums is called groundwater (Tinsley, 1979).

Underground layers of porous material that are saturated with groundwater are called aquifers (Tinsley, 1979). Depending on local rainfall conditions, water levels may rise or fall in shallow or surface aquifers. When a shallow aquifer is underlain by an aquiclude (a stratum of low permeability), water may move laterally through the aquifer and emerge into a surface stream or lake. On the other hand, when groundwater levels are low, water may flow in the opposite direction from surface streams and lakes into the shallow aquifer.

Sometimes freshwater exists deep underground in "confined" aquifers, so-called because these water-bearing aquifers are confined below a stratum of low permeability. Confined aquifers may sometimes hold water under sufficient pressure so that the water will rise above the confining stratum when a tightly-cased well penetrates the aquiclude. These are known as "artesian" aquifers. When tapped, they sometimes produce free-flowing artesian wells. Naturally-occurring springs also result from this same phenomenon. Water may enter the aquifer through recharge areas. Recharge areas are those areas where a water-bearing stratum emerges at the surface, or where the confining layer is broken up by faults or natural sinkholes that allow the downward infiltration of water. Recharge areas may be some distance away from the spring or well that is fed by the aquifer.

Water that does not enter the ground will collect in rivers and streams, comprising the runoff phase of the hydrologic cycle. This water either evaporates, percolates into the ground, or flows out to sea. Some of the surface water is tapped as a water supply for agricultural, residential, or industrial use.

The fifth, and final, phase of the hydrologic cycle is *evapotranspiration*. "Evaporation" is the process by which water (or ice) is changed into a gaseous form called water vapor. "Transpiration" is the process whereby moisture in plants is returned to the atmosphere through the plants' leaves. To prevent wilting, plants must absorb water through their roots to replenish water lost through evapotranspiration.

Florida's Hydrologic Cycle

Analyzing Florida's water resources by referencing the hydrologic cycle provides a sense of where the water is at any point in time, and a perception of how much water is accessible in each phase of the hydrologic cycle.

Rainfall in Florida

Florida receives an average of 53 inches of rainfall each year (Geraghty, 1973), as compared to a national average of 30 inches per year and nine inches per year in Nevada (the driest state in the nation).

Total annual rainfall for Florida may vary considerably from one part of Florida to another, from one season of the year to another, and from one year to the next. The highest mean annual rainfall occurs in northwest Florida ("the Panhandle") and southeast Florida (Palm Beach and Broward Counties), where rainfall averages 64 inches per year (Hughes, 1971). The Florida Keys is the region of lowest mean annual rainfall, averaging 40 inches per year. The rest of the state experiences rainfall close to the state average of 53 inches (Figure 2).

Seasonal variations in rainfall are evident. Traditionally, summer is the wettest season in Florida, with 70 percent of the annual rainfall occurring during the period from May to October (*Florida's Water: A Shared Resource*, 1977).

Extreme annual variations in rainfall may occur. For example, Pensacola received about 90 inches of rainfall in 1953 and less than 29 inches in 1954 (Hughes, 1971). Similar extremes in annual rainfall have been recorded for other parts of Florida, causing drought in some years and frequent flooding in other years. Tropical storms delivering over 10 inches of rainfall during a 24-hour period are not uncommon, and such events usually produce flooding.

Rainfall variations will continue to be part of Florida's climate. Flow characteristics of streams, groundwater recharge, and water levels of lakes and reservoirs are all functions of the amount and intensity of rainfall. Plans for water-supply development and flood control must take into account the short-term and long-term variations in rainfall amounts (Hughes, 1971).

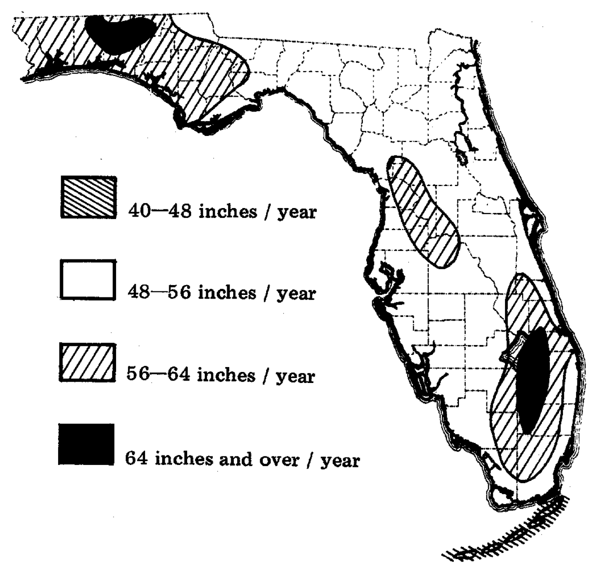

Figure 2. Mean annual rainfall in Florida.

Outflow: Rainfall Minus Evapotranspiration

Although rainfall is relatively abundant in Florida, a major portion of it is never available for controlled use due to evaporation (Visher, 1969). The difference between the rainfall on a particular area and the evaporation from that area is called "outflow." Outflow is the total amount of water that is available as surface or ground flow from an area.

The potential for evaporation depends on atmospheric conditions such as temperature and wind speed. Actual evaporation is affected by the permeability of the soil, the type and amount of vegetative ground cover, and the slope of the land (Visher, 1969). For example, actual outflow is relatively high in parts of northwest Florida. This area is well drained and, compared to other parts of Florida, has steep slopes. Much of the area is covered by permeable soils that readily pass rainfall into a shallow aquifer. An aquiclude underlying the shallow aquifer in this area ensures that most of the outflow appears in streams. Surface runoff for basins west of the Choctawhatchee River has been measured at 29 inches per year.

On the other hand, for portions of extreme southern Florida where topography is flat and drainage is poor, water is readily available for evaporation (Visher, 1969). Actual outflow in parts of this region is the lowest for the state (in some areas approaching zero).

Runoff

Runoff is that part of the outflow in surface streams that flows directly into gullies, creeks, and rivers, as well as water that emerges into surface streams from underground aquifers such as springs (Hughes, undated). Measured runoff averages from zero to 10 inches per year in much of extreme south Florida, from 20 to 40 inches in parts of northwest Florida (the Panhandle), and from 10 to 20 inches per year over much of the rest of the state (Kenner, 1966).

Runoff in Florida comes from several major streams and rivers (Figure 3). Twelve of Florida's streams have an average flow in excess of 1,000 cubic feet per second, or 646 million gallons per day (Kenner, 1975). Of Florida's five largest streams, four are in the drainage basins of northern Florida: the Apalachicola, Choctawhatchee, Escambia, and Suwannee Rivers. The fifth largest stream is the St. Johns River, which has drainage in both southern and northern Florida.

The largest of Florida's streams, the Apalachicola River, forms where the Flint and Chattahoochee Rivers come together at the Georgia-Florida line (Kenner, 1975). The Apalachicola River has 17,200 square miles of drainage in Alabama and Georgia, and 2,400 square miles of drainage in Florida. At the Florida state line,

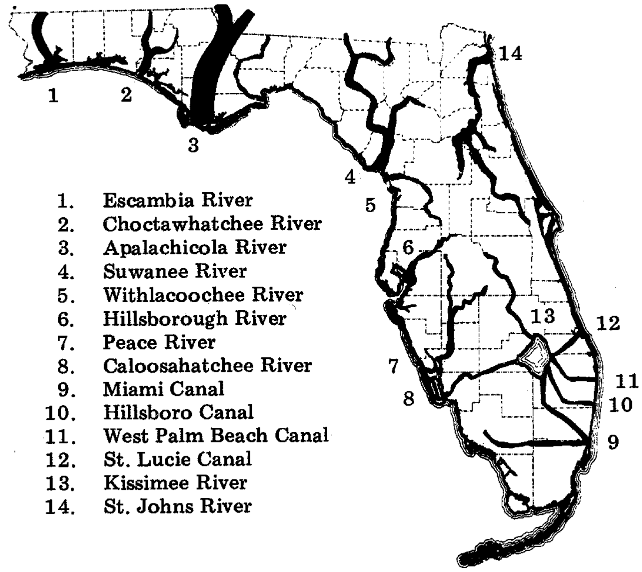

Figure 3. Major streams in Florida (width of ribbon reflects relative magnitude of streamflow).

its average flow is 14,300 million gallons per day. The Jim Woodruff Lock and Dam impounds (dams up) the Apalachicola River at the Georgia-Florida state line to form Lake Seminole (37,500 acres). At the Gulf of Mexico, the average flow of the Apalachicola River is 16,400 million gallons per day.

The Suwannee River, Florida's second largest river, has a drainage of 10,000 square miles from its headwaters in southern Georgia to its mouth in the Gulf of Mexico (Kenner, 1975). Average flow of the Suwannee River at its mouth is about 7,100 million gallons per day. The Santa Fe River flows into the Suwannee River, as do a number of springs such as Fannin, Ichetucknee, Manatee, and Troy.

The Choctawhatchee River, Florida's third largest river, has a drainage of 3,100 square miles in southeastern Alabama and 1,500 square miles in Florida before flowing into Choctawhatchee Bay near Fort Walton Beach at a rate of over 4,400 million gallons per day (Kenner, 1975).

The Escambia River and its tributaries have drainages of 3,760 square miles in Alabama and 425 square miles in Florida before flowing into Pensacola Bay at a rate of over 4,000 million gallons per day (Kenner, 1975).

Florida's St. Johns River has a drainage of about 9,400 square miles from the marshes west of Vero

Beach to its mouth at the Atlantic Ocean in Jacksonville (Kenner, 1975), with an average flow of 3,600 million gallons per day. The St. Johns River connects seven major lakes from Lake Washington to Lake George. Its tributary, the Oklawaha River, connects nine lakes from Lake Apopka to Lake Lochloosa.

The Kissimmee River, with headwaters near Orlando, Florida, flows south down the center of the state, emptying into Lake Okeechobee at a rate of about 1,400 million gallons per day (Kenner, 1975). The Kissimmee River has a drainage of about 3,000 square miles and connects nine major lakes from East Lake Tohopekaliga to Lake Placid. Lake Okeechobee, which is roughly 30 miles wide, is a managed source of water supply for much of southeastern Florida.

The Peace River, Withlacoochee River, and the Hillsborough River have drainage from central Florida to the Gulf of Mexico (Kenner, 1975). The Peace River flows into Charlotte Harbor at a rate of about 1,400 million gallons per day. The Withlacoochee River flows to the northwest from an area called the Green Swamp in Polk, Sumter, and Lake Counties, emptying into the Gulf of Mexico near Yankeetown at a rate of about 1,300 million gallons per day. The Hillsborough River also originates in the Green Swamp, discharging about 430 million gallons per day into Tampa Bay.

In southern Florida, streams, for the most part, are poorly developed, and most of the drainage occurs through a system of canals that have been expanded to relieve high water conditions and deliver water supplies to growing population centers (Kenner, 1975). The St. Lucie Canal connects Lake Okeechobee to the Atlantic Ocean near Stuart, and the Caloosahatchee Canal and River connect Lake Okeechobee with the Gulf of Mexico near Fort Meyers. Together they form a navigable cross-state waterway. Canals from Lake Okeechobee to the Atlantic Ocean include the Hillsboro, North New River, Miami, and West Palm Beach Canals, delivering 200, 300, 350, and 500 million gallons per day, respectively.

The streams, rivers, springs, and lakes produced by the runoff phase of Florida's hydrologic cycle are familiar to Floridians as sources of water supplies, recreational attractions, transportation routes, and a haven for the state's abundant fish and wildlife populations. Closely related to Florida's surface water systems, and equally important as a source of water supply, are Florida's major groundwater systems.

Principal Aquifers in Florida

Florida has several prolific aquifers that yield large quantities of water to wells, streams, lakes, and some of the world's largest springs (Figure 4) (Hyde, 1975). The principal source of groundwater for most of Florida is the Floridan Aquifer. It is the source for the municipal water supplies of Daytona Beach, Jacksonville, Gainesville, Orlando, St. Petersburg, Tallahassee, and Tampa (Klein, 1975). It also yields water to thousands of domestic, industrial, and irrigation wells throughout the state.

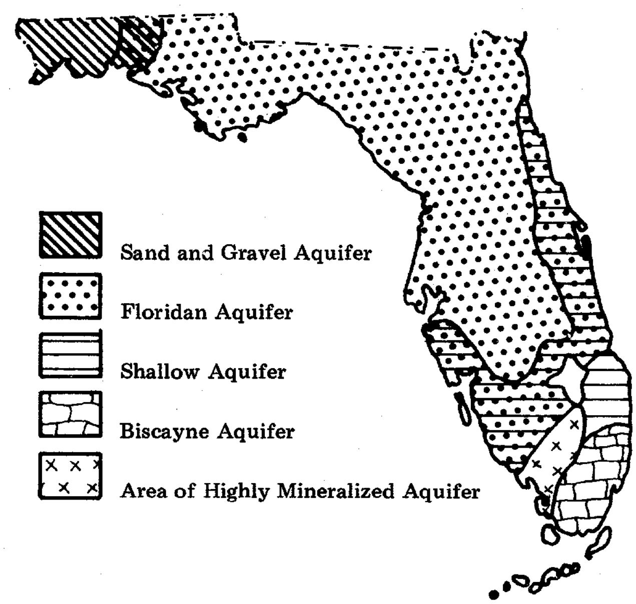

Figure 4. Principal aquifers in Florida.

The thick layers of porous limestone of the Floridan Aquifer underlie all of the state; although in the southern portion of the state, the water it contains is too highly mineralized to be useable (Hyde, 1975). Except in those areas where its limestone formations break the surface of the ground, the Floridan Aquifer underlies several hundred feet of sediment, including thick beds of relatively impermeable material that restrict the upward movement of water. This causes the aquifer to have artesian pressure. Water in the Floridan Aquifer is replenished by rainfall in central and northern Florida, where the aquifer emerges at the surface or is covered by permeable materials, or where the confining material is broken up by sinkholes.

The non-artesian Biscayne Aquifer underlies an area of about 3,000 square miles in Broward, Dade, and Palm Beach Counties (Hyde, 1975). This wedge-shaped non-artesian aquifer is 100 to 400 feet thick near the coast, but thins to only a few feet farther inland. Water in the Biscayne Aquifer is derived chiefly from local rainfall and, during dry periods, from canals ultimately linked to Lake Okeechobee. The Biscayne Aquifer is an important source of water supply for the lower east coast cities.

A non-artesian, sand-and-gravel aquifer is the major source of groundwater in the extreme western part of the Florida panhandle (Hyde, 1975). The aquifer ranges in thickness from 300 to 700 feet and consists primarily of very coarse quartz sand. Water in the sand-and-gravel aquifer is derived chiefly from local rainfall and is of good chemical quality. Wells in this aquifer system furnish most of the groundwater used in Escambia and Santa Rosa Counties and part of Okaloosa County.

A shallow non-artesian aquifer is present over much of the state, but it is not an important source of groundwater for most of Florida because a better supply is available from other aquifers (Hyde, 1975). However, in rural areas where water requirements are small, this aquifer is tapped by small-diameter wells. In south Florida, the shallow aquifer is a major source of groundwater in Charlotte, Collier, Glades, Hendry, Indian River, Lee, Martin, Palm Beach, and St. Lucie Counties. The water in this shallow aquifer is derived primarily from local rainfall.

Salt Water Intrusion

Florida's situation as a peninsula between two bodies of salt water creates the potential for salt water intrusion into the fresh groundwater supply (Reichenbaugh, 1972). Salt water is more dense than fresh water and exerts a constant pressure to permeate porous aquifers. As long as freshwater levels in the aquifers are above sea level, the freshwater pressure keeps salt water from moving inland and upward into the aquifers. For example, the level of water flowing through south Florida's coastal canals is generally several feet above sea level—enough to hold out the dense salt water (McCoy, 1968). However, during dry periods, the freshwater levels in canals without locks and dams may fall to or below sea level, which would allow salt water to move upward into the canals.

In some places, overpumping a well can increase salt water intrusion. As water is pumped at a rate faster than the aquifer is replenished, the pressure of freshwater over salt water in the land mass decreases. This may cause the level at which the saltwater and freshwater meet to rise in the aquifer, degrading the water quality. This problem must be controlled by careful attention to well location and pumping rates. The problem of saltwater intrusion is aggravated by periods of drought during which there is not enough rainfall to replenish the freshwater aquifers.

Florida's Springs

There are more than 200 springs in Florida (Rosenau, 1975). Most of these springs emerge from cavities in the porous limestone of the Floridan Aquifer to become part of the water in streams and lakes. The Floridan Aquifer is replenished by rainfall over northern and central Florida, southern Alabama, and southern Georgia. The combined flow of Florida's springs is about seven billion gallons a day (Leach, 1978).

Conclusion

A description of Florida's water resources is usefully organized in terms of the hydrologic cycle. Since the cost and feasibility of making water supplies available for municipal, irrigation, and industrial uses is determined to a great extent by the patterns of rainfall, runoff, and infiltration over time and space, it is important that Florida's citizens become familiar with the water cycle.

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