Maryland Department of Natural Resources
Resource Assessment Service
MARYLAND GEOLOGICAL SURVEY
Richard A. Ortt, Jr., Director

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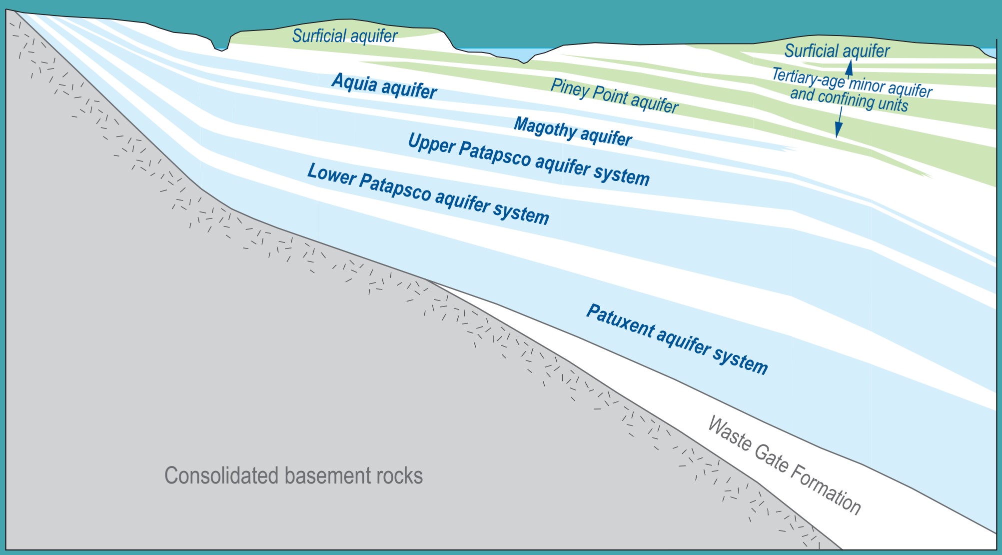
POTENTIOMETRIC SURFACE AND WATER-LEVEL DIFFERENCE MAPS OF SELECTED CONFINED AQUIFERS IN SOUTHERN MARYLAND AND MARYLAND'S EASTERN SHORE, 1975-2013

by

Andrew W. Staley, David C. Andreasen, and Stephen E. Curtin



Prepared in cooperation with the
Maryland Power Plant Research Program of the Maryland Department of Natural Resources
and the
U.S. Geological Survey

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Potentiometric Surface and Water-Level Difference Maps of Selected Confined Aquifers in Southern Maryland and Maryland's Eastern Shore, 1975-2013

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KEY RESULTS

Groundwater is the principal source of freshwater supply in most of Southern Maryland and Maryland's Eastern Shore. It is also the source of freshwater supply used in the operation of the Calvert Cliffs, Chalk Point, and Morgantown power plants. Increased groundwater withdrawals over the last several decades have caused groundwater levels to decline. This report presents potentiometric-surface maps of the Aquia and Magothy aquifers and the Upper Patapsco, Lower Patapsco, and Patuxent aquifer systems using water levels measured during September 2013. Water-level difference maps are also presented for four of these aquifers. The water-level differences in the Aquia aquifer are shown using groundwater-level data from 1982 and 2013, while the water-level differences are presented for the Magothy aquifer using data from 1975 and 2013. Water-level difference maps for both the Upper Patapsco and Lower Patapsco aquifer systems are presented using data from 1990 and 2013.

The potentiometric surface maps show water levels ranging from 165 feet above sea level to 199 feet below sea level. Water levels have declined by as much as 113 feet in the Aquia aquifer since 1982, 81 feet in the Magothy aquifer since 1975, and 61 and 95 feet in the Upper Patapsco and Lower Patapsco aquifer systems, respectively, since 1990.

INTRODUCTION

The Maryland Geological Survey (MGS) and U.S. Geological Survey (USGS) have maintained a groundwater-level monitoring network since the 1940s to observe changes in groundwater levels through time. Groundwater-level monitoring has been especially critical for Southern Maryland and Maryland's Eastern Shore where groundwater is the primary source of water supply. Many observation wells were added to the network in the early 1970s following the establishment of the Power Plant Research Program (PPRP) of the Maryland Department of Natural Resources in order to monitor groundwater levels at Maryland's power plants. Water-level data collected from the monitoring network and water-withdrawal data from the confined aquifer systems that supply water for the operation of Maryland's power plants are used by the PPRP to evaluate potential impacts of Maryland's power plants on groundwater resources.

Purpose and Scope

The purpose of this report is to assess the regional effects of groundwater withdrawals on water levels in Southern Maryland and Maryland's Eastern Shore. This report presents potentiometric surface maps for the Aquia and Magothy aquifers and the Upper Patapsco, Lower Patapsco, and Patuxent aquifer systems for September 2013. The potentiometric surface maps in this report are meant to represent groundwater levels and withdrawal amounts at an instant in time. The water-level measurements were actually made over a period of approximately one month and may reflect short-term variations in water levels throughout the study area, related primarily to short-term changes in withdrawal rates. This report also presents water-level difference maps for the Aquia aquifer (1982-2013), the Magothy aquifer (1975-2013), and the Upper and Lower Patapsco aquifer systems (1990-2013). The water-level difference maps represent the change in potentiometric surfaces over time.

Description of Study Area

The study area for this report includes all of Anne Arundel, Prince George's, Calvert, Charles and St. Mary's Counties, and parts of Baltimore City and Howard, Baltimore, and Harford Counties which are located west of Chesapeake Bay. On Maryland's Eastern Shore, the study area includes all of Talbot County, and parts of Cecil, Kent, Queen Anne's, Caroline, and Dorchester Counties (fig. 1). Two wells used for these maps are located in Northern Virginia, just across the Potomac River from southern Charles County.

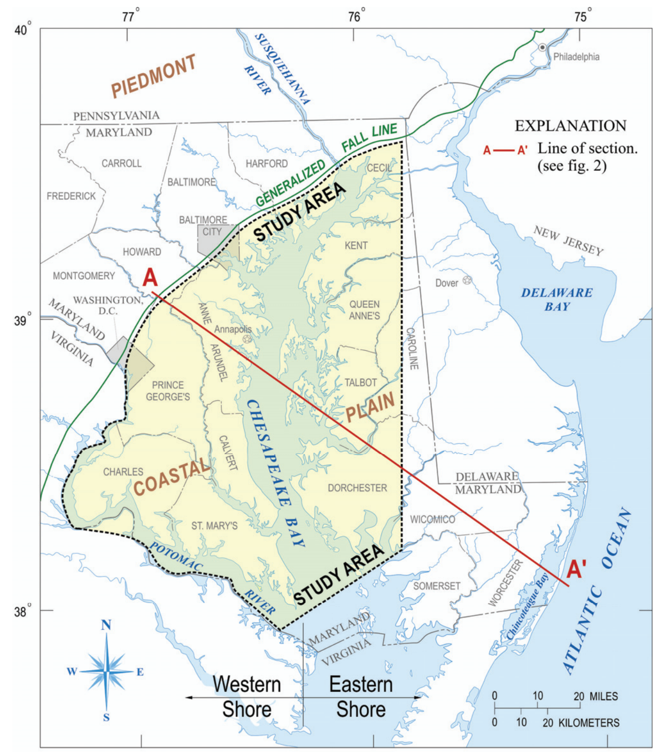

Figure 1. Location of study area in the Atlantic Coastal Plain of Maryland and part of northern Virginia.

The Aquia aquifer, Magothy aquifer, and Upper Patapsco, Lower Patapsco, and Patuxent aquifer systems are part of the Atlantic Coastal Plain sediments, which become deeper and thicker towards the southeast (fig. 2; tab. 1). The Paleocene-age Aquia Formation, which comprises the Aquia aquifer, is composed of fine to coarse-grained, greenish-brown sand that contains layers of silty clay. Cemented layers of shell debris are found throughout the formation. The Aquia's characteristic green color is caused by the presence of glauconitic sand. The Aquia aquifer is the source of water for

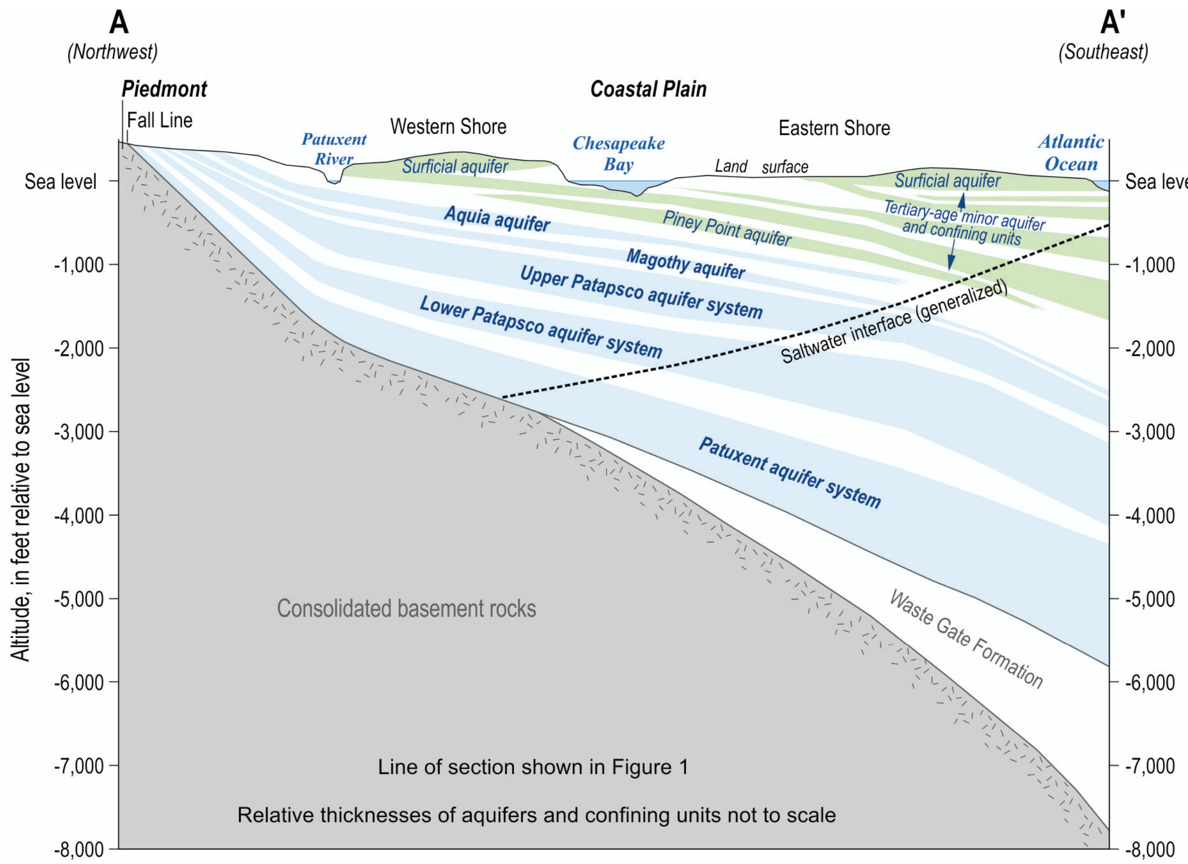

Figure 2. Schematic diagram of the Atlantic Coastal Plain aquifer system in Maryland. Aquifers shaded in blue are discussed in this report.

many self-supplied private residences and some public suppliers. The late Cretaceous Magothy Formation, which comprises the Magothy aquifer, consists of light gray to white sand and fine gravel interbedded with thin layers of clay. The aquifer's excellent water-bearing characteristics make it a valuable source of water for some users, including public suppliers in many areas of Southern Maryland and the Eastern Shore. The early Cretaceous Patapsco Formation, which is included in the Potomac Group, comprises the Upper and Lower Patapsco aquifer systems and is a complexly layered unit having lenses of tan and gray sand and gravel, interbedded with variegated red, brown, and gray silt and clay. The Upper and Lower Patapsco aquifer systems are generally very productive and widely used, particularly by public suppliers and industries. The early Cretaceous Patuxent Formation, which includes the Patuxent aquifer system, is the basal unit of the Potomac Group and is lithologically similar to the Patapsco Formation. The Patuxent aquifer system is also generally very productive and widely used in southern Baltimore County, the northern part of Anne Arundel and Prince George's Counties, and northwestern Charles County, but is not widely used in the rest of Southern Maryland and the Eastern Shore.

Background

In the early 1940s MGS, in cooperation with the USGS, began systematic monitoring of groundwater levels to evaluate the effects of groundwater withdrawals. The monitoring effort was expanded in the early 1970s to evaluate groundwater withdrawals from the Chalk Point coal-fired power plant in southern Prince George's County. In subsequent years, monitoring was further expanded to evaluate groundwater withdrawals from the Calvert Cliffs nuclear power plant in southern Calvert County and the Morgantown coal-fired power plant in southern Charles County, as well as from an increased number of municipal, commercial, domestic, and irrigation wells. The Power Plant Research Program (PPRP) of the Maryland Department of Natural Resources was established as

Table 1. Generalized stratigraphy and hydrogeology of Southern Maryland and Maryland's Eastern Shore. Aquifers shaded in blue are discussed in this report.

System		Series	Group	Formation	Hydrogeology
Quaternary		Holocene		undifferentiated	*surficial aquifers*
Quaternary		Pleistocene		undifferentiated	*surficial aquifers*
Tertiary	**Neogene**	Pliocene			*surficial aquifers*
Tertiary	**Neogene**	Miocene	Chesapeake	St. Mary's	confining units and minor aquifers
Tertiary	**Neogene**	Miocene	Chesapeake	Choptank	confining units and minor aquifers
Tertiary	**Neogene**	Miocene	Chesapeake	Calvert	confining units and minor aquifers
Tertiary	**Paleogene**	Oligocene		unnamed	*Piney Point aquifer*
Tertiary	**Paleogene**	Eocene	Pamunkey	Piney Point	*Piney Point aquifer*
Tertiary	**Paleogene**	Eocene	Pamunkey	Nanjemoy	*Piney Point aquifer* / confining unit
Tertiary	**Paleogene**	Eocene	Pamunkey	Marlboro	confining unit
Tertiary	**Paleogene**	Paleocene	Pamunkey	Aquia	*Aquia aquifer*
Tertiary	**Paleogene**	Paleocene	Pamunkey	Brightseat/ Hornerstown	*Aquia aquifer*
Cretaceous		Upper Cretaceous		Severn or Monmouth	confining units and minor aquifers
Cretaceous		Upper Cretaceous		Matawan	confining units and minor aquifers
Cretaceous		Upper Cretaceous		Magothy	*Magothy aquifer*
Cretaceous		Lower Cretaceous	Potomac	Patapsco	confining unit
Cretaceous		Lower Cretaceous	Potomac	Patapsco	*Upper Patapsco aquifer system*
Cretaceous		Lower Cretaceous	Potomac	Patapsco	confining unit
Cretaceous		Lower Cretaceous	Potomac	Patapsco	*Lower Patapsco aquifer system*
Cretaceous		Lower Cretaceous	Potomac	Arundel Clay	confining unit
Cretaceous		Lower Cretaceous	Potomac	Patuxent	*Patuxent aquifer system*
Cretaceous		Lower Cretaceous	Potomac	Waste Gate	*"Waste Gate" brine aquifer*
Jurassic, Triassic, Paleozoic to Precambrian					**consolidated basement rocks**

[Modified from Soeder and others, 2007]

a result of the Power Plant Siting and Research Act of 1971. This act required the evaluation of the environmental impacts associated with power generation plants in Maryland. Potentiometric surface and water-level difference maps were prepared and published as part of a funding agreement between USGS, MGS, and PPRP in order to supply groundwater data for inclusion in PPRP's periodic Cumulative Environmental Impact Reports. The first potentiometric surface map published as part of this effort was for the Magothy aquifer using groundwater levels from September 1975, followed by a map of the Aquia aquifer using groundwater levels from September 1982. These maps helped evaluate the effects of withdrawals at the Chalk Point plant in southern Prince George's County and the Calvert Cliffs nuclear power plant in southern Calvert County, respectively. To evaluate the effects of withdrawals at the Morgantown power plant in southern Charles County and from additional wells at the Chalk Point power plant, potentiometric surface maps were published for the Upper and Lower Patapsco aquifer systems using groundwater levels from September 1990. In 2009, a potentiometric surface map was published using groundwater levels from September 2007 to evaluate the effects of groundwater withdrawals from the Patuxent aquifer system at the Chalk Point power plant. The most recent set of maps displayed water-level data for 2011 (Curtin and others, 2012).

In addition to the maps published for the PPRP reports, Achmad and Hansen (2001) assembled a comprehensive set of potentiometric surface and water-level difference maps for the Piney Point, Aquia, Magothy, Upper Patapsco, Lower Patapsco, and Patuxent aquifers using groundwater level data from 1970 through 1996. This report also includes a compilation of groundwater withdrawals and select hydrographs. Soeder and others (2007) published a similar report for the same set of aquifer systems for the period 1980-2005, which included a model evaluation of the relationship between withdrawals and water levels.

METHOD OF ANALYSIS

MGS and USGS personnel measured groundwater levels during the month of September of selected years that were used to construct the potentiometric surface and water-level difference maps. The water-level data were reviewed and approved by the MGS and USGS and stored in the Groundwater Site Inventory (GWSI) database, which is part of the National Water Information System (NWIS) maintained by USGS. This database is available to the public through the NWIS website (http://waterdata.usgs.gov/nwis/). Selected water-level data were retrieved from GWSI and used in the preparation of the maps in this report (app. 1a through 1e). Water-withdrawal data included on the maps were derived from the Site-Specific Water-Use Data System (SWUDS), also maintained by USGS. Water-use data are presented on the maps using a series of symbols representing the location and rates of groundwater withdrawals for users that have groundwater appropriation permits for average annual rates greater than 10,000 gallons per day. Actual withdrawals may be less than permitted amounts in some instances. Domestic wells and other small users are not shown on the maps. The 2013 potentiometric surface maps show water-withdrawal data for 2012 (the most recent data available). The withdrawal data originated from the Maryland Department of the Environment (MDE) water-withdrawal database. Permitted users of water greater than 10,000 gallons per day (gal/d) are required to submit monthly withdrawal amounts, which are subsequently entered into MDE's database. USGS periodically retrieves these data, checks for quality assurance, and enters them into SWUDS.

In preparing the potentiometric surface maps, groundwater levels were adjusted to feet (ft) related to sea level using North American Vertical Datum of 1988 (NAVD88) land-surface elevations. Previous maps presented groundwater levels using the National Geodetic Vertical Datum of 1929 (NGVD29). The data were plotted and manually contoured by visually interpolating between data points. The contours are dashed in areas of sparse data. The maps also include the outcrop and subcrop areas of the aquifers or aquifer systems, and the aquifer boundary if its location is within the area presented. Water levels located in outcrop and subcrop areas are variable due to their unconfined condition, and are therefore not contoured for the maps in this report.

POTENTIOMETRIC SURFACE AND WATER-LEVEL DIFFERENCE MAPS

Maps are presented for the Aquia aquifer, Magothy aquifer, and Upper Patapsco, Lower Patapsco, and Patuxent aquifer systems for Southern Maryland and Maryland's Eastern Shore using water levels measured in September 2013. The location and quantity of major groundwater-withdrawal sites in 2012 are presented on the maps to help show the relation between pumping centers and aquifer drawdowns. Maps showing the decline in water levels from 1975, 1982, or 1990 to 2013 are also presented. The maps include the outcrop and subcrop areas of the aquifers or aquifer systems, and the aquifer boundary if located within the area presented.

Aquia Aquifer

The potentiometric surface of the Aquia aquifer during September 2013 is shown in figure 3. The map is based on water-level measurements in 106 wells. The highest measured water level on the Western Shore was 52 ft above sea level in the outcrop area of the aquifer in the central part of Anne Arundel County. Water levels in the subcrop area of Kent County were as high as 55 above sea level. South of those areas, water levels are lower and mostly below sea level. The hydraulic gradient increased southeastward toward a cone of depression around well fields at Lexington Park and Solomons Island. The Calvert Cliffs nuclear power plant is located along the northern edge of this cone of depression, where the water level was measured at 105 ft below sea level. The lowest measured water level of 155 ft below sea level occurred at the center of a cone of depression at Lexington Park. The lowest measured water level on the Eastern Shore occurred in the Easton area at 65 ft below sea level. While the greatest concentration of production wells occur in northern and central Queen Anne's County, no regional cones of depression have formed in that area.

The water-level differences in the Aquia aquifer in Southern Maryland and Maryland's Eastern Shore between September 1982 and September 2013 are shown on figure 4. The map, based on water-level differences obtained from 51 wells, shows that the potentiometric surface during the 31-year (yr) period ranged from an increase of 7 ft in the northernmost part of the study area and in the outcrop area of the aquifer, to a decline of 113 ft at Lexington Park. Lexington Park is near the southeastern-most part of the study area and approaches the downdip boundary of the aquifer. At the Calvert Cliffs nuclear power plant, water levels declined by 75 ft. Withdrawals from the Aquia aquifer in the study area have increased from approximately 5 million gallons per day (Mgal/d) in 1982 (Wheeler and Wilde, 1989) to approximately 16 Mgal/d in 2012.

Magothy Aquifer

The potentiometric surface of the Magothy aquifer in the Magothy Formation in Southern Maryland and Maryland's Eastern Shore during September 2013 is shown in figure 5. The map is based on water-level measurements in 75 wells. The highest measured water level was 83 ft above sea level in the outcrop area of the aquifer in the northern part of Anne Arundel County.

Water levels are lower towards the south. As a result of withdrawals predominantly from municipal supply wells, shallow, localized cones of depression formed around well fields in east-central Anne Arundel County. A relatively large cone of depression has developed in the Waldorf area, where groundwater levels are as low as 73 ft below sea level. Groundwater withdrawals from the Chalk Point power plant resulted in a water level of 55 ft below sea level in an observation well at that site. A relatively large cone of depression has developed at Easton on the Eastern Shore, which resulted in a water level of 108 ft below sea level. The groundwater level at Easton is likely highly affected by localized, short-term pumping from the Easton well field. Relatively high groundwater levels in the northwestern portion of Kent County likely indicate an area of groundwater recharge.

The water-level differences in the Magothy aquifer in Southern Maryland and Maryland's Eastern Shore between September 1975 and September 2013 are shown in figure 6. The map, based on water-level differences obtained from 45 wells, shows that during the 38-yr period, the potentiometric surface had changed relatively little near the outcrop area (in the northernmost part of the study area), but declined as much as 81 ft at Waldorf. Waldorf is located near the southern extent and downdip boundary of the aquifer.

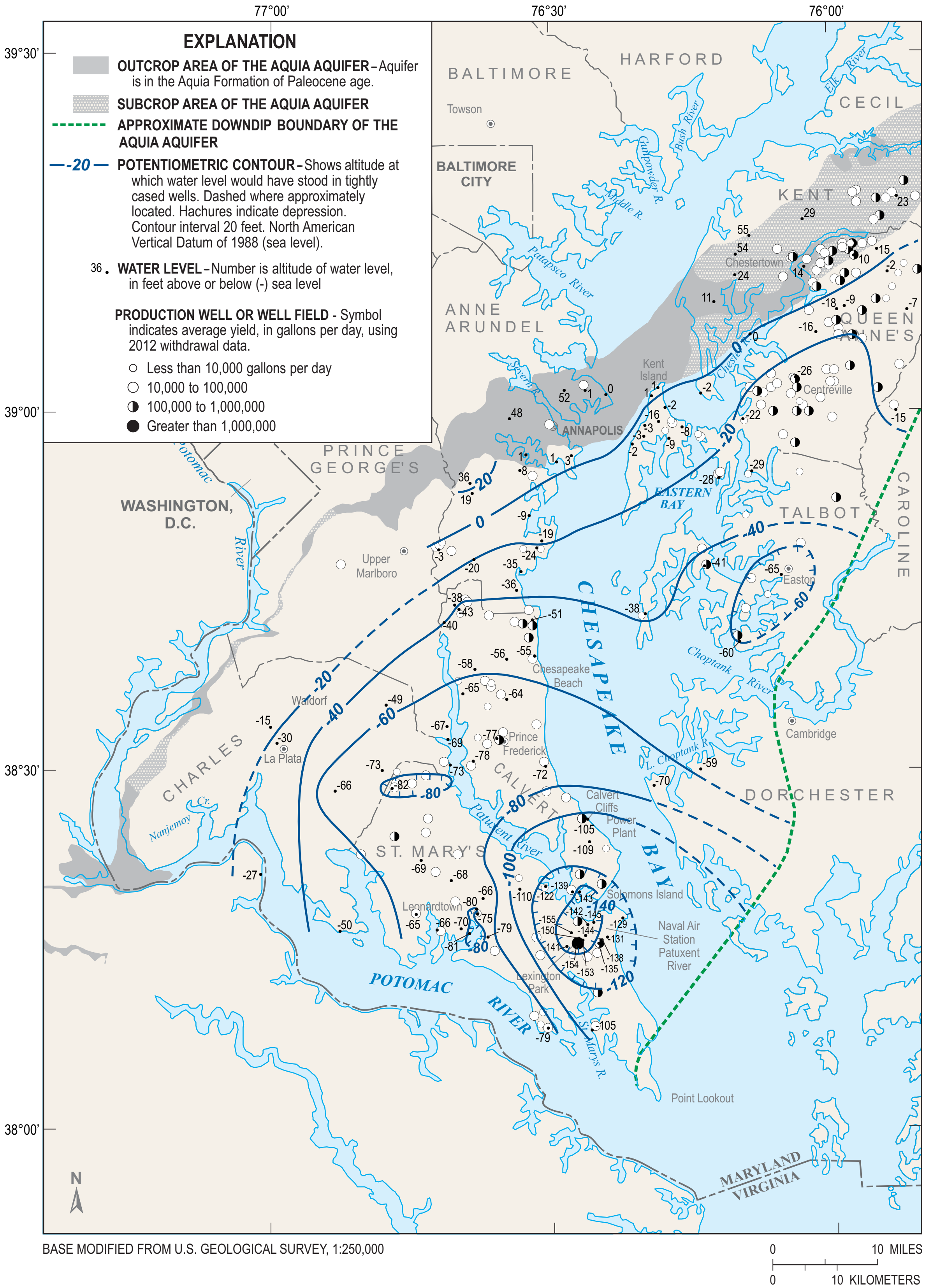

Figure 3. Potentiometric surface of the Aquia aquifer in Southern Maryland and Maryland's Eastern Shore, September 2013.

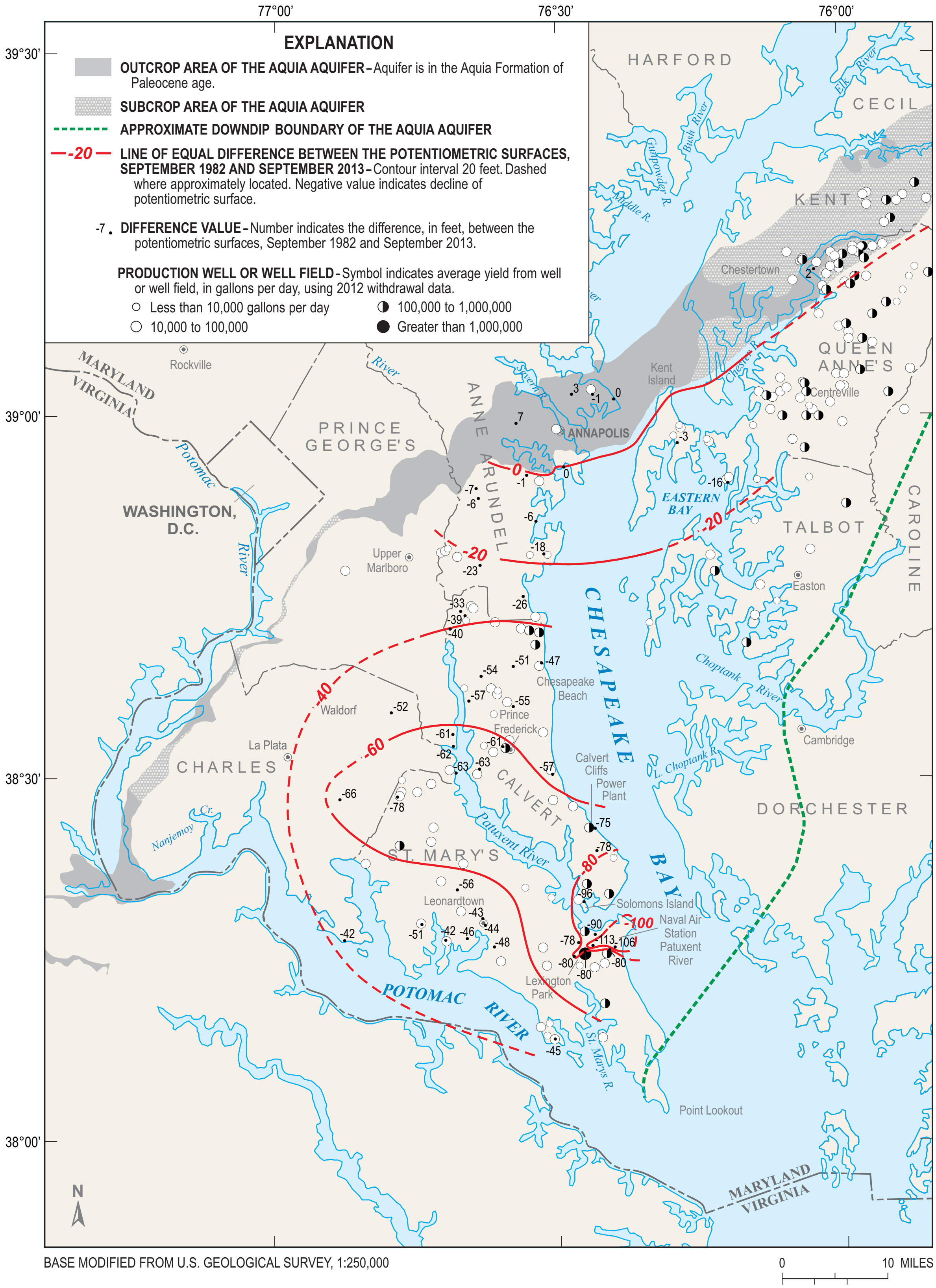

Figure 4. The difference between the potentiometric surfaces of the Aquia aquifer in Southern Maryland and Maryland's Eastern Shore, September 1982 and September 2013.

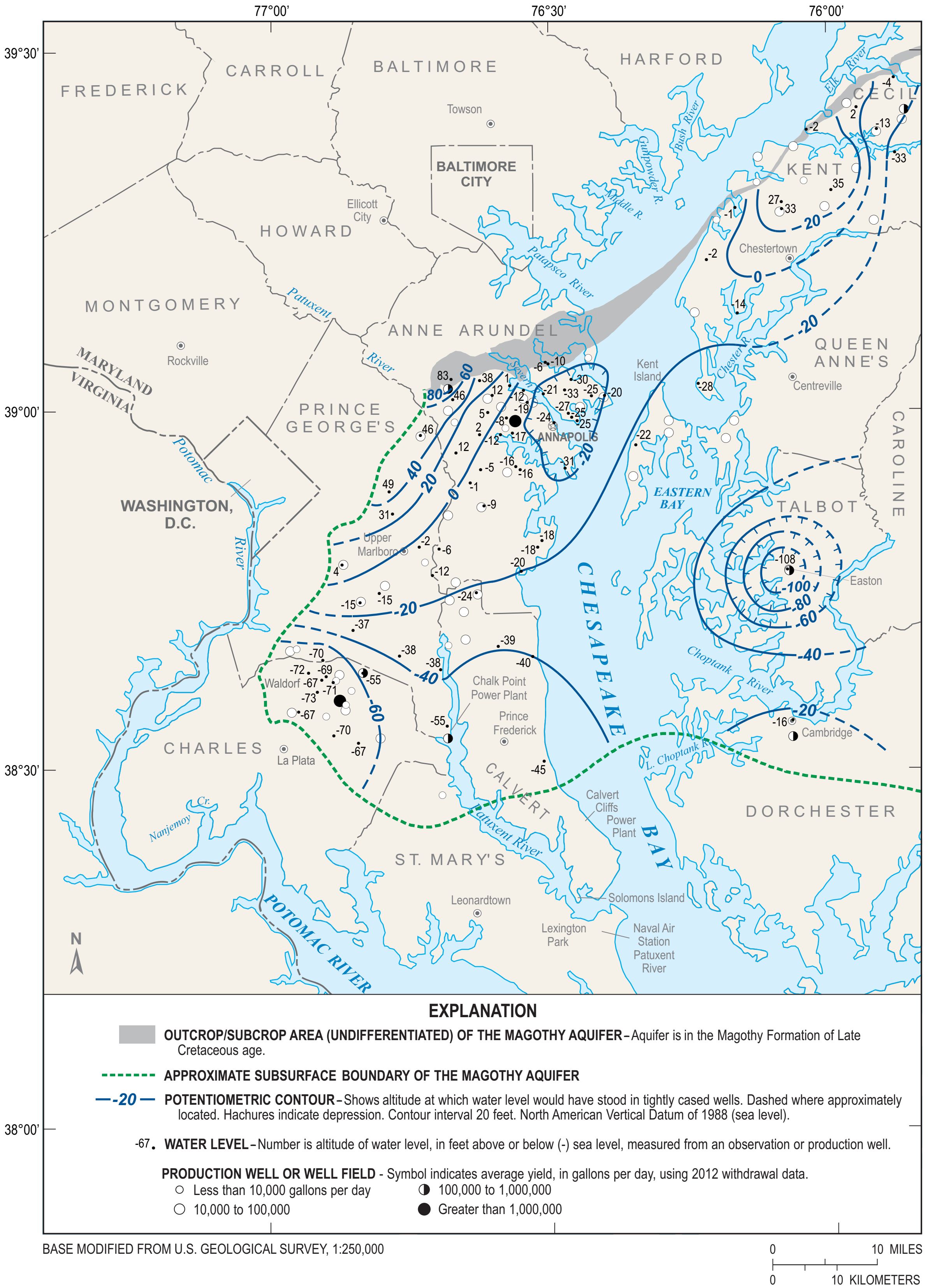

Figure 5. Potentiometric surface of the Magothy aquifer in Southern Maryland and Maryland's Eastern Shore, September 2013.

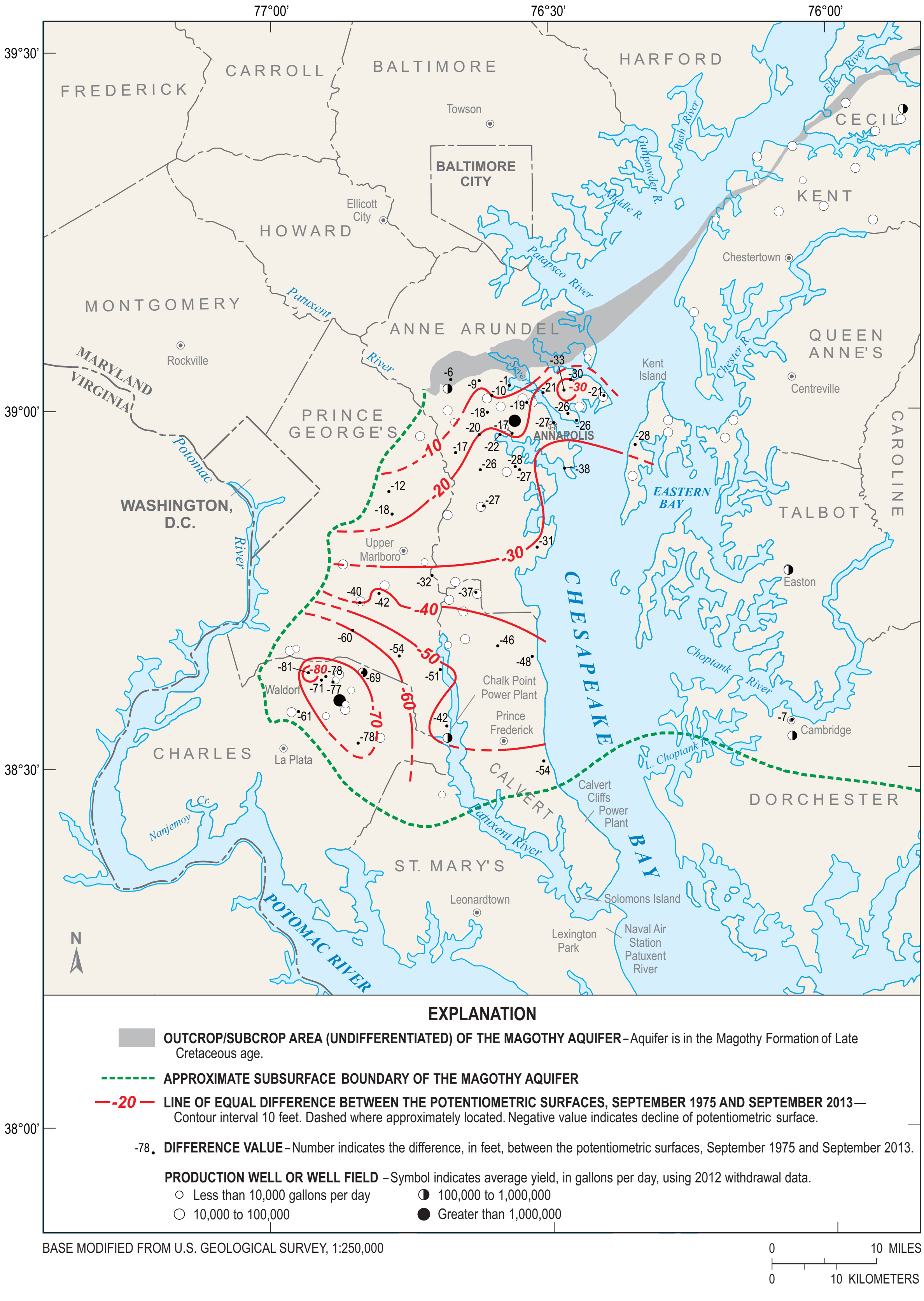

Figure 6. The difference between the potentiometric surfaces of the Magothy aquifer in Southern Maryland and Maryland's Eastern Shore, September 1975 and September 2013.

Withdrawals from the Magothy aquifer in the study area increased from approximately 7 Mgal/d in 1975 (Wheeler and Wilde, 1989) to approximately 8 Mgal/d in 2012.

Upper Patapsco Aquifer System

The potentiometric surface of the Upper Patapsco aquifer system in Southern Maryland and Maryland's Eastern Shore during September 2013 is shown in figure 7. The map is based on water-level measurements in 70 wells. The highest measured water level was 115 ft above sea level near the outcrop area of the aquifer system in northern Anne Arundel County. From this area, water levels are lower to the southeast toward a well field in the Annapolis-Arnold area, where the lowest water level was 67 ft below sea level. Two relatively large cones of depression were located in the Waldorf-La Plata area in southern Charles County and the Lexington Park-Leonardtown area in southern St. Mary's County. The lowest measured groundwater levels were 110 ft below sea level south of Waldorf, and 84 ft below sea level near Leonardtown. A smaller cone of depression formed around the Chalk Point power plant where the water level was as low as 67 ft below sea level. On the Eastern Shore, two cones of depression formed around Easton and Cambridge, with water levels of 69 and 73 ft below sea level, respectively.

The water-level differences in the Upper Patapsco aquifer system in Southern Maryland and Maryland's Eastern Shore between September 1990 and September 2013 are shown in figure 8. The map, based on water-level differences obtained from 40 wells, shows that during the 23-yr period, the potentiometric surface changed little at the edge of the outcrop area in northern Anne Arundel County. Water-level declines of 19 ft at Broad Creek, 61 ft near Arnold, 38 ft at Waldorf, 43 ft at the Chalk Point power plant, and 50 ft at Lexington Park were observed during the same 23-yr period. Total withdrawals from the Upper and Lower Patapsco aquifer systems increased from approximately 29 Mgal/d in 1990 to approximately 36 Mgal/d in 2012. Withdrawals in 2012 from the Upper Patapsco aquifer system totaled approximately 12 Mgal/d. Withdrawals reported in 1990 were not differentiated between the Upper and Lower Patapsco aquifer systems.

Lower Patapsco Aquifer System

The potentiometric surface of the Lower Patapsco aquifer system in Southern Maryland and Maryland's Eastern Shore during September 2013 is shown in figure 9. The map is based on water-level measurements in 77 wells. The highest measured water level was 105 ft above sea level near the outcrop area of the aquifer system in northern Prince George's County. Water levels were lower towards well fields at Severndale, Broad Creek, Arnold, and Crofton Meadows. Measured groundwater levels were 60 ft below sea level at Severndale, 43 ft below sea level at Broad Creek, 96 ft below sea level at Arnold, and 5 ft below sea level at Crofton Meadows. There is also a relatively large cone of depression in Charles County that includes Waldorf, La Plata, Indian Head, and the Morgantown power plant. The groundwater levels measured were as low as 199 ft below sea level at Waldorf, 149 ft below sea level at La Plata, 115 ft below sea level at Indian Head, and 91 ft below sea level at the Morgantown power plant.

The water-level differences in the Lower Patapsco aquifer system in Southern Maryland and Maryland's Eastern Shore between September 1990 and September 2013 are shown in figure 10. The map, based on water-level differences obtained from 47 wells, shows that the change of the potentiometric surface during the 23-yr period ranged from increases of 27 ft at Indian Head and 10 ft near the outcrop area in Glen Burnie, to declines of 95 ft at Arnold, 17 ft at Severndale, 14 ft at Crofton Meadows, 56 ft at Waldorf, 82 ft near La Plata, 29 ft at the Morgantown power plant, 38 ft at the Chalk Point power plant, and 34 ft at Swan Point. There are no groundwater withdrawals from the Lower Patapsco aquifer system at the Chalk Point power plant, therefore the decline in water level may be due to upward leakage to the Upper Patapsco aquifer system. Total withdrawals from the Upper and Lower Patapsco aquifer systems increased from approximately 29 Mgal/d in 1990 to approximately 36 Mgal/d in 2012. Withdrawals in 2012 from the Lower Patapsco aquifer system totaled approximately 24 Mgal/d. Withdrawals reported in 1990 were not differentiated between the Upper and Lower Patapsco aquifer systems.

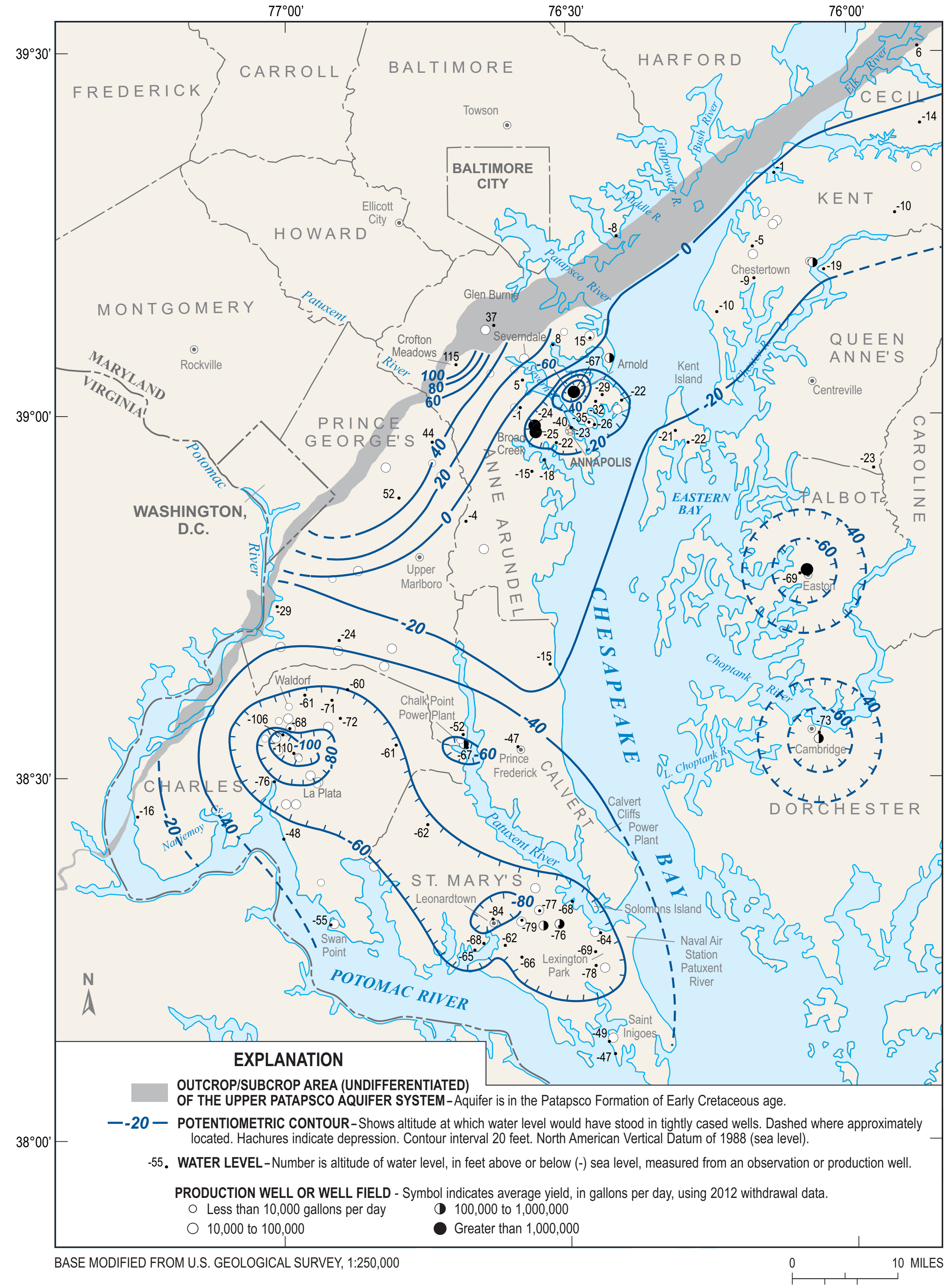

Figure 7. Potentiometric surface of the Upper Patapsco aquifer system in Southern Maryland and Maryland's Eastern Shore, September 2013.

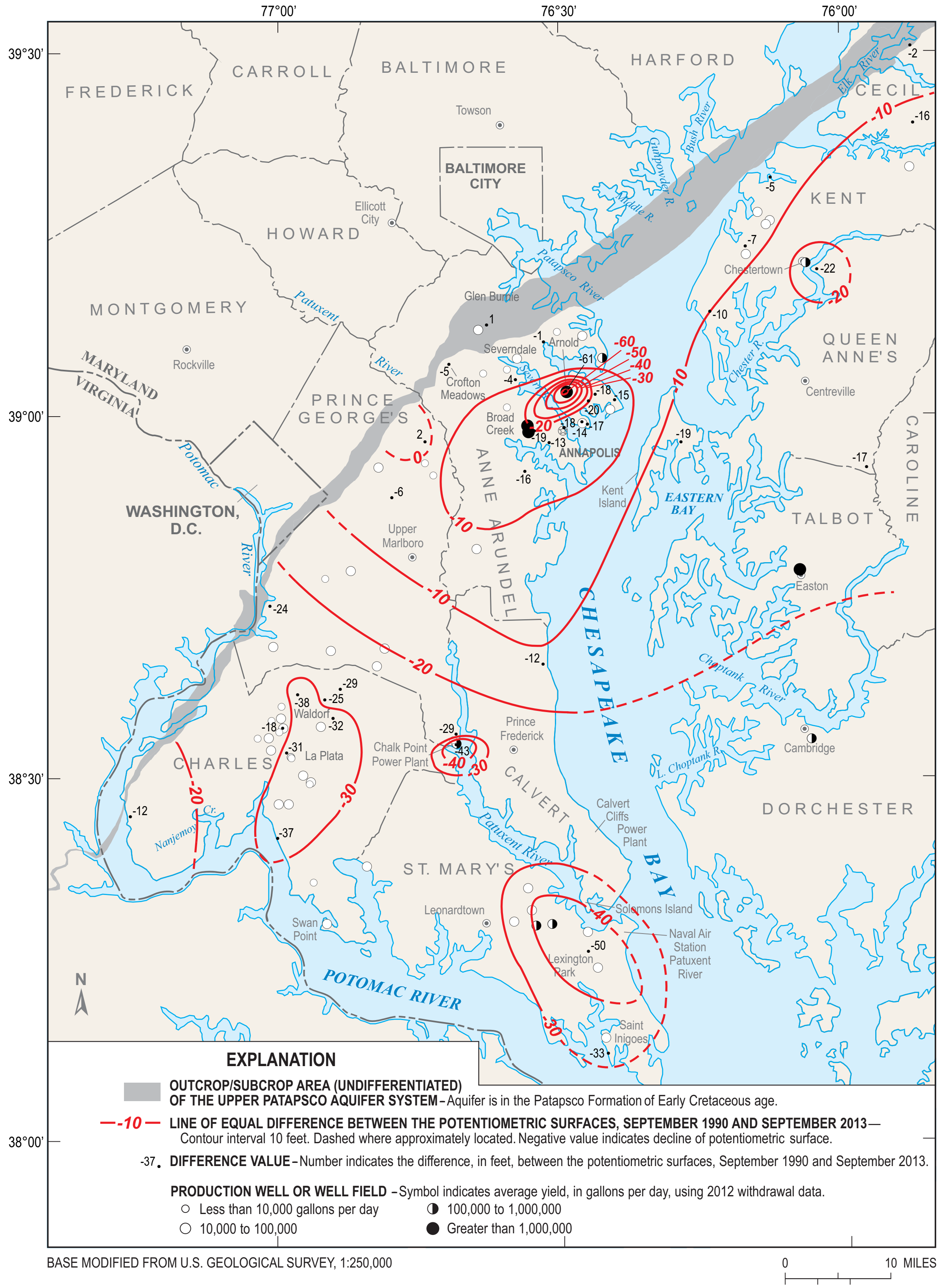

Figure 8. The difference between the potentiometric surfaces of the Upper Patapsco aquifer system in Southern Maryland and Maryland's Eastern Shore, September 1990 and September 2013.

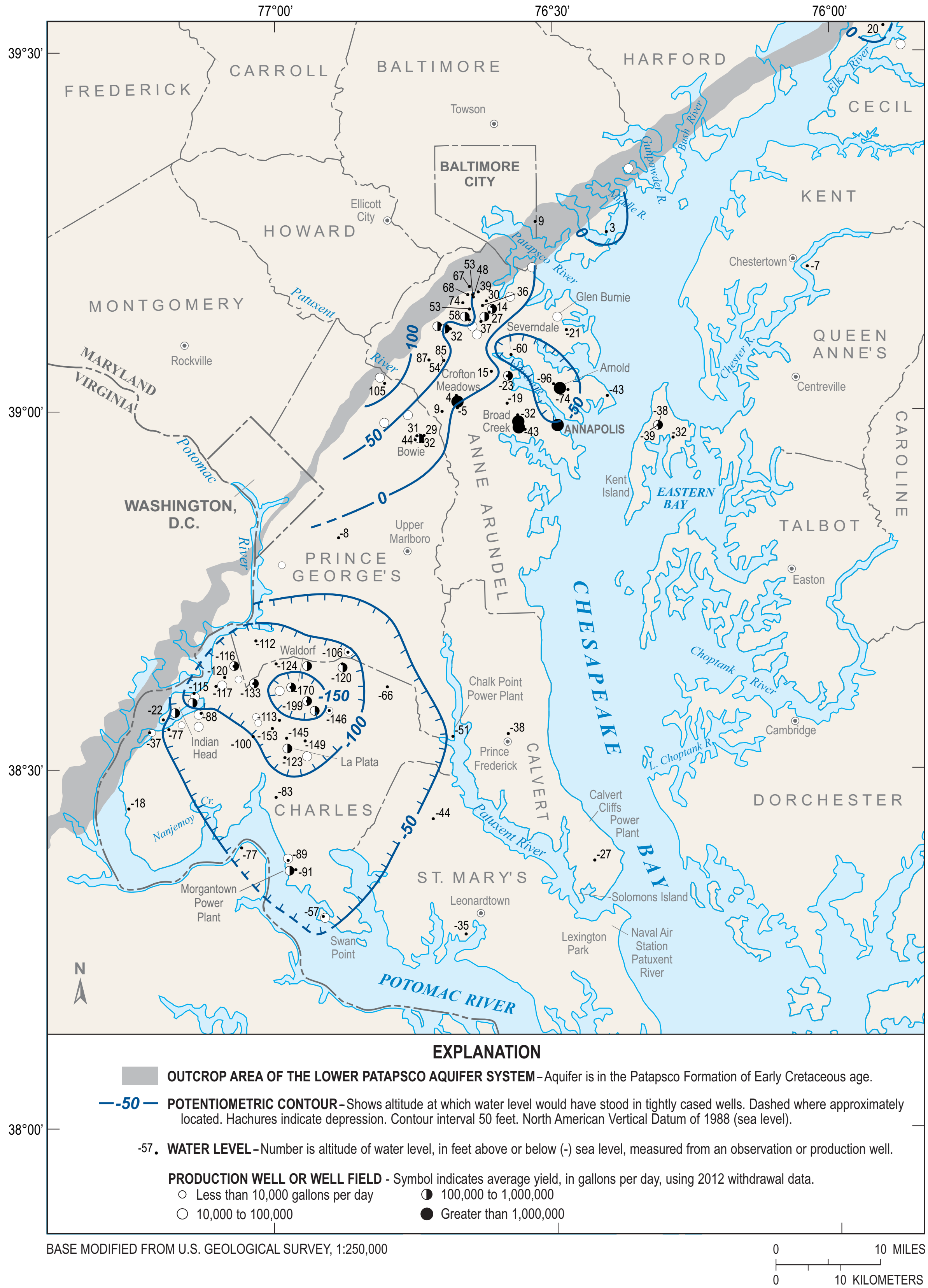

Figure 9. Potentiometric surface of the Lower Patapsco aquifer system in Southern Maryland and Maryland's Eastern Shore, September 2013.

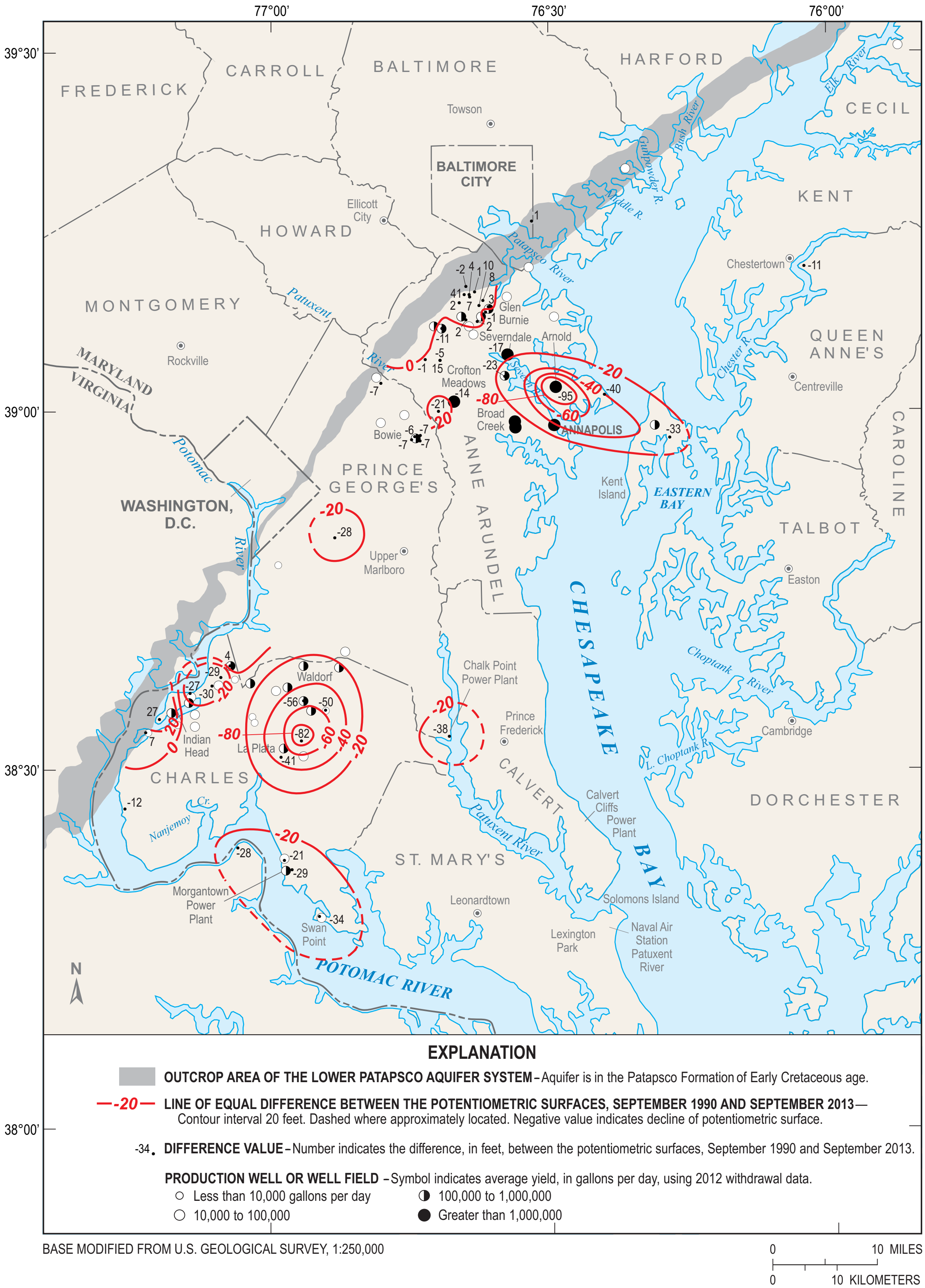

Figure 10. The difference between the potentiometric surfaces of the Lower Patapsco aquifer system in Southern Maryland and Maryland's Eastern Shore, September 1990 and September 2013.

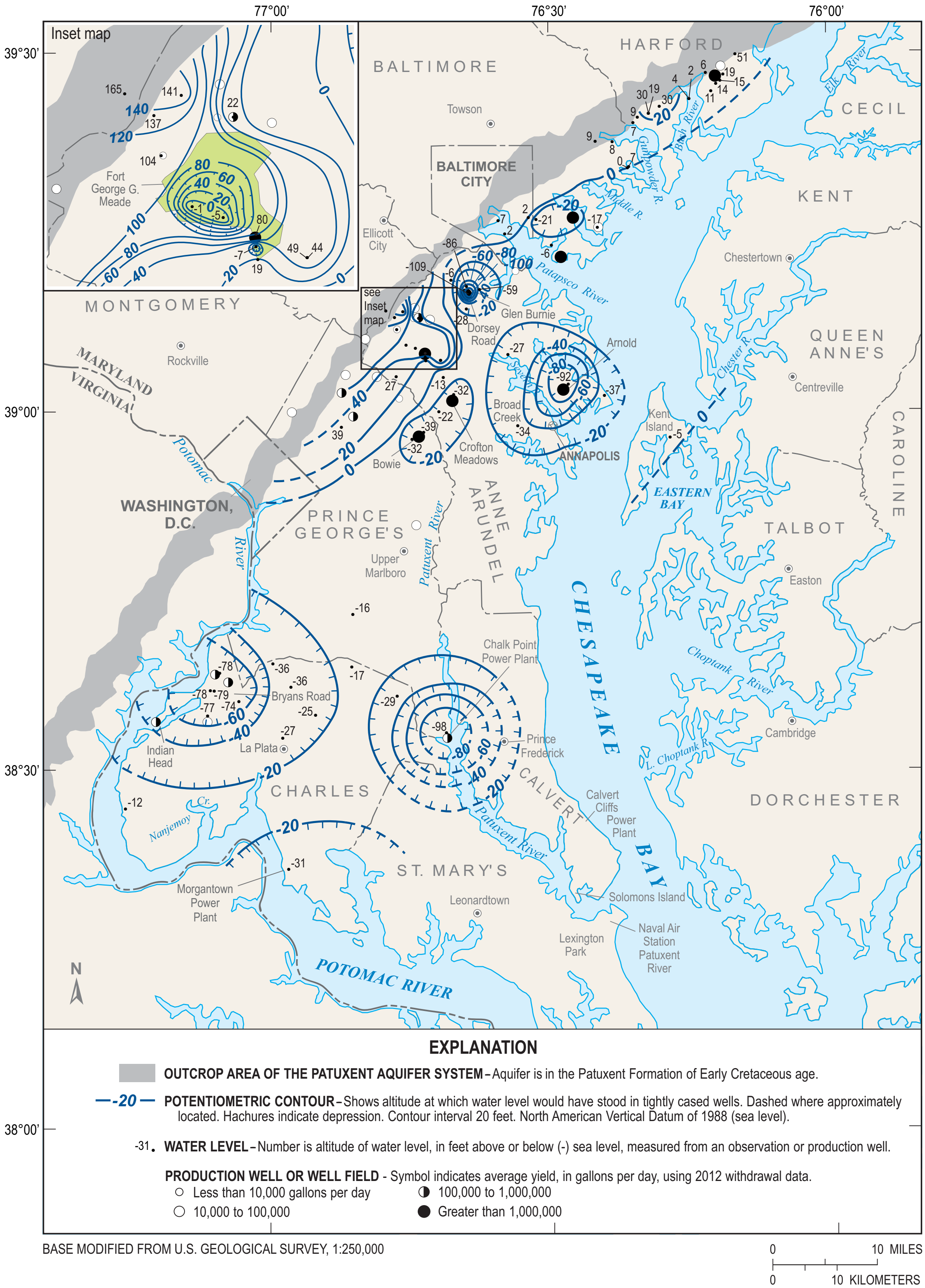

Figure 11. Potentiometric surface of the Patuxent aquifer system in Southern Maryland and Maryland's Eastern Shore, September 2013.

Patuxent Aquifer System

The potentiometric surface of the Patuxent aquifer system in Southern Maryland and Maryland's Eastern Shore during September 2013 is shown in figure 11. The map is based on water-level measurements in 68 wells. The highest measured water level was 165 ft above sea level in the outcrop area of the aquifer system in southeastern Howard County. Water levels are lower south and east towards well fields at Glen Burnie, Bryans Road, the Morgantown power plant, and the Chalk Point power plant. The measured groundwater levels were 109 ft below sea level at Dorsey Road, 79 ft below sea level near Bryans Road, 31 ft below sea level at the Morgantown power plant, and 98 ft below sea level at the Chalk Point power plant. Relatively deep cones of depression have formed around the Dorsey Road, Arnold, and Bryans Road well fields and the Chalk Point power plant. An additional significant cone of depression has formed around the well field at Fort George G. Meade (fig. 11, inset map). The water-use symbol for that well field represents multiple wells and is not centered in the cone of depression. A shallower cone of depression has formed around Crofton Meadows and Bowie. The withdrawal rates in the Patuxent aquifer system in the study area in 1990 and 2012 were approximately 23 and 22 Mgal/d, respectively; however, the locations of withdrawals have shifted between 1990 and 2012. The most significant changes in Patuxent withdrawals since 1990 have been the start of pumpage in Charles County and at the Chalk Point power plant, and the reduction of pumpage in northern Anne Arundel County, the City of Bowie, and the industrial areas of municipal Baltimore.

SUMMARY AND CONCLUSIONS

Groundwater has been and is expected to continue to be a major source of freshwater supply for Southern Maryland and Maryland's Eastern Shore. The principal aquifers in the study area from which groundwater is withdrawn are the Aquia aquifer, Magothy aquifer, and Upper Patapsco, Lower Patapsco, and Patuxent aquifer systems. Groundwater withdrawals from these aquifers have increased substantially over the last several decades as a direct result of population increases and increased use of water for irrigation. In each aquifer the water levels tend to be lower in wells farther away from the outcrop areas where most of the aquifer recharge occurs. Water levels in the Aquia aquifer ranged from 55 ft above sea level to 155 ft below sea level in 2013, and declined by as much as 113 ft between 1982 and 2013. Withdrawals from the Aquia aquifer have increased from approximately 5 Mgal/d in 1982 (Wheeler and Wilde, 1989) to approximately 16 Mgal/d in 2012. Water levels in the Magothy aquifer ranged from 83 ft above sea level to 108 ft below sea level in 2013, and declined by as much as 81 ft between 1975 and 2013. Withdrawals from the Magothy aquifer increased from approximately 7 Mgal/d in 1975 (Wheeler and Wilde, 1989) to approximately 8 Mgal/d in 2012. Water levels in the Upper Patapsco aquifer system ranged from 115 ft above sea level to 110 ft below sea level in 2013, and declined by as much as 61 ft between 1990 and 2013. Water levels in the Lower Patapsco aquifer system ranged from 105 ft above sea level to 199 ft below sea level in 2013, and declined by as much as 95 ft between 1990 and 2013. Total withdrawals from the Upper and Lower Patapsco aquifer systems increased from approximately 29 Mgal/d in 1990 to approximately 36 Mgal/d in 2012. Most of the withdrawals in 2012 were from the Lower Patapsco aquifer system (approximately 24 Mgal/d). Withdrawals reported in 1990 were not differentiated between the Upper and Lower Patapsco aquifer systems. Water levels in the Patuxent aquifer system ranged from 165 ft above sea level to 109 ft below sea level. The withdrawal rates in the Patuxent aquifer system in the study area in 1990 and 2012 were approximately 23 and 22 Mgal/d, respectively. The groundwater-level and withdrawal data presented in this report can be used to evaluate the sustainability of the confined aquifers in Southern Maryland and Maryland's Eastern Shore.

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Appendix 1a. Water-level data for Southern Maryland and Maryland's Eastern Shore wells used in this report (Aquia aquifer).

[All land surface and water-level measurements are in feet. Land elevations and water altitudes are measured from the North American Vertical Datum of 1988 (NAVD 88). Digital latitude and longitude measured relative to the North American Datum of 1983 (NAD 83); --, no data; USGS, U.S. Geological Survey]

Well number	USGS site identification number	Latitude (decimal degrees)	Longitude (decimal degrees)	Land surface elevation	Water-level altitude 2013	Water-level difference 1982-2013
AA Cf 98	390150076283003	39.03066661	-76.47468304	92.62	51.63	2.61
AA Cf 122	390149076261702	39.03061111	-76.43738889	19.20	0.85	-0.86
AA Cg 25	390127076240301	39.02427797	-76.40051418	16.53	0.49	0.05
AA De 102	385512076331602	38.92002778	-76.55419444	48.77	8.19	-0.78
AA De 137	385930076342102	38.99177795	-76.57218569	132.81	47.85	7.04
AA De 195	385628076323603	38.94093611	-76.54290000	36.20	1.11	--
AA Df 98	385550076292101	38.93077778	-76.48877778	10.49	0.82	0.25
AA Df 103	385623076274401	38.94030556	-76.46188889	25.69	3.26	--
AA Ed 45	385406076383901	38.90204167	-76.64363889	106.42	36.49	-7.07
AA Ed 49	385249076382101	38.88808333	-76.63933333	59.19	19.13	-6.15
AA Ee 67	385124076322001	38.85661111	-76.53805556	10.36	-9.20	-6.28
AA Fc 35	384833076415602	38.80952778	-76.69875000	50.48	-2.81	--
AA Fd 46	384727076382501	38.79568333	-76.63681111	138.09	-19.71	-22.89
AA Fe 46	384840076312801	38.81147222	-76.52425000	7.64	-23.71	-17.83
AA Fe 48	384508076334101	38.75244444	-76.56119444	84.20	-36.22	-26.35
AA Fe 60	384917076305802	38.82150473	-76.51579051	7.66	-19.21	--
AA Fe 92	384644076331201	38.77872222	-76.55269444	8.19	-34.92	--
CA Ba 11	384357076401601	38.73263889	-76.67083333	114.38	-37.63	-33.26
CA Ba 13	384231076412501	38.70858333	-76.69005556	55.07	-39.57	-39.99
CA Bb 27	384333076394701	38.72611111	-76.66338889	136.93	-42.62	-39.47
CA Bc 44	384243076320201	38.71188889	-76.53352778	6.77	-51.44	--
CA Cb 26	383837076381001	38.64352778	-76.63561111	114.36	-57.58	-54.44
CA Cb 32	383632076392701	38.60902778	-76.65694444	94.30	-65.10	-56.88
CA Cc 18	383940076314801	38.66141667	-76.52972222	110.50	-55.28	-47.19
CA Cc 57	383605076344601	38.60119444	-76.57969444	137.75	-63.52	-55.02
CA Cc 58	383924076341201	38.65683333	-76.57905556	121.62	-55.96	-51.18
CA Db 40	383053076382101	38.51527778	-76.63972222	22.51	-77.87	-62.62
CA Db 47	383239076354201	38.54355556	-76.59466667	139.54	-77.17	-60.94
CA Dc 29	383025076304701	38.50747222	-76.51094444	122.27	-71.72	-56.75
CA Ed 52	382549076260101	38.43325000	-76.43694444	9.14	-104.89	-75.23
CA Fd 54	382407076260301	38.40225000	-76.43461111	128.56	-108.51	-77.82
CA Gd 6	381952076270901	38.33194444	-76.45213889	11.74	-142.59	-96.15
CA Gd 61	381956076275301	38.33236111	-76.46461111	17.26	-139.43	--
CH Bg 11	383536076473601	38.59361111	-76.79302778	195.94	-48.54	-51.94
CH Ce 41	382225076591002	38.54102778	-76.98694444	193.43	-30.10	--
CH Ce 62	383348076595401	38.56316667	-76.99816667	194.19	-15.41	--
CH Cg 30	383008076480201	38.50227778	-76.80063889	183.13	-72.78	--
CH Ch 15	383043076404501	38.51013889	-76.68052778	8.90	-73.38	-62.51
CH Df 17	382800076530301	38.47372222	-76.88400000	160.10	-66.26	-66.02
CH Ff 59	381639076523201	38.27347222	-76.87522222	7.15	-49.69	-42.07
CO Cc 101	385959075525901	38.99972222	-75.88277778	59	-15.27	--

Appendix 1a. Continued.

Well number	USGS site identification number	Latitude (decimal degrees)	Longitude (decimal degrees)	Land surface elevation	Water-level altitude 2013	Water-level difference 1982-2013
DO Cc 55	383009076141301	38.50250000	-76.23666667	4	-58.90	--
DO Db 19	382847076190901	38.48019444	-76.31938889	0.72	-70.44	--
KE Bd 129	391600076025001	39.26666667	-76.04694444	49	28.66	--
KE Bf 93	391752075523901	39.29777778	-75.87722222	44	23.38	--
KE Cb 41	391308076100301	39.21888889	-76.16722222	89	53.60	--
KE Cb 100	391124076101004	39.18986111	-76.16861111	64.90	24.02	--
KE Cc 101	391442076083401	39.24500000	-76.14250000	89.67	54.86	--
KE Db 42	390909076122302	39.15294444	-76.20630556	24.19	10.75	--
KE Dc 91	390626076083302	39.10733302	-76.14217115	3.85	-0.29	--
KE Eb 11	390141076135801	39.02555556	-76.23138889	24	-2.50	--
PG Hf 35	383228076410601	38.54141667	-76.68430556	10.35	-69.26	-62.15
PG Hf 42	383348076411303	38.56338889	-76.68530556	26.89	-67.15	-60.92
QA Be 17	391203076024303	39.20094315	-76.04494493	24.21	14.11	1.77
QA Bf 34	391308075571001	39.21888889	-75.95250000	69	10.45	--
QA Bg 59	391135075534601	39.19305556	-75.89583333	49	-1.50	--
QA Bg 62	391328075545301	39.22472222	-75.91388889	59	14.75	--
QA Ce 37	390634076013001	39.10980556	-76.02444444	39	-15.57	--
QA Cf 65	390829075591201	39.14138889	-75.98638889	34	-17.53	--
QA Cf 78	390845075582302	39.14583333	-75.97305556	60	-9.18	--
QA Cg 71	390823075514201	39.13997222	-75.86177778	67.7	-6.77	--
QA Db 32	390201076182703	39.03372248	-76.30717813	17.21	0.69	--
QA Db 35	390119076191001	39.02205595	-76.31912290	6.72	0.73	--
QA Db 37	390023076174302	39.00650065	-76.29495549	6.32	-1.66	--
QA De 27	390251076034401	39.04761175	-76.06188876	9.42	-25.65	--
QA Ea 78	385718076211502	38.95511290	-76.35384487	11.02	-2.22	--
QA Ea 80	385757076200102	38.96594599	-76.33328901	7.72	-3.24	--
QA Eb 113	385748076172001	38.96344615	-76.28856542	10.57	-9.27	-3.36
QA Eb 155	385843076155302	38.97872357	-76.26439846	3.13	-7.62	--
QA Eb 156	385852076195201	38.98122338	-76.33078935	11.23	-2.88	--
QA Eb 159	385912076182601	38.98638889	-76.30638889	11	-16.20	--
QA Ed 44	385903076092102	38.98944400	-76.15638900	14	-22.25	--
QA Fc 7	385429076120201	38.90816973	-76.20022712	9.27	-27.78	-15.96
QA Fd 6	385459076082801	38.91638889	-76.14083333	14	-28.79	--
SM Bb 15	382838076470101	38.47755556	-76.78322222	164.43	-82.14	-78.50
SM Cc 8	382235076435801	38.37722222	-76.73247222	127.99	-68.61	--
SM Cc 22	382055076404601	38.34873729	-76.67912944	132.10	-68.01	-56.41
SM Ce 38	382222076304602	38.33975000	-76.51258333	15.08	-122.12	--
SM Ce 43	382012076332901	38.33666667	-76.55780556	87.13	-110.41	--
SM Dc 42	381648076421801	38.28012808	-76.70468677	12.63	-66.13	-41.80
SM Dc 59	381807076442801	38.30207246	-76.74079961	40.01	-65.11	-50.71
SM Dd 39	381834076381301	38.30883333	-76.63472222	106.57	-79.74	-43.19
SM Dd 49	381616076364702	38.27025000	-76.61394444	118.00	-79.23	-48.08
SM Dd 50	381807076380001	38.30250000	-76.63263889	98.47	-75.05	-43.84

Appendix 1a. Continued.

Well number	USGS site identification number	Latitude (decimal degrees)	Longitude (decimal degrees)	Land surface elevation	Water-level altitude 2013	Water-level difference 1982-2013
SM Dd 68	381654076394502	38.28179411	-76.66218455	124.08	-70.10	-46.48
SM Dd 69	381923076372501	38.32386111	-76.62325000	124.09	-65.90	--
SM Dd 74	381616076384502	38.27111111	-76.64583333	19	-80.96	--
SM Df 1	381552076265001	38.26472222	-76.44713889	92.46	-153.05	--
SM Df 10	381715076261601	38.28679129	-76.43800705	45.14	-142.15	-90.14
SM Df 61	381604076271701	38.26788889	-76.45352778	107.97	-150.30	--
SM Df 62	381632076275301	38.27580556	-76.46738889	103.12	-154.74	-78.43
SM Df 71	381527076283101	38.25697222	-76.47527778	68.25	-141.27	-79.61
SM Df 80	381532076250101	38.25902778	-76.41655556	41.10	-134.83	--
SM Df 86	381548076272103	38.26325000	-76.45563889	111.20	-154.20	-80.33
SM Df 95	381617076263201	38.27144444	-76.44200000	79.12	-144.49	-112.61
SM Df 96	381724076253901	38.29013889	-76.42758333	8.14	-144.80	--
SM Dg 10	381555076244801	38.26536111	-76.41302778	21.11	-138.29	-79.77
SM Dg 18	381607076241401	38.26938889	-76.40327778	17.11	-130.99	-106.50
SM Dg 19	381747076223901	38.29600000	-76.37638889	9.14	-128.69	--
SM Fe 31	380834076303402	38.14291667	-76.50927778	8.22	-79.17	-45.06
SM Ff 64	380821076255501	38.13941667	-76.43144444	9.06	-104.52	--
TA Cc 50	384707076133202	38.78550000	-76.22658333	7.22	-40.83	--
TA Cd 55	384620076052401	38.77194444	-76.09055556	14.22	-65.37	--
TA Db 64	384308076195901	38.71888889	-76.33277778	9	-37.70	--
TA Dc 54	384052076101201	38.68111111	-76.16972222	4	-60.46	--
VA 54Q-21	382129077005801	38.35805550	-77.01611100	19.66	-26.74	--

Appendix 1b. Water-level data for Southern Maryland and Maryland's Eastern Shore wells used in this report (Magothy aquifer).

[All land surface and water-level measurements are in feet. Land elevations and water altitudes are measured from the North American Vertical Datum of 1988 (NAVD 88). Digital latitude and longitude measured relative to the North American Datum of 1983 (NAD 83); --, no data; USGS, U.S. Geological Survey]

Well number	USGS site identification number	Latitude (decimal degrees)	Longitude (decimal degrees)	Land surface elevation	Water-level altitude 2013	Water-level difference 1975-2013
AA Cc 95	390247076403501	39.04638889	-76.67633333	130.33	82.98	-5.88
AA Cc 117	390103076402603	39.01769444	-76.67388889	133.36	46.24	--
AA Cd 12	390124076361202	39.02350000	-76.60308333	98.03	11.69	-10.10
AA Cd 78	390238076373301	39.04413889	-76.62563889	128.04	38.46	-9.03
AA Cd 143	390000076364001	38.99991667	-76.61122222	102.21	4.52	-17.55
AA Ce 103	390214076342201	39.03727778	-76.57255556	58.40	1.05	-0.69
AA Ce 128	390404076300703	39.06800000	-76.50116667	6.33	-10.25	--
AA Ce 130	390148076325202	39.03022222	-76.54738889	1.88	-11.69	--
AA Ce 133	390410076302401	39.07025000	-76.50636111	14.34	-6.08	--
AA Ce 138	390049076322702	39.01361111	-76.54072222	68.20	-18.83	-18.54
AA Ce 151	390132076311401	39.02561111	-76.52061111	83.20	-20.56	-20.54
AA Cf 99	390150076283002	39.03066661	-76.47468304	92.90	-32.98	-32.64
AA Cf 104	390242076274501	39.04522222	-76.46233333	25.97	-29.90	-29.93
AA Cf 152	390121076253301	39.02257778	-76.42625833	24.64	-25.36	--
AA Cg 7	390123076241102	39.02316687	-76.40273647	16.20	-19.55	-21.31
AA Dc 20	385637076400802	38.94372222	-76.66819444	91.39	11.98	-17.21
AA Dd 37	385807076351901	38.96863889	-76.58872222	132.13	-11.69	-21.69
AA Dd 40	385511076373101	38.91986111	-76.62488889	134.99	-5.36	-25.95
AA Dd 42	385808076373502	38.96900041	-76.62607589	104.68	2.37	-20.22
AA De 1	385915076340401	38.97108330	-76.56752770	12.92	-16.98	-16.53
AA De 103	385512076331603	38.92002778	-76.55413889	48.87	-16.15	-26.97
AA De 124	385528076334601	38.92455556	-76.56219444	27.04	-16.37	-28.09
AA De 135	385932076344401	38.99233346	-76.57857479	48.01	-7.83	--
AA Df 20	385916076270702	38.98816667	-76.45188889	21.07	-25.05	-26.03
AA Df 79	385905076293601	38.98486111	-76.49325000	4.36	-23.87	-27.33
AA Df 82	385953076280201	38.99822222	-76.46763889	86.97	-27.28	-26.50
AA Df 84	385518076282701	38.92177778	-76.47447222	6.50	-30.86	-37.65
AA Df 87	385934076274301	38.99297222	-76.46144444	19.06	-25.44	--
AA Ed 39	385210076371002	38.86955831	-76.61912966	175.67	-8.57	-26.54
AA Ed 65	385406076383902	38.90211944	-76.64361667	108.83	-0.72	--
AA Fc 34	384833076415601	38.80947222	-76.69872222	50.18	-5.85	--
AA Fe 47	384843076312601	38.81236111	-76.52386111	5.52	-17.84	-31.30
AA Fe 51	384917076305801	38.82150473	-76.51579051	7.66	-17.84	--
AA Fe 93	384644076331202	38.77866667	-76.55272222	7.22	-19.54	--
CA Bb 10	384028076354201	38.67419444	-76.59422222	186.00	-39.20	-46.10
CA Bb 23	384458076375501	38.74927778	-76.63297222	145.96	-24.39	-37.29
CA Cc 56	383934076320001	38.65977778	-76.53363889	95.30	-40.41	-48.29
CA Dc 35	383050076305501	38.51419444	-76.51441667	90.76	-45.13	-53.59
CE Dd 87	392519075565601	39.42194444	-75.94861111	69.21	2.06	--
CE De 64	392746075524901	39.46288889	-75.88036111	16	-4.40	--
CE Ec 22	392328076021901	39.39122394	-76.03828041	44.20	-2.26	--

Appendix 1b (continued)

Well number	USGS site identification number	Latitude (decimal degrees)	Longitude (decimal degrees)	Land surface elevation	Water-level altitude 2013	Water-level difference 1975-2013
CE Ee 61	392328075544601	39.39111111	-75.91277778	85	-13.07	--
CH Be 17	383502076565101	38.58336111	-76.94850000	203.46	-67.29	-60.52
CH Be 43	383819076555501	38.63777778	-76.93138889	216.03	-71.87	-80.64
CH Bf 98	383739076543001	38.62772222	-76.90797222	215.62	-67.36	-70.54
CH Bf 124	383750076540801	38.63219444	-76.90044444	207.02	-68.86	-77.66
CH Bf 133	383640076545901	38.61100000	-76.91591667	222.73	-72.70	--
CH Bf 134	383728076531701	38.62505556	-76.88777778	201.32	-71.46	-77.12
CH Bf 135	383814076500301	38.63752778	-76.83272222	207.03	-55.02	-68.79
CH Bf 143	383918076522201	38.65544444	-76.90580556	205.83	-69.98	--
CH Cf 29	383219076503502	38.53980556	-76.84319444	177.21	-66.86	-77.62
CH Cf 39	383259076531001	38.54967778	-76.88629444	138.82	-70.03	--
DO Ce 15	383408076042402	38.56905556	-76.07288889	5.23	-15.64	-6.87
KE Af 63	392143075524901	39.36194444	-75.88000000	29	-32.57	--
KE Bb 41	391659076100301	39.28305556	-76.16722222	4	-0.59	--
KE Bc 184	391650076050401	39.28055556	-76.08416667	81.23	33.15	--
KE Bc 186	391650076050403	39.28055556	-76.08416667	81.21	26.57	--
KE Be 43	391823075594701	39.30672222	-75.99505556	64.21	34.66	--
KE Cb 106	391238076131001	39.21066667	-76.21950000	30	-1.58	--
KE Dc 32	390758076095801	39.13277778	-76.16583333	4	-14.37	--
KE Eb 14	390218076140901	39.03833333	-76.23555556	14	-27.74	--
PG Cf 33	385806076435303	38.96833333	-76.73175000	114.62	46.41	--
PG De 21	385130076465501	38.85883333	-76.78161111	94.89	31.30	-17.59
PG De 32	385323076471801	38.88983461	-76.78802541	131	49.00	-12.40
PG Ed 50	384715076522001	38.78777778	-76.87166667	240.11	3.63	--
PG Ef 34	384623076424001	38.77316667	-76.71113889	38.32	-11.86	-31.51
PG Ef 40	384847076440401	38.81316667	-76.73380556	79.03	-1.60	--
PG Fd 32	384148076510901	38.69678323	-76.85219305	225	-36.98	-60.11
PG Fd 39	384410076502501	38.73544444	-76.83980556	232.66	-15.31	-40.42
PG Fe 30	384453076482101	38.74805556	-76.80569444	236.82	-14.58	-41.92
PG Ge 15	383940076461301	38.66122904	-76.76996804	209.68	-37.73	-54.44
PG Gf 35	383832076414701	38.64213889	-76.69686111	34.05	-37.99	-51.02
PG Hf 41	383348076411302	38.56338889	-76.68538889	27.43	-55.06	-42.19
QA Ea 27	385718076205501	38.95400183	-76.34801133	17.49	-21.68	-27.62
TA Ce 80	384644076044602	38.77888889	-76.07944444	14	-108.46	--

Appendix 1c. Water-level data for Southern Maryland and Maryland's Eastern Shore wells used in this report (Upper Patapsco aquifer system).

[All land surface and water-level measurements are in feet. Land elevations and water altitudes are measured from the North American Vertical Datum of 1988 (NAVD 88). Digital latitude and longitude measured relative to the North American Datum of 1983 (NAD 83); --, no data; USGS, U.S. Geological Survey]

Well number	USGS site identification number	Latitude (decimal degrees)	Longitude (decimal degrees)	Land surface elevation	Water-level altitude 2013	Water-level difference 1990-2013
AA Bd 159	390737076374402	39.12708333	-76.62908333	74.69	36.89	1.13
AA Be 102	390559076312602	39.10005556	-76.52425000	35.56	8.11	-0.71
AA Bf 100	390629076273601	39.10836389	-76.45951667	44.9	14.88	--
AA Cc 43	390422076414501	39.07272500	-76.69595278	175.3	115.35	-5.17
AA Cc 116	390103076402602	39.01769444	-76.67388889	133.57	-4.88	-29.95
AA Ce 120	390303076344301	39.05088889	-76.57844444	161.00	5.07	-3.65
AA Ce 137	390043076345402	39.01290833	-76.58266667	57.88	-1.48	--
AA Cf 118	390207076292802	39.03527778	-76.49027778	119.76	-67.09	-60.61
AA Cf 128	390149076261703	39.03038892	-76.43773751	13.20	-28.97	-12.97
AA Cf 134	390121076270501	39.02188889	-76.44988889	23.20	-32.07	-17.73
AA Cg 24	390123076241603	39.02316687	-76.40412540	11.88	-22.39	-15.23
AA De 95	385853076333001	38.98172222	-76.55777778	72.41	-25.36	-19.01
AA De 128	385530076334701	38.92488889	-76.56261111	27.51	-14.94	-16.46
AA De 199	385753076310801	38.96430278	-76.51938611	37.05	-21.77	-13.01
AA De 219	385915076335303	38.98761143	-76.56440759	119.21	-24.27	--
AA De 230	385627076322901	38.94076389	-76.54138889	35.37	-17.95	--
AA Df 19	385921076270701	38.98955556	-76.45194444	15.04	-26.24	-16.83
AA Df 89	385934076274302	38.99300000	-76.46186111	19.78	-34.97	-20.12
AA Df 99	385905076293604	38.98486111	-76.49325000	4.36	-39.67	-17.60
AA Df 100	385905076293603	38.98486111	-76.49325000	4.36	-22.56	-14.40
AA Ec 12	385125076404801	38.85694444	-76.67947222	54.21	-3.78	--
BA Gg 14	391457076244201	39.24930556	-76.41169444	15	-7.79	--
CA Cc 55	383934076320201	38.65997222	-76.53286111	104	-15.02	-12.35
CA Db 96	383244076354201	38.54588889	-76.58963889	151.56	-47.28	--
CE Ce 56	393026075523101	39.50761111	-75.87491667	37.22	6.35	-1.51
CE Ee 29	392403075521801	39.40147222	-75.87152778	74.20	-13.60	-15.59
CH Be 60	383706076575604	38.61777778	-76.96388889	212.02	-61.38	-38.47
CH Bf 151	383508076540703	38.58583333	-76.90100000	192.03	-72.16	-32.45
CH Bf 157	383637076545803	38.61091667	-76.91600000	224.23	-70.89	-25.42
CH Bf 158	383732076531902	38.62563889	-76.88819444	192.23	-59.57	-28.82
CH Cd 54	383346077000901	38.56280556	-77.00247222	179.18	-106.24	--
CH Ce 16	383217076590201	38.53764167	-76.98323056	186.65	-109.98	-31.04
CH Ce 50	383420076592501	38.57232222	-76.98957778	201.37	-68.47	-17.62
CH Cg 24	383254076481401	38.54877778	-76.80338889	171.04	-61.25	--
CH Da 21	382659077152401	38.44952778	-77.25666667	89.20	-16.11	-11.60
CH Dd 33	382607077002601	38.41927778	-77.00022222	98.98	-47.61	-37.33
CH Dd 38	382925077010101	38.49920278	-77.01667778	76.4	-76.36	--
CH Fe 5	381803076550801	38.30133333	-76.91780556	11.16	-55.02	--
DO Ce 82	383346076033901	38.56305556	-76.06111111	14.23	-72.77	--
KE Ac 20	392007076075501	39.33491667	-76.13150000	6.19	-1.38	-5.05
KE Be 171	391643075550901	39.27861111	-75.91805556	40.62	-9.58	--

Appendix 1c (continued)

Well number	USGS site identification number	Latitude (decimal degrees)	Longitude (decimal degrees)	Land surface elevation	Water-level altitude 2013	Water-level difference 1990-2013
KE Cb 36	391400076101401	39.23316667	-76.17061111	39.20	-5.17	-6.94
KE Cb 103	391124076101005	39.18986111	-76.16836111	64.81	-8.80	--
KE Db 40	390837076140401	39.14377778	-76.23416667	14.19	-10.44	-10.42
PG Cf 31	385757076442001	38.96575000	-76.73886111	146.22	43.66	1.61
PG De 33	385323076471802	38.88944444	-76.79786111	102.83	52.37	-5.58
PG Fb 36	384423077004501	38.73977778	-77.01216667	77.19	-28.50	-23.54
PG Fd 80	384134076541001	38.69297222	-76.90291667	220	-23.84	--
PG Hf 40	383348076411301	38.56350000	-76.68533333	27.11	-52.32	-28.77
PG Hf 44	383250076405304	38.54734373	-76.68107351	9.58	-66.59	-43.05
QA Be 16	391203076024302	39.20094315	-76.04494493	24.21	-19.27	-22.23
QA Eb 111	385751076171601	38.96427946	-76.28745430	13.26	-21.93	-18.62
QA Eb 167	385850076183601	38.98055556	-76.31000000	14	-20.63	--
QA Ef 29	385534075573601	38.92733560	-75.96077192	60.92	-23.27	-16.84
SM Bc 41	382621076445301	38.43911111	-76.74788889	159.14	-62.44	--
SM Dc 64	381559076400201	38.26666667	-76.66666667	32.08	-65.25	--
SM Dd 78	381827076350402	38.30750000	-76.58416667	129.08	-79.40	--
SM Dd 79	381834076381303	38.30883333	-76.63472222	112	-84.06	--
SM Dd 80	381616076384503	38.27111111	-76.64583333	26	-68.04	--
SM Dd 81	381509076351401	38.25611111	-76.58472222	113	-65.92	--
SM Dd 83	381621076364701	38.27250000	-76.61305556	119.06	-61.81	--
SM De 52	381753076310001	38.29805556	-76.51805556	109.11	-75.87	--
SM De 59	381914076331002	38.32000000	-76.55277778	150	-76.78	--
SM Df 84	381548076272102	38.26311111	-76.45605556	107.50	-68.76	-49.85
SM Df 88	381955076293901	38.33313889	-76.49630556	19.16	-67.80	--
SM Df 100	381721076264801	38.28916667	-76.44652778	20.14	-64.14	--
SM Ef 94	381440076271701	38.24444444	-76.45472222	79.09	-77.55	--
SM Ff 36	380724076251901	38.12261111	-76.42166667	5.06	-47.26	-33.24
SM Ff 65	380823076255501	38.13986111	-76.43208333	9.06	-48.54	--
TA Cd 57	384709076050301	38.78594908	-76.08383090	11.23	-69.20	--

Appendix 1d. Water-level data for Southern Maryland and Maryland's Eastern Shore wells used in this report (Lower Patapsco aquifer system).

[All land surface and water-level measurements are in feet. Land elevations and water altitudes are measured from the North American Vertical Datum of 1988 (NAVD 88). Digital latitude and longitude measured relative to the North American Datum of 1983 (NAD 83); --, no data; USGS, U.S. Geological Survey]

Well number	USGS site identification number	Latitude (decimal degrees)	Longitude (decimal degrees)	Land surface elevation	Water-level altitude 2013	Water-level difference 1990-2013
3S5E- 46	391556076315301	39.26569444	-76.53102778	9.19	9.01	0.99
AA Ad 102	391032076385904	39.17586111	-76.64916667	75.93	66.64	-2.35
AA Ad 109	391006076380101	39.16800000	-76.63405556	34.99	39.07	1.15
AA Bc 215	390700076412601	39.11688889	-76.69072222	123.24	31.84	-11.42
AA Bd 37	390848076363601	39.14722222	-76.60944444	37.40	14.31	-1.11
AA Bd 56	390950076384001	39.16391667	-76.64413889	60.81	52.53	3.86
AA Bd 91	390950076391101	39.16391667	-76.65272222	81.85	68.05	40.53
AA Bd 101	390855076373402	39.14900000	-76.62655556	54.21	36.34	10.47
AA Bd 152	390821076365401	39.13963889	-76.61502778	52.49	26.68	3.40
AA Bd 155	390938076383701	39.16116667	-76.64313889	56.71	47.93	6.84
AA Bd 156	390922076371001	39.15583333	-76.61908333	68.19	29.82	8.42
AA Bd 157	390737076374401	39.12711111	-76.62913889	74.96	37.30	1.51
AA Bd 158	390744076390001	39.12919444	-76.64972222	107.47	57.84	2.49
AA Bd 160	390908076394402	39.15255556	-76.66183333	87.22	74.33	1.85
AA Bd 181	390839076385702	39.14421944	-76.64940833	176.7	53.28	--
AA Bf 99	390654076283601	39.11486111	-76.47697222	39.19	-21.38	--
AA Cc 40	390423076432001	39.07350000	-76.72211111	136.17	87.09	-0.62
AA Cc 82	390422076414505	39.07289722	-76.69600556	177.96	54.10	-5.37
AA Cc 83	390422076414506	39.07289722	-76.69600556	177.94	85.15	14.57
AA Cc 89	390010076415703	39.00186111	-76.69944444	51.99	9.09	-21.36
AA Cc 115	390103076402601	39.01769444	-76.67388889	133.60	-5.31	-14.08
AA Cc 137	390126076402901	39.02427778	-76.67427778	114.57	4.33	--
AA Cd 128	390327076363701	39.05746111	-76.61071111	109.22	14.75	--
AA Ce 94	390450076343503	39.08066544	-76.57607530	89.20	-59.93	-16.98
AA Ce 124	390303076344303	39.05063889	-76.57869444	159.20	-22.50	-22.57
AA Ce 136	390043076345401	39.01296111	-76.58271111	59.4	-19.41	--
AA Cf 137	390205076292702	39.03455556	-76.49011111	123.50	-96.20	-94.53
AA Cf 167	390154076282802	39.03154444	-76.47438056	105.89	-74.49	--
AA Cg 23	390123076241602	39.02316687	-76.40412540	11.77	-42.87	-40.35
AA De 206	385833076332801	38.97616667	-76.55722222	80.95	-42.97	--
AA De 232	385915076335304	38.98750000	-76.56472222	118.21	-31.73	--
BA Fg 70	391502076241301	39.25077778	-76.40369444	11	2.68	--
CA Db 99	383311076350301	38.55305555	-76.58416666	149	-37.92	--
CA Fd 85	382236076255401	38.37647222	-76.43197222	105.98	-27.21	--
CE Ce 98	393209075541401	39.53588889	-75.90388889	103	20.10	--
CH Bc 24	383633077083001	38.60963889	-77.14127778	71.17	-115.29	-27.08
CH Bc 76	383754077051201	38.63191667	-77.08652778	170.17	-120.36	-28.53
CH Bc 81	383709077061002	38.61919444	-77.10269444	155.63	-116.80	-29.90
CH Bd 33	383844077040701	38.64702778	-77.06558333	179.19	-116.33	3.88
CH Bd 51	383715077014901	38.62055556	-77.02958333	184.19	-133.01	--
CH Be 58	383706076575602	38.61783333	-76.96400000	211.72	-169.88	--

Appendix 1d (continued)

Well number	USGS site identification number	Latitude (decimal degrees)	Longitude (decimal degrees)	Land surface elevation	Water-level altitude 2013	Water-level difference 1990-2013
CH Be 64	383553076562002	38.59916667	-76.93997222	208.22	-198.66	-55.81
CH Be 72	383903076594301	38.65083333	-76.99527778	109.23	-124.03	--
CH Bf 146	383508076540701	38.58588889	-76.90083333	192.03	-145.76	-50.46
CH Bf 150	383901076524301	38.65036111	-76.87811111	214.24	-120.30	--
CH Bg 17	383706076475401	38.61845242	-76.79802398	199.16	-65.53	--
CH Cb 7	383422077114601	38.57286111	-77.19572222	35.18	-22.06	27.43
CH Cb 28	383315077131401	38.55444444	-77.22022222	4.18	-37.36	6.56
CH Cb 42	383328077111702	38.55880556	-77.18544444	4.19	-76.72	--
CH Cc 31	383455077074401	38.58208333	-77.12836111	34.19	-88.22	--
CH Cd 42	383256077015301	38.54894167	-77.03612222	187.62	-100.47	--
CH Cd 53	383340077000901	38.56094444	-77.00277778	159.18	-152.58	--
CH Ce 35	383111076584801	38.52018889	-76.97973611	172.37	-122.96	-40.72
CH Ce 37	383236076563901	38.54345407	-76.94386147	184.18	-149.00	-82.38
CH Ce 53	383420076592504	38.57219444	-76.98947222	201.55	-113.32	--
CH Ce 56	383251076583901	38.54730556	-76.97713889	195.69	-144.69	--
CH Da 20	382654077152701	38.44822222	-77.25647222	89.20	-17.69	-12.00
CH De 52	382752076593601	38.46472222	-76.99527778	165	-82.92	--
CH Ee 70	382154076574801	38.36413889	-76.96027778	21.99	-90.99	-29.11
CH Ee 78	382240076582801	38.37652778	-76.97394444	74.16	-89.11	-21.44
CH Ff 60	381806076545401	38.29886111	-76.91191667	11.15	-57.42	-34.15
PG Be 14	390226076481001	39.04096944	-76.80231111	149.7	105.09	-6.74
PG Cf 32	385806076435302	38.96841667	-76.73169444	114.62	29.50	-7.43
PG Cf 76	385757076440402	38.96583333	-76.73486111	126.83	32.12	-6.99
PG Cf 77	385757076442002	38.96575000	-76.73886111	146.22	31.34	-5.94
PG Cf 80	385816076434502	38.96266667	-76.74744444	149.22	44.37	-7.45
PG Ed 34	384933076530001	38.82580556	-76.88447222	269.21	-8.19	-27.59
PG Fb 57	384056077015501	38.68233859	-77.03164270	169.16	-112.38	--
PG Gd 6	383958076520601	38.66633333	-76.86816667	216.24	-105.94	--
PG Hf 32	383250076405303	38.54953333	-76.68140556	9.58	-50.60	-38.46
QA Be 15	391203076024301	39.20094315	-76.04494493	24.21	-6.53	-11.09
QA Eb 112	385751076171602	38.96427946	-76.28745430	13.15	-32.43	-32.99
QA Eb 182	385850076183501	38.98055556	-76.30944444	13	-38.48	--
QA Eb 184	385850076183502	38.98055556	-76.30944444	13	-39.00	--
SM Bc 39	382605076430201	38.43475000	-76.71677778	161.54	-43.85	--
SM Dd 72	381626076393401	38.27400000	-76.65961111	109.99	-34.86	--
VA 54R-2	382341077032401	38.39472220	-77.05666660	69.19	-77.26	-27.65

Appendix 1e. Water-level data for Southern Maryland and Maryland's Eastern Shore wells used in this report (Patuxent aquifer system).

[All land surface and water-level measurements are in feet. Land elevations and water altitudes are measured from the North American Vertical Datum of 1988 (NAVD 88). Digital latitude and longitude measured relative to the North American Datum of 1983 (NAD 83); --, no data; USGS, U.S. Geological Survey]

Well number	USGS site identification number	Latitude (decimal degrees)	Longitude (decimal degrees)	Land surface elevation	Water-level altitude 2013
2S5E- 1	391617076322001	39.27158333	-76.53847222	27.39	2.00
3S2E- 5	391600076353301	39.26663889	-76.59230556	15	7.15
4S2E- 6	391456076345001	39.24893333	-76.58075555	6.88	2.18
AA Ac 11	391101076404001	39.18383333	-76.67738889	136.12	-5.81
AA Ad 29	391015076373501	39.17112222	-76.62587222	35.65	-58.84
AA Ad 90	391032076385902	39.17600000	-76.64922222	77.06	-85.74
AA Bb 67	390538076453001	39.09463889	-76.75730556	132.26	-0.57
AA Bb 87	390826076454802	39.14055556	-76.76333333	268.55	140.87
AA Bb 88	390756076464201	39.13222222	-76.77833333	174.11	136.83
AA Bb 90	390657076462601	39.11583333	-76.77388889	162.76	103.51
AA Bc 163	390524076442501	39.08997222	-76.74105556	134.37	-4.72
AA Bc 240	390752076441001	39.13150000	-76.73544444	259.25	21.57
AA Bd 57	390952076384102	39.16472222	-76.64441667	69.21	-109.39
AA Bd 182	390839076385703	39.14426389	-76.64933889	178.06	-28.19
AA Cb 1	390303076463201	39.05011111	-76.77575000	128.35	27.41
AA Cc 80	390422076414503	39.07289722	-76.69600556	177.99	49.00
AA Cc 81	390422076414504	39.07289722	-76.69600556	177.98	43.51
AA Cc 102	390004076420001	39.00136111	-76.69947222	53.18	-22.02
AA Cc 113	390256076413101	39.04900833	-76.69180556	150.73	-12.99
AA Cc 119	390437076432302	39.07766667	-76.72336111	138.25	-6.89
AA Cc 121	390456076432501	39.08246111	-76.72382222	119.57	79.81
AA Cc 124	390419076432301	39.07201389	-76.72283333	126.87	19.36
AA Cc 135	390126076403001	39.02430556	-76.67433333	114.04	-32.36
AA Ce 117	390450076343402	39.08088889	-76.57600000	85.20	-27.29
AA Cf 166	390154076282801	39.03155833	-76.47446667	105.93	-91.63
AA Cg 22	390123076241601	39.02316687	-76.40412540	11.81	-37.38
AA De 203	385854076333202	38.98136111	-76.55877222	92.59	-33.65
BA Ef 267	392235076250401	39.37652778	-76.41786111	76	8.78
BA Eg 148	392233076231201	39.37605556	-76.38683333	20	7.96
BA Eg 150	392029076213201	39.34149697	-76.35856979	9.17	6.78
BA Eg 261	--	39.33963889	-76.36052778	7	0.24
BA Fe 19	391607076312901	39.26859444	-76.52430000	11.7	-20.83
BA Fg 69	391526076245601	39.25733029	-76.41523737	19.11	-16.78
BA Gf 11	391356076293501	39.23216667	-76.49255556	12.72	-5.50
CH Bc 75	383645077062401	38.61302778	-77.10594444	123.77	-78.17
CH Bc 77	383644077055501	38.61211111	-77.09933333	95.82	-78.58
CH Bc 78	383809077053401	38.63605556	-77.09238889	20.13	-78.39
CH Bd 52	383553077032401	38.59833333	-77.05611111	46.68	-74.03
CH Be 57	383706076575601	38.61777778	-76.96388889	211.48	-36.25
CH Be 73	383903076594302	38.65083333	-76.99541667	106	-35.83
CH Bf 166	383846076512001	38.64625000	-76.85561111	211	-16.65

Appendix 1e (continued)

Well number	USGS site identification number	Latitude (decimal degrees)	Longitude (decimal degrees)	Land surface elevation	Water-level altitude 2013
CH Bg 18	383621076462801	38.60574444	-76.77449167	187.16	-28.77
CH Cb 45	383255077121201	38.54858333	-77.20322222	29.19	-193.51
CH Cc 34	383441077063901	38.57844444	-77.11072222	41.01	-76.78
CH Ce 57	383250076584001	38.54725000	-76.97761111	192.68	-26.74
CH Ce 66	383445076551301	38.57880556	-76.91986111	179	-25.18
CH Da 18	382654077152501	38.44833333	-77.25644444	89.10	-11.98
CH Ee 96	382151076580901	38.36434167	-76.96745278	22.16	-31.05
HA Dd 89	392529076180901	39.42483045	-76.30217972	98.23	30.16
HA De 126	392722076120501	39.45611111	-76.20111111	38.03	14.00
HA De 163	392645076123701	39.44583333	-76.21000000	29.05	10.65
HA De 181	392606076145801	39.43510856	-76.24912239	11.34	3.75
HA De 183	392606076145803	39.43510856	-76.24912239	11.65	1.96
HA De 197	392819076130901	39.47205389	-76.21884372	18.21	6.18
HA De 250	392740076115401	39.46111111	-76.19805556	39	15.32
HA De 256	392808076111604	39.46888889	-76.18750000	40	19.20
HA Df 65	392950076095501	39.49758333	-76.16541667	82	50.70
HA Ec 11	392435076203301	39.40983023	-76.34218097	10.88	9.17
HA Ec 46	392408076210101	39.40233020	-76.34995895	22.35	7.13
HA Ed 47	392455076192101	39.41538590	-76.32218033	89.68	19.42
HA Ed 48	392455076192102	39.41538590	-76.32218033	90.38	29.51
HO Df 60	390830076473902	39.14166667	-76.79416667	210.68	164.61
PG Cd 28	385847076522501	38.97977778	-76.87361111	154.3	39.00
PG Cf 66	385745076445201	38.96275000	-76.74716667	149.29	-32.23
PG Cf 81	385745076445202	38.97088889	-76.72958333	116.57	-39.13
PG Fd 62	384309076511401	38.71955556	-76.85327778	227.85	-16.02
PG Hf 43	383300076411601	38.55003333	-76.68738611	44.17	-98.27
QA Eb 110	385751076171603	38.96427946	-76.28745430	13.21	-5.20

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A message to Maryland's citizens

The Maryland Department of Natural Resources (DNR) seeks to balance the preservation and enhancement of the living and physical resources of the state with prudent extraction and utilization policies that benefit the citizens of Maryland. This publication provides information that will increase your understanding of how DNR strives to reach that goal through the earth science assessments conducted by the Maryland Geological Survey.

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