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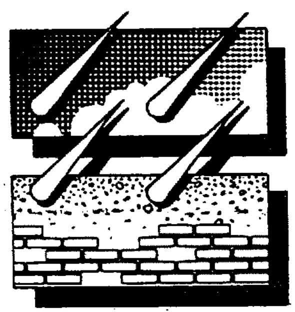
Technical Information Planning Series Report:

"Prime Recharge"; SWFWMD, December 1987

PRIME RECHARGE

Technical Information Planning Series 87-2



Southwest Florida Water Management District

PRIME RECHARGE

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Technical Information
Planning Series

87-2

Southwest Florida Water Management District
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Introduction

This is one in a series of technical information papers prepared by the Planning Department at the Southwest Florida Water Management District (SWFWMD). The purpose of the series is to provide information to local planners on timely water resources issues with particular relevance to growth management and planning. The papers will provide technical information; clarify the role and responsibility of the District; provide a status report on relevant District activities; and suggest means by which the District and local governments can work cooperatively to achieve common water management goals.

This paper will examine the issues of ground-water recharge and the designation of so-called "prime" recharge areas. The development of the term "prime recharge" will be reviewed, followed by a background discussion of ground-water concepts and hydrogeologic conditions in the SWFWMD. Next, we will take a closer look at recharge, including physical determining factors, calculation techniques, and some of the possible criteria for application of the "prime" classification. Finally, the status of prime recharge designation in the Southwest Florida Water Management District will be considered, followed by a discussion of the administrative and technical aspects of recharge area protection.

History

The concept of prime ground-water recharge areas first appeared in Florida's water policy framework in 1982, when the state legislature adopted amendments to the Florida Water Resources Act. The 1982 amendments added Section 373.0395 to Florida Statutes, which directs each water management district to develop a ground-water basin resource availability inventory covering areas deemed appropriate by the district's governing board. Prime recharge areas are specifically mandated for inclusion in the inventories.

Further revisions to Chapter 373, F.S., in 1985, added requirements for publication of a legal notice and a public hearing prior to the adoption by a water management district of a prime recharge area for the Floridan or Biscayne Aquifers (Section 373.0397, F.S.).

The Florida State Comprehensive Plan (Chapter 187, F.S.) mandates the identification of water recharge areas, the protection of their function, and incentives for their conservation. The word "prime" is not used.

The State Water Use Plan and the State Land Development Plan both contain policies calling for special protection for 50% of Florida's prime recharge areas by 1995.

Florida's recent growth management legislation, the Local Government Comprehensive Planning and Land Development Regulation Act of 1985, requires local government comprehensive plans to include a topographic map depicting any areas adopted by a regional water management district as prime groundwater recharge areas for the Floridan or Biscayne aquifers. The law further states that, "these areas shall be given special consideration when the local government is engaged in zoning or considering future land use for said designated areas" (Section 163.3177(6)(c), F.S.).

The minimum criteria rule for local comprehensive plans, Chapter 9J-5, Florida Administrative Code, requires that objectives and policies be included in local plans addressing the regulation of land use and development for the purpose of protecting the functions of natural ground-water aquifer recharge areas (Rules 9J-5.011(2)(b)5 and 9J-5.011(2)(c)4, F.A.C.). These requirements are more general, and do not depend upon the designation of prime recharge areas by a water management district.

Background Discussion--Ground Water

In simplest terms, *ground water* refers to the water found beneath the surface of the earth, in soils or geologic formations that are saturated. Ground water is one component of the *hydrologic cycle*, illustrated in **Figure 1**. Ground water is found in usable quantity and quality in geologic formations called *aquifers*. An aquifer is commonly defined as a geologic formation, group of formations, or part of a formation containing enough saturated permeable material to yield significant quantities of water. Aquifers vary widely in their geologic and hydrologic characteristics, the common denominator being the capacity to store and transmit water.

Surficial aquifers are *unconfined*, meaning that there are no continuous, impermeable layers between the aquifer and the land surface. The top of the saturated

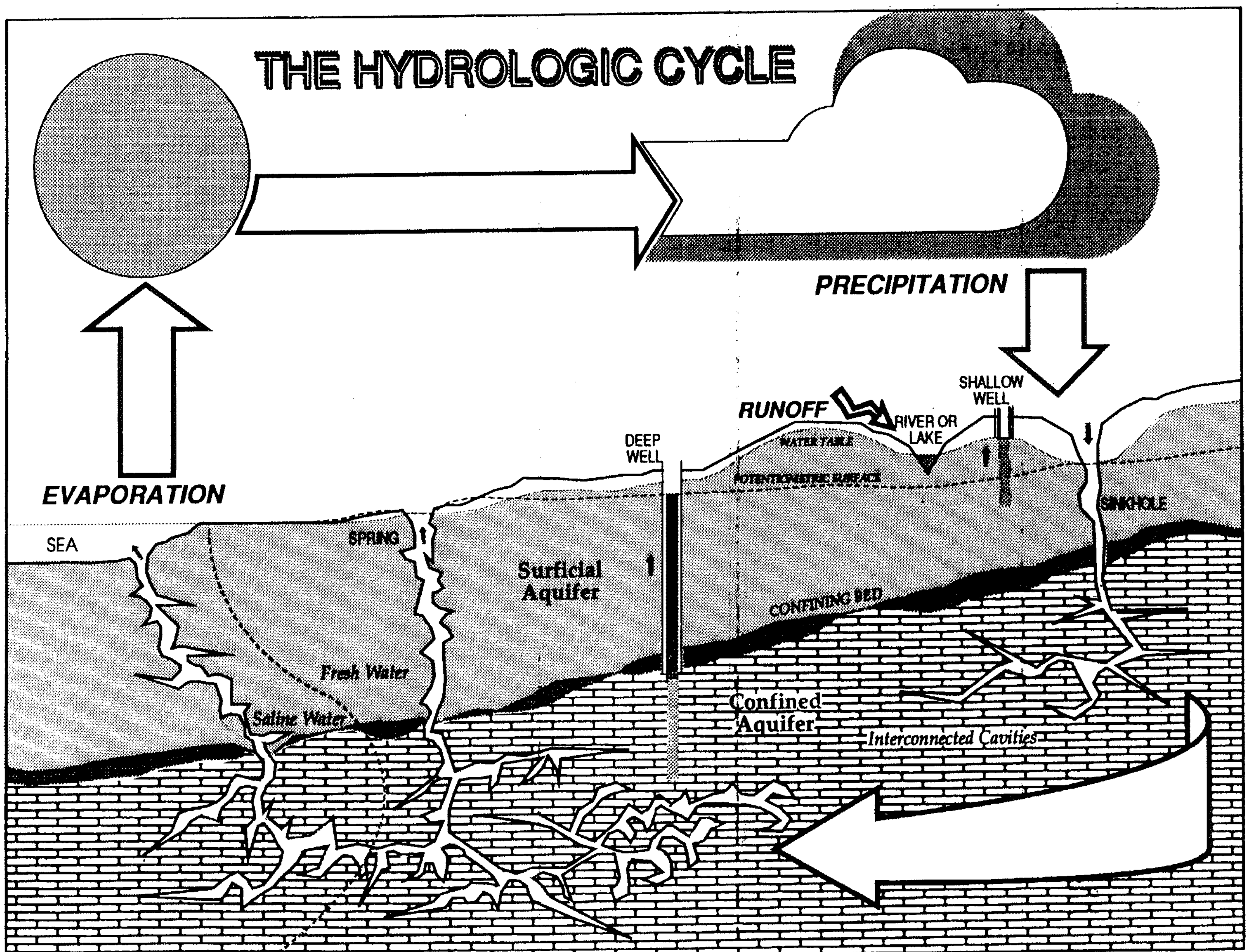

Figure 1: The Hydrologic Cycle
Modified From: Florida State University, Water Resources Atlas of Florida

zone in a surficial aquifer is at atmospheric pressure and is referred to as the *water table.*

Confined aquifers are separated from the land surface by one or more relatively less permeable geologic formations called *confining units.* The presence of a confining unit allows the development of hydraulic pressure, so that when a tightly cased well penetrates the aquifer, water rises to an elevation above the top of the aquifer. This elevation is called the *potentiometric level.* An aggregation of the estimated or observed potentiometric levels over a given area is called the potentiometric surface, and is analogous to the water table of a surficial aquifer.

Recharge can be defined as the replenishment of ground water in an aquifer. Recharge occurs primarily as a result of the infiltration of rainfall, and has a downward vertical flow component. Aquifers may also be recharged by the movement of water from adjacent aquifers or surface water bodies.

Ground water moves from recharge areas to discharge areas within complex regional and local flow systems. Natural discharge areas include springs and seeps, streams, lakes, wetlands, and undersea springs. Wells create additional discharge points which influence ground-water flow patterns. The movement of ground water is generally very slow, although flow may be locally faster, especially in some limestone aquifers which have large, interconnected joints and cavities.

The amount of water stored in an aquifer is determined by a dynamic balance between recharge, evapotranspiration, leakage to or from adjacent aquifers, withdrawals, and discharges to surface waters. When total water losses exceed inflow over time, the amount of water stored in an aquifer decreases. This situation, when caused by the pumping of wells, is known as *overdrafting* or *mining* an aquifer.

Hydrogeologic Regime of the SWFWMD

The SWFWMD includes all or part of 16 counties in West-Central Florida (**Figure 2**). The District's ground-water systems exhibit considerable variability over the region.

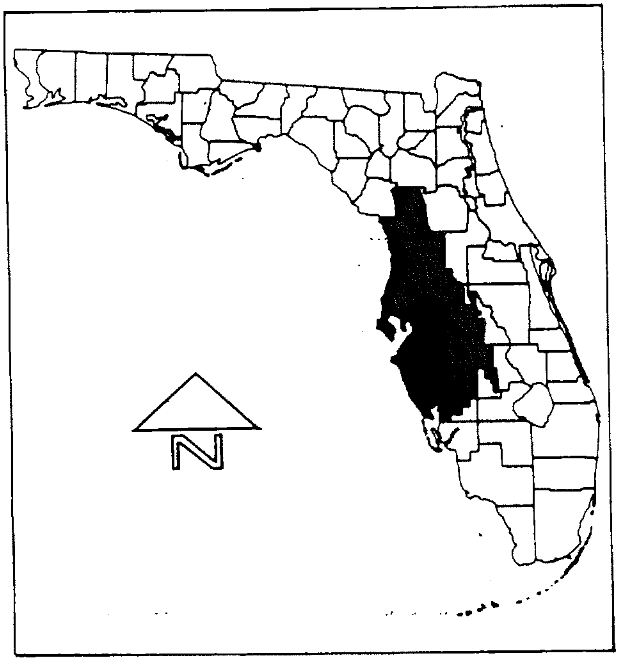

Figure 2: Boundaries of the Southwest Florida Water Management District

The entire area is underlain by the *Floridan aquifer system,* one of the world's most extensive and highly permeable aquifers. The Floridan represents the most important water source in the region, but conditions vary considerably in different parts of the District. In the north, the Floridan aquifer is generally unconfined, is recharged at high rates over wide areas, yields large quantities of high-quality water, and provides essentially all of the water used in the area. In contrast, further south, and along the coast, the Floridan is under confined conditions, receives little or no local recharge, and contains water that is so highly mineralized that in some areas it is unsuitable for any use without expensive treatment. **Figures 3 through 5** show these regional variations in the Floridan aquifer system.

The greatest amount of recharge to the Floridan aquifer system occurs in areas where the confining unit is absent or discontinuous, where the water table is at a significantly greater elevation than the potentiometric surface of the aquifer, and areas where the aquifer system is overlain with relatively permeable materials such as the thick sand deposits found locally in northern and eastern sections of the District (SWFWMD, 1987). The elevation difference between the potentiometric surface and the water table provides the driving head needed to move water through the confining unit, where one exists. Thick, permeable soils and sands allow rainwater to infiltrate quickly, minimize runoff, and provide temporary storage.

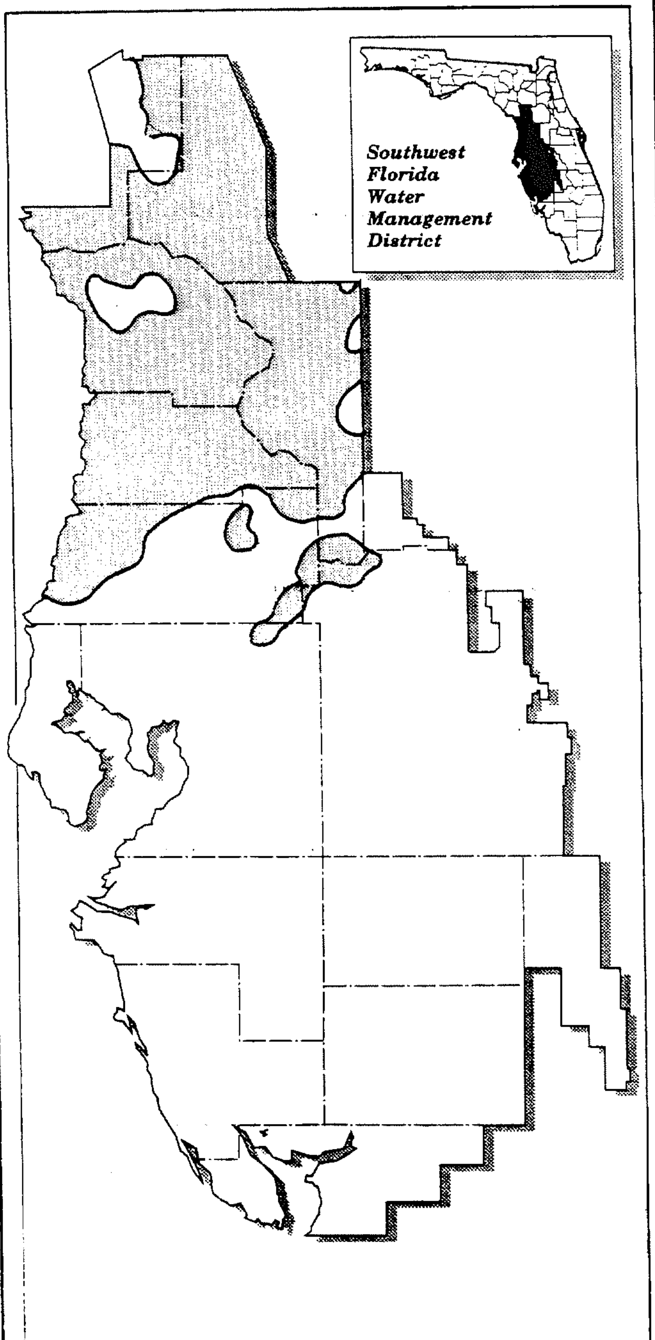

Figure 3: Interpretation of where the Floridan Aquifer is under water table conditions (as designated by shaded area)

Source: SWFWMD Ambient Ground-Water Quality Monitoring Program

The *surficial aquifer system* is a permeable hydrogeologic unit contiguous with the land surface, comprised principally of unconsolidated or poorly consolidated materials. It does not exist as a continuous unit over the entire region, but is a locally important water source, particularly in southern parts of the District. Recharge is variable and is generally greatest in upland areas with highly permeable soils or surficial deposits.

In roughly the southern half of the District, an *intermediate aquifer system* occurs between the surficial and Floridan systems. This is a confined system which yields significant quantities of usable water in some areas. Recharge to this aquifer system is from downward leakage from the surficial aquifer and upward leakage from the Floridan system.

Figure 6 presents a generalized cross section of the District from north to south, showing the relationships among the three aquifer systems.

Aspects of Ground Water Recharge

Concern for recharge areas reflects the importance of ground water, generally. Ground water provides approximately 86% of the fresh water used in the SWFWMD for all purposes combined (Stieglitz, 1986). In some parts of the District, ground water is the only available source of water.

Recharge Functions

Ground-water recharge provides many benefits, some of which are listed below.

- *Replenishment of water supplies.* As noted earlier, water withdrawals from an aquifer must be balanced by recharge to ensure the sustainable use of ground water.

- *Saltwater intrusion protection.* The Florida Peninsula is both surrounded and underlain by saline water. Any reduction in the volume of water stored in freshwater aquifers above the saline zone results in the upward or lateral movement of salt water. Once freshwater aquifers are thus contaminated, restoration is difficult and costly if not impossible.

- *Maintenance of lake levels, stream flows, and spring flows*. Many surface water systems have hydraulic connections to ground water, which may support surface water levels for all or part of the year via baseflow. Reduced ground-water recharge can result in a decline in ground-water levels, and a corresponding decline in surface water levels and spring flows.

- *Dilution of contaminants*. Ground-water recharge introduces fresh water underground which may serve to improve water quality where the ambient ground water is degraded.

- *Reduction of surface flooding*. Natural recharge provides water storage during rainfall events, reducing and delaying stormwater runoff and thus the potential for flooding.

- *Prevention of sinkhole formation*. In some susceptible areas, the hydrostatic pressure of ground water can prevent or retard the development of sinkholes. A drop in ground-water levels in susceptible areas can induce a series of sinkhole formations.

Impacts of Growth

Florida's population continues to grow at a rapid rate, as it has for the past three decades. This growth creates several impacts on ground-water recharge. The primary problem involves large scale land development, which creates impervious surfaces such as building roofs and pavement. These surfaces block the natural infiltration of rainwater, and add to the volume of stormwater runoff.

Stormwater runoff has been identified as a major source of surface water pollution. It may also contaminate aquifers where direct recharge is possible, through natural or artificial means (for example, sinkholes or drainage wells). Other potential pollution sources associated with development include septic tank and wastewater treatment plant effluents, industrial discharges, landfill leachate, and agricultural chemicals.

Population growth also creates additional demand for water. When these new requirements are met through larger withdrawals of ground water, aquifer recharge assumes critical importance in the replenishment of supplies.

Determining Factors

Recharge rates depend on many variables, the most important of which are listed below:

- Permeability of surface soils and materials;
- Storage capacity of surface soils and materials;
- Elevation of the water table relative to the land surface;
- Elevation of the potentiometric surface relative to the land surface(confined aquifers);
- Rainfall frequency, duration and intensity;
- Rate of evapotranspiration;
- Vegetative cover, type and density;
- Topography;
- Degree of development of natural surface drainage;
- Depth to the aquifer;
- Presence and nature of confining units;
- Hydraulic conductivity of the confining unit;
- Vertical hydraulic gradient; and
- Transmissivity and hydraulic gradient of the receiving aquifer.

Notice that some of the factors are interdependent, a fact that complicates the estimation of recharge.

In general, the most productive recharge areas are uplands with highly permeable soils and poorly developed surface drainage. Most wetlands are not highly productive recharge areas, due to their tendency to hold water above ground (Sather and Smith, 1984). Many wetlands are in fact discharge areas, where ground water seeps to the surface.

Calculation of Recharge

There are two basic methods used to estimate recharge. The first is a simple water budget calculation. Estimates of runoff and evapotranspiration are subtracted from the amount of precipitation measured during the period of interest, normally a year. The result is the amount of water available for recharge.

Complex computer models provide a method to calculate recharge more accurately. Models simulate the behavior of aquifer systems using known measurements of aquifer characteristics, rainfall, evapotranspiration, stream and spring discharge, withdrawals, and other parameters. Models are calibrated by adjusting variables within known ranges

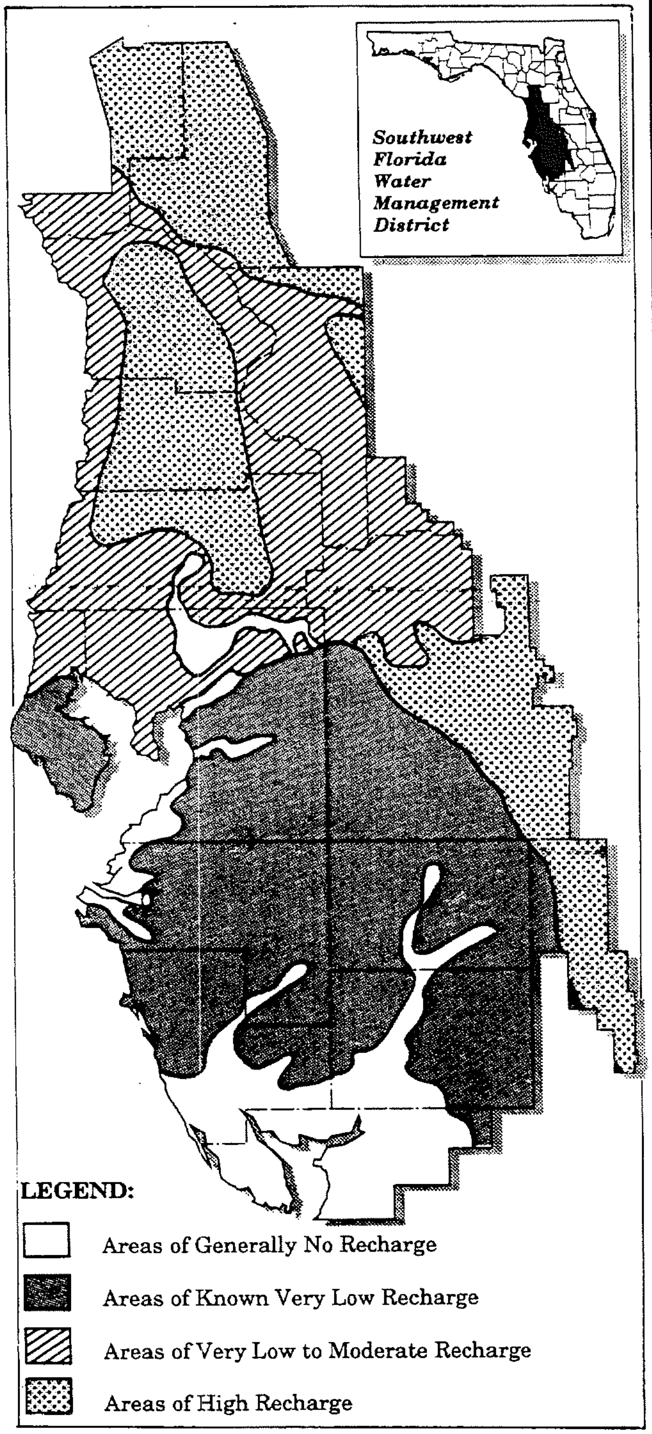

Figure 4: Areas of Natural Recharge to the Floridan Aquifer in the Southwest Florida Water Management District

Source: Modified from Stewart, J. W., 1980, Areas of Natural Recharge to Floridan Aquifer in Florida, Florida Department of Natural Resources, Bureau of Geology, Map Series No. 73

until calculated results most closely match observed values. The accuracy of model-derived recharge values depends on the quality and completeness of the input data, but this is generally a more sophisticated technique than the water budget method.

Applicability of the "Prime" Designation

Although Florida law directs the water management districts to designate prime recharge areas, no statutory definition has been provided. Based on the dictionary definition of prime, we can infer that prime recharge areas are those of the greatest importance or value. But this still leaves a very subjective task in the rating of recharge areas.

There are two basic dimensions to the issue of recharge area protection: water quantity and water quality. From the quantity perspective, it is desirable to ensure enough recharge to sustain projected ground-water requirements for natural systems and the future population of the region. But in terms of water quality, recharge areas are sensitive zones, because water moving downward from the surface can transport contaminants to the aquifer.

Depending on local conditions, the appropriate priorities for recharge area protection may vary from place to place. Some of the factors which should be evaluated in the ranking of potential prime recharge areas include the following.

- *Recharge rate.* Areas with high recharge rates provide the maximum amount of total recharge relative to the area of land protected.

- *Volume of recharge contributed.* Areas that provide a large volume of recharge or a large proportion of the total recharge to an aquifer are clearly valuable. The recharge rate may not necessarily be high.

- *Potentiometric highs.* Areas with potentiometric levels that are higher than the surrounding region are significant. Recharge in these areas maintains the pressure in confined aquifers and helps to drive regional ground water flow systems. The Green Swamp area of Central Florida is an example of a potentiometric high for the Floridan aquifer.

- *Susceptibility to saltwater intrusion.* Responsible resource management should include the maintenance of sufficient recharge to prevent saltwater intrusion in critical areas, such as the coastal zone and areas of heavy pumpage.

- *Susceptibility to contamination.* Based on physical characteristics, such as soil permeability and water table depth, some areas are particularly sensitive to ground-water pollution, and merit special protection.

- *Recharge contribution to major wells.* Through computer modeling, zones of contribution to major withdrawal points, such as public supply wells, can be identified and protected. Future wellfield sites may also be protected in this manner. Protecting areas of contribution serves both quantity and quality purposes.

- *Threats to the recharge function.* It may be appropriate to assign higher priority to important recharge areas that are threatened by imminent development. Protection of the recharge function is much easier to accomplish prior to development rather than attempting to retrofit a developed area.

Status of Prime Recharge Area Designation in the SWFWMD

The mission of the Southwest Florida Water Management District can be divided into five categories:

- *Ensuring Adequate Water Supply;*
- *Promotion of Water Conservation;*
- *Protection of Water Quality;*
- *Integration of Land and Water Management; and*
- *Management of Surface Waters.*

In pursuit of these goals, and in accordance with specific statutory and administrative delegations of authority, the District has implemented a variety of regulatory, scientific, planning, and administrative programs. The task of prime recharge area designation must be incorporated into this regional water management framework.

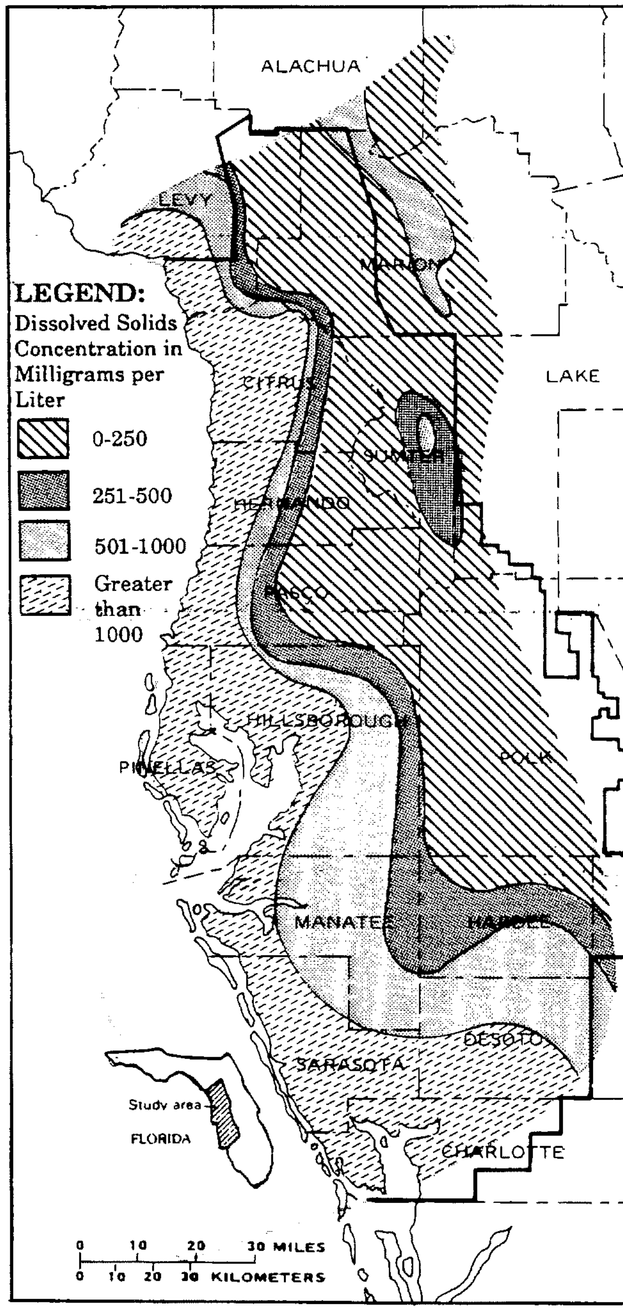

Figure 5: Dissolved Solids Concentration in Water from the Upper Floridan Aquifer

Source: USGS, Hydrogeology of the Floridan Aquifer in West Central Florida

The SWFWMD staff is currently preparing the Ground-Water Basin Resource Availability Inventories for 13 counties in the District (ground-water information for Levy, Lake, and Highlands Counties is being provided by other water management districts). This first-generation series of inventory reports will not contain any designations of prime recharge areas. They will, however, include generalized maps showing natural recharge amounts, areas susceptible to ground-water contamination, and areas suitable for water supply development. This information should prove valuable to local governments in the process of identifying and protecting environmentally sensitive areas.

Because of the complex nature of the task, identification and designation of prime recharge areas by the District will require a major commitment of time and resources. More data will have to be collected, and computer models will have to be developed and calibrated. And perhaps most importantly, criteria and guidelines will have to be developed to more clearly define prime recharge areas.

Efforts are underway at the District to lay the groundwork for prime recharge area designation. Data collection is being expanded, and district-wide and regional ground-water flow models are under development. The technical capacity for prime recharge designation will probably be available in the near future. The political and legal complexities may prove to take more time to resolve.

The designation of prime recharge areas will provide additional information which may be utilized in the formulation of local land use policy. Any specific actions to protect these areas will be at the discretion of local governments. Protection of prime recharge areas is not mandatory, but as noted earlier, the state's 1985 growth management legislation does require local governments to give prime recharge areas special consideration in land use planning and regulation.

Discussion of Recharge Area Protection

The issue of recharge area protection demonstrates the interdependence of land and water resources. Land and water are intimately connected and cannot be effectively managed separately. Human activities in one sphere have effects on the other. This complexity and interdependency of natural systems indicates the need for a comprehensive approach to resource management.

Existing political and administrative systems create additional complexity for ground-water management. Because political boundaries often cut across natural systems, a high degree of cooperation is necessary to achieve consistency in water policy. Also, authority for various functional areas is highly fragmented. Water management responsibility is distributed among several state agencies and the water management districts. Land development regulatory authority remains largely in the domain of local governments. Given this system, it is clear that a comprehensive ground-water management program can only be implemented through a coordinated effort involving local governments and a number of state and regional agencies.

Roles

Because local governments have almost exclusive authority for the regulation of land development, they have an opportunity to play a leading role in protection of recharge areas. Of primary interest to local governments is the replenishment and protection of local water supplies. In some instances, protecting the local water supply will necessitate the conservation of recharge areas in neighboring jurisdictions. Interlocal cooperation is crucial in these cases. The water management district could play an important role in such regional coordination.

The responsibilities of the SWFWMD involve a full range of functions in the management of regional water resources. Several mechanisms available to the District to help protect the recharge function are summarized below:

- Designation of prime recharge areas for regionally significant aquifers;
- Review and comment on Local Government Comprehensive Plans;
- Collection and dissemination of hydrogeologic information;
- Technical assistance to local governments.

- Acquisition and preservation of important recharge areas.
- Imposition of conditions on surface water management permits.

These last two activities are opportunities for direct involvement in recharge area protection which are not currently being fully utilized, but could be in the future. The primary means of land acquisition involves the "Save Our Rivers" program. Section 373.59(3), F.S., authorizes the water management districts to use money from the Water Management Lands Trust Fund to acquire lands "necessary for water management, water supply, and the conservation and protection of water resources." Clearly, recharge areas qualify for acquisition under this statutory directive.

Section 373.416(1), F.S., expressly authorizes the imposition of reasonable conditions on surface water management permits. Permit conditions in recharge areas could require the incorporation of features to enhance recharge in the design of retention ponds and other water management system components.

In addition to the above, District activities in water conservation, water shortage planning and water quality protection, serve to complement recharge protection efforts.

Various other state, regional, and private agencies could also become involved in recharge area protection. The Department of Natural Resources, Department of Environmental Regulation, Department of Community Affairs, the Regional Planning Councils, the Regional Water Supply Authorities, and private environmental organizations are examples of agencies that could incorporate ground-water recharge considerations into many of their activities.

Methods of Recharge Area Protection

There are numerous methods by which the functions of ground-water recharge areas may be protected. As noted earlier, much of the implementing authority rests with local governments, through their broad powers to regulate land use. Protection methods are summarized below.

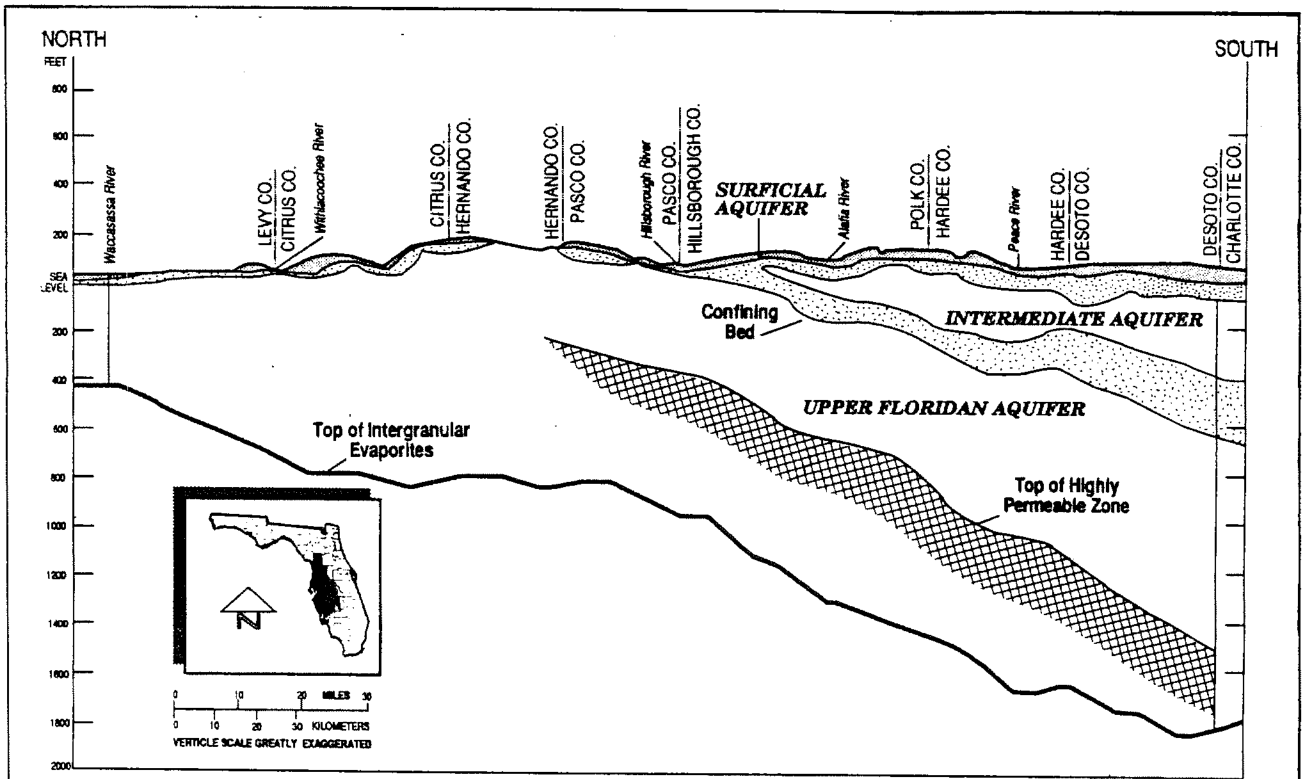

Figure 6: Hydrogeology of the Florida Aquifer System in West-Central Florida

Source: USGS, Hydrogeology of the Florida Aquifer System in West-Central Florida

1. ***Performance Standards Incorporated into Land Development Regulations or Permit Criteria***
   - Density limits
   - Impervious surface coverage limits
   - Balanced water budget requirements
   - Stormwater retention design considerations
   - Vegetation preservation/enhancement

   The various performance standards are intended to minimize or mitigate the loss of natural recharge capacity caused by clearing of vegetation and development of impervious surface area. Performance standards can be employed through overlay zoning districts, land development regulations, and other regulatory techniques.

2. ***Aquifer Protection Ordinances***

   To protect the quality of local water resources, local governments may choose to identify sensitive areas and regulate land uses in those areas accordingly. Areas upgradient from public supply wells are normally the highest priority.

3. ***Conservation or Agriculture Zoning***

   Restrictive zoning prohibits incompatible development. Only low intensity uses are permitted, minimizing the loss of natural recharge capacity.

4. ***Fee Simple Acquisition***

   Outright purchase of land by government or private agencies for preservation purposes is the most direct method of recharge area protection. Acquired lands can also be used for recharge-compatible activities such as certain types of recreation.

5. ***Conservation Easements***

   This method involves the payment of a fee or other considerations to a landowner in exchange for an agreement to maintain the land in such a state that the natural recharge function is preserved. Tax incentives may also be available through state and county programs.

6. ***Transfer of Development Rights***

   A variety of techniques can be used to transfer the development rights for a particular area (e.g. recharge areas) to another location. The receiving area may then be developed at a higher density than normally allowed, while the donating area is preserved.

7. ***Artificial Recharge as Mitigation***

   Under this option, development is permitted only if lost natural recharge capacity is compensated. Various methods exist to artificially recharge an aquifer. These include injection wells, drainage wells, seepage basins, etc. Water quality safeguards must be incorporated into mitigation requirements to prevent aquifer contamination.

Summary and Conclusions

The adoption by a water management district of prime ground-water recharge areas does not by itself afford any protection for these areas. The state statutes that provide for the prime designation do not impose any restrictions in prime recharge areas per se. Furthermore, the "prime" label is not a prerequisite for protection of vital recharge areas. Several options for recharge protection have been presented here, none of which depend upon the prime designation.

Perhaps the best opportunity for recharge area protection involves the authority of local governments to regulate land development. Through various regulatory techniques, development impacts on the recharge function can be eliminated, minimized, or mitigated. Acquisition and preservation of recharge areas by state, regional, local, or private agencies could become an important recharge protection mechanism, but high costs limit the extensive use of this alternative. The water management districts and state agencies can regulate the use of water resources, provide technical assistance to local governments, and support recharge efforts through other water management programs.

Because the boundaries of hydrogeologic systems seldom coincide with those of political and administrative jurisdictions, coordination is necessary to protect recharge areas. Local governments, state agencies, and the water management districts all have important roles to play.

Recharge protection needs vary according to local and regional conditions. Replenishment of water supplies, protection of water quality, saltwater intrusion protection, or wellfield protection are appropriate priorities in various locations.

The statewide planning and growth management administrative framework established by the Local Government Comprehensive Planning Act and related legislation provides a basis for a coordinated effort to protect the recharge function. Development and implementation of ground-water recharge policies at the state, regional and local levels should be an essential component of the planning process. Requirements for consistency and technical assistance within the planning framework provide a convenient coordination mechanism.

The continued use of ground water to meet the full range of demands throughout the SWFWMD is dependent upon the availability of adequate amounts of high-quality recharge water. Rapid growth and development in the region impairs the functioning of recharge areas, creates additional demand for water, and threatens water quality in vital aquifers. It has become increasingly clear that inevitable growth must be managed to maintain the environmental quality that gives this state its character. In order to ensure the future availability and quality of the ground water upon which we depend, protection of the recharge function must be accorded high priority in the state's growth management program.

References

Driscoll, Fletcher G., 1986. Groundwater and Wells. Johnson Division, St. Paul, Minnesota.

East Central Florida Regional Planning Council, 1974. Policy Alternatives in Water Recharge Areas. Winter Park, Florida.

Fernald, Edward A. and Donald J. Patton, 1984. Water Resources Atlas of Florida. Florida State University, Tallahassee, Florida.

Freeze, R. Allen and John A. Cherry, 1979. Groundwater. Prentice-Hall, Englewood Cliffs, New Jersey.

Gilboy, A.E., 1985. Hydrogeology of the Southwest Florida Water Management District. Southwest Florida Water Management District, Brooksville, Florida.

Jaffe, Martin and Frank DiNovo, 1987. Local Groundwater Protection. American Planning Association, Chicago, Illinois.

Maloney, Frank E. and Richard Hamann, 1981. Integrating Land and Water Management. Publication No. 54, Water Resources Research Center, Gainesville, Florida.

Page, G. William (ed.), 1987. Planning for Groundwater Protection. Academic Press, Orlando, Florida.

Ryder, Paul D., 1985. Hydrogeology of the Floridan Aquifer System in West-Central Florida. Professional Paper 1403-F. U.S. Geological Survey Washington, D.C.

Sather, J. Henry and R. Daniel Smith, 1984. An Overview of Major Wetland Functions and Values. U.S. Fish and Wildlife Service, Fort Collins, Colorado.

Southwest Florida Water Management District, 1987. Aquifer Characteristics Within the Southwest Florida Water Management District. Brooksville, Florida.

Stangland, Herb, 1973. Ground Water Recharge in Florida. Reynolds, Smith, and Hills, Jacksonville, Florida.

Stieglitz, Elizabeth H., 1986. Water Use Estimates 1985. Southwest Florida Water Management District, Brooksville, Florida.

U.S. Department of Agriculture, 1967. Ground-Water Recharge. Technical Release No. 36, Soil Conservation Service.