Potential for Groundwater Pollution of the Floridan Aquifer,

Based Upon Surficial Drainage, Karst Development, and Overburden Characteristics,

Explanatory Text

Barry F. Beck

Much of Florida's land surface is karst: a landscape characterized by sinkholes, sinking streams, caves, and large springs. The characteristics of this topography determine the path of the water that recharges the Floridan Aquifer, and the movement of water within the aquifer. The nature of the karst topography also controls the route by which contaminants may reach the aquifer and pollute our valuable ground-water supply. Because Florida relies on ground water for its water supply more than any other state--approximately 90% of the water used in Florida is ground water--it is critical that we understand the nature of karst and how it controls the potential for ground-water pollution.

Karst topography occurs in Florida because limestone and dolomite underlie the entire state and often occur at or near the surface. The Floridan Aquifer comprises thousands of feet of limestone and dolomite (a similar and related rock) of Tertiary age. The discussion which follows, and the accompanying maps, relate particularly to this aquifer and do not refer to karst features which may be forming on the younger limestones which are important aquifers in South Florida.

Limestone and dolomite are distinctly more soluble than other rocks. Over millions of years the limestone underlying Florida has been riddled with cavities created by the dissolving action of ground water. Primary pores, joints, 3-dimensional network of interconnecting cavities. The upper portion (ca. 30-35') of the limestone is most intensely dissolved and thereby most permeable. This zone has been called the epikarstic zone (Williams, 1985). The process of dissolution is slow and complex and the enlarged drainage paths throughout the aquifer have developed over millions of years. The process of solution **itself is not** causing any significant changes within man's time frame.

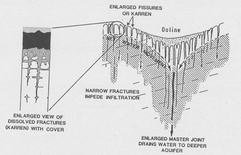
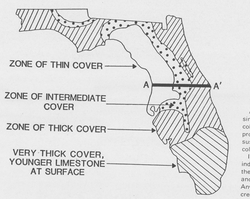
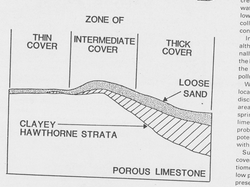


Figure 1: Generalized cross-section of the upper portion of the limestone and the overlying sediment: the epikarstic zone (modified from Williams, 1985).





A-A' CROSS SECTION

Figure 2: Generalized map and cross-section of zones of karst geomorphology, as related to the Tertiary limestones in Florida.

During the last two million years, the Floridan peninsula has been alternately exposed to weathering above sea level, or submerged by the sea and covered with sediment. Due to the recent deposition of marine sediments, dominantly sand and clay, the limestone in Florida is generally not exposed and the karst terrane is referred to as a mantled karst. Because of the recent interaction of sea level fluctuations, marine sedimentation, and surficial erosion, Florida's karst topography can be divided into four geomorphic zones (Figure 2).

In the thinly mantled zone the limestone generally is overlain by less than 25' of clayey confining beds overlain by less than 25' of surficial sand. However, in a few areas within this zone the cover thickness may be much greater (circa 100'), particularly beneath the Brooksville Ridge and in Southern Pinellas County. Where a continuous confining layer is present, a surficial aquifer occurs in the sands. Along the west coast, from Pasco to Levy Counties, the limestone is nearly bare, being overlain by less than 25' of cover sediments in total. In the northern half of the thinly covered zone the sands may overlie the limestone directly with no hydrologic separation.

In the zone of intermediate cover thickness the overlying sediments are **generally** more than 50' thick and in the thickly covered zone the overburden generally exceeds 175'. The limestone aquifer is confined in both zones, usually by more than 50' of clayey, low permeability Hawthorn Group sediments which in turn are overlain by younger, surficial sands. The Hawthorn sediments also protect the aquifer from the downward leakage of surface pollutants. The sands overlying the Hawthorn form a perched surficial aquifer which often contains water of poor quality.

Within the intermediate zone there are a few scattered areas, too small to be shown in Figure 2, where erosion has thinned or removed the cover and artesian springs are found. The boundary between intermediate and thick cover was selected as 175' because 97% of all **new** sinkholes in the Orlando area occur in areas where the cover is less than 175' thick (Wilson and others, 1988). Thus, the intermediate zone is an area of active karst collapse, whereas in the thickly covered zone this problem rarely effects the land surface today.

It is the relationship between the unconsolidated, surficial sediment, sinkholes, the epikarstic zone, and the deeper Floridan Aquifer which determines the potential for ground-water pollution in many areas of Florida. In the thinly covered zone, sinkholes are often open directly to the water table. In the area west of Gainesville these are vertically-walled pits in limestone which expose the ground water in the bottom. These are known to geologists as cenotes. In many other areas, such as along the west coast from Pasco to Citrus Counties, a more-or-less funnel-shaped depression in the sand may connect to an open shaft in the limestone, or the collapsed sand may cover up the limestone. Where the water table is close to the land surface, such sinkholes will be water-filled. On the other hand, if the water table is deeper, such as in the area west of Ocala, small sinkholes may be dry, even when the limestone can be seen in the bottom. Older, broad, shallow sinkhole basins are often dry because they usually do not intercept the water table. However, throughout the thinly covered zone it is obvious that any contaminated water which is allowed to drain directly into a sinkhole will quickly reach the ground water in the aquifer and degrade the quality of the potable water supply.

In the zones of intermediate and thick cover a cap of low permeability Hawthorn sediment generally protects the Floridan (limestone) Aquifer from direct infiltration from the surface. However, throughout most of these zones, karstic collapses have punctured the protective cap of Hawthorn strata. The large sinkhole basins and circular lakes common in this area may be ancient karst features caused by repeated collapse and erosion. Even the larger (one mile or more) irregular lakes are often formed from several sinkholes which have coalesced. Beneath these basins a vertical channel of permeable sediment interconnects the surficial sands and the Floridan Aquifer (see Figure 3).

Figure 3: Leakage through the bottom of a sinkhole lake in Florida.

At many localities younger sediments may have completely covered ancient sinkholes or lakes, obscuring them from detection. However, the permeable column of collapsed sediments still perforates the Hawthorn confining layer providing an avenue for groundwater pollution, and also making the site susceptible to reactivated collapse. In the zone of intermediate cover, sinkhole collapse is still occurring today, opening direct pathways to the aquifer.

In fact, man's modification of the local hydrologic conditions may trigger or induce collapse. The rate of infiltration from the surficial aquifer depends on the elevation difference between the shallow water table in the surficial sand and the potentiometric surface of the underlying limestone (Floridan) aquifer. Any changes which increase the difference may trigger sinkholes. The creation of lakes, percolation ponds, or retention basins will raise the shallow water table. The withdrawal (pumping) of water from the Floridan Aquifer will lower the potentiometric surface. Both types of activities can cause sinkhole collapse. Of course, sinkholes also collapse sporadically under purely natural conditions as part of the ongoing erosion process.

In the thickly mantled zone along the east coast, modern collapses are rare, although large, ancient sinkholes are present. These probably formed originally during periods when sea level was lower, and ground-water levels and the base level of erosion were also correspondingly lower. The breaks through the Hawthorn Group still constitute a potential avenue for ground-water pollution, although the impact of these features has not been investigated.

Within the zone of intermediate cover, some areas occur where erosion has locally thinned the cover and the artesian pressure causes ground water to discharge upward from the limestone, forming spring runs and streams. These areas of thin cover are too small to show in Figure 2. In Central Florida many spring-fed streams flow eastward into the St. Johns River. Although the limestone is close to the land surface, pollution is not now a significant problem because water is discharging from the aquifer. However, if the potentiometric surface is lowered, these areas could become recharge sites with potential contamination problems.

Surface streams also flow in many areas of the intermediate and thickly covered zones, where the shallow water table is higher than the potentiometric surface and is recharging the Floridan Aquifer slowly through the low permeability Hawthorn confining strata. However, if buried sinkholes are present, these breaks provide more direct avenues for rapid recharge or contamination.

In southern Florida the cover over the Tertiary limestones is so thick (app. 1,000') that surface drainage is generally normal and karst is not a significant factor with respect to pollution of the Floridan Aquifer. However, karstic features are developing on the younger, near surface limestones which are the major aquifers in southeastern Florida.

In northern Florida, some of the surface drainage flows westward or southward, from the intermediate zone onto the thinly mantled zone. Where surface drainage flows onto an area where the limestone is unconfined, the flow disappears underground into the limestone aquifer at discrete sinking points: stream sinks, swallets or ponors (see Figure 4). Much of this subterranean flow reappears on the thinly covered zone as springs feeding the Suwannee, Withlacoochee, or Santa Fe Rivers. In fact, several of the major rivers, such as the Santa Fe, St. Mark's, and Aucilla, themselves sink and reappear. In the latter cases, where a major stream sinks and resurges a short distance away, there may be caves conveying the flow directly between the two points. However, in the case of the numerous smaller sinking streams and the more distant springs, it is probable that this point recharge disseminates into diffuse flow through the aquifer, later to converge at the spring. Any contamination reaching these sinking streams will flow directly into the aquifer and has the potential to contaminate ground-water supplies over a broad area.

From the foregoing discussion it is obvious that karstic processes and land forms are complex and highly variable from one area to another. It is also obvious that these processes are a critical factor in evaluating the pollution potential of the Floridan Aquifer and protecting our valuable ground-water supplies.

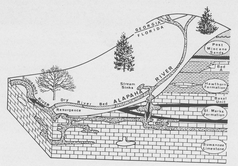


Figure 4: Cross-section showing surface drainage sinking as it passes from the intermediate (right side) to the thinly covered zone. The steep change in elevation at the boundary is called the Cody Scarp. Modified from Ceryak, 1977.

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Sources of Map Data

This series of fourteen maps was prepared from *published* data only. The topography and drainage were interpreted from the U.S.G.S. 7½' topographic quadrangle maps. The information on the geology and hydrology was summarized from various State, Federal, local, and professional publications. The data was not verified in the field.

In assembling such composite data from maps of various scales, some error is found to occur in the precise placement of the margins. Further, in assigning the various geohydrologic settings to one of eleven categories, some subjective decisions must be made, because all areas will not fit into a category perfectly. Therefore, the reader is cautioned to use these maps as a starting point only, and to conduct more specific local investigations to confirm the precise site data.

These maps were prepared by professionals with due care. However, the Florida Sinkhole Research Institute makes no warranty, express or implied, as to the absolute validity of the data.

ADDITIONAL INFORMATION ON KARST IN FLORIDA

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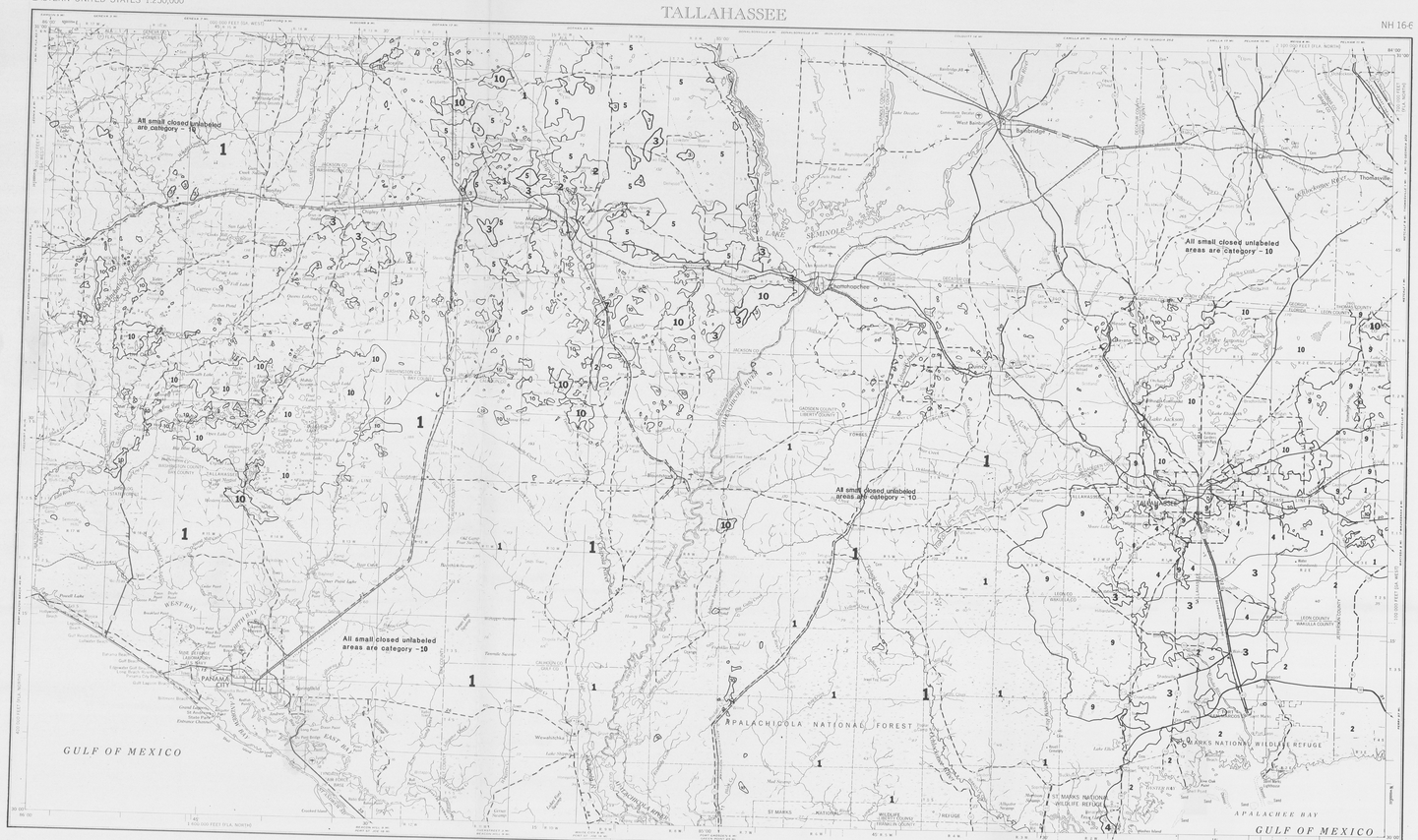
EASTERN UNITED STATES 1:250,000



Prepared by the Army Map Service (USGS), Corps of Engineers, U.S. Army, Washington, D.C. Compiled in 1954 from aerial photographs taken 1951 and from ground control surveys by USGS, 1951-1953. Planimetry compiled from aerial photographs taken 1951 and from ground control surveys by USGS, 1951-1953. Map field checked 1954. Control by USGS, USC&GS, and Florida Geological Survey (FGS).

10,000-foot grids based on Florida coordinate system, north zone and west zone, Lambert conformal conic projection

10,000-meter Universal Transverse Mercator grid ticks, zone 16, shown in blue

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LEGEND

KEY TO NUMBERED AREAS

GROUP I (Categories 1 and 2): Areas drained by surface water flow which does not directly recharge the limestone aquifer.

1 Areas where the limestone aquifer is confined by overlying "impermeable" strata.

2 Areas where the limestone is at, or very close to, the land surface but there is no infiltration because groundwater is discharging from the limestone. If the potentiometric level in the limestone is lowered, such as by heavy pumping or severe drought, such areas may alter to category 3.

GROUP II (Categories 3-11): Areas which are internally drained. These areas are generally marked by closed basins which drain into the ground. No overland flow leaves the area.

3 Limestone is at, or nearly at, the land surface. Infiltration is immediate. Cenotes may be a common feature on this terrain.

4 The limestone is covered by a limited (approximately 20' or less) thickness of highly permeable sediment. Infiltration is rapid. There is unrestricted movement of water between the limestone and the overlying surficial sediments. Small, cover-collapse sinkholes may be common and some may expose limestone in the bottom. The groundwater level may be either below the top of the limestone or in the surficial sediments, depending on local conditions.

5 The limestone is covered by thin, low permeability sediments. Infiltration is impeded and surface water may be perched for extended periods of time. Sinkholes may drain slowly due to low permeability sediment restricting infiltration.

6 The limestone is at, or near, the land surface but has lower than normal permeability. Precipitation may exceed infiltration and surface flow may occur.

7 The limestone is confined and perched surface streams drain the area. However, the confining layer is breached and surface streams sink underground after less than one mile of overland flow. Such sinkholes where streams sink underground are termed ponors or swallets, or simply stream sinks.

8 Same as category 7 but surface streams flow for more than one mile but less than five miles, before sinking.

9 Same as category 7 but surface streams flow for more than five miles before sinking underground.

10 The sediments overlying the limestone are relatively thick (up to approximately 175'). A shallow aquifer usually exists perched above the limestone. Ancient cover-collapse sinkholes may have grown quite large and deep. Several may have coallesced into a larger irregular composite basin. Most of these large ancient sinkholes are now lakes, but they may still be leaking into the aquifer through the collapse "pipe" which breaches the confining layer. Cover-collapse sinkholes may still develop in these areas, but they will be much smaller than the aforementioned ancient sinkhole basins--generally 30 to 200' in diameter. The largest recorded collapse was 350' in diameter.

11 The limestone is thickly covered (>175'). A shallow aquifer usually exists perched above the limestone. Deep cover-collapse sinkholes occur. Many are prehistoric and through repeated episodes of collapse have grown quite large. Several may have coallesced into a larger, irregular composite basin. Most of these large ancient sinkholes are now lake basins, but they may still be leaking into the aquifer through the collapse "pipe" which breaches the confining layer. Recent collapses are rare, although still possible.

Map Series 87-88-1

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TALLAHASSEE SHEET

No. 2 of 14 Sheets in This Series

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