CARBONATE-ROCK AQUIFERS—
Continued

Some of the variations within the Floridan aquifer system and the complexity of the system are shown by a geohydrologic section that extends from south-central Georgia to southern Florida (**fig. 33**). The aquifer system thickens southeastward; it is only about 250 feet thick in south-central Georgia, but is more than 3,000 feet thick in southern Florida. A graben called the Gulf Thrugh, shown near the left side of the section, is between two faults that completely cut the aquifer system; thick clay of the upper confining unit of the Floridan accumulated in the graben. In Georgia, the aquifer system contains only scattered, local confining units or none at all. By contrast, in most of Florida, the system contains one to several thick confining units of regional extent. These confining units consist of carbonate rocks that are much less permeable than the water-yielding strata of the aquifer system, and retard the vertical movement of water within it. The Boulder Zone in southern Florida is a deeply-buried, cavernous zone that is filled with saline water and used as a receiving zone for injected wastes. In Georgia, the Floridan aquifer system directly overlies the Southeastern Coastal Plain aquifer system, which consists of interbedded sand aquifers and clayey confining units, all of which are much less permeable than the carbonate rocks of the Floridan.

The major features of the regional ground-water flow system of the Floridan aquifer system are shown by a map of the potentiometric surface of the Upper Floridan aquifer (**fig. 34**). The water moves regionally southeastward and southward from recharge areas in central Georgia and southern Alabama where the aquifer is exposed at the land surface or is covered by a thin layer of younger sediments. Water also moves outward in all directions from local potentiometric highs in south-central Georgia and in the northern and central parts of the Florida peninsula. Depressions on the potentiometric surface mark major withdrawal centers at Savannah, Georgia, and at Fernandina Beach, Fort Walton Beach, and the Hillsborough–Pinellas County area, Florida. The band of closely spaced contours that extends northeastward from Grady County to Jeff Davis County, Georgia, is located just up the hydraulic gradient from the Gulf Trough graben that is filled with a thick sequence of clay. This clay, which is part of the upper confining unit of the Floridan aquifer system, has been downdropped opposite the permeable limestone of the Floridan, thus impeding the coastward flow of water in the aquifer. This impedance is represented by the closely spaced contours.

Florida has 27 first-magnitude springs (**fig. 35**), or springs which discharge 100 cubic feet per second or more, out of 78 in the Nation. All these springs issue from the Upper Floridan aquifer, and practically all of them are located in places where the aquifer is exposed at the land surface or is covered by less than 100 feet of clayey upper confining unit. Dissolution of the carbonate rocks of the aquifer in these places has resulted in the development of large caverns, many of which channel the ground water to major spring orifices. Some of the springs are large enough to form the headwaters of surface streams.

Large withdrawals from the Upper Floridan aquifer at several major pumping centers lowered hydraulic heads in the aquifer more than 80 feet from predevelopment levels in several places by 1980 (**fig. 36**). Regional declines of 10 to 30 feet have developed in three multicounty areas, one of which extends over almost half the Georgia Coastal Plain. The withdrawals have locally reversed predevelopment hydraulic gradients in some coastal areas, creating the potential for the encroachment of saline water from the Gulf of Mexico, the Atlantic Ocean, or from deep parts of the Floridan aquifer system that contain saline water. However, saline water encroachment is limited to a few localized areas at present (1998). Although withdrawals are large, they have not greatly altered the major characteristics of the predevelopment ground-water flow system. The dominant forms of discharge from the aquifer system are springflow and baseflow to streams, just as before development began. Water-budget calculations indicate that withdrawal of about 3.4 billion gallons per day of freshwater during 1990 accounts for only about 20 percent of the total discharge from the aquifer system.

The chemical quality of water in the Floridan aquifer system is suitable for most uses over an area of about two-thirds of the aquifer system. Water with dissolved-solids concentrations of 1,000 milligrams per liter or greater is not considered by the U.S. Environmental Protection Agency to be suitable for drinking. A map of dissolved-solids concentrations of water in the Upper Floridan aquifer (**fig. 37**) shows that mineralization of the water is greater near the coast than inland. The distribution of dissolved solids is related to the ground-water flow system and proximity to seawater. Where the aquifer is unconfined or overlain by a thin confining unit, ground-water flow is vigorous. Large volumes of water move quickly in and out of the aquifer, and dissolved-solids concentrations are minimal. By contrast, water that travels coastward down long, regional flow paths is in contact with aquifer materials, such as limestone or local gypsum beds, for a much longer time and dissolves more mineral material. Thus, the water has larger dissolved-solids concentrations. Near the coasts, large dissolved-solids concentrations are due to the mixing of fresh ground water with seawater that migrates into the aquifer from the ocean or the Gulf of Mexico. In southern Florida and along the St. Johns River in east-central Florida, areas of large dissolved-solids concentrations represent unflushed seawater that was either trapped in the limestone of the aquifer system as it was deposited or entered the aquifer system later, during high stands of sea level. Dissolved-solids concentrations in water from the Lower Floridan aquifer are larger than those in the Upper Floridan aquifer because the water in the Lower Floridan has followed longer flowpaths and, accordingly, has had more time to dissolve aquifer minerals.

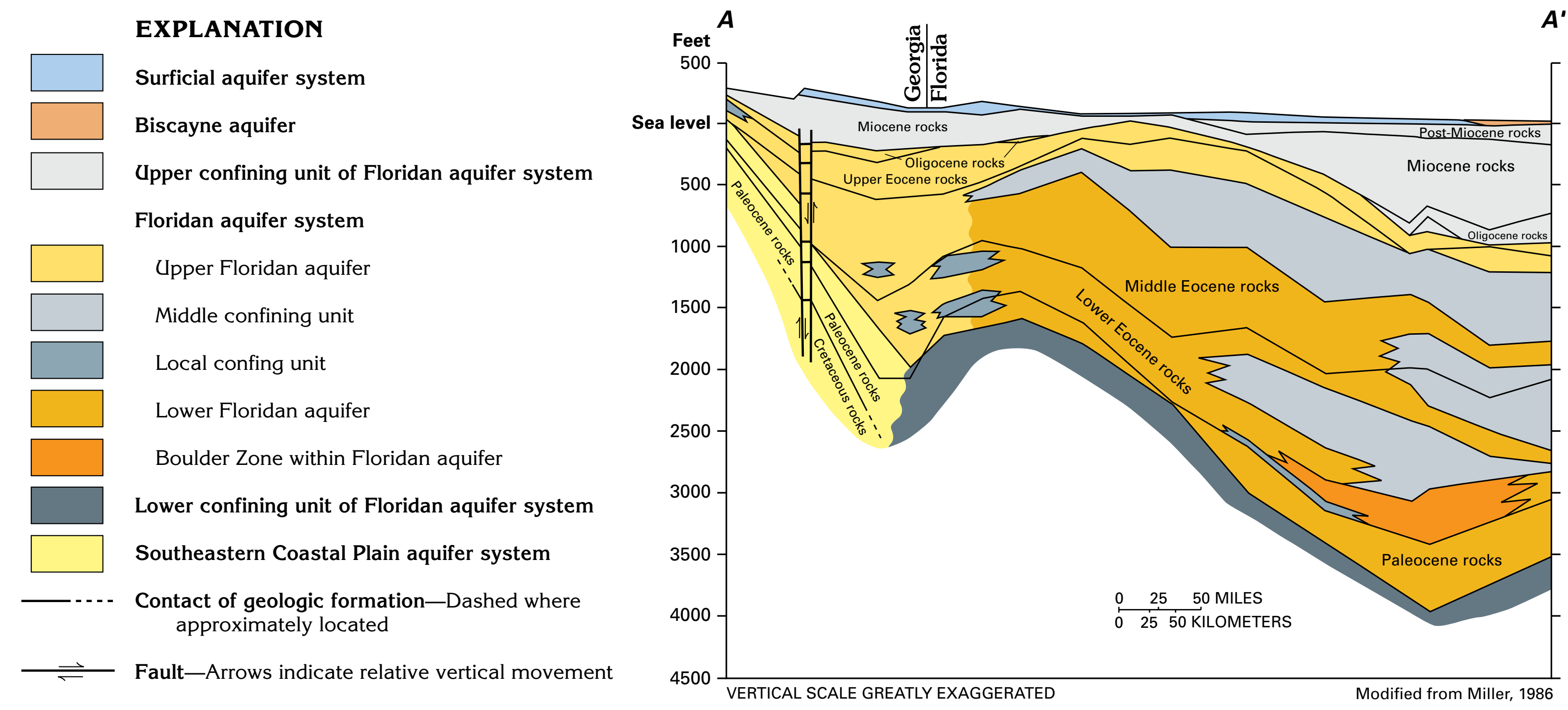

Figure 33. *The Floridan aquifer system is thin in south-central Georgia, where it consists of a single aquifer that contains local confining units. The system thickens greatly in Florida, where it consists of complexly interfingering, lens-shaped bodies of permeable and less-permeable carbonate rocks. The line of the hydrogeologic section is shown in figure 32.*

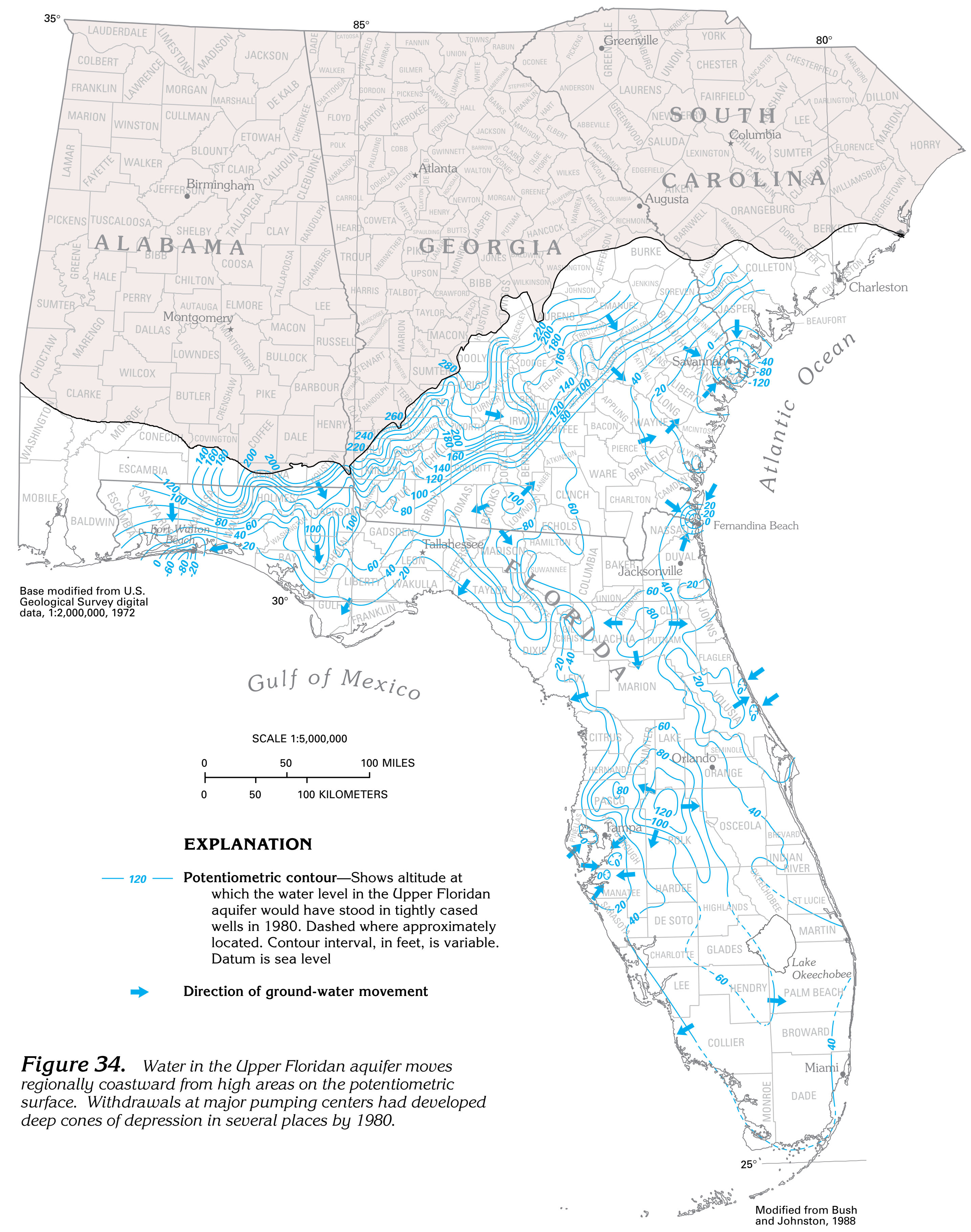

Figure 34. *Water in the Upper Floridan aquifer moves regionally coastward from high areas on the potentiometric surface. Withdrawals at major pumping centers had developed deep cones of depression in several places by 1980.*

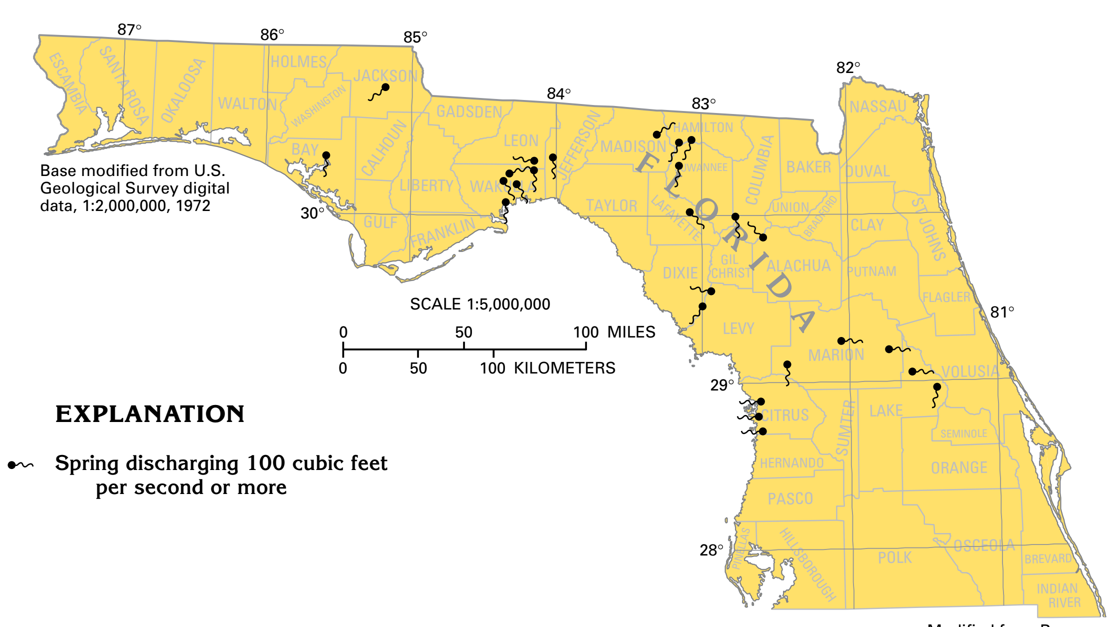

Figure 35. *Florida has 27 first-magnitude springs that issue from large solution openings in the Upper Floridan aquifer. These openings are features of the karst topography that has developed on the carbonate rocks of the aquifer where its upper confining unit is thin or absent.*

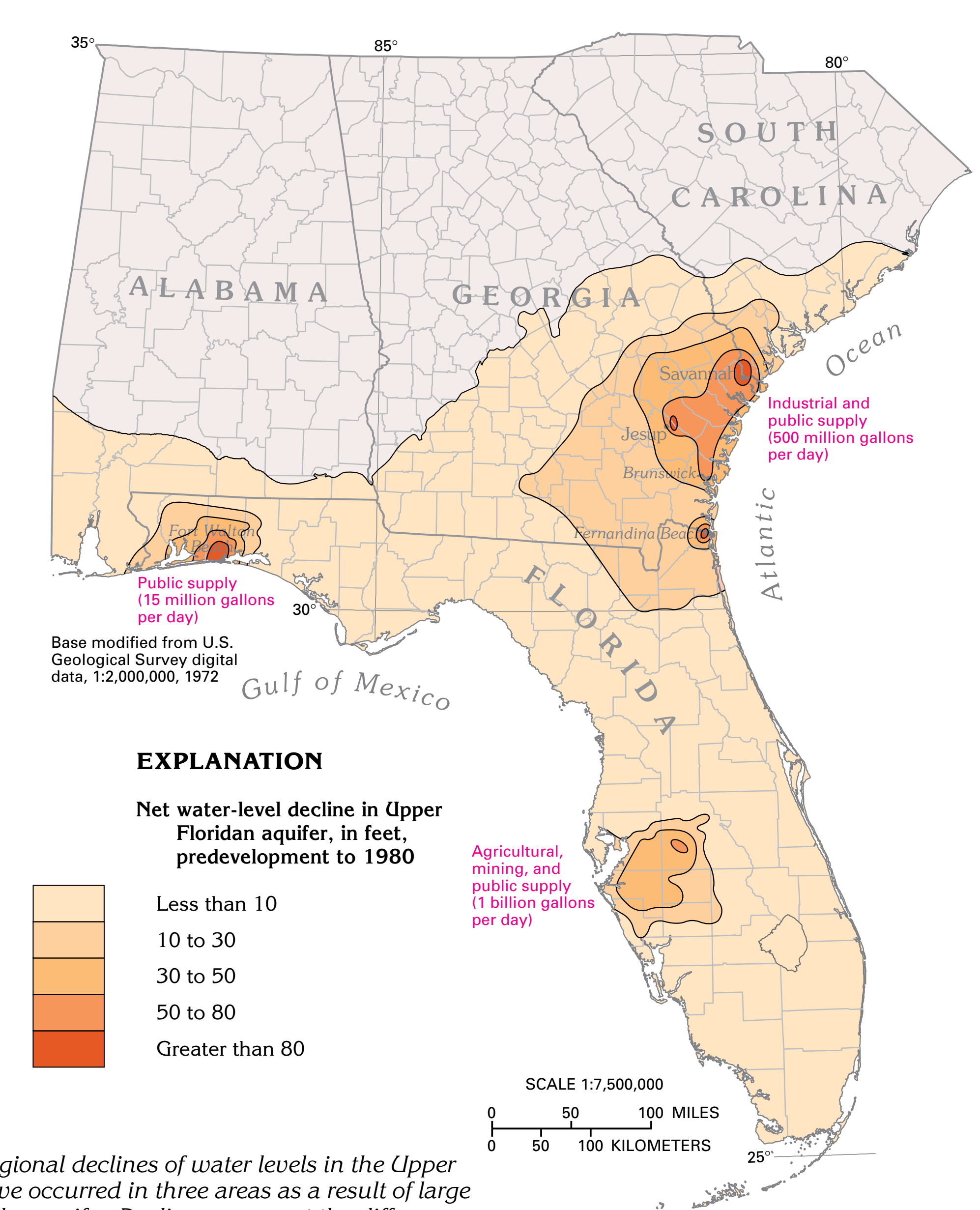

Figure 36. *Regional declines of water levels in the Upper Floridan aquifer have occurred in three areas as a result of large withdrawals from the aquifer. Declines represent the difference between predevelopment and 1980 water levels.*

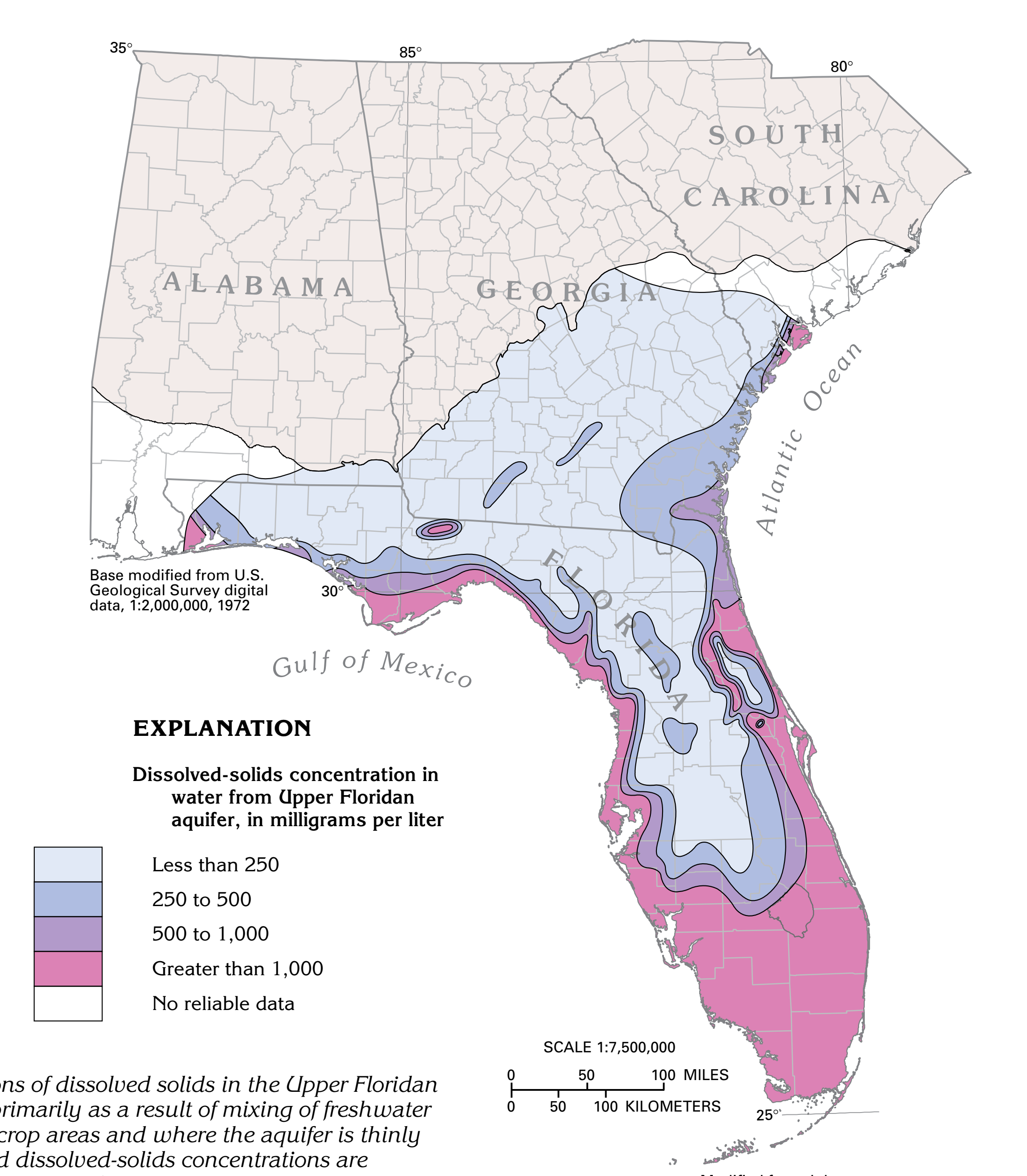

Figure 37. *Concentrations of dissolved solids in the Upper Floridan aquifer increase coastward, primarily as a result of mixing of freshwater with seawater. In aquifer outcrop areas and where the aquifer is thinly confined, flow is vigorous and dissolved-solids concentrations are generally less than 250 milligrams per liter.*