The Floridan aquifer supplies most of the fresh ground water for municipal, industrial, and agricultural uses within the 12,400-square mile St. Johns River Water Management District (location shown in fig. 5). Water discharged by pumping, springflow, upward leakage, and lateral outflow is replenished by areal rainfall. Because of the growing demand for water and the variation in rainfall, resource managers need timely information on short-term and long-term changes in the availability of freshwater. The purpose of this report is to explain potentiometric surface maps and their value in assessing the resource, particularly during drought conditions. It is intended to convey a lay understanding of the process by which gains or losses of freshwater storage in the aquifer are determined.

In most of the Water Management District, water in the Floridan aquifer is confined and under artesian pressure, which means that the water level in tightly cased wells that tap the aquifer rises above the top of the aquifer (fig. 1). This water level in a number of wells distributed across the area of interest is used to construct the potentiometric surface of the aquifer. The water levels are converted to altitudes, referenced to the National Geodetic Vertical Datum of 1929 (sea level), plotted on a map, and lines of equal altitude drawn to construct a potentiometric surface map. (A more detailed explanation of the Floridan aquifer and its potentiometric surface is given in fig. 1.)

An example of a potentiometric surface map is shown in figure 2. Even though this map was constructed from accurate water-level measurements made in more than 800 wells, maps such as this represent only the approximate potentiometric surface because of variations in hydrogeologic conditions such as: (1) wells were measured over a 1-week period, (2) wells are of different depths, (3) water levels were affected by pumping, and (4) changes in climatic conditions. The potentiometric contours are interpolated between wells, and may not conform exactly with individual water-level measurements.

The Floridan aquifer is recharged by rainfall falling directly on the outcrop of the aquifer, and, where the aquifer is overlain by the surficial aquifer with the water table above the potentiometric surface of the Floridan, by water infiltrating downward from the overlying surficial aquifer. Water is discharged by pumping and free-flowing wells, springflow, and upward leakage into overlying formations, streams, and lakes or into the ocean.

Fluctuations in the potentiometric surface reflect net gains (recharge) or losses (discharge) of water stored in the aquifer. Net gains occur during the wet season (June through September) when recharge exceeds discharge and causes the potentiometric surface to rise in most places. Net losses in storage, and declines in the potentiometric surface, follow during the dry season (October through May) when discharge exceeds recharge.

Seasonal changes in the potentiometric surface, based on a 2-year average of water-level measurements during May and September 1977, and May and September 1978, are shown in figure 3. The map shows that at the end of the wet season the potentiometric surface ranged from 1 to 5 feet higher than at the end of the dry season. However, in about half the Water Management District, the average rise was less that 1 foot. Because of the small scale, figure 3 does not show effects of local agricultural and municipal pumping, where the potentiometric surface may fluctuate as much as 25 feet or more during the year.

Long-term changes in the potentiometric surface have also occurred. Based on an estimated predevelopment potentiometric surface (Johnson and others, 1980), figure 4 shows that between that time and May 1980 (dry season), the potentiometric surface declined in most of the Water Management District. The greatest change was in the eastern part of the District where the potentiometric surface declined between 5 and 25 feet; least change occurred in the western part where the potentiometric surface declined less than 5 feet in most areas. If the predevelopment potentiometric surface were compared to the September 1980 (wet season) potentiometric surface, the decline would be 1 to 5 feet less in most of the District. The long-term decline is attributed mostly to a 5 to 10 percent deficiency in rainfall within the District during 1961-77 (fig. 5) continuing through 1980 (insets, figs. 6 and 7), and to progressively larger withdrawals from the aquifer, especially in the eastern part of the District where most development has taken place. Thus, rainfall deficiency causes a decline in the potentiometric surface two ways—it reduces recharge, and it increases discharge (pumping from the aquifer to replace water usually supplied by rainfall).

Two of the greater long-term declines in the potentiometric surface have occurred in the growing metropolitan areas of Jacksonville and Orlando-Winter Park, the two largest public suppliers of water in the Water Management District. Figure 6 shows that municipal pumpage increased in Jacksonville from 37 Mgal/d (million gallons per day) in 1961 to 56 Mgal/d in 1980. The increased pumpage and a deficiency in rainfall of 15.8 inches (inset, fig. 6) contributed to a decline in the potentiometric surface of as much as 15 feet. Figure 7 shows Orlando-Winter Park municipal pumpage increasing from 27 Mgal/d in 1961 to 62 Mgal/d in 1980. Here too, the increase in pumpage combined with a cumulative deficiency in rainfall of 72 inches (inset, fig. 7) contributed to a decline in the potentiometric surface comparable to that at Jacksonville. In both areas, deficient rainfall prompted increased pumpage, which further lowered the potentiometric surface. For this reason, it is difficult to separate the effect of rainfall from the effect of ground-water withdrawals on the potentiometric surface.

The largest single long-term decline occurred in the extreme northeast part of the Water Management District at Fernandina Beach (fig. 4). Here large quantities of water are withdrawn from the aquifer by industrial wells.

Because of the anticipated increase in water use within the Water Management District due to projected increases in population (Kiplinger Washington Letter, Inc., 1981) and the unpredictability of rainfall, it is important to monitor changes in the amount of freshwater available in the Floridan aquifer. This is not only necessary in areas where supplies of freshwater are marginal, such as the central and southeast coastal areas, but also in localities where water supplies now appear plentiful.

In summary, the periodic preparation of maps showing changes in the potentiometric surface of the aquifer provide the best base information for both short-term and long-term management of the water resources in the St. Johns River Water Management District.

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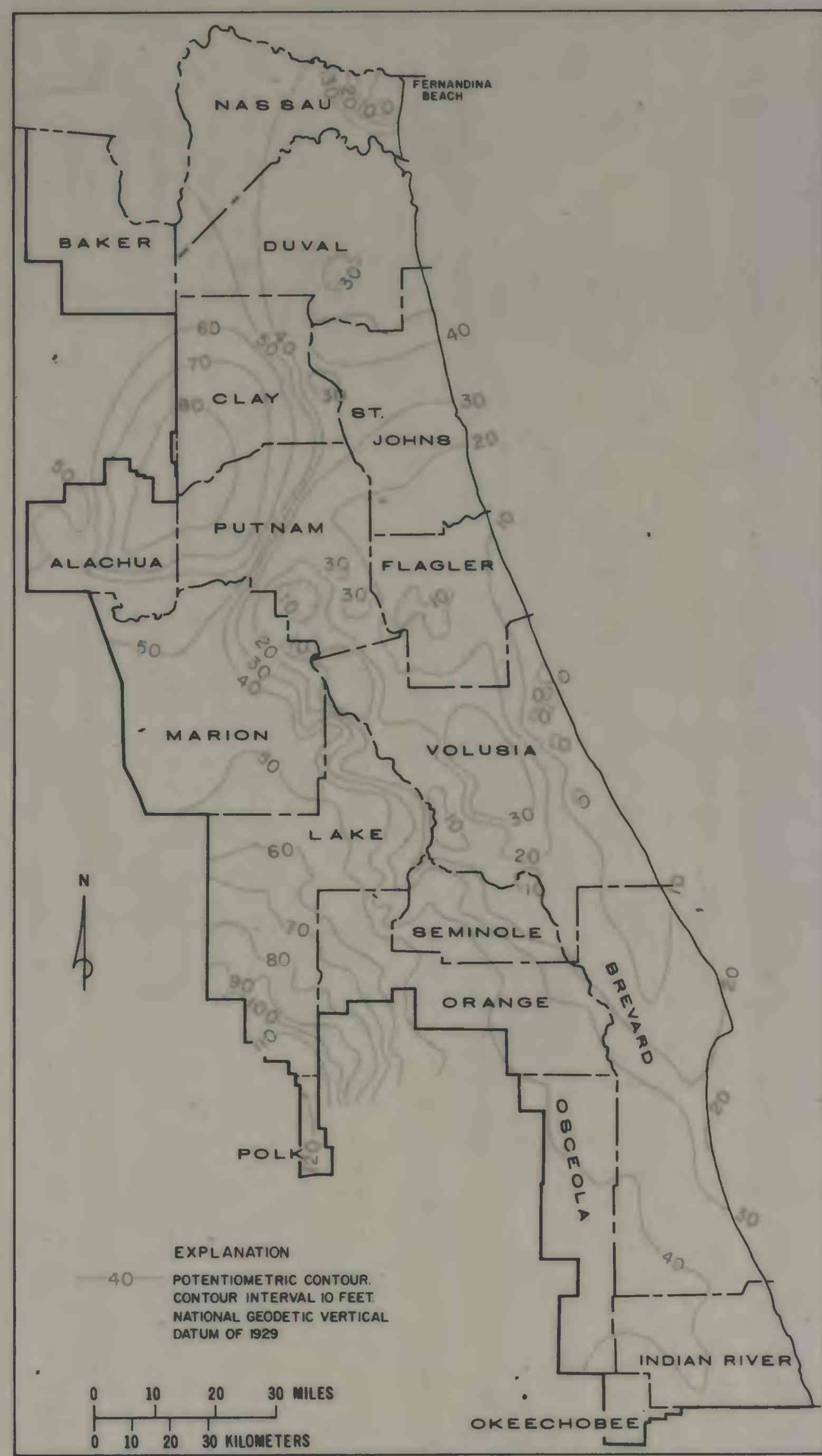

Figure 2.—Potentiometric surface of the Floridan aquifer, May 1980 (modified from Schiner and Hayes, 1980a).

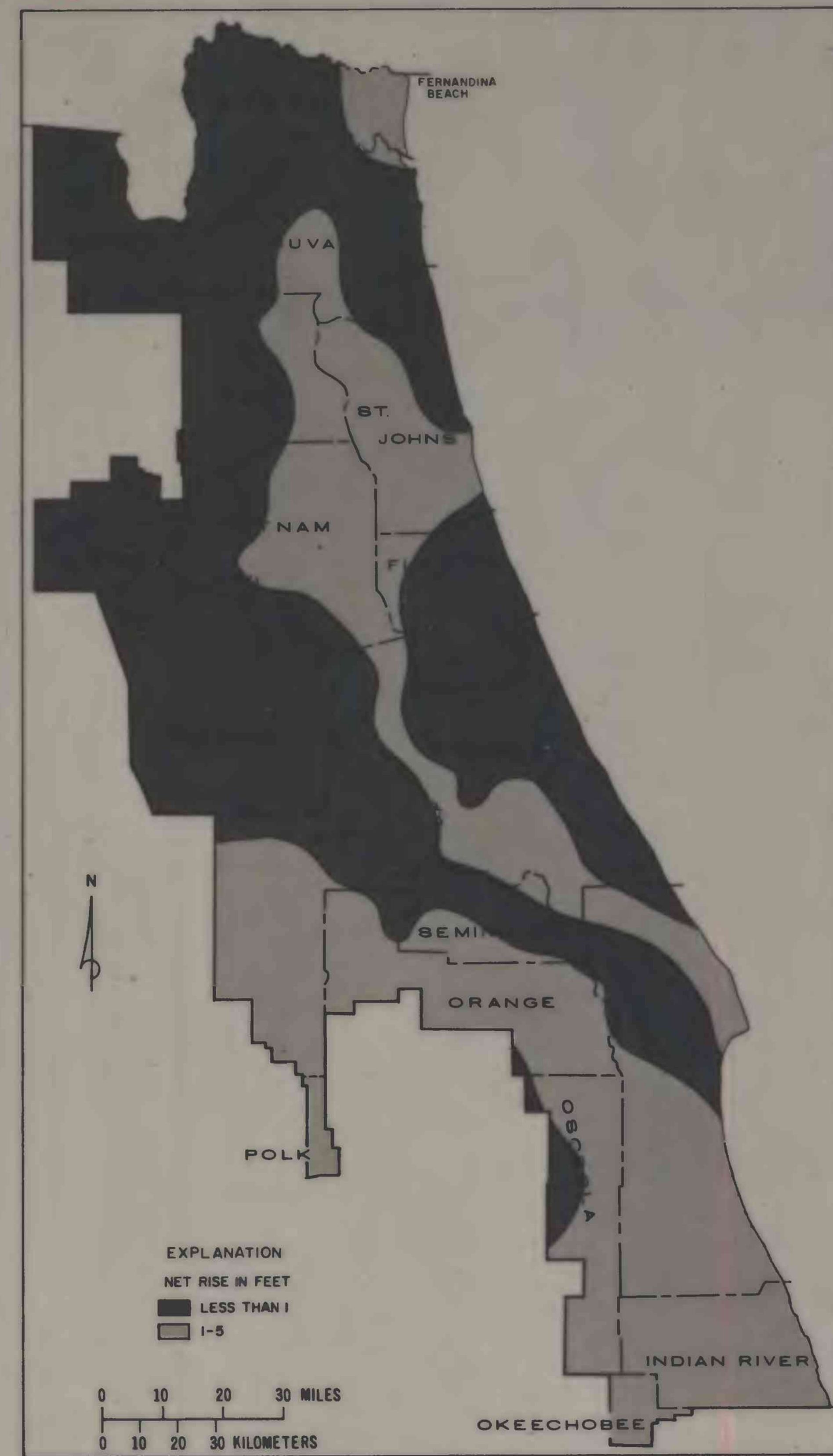

Figure 3.—Average seasonal change in potentiometric surface from May 1977 through September 1978 (Laughlin and Hayes, 1977; Watkins and others, 1978; Watkins, 1979; and Watkins and others, 1979).

Figure 4.—Approximate decline of potentiometric surface of Floridan aquifer from 1934-80 (data from Johnston and others, 1980; Schiner and Hayes, 1980a).

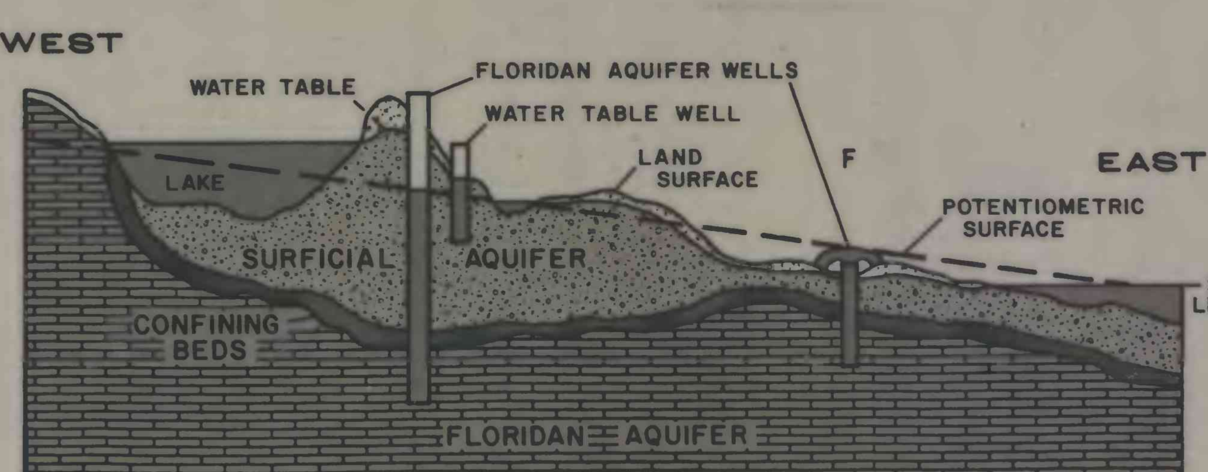

Figure 1.—Hydrologic sketch of theoretical section from central Florida to the coast showing relation between the Floridan aquifer, its potentiometric surface, and surficial aquifer water table.

The Floridan aquifer is composed chiefly of limestone and dolomite that range in total thickness from about 500 to 2,000 feet. In most places the Floridan is overlain by a surficial aquifer composed largely of unconsolidated sand that ranges from 0 to 400 feet in thickness.

Water in the Floridan is generally under artesian pressure because the aquifer is confined in most places by less permeable beds of silt and clay. When wells such as shown in the above sketch are drilled and tightly cased into the Floridan, the water in the Floridan will rise under pressure in the wells to the level of the potentiometric surface; if the well is located where the potentiometric surface is above land surface such as at "F", the well will flow freely. The potentiometric surface represents an imaginary surface based on the levels that water will stand in tightly cased wells in the upper part of the Floridan aquifer.

In contrast to the Floridan, water in the surficial aquifer is generally unconfined. When a water table well such as shown above is drilled into the surficial aquifer, the water level in the well will coincide with the water table.

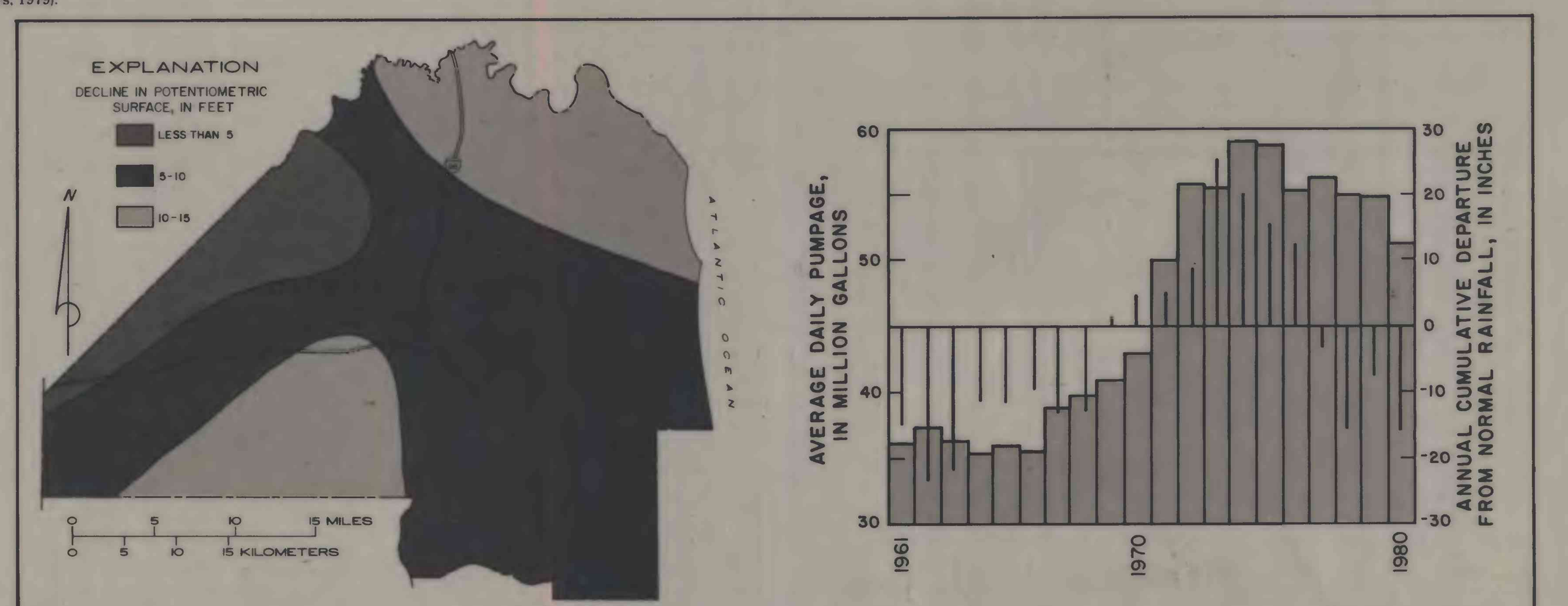

Figure 6.—Map of decline in potentiometric surface of the Floridan aquifer in Duval County from February 1960 to May 1980 (modified from Leve, 1980), and graphs showing Jacksonville average daily pumpage and annual cumulative departure from normal rainfall at Jacksonville, 1961-80.

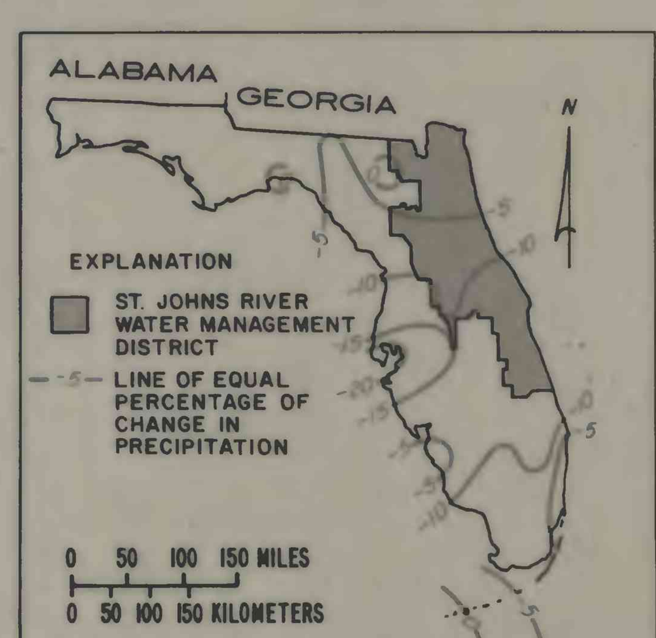

Figure 5.—Precentage change of 1961-77 annual precipitation in Florida, from the period 1944-60 (Coleman, 1979). Shaded area in St. Johns River Water Management District.

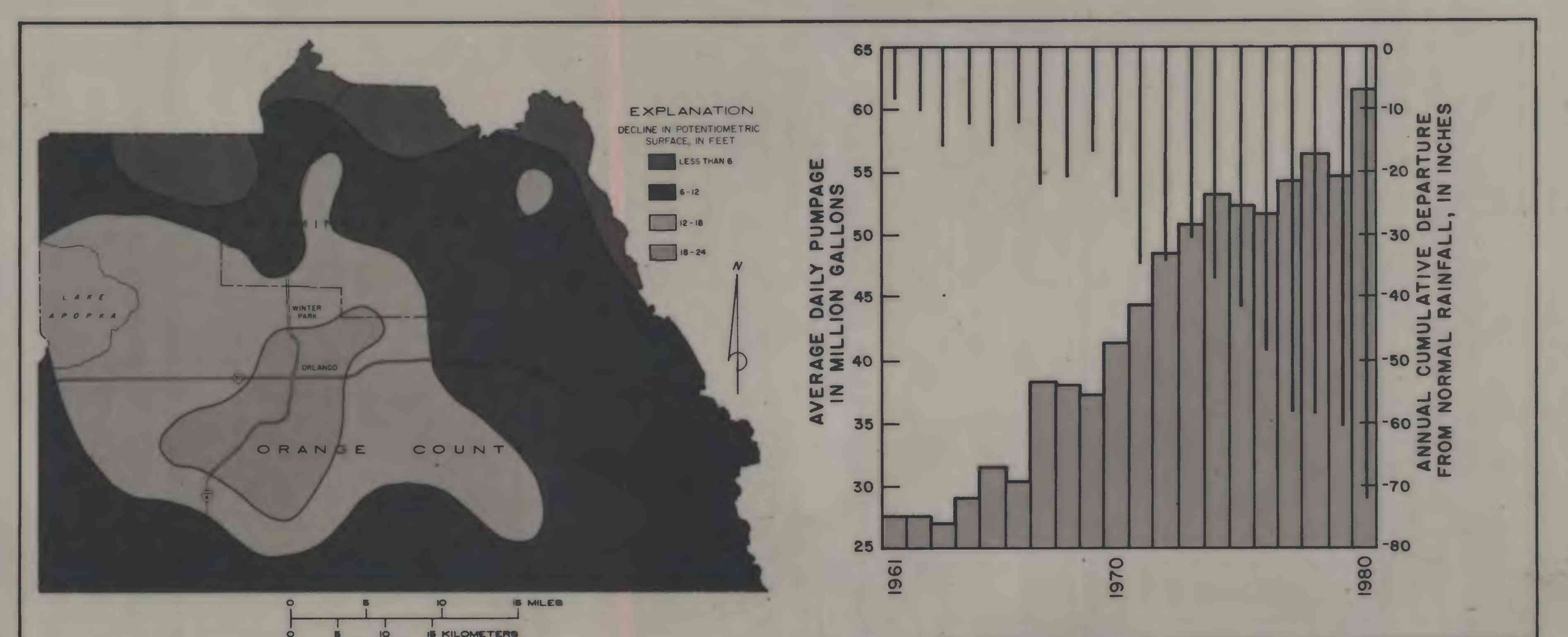

Figure 7.—Map of decline in potentiometric surface of the Floridan aquifer in Orange and Seminole Counties from September 1960 to September 1980 (Lichtler, 1968; Tibbals, 1976; Schiner and Hayes, 1980), and graphs showing Orlando-Winter Park average daily municipal pumpage and annual cumulative departure from normal rainfall, 1961-80, at Orlando.

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POTENTIOMETRIC SURFACE OF THE FLORIDAN AQUIFER AND ITS USE IN MANAGEMENT OF WATER RESOURCES, ST. JOHNS RIVER WATER MANAGEMENT DISTRICT, FLORIDA

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