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HYDROGEOLOGIC FRAMEWORK OF THE VIRGINIA COASTAL PLAIN

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REGIONAL AQUIFER-SYSTEM ANALYSIS

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information. There are no wells that extend to the basement in this area. Water wells located on Tangier Island (63L1, fig. 7) and the water-test well (62D2, fig. 7) located at milemarker 3.7 on the Chesapeake Bay Bridge-Tunnel provide only partial borehole information to depths of 1,000 ft and 1,500 ft, respectively. The uppermost hydrogeologic units beneath the Chesapeake Bay and its tributaries were studied in detail because of interest in the erosional effects induced by sea-level lowering during Pleistocene glaciations. This erosion created deeply incised stream channels in the Coastal Plain sediments (Hack, 1957; Harrison and others, 1965), which caused a disruption in aquifer and confining-unit continuity and a change in the distribution of hydraulic heads within the affected aquifers.

The hydrogeology of the sediments beneath the Eastern Shore Peninsula has been previously investigated to a depth of approximately 450 ft (Sinnott and Tibbitts, 1954, 1957, 1968; Fennema and Newton, 1982). This area has only three wells—the J&J Taylor oil-test well, the Coast Guard Cobb Island well, and the New York, Philadelphia, and Norfolk Railroad Co. well—which were drilled to 1,000 ft or greater. Only the J&J Taylor well (66M1, fig. 7) has either geophysical and geologic information available for analysis. The general lack of deeper hydrogeologic data throughout the Eastern Shore Peninsula area makes correlations of most hydrogeologic units only tentative south of well 66M1.

The information obtained from the interpretation and correlation of geophysical logs, as illustrated in the hydrogeologic sections, was then used to construct sets of hydrogeologic unit maps (figs. 8–24) delineating thicknesses of confining units and altitudes of aquifer tops. For the most part, the hydrogeologic sections and maps can be used to determine the relative positions of, and depths to, the major aquifers and confining units. However, these hydrogeologic sections and maps are to be used only as a guide, and, because of the variable nature of subsurface sediments, should not be a substitute for test-hole drilling, especially in areas where data are sparse. Outcrop areas of the geologic formation, or formations, that form hydrogeologic units are illustrated on the Geologic Map of Virginia (Milici and others, 1963). It is important to note that, in many cases, the hydrogeologic units constitute only the sandy or clayey facies of specific geologic formations and, therefore, represent an undefined part of the geologic outcrop areas.

Identification of each hydrogeologic unit is based on biostratigraphic and lithostratigraphic analysis obtained from literature describing outcrops, core samples, and (or) cuttings. A test hole (well 58H4, fig. 7) was drilled, in cooperation with the Virginia State Water Control Board's Bureau of Surveillance and Field Studies, to obtain stratigraphic and hydrologic data by analyses of core samples, cuttings, water-level measurements, water samples, and geophysical logs. Correlation and delineation of the identified hydrogeologic units are based on compiled data in combination with the interpretation of geophysical logs, drillers' logs, and water-level data.

BASEMENT COMPLEX

The basement, which is overlain unconformably by the unconsolidated deposits of the Virginia Coastal Plain, generally consists of a gently eastward-dipping erosional surface of warped, crystalline rocks (fig. 8). This basement rock emerges along the Fall Line and extends westward forming the Piedmont province. The exposed Piedmont complex consists mainly of massive igneous and highly deformed metamorphic rocks that range in age from Precambrian to Lower Paleozoic (Milici and others, 1963), but also includes unmetamorphosed, consolidated sediments and igneous intrusives of probable Triassic age within isolated grabens and half grabens (fig. 8). It seems reasonable to assume that basement rocks underlying the Coastal Plain in Virginia are similar to the adjacent exposed rocks of the Piedmont terrain. It should be noted that evidence is conflicting (Brown and others, 1972; Doyle and Robbins, 1977) concerning the presence of consolidated Jurassic sediments within the study area. If, in fact, these consolidated sediments are present, they would be considered as part of the basement complex.

The slope of the basement-rock surface ranges from 50 to 100 ft/mi near the Fall Line; the slope then decreases to about 40 ft/mi to the Atlantic Coast (fig. 8). Data from wells that penetrate basement rock in the Coastal Plain (fig. 8) indicate an irregular, undulating surface composed of the aforementioned variable lithologies. Many authors document these irregularities in the basement surface beneath the Coastal Plain and suggest various origins. Cederstrom (1945b) interprets many of the local steep-sided basement features common throughout the Coastal Plain to be stream-cut channels and erosional scarps. Other studies, however, (Minard and others, 1974; Mixon and Newell, 1977) suggest that major breaks in slope of the basement surface can be attributed more to faulting and warping than to erosion. In wells that penetrate the basement, drillers' logs indicate that a saprolitic mantle overlies the basement surface in many places, which suggests that not all of the underlying basement surface was eroded. The basement surface forms the basal limit of the study area and is overlain principally by sediments of the lower Potomac aquifer. The basement surface is overlain by younger-age deposits only near the Fall Line.

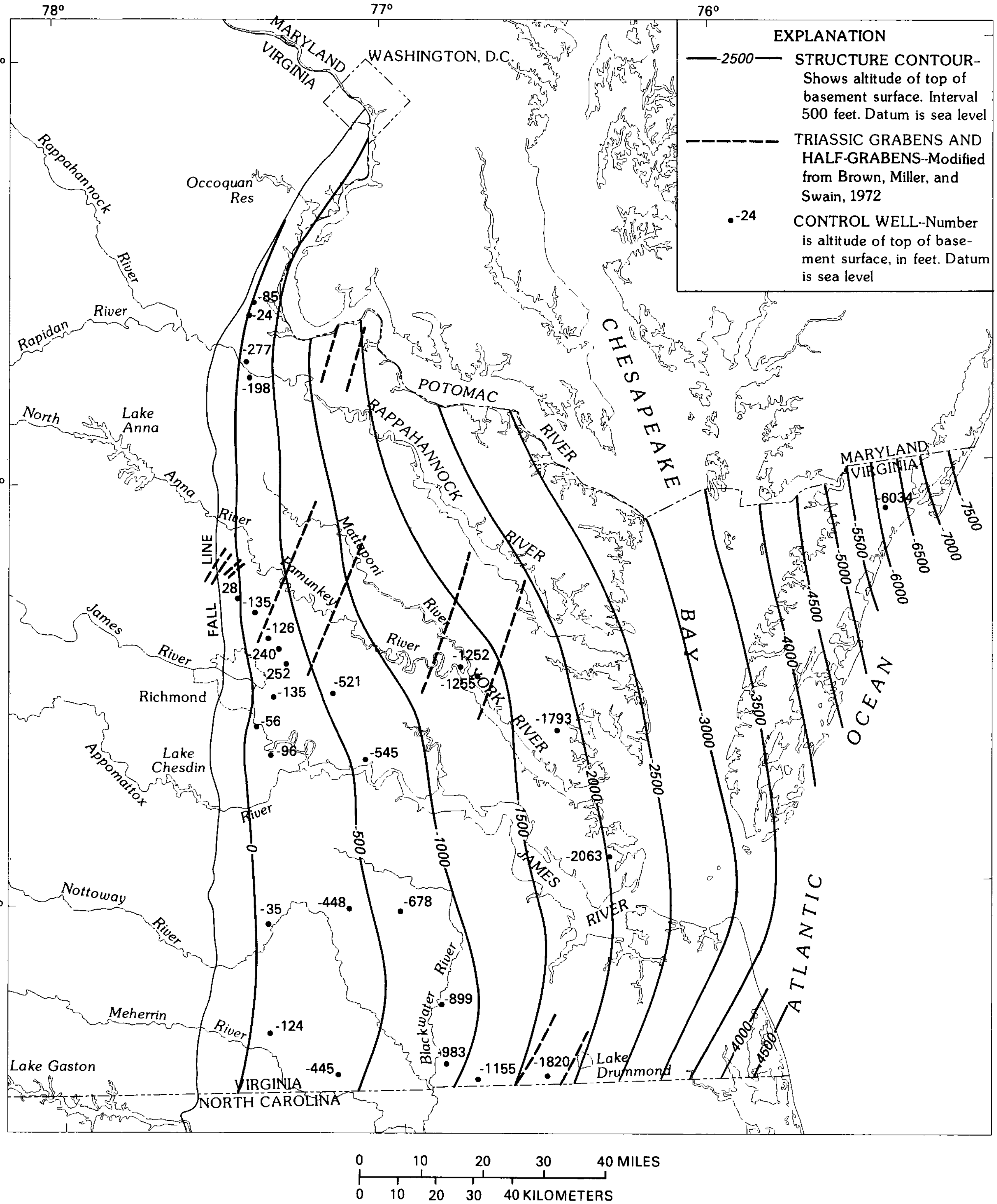

FIGURE 8.—Altitude of top of basement surface.

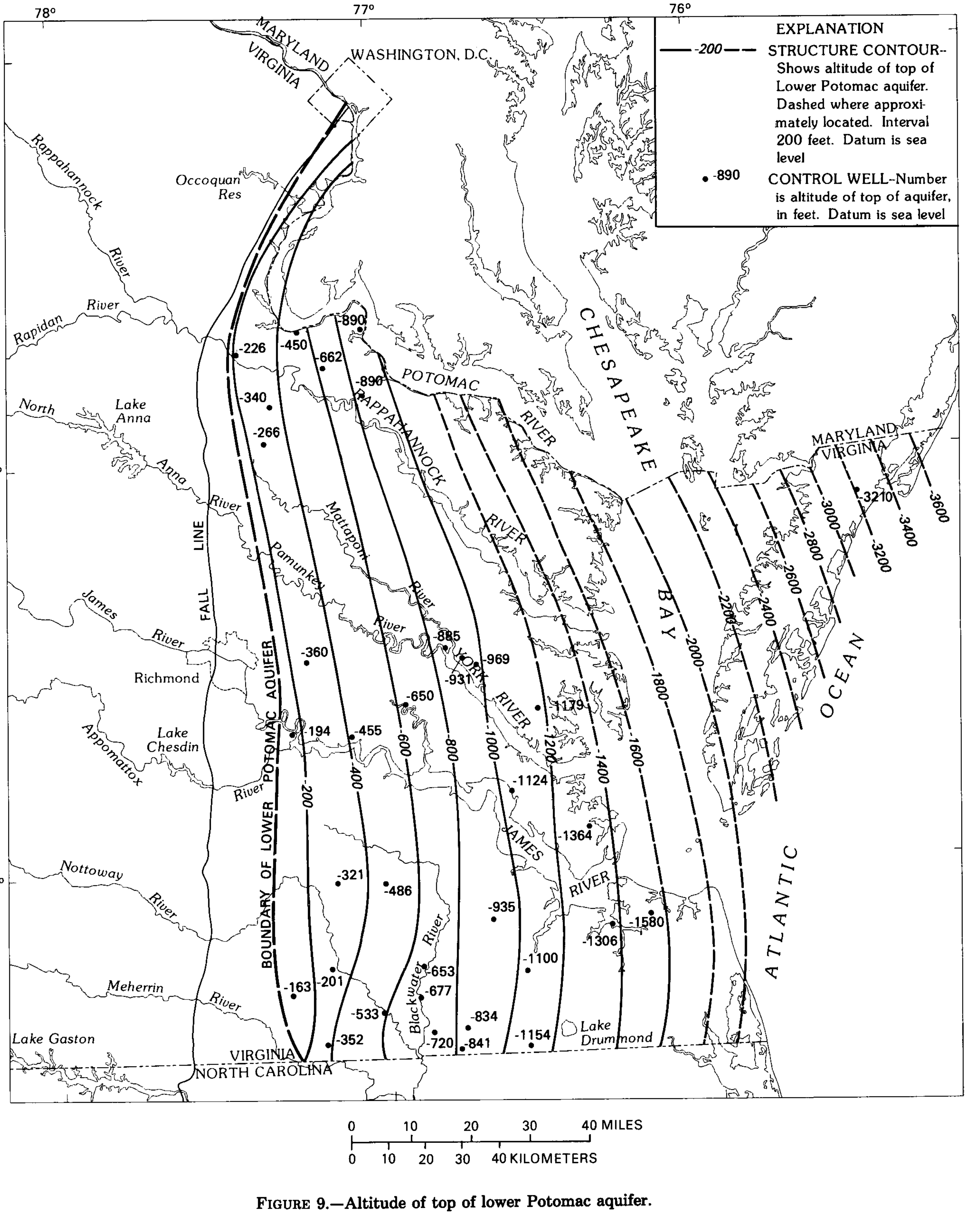

FIGURE 9.—Altitude of top of lower Potomac aquifer.

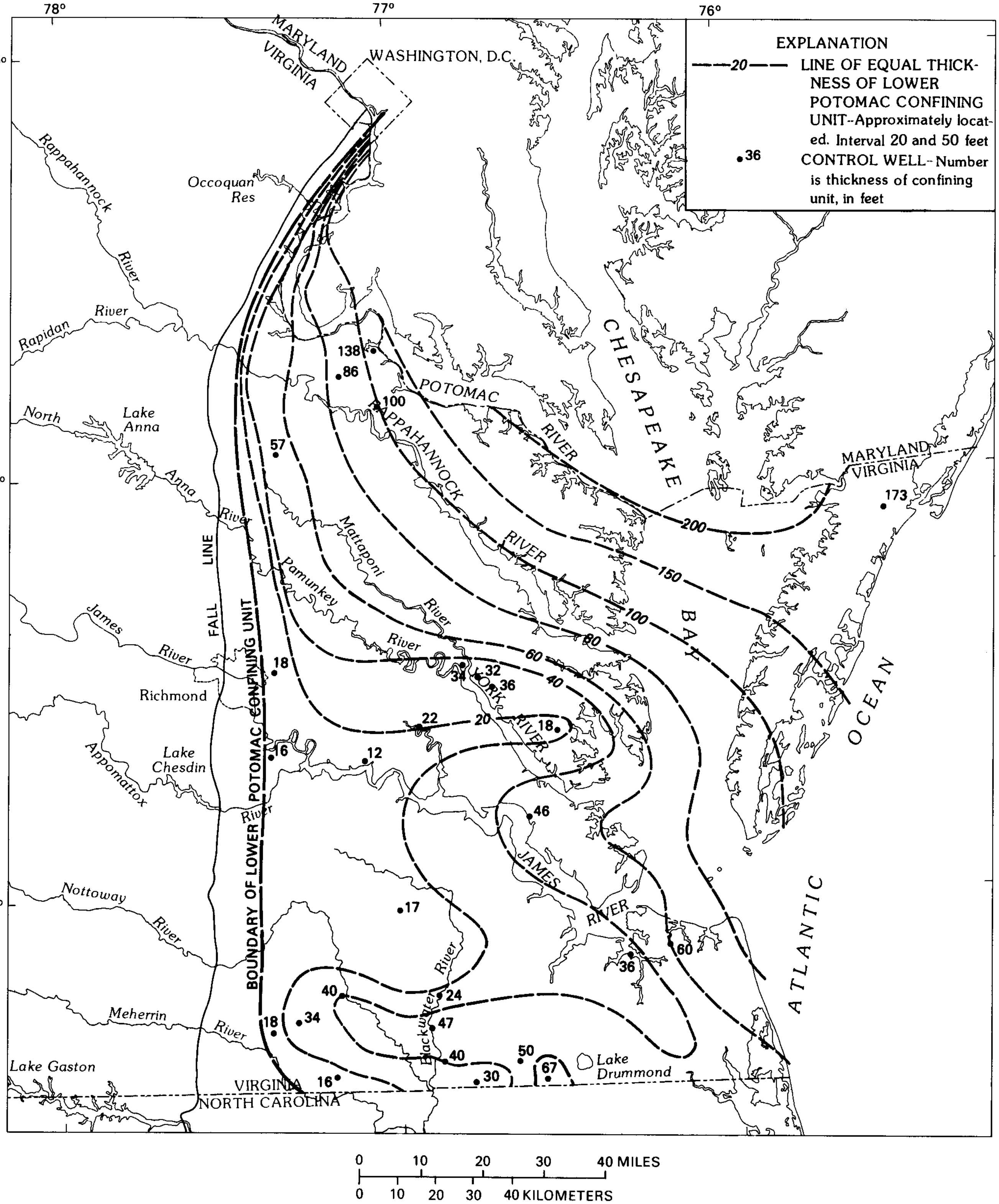

FIGURE 10.—Thickness of lower Potomac confining unit.

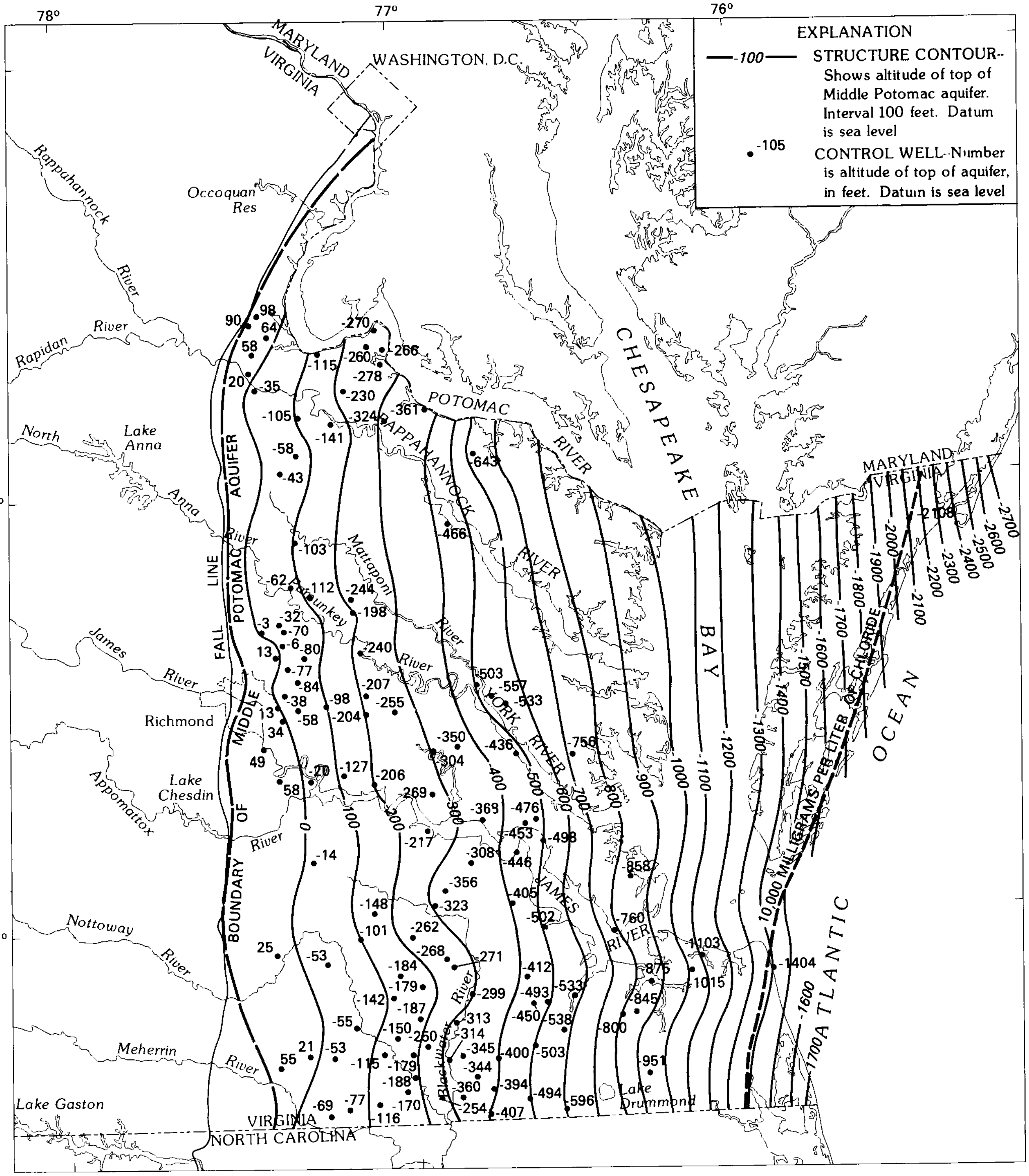

FIGURE 11.—Altitude of top of middle Potomac aquifer.

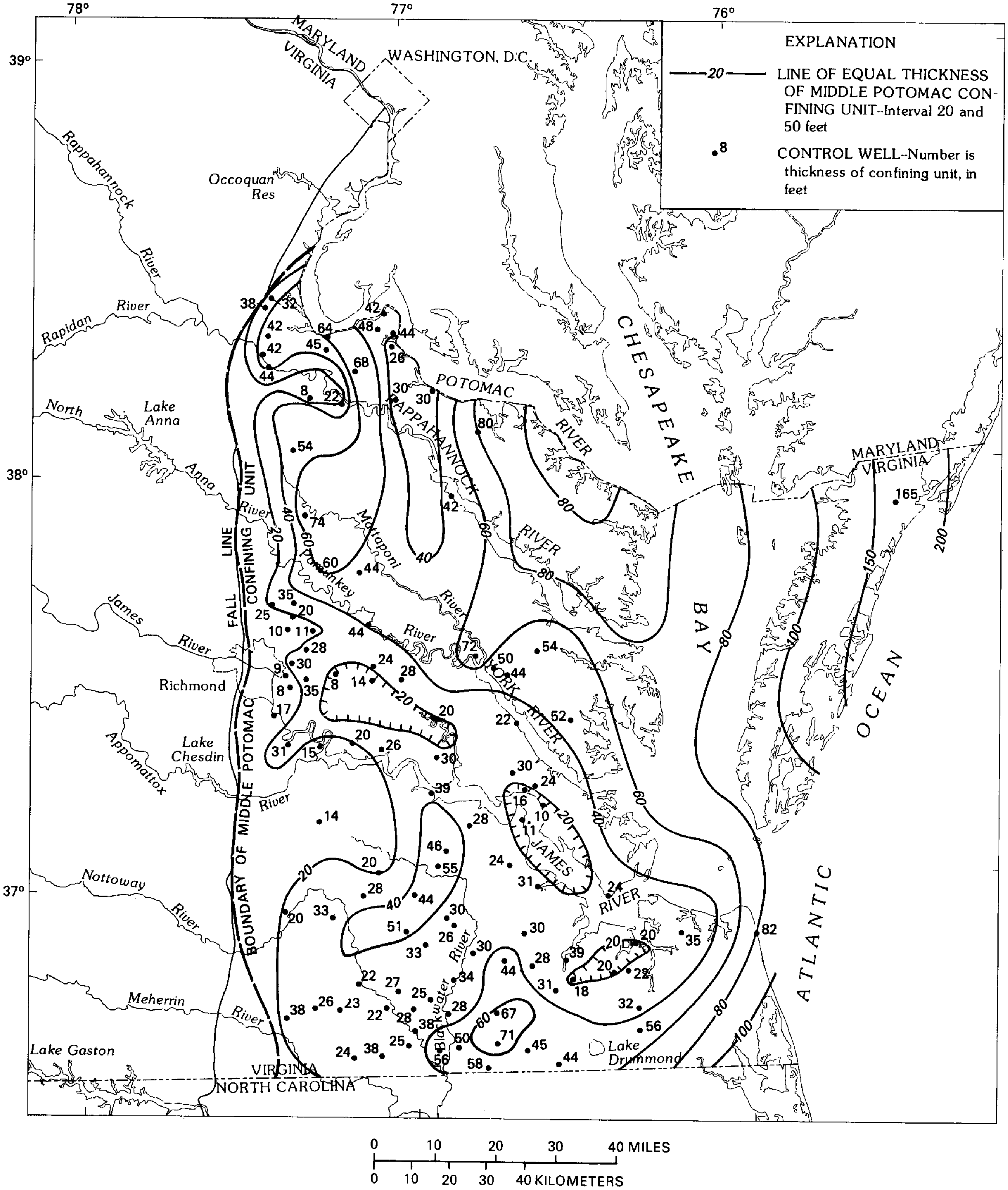

FIGURE 12.—Thickness of middle Potomac confining unit.

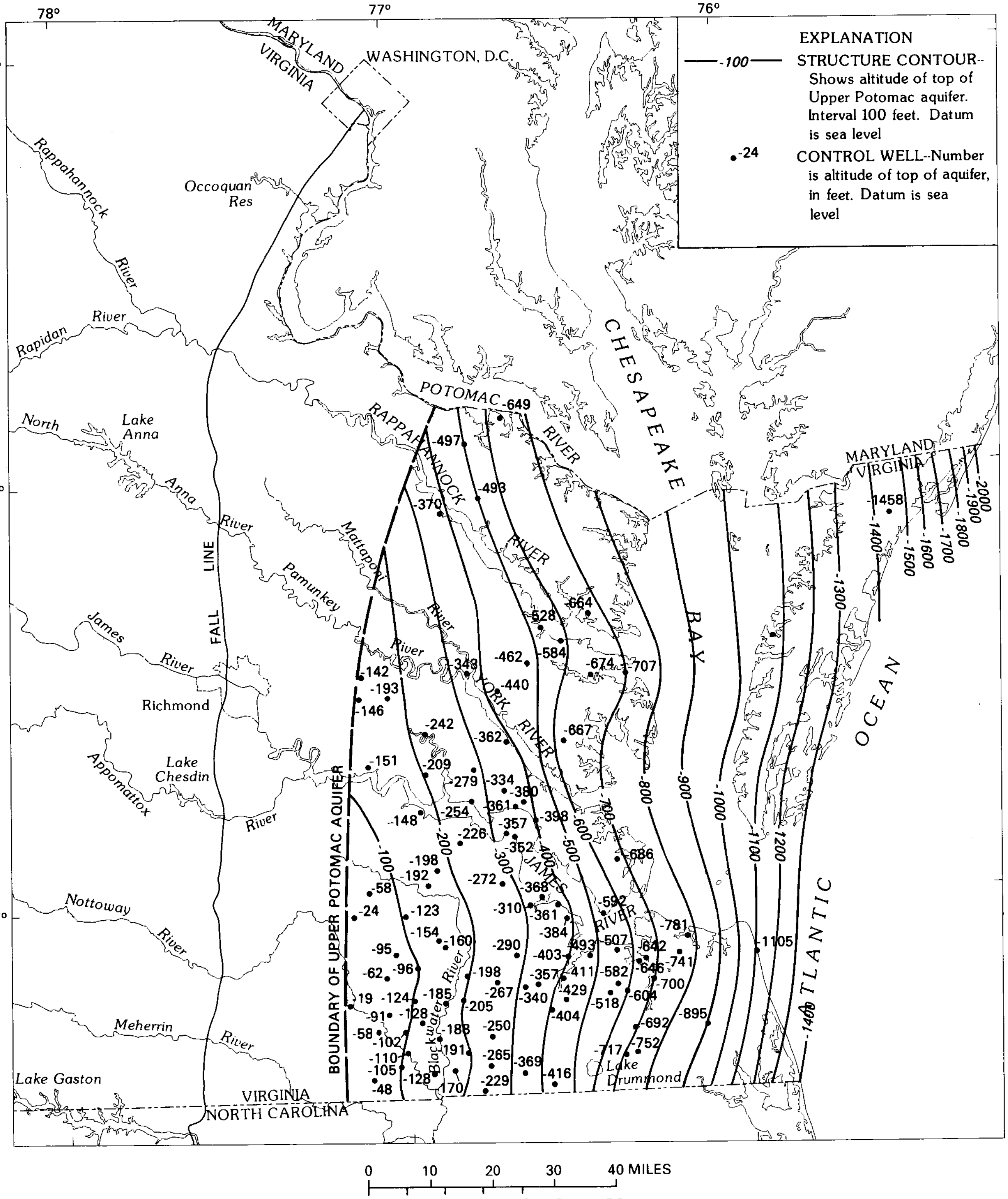

FIGURE 13.—Altitude of top of upper Potomac aquifer.

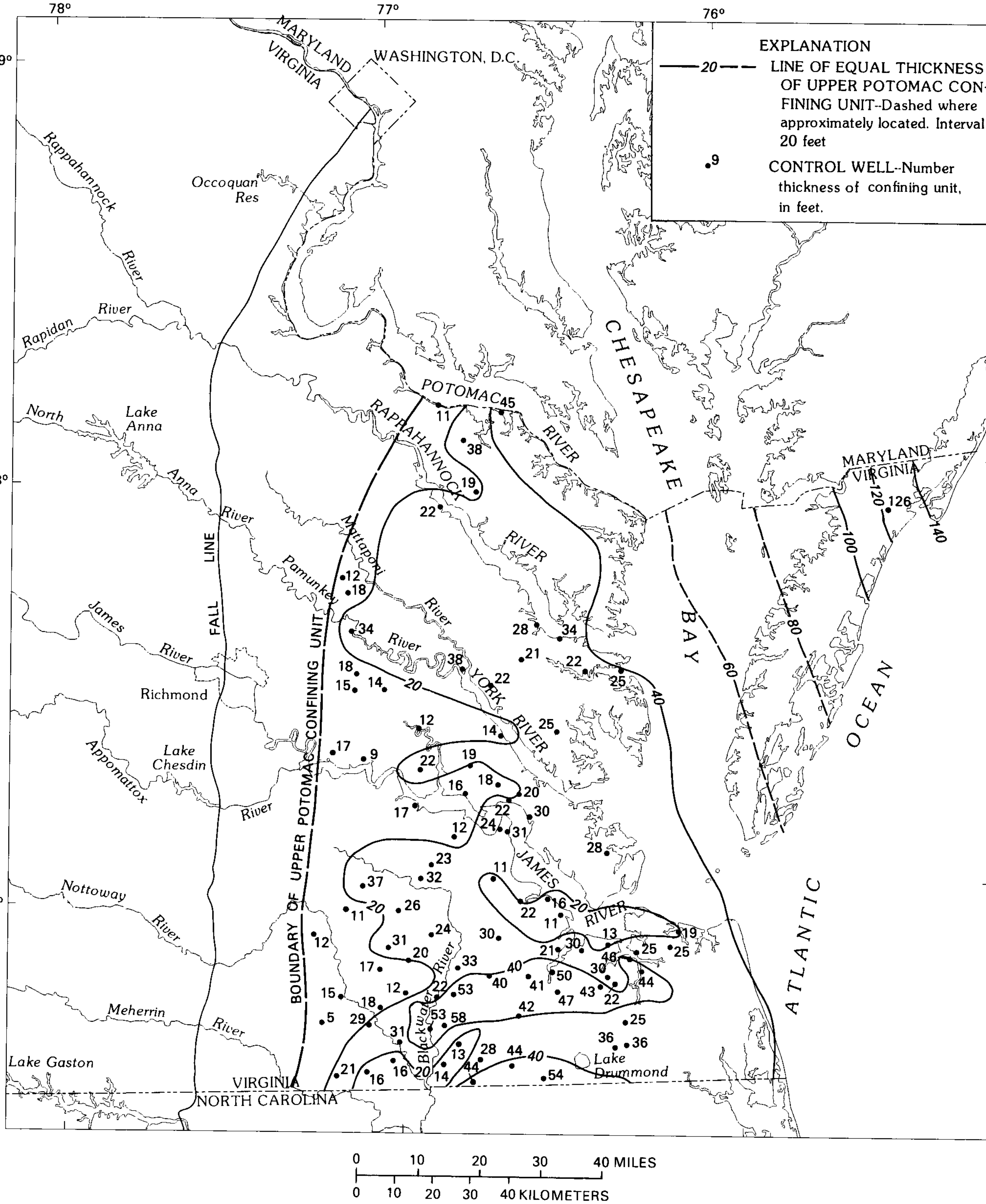

FIGURE 14.—Thickness of upper Potomac confining unit.

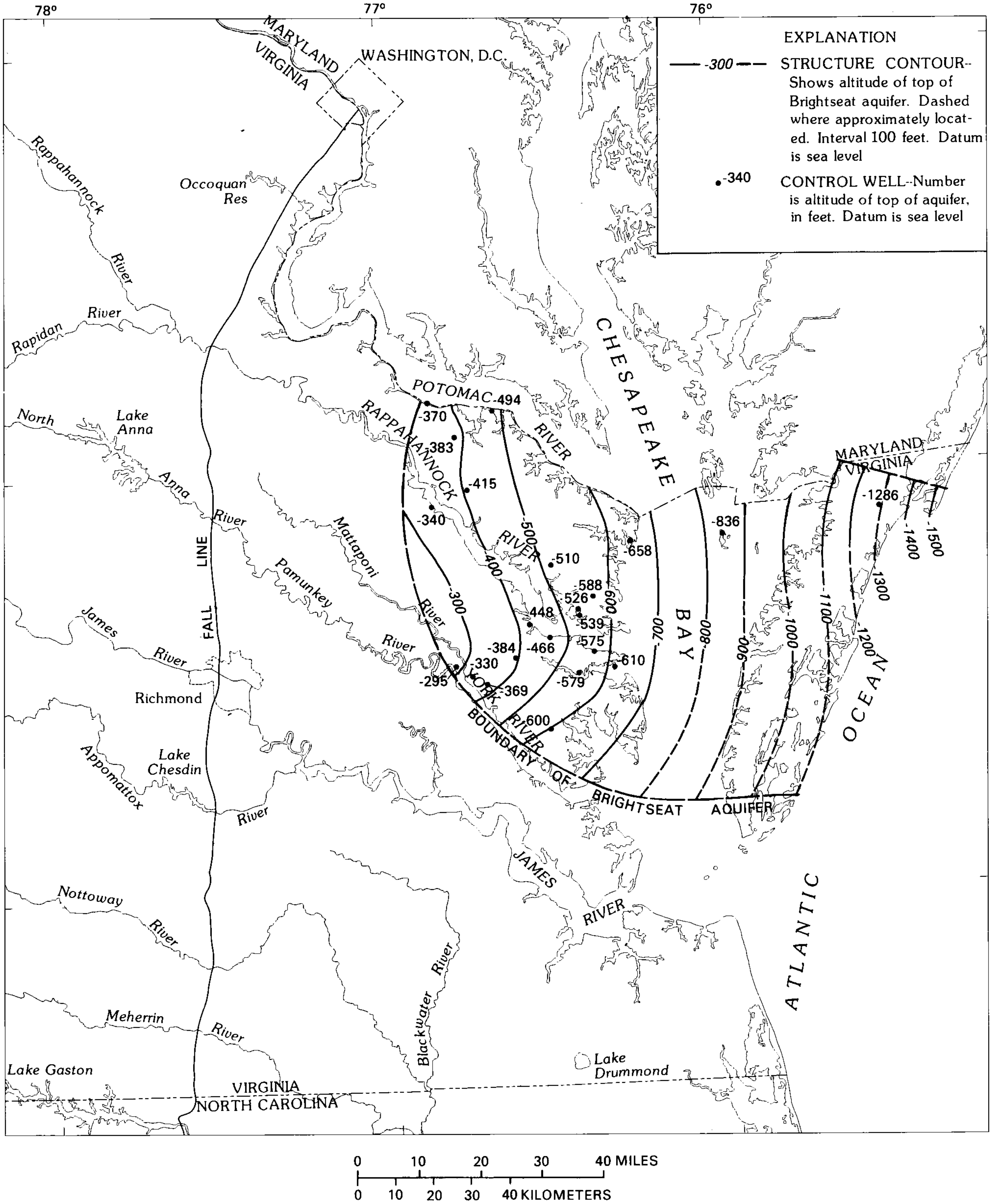

FIGURE 15.—Altitude of top of Brightseat aquifer.

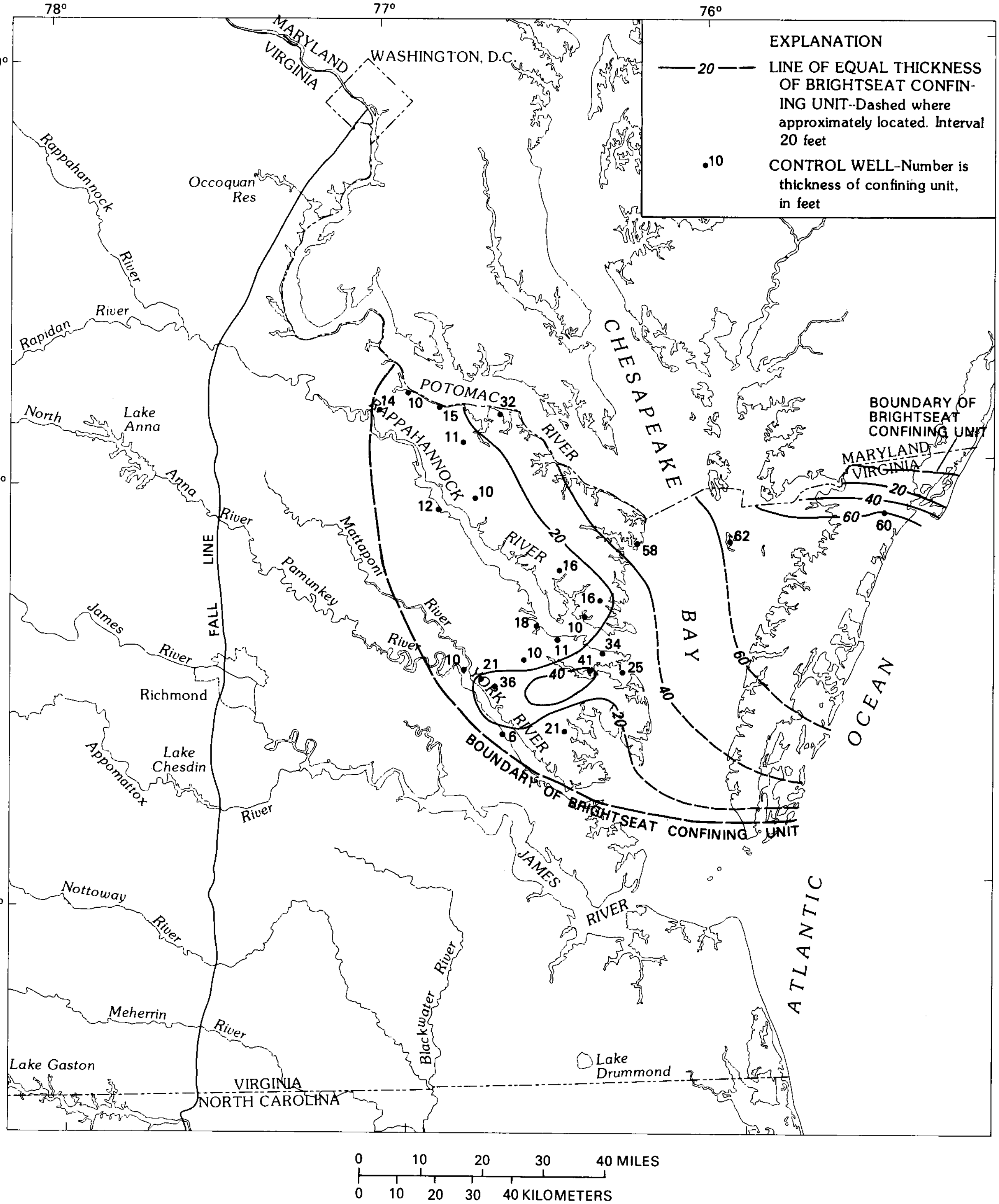

Figure 16.—Thickness of Brightseat confining unit.

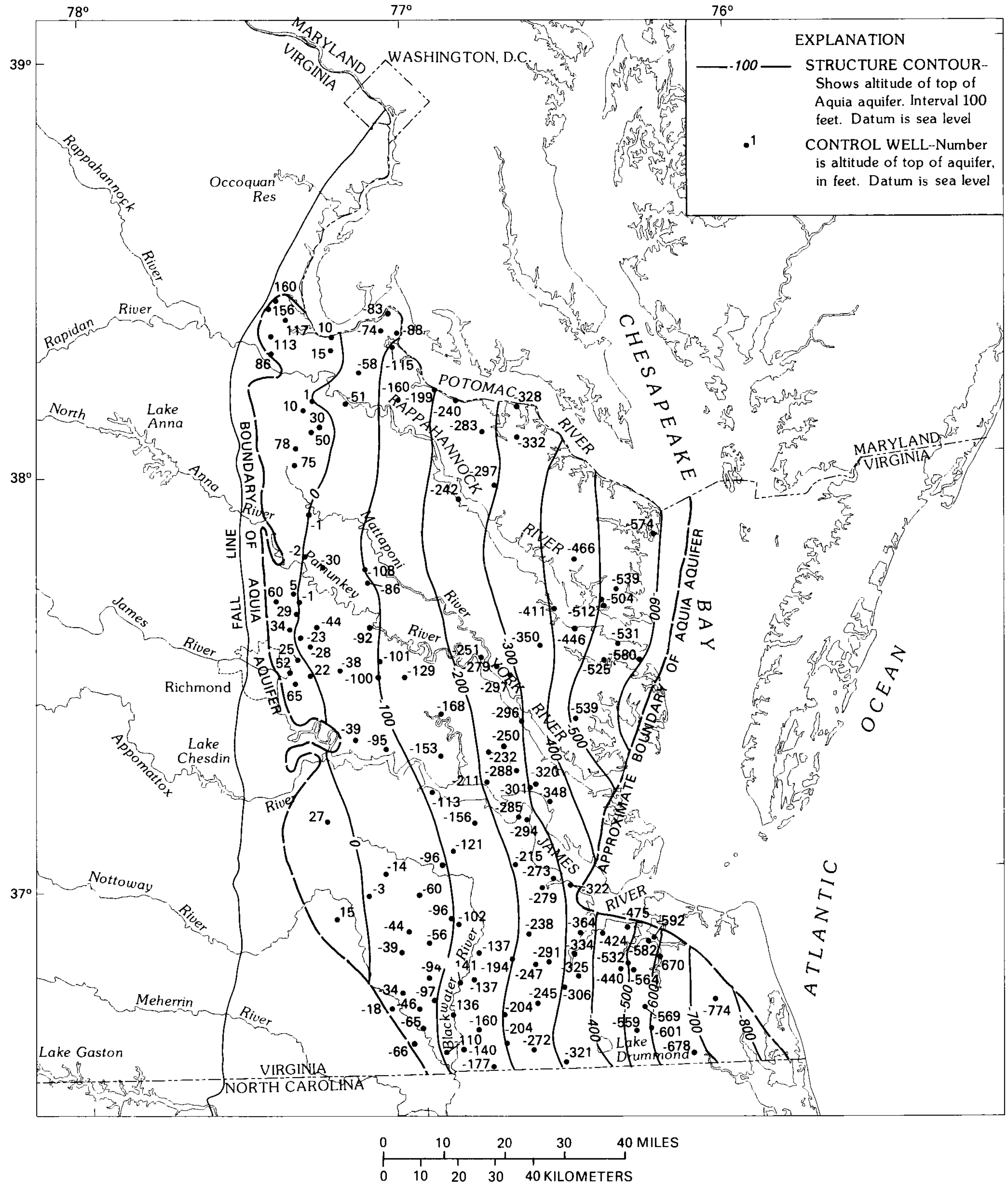

FIGURE 17.—Altitude of top of Aquia aquifer.

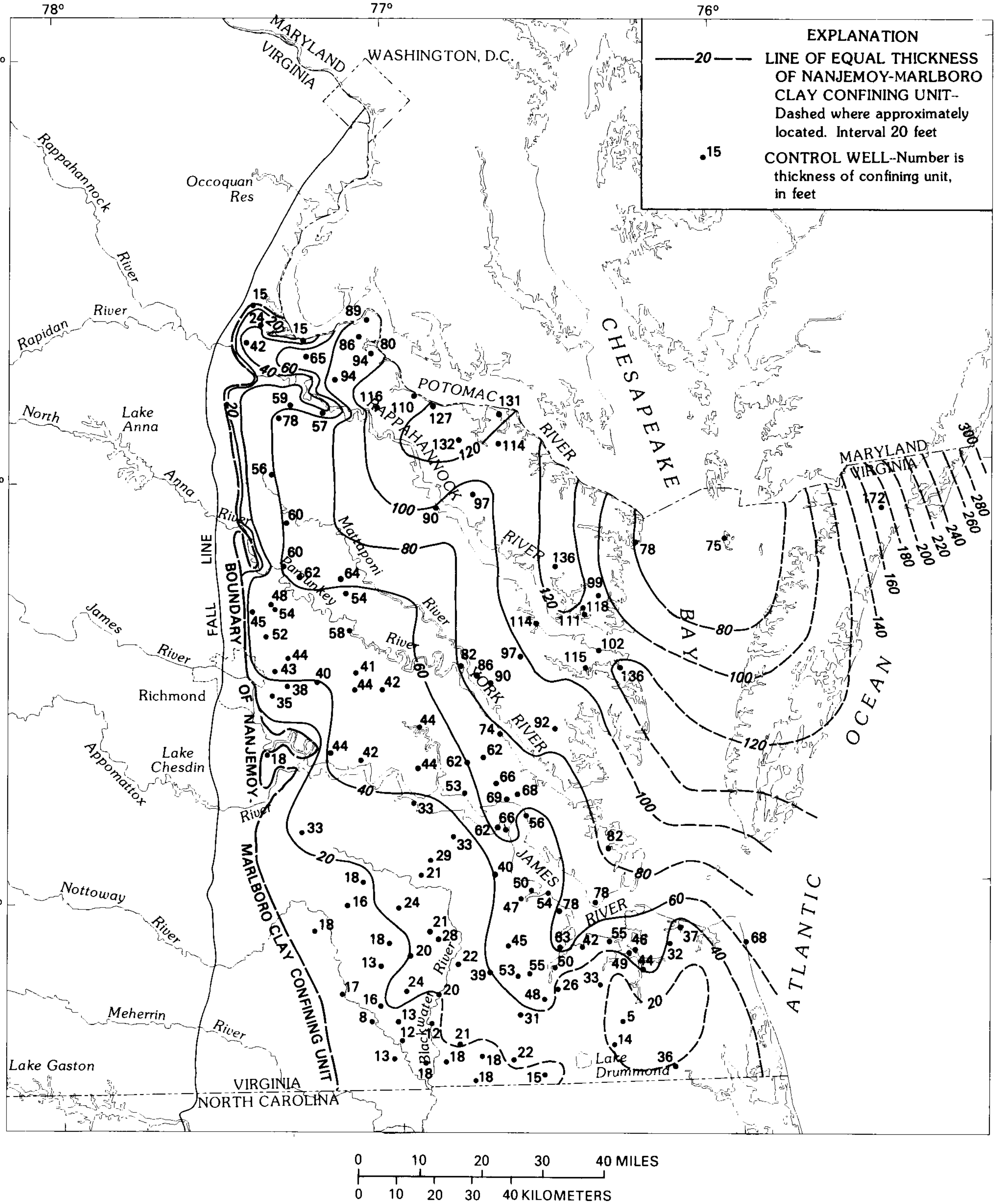

FIGURE 18.—Thickness of Nanjemoy-Marlboro Clay confining unit.

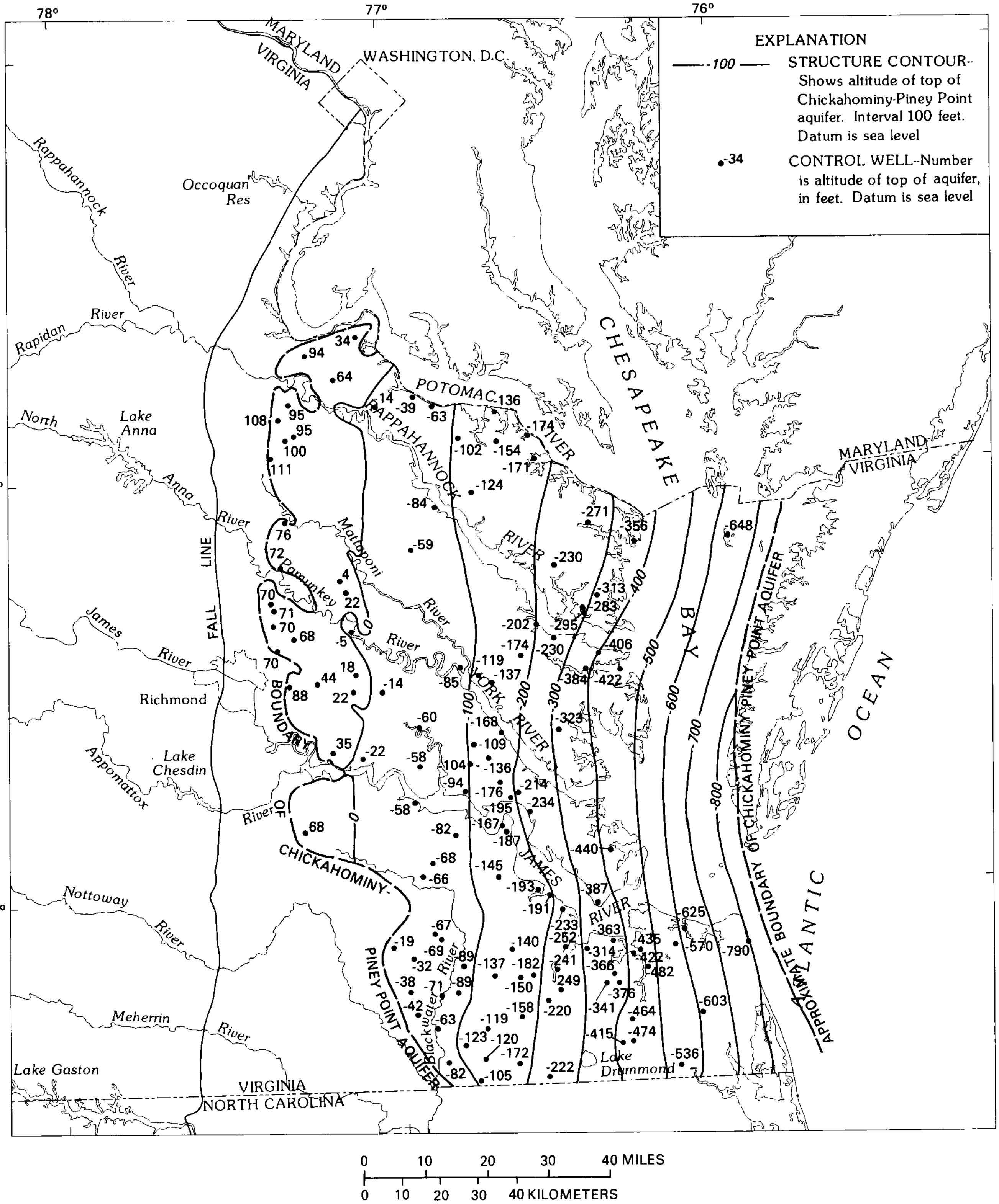

FIGURE 19.—Altitude of top of Chickahominy-Piney Point aquifer.

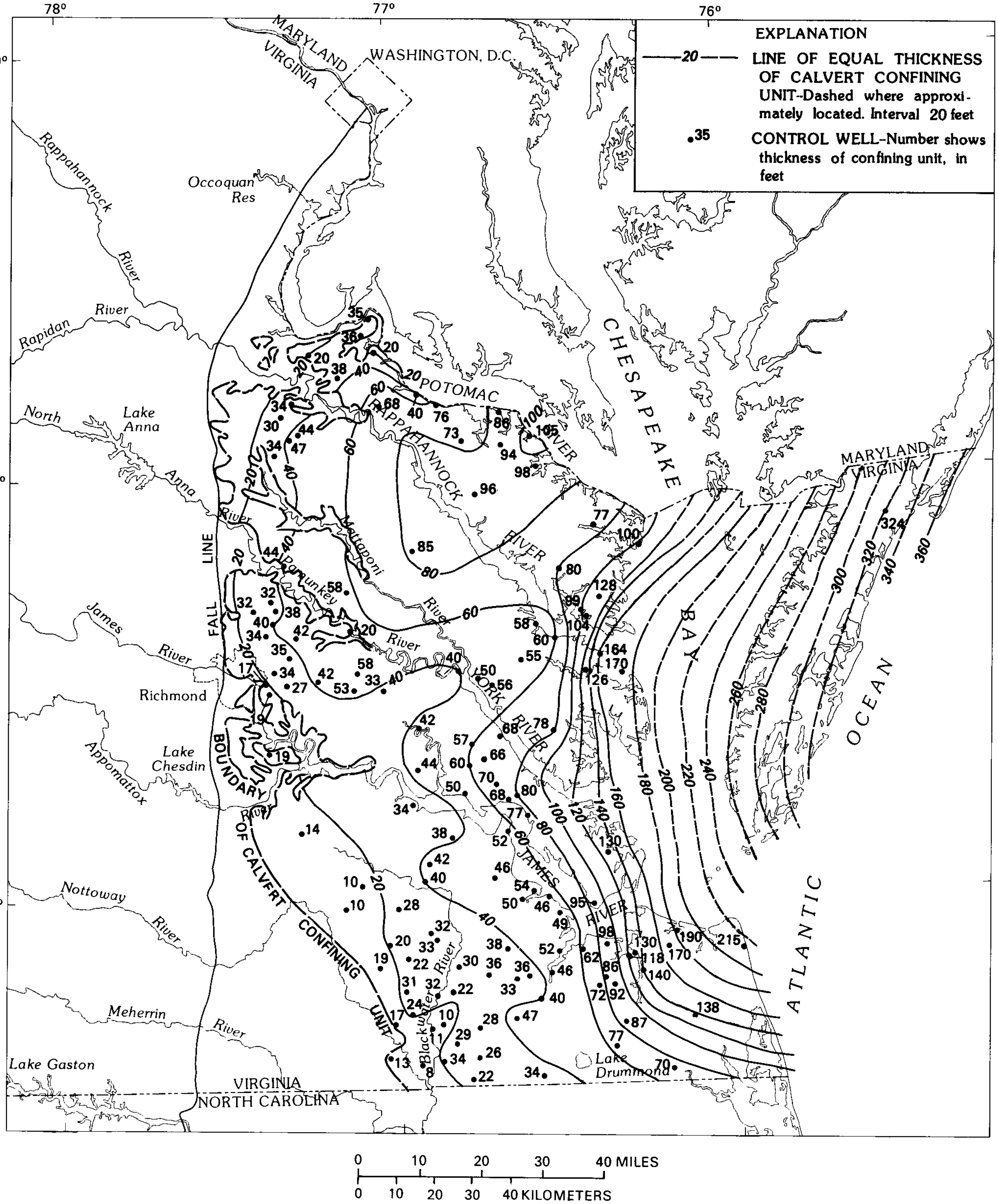

Figure 20.—Thickness of Calvert confining unit.

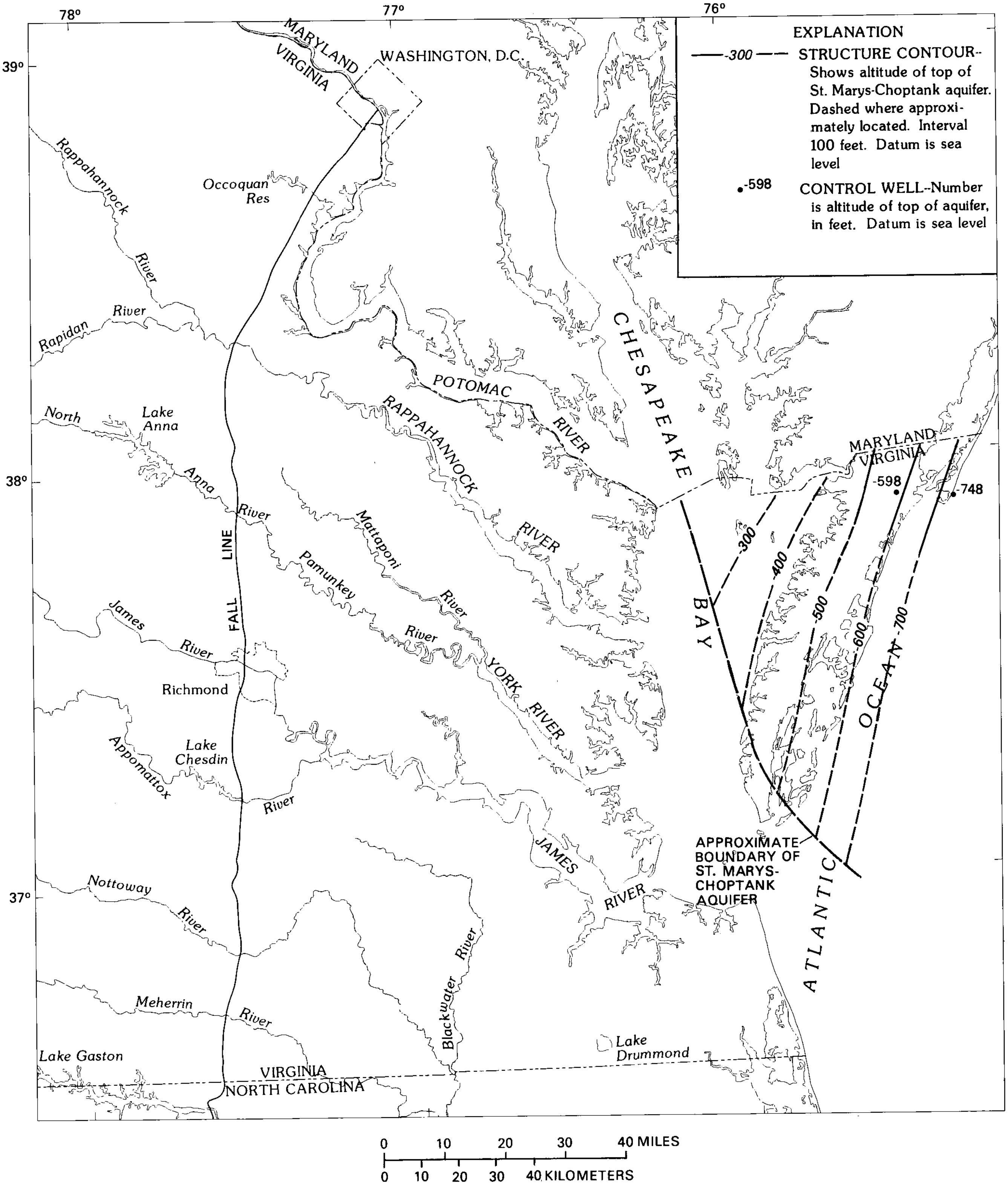

FIGURE 21.—Altitude of top of St. Marys-Choptank aquifer.

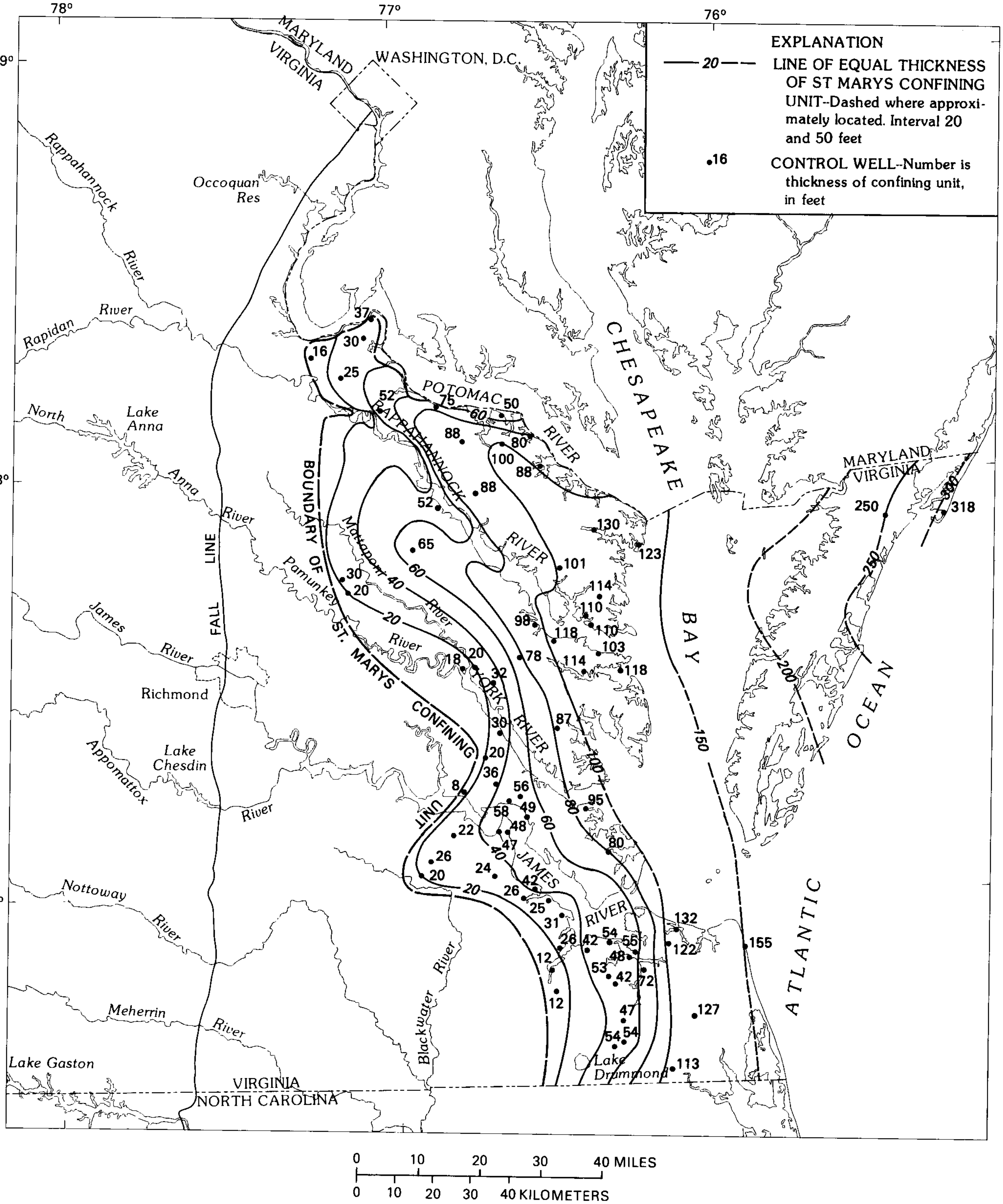

FIGURE 22.—Thickness of St. Marys confining unit.

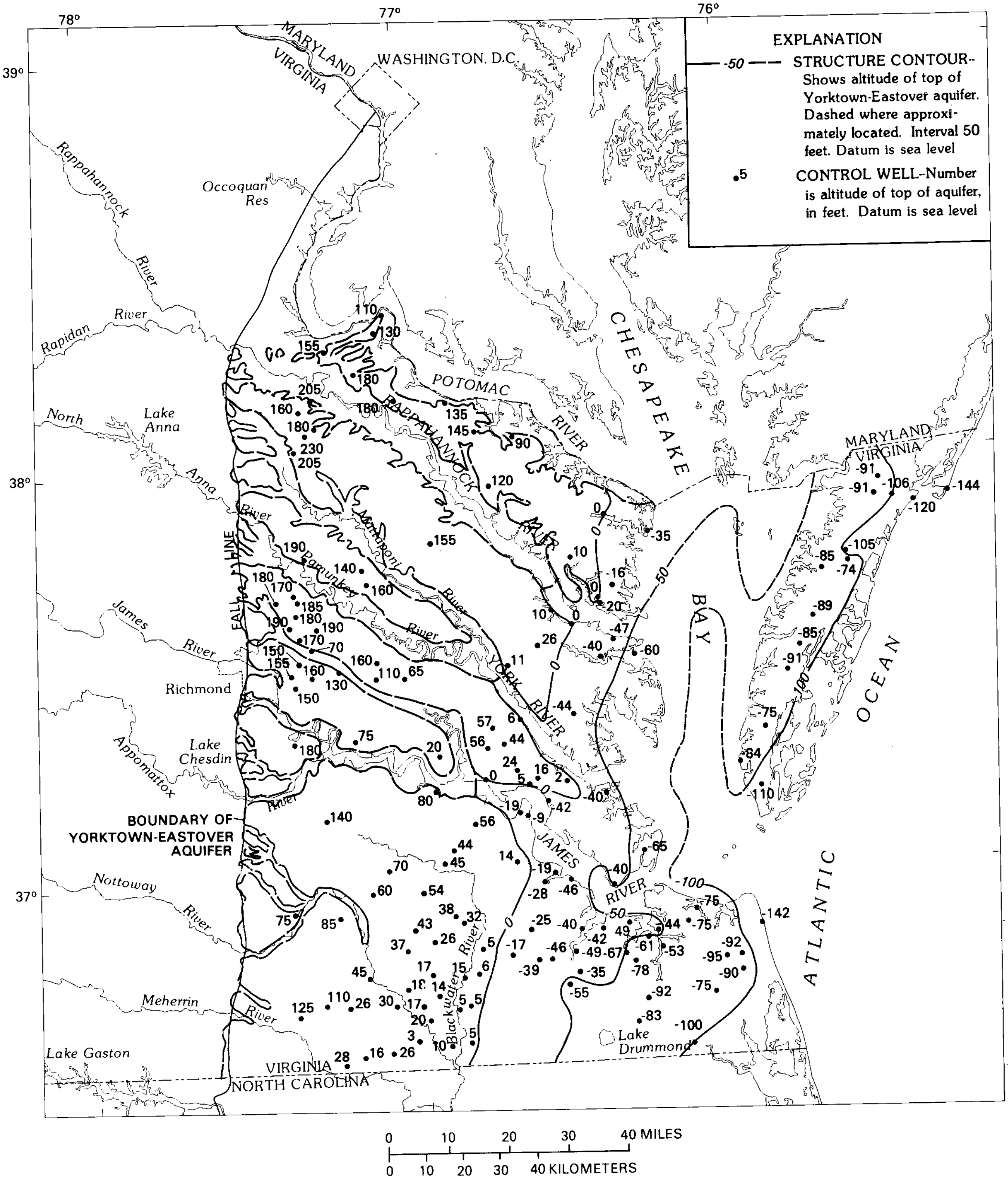

FIGURE 23.—Altitude of top of Yorktown-Eastover aquifer.

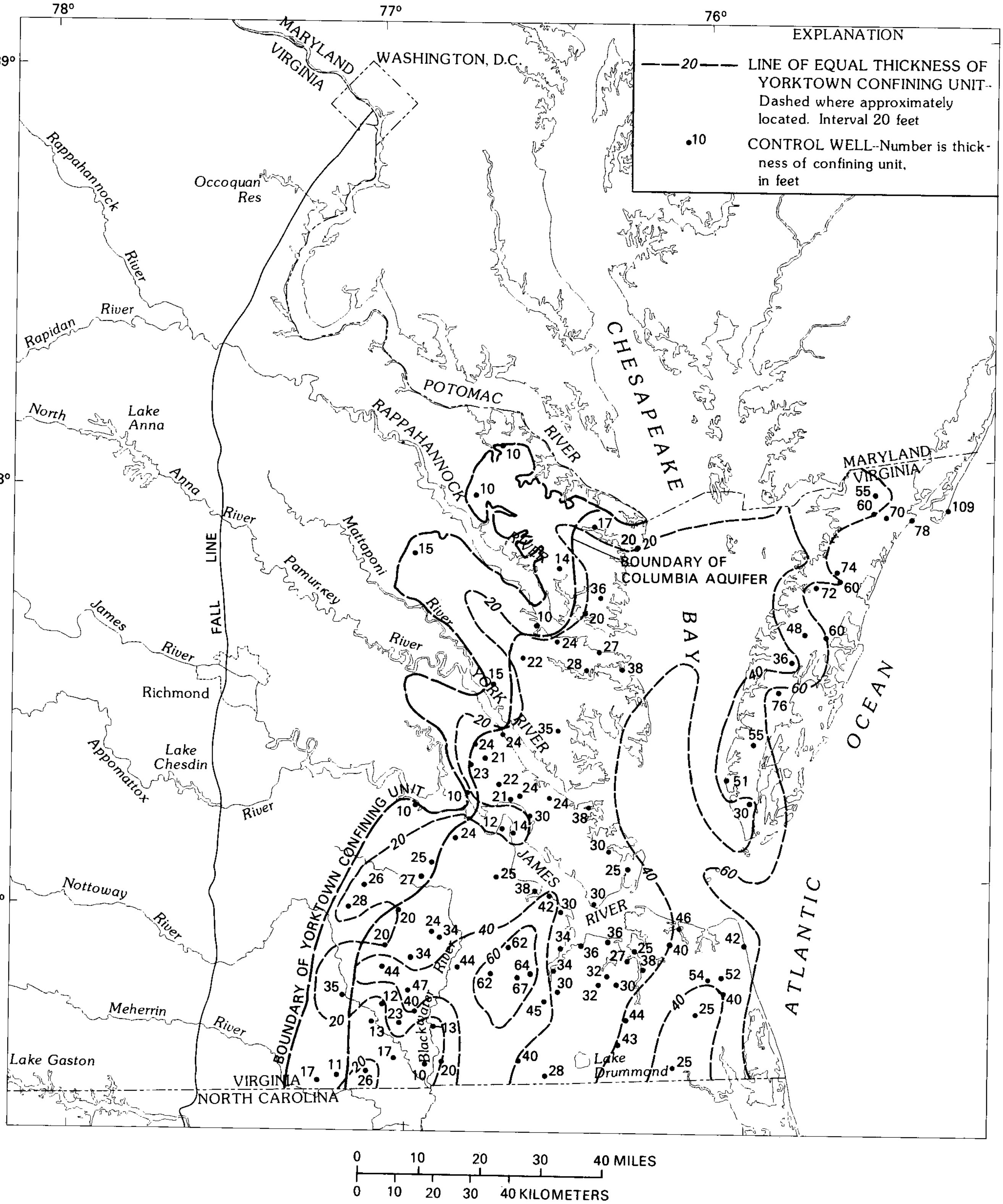

FIGURE 24.—Thickness of Yorktown confining unit.

LOWER AND LOWERMOST UPPER CRETACEOUS POTOMAC FORMATION

Fluvial-deltaic continental and marginal-marine deposits of Early to early Late Cretaceous age constitute the basal lithostratigraphic section known as the Potomac Formation (R.B. Mixon and A.J. Froelich, U.S. Geological Survey, oral commun., 1982). This stratigraphic section comprises the six lowermost hydrogeologic units and consists of three aquifers and three confining units in the hydrogeologic framework of the Virginia Coastal Plain. These hydrogeologic units are the lower, middle, and upper Potomac aquifers and the corresponding lower, middle, and upper Potomac confining units. The Potomac Formation, as used in this report, is commonly referred to in previous literature as the Potomac Group. The Potomac sediments consist of a massive, eastward-thickening wedge of interlensing gravels, sands, silts, and clays. Throughout the study area, the Potomac Formation rests nonconformably upon the basement rock surface and is separated by major regional unconformities from the overlying latest Cretaceous and various Tertiary-age deposits.

The Potomac sediments crop out just east of the Fall Line in the major river valleys of the study area and in an extensive arcuate band extending from the northwestern part of the study area northeastward through Maryland. Clark and Bibbins (1897) divided the Potomac sediments into four formations based on characteristic lithofacies recognized in outcrops between Washington, D.C., and Baltimore. The four formations consist of, from oldest to youngest: the Patuxent Formation, Arundel Clay, Patapsco Formation, and rocks of the former "Maryland Raritan" now assigned to the Patapsco. Corresponding associated lithologies of these four formations consist of massively bedded, light-colored coarse arkosic clayey sands and sandy clays that commonly contain gravels; massively bedded clays and finely laminated carbonaceous clays, typically light to dark in color; interbedded medium, lenticular sands and well-bedded, highly colored clays; and interbedded fine, blanket sands and thinly to thickly bedded, dark-colored clays. Similar lithologic units have been recognized (Cederstrom, 1945a; Spangler and Peterson, 1950; Richards, 1967) in the Potomac section throughout the study area, although they are not generally mapped as such because of their seemingly similar and discontinuous nature. Lack of definitive age relationships for the various Potomac sediments in the subsurface has, in the past, also hindered areal correlation of major lithic units owing to the sparsity of readily apparent guide fossils associated with these continental-deltaic deposits.

In Virginia, the Potomac sediments have not been as extensively studied as those in Maryland. In early studies of the Virginia Coastal Plain, Darton and Keith (1901), Clark and Miller (1912), and Sanford (1913) divided the Potomac sediments into the Patuxent and Patapsco Formations based primarily on lithologic and stratigraphic similarities with the type formations in Maryland. Later studies, however, generally have not recognized these formal divisions. These later studies can be divided into two basic groups: those that refer to the Potomac sediments as "Potomac Group undifferentiated" (primarily Cederstrom's works); and those that recognize the "Patuxent" with overlying "transitional beds" (Onuschak, 1972; Teifke, 1973; Daniels and Onuschak, 1974). The "Patuxent," as recognized and delineated by these later studies, is not correlative with the type Patuxent Formation of Maryland because it generally includes all Potomac sediments of Early Cretaceous age in the study area. This "Patuxent" should more properly be referred to as "Potomac Group undifferentiated," in comparison with other lithologic and stratigraphic studies (Brenner, 1963; Glaser, 1969; Robbins and others, 1975; Doyle and Hickey, 1976).

The characteristically variable lithologies and sparse macrofossils have made past stratigraphic correlation of these sediments as formations difficult, especially in the subsurface. The study of palynology (pollens and spores) has recently produced a systematic zonation scheme that qualitatively identifies and correlates the age relationships of sediments. This zonation is based on the analysis and identification of index microfossil flora that resulted from the evolution of land plants and are recognized worldwide as age indicators. Palynologic studies of the Potomac sediments provide, for the first time, a comprehensive stratigraphic zonation that can be used to identify equivalent-age deposits of continental and marginal-marine origins that normally contain few other diagnostic fossils.

Brenner's (1963) analysis of Lower Cretaceous pollens in the Potomac section of Maryland and Virginia resulted in the development of the first comprehensive palynostratigraphic zonation that definitively correlates the ages of sediments in outcrop with the ages of sediments in the subsurface. Other detailed palynological studies by Groot and others (1961), Doyle (1969), Wolfe and Pakiser (1971), Sirkin (1974), and Doyle and Hickey (1976) have led to important modifications and a more complete zonation of the total Potomac section. Robbins and others (1975) recently refined Brenner's zonation based on palynologic analysis of samples from four deep oil-test wells located within the Salisbury embayment. The palynostratigraphic zonation scheme developed by the above studies is now accepted and used to define the standard stages of the

Cretaceous Potomac Formation. Combined palynostratigraphic analyses (Brenner, 1963; Robbins and others, 1975; Doyle and Hickey, 1976; Doyle and Robbins, 1977; Reinhardt and others, 1980; L.A. Sirkin, Adelphi University, written commun., 1983) have identified five major pollen zones in the Cretaceous Potomac Formation of Virginia. These major pollen zones and their corresponding ages are: pre-Zone I, Berriasian to Barremian; Zone I, Barremian to early Albian; Zone II, middle to late Albian; Zone III, early Cenomanian; and Zone IV, middle to late Cenomanian (pl. 1). Other investigators (Glaser, 1969; Hansen, 1969a; Brown and others, 1972) have proposed that correlatable lithological and depositional patterns are related to most of the major pollen zones and their corresponding "formations." In this study, the hydrogeologic units identified within the Potomac section of Virginia are based on palynostratigraphic zonation, mode of deposition, lithologic characteristics, and hydrologic data. These units are then correlated and delineated throughout the study area by interpreting geophysical logs, drillers' logs, and water-level data. In general, all Cretaceous units strike approximately north-south and dip and thicken eastward. The delineated aquifer units are wedge-shaped in cross section and consist of a series of interbedded sands and clays. The delineated confining units are highly variable in thickness and consist of a series of areally interlayered silty and clayey deposits.

LOWER POTOMAC AQUIFER

The lower Potomac aquifer, by definition, consists of sandy palynostratigraphic pre-Zone I and Zone I sediments of the Potomac Formation. These sediments are early to middle Early Cretaceous (Berriasian through early Albian) in age and correlate with the Patuxent aquifer in Maryland, and the Lower Cretaceous aquifer in North Carolina (pl. 1). The lower Potomac aquifer is the lowermost confined aquifer in the hydrogeologic framework. It rests entirely on the basement surface and is overlain throughout its extent by the lower Potomac confining unit, except where it crops out along the Fall Line in the northwestern part of the study area. This aquifer attains a maximum thickness of 3,010 ft at well 66M1, in the northeastern part of the study area and thins to a featheredge along its western limit near the Fall Line. It dips eastward at about 30 ft/mi throughout the area. The lower Potomac aquifer consists predominantly of thick, interbedded sequences of angular to subangular coarse sands, clayey sands, and clays. This aquifer unit is equivalent to the Patuxent Formation of Maryland for which numerous lithologic descriptions concerning its characteristics have been written.

From outcrops in Virginia, Berry (in Clark and Miller, 1912, p. 63) describes the Patuxent Formation as medium to coarse, light-colored quartz sands containing lenses and beds of interstratified yellow, gray, and brown clays. Berry also reports that, in general, the sands are highly arkosic, crossbedded and clayey, commonly with micaceous and lignitic material, and that the Patuxent also contains varying amounts and sizes of gravels, either in beds, or sometimes interspersed through strata of finer materials. Palynostratigraphic and lithostratigraphic analysis of the Lower Cretaceous deposits from the Oak Grove core (well 54P3, fig. 7), by Reinhardt and others (1980), reveals that sediments of Cretaceous Zone I contain a massive lower interval of thickly bedded coarse sands and associated clay-clast conglomerates. This lower interval of Zone I sediments is herein identified in the hydrogeologic framework of the Virginia Coastal Plain as the lower Potomac aquifer. Typically, the sands of this series are composed of medium to very coarse subangular quartz, with abundant weathered potassium feldspar and some plagioclase. Reinhardt and others (1980) also note that the well-bedded clays of this lower interval are typically mixed-layer illite/smectite, whereas the interstitial and laminated clays are predominantly kaolinitic.

Few wells drilled in the study area penetrate the lower Potomac aquifer (fig. 9). Generally, only deep stratigraphic test wells and high-capacity production wells provide data required to correlate this aquifer. The lower Potomac aquifer is capable of producing large quantities of water, but generally lies too deep for all but large industrial applications. The overlying middle and upper Potomac aquifers supply much of the water used for smaller industrial, municipal, and domestic purposes. In addition, the lower Potomac aquifer contains increasingly higher chloride concentrations in the downdip direction, which further restricts its usage as a potable source of water.

Typical electric-resistivity log patterns of the lower Potomac aquifer sediments are best illustrated in geophysical logs of wells 54P3, plate 2, B-B′; 55H1, plate 3, D-D′ and E-E′; 58F3, plate 3, E-E′; 54G10, plate 3, D-D′ and F-F′; 58A2, plate 3, G-G′; and 53A3, plate 4, J-J′. Generally, these resistivity patterns are characteristically blocky in profile, indicating massively bedded sequences with relatively sharp lithologic contacts among sands, clayey sands, and clays. Very few patterns of gradational, fining-upwards sequences are observed on resistivity logs of the lower Potomac aquifer. However, where these patterns occur, they are usually restricted to the uppermost part of the sand beds. Resistivity logs also characteristically show low resistance values for the sandy sediments. The low resistance values are probably caused by the high percentage of interstitial clays commonly found in the aquifer sands, or by the higher chloride concentrations generally associated with the eastern half of this aquifer unit. Corresponding natural-gamma log patterns commonly reflect a high interstitial clay content also characteristic of the aquifer sands. Drillers commonly refer to the lower Potomac aquifer sediments as "coarse gray sands" that may contain "gravels," and "light to drab-colored clays." Most of the larger gravels encountered in the drilling process are too heavy to be brought to the surface by the drilling fluid and are pushed away from the borehole by the drill bit. Drillers also commonly describe the sands as "hard" or "tough" and the clays as "tight" or "hard." Either of these conditions results in noticeably increased drilling resistance and drilling time. Commonly, the drilled clays reach the surface as small, angular pieces.

The lithologic heterogeneity and discontinuous nature of the sediments in this unit makes correlation of individual sand and clay bodies extremely difficult, even over relatively short distances. The contour map delineating the top of this aquifer unit (fig. 9) is based on the tops of the uppermost sands in the unit. Because of the sparse data base available and the large distances between control wells, this map should only be used as a guide to indicate the approximate altitude at any specific site. Also, the uppermost part of this aquifer, as it is presently delineated, may include sediments of younger age. As more definitive data becomes available, especially from pollen analysis and water-level information, structure contours that depict the top of the lower Potomac aquifer can be refined accordingly.

Numerous studies (Glaser, 1969; Hansen, 1969a; Reinhardt and others, 1980; Hansen, 1982) of the lower Potomac sediments (pre-Zone I to middle Zone I) postulate that the paleoenvironment consisted of a subaerial high-gradient fluvial flood plain dominated by braided streams. Their interpretations are based on the predominance of coarse materials, the general lack of sorting, and overall bedding characteristics. Reinhardt and others (1980) observed glauconite and illitic clays in the lower Potomac sediments of the Oak Grove core (well 54P3). From this, they suggested that deposition occurred in a broad alluvial plain that was occasionally inundated by marine seas. The presence of glauconite was also observed by Anderson and others (1948) among alluvial sediments in cores from the lower Patuxent Formation at two deep oil-test wells, the Hammond and the J.D. Bethards, located in eastern Maryland, and a similar hypothesis was suggested. When viewed as a whole, sediments of the lower Potomac aquifer appear to represent the development of a continental delta (Reinhardt and others, 1980).

LOWER POTOMAC CONFINING UNIT

The lower Potomac confining unit is defined by the major clayey strata directly above the lower Potomac aquifer. These clay beds are predominantly restricted to upper palynostratigraphic Zone I, but may also include younger sediments (basal pollen Zone II). For the most part, this confining unit is middle Early Cretaceous (late Aptian to early Albian) in age. The lower Potomac confining unit correlates with the Potomac confining unit of Maryland and with the confining unit overlying the Lower Cretaceous aquifer of North Carolina (pl. 1). This confining unit crops out in the northwestern part of the study area between the Fall Line and the Potomac River just east of the outcropping lower Potomac aquifer, and in the major stream valleys just east of the Fall Line. It overlies and transgresses the lower Potomac aquifer throughout the study area, except where the aquifer crops out and is overlain by the middle Potomac aquifer. It attains a maximum known thickness of 173 ft (well 66M1) in the northeastern part of the study area and thins to a featheredge along its western limit near the Fall Line. The lower Potomac confining unit is usually the thickest bedded clay or, interbedded clay and sandy clay sequence, of pollen Zone I sediments. Most of this sequence of clayey sediments correlates with the Arundel Clay of Maryland, although the Arundel Clay is not generally recognized as a continuous unit in the subsurface. From outcrops in Maryland, Clark and Bibbins (1897, p. 485) originally identified and defined the Arundel Clay as a series of large and small lenses of drab-colored, tough clays, that are commonly highly carbonaceous and ferruginous. Analysis of the Cretaceous section in the Oak Grove core (well 54P3, fig. 7) by Reinhardt and others (1980) and Estabrook and Reinhardt (1980) provides the most definitive lithologic data for the lower Potomac confining unit. These studies identify and describe an upper interval of pollen Zone I sediments as a massive clay-dominated interval composed of thick sequences of finely laminated, carbonaceous clays interbedded with thin sandy clay beds. This upper interval of pollen Zone I sediments is herein identified as the lower Potomac confining unit in the hydrogeologic framework described in this report. Typically, the thickly bedded clays and sandy clays of this interval are mixed-layer illite/smectite that also contain a high percentage of expandable clays, while the laminated carbonaceous clays are predominantly kaolinitic (Reinhardt and others, 1980; Estabrook and Reinhardt, 1980).

As with the underlying lower Potomac aquifer, few wells drilled in the study area penetrate the lower Potomac confining unit. Generally, only data from deep stratigraphic test wells and high-capacity production wells can be used to correlate this unit.

Clay beds comprising the lower Potomac confining unit are not a continuous, areally extensive layer. Instead, these clays are a series of interlensing clayey deposits. Water-level measurements from observation wells indicate that these deposits act locally as confining units and when viewed regionally, represent a single confining unit, as shown by the thickness map of the lower Potomac confining unit (fig. 10). In some areas, such as in the western and central regions, the confining unit is relatively thin, ranging from 15 to 30 ft in thickness; in other areas, such as in the northern region, it attains a thickness of more than 200 ft.

Typical electric-resistivity log patterns of the lower Potomac confining unit sediments are best illustrated in geophysical logs of wells 51R5, plate 2, A-A'; 53P4, plate 2, A-A' and B-B'; 54P3, plate 2, A-A'; 52N16, plate 2, B-B'; 57J3, plate 3, D-D'; 58F3, plate 3, E-E'; 54G10, plate 3, D-D' and F-F'; 53D3, plate 3, G-G'; 55C12, plate 3, G-G' and plate 4, H-H'; and 58A2, plate 3, G-G' and plate 4, I-I'. Generally, these resistivity patterns are blocky in profile, indicating relatively sharp lithologic contacts between the thickly bedded confining clays with the overlying and underlying aquifer sands. Corresponding natural-gamma log patterns reflect the massively bedded nature of these clays; few interbedded sands are present. Drillers often refer to the lower Potomac confining unit clays as "hard" or "tough" and as "gray, red, or brown clay." Like the underlying interbedded clays of the lower Potomac aquifer, drillers commonly observe an increase in drilling time and resistance when penetrating these sediments, and the resulting cuttings are commonly small, angular pieces. Also, the underlying interbedded clays of the lower Potomac aquifer usually contain significantly more interbedded sands and sandy clays than are present at this horizon.

Studies (Brenner, 1963; Glaser, 1969; Hansen, 1969a, 1982; Reinhardt and others, 1980) of correlative strata to the lower Potomac confining unit suggest a change in the paleoenvironment from that of the lower Potomac aquifer. These studies indicate that the depositional environment and drainage patterns changed from a high-gradient to a lower-gradient fluvial flood plain, based on the predominance of finer grained clayey materials and their associated bedding characteristics. These studies also suggest that the resulting paleoenvironment consisted of quiet, shallow, discontinuous backswamp basins with little sediment input.

MIDDLE POTOMAC AQUIFER

The middle Potomac aquifer, by definition, consists of sandy palynostratigraphic Zone II sediments of the Potomac Formation. These sediments are late Early Cretaceous (middle to late Albian) in age and correlate with the lower part of the Patapsco aquifer in Maryland and the lower Cape Fear aquifer of North Carolina (pl. 1). The middle Potomac aquifer is the second lowest and thickest confined aquifer in the hydrogeologic framework. This aquifer crops out just east of the lower Potomac confining unit in the northwestern region of the study area and in a small area along the James and Appomattox Rivers near the Fall Line. It overlies the lower Potomac confining unit and is overlain by the middle Potomac confining unit. The middle Potomac aquifer attains a maximum known thickness of 929 ft (well 66M1) in the northeastern part of the study area and thins to a featheredge along its western limit near the Fall Line. It dips eastward at approximately 15 ft/mi in the western half of the study area and at 25 ft/mi in the eastern half. The middle Potomac aquifer consists of interlensing medium sands, silts, and clays of differing thickness. This aquifer is equivalent to the Patapsco Formation in Maryland as defined by Brenner (1963).

From outcrops in Maryland, Glaser (1968, p. 8) describes the Patapsco Formation as a thick sequence of interbedded variegated silty clay and fine to medium, gray to yellow sand. Glaser (1968) also reports that the clay lenses are typically thick, internally massive, and brightly mottled in red, yellow, gray, and purple, whereas the sands, occasionally with gravels, are similar to those in the Patuxent Formation, although they tend to be finer grained, more uniform, and more argillaceous. Berry (in Clark and Miller, 1912, p. 67) describes "Patapsco" sediments in Virginia much the same as Glaser describes them in Maryland, although Berry notes that the outcropping Virginia deposits are generally much more evenly colored than those in Maryland. Analysis of the Oak Grove core (well 54P3, fig. 7) by Reinhardt and others (1980, p. 41) reveals that sediments of Cretaceous pollen Zone II contain a lower sand-dominated interval characterized by distinct fining-upwards sand sequences interbedded with laminated or massive clays. This lower interval of pollen Zone II strata is herein identified in the hydrogeologic framework of the Virginia Coastal Plain as the middle Potomac aquifer. Typically, the sands of these fining-upwards sequences are composed of coarse to fine, angular to subangular quartz, and some plagioclase. These sands are also commonly micaceous and contain abundant heavy minerals. Reinhardt and others (1980) also note that the laminated and massive clays of this sequence are composed of mixed kaolinite and highly expandable illite/smectite.

More wells drilled in the study area penetrate this aquifer (fig. 11) than the underlying lower Potomac