Prepared in cooperation with
VOLUSIA COUNTY, FLORIDA

INTRODUCTION

In the early 1970's, the Volusia County Council recognized the need to develop new sources of freshwater for future growth and development. County Council, using data from the U.S.Geological Survey and private consultants, concluded that the central wetlands were an optimal area for well-field development. With this in mind, Volusia County requested that the State of Florida buy land in the central wetlands of Volusia County under the Land Conservation Act of 1972, hoping to protect both the environmentally endangered lands and a potential water resource. In 1974, the State acquired 7.28 mi^2 within this area, and presently (1979) plans to acquire an additional 3.33 mi^2. The State later became concerned that wetland protection may not be compatible with development of water resources due to the vegetation changes that might occur if shallow ground-water levels are lowered by a producing well field. Consequently, because of mutual interest, the U.S. Geological Survey with the State entered into a program of documenting for future reference the vegetation in the State-owned land.

The purposes of this report and associated map (fig. 1) are (1) to document existing vegetation in an approximately 140 mi^2 area in central Volusia County, and (2) to investigate natural water-level fluctuations in selected vegetative communities to the extent possible with relatively short-term data. The study area (fig. 2) is that part of the Talbot Terrace bounded on the east by Rima Ridge, to the west by De Land Ridge, to the north by State Road 40, and to the south by latitude 28°57′.

ENVIRONMENTAL SETTING

Volusia County in east-central Florida (fig. 2) is characterized topographically by flat, marine terraces separated by narrow ridges. The ridges are alined northwest to southeast and range from about 15 to 30 feet higher than the adjacent terraces. The terraces, which are poorly drained seasonally inundated lands, are arranged in step-like succession from the Atlantic Ocean to the De Land Ridge, with the Silver Bluff Terrace at 5 feet above sea level, the Pamlico Terrace at 25 feet, and the Talbot Terrace at 42 feet (Cooke, 1945). West of the De Land Ridge the land drops to near sea level at the St. Johns River (Wyrick, 1960).

Two major aquifers underlie central Volusia County—the surficial aquifer and the Floridan aquifer. The surficial aquifer, consisting primarily of fine to very fine sands, extending from the land surface to depths of 25 to 80 feet, is separated from the deeper Floridan aquifer by semiconfining beds of sand and clay. The top of the Floridan aquifer is at an average depth of about 100 feet beneath land surface, and the aquifer extends to depths greater than 500 feet. It consists mainly of limestone of Eocene age.

The water in the Floridan aquifer is generally confined but in some areas the confining layer is thin or missing, implying a better hydraulic connection between the two aquifers in those areas. The potential for water to move downward from near the surface depends on the altitude of the water table of the surficial aquifer, the thickness and permeability of the soil and underlying material, and on the altitude of the potentiometric surface of the Floridan aquifer. Water will move downward if the water table stands higher than the potentiometric surface of the Floridan aquifer.

The relatively flat topography, abundant rainfall, and aquifer characteristics of central Volusia County have fostered wetland ecosystems. Rainfall in Volusia County averages about 52.5 inches per year. Rainfall accumulates near the surface of the shallow aquifer and drains slowly into streams, swamps, and other wetlands or seeps downward into the Floridan aquifer. Much of the study area is inundated for most of the year when rainfall is near average. Swamps of cypress or mixed hardwood trees are in areas of low relief and nonforested wetlands are on slightly higher land where periods of inundation last only a few weeks per year. Bay forests typically occur on organic soils, while the pine flatwoods are usually on sandy soil. The sand ridges that separate the marine terraces are not flooded and support vegetation adapted to well-drained, sandy soil.

The wetlands of central Volusia County are sparsely populated; most people live near the coast or on the De Land Ridge. Between 1970 and 1975 the population of Volusia County increased by 43,000 (Division of Population Studies, Bureau of Economic and Business Research, and University of Florida, 1978). During this same period water use for public supplies increased by 5 Mgal/d (Pride, 1973; Leach, 1978). Population and water use are expected to continue to increase in the future, thus increasing the amount of freshwater needed in Volusia County.

As withdrawals increase near the coast, so does the potential for lateral and vertical saltwater intrusion in the Floridan aquifer. This danger can be lessened by locating well fields in the interior of the county, where the potentiometric surface of the Floridan aquifer is higher than in the coastal areas. One source of water to replenish a well field withdrawing water from the Floridan aquifer will be induced leakage from the overlying surficial aquifer. A potential result of induced leakage is that the long-term average water-table altitude in the surficial aquifer will be lowered over the area of influence of the well field, thus raising the possibility of gradual, long-term vegetative changes.

METHODS AND MATERIALS

The vegetation map of central Volusia County (fig. 1) was made using aerial photographs in conjunction with field surveys. Color photographs taken February 26, 1975, at a scale of 1:24,000 and color-infrared photographs taken December 28, 1972, at a scale of 1:80,000 were used to identify the vegetative categories. Field surveys were made by automobile and helicopter to check the photo interpretations. Similar methods were used by B. F. McPherson in producing the vegetation map of Big Cypress Swamp (McPherson, 1973).

U.S. Geological Survey quadrangle maps at a scale of 1:24,000 were used as the control for the vegetation map. The location of roads, trails, structures, contours, and symbols were traced directly from the quadrangle maps.

Categories of vegetation and other land cover (fig. 1) were adapted from a land-use and land-cover classification system developed by Anderson and others (1976) and modified by the Florida Department of Administration (1976). This hierarchical system has several levels of classification based on the increasing detail. At level I land is classified into several basic categories. At succeeding levels, land is classified in increasing detail. On figure 1, for example, the category Water corresponds to level I, lakes and other water area to level II and lakes, streams, canals, borrow pits to level III.

Six shallow wells with digital recorders were installed in selected vegetative communities in central Volusia County to measure water-level fluctuations. The average land-surface altitude at each recorder well was determined, based on about 50 measurements within 100 feet of each well. All wells were designed to be open just below the water table during the dry season. The intent of this water-level monitoring was to record the range of fluctuation in water level for different vegetative communities under natural conditions. One year of water-level data, representing a complete seasonal cycle, May 1977 through April 1978, is summarized herein.

WATER-LEVEL FLUCTUATIONS IN SELECTED VEGETATIVE COMMUNITIES

Ideally, many years of water-level data from a large number of shallow wells would be needed to fully document the range of natural water-level fluctuations in all of the vegetative communities. To remain within the scope of the project, five different vegetative communities, representing the most important communities in the central part of the county, were selected for continuous water-level monitoring. The wells and their vegetative communities are Well 1 on Gopher Ridge, in the pine flatwoods, Well 2 (56 WSM) in the coniferous planted forest (pine), Well 3 near Indian Lake, in the sand pine scrub, Well 4 on Interstate Highway 4 in the rangeland, Well 5 at Tiger Bay, in the cypress forest, and Well 6 on State Road 44 in the cypress forest. Two wells were constructed in the cypress forest because this category represents a relatively large part of the mapped area. The location of each site is shown in figure 1.

Rainfall, the major controlling factor on water levels, was less than average during the study period and did not follow the typical seasonal pattern. The average annual rainfall at DeLand and Daytona Beach is 52.5 inches; during the study period it was 46.8 inches (U.S. Department of Commerce, 1978). About 66 percent of the annual rainfall usually occurs from June through October; during the study period only 46 percent occurred during these months. The relatively dry conditions during these five months, and to some extent during the spring preceding the study period, are shown by the departure-from-average of monthly rainfall in figure 3. Rainfall was slightly above average during the winter, November 1977 through February 1978 (fig. 3). Annual rainfall during the study period was exceeded about 70 percent of the time over the last 30 years (fig. 4).

Lake Winona, a closed-basin water body 1.6 miles west of the study area, can be used as an overall hydrologic indicator. Rainfall, evaporation, transpiration, leakage, and runoff act simultaneously to determine water levels in the lake. Average monthly water level in the lake during the study period is compared with average and extreme conditions in figure 5. Water levels in the lake are consistent with the deficient summer rainfall, excess winter rainfall, and overall rainfall deficiency during the study year as shown in figures 3 and 4.

Water levels in the wells of the representative plant communities, relative to land surface, are shown in figures 6–11. The fluctuation shown by these hydrographs are generally similar to the pattern for the lake hydrograph (fig. 5) and the deviation from average rainfall (fig. 3).

The cypress forest is the wettest of the plant communities in central Volusia County. Even in the relatively dry study year, water levels at the two well sites in the cypress forest, Well 5 and Well 6(figs. 6 and 7), were above land surface about 40 and 80 percent of the time, respectively. Water levels in the cypress forest fluctuated considerably more in response to rainfall when below the land surface than when above land surface because: (1) the same volume of water occupies more space in the aquifer than on the surface, because intergranular space makes up a relatively small percentage of the total volume of aquifer materials and (2) runoff and evaporation tend to minimize the depths to which water ponds on the land surface. Maximum water levels at these cypress forest sites for a year of average rainfall are probably not much higher than those shown, whereas minimum water levels for a year of average rainfall might not be as low or as prolonged as those shown. Water levels in the cypress forest during a year of average rainfall probably range from a low of 3 feet or less below land surface during the dry season to a high of 1 foot or more above land surface in the wet season.

Water-level fluctuations in coniferous planted forest (Well 2) and pine flatwoods (Well 1) are depicted in figures 8 and 9, respectively. The coniferous planted forest differs from the pine flatwoods primarily by having a more dense stand of trees. Water-level fluctuations in the two communities are similar, but the range of fluctuation shown in the duration curves (fig. 12) differs. Water levels in the coniferous planted forest varied almost 7 feet during the monitored period; while water levels in the pine flatwoods varied almost 5 feet. Although the water levels remained below land surface at the sites monitored, certain areas of coniferous planted forest were observed to be inundated at times during the study year. During wet years water levels rise above land surface at the monitored sites. The dominant species of the coniferous planted forest and pine flatwoods is slash pine which is tolerant of some surface-water inundation. Water levels during years of average rainfall in coniferous planted forest and pine flatwoods communities probably range from lows of about 7 feet below land surface in the dry season to highs of about one-half foot above land surface in the wet season.

The hydrograph for Well 4 is representative of rangeland (fig. 10). Water levels flatten off a few hundredths of a foot below average land surface probably because ground-water movement toward slightly lower adjacent areas prevents surface inundation. The shape of the rangeland duration curve (fig. 12) when water levels were within about one-half foot of the land surface is similar to the shape of the cypress forest duration curves when water levels are above land surface.

Water levels in years of average rainfall at the rangeland site probably vary from a low of about 4 feet below land surface during the dry season to highs of about one-half foot above land surface during the wet season.

The water level at the sand pine scrub site, represented by the hydrograph from Well 3, ranged from about 7½ to 9½ feet below land surface (fig. 11). Individual periods of rainfall did not cause rapid, sporadic rises in water levels as they did in vegetative communities where the water table is close to land surface. Most of the rainfall that occurred from the beginning of the study year until late August never reached the water table; it was either evaporated, transpired by plants, or held in the relatively thick, sandy unsaturated zone. The range of fluctuation of water levels at this particular site, shown best by the duration curve (fig. 12), was considerably less than at the other recorder sites. Water levels at the sand pine scrub site in years of average rainfall probably range from about 9 feet below land surface during the dry season to about 7 feet or less below land surface during the wet season.

CONVERSION FACTORS

For those readers who may prefer to use metric units (SI) rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply inch-pound unit	*By*	*To obtain metric (SI) unit*
inch	25.4	millimeter (mm)
foot (ft)	.3048	meter (m)
square mile (mi^2)	2.590	square kilometer (km^2)
million gallons per day (Mgal/d)	.04381	cubic meter per second (m^3/s)
acre	4,047.	square meter (m^2)

Temperature in degrees Celsius can be converted to degrees Fahrenheit as follows: °F = 1.8°C + 32

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called *"Mean Sea Level."*

REFERENCES

Anderson, J. R., Hardy, E. E., Roach, J. T., and Witmer, R. E., 1976, A land use and land cover classification system for use with remote sensor data: U.S. Geological Survey Professional Paper 964, 28 p.

Cooke, C. W., 1945, Geology of Florida: Florida Geological Survey Bulletin 29, 248 p.

Division of Population Studies, Bureau of Economic and Business Research, and University of Florida, 1978, Florida estimates of population, July 1, 1977, state, counties, municipalities: Florida Department of Administration, 35 p.

Florida Department of Administration, Division of State Planning, and Bureau of Comprehensive Planning, 1976, A land use and cover classification system for Florida: A Technical Report: Florida Department of Administration, 10–15 p.

Knochenmus, D. D., and Beard, M. E., 1971, Evaluation of the quantity and quality of the water resources of Volusia County, Florida: Florida Bureau of Geology Report of Investigations 57, 6 p.

Leach, S. D., 1978, Source, use, and disposition of water in Florida, 1975: U.S. Geological Survey Water-Resources Investigations 78–17, 67 p.

McPherson, B. F., 1973, Vegetation map of southern parts of subareas A. and C, Big Cypress Swamp, Florida: U.S. Geological Survey, Hydrologic Investigations Atlas HA—492.

Pride, R. W., 1973, Estimated use of water in Florida, 1970: Florida Bureau of Geology Information Circular 83, 31 p.

U.S. Department of Commerce, 1978, Climatological data: National Oceanic and Atmospheric Administration, Annual Summary 1978, Florida, v. 82, No. 13, 12 p.

Wyrick, G. G., 1960, The ground-water resources of Volusia County, Florida: Florida Bureau of Geology Report of Investigations 22, 65 p.

Table 1.—Description of land use and land cover in central Volusia County

Land-use and land-cover classification	Classification level[1]	Description	Commonly found plants	Remarks
Urban or built-up land	I	Land used for residential, commercial, industrial, and transportation purposes where structures exceed 4 per acre over 10 acres.	—	Land right-of-way on interstate highways is included in this category
Cropland, pastureland, or citrus	II	Land cleared of native plants, generally planted in rows or grasses.	—	This land was probably pine flatwoods or sand pine scrub originally. Citrus would be located on the higher well-drained land.
Mixed rangeland	II	Land less than 10 percent tree cover, with a mixture of scrubs and grasses.	Saw-palmetto (*Serenoa repens*) Gallberry (*Ilex glabra*) Waxmyrtle (*Myrica cerifera*) St. Johnswort (*Hypericum fasciculatum*) Wire grass (*Aristida* spp.) Broomsedge (*Andropogon virginicus*) Marsh pink (*Sabatia grandiflora*)	Found primarily south of U.S. Highway 92. St. Johnswort in the wetter areas.
Pine flatwoods	III	Land more than 10 percent tree crown cover. Predominantly pine. Natural seeding.	Slash pine (*Pinus elliottii*) Longleaf pine (*Pinus palustris*) Saw-palmetto Gallberry Wire grass Lyonia (*Lyonia lucida*) Broomsedge Small oaks (*Quercus minima, Q. pumila*)	Slash pine is the most common species but in some areas long leaf pines may predominate. Relatively open land with a wide range of soil types.
Sand pine scrub	III	Well drained high, sandy soil with the dominant tree sand pine (shortleaf pine). Greater than 10 percent tree cover. Natural seeding.	Sand pine (*Pinus clausa*) Turkey oak (*Quercus laevis*) Various small oaks Saw-palmetto	Probably more common along the higher ridges before lumber companies replanted with slash pine. A good potential recharge area.
Xeric oak scrub	III	Land more than 10 percent tree cover with the dominant species being oak trees. High, sandy soils.	Turkey oak Sand live oak (*Quercus virginiana* var *geminata*) Myrtle oak (*Q. myrtifolia*) Chapman's oak (*Q. chapmanii*) Bluejack oak (*Q. incana*) Sand pine Saw-palmetto Holly (*Ilex caroliniana*) Blueberry (*Vaccinium* sp.)	Turkey oak is the most common tree. Small areas of sand live oaks. A good potential recharge area.
Coniferous planted forest	III	Land greater than 10 percent tree cover resulting from artificial seeding or planting[2].	Slash pine	Slash pine is tolerant of periodic water inundation that sometimes occurs in central Volusia County.
Clearcut	III	Land where block timbering or clearcutting is practiced[2].	—	Less than 10 percent tree cover, generally no trees remaining. Complete destruction of the understory is common.
Other water bodies	III	Lakes, streams, canals, and borrow pits.	—	Small streams often hidden by cypress overstory.
Cypress forest	III	Wetland coniferous forest with cypress dominant.	Cypress (*Taxodium* sp.) Blackgum (*Nyssa sylvatica* var *biflora*) Red maple (*Acer rubrum*) Slash pine Dahoon holly (*Ilex cassine*) Ash (*Fraxinus* sp.) Waxmyrtle Buttonbush (*Cephalanthus occidentalis*) Willow (*Salix caroliniana*) Dogwood (*Cornus foemina*) Virginia willow (*Itea virginica*) Bay trees (*Persea palustris, P. borbonia*) Hat pins (*Eriocaulon* sp.) Sphagnum moss (*Sphagnum* spp.) Lizardtail (*Saururus cernuus*) Pickerelweed (*Pontederia cordata*) Swamp fern (*Blechnum serrulatum*) Bromeliad (*Tillandsia* spp.) Vines (*Vitis rotundifolia; Smilax* spp.)	Land typically inundated much of year.
Bayhead and bogs	III	Wetland hardwood forest with the dominant species being bay trees.	Bay trees (*Gordonia lasianthus; Magnolia virginiana; Persea palustris; P. borbonia*) Slash pine	Found in areas with organic soil, often saturated.
Mixed swamp	III	Wetland forest with a mixture of hardwoods and conifers.	Cypress Bay Blackgum Ash Dahoon Slash pine Willow Elm (*Ulmus americanus*) Laurel oak (*Quercus laurifolia*) Waxmyrtle	Land typically inundated for months during a year.
Freshwater marsh or wet prairies	III	Nonforested land, less than 10 percent trees. Herbaceous plants and some shrubs.	Sawgrass (*Cladium jamaicensis*) Arrowhead (*Sagittaria latifolia*) Pickerelweed (*Pontederia lanceolata*) Maidencane (*Panicum hemitomom*) Coinwort (*Centella asiatica*) Juncus (*Juncus* spp.) Hat pins (*Eriocaulon* sp.) Beak-rush (*Rhynchospora* sp.) St. Johnswort Buttonbush	Land seasonally inundated

[1]See explanation of figure 1 for classification breakdown.
[2]The percentage of the map area occupied by clearcut or coniferous planted forest may increase or decrease depending on logging activities.

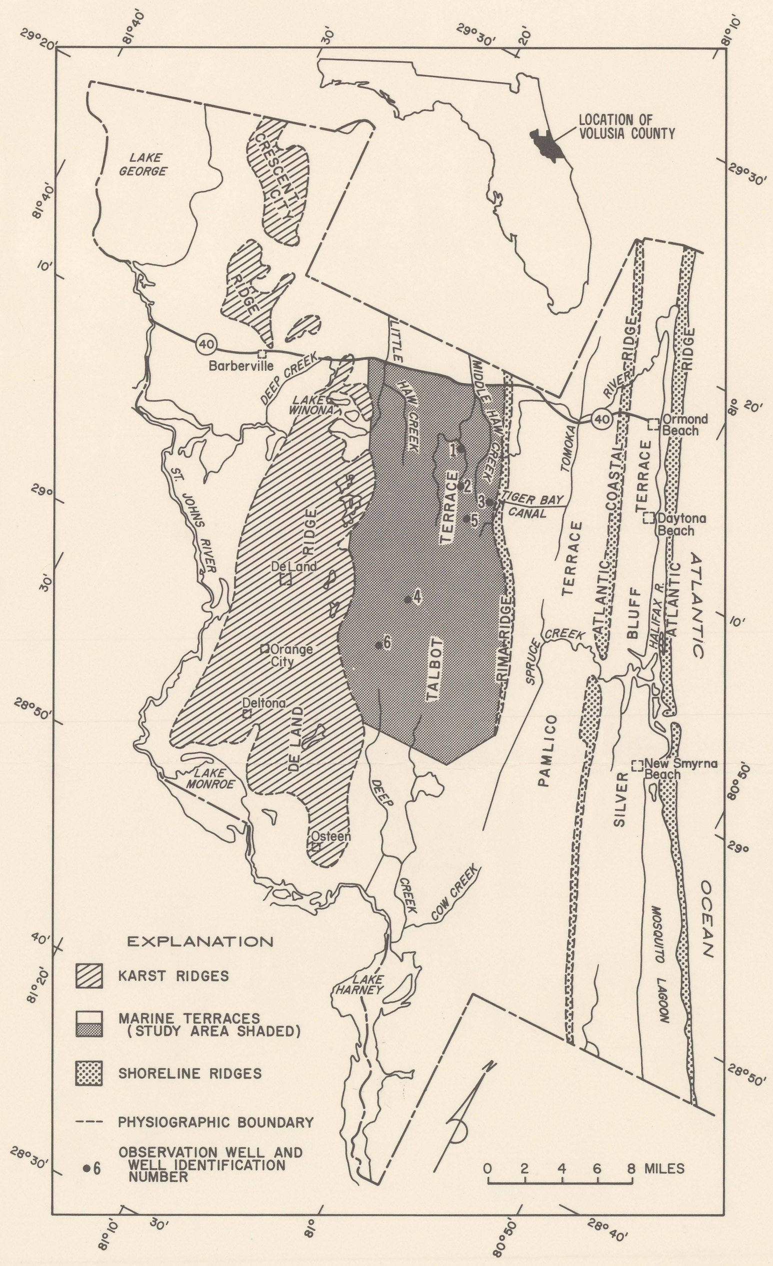


Figure 2.—Map showing physiographic features of Volusia County (modified from Knochenmus and Beard, 1971).

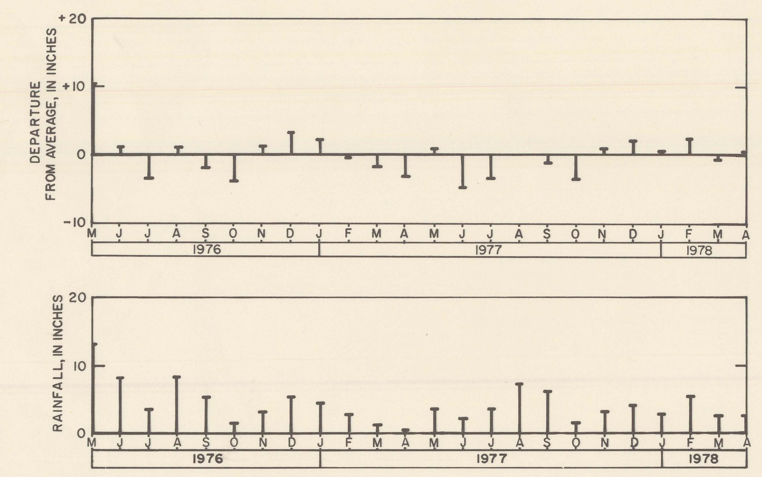


Figure 3.—Average of monthly rainfall at De Land and Daytona Beach, May 1976 through April 1978 and departure from long-term average.

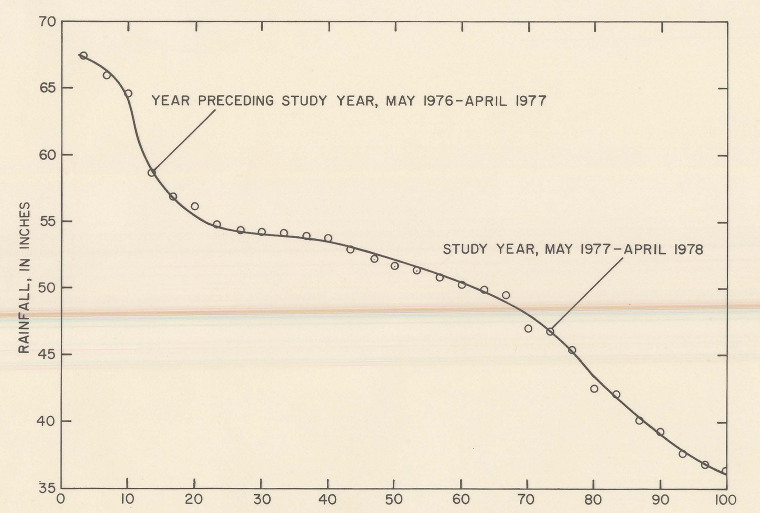


Figure 4.—Duration curve of annual rainfall (May through April) at De Land and Daytona Beach, May 1948 through April 1978.

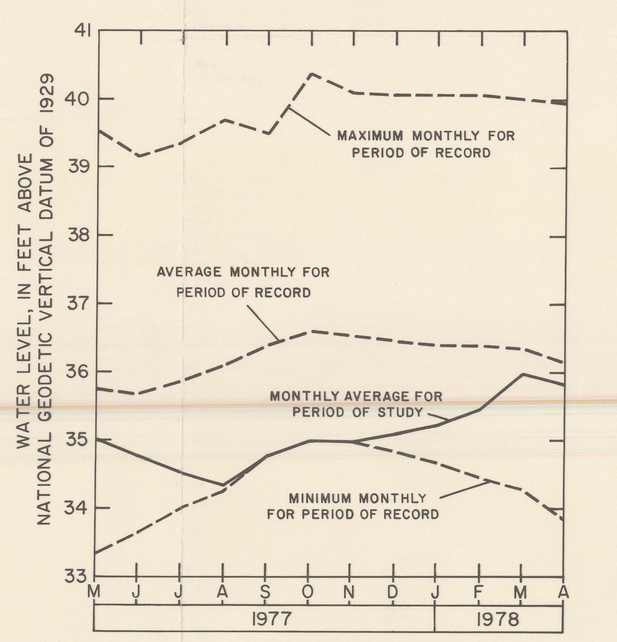


Figure 5.—Monthly water levels of Lake Winona for study period, May 1977 through April 1978, and for period of record, May 1965 through April 1978.

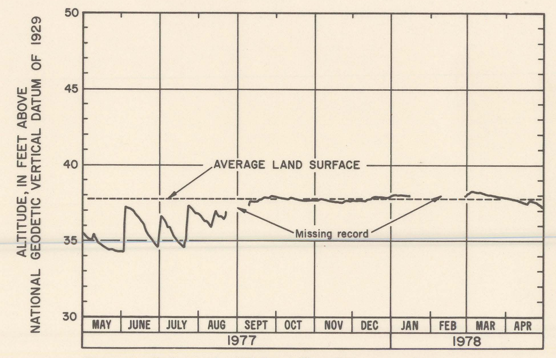


Figure 6.—Hydrograph of Well 5 at Tiger Bay, cypress forest, May 1977 through April 1978.

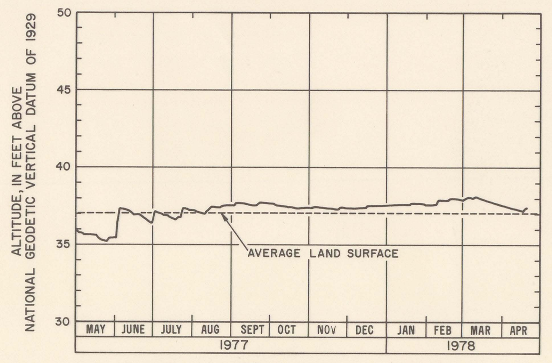


Figure 7.—Hydrograph of Well 6 on State Road 44, cypress forest, May 1977 through April 1978.

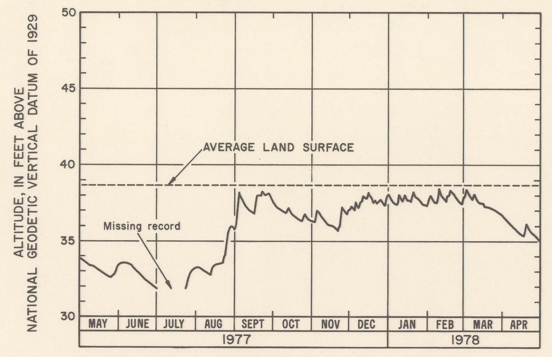


Figure 8.—Hydrograph of Well 2 (56 WSM), planted coniferous forest, May 1977 through April 1978.

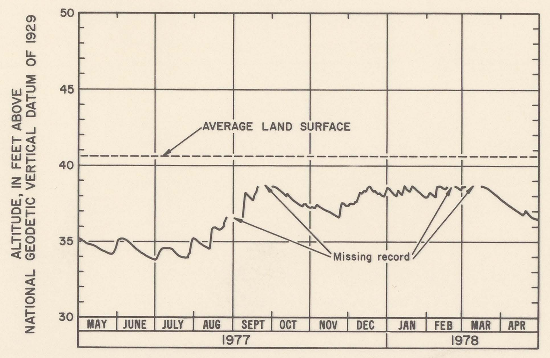


Figure 9.—Hydrograph of Well 1 on Gopher Ridge, pine flatwoods, May 1977 through April 1978.

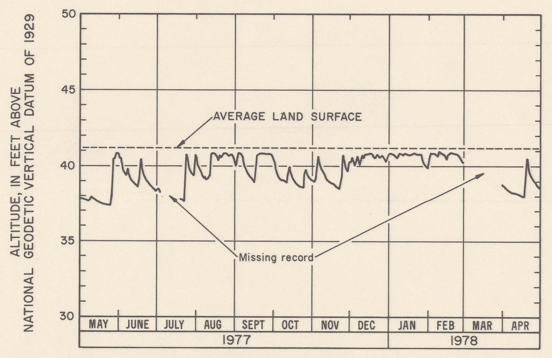


Figure 10.—Hydrograph of Well 4 on Interstate Highway 4, rangeland, May 1977 through April 1978.

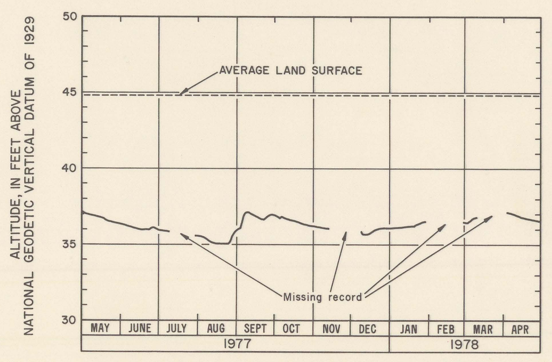


Figure 11.—Hydrograph of Well 3 near Indian Lake, sand pine scrub, May 1977 through April 1978.

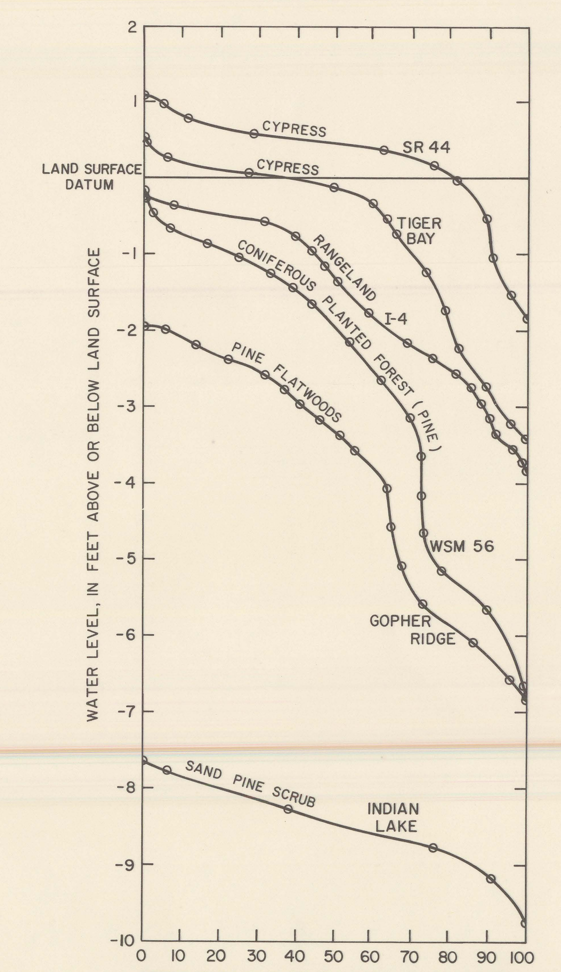
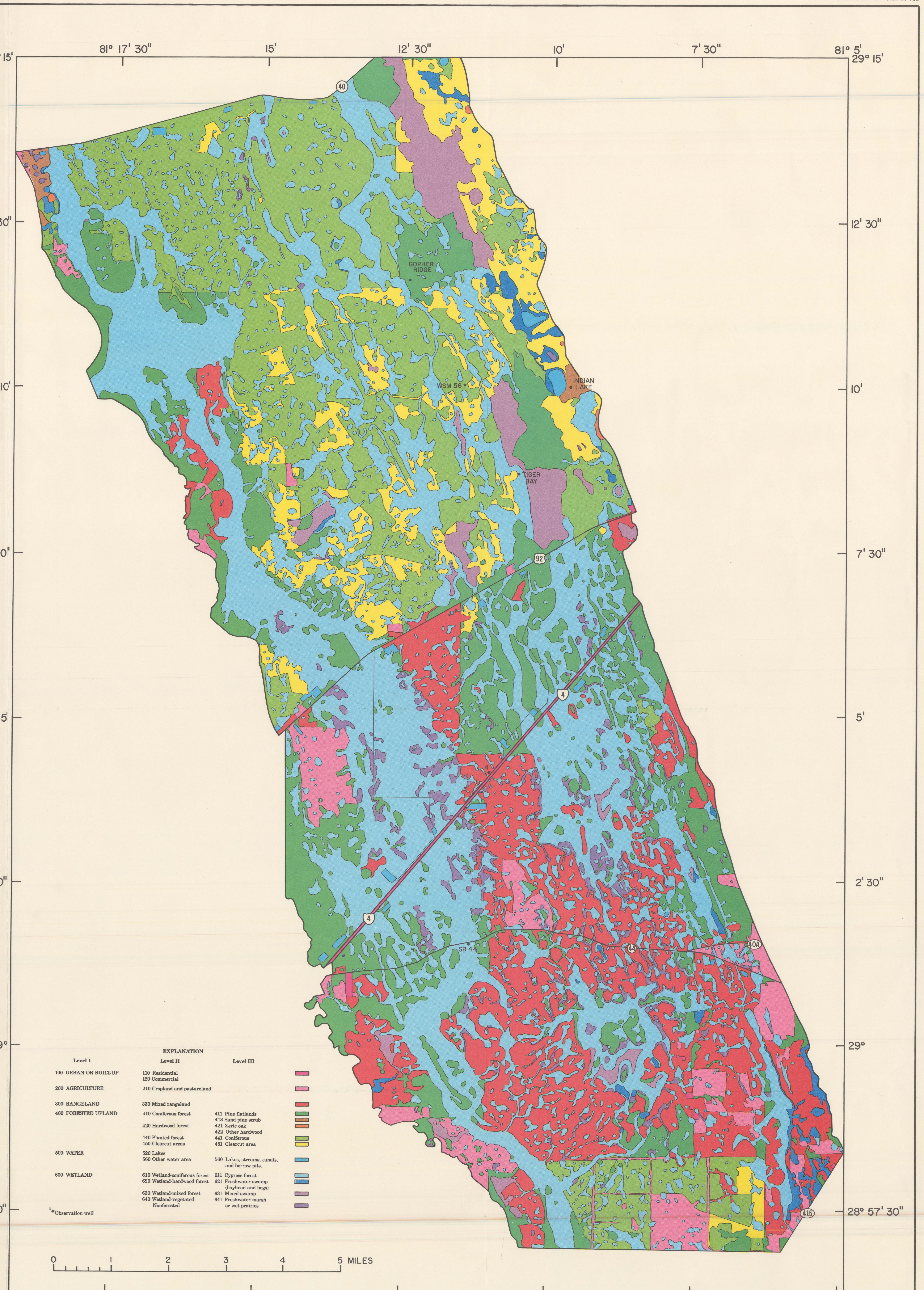


Figure 12.—Duration curves of water levels relative to average land surface at six recorder wells in the study area, May 1977 through April 1978.



Base from U.S. Geological Survey 1:24,000 topographic quadrangles

Figure 1.—Vegetation of central Volusia County

SHALLOW GROUND-WATER CONDITIONS AND VEGETATION CLASSIFICATION, CENTRAL VOLUSIA COUNTY, FLORIDA.

By
Edward P. Simonds, Jr., Benjamin F. McPherson, and Peter W. Bush
1981