URBANIZATION AND HYDROLOGIC CHANGE IN NORTHWEST HILLSBOROUGH COUNTY, FLORIDA

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Hillsborough County, located in west-central Florida on the shores of Tampa Bay has long been among the most rapidly urbanizing areas of the United States (Fig. 1). Examination of aerial photography reveals that recent urban growth is proceeding towards areas of increasing environmental sensitivity. This is especially true of the hydrologic environment. In 1938, the date of the earliest photography available, northern Hillsborough County was rural. Economic activities for the area were based on agriculture. Well drained areas contained citrus, and poorly drained areas were used as pasture. Cypress sloughs were evident throughout the region.

Beginning in the immediate post-war era, urban development began to spread north from the city of Tampa. During the late 1950s, construction of the University of South Florida resulted in increased pressure for development in the north of the county. Citrus groves, the easiest land upon which to build, began to disappear. During the 1960s and 70s, construction of Tampa International Airport and the extension and widening of Dale Mabry Highway caused the focus of development to move to the west side of the county. Later photography reveals that from 1960 to 1980, the major trend of development has been northward from west Tampa along Dale Mabry Highway. Much of this development had been poorly planned and even less well regulated. It seemed as though officials had been either unwilling or unable to exercise any meaningful degree of restraint or control over development or developers.

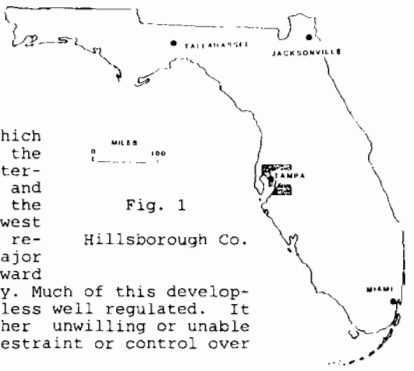

Fig. 1

Hillsborough Co.

Northwest Hillsborough Study Area

The study area is a 12.3 mi.2 (32 km2) part of northwest Hillsborough County (Fig. 2). Busch Boulevard (SR 580) forms the southern boundary of the study area. Gunn Highway (SR 587) is the western boundary, Armenia Avenue marks the east, and Lake Magdalene Boulevard and Ehrlich Road form the northern boundary. Typical of a karst landscape, the region contains numerous lakes and sinkholes. Although much of the area's drainage is underground, two streams, Sweetwater Creek and Rocky Creek, do provide surface drainage. Man-made ditches and canals augment the natural drainage. Prior to its conversion to urban uses, drainage was mostly underground. Surface streams were important primarily in providing for storm runoff (Hillsborough County Planning Commission 1974). As conditions changed, surface streams and man-made drainage networks came to play an increasing role in the local hydrology. Further changes in land use will place additional burdens upon surface drainage.

The study area is significant in many ways. It is located just north of Carrollwood, a prestigious subdivision. New developments will benefit from the use of the Carrollwood name. Building sites, especially residential lots, command high prices. The area has access to the airport and Tampa's fast growing Westshore business complex. Planned realignments of Fletcher and Bearss Avenues will provide improved access to the central and eastern parts of the county, including the university area. Prestige, access, and long term urban growth have led to intense pressure for development. Many feel that this portion of northwest Hillsborough County represents a last opportunity for quick profit on high-priced real estate in the area (Wagner 1983). Developers, it seems, are intent on building on every piece of open land, or at least every piece of land for which a permit may be obtained.

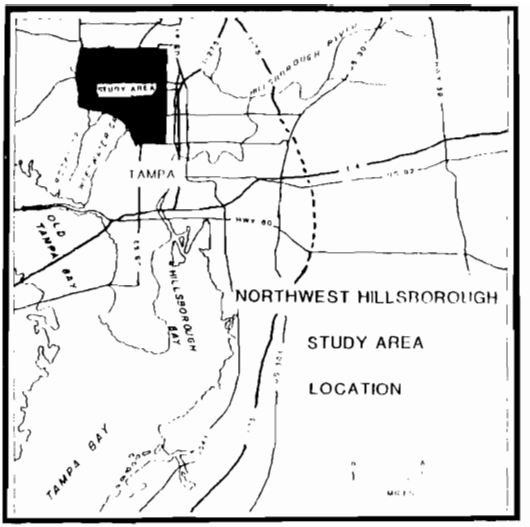

Fig. 2

Development and Water

Development in the area relies on local groundwater supplies. Several existing wells are no longer productive, yet because population is on the increase, a new well field in the area is being developed. This new field, located near the intersection of Dale Mabry and Ehrlich Roads, is intended to augment present supplies and replace non-productive wells. Plans for water yield are based on projected needs for the year 1990, but even before the new wells begin producing, it is likely that they will be inadequate to meet demands.

In 1983, approximately 43,000 people were served by local wells, consuming an average of 6.5 million gallons per day (MGD). Projections for 1990 call for a population of 59,000 within average consumption of 8.8 MGD. However developments already planned and at various stages of approval call for an additional 4,630 dwelling units and a consumption of an additional 2.5 MGD by 1986. Obviously there is a problem. If current (1983) consumption rates are added to proposed 1986 rates, a figure of 8.9 MGD results. This exceeds the projected use for 1990 by some 100,000 gallons a day. Apparently there is a lack of communication if not cooperation among the various agencies charged with the management of local land use and water supplies. Moreover, the city of Saint Petersburg in neighboring Pinellas County also draws water from the local aquifer. Changes in consumption in that jurisdiction profoundly affect local water supplies.

Another problem is the lack of attention paid to the historical record. The new well field which is intended to meet local demands will have a maximum yield of 18.4 MGD. This figure has been exceeded in the past when population was much lower. As recently as 1973, pumping rates as high as 18.8 MGD were reported. Also, water yield projections are based upon current recharge rates and normal to above normal precipitation. As will be discussed later, this could lead to additional problems.

Ground Water Recharge

Summer thunderstorms provide the bulk of local precipitation. These convectional storms normally develop in the late afternoon during the summer

months (June through September). In a normal year, about 30 inches (76 cm) of rainfall is received from these storms. This amounts to slightly less than 60 percent of the area's total. Spring and fall tend to be relatively dry, April being the driest month. Frontal storms, concentrated in the winter months, account for most of the remaining rainfall bringing the annual average to 52.5 inches (131 cm). However, if the last twenty years are considered, the area average drops to around 50 inches (125 cm). Since 1960, Hillsborough County has experienced a mean annual rainfall deficit of 5.91 inches (15 cm). Only four years of the last twenty exceeded or met the norm for precipitation. If the trend continues, the U.S. Weather Service will most likely revise its regional norms downward.

Over the past thirty years, 1956, with 28.89 inches (73.4 cm), was the driest, and 1959, which received 76.5 inches (194.5 cm), was the wettest. Part of the apparent decline in local precipitation may be that the Tampa Bay area has not experienced a hurricane since Donna in 1960. Tropical cyclones are a major contributor to monthly and yearly averages, but they are not regularly occurring phenomena. A single storm, especially if it occurs very early or late in the season, will distort averages. The average for both the month in which it occurred and the annual average will be skewed. Certain freak or anomalous meteorological events can also distort averages. The storm of May 8, 1979 provides an example of this. Within a single 24 hour period 11.4 inches (29.0 cm) of rainfall was recorded at Tampa International Airport. This figure represents the total which can normally be expected during May in three years (Stowers and Levasseur 1980). The average figure for May is unrealistically high if short term trends are considered. Largely because of that storm, 1979 was the wettest year in recent memory. This leads to another problem. When recharge rates are calculated on the basis of precipitation averages, the type of storm is seldom considered. Most of the rainfall received from the May 8 storm became runoff. It did not contribute greatly to local water reserves.

Urban Development and Runoff

Because so much local precipitation comes from violent storms, a large amount of rainfall enters overland flow. Where construction interferes with that flow, flooding results. Pressure is placed upon the water management officials to provide better drainage. Water is diverted from natural recharge areas to Old Tampa Bay. It no longer is available for groundwater recharge. This leads to the diminution of groundwater reserves. In the Tampa Bay area, only the city of Tampa uses surface water to help meet its demand. All other jurisdictions rely on groundwater.

Recent and proposed changes in surface conditions also profoundly affect the area's ability to handle runoff and to provide for groundwater recharge. Even events of a relatively low magnitude may produce surface flows which are in excess of the capacity of the local drainage system. Prior to 1960, when the study area was still a primarily rural region, groves, pasture and cypress sloughs dominated the landscape. Soil maps of the period indicate that porous sands covered about one-third of the study area (Soil Conservation Service 1958). Rain which would fall on those sands would percolate almost immediately into the ground. Pasture and cypress areas tended to collect water. Due to the area's low relief, runoff was minimal. Except for losses from evapotranspiration, most of their rainfall was available for recharge.

Using published tables (U.S. Water Resource Council 1977, pp. 8-11) and existing soils data, an area-wide runoff coefficient of 0.10 was estimated for the pre-development era. This meant that approximately 90 percent of all rainfall received in the area was available for groundwater recharge or evapotranspiration. Potential evapotranspiration for the region has been estimated at between 35 and 40 inches (87-100 cm) per year. This left some 10 to 15 inches (25-40 cm) of rainfall for recharge.

Under pre-development conditions the local hydrologic system was adequate to meet all but the most severe runoff demands and provide for recharge. Urbanization has profoundly reduced the ability of the system to perform in both areas. Since runoff problems tend to be of highest concern to area residents, those changes will be addressed first.

Computing Discharge

In estimating runoff characteristics for the pre-urban era, the coefficient 0.10 was adopted. Total discharge is arrived at from the formula

$$Q = A\ C\ I,$$

where Q = total discharge in ft.3 /sec; A = total area in acres; C = coefficient of runoff; and I = rainfall intensity in inches/hour. Based upon the five-year, one hour storm, runoff was computed to be 2518 ft.3 /sec. A rainfall intensity of 3.2 inches (8.2 cm) per hour was used in calculation (Marsh 1983). Runoff coefficients change with land use. By 1980, much of the area was already given over to urban uses. If developments planned through 1985 are taken into consideration (Fig. 3) it is conceivable that a runoff coefficient as high as 0.60 may be reached. This figure was estimated from examination of both present and projected land use. If all plans for development are implemented, 25 percent of the study area will either be under pavement or in buildings. For these areas a coefficient approaching 1.0 was assumed. No porous sands will be at the surface. Pasture and almost one-half of the cypress sloughs will be filled. Fill dirt for the most part is obtained from borrow pits located in eastern Hillsborough and southern Pasco Counties. Both areas contain soils which are relatively high in clay. None of the borrow pit operators would cooperate by providing information regarding the proportions of clay in their pits, and estimates of drainage characteristics were made using the county soils map cited earlier and simply estimating the portion of land to be filled with that material Unless there are profound changes in land use plans and borrow pit regulations in the immediate future, an area-wide runoff coefficient for the northwest Hillsborough study of 0.60 would seem to be a reasonable projection. The figure would be higher, but designated retention areas have been considered.

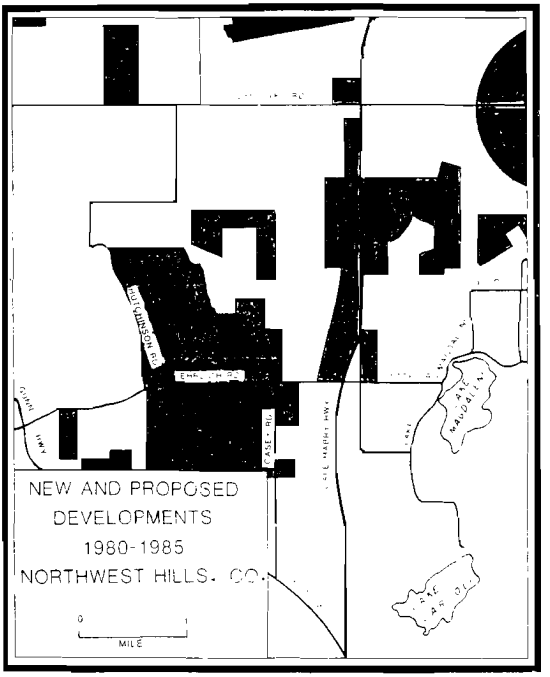

Fig. 3

Adopting the 0.60 coefficient and using the same storm described above, a rate of runoff of 15,408 ft3 /second may be experienced. The natural drainage system, which by this time will be so deranged as to be inrecognizable, will simply be inadequate to provide for this amount of runoff.

Problem of Flooding

The additional runoff represents water which would have been absorbed by the subterranean system. Flooding will become an ever present danger to area residents. Adding to the problem is the reduction in water available for recharge of the aquifer. While it may be argued that runoff does not present a threat to residents, as each developer must include plans to provide drainage before the development may begin, planning only considers what has gone on in the past, and does not address changed requirements. Furthermore, the threat of flood is the paramount concern of developers and many officials. Yet the

impact of development on recharge rates has received but scant attention from developers, the public, and the various local media.

Groundwater Misconception

Lack of concern regarding groundwater supplies rests in part on a popularly held misconception. Florida, especially coastal Florida, has long been viewed as floating upon an inexhaustible reserve of groundwater. The problem facing developers was to divert surface flow from areas of development, not trying to provide a potable water supply. Historically, groundwater in west-central Florida has been perceived as an extralocal phenomenon. An early study held that Florida's groundwater supplies were derived from a huge aquifer which extended as far north as West Virginia (Hoy, Simmons, and Czajkoski 1980). The Floridan Aquifer, it was believed, could meet any possible demand and placed no limit on consumption. Concerns over groundwater depletion were not even considered, let alone encouraged.

By the 1950s that view was being held in question. It has since been determined that for southern Florida, south of a line extending across the state from Daytona Beach on the Atlantic to Cedar Keys on the Gulf, water supplies (both surface and ground) are totally derived from local precipitation (Hoy, Simmons, and Czajkoski 1980). A most realistic view has been presented that water supplies for Hillsborough County are the result of local precipitation and that urbanization diminishes both the quantity and quality of those supplies (Segretto 1975).

In west-central Florida in general, and northwest Hillsborough County in particular, surface and sub-surface drainage comprise a single system. As long as system unity is maintained, the system will function. Current trends and practices tend to bifurcate the system. Major impacts of that bifurcation include both the reduction of potable water supply and increased potential for flood. In may be that in the future, a lack of potable water will become more important than hazard from flooding limiting the spread of an urban landscape in northwest Hillsborough County.

Administration of Water Resources: SWFWMD

Responsibility for administering local water resources rests primarily with the Southwest Florida Water Management District (SWFWMD). Despite its charge, SWFWMD has until recently been unable to exert its full authority. Funding and political exigencies have hampered its effectiveness. Formed in 1960 in response to demands for improved flood control, SWFWMD is concerned with all areas of water management. Using the water crop concept, the amount of precipitation received in a water year (July-June), SWFWMD attempts to allocate regional water supplies on an availability basis while providing for flood control. A major failing of the allocation and flood control system is its inability to include proposed land use changes in its calculation. This is a policy decision and does not reflect upon the agency's professional staff. Because of administrative decisions, programs may be implemented over the objections of staff, or may be implemented based on incomplete or erroneous data. This, plus sovereignty disputes, tend to reduce the agency's effectiveness.

The area-wide rainfall deficit (mentioned earlier) and increased runoff due to the conversion of land to urban uses have led to a severe reduction in groundwater supplies. Those same forces have led to an increased demand for groundwater. Increased pumping is usual during dry seasons. The longer the dry season, the lower the reserve, and the greater the pressure to withdraw water. The city of Saint Petersburg was recently granted permission to withdraw an additional 26 MGD from its field which is adjacent to the present study area (Huer 1982). This was not considered in the projection used in determining the yield of the field mentioned earlier, but both the northwest Hillsborough area and the city of Saint Petersburg are drawing from the same aquifer. The permit was granted over strong opposition from northwest Hillsborough residents and development interests. Developers expressed the fear that their allotted 8.8 MGD would be reduced, and some residents felt that increased pumping would result in lake drawdowns. Although SWFWMD has gone on record stating that no new drilling permits will be issued, as the aquifer is already being utilized to its maximum extent (Huer 1982), the fears of residents are not unfounded.

Problems -- Lake Magdalene

During the 1973-74 water year, Lake Magdalene went dry. Although this was a dry year, it was not the driest on record. During the 1950s, several years produced less rainfall than 1973-74, and while lake levels dropped, Lake Magdalene always had water. By the early 1970s, urbanization had increased such that Lake Magdalene went dry primarily from excess pumping. Today, Lake Magdalene is maintained from groundwater supplies.

Problems associated with Lake Magdalene are illustrative of many of the barriers to efficient, effective, and rational water management which SWFWMD and other regulatory agencies must overcome. During those years when lake levels were low, and before the formation of SWFWMD or any other area-wide regulatory agency, the Hillsborough County Commission changed zoning and granted building permits for land which in most years would be under the lake. In order to reduce flood hazard for residents of lakeside homes, SWFWMD has to maintain Lake Magdalene at its low management level. The result of this legacy from past practices is that SWFWMD is forced to pump from ground water during dry years to maintain both lake habitat and property values, and when it does rain, it must pump water out of the lake to avoid flooding. Under present circumstances this cannot be viewed as a receptor for any amount of storm runoff. As rapidly as water accumulates in the lake it is pumped into Sweetwater Creek, which flows through the heart of the area which today is under the most pressure from urban interests. The present stream slowly works its way from slough to slough toward the bay. When the area is fully converted, the stream will be canalized. When a severe storm strikes the Tampa Bay area in the future, SWFWMD will be placed in the unenviable position of deciding whom to inundate. Meanwhile, recharge declines.

Problems -- Cypress Sloughs

Among the more alarming trends is the propensity to build in the cypress sloughs. As mentioned earlier, cypress sloughs are important as discharge areas for overland flow, but recent research by USGS shows that the sloughs play a much larger role in the hydrologic system than was previously realized (Hillsborough County Planning Commission 1974). Water tends to accumulate in the slough, making them important discharge areas. From the slough, water tends to move slowly into the surface drainage system. Thus they are effective regulators of stream flow. However, while the water is in the slough, it also moves slowly into the subsurface system where flows along the potentiometric gradient and thus sloughs are a major contributor to groundwater recharge. In order to compensate for the co-option of the slough, developers are required to provide retention areas for their projects. Usually these are ponds strategically placed throughout the area. Unlike the slough, which is shaded, the pond is exposed to direct sunlight. Evaporation rates are high. Potential evaporation rates for the area are estimated at about 50 inches (125 cm) per year (Fernald 1981). Excessive losses from evaporation and increased runoff leave virtually no water for local recharge. Each year --- and each new subdivision --- sees a growing water deficit.

Retention ponds, because they are intended to collect runoff from urban areas, tend to be sources of pollution. They collect runoff from streets and lawns. Golf courses are sometime used to provide flood control, recharge, and recreational space. But watering, often from wells on the course itself, insures that evaporation will be high, and the copious use of pesticides and herbicides leads to more pollution and a further reduction of water quality. Unfortunately, golf courses and parks represent the best that can be done given present technology to address problems of flood control and recharge. Thus far, nothing, no scheme or artifice devised by human ingenuity, is as effective or efficient as the cypress slough in controlling surface runoff and providing for groundwater recharge.

Flooding and groundwater represent problems of great magnitude. Floods receive the most attention, yet even those are often played down when other considerations come to the fore. Flooding which occurred in February, 1981, for instance, was relegated to the back pages of the Tampa Tribune when any type of story less than positive would have interfered with the local Gasparilla Festival (Beamguard 1981). In fact, the story of the flood contained several references to the festival and assured readers that the parade would go on as scheduled.

It is most difficult to sustain public opinion about any issue when the news media tend to ignore it, but the 1980-81 water year was important for another reason. While the passage of a winter cold front could produce enough precipitation to cause localized flooding in northwestern Hillsborough County, there was insufficient rainfall that year to provide for the water needs of the population. By May, reserves had become so depleted that it was necessary for local officials to call for water rationing. Saint Petersburg and Hillsborough County, which rely upon groundwater, were most severely affected. Tampa, which uses the Hillsborough River was not rationed. Clearly, however, as demands on the local water supply increase, and demands for increased flood control do likewise, the events of 1981 will no doubt be repeated.

Northwest Hillsborough County suffers from a legacy of lack of concern and understanding. This legacy includes a new hydrologic system which reflects cultural and economic pressures, not the laws of nature. The most significant feature of this new system is its bifrucration which places area residents at increasing peril from flood and drought simultaneously.

References

Beamguard, J. 1981. Streets flooded, residents irate... Tampa Tribune (9 February): 1B-2B.

Fernald, E., ed. 1981. Atlas of Florida. Tallahassee: The Florida State University Foundation, Inc.

-----, and Patton, D., eds. 1984. Water resources atlas of Florida. Tallahassee: The Florida State University Institute of Science and Public Affairs.

Hillsborough County Planning Commission. 1974. Natural environment and development. Tampa.

Huer, J. W. 1982. Evidentiary evolution, CUP No. 206676, Northwest Hillsborough regional well system, renewal with modification to add eight (8) new wells. Southwest Florida Water Management District. Typed draft.

Hoy, N. D. Simmons, J. D., and Czajkoski, R. D. 1980. United States Geological Survey reports on the water resources of Florida, 1866-1979. Tallahassee.

Jolly, P. D. 1982. "Water uses and urbanization in Hillsborough County, Florida." Unpublished paper, Department of Geography, University of South Florida, Tampa.

Segretto, P. S. 1975. The relationship between urbanization and stream flow in the Hillsborough River Basin, 1940-1970. Unpublished Ph.D. dissertation, University of Florida, Gainesville.

Soil Conservation Service. 1958. Soil Survey, Hillsborough County, Florida. Washington.

Stowers, D. M., and Levasseur, M. The Tampa Bay storm of May 8, 1979. The Florida Geographer 14(2): 15-21.

U. S. Water Resource Council. 1977. Guidelines for determining flood-flow frequency. Hydrology Committee Bulletin no. 174. Washington.

Wagner, C. 1983. Interview with Charles ("Chuck") Wagner, Merrill Lynch Realty, 31 October.