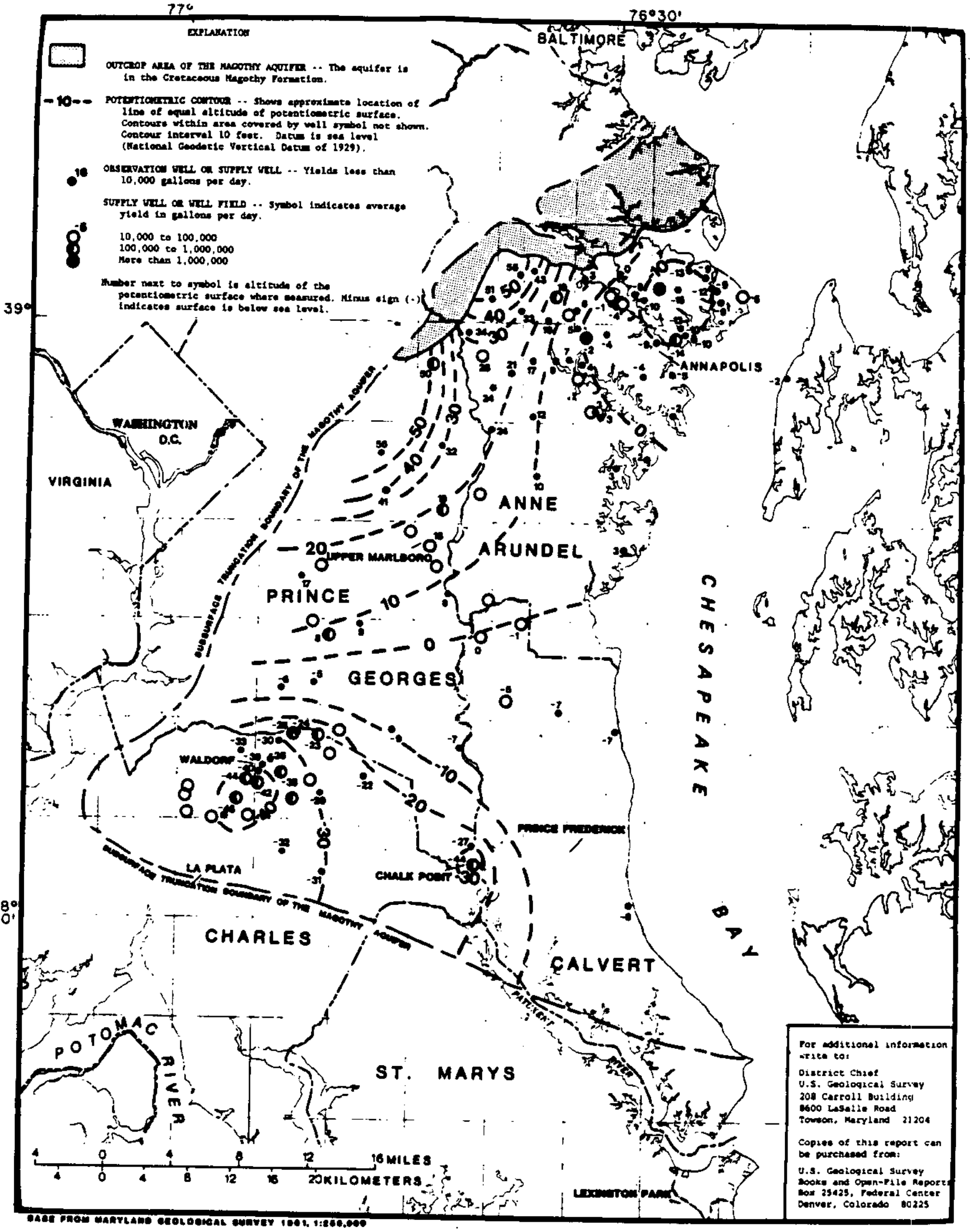
Despite these effects observed in the Patapsco aquifer, the pumping of the Patapsco production well does not appear to affect the wells screened in the overlying Magothy aquifer.

Water level data from an Aquia aquifer observation well are also presented in Figure VI-7. Although Chalk Point does not withdraw water from the Aquia aquifer, this aquifer is monitored to assess any effects of ground water withdrawal from the underlying Magothy and Patapsco aquifers. Figure VI-7 shows that the water level in the aquifer declined approximately 5 feet during 1985 and 1986. This magnitude of decline in the water level is similar to the declines observed in 1983 and 1984 (MD-PPRP 1986). However, Figure VI-7 indicates that these declines do not correlate with fluctuations in pumpage from the underlying Magothy or Patapsco aquifers. This, coupled with geologic data for the area which show no interconnections between the two aquifers (Mack 1976), indicates that the Chalk Point withdrawals do not influence the water levels in the Aquia aquifer. Instead, it is more likely that the decline observed in this well correlates with the regional decline of the potentiometric surface of the Aquia aquifer in southern Maryland (see Figure VI-5). Since the observation well shows no influence from the pumping at Chalk Point, it can be expected that the domestic wells in Eagle Harbor, which all tap the Aquia or other shallow aquifers, will not be affected by the Chalk Point ground water withdrawals.

Figure VI-10 indicates that the potentiometric surface of the Magothy aquifer in the vicinity of Chalk Point remains essentially unchanged since 1984 (MD-PPRP 1986). In the Waldorf area, however, the cone of depression of the Magothy aquifer has enlarged toward the southeast, indicating a slight decline of water levels in this area.

Figure VI-11 is a map of the difference between the potentiometric surfaces of the Magothy aquifer of the fall of 1975 and the fall of 1986. During this period, water levels declined at least 12 feet in the immediate area of Chalk Point and up to 40 feet in the Waldorf area. It appears that the withdrawals in the Waldorf area between 1975 and 1986 had a much greater effect on the water levels in the Magothy aquifer than did the withdrawals at Chalk Point. In fact, PEPCO's recent decrease in pumping of the Magothy aquifer may eventually lead to some recovery of the Magothy potentiometric surface at Chalk Point, thus further



EXPLANATION

▨ OUTCROP AREA OF THE MAGOTHY AQUIFER -- The aquifer is in the Cretaceous Magothy Formation.

—10— — POTENTIOMETRIC CONTOUR -- Shows approximate location of line of equal altitude of potentiometric surface. Contours within area covered by well symbol not shown. Contour interval 10 feet. Datum is sea level (National Geodetic Vertical Datum of 1929).

●16 OBSERVATION WELL OR SUPPLY WELL -- Yields less than 10,000 gallons per day.

SUPPLY WELL OR WELL FIELD -- Symbol indicates average yield in gallons per day.

○-6 10,000 to 100,000
◐ 100,000 to 1,000,000
● More than 1,000,000

Number next to symbol is altitude of the potentiometric surface where measured. Minus sign (-) indicates surface is below sea level.

For additional information write to:

District Chief
U.S. Geological Survey
208 Carroll Building
8600 LaSalle Road
Towson, Maryland 21204

Copies of this report can be purchased from:

U.S. Geological Survey
Books and Open-File Reports
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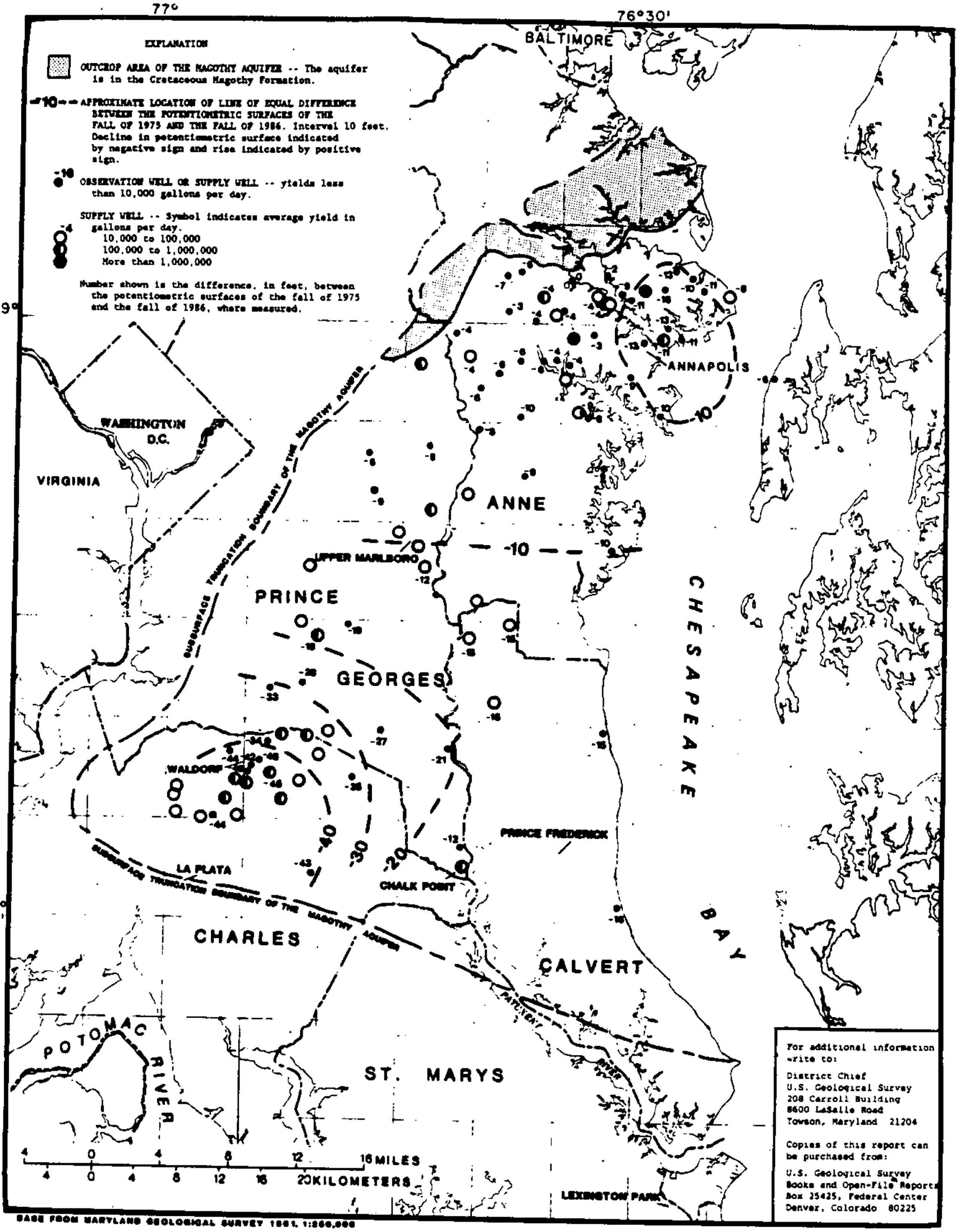
Denver, Colorado 80225

BASE FROM MARYLAND GEOLOGICAL SURVEY 1961, 1:250,000

Figure VI-10. Potentiometric surface of the Magothy aquifer in southern Maryland during fall of 1986

Prepared by: Frederick K. Mack, David C. Andreasen, Stephen E. Curtin, and Judith C. Wheeler
In cooperation with: Maryland Geological Survey and Maryland Power Plant Research Program
United States Department of the Interior Geological Survey
Water Resources Investigation Report 87 - 4216



EXPLANATION

▨ OUTCROP AREA OF THE MAGOTHY AQUIFER -- The aquifer is in the Cretaceous Magothy Formation.

-10-- APPROXIMATE LOCATION OF LINE OF EQUAL DIFFERENCE BETWEEN THE POTENTIOMETRIC SURFACES OF THE FALL OF 1975 AND THE FALL OF 1986. Interval 10 feet. Decline in potentiometric surface indicated by negative sign and rise indicated by positive sign.

● -10 OBSERVATION WELL OR SUPPLY WELL -- yields less than 10,000 gallons per day.

SUPPLY WELL -- Symbol indicates average yield in gallons per day.
○ 10,000 to 100,000
◐ 100,000 to 1,000,000
● More than 1,000,000

Number shown is the difference, in feet, between the potentiometric surfaces of the fall of 1975 and the fall of 1986, where measured.

For additional information write to:

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Towson, Maryland 21204

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Books and Open-File Report
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Denver, Colorado 80225

BASE FROM MARYLAND GEOLOGICAL SURVEY 1961, 1:250,000

Figure VI-11. Difference between the potentiometric surfaces of the Magothy aquifer in fall of 1975 and fall of 1986 in southern Maryland

Prepared by: Frederick K. Mack, David C. Andreasen, Stephen E. Curtin, and Judith C. Wheeler
In cooperation with: Maryland Geological Survey and Maryland Power Plant Research Program
United States Department of the Interior Geological Survey
Water Resources Investigation Report 87 - 4217

reducing the effect of the Chalk Point withdrawals on the Magothy aquifer. Furthermore, it should be emphasized that the declines in the Magothy aquifer have not approached the critical stage since there is more than 400 feet of hydraulic head left in the aquifer.

- Morgantown Power Plant (PEPCO)

The Morgantown Power Plant (see Figure VI-1 for location) pumps ground water from the Patapsco aquifer using four production wells with an average total depth of 1,100 feet. Water level data and pumping rates for this facility from 1975 through 1986 are presented in Figure VI-12. Overall, pumping rates decreased slightly from an average rate of 0.66 mgd in 1983 and 1984, to 0.61 mgd in 1985 and 0.62 mgd in 1986. As a result of the reduced withdrawal, the "monthly low" water levels appear to show some recovery during part of 1985 and 1986. However, a similar trend is not evident in the "monthly high" water levels.

Figure VI-13 illustrates the effects of pumping at Morgantown on a well located approximately one mile north of the power plant. This production well (Ch-Ee 91) was completed with three screened intervals at depths between 1000 and 1096 feet. Continuous water level measurements were obtained from this well by MGS for a brief period (May 1984 through August 1985) between the time the well was drilled and the time it was placed in operation. The close correlation between the water levels measured in the Morgantown power plant observation well (Ch-Ee 70) and well Ch-Ee 91 clearly demonstrates that pumping at Morgantown influences the ground water gradients in the Patapsco aquifer at least a mile away.

Several large municipal well users (>0.1 mgd) located in the towns of Waldorf, La Plata, St. Charles, and Indian Head, as well as other commercial users located throughout Charles County, withdraw ground water from the same Patapsco aquifer zone as the PEPCO wells. Water level drawdown for this Patapsco aquifer zone has been predicted using calculations assuming worst-case pumping conditions for both existing and requested ground water appropriations (WRA 1984). Based upon these calculations, a water level decline of as much as 150 feet was estimated for one observation well in the county over the next 100 years. However, this magnitude of decline is reasonable in view of the existing 850 feet of total available drawdown and WRA management policy limiting use to a

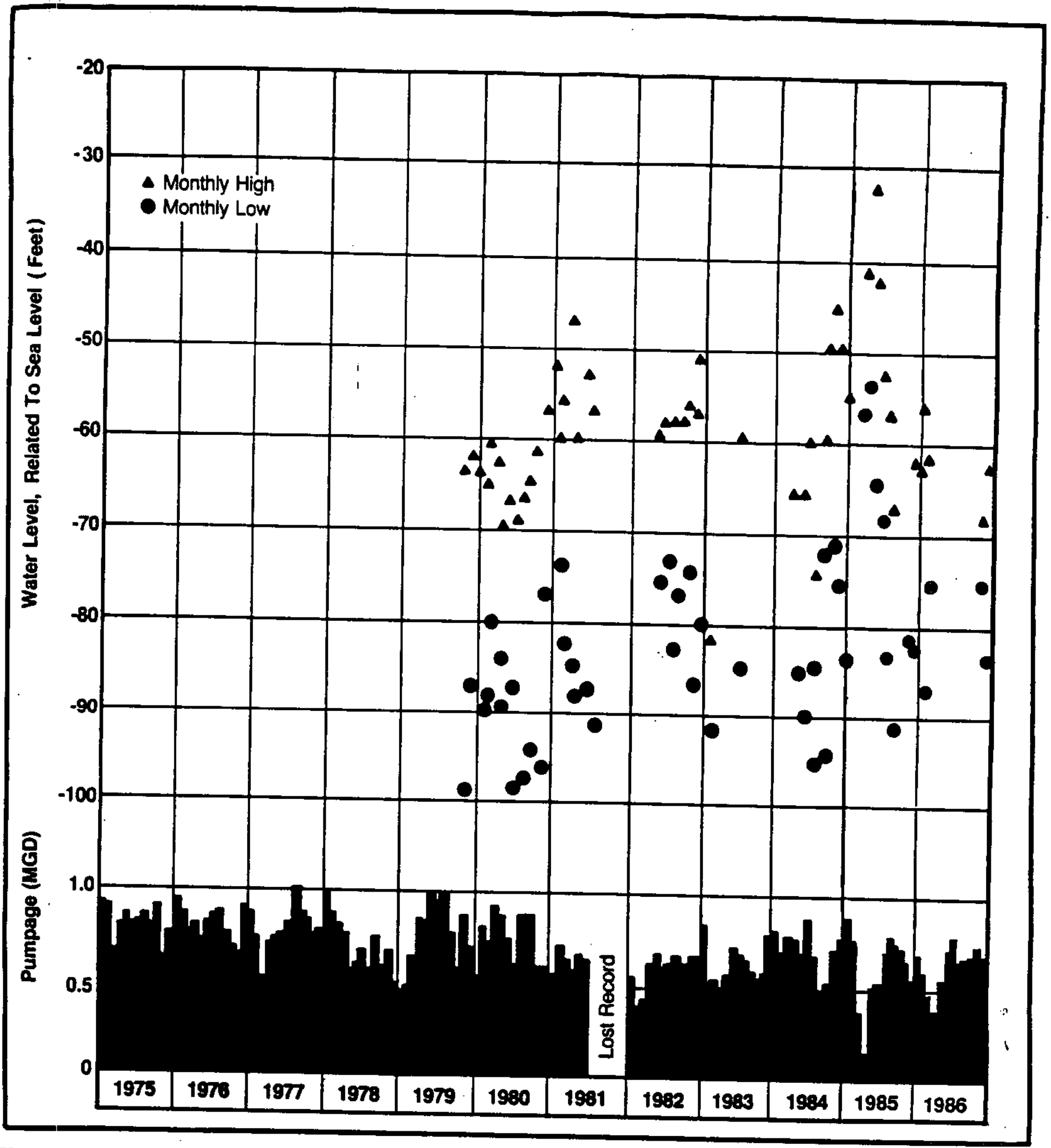

Figure VI-12. Ground water pumpage and water levels in observation well Ch-Ee 70 at the Morgantown Power Plant from 1975 through 1976

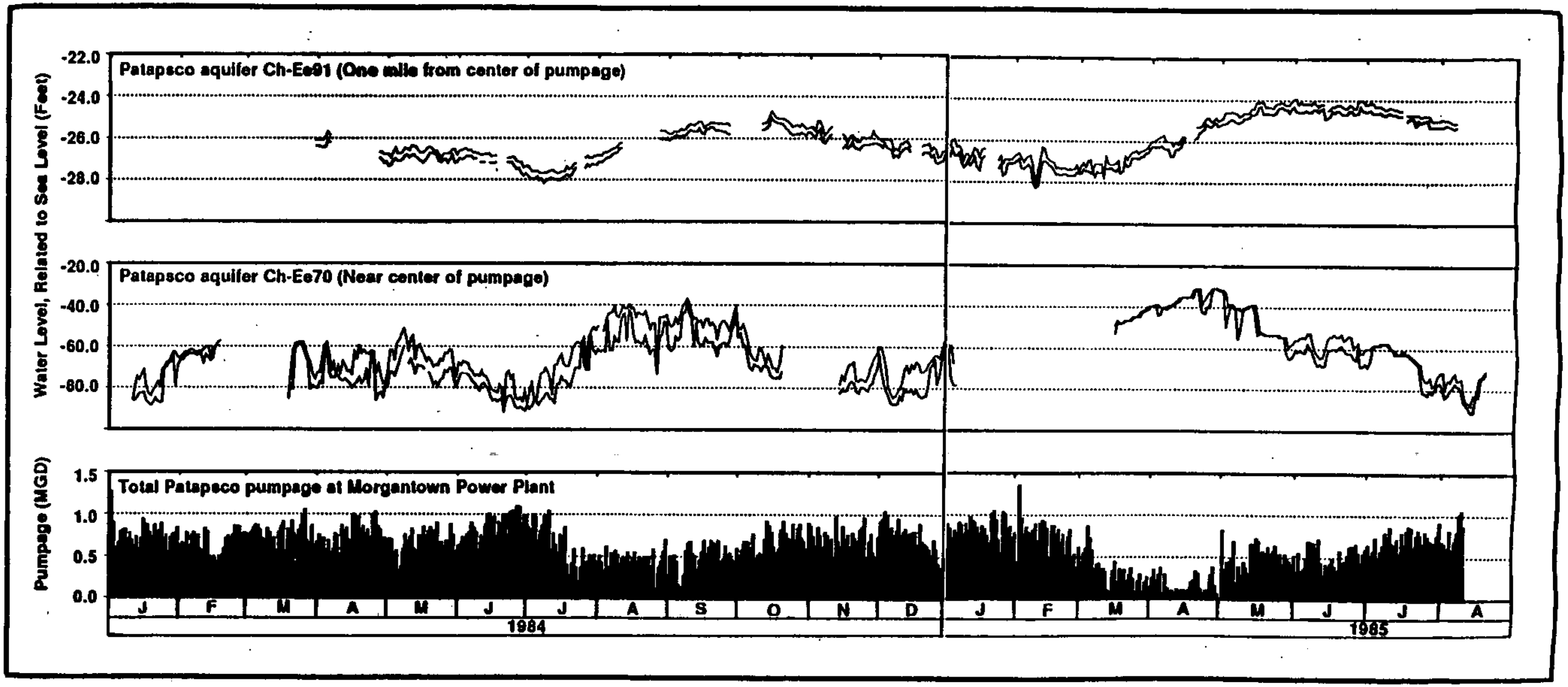

Figure VI-13. Pumpage and daily high and low water levels at the Morgantown Power Plant (January 1984 - August 1985) maximum of 80 percent of available drawdown. Subsequently, it can be concluded that PEPCO and any other current or proposed user should be able to utilize the Patapsco aquifer without creating an unacceptable impact on the aquifer in the next 100 years.

- Vienna Power Plant (DP&L)

Since 1979, the Vienna Power Plant (see Figure VI-1 for location) has obtained ground water from the unconfined Pleistocene age Columbia Group aquifer. Prior to 1979, water was also withdrawn from a deeper confined aquifer in the Miocene age Chesapeake Group (Figure VI-14). Ground water is currently obtained from one production well screened at a depth of 54 feet.

Figure VI-14 shows the monthly ground water withdrawal at the Vienna plant during the period from 1975 through 1986. This figure illustrates the effects of reduced pumping at Vienna which resulted from the retirement of Units 5 through 7 in 1980.

The average withdrawal rate at the Vienna plant was 0.023 mgd in 1985, and 0.028 mgd in 1986. For comparison, average withdrawal rates for 1983 and 1984 were approximately 0.028 mgd and 0.032 mgd, respectively. The Vienna facility continues to pump considerably less ground water than the maximum rate of 0.1 mgd allocated by their WRA permit. Since the Vienna facility has such a low withdrawal rate from the Columbia aquifer, the impacts from this ground water withdrawal on nearby wells or the regional water levels in the aquifer are negligible.

Summary of Ground Water Withdrawal Impacts

The Calvert Cliffs, Chalk Point, Morgantown and Vienna power plants rely on ground water resources from the Aquia, Magothy, Columbia, and Patapsco aquifers to supply high quality water needed for plant operation. In 1985 and 1986, these four facilities combined withdrew an approximate average of 1.8 mgd from these four aquifers. Although this amount represents less than one percent of the ground water use throughout the State, these facilities have contributed to long-term impacts on ground water resources in some of the Coastal Plain

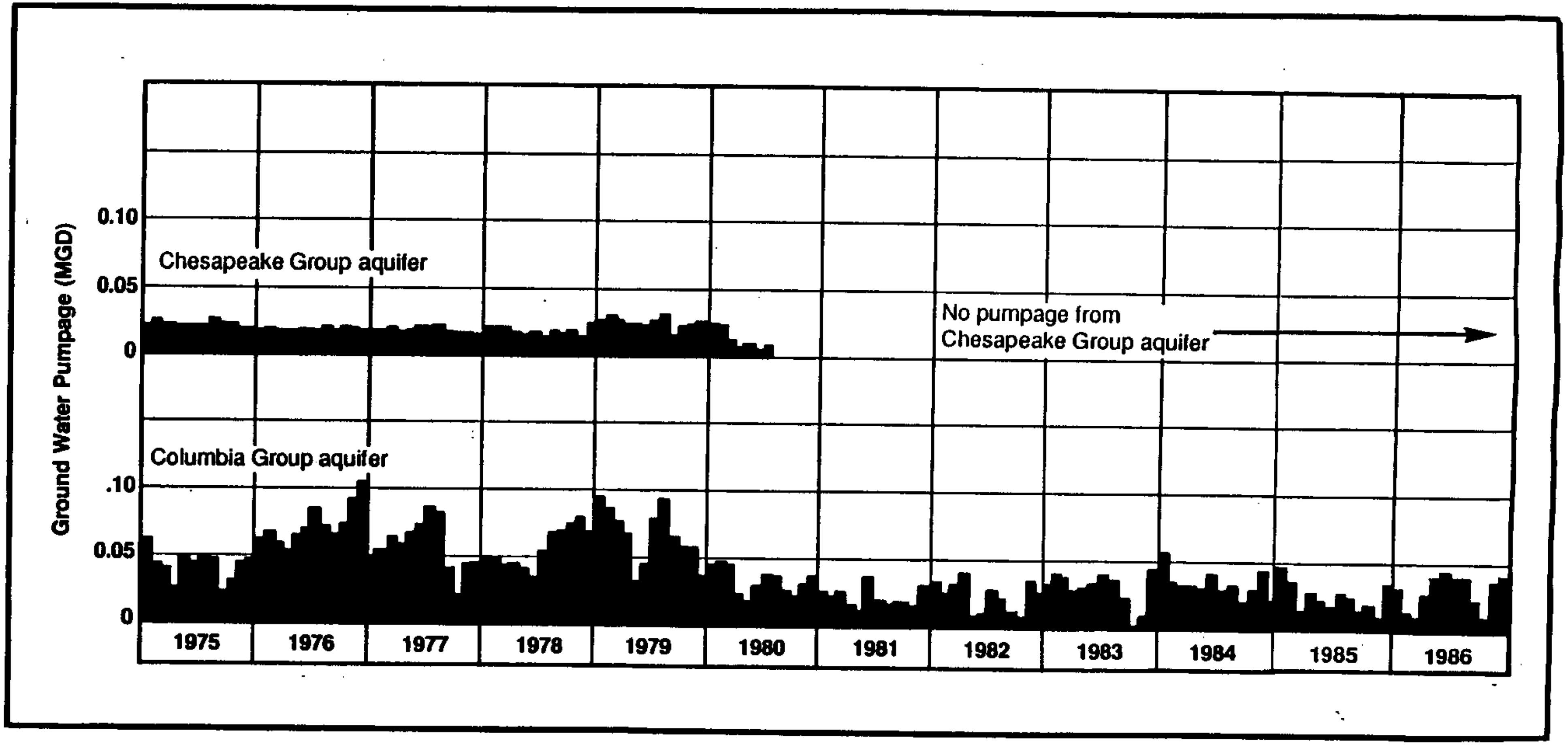

Figure VI-14. Ground water pumpage at the Vienna Power Plant, by aquifer, from 1975 to 1986 aquifers. The major impact from ground water withdrawal has been the contribution of the Calvert Cliffs and Chalk Point power plants to overall declining water levels in the Aquia and Magothy aquifers. Despite the water level declines observed to date, the potentiometric surfaces of these aquifers indicate that hydraulic heads are still adequate to assure continuous water supplies at current pumping rates for many years. Furthermore, should these power plants significantly reduce pumping or cease pumping, the water levels in these aquifers are expected to recover quickly.

WRA is in the process of implementing a solution to the declining water levels in the Aquia and Magothy aquifers by limiting their industrial and commercial use and increasing the development of the Patapsco aquifer (Miller 1987). This approach, in fact, has already shown positive results at Chalk Point. In 1986, PEPCO's shift in withdrawal from the Magothy to the Patapsco has already caused the water levels in the Magothy to rise. This shift in overall aquifer usage reduced the stress on the heavily utilized Magothy without affecting power plant requirements for large volumes of high quality water. Increased use of such management practices will become necessary in the future if ground water demands in southern Maryland continue to increase.

In conclusion, the primary impact of ground water withdrawals at Maryland power plants is their contribution to overall declining water levels throughout the Aquia and Magothy aquifers. Although this decline is significant, it does not appear to have adversely affected other ground water users.

B. Ground Water Quality Degradation

Dynamics of Solute Migration

Constituents released from power plant fuel, combustion by-products, and other waste sources can become dissolved in ground water (solutes) and degrade water quality in the underlying aquifers. In order to evaluate the potential impacts from ground water quality degradation, it is necessary to understand the mechanics of solute transport from the source area downward to the aquifer. The process of solute transport is best described by breaking it down into three separate components: the leaching of constituents from stored or landfilled material, vertical migration through the unsaturated zone, and lateral transport through the aquifer. The sequential process of solute transport through several Coastal Plain aquifers is illustrated in Figure VI-15.

Solutes can be leached from several sources at most power plants. These sources include: fuel, such as oil or coal; oil and coal combustion by-products, such as oil ash, fly and bottom ash, and flue gas desulfurization sludge; and other low-volume utility wastes such as boiler wash waters, wastewater treatment sludges, and demineralizer regenerates. In many cases these materials are stored or landfilled without liners or covers. Consequently, precipitation infiltrates through the material and mobilizes soluble chemical species adsorbed onto its surfaces. As precipitation infiltrates through the material, the concentrations of the chemical species increase, forming a leachate solution.

The chemical species common to power plant leachate are certain major and trace elements or heavy metals, which can be toxic to humans or wildlife even in dilute solutions. The heavy metals commonly include cadmium, mercury, lead, nickel and chromium. The trace constituents commonly found at power plant sites that are of environmental concern include arsenic, selenium, molybdenum, chlorine, fluorine, and sulfate.

Should leachate seep into the subsurface, the solutes must first pass through the unsaturated zone extending from the ground surface to the surface of the water table. In the unsaturated zone, solutes may be removed from the liquid by interaction with the soil/rock matrix. The capacity of these materials to immobilize (attenuate) leachate-related constituents will depend upon their physical and chemical properties such as texture, permeability, cation exchange capacity, and pH. Extensive attenuation reactions in the unsaturated zone may prevent or at least mitigate potential adverse impacts to ground water quality.

Once solutes enter the aquifer, a three-dimensional plume expands vertically and laterally following the directions of ground water flow. Solute migration rates depend upon the ground water velocity through the aquifer. Additional attenuation reactions as well as dilution from clean ground water sources can minimize the extent of the solute plume.

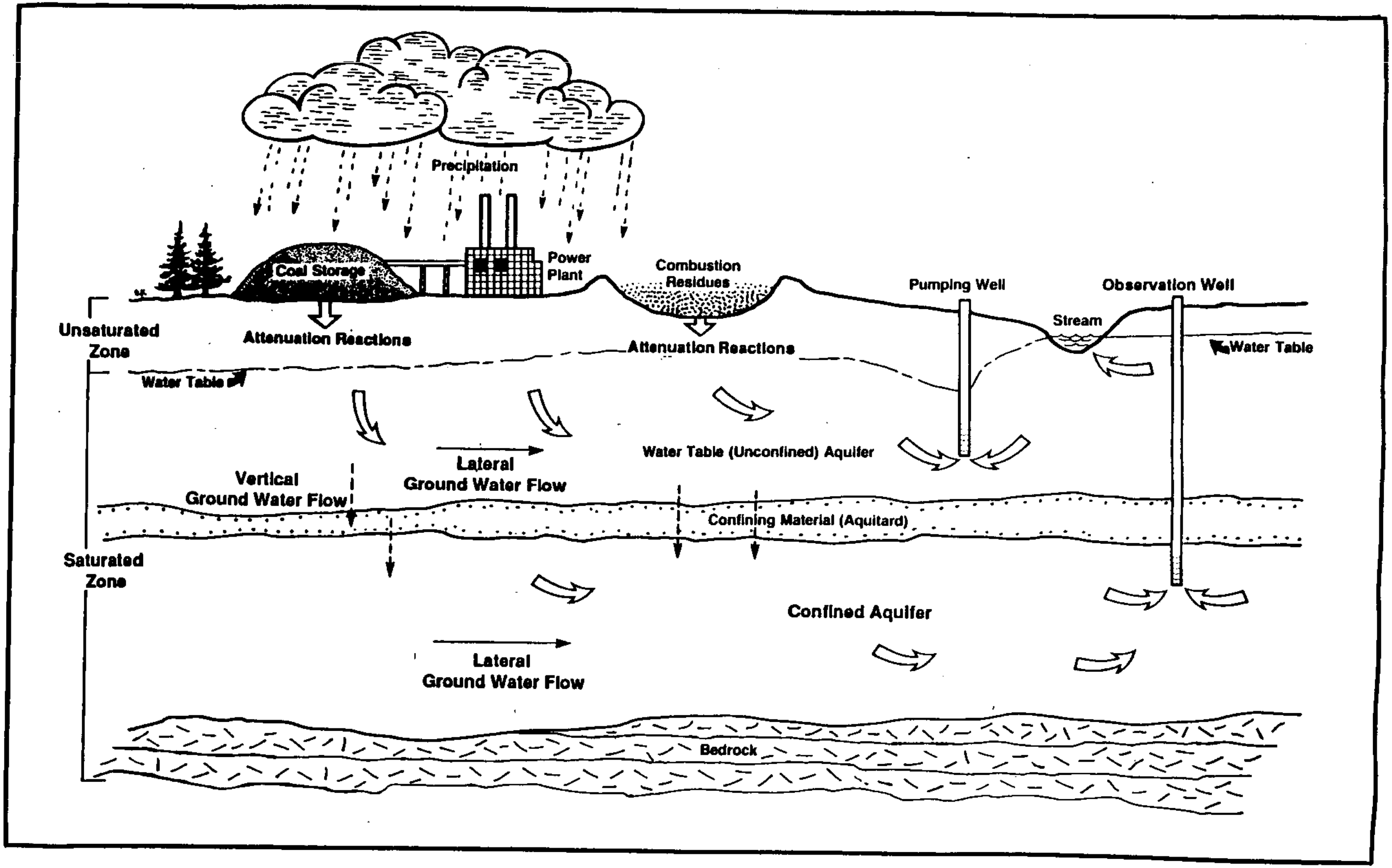

Figure VI-15. Solute transport through the Coastal Plain aquifers

Potential impacts which may result from solutes entering an aquifer are two-fold: (1) water quality in downgradient supply wells may be degraded; (2) the solutes may discharge into surface waters, affecting aquatic life. Once the water quality in an aquifer is degraded, it may be very difficult to remediate, forcing the development of alternate water supplies or installation of treatment systems to reduce solute concentrations prior to water use.

Ground Water Quality Degradation From Fuel Sources

Currently there are seven coal-fired steam generating power plants in Maryland, which collectively burned about eight million tons of coal in 1986. In addition, six oil-fired steam generating plants collectively burned about 4.7 million barrels of oil during the same period (EIA 1987). Mismanagement or mishandling of either of these fossil fuels can result in the release of organic or inorganic solutes into the subsurface, which could possibly impact ground water quality.

- Coal Pile Leachate

Maryland power plants store large quantities of coal by placement on the ground surface without cover. When these piles become exposed to rain water, acidic solutions (leachates) are formed in the runoff. Pyrite in stockpiled coal oxidizes to iron sulfate under the aerobic conditions of storage. In addition to the release of iron and sulfate and the concomitant depression of pH, coal pile runoff generally contains various trace elements such as arsenic, cadmium, chromium, cobalt, copper, manganese, mercury, nickel, selenium, and zinc. However, since the Maryland coal-fired power plants use low-sulfur coal (sulfur content of less than three percent), the sulfate concentrations in Maryland power plant coal pile leachates are less severe than those derived from high-sulfur coals.

Recently the Power Plant Research Program conducted preliminary environmental assessments at the seven coal-fired power plant sites to evaluate the potential for ground water quality degradation. In general, the findings indicate that most of the sites are providing some type of protection to the underlying ground water systems (Keating 1988). All of the sites, with the exception of P.E.'s R.P. Smith site, collect and treat their coal pile runoff. The State of Maryland is in the process of requiring that the runoff collection and treatment system at R.P. Smith be upgraded before the National Pollutant Discharge Elimination System (NPDES) permit is renewed. Otherwise, it was determined that the three BG&E sites appear to be providing good protection by using clay liners under the piles and in the runoff collection systems. Although PEPCO has not installed clay liners under its piles, ground water monitoring wells have been installed at the Chalk Point and Dickerson Plants to monitor downgradient water quality. PEPCO's Morgantown site affords less protection against ground water quality impairment than the other two PEPCO sites, because it lacks both a clay liner and a ground water monitoring system to provide early detection of ground water quality degradation. Results of this study also indicate that an accurate assessment of ground water quality conditions can only be made after the collection and evaluation of data defining the ground water quality beneath the coal piles. Only such data can indicate whether potential problems are being realized.

- Petroleum Products

Petroleum products pose a threat to ground water quality during transportation to or storage at power plants. Oil is transported to plants via pipelines, tank trucks, barges, ships, or railcars. Accidents, such as valve miscues, loading/unloading spillage, and equipment leaks, are all potential sources for ground water quality degradation. Once delivered, the oil is stored in above-ground or buried tanks, both of which have potential to leak. In addition to fuel oil, power plants use transformer oils, lubricating oils, and gasoline during their day to day operations.

Contamination of ground water by petroleum products is a slightly different process from that of solute migration. The major difference is that petroleum hydrocarbons are immiscible in water. Consequently, oil migrates almost exclusively as a separate phase through the unsaturated zone as well as in the aquifer. Once the oil reaches the surface of the water table, it will spread laterally on top of the water table surface, following ground water flow directions. However, over time, certain hydrocarbon components that make up petroleum products (e.g. benzene) are slightly soluble in water. Consequently, if the oil remains on the water table surface for long periods of time, solubilized hydrocarbon concentrations may increase to form a plume of contamination within the aquifer.

Very little information is available that documents the impact of power plant fuel oil on Maryland's ground water resources. The oil spill records of the Maryland Department of the Environment (MDE) Oil Control Division were reviewed to determine the volume and frequency of oil spills associated with the electric utilities during 1985 and 1986. These records indicate that most of the oil spills resulted from accidents associated with transformers. These cases involved vehicular accidents, transfer spills, or electrical explosions and typically resulted in the spillage of low volumes ranging from 2 to 90 gallons. In some cases, the transformer oil contained PCBs; however, according to available MDE records, these cases were immediately remediated. Besides the transformer accidents, there were several pipeline leaks and the spillage of hydraulic oil. In all the investigated cases, spills were remediated to the satisfaction of the Oil Control Division personnel.

The Oil Control Division files also indicate that the electric utilities have conducted extensive underground tank testing in response to the requirements of the Maryland Oil Pollution Control law (Maryland Natural Resources Code Annotated, Title 8, Subtitle 14). Oil Control Division records indicate that underground tanks containing petroleum fuels at several power plant sites failed leak testing. In these instances the tanks were removed or repaired and, if necessary, the electric utility proceeded with proper remediation. No data describing testing of above ground tanks is available at this time. In conclusion, no significant ground water contamination associated with fuel oil storage has been identified at Maryland power plants.

Ground Water Quality Degradation From Combustion By-Product Landfills

- **Coal Combustion By-Products**

In the process of coal combustion and cleaning the resulting flue gases, several by-products are formed. These by-products include fly ash, bottom ash, slag and flue gas desulfurization (FGD) sludge. Currently, some of the combustion by-products produced by the seven coal-fired plants operating in Maryland are sold, but most are landfilled at sites owned by the electric utilities. To date, no desulfurization scrubbers have been installed at Maryland power plants, and therefore no FGD sludge has been generated or landfilled in Maryland. Hence, it will not be discussed further in this chapter.

Typical laboratory leachate test data generated using the Environmental Protection Agency (EPA) Extraction Procedure (EP) Toxicity Characteristic Test for some Maryland power plant by-products are presented in Table VI-1. The EP test uses the National Interim Primary Drinking Water Standards as the toxicity thresholds for individual constituents, and combines them with a generic dilution/attenuation factor (100) to calculate regulatory concentration levels for individual toxicants (i.e., 100 times the drinking water standards). For the by-products to be considered hazardous by the EP test, one or more of the constituents in the leachate extract must exceed EPA's test standards.

Constituent concentrations for trace metals in the Maryland ashes presented are far below the EP test standards, and most are even below the drinking water standards. However, ash leachates also contain constituents not included in the EP test such as iron, manganese, chloride, sulfate, and nitrate, all of which also have the potential to degrade ground water quality, albeit with less toxic effects. Furthermore, the classification or non-classification as a hazardous substance by laboratory methods does not determine final environmental or health impacts. Site-specific factors may either mitigate or enhance the flow of any substance through environmental pathways.

The Power Plant Research Program has conducted environmental assessments at presently operating and closed coal ash sites to evaluate the effectiveness of their design and operation in protecting the environment. The results of several of these studies were reported in the 1984 and 1986 CEIRs. These studies generally indicated that ground water quality has been impaired at several sites, but that these impacts are localized and minimal.

- Oil Ash

Ash content in fuel oil generally ranges between 0.10 percent and 0.15 percent by weight, although it can reach as high as 0.20 percent. Nevertheless, the maximum amount of ash produced by an oil-burning power plant is less than one

Table VI-1

Metals concentration in leachate extracted from fly ash from some Maryland power plants

Constituent (mg/l)	BG&E's H.A.Wagner Plant (a) (3 Samples)	BG&E's Brandon Shores Plant (b) (2 Samples)	PEPCO's Morgantown Plant (c) (3 Samples)	PEPCO's Chalk Point Plant (c) (3 Samples)	EPA Drinking Water Standards
Arsenic	<0.001-0.004	0.048-0.87	0.072-0.14	0.56-0.71	0.05
Barium	<0.2-1.0	0.320-0.347	2.43-2.77	2.98-3.05	1.0
Cadmium	<0.02	0.0007-0.0041	0.004-0.0076	<0.0027-0.0076	0.01
Hexavalent Chromium	<0.05	<0.002	<0.01	<0.01	0.05
Fluoride	0.77-0.94	<0.1-0.1	20.0-28.0	14.2-30.0	1.4-2.4
Lead	<0.1	<0.001-0.001	<0.014	<0.014	0.05
Mercury	<0.0005	<0.0002	<0.000094	<0.000094	0.002
Nitrate-N	0.01-0.45	0.04-0.09	0.3-2.8	0.4-5.8	10
Selenium	<0.003-0.003	0.004-0.006	0.019-0.024	0.096-0.18	0.01
Silver	<0.03	<0.0002	<0.0046	<0.046	0.05
Chloride	2.1-10.4	13.1-20.0	<0.08-0.11	<0.08	250
Copper	0.19-0.21	0.221-0.224	0.034-0.096	0.028-0.10	1.0
Iron	0.05-0.1	0.006	0.017-0.28	<0.0085	0.3
Manganese	0.09-0.10	0.039-0.086	0.16-0.19	0.14-0.16	0.05
Sulfate	385-420	84-145	182-211	252-261	250
Zinc	0.24-0.27	0.19-0.34	0.28-0.35	0.11-0.33	5.0

(a) Reported in BG&E (1981).
(b) Reported in letter from Davis (1987a).
(c) Reported in Dames and Moore (1981).

percent, on an unit-energy basis, than that from a coal-fired plant. Consequently, oil-fired plants produce much smaller quantities of ash than coal-fired plants.

It is important to note that the composition of oil ash is extremely variable due to the compositional differences in oil. In general, oil ash consists primarily of oxides and salts of cadmium, nickel, vanadium, zinc, and iron, plus organometallic compounds and carbon (soot), the latter being a possible source of hydrocarbon compounds. Sulfuric acid and traces of other metals may also be present. Oil ash subjected to EP tests has yielded trace concentrations of arsenic, barium, chromium, cadmium, lead, mercury, selenium, and silver (Summers *et al.* 1983).

Final disposition methods for oil ash varies among the three major Maryland electric utilities. BG&E spreads what little oil ash is collected onto its coal piles where it is subsequently reburned and collected with coal ash (Davis 1987b). DP&L only produces 30 to 60 tons of oil ash a year at the Vienna plant and sells all of the ash to a company that recovers vanadium (Molzahn 1987). PEPCO currently does not burn oil at any power plant in Maryland, and hence does not generate oil ash in the State at this time. During previous periods, when PEPCO did burn oil at Chalk Point and the Benning Road facility in Washington, D. C., 100% of the oil ash generated was sold. Because of the generally low-volume nature of oil ash and the disposition practices used in Maryland, it is not anticipated that the oil ash will cause any detectable ground water quality impacts in Maryland.

Ground Water Quality Degradation from Low-Volume Waste Sources

Low-volume utility wastes include a variety of streams from coal-, oil-, and gas-fired boilers, including wastewaters, washwaters, and solid residual from aqueous waste streams. The handling, treatment, and disposition of each of these waste streams varies from plant to plant. In many cases, low-volume liquid wastes are treated in wastewater treatment plants, and the sludge generated from this treatment is stabilized with high-volume material (fly ash, bottom ash, and slag), and codisposed in landfills. Conscientious management of these low-volume wastes should prevent ground water impacts. However, in the event of mismanagement or unforeseen circumstances, the principal hydrogeological concern will be either leachates derived from the solids, or the wastewaters themselves, entering the ground water system.

The general characteristics of several low-volume power plant wastes were studied by Holocombe *et al.* (1985). Depending on many factors, the most important of which is the combustion technology used at the plant, many different low-volume waste streams can be generated at power plants. The characteristics of six common low-volume wastes generated at Maryland power plants are summarized below.

- Waterside Washwater - Washing of the waterside of the boiler tubes is performed with dilute acids or chelating agents to remove scale and corrosion deposits on tubing walls. This cleaning is performed every two to five years to improve heat transfer from the boiler to the piping carrying the steam. Waterside washwater typically contains high concentrations of metal oxides (copper, iron, and nickel) and alkaline constituents (calcium carbonate, sulfates, and other salts).

- Fireside Washwater - The fireside of the boiler tubes is sometimes washed with water or alkaline solutions to remove ash and soot. This is generally done at the same time that the waterside washing is performed. The washwater typically contains suspended ash and soot, and elevated levels of dissolved iron, nickel, chromium, vanadium, zinc, or other metals associated with oil and coal ashes.

- Wastewater Treatment Liquids and Sludges - Low-volume streams are often routed to an equalization basin where they undergo chemical treatment. As a result, the solid or semi-solid waste resulting from this chemical treatment is enriched in alkaline materials and metals including sulfate, chloride, calcium, iron, magnesium, sodium, copper, and nickel.

- Cooling Tower Basin Sludge - Airborne soil and dust from the plant area may become trapped in the basins of cooling towers. The soil-like material typically contains aluminum, calcium, and iron.

- Demineralizer Regenerant - Makeup water for use in boilers is often polished using ion exchange demineralization. Fixed-bed ion exchangers require daily to weekly regeneration, typically with acidic and basic solutions. Because regenerant streams can be corrosive, they are often mixed with other waters. The major ions found in these streams are calcium, sodium, and sulfate.

- Pyrite Rejects - Pyrite rejects are produced from preparation of coal prior to burning. In the low-sulfur coals burned at Maryland power plants, pyrite constitutes a small percentage of the coal by weight. Leachates from pyrite rejects are similar in composition to coal pile runoff. Generally, pyrite rejects are codisposed with other waste or combustion by-product streams to prevent the formation of a low pH leachate. For example, PEPCO codisposes pyrite rejects with wastewater treatment sludge.

Holocombe *et al.* (1985) collected samples from the six waste streams discussed above and tested these samples using the EP test. Of the low-volume waste samples tested, only the untreated waterside washings of boiler tubes exceeded the EP Test allowable limits for toxicity. Chromium, calcium, and lead were present in these wastes at elevated concentrations. The remaining low-volume waste samples had low concentrations of extractable metals under the EP test.

In Maryland, low-volume power plant wastes appear to be handled in an environmentally sound manner. Both BG&E and PEPCO operate wastewater treatment plants which are designed to capture wastewater streams from various plant sources and treat by pH adjustment and precipitation of dissolved metals before discharge. Furthermore, the National Pollutant Discharge Elimination System (NPDES) permit provides performance standards to ensure that these treatment systems discharge effluent that meets NPDES water quality requirements. PEPCO also uses what it has termed a "controlled storage area" located on the facility property for the final disposition of wastewater treatment sludge and pyrite rejects. Ground water monitoring wells are in place in these areas to provide early detection of any leachate releases. BG&E, on the other hand, disposes of the wastewater treatment sludges at privately owned and operated landfills.

To date, no ground water quality impacts from low-volume wastes have been identified at Maryland power plant sites. The low-volume nature of these wastes coupled with sound management practices appear to minimize potential ground water quality degradation from them.

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CHAPTER VII

TERRESTRIAL IMPACT

Power plant construction and operation can affect terrestrial ecosystems in diverse ways through a variety of potential modes. Direct impacts result from the placement of the facility and the construction of ancillary facilities or supporting structures, such as transmission lines. A certain amount of the local terrestrial ecosystem is destroyed. The creation of right-of-way for transmission line towers may modify portions of the existing ecosystem and change their form. The indirect modes of impact of plant construction and operations tend to produce more subtle effects. Such effects are often difficult to quantify or to distinguish from the effects of other factors. Indirect modes of impact include surface water runoff from fly ash storage piles and particulate and gaseous emissions from the plant.

Figure VII-1 provides a diagrammatic characterization of the various potential modes of impact of power plants on terrestrial ecosystems. Elements of terrestrial ecosystems that are exposed to impacts include vegetation and vertebrate and invertebrate organisms, whose sensitivity differs considerably by species and habitat type. In order to provide a comprehensive perspective of impacts on terrestrial ecosystems in Maryland, the ecosystems characteristic of different portions of the state will first be described. Categories of impacts will then be discussed, together with potential for impact. Many of the potential impact modes have not been studied in Maryland, and as a result cumulative impacts have not been quantified. This chapter therefore covers the information that is available on actual impacts, and discusses potential impacts on different elements of terrestrial ecosystems.

A. Geographical Provinces and Ecosystem Types

Maryland has great physiographic diversity, including portions of the eastern Coastal Plain, Piedmont and Appalachian provinces (Figure VII-2). These physiographic provinces comprise distinct associations of soils, geologic formations and topography. Maryland's diverse geography supports diverse native flora and fauna. It has approximately 2,400 species of native plants in the state, of which 800 species are potentially rare in the state (Norden *et al.* 1984). The

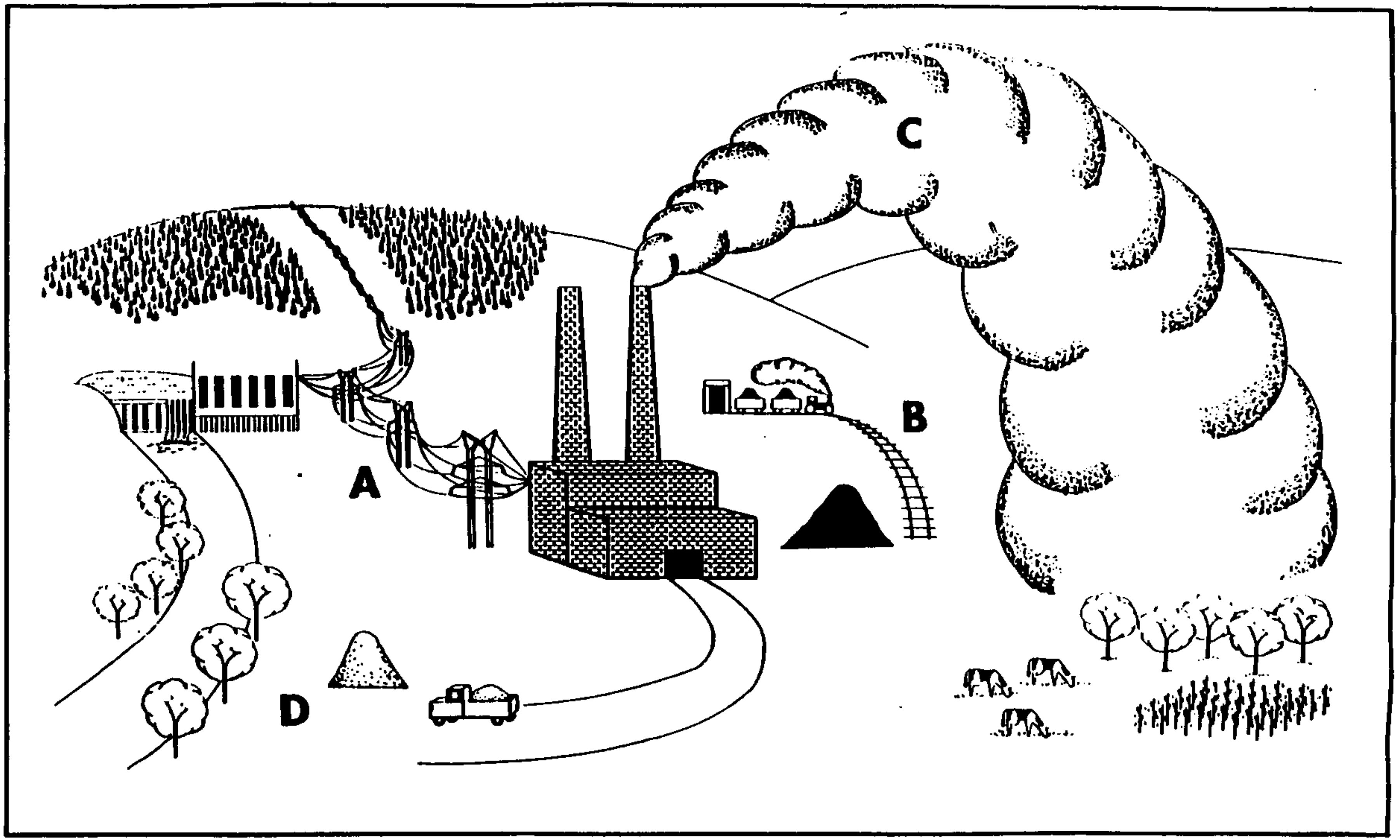

Figure VII-1. Modes of power plant impact on terrestrial ecosystems:
A. Elimination or modification of habitat
B. Mining, handling & storage of coal
C. Stack and cooling tower emissions
D. Disposal of power plant wastes

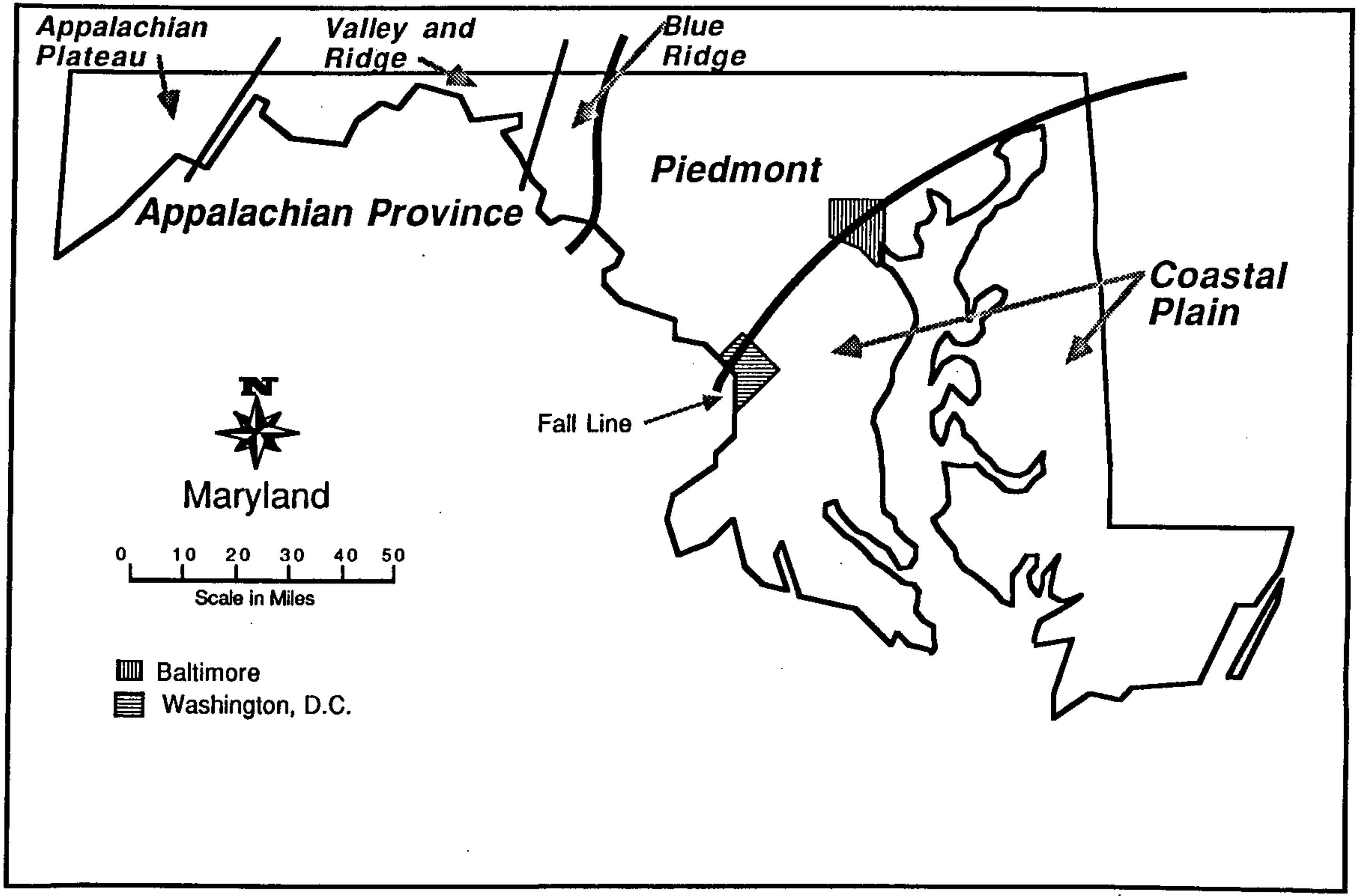

Figure VII-2. Maryland's five physiographic provinces

Maryland Department of Natural Resources (MD-DNR 1987) lists 8 of the 63 native species of mammals as endangered, threatened or in need of conservation. Similarly, 2 of the 108 species of native freshwater fish fall in one of those three categories, as do 5 of the 40 species of native amphibians, 3 of the 54 species of native reptiles, 17 of the 348 species of native birds, 12 of an unknown number of species of native invertebrates and 129 of approximately 2,000 species of plants. Seventeen species of animals and 138 species of plants have been extirpated from Maryland.

Human population is concentrated in the upper Coastal Plain and lower Piedmont, along the western shore of the Chesapeake Bay and in the Baltimore-Washington metropolitan corridor. These and other factors have greatly modified the terrestrial ecosystems of Maryland from primeval conditions. Forests older than 150 years are rare, and most are less than 100 years old. Disturbances to the native vegetation include clearing for agriculture, mining, lumbering, urbanization and industrialization (Brush *et al.* 1977).

Despite centuries of intense disturbance, geography still significantly determines the patterns of existing landscapes. Pronounced differences in substrates and hydrologic characteristics among the physiographic provinces are reflected in the distribution of species and biotic communities. The following paragraphs provide descriptions of the terrestrial habitats of Maryland in each major physiographic province.

Coastal Plain Province

The Coastal Plain encompasses nearly 5,000 square miles from the fall line to the Atlantic Ocean (Figure VII-2). Its topography is low and uniform, resulting in extensive floodplains and alluvial terraces. Substrates are unconsolidated sedimentary deposits overlying crystalline bedrock, and range from silts and clays to gravels. Because substrates are so heterogeneous, hydrologic conditions vary greatly from inundated mucks to well-drained gravels. Siltation across alluvial plains and along estuarine margins has formed numerous and extensive wetlands. Mean monthly precipitation ranges from 2.7 in. (February) to 5.4 in. (August), and mean monthly temperatures range from 36.1° F (February) to 77.3° F (July) (NOAA 1986).

The heterogeneous landscape of the Coastal Plain province is primarily due to the variety of its substrates and their hydrologies (Brush *et al.* 1977). Poorly drained soils (alluvial silts and mucks) and riparian plains support vegetation communities characterized by moisture-tolerant canopy species (bald cypress, sycamore, river birch, tulip poplar and basket oak). Drier sands, clays and loamy substrates support forest communities that include willow oak, loblolly pine, chestnut oak, blackjack oak and post oak. Extensive tidal marshes support characteristic grasses (e.g., *Spartina, Distichlis)* and shrubs (e.g., *Iva, Baccharus*), with loblolly pine communities on higher areas where fresh water lenses perch on the saline estuarine ground water. The northern and southern Coastal Plain support quite different vegetation communities. Northern Coastal Plain forests are composed of beech, dogwood, pignut and mockernut hickories, tulip poplar, black cherry, black locust and ironwood. Southern forests include loblolly pine; sweetbay magnolia; water oak, basket oak and willow oak; sweet gum; and holly. Bald cypress communities are restricted to the southern Coastal Plain, primarily on the Eastern Shore (Brush *et al.* 1977).

Several rare and sensitive plant communities exist in the Coastal Plain. Maryland has 307,000 acres (124,000 ha) of wetlands, most of which are tidal marshes. There are also several non-tidal swamps and bogs in the Coastal Plain region (Sipple and Klockner 1984) ranging in size from one to thousands of acres (Table VII-1). The smaller sites are quite sensitive to physical disturbance or perturbation of adjoining "buffer" habitats. The small watersheds associated with these tiny wetlands and the acidic, possibly nutrient-poor status of their substrates suggest that they may also be sensitive to runoff and chemical pollutants.

Piedmont Province

The Piedmont includes approximately 3,000 square miles of area extending from the fall line west to the Catoctin Mountains in Frederick County (Figure VII-2). The land is hilly throughout, with greater topographic relief in the west. Soils are mainly saprolitic, formed in place from the weathering of the underlying crystalline bedrock. Along the fall line, sedimentary deposits of sand and gravel predominate, and throughout the Piedmont there are well-developed floodplains. Soils are generally well- to moderately well-drained, due to the topographic relief. Mean monthly precipitation ranges from 2.7 in. in February to 4.6 in. in August, with an annual average of approximately 44 in. The range of mean monthly

Table VII-I

Unique wetland systems of Maryland (tidal and non-tidal)

Name	County	Acres	Type (1)
Severn Run Tributaries	Anne Arundel	3,000	T,N
Jug Bay	Anne Arundel	4,800	T,N
Eagle Hill Bog	Anne Arundel	320	T,N
South River Headwaters	Anne Arundel	9,500	T,N
Round Bay Bog	Anne Arundel	90	T,N
Sullivan's Cove Marsh	Anne Arundel	20	T
Deep Pond	Anne Arundel	350	T
Fresh Pond/Angle's Bog	Anne Arundel	200	N
Cypress Creek Cedar Swamp and Savannah	Anne Arundel	5	N
South Gray's Bog	Anne Arundel	2	N
Gunpowder Delta Marsh	Baltimore	1,350	T,N
Black Marsh	Baltimore, Harford	500	T
Zekiah Swamp	Charles, Prince Georges	17,800	T,N
Mattawoman Creek	Charles, Prince Georges	6,000	T,N
Broad/Hensen Creek Marsh	Prince Georges	200	T,N
Piscataway Creek	Prince Georges	2,450	T,N
Suitland Bog	Prince Georges	25	N
Chaptico Run	St. Mary's	1,050	T,N
Millpeck/Trent Hall Creek	St. Mary's	450	T,N
Battle Creek Cyprus Swamp	Calvert	125	N
Cove Point	Calvert	210	N
Bush Creek Marsh	Harford	300	T
Church Creek Marsh	Harford	300	T
Otter Point Creek marsh	Harford	900	T
Swan Creek Marsh	Harford	325	T
Big Marsh/Howell Point	Kent	850	T,N
Eastern Shore Potholes	Kent, Queen Anne's, Caroline	1-5	N
Pocomoke River	Somerset, Worcester, Wicomico	18,700	T,N
Potomac Shoreline Marshes	Montgomery	500	N
Finzel (Cranberry) Swamp	Garrett	100	N

Source: Sipple and Klockner 1984; MD-DSP 1981.
(1) T-tidal / N-non-tidal

temperatures is from 33.7°F in January to 75.4°F in July, with an annual average of 54.2°F (NOAA 1986).

Tulip poplar associations cover much of the lower Piedmont, being found on schist, granite and gneiss soils. Shingle and chestnut oak communities predominate in the upper Piedmont on diabase, quartzite and coarse textured schists. Wetlands of the Piedmont are primarily river floodplain swamps and marshes (Table VII-1). On dry and nutrient-poor gravels and serpentine soils, canopies are dominated by mixed oak communities -- including chestnut, post, blackjack, red, white and black oaks -- and a variety of hickories and other species that require relatively little moisture.

Several rare and sensitive biotic communities are found the the Piedmont province. Scattered serpentine barrens support species that are very tolerant of metals found naturally in this substrate (Whittaker 1954). A rare and sensitive flora inhabits limestone barrens in the extreme upper portions of the Piedmont in Frederick County (Reifner and Hill 1984). Limestone habitats are basic in pH and high in nutrients, but are generally very dry. Urbanization is the major general threat to unique habitats and animal populations in the Piedmont. All Piedmont counties in Maryland are growing rapidly in human population density: the Baltimore-Washington corridor is one of the fastest developing areas in the United States.

Appalachian Province

The Appalachian province in Maryland extends from the Piedmont in Frederick County to the western border of the state, and encompasses approximately 5,180 square miles. It comprises three subregions: i) the Blue Ridge, in western Frederick and eastern Washington counties, ii) the Valley and Ridge, in central Washington County, and iii) the Appalachian Plateau, in western Washington and Garrett counties. These three distinct areas lend considerable topographic diversity to western Maryland. Elevations in the Appalachian province range from 1,400 to over 3,000 ft, with the higher elevations to the west. Topography is diverse, with broad alternating ridges and valleys of the east and a high upland plateau in the west. Eastern valleys are underlain by limestone and/or shale, while ridges are underlain by sandstone and quartzite. Substrates on the

Appalachian Plateau are mostly shale high in calcite and readily weathered. Substrates on the plateau are frequently coal-bearing.

Soils in slope areas are saprolites, and extensive floodplains and other depositional environments are confined to the eastern portions of the province where topography is less rugged. Most soils in the province are well-drained, although some basins on the plateau support saturated substrates and bog vegetation. Mean monthly precipitation ranges from 2.2 in. in February to 4.6 in. in July, and mean monthly temperatures range from 28.3° F in January to 74.2° F in July (NOAA 1986).

Natural vegetation in the Appalachian province is patterned spatially in response to local topography (including such natural disturbances as landslides and snowfall) and hydrology. Eastern valleys are dominated by sugar maple-basswood communities, with chestnut oak and burr oak assemblages on ridges. More mountainous western areas support similar communities in addition to hemlock and birch forests of boreal affinities. Sycamore, river birch and ash forests inhabit riparian corridors and alluvial plains throughout the province. Bogs on the Appalachian Plateau may support tamarack. Man-made disturbances superimposed on the natural landscape mosaic include agricultural, lumbering, mining and increasing residential and industrial development.

Several rare and sensitive biotic communities are found in the Appalachian province of Maryland (Norden *et al.* 1984). In the Valley and Ridge subregion, shale barrens on xeric slopes host a number of endemic, rare and disjunct populations of plants. Limestone areas, described above for the Piedmont province, also occur in the Appalachian province, although west of Frederick County outcrops are small and localized. Various kinds of peatlands, including some riverbottom swamps and mountain bogs, are found in Garrett County (Table VII-1). These habitats are generally small, nutrient-poor, acidic and poorly drained. They support a unique flora, and are sensitive to both physical and chemical disturbance.

Many of the vertebrate species in the Appalachian province are unique to the region. Such boreal and mountain forms as the green salamander, mountain earth snake, coal skink, winter wren, dark-eyed junco, porcupine, spotted skunk, fisher and other species occur only in the Appalachian province of Maryland.

Streams in western Garrett County are part of the Mississippi drainage. As a result, some species that are rare or nonexistent elsewhere in Maryland, including several fish species and the hellbender salamander, are found in those streams. In addition, eastern portions of the province have southern and Piedmont faunal affinities, so that overall faunal diversity of the Appalachian province is quite high.

B. Modes of Impact

Direct Habitat Alterations

Power plants, whether steam electric or hydropower, displace a certain amount of terrestrial habitat. Ancillary facilities and structures, such as transmission corridors and combustion by-product landfills, similarly eliminate or modify more habitat. There are currently 14 power plants in Maryland of greater than 100 MW capacity, nine of which are located in rural areas and five in urban, developed areas. Excluding Conowingo Dam, the total area of all the non-urban sites is over 5,100 acres, the majority occurring within the Coastal Plain province (MD-PPRP 1975).

- Steam Electric Power Plants

Table VII-2 identifies the physiographic province within which each of the steam or nuclear plant sites is located and the habitat type typical of that area. Clearly, steam electric power plant sites occupy an insignificant portion of Maryland's 6.3 million acres. In addition, facilities situated in urban areas did not displace native vegetation and habitats and, thus, have had no impact on Maryland's terrestrial ecosystems. Even within specific plant sites, such as Calvert Cliffs, buildings and structures on the site typically occupy only a small percentage of the total acreage. At Calvert Cliffs, the remainder of the site (90%) is maintained as natural native habitat or agricultural land, providing substantial protected terrestrial habitat occupied by typical Coastal Plain flora and fauna (MD-PPRP 1975).

Table VII-2

Power plant sites in Maryland, their geographical province and dominant vegetation associations likely subject to potential direct effects

Site	Province	Vegetation Association Type	Acreage
R.P Smith	Appalachian	river birch-sycamore, sugar maple, basswood	NA
Dickerson	Piedmont	river birch-sycamore, tulip poplar	1,003
Notch Cliff	Piedmont	sycamore-green ash, tulip poplar	443
C.P. Crane	Coastal Plain	chestnut oak-post oak-blackjack oak	
Riverside	Coastal Plain	urban	
Westport	Coastal Plain	urban	
Gould Street	Coastal Plain	urban	
Wagner	Coastal Plain	urban	
Brandon Shores	Coastal Plain	urban	375
Chalk Point	Coastal Plain	river birch-sycamore, tulip poplar	1,149
Calvert Cliffs	Coastal Plain	Loblolly pine, chestnut oak-post oak	1,140
Morgantown	Coastal Plain	chestnut oak-post oak	427
Vienna	Coastal Plain	Loblolly pine, river birch-sycamore	296
Perryman (a)	Coastal Plain	tulip poplar	708
		Total =	5,541

Source: MD-PPRP 1975; Brush et al. 1977.
(a) Proposed Site