CHAPTER VIII

GROUNDWATER IMPACT

An operating power plant need s freshwater for several purposes: equipment cooling water, boiler make-up, pump sealing systems, sanitary supplies and pollution control equipment[1]. A diagram showing typical uses of freshwater is given in Figure VIII-1. Freshwater demands for these purposes can be very significant, as much as 1,200,000 gallons per day (gpd) for the 2,000 MW fossil-fueled Chalk Point Power Plant (4 units) in Maryland.

Depending upon location, power plants draw their freshwater from one of four sources:

1) Non-tidal River - Power plants located on non-tidal rivers typically use purified river water as a source of freshwater.

2) Municipal Water Supply - Large cities like Baltimore and Washington provide industrial quality water to power plants.

3) Brackish Surface Water - Brackish surface water must be desalinated before it is suitable for purposes other than once-through cooling in power plants.

4) Groundwater - Where acceptable surface water supplies are not available, groundwater can be utilized to meet freshwater needs.

This chapter concerns the impact which the power plants in the final category (Calvert Cliffs, Vienna, Morgantown, and Chalk Point) have on groundwater supplies in Maryland.

The most common impact of power plants on groundwater supplies is a decrease in the hydraulic head, or "potentiometric surface," in the area of the aquifer surrounding the point of withdrawal.[2] When water is pumped from a well, a "cone of depression" centered at the well is created in this surface. Pumping can cause a lowering of the potentiometric surface of an aquifer below the intake levels of pumps for neighboring wells. If that occurs, pump intakes must be lowered below the new

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[1]Steam condensers do not require fresh water for cooling and their water requirement will not be discussed in this Chapter.

[2]The potentiometric surface for a given aquifer is the level to which the water would rise in a well screened in the aquifer.

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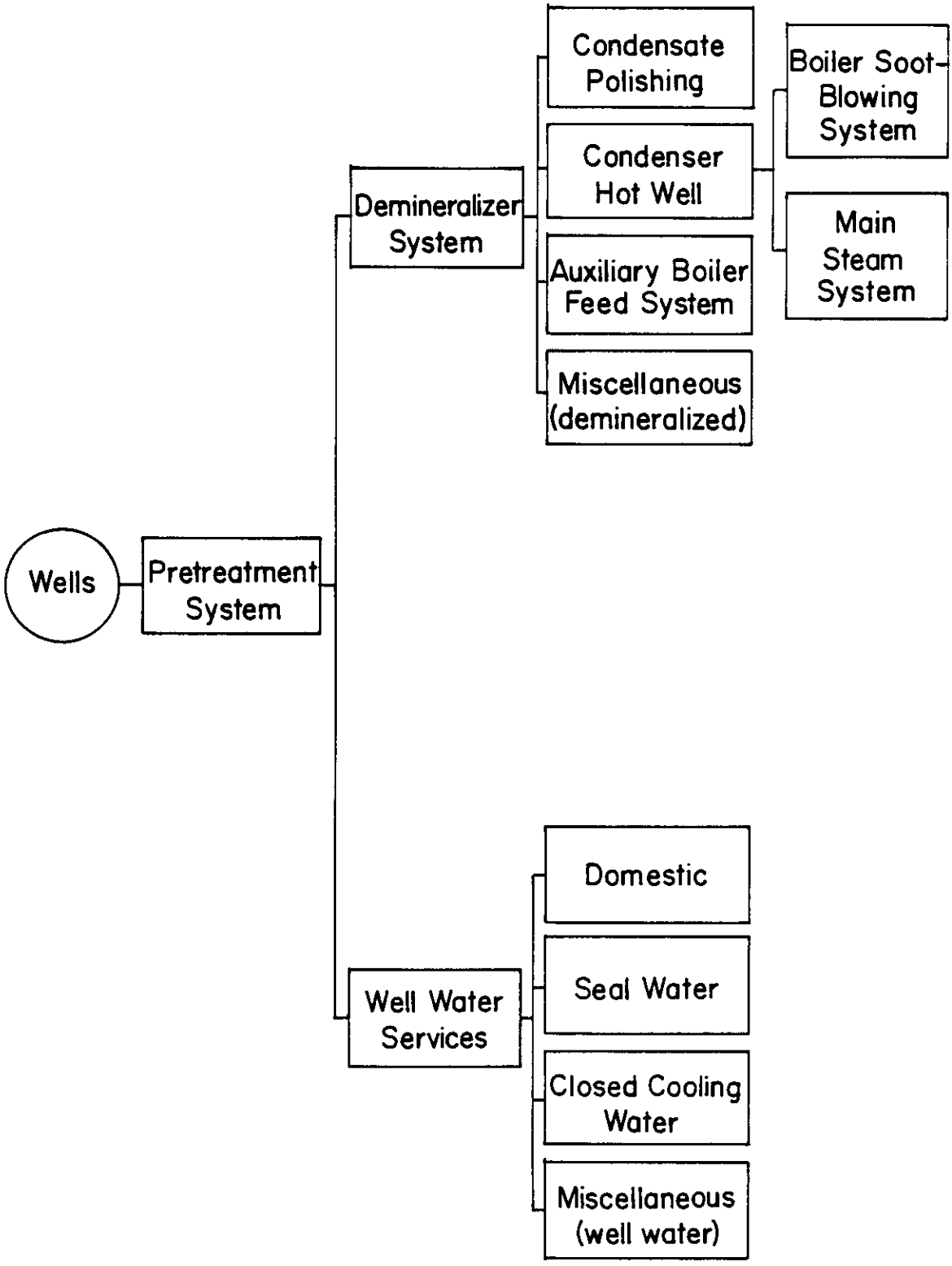

Figure VIII-1. Typical freshwater uses for a fossil-fueled power plant.

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potentiometric surface for such wells to operate. It is expected, however, that the ground water would return to its earlier level if pumping ceased.

The Calvert Cliffs Nuclear Power Plant, located on the Western shore of the Chesapeake Bay, withdraws water from the Aquia aquifer. During 1981 and 1982, Calvert Cliffs pumped an annual average of approximately 240,000 gpd from 3 wells averaging 620 feet in depth. At no time did withdrawal approach the permitted average appropriation of 600,000 gpd. The observation well data in Figure VIII-2 show the pumping rates and the level of the potentiometric surface. The Figure also indicates a general lowering of the potentiometric surface over the 1980 to 1982 period.

A map of the potentiometric surface of the Aquia aquifer in September 1982 is shown in Figure VIII-3. The effect of withdrawal by the power plant on the aquifer can be seen from Figure VIII-4, which shows the difference between the potentiometric surfaces of April 1979 and September 1982.[1]

The Vienna Power Plant, located on the Nanticoke River, has traditionally withdrawn water from the Federalsburg aquifer and an unconfined aquifer (Pleistocene). During 1981 and 1982, Vienna pumped only from two wells (35-54 feet depth) in the unconfined aquifer at an average rate of 25,000 gpd (Figure VIII-5). The reduction in pumping beginning in 1980 resulted from the retirement of Vienna Units 5-7. Usage is not expected to increase until the start-up of Unit 9, now projected for 1995. Unit 9 is expected to withdraw approximately 390,000 gpd, but because of the high potential yield of the aquifers, no supply problems are anticipated (1,2).

The Morgantown Plant, located on the Potomac River, withdraws water from the Patapsco aquifer.[2] In 1981 and 1982 Morgantown pumped an average of approximately 630,000 gpd from 5 wells averaging 1,100 feet in depth. Figure VIII-6 shows pumpage rates and water level data for Morgantown. Water level data is provided by a water-level recorder installed on the observation well by the U.S. Geological Survey in 1979. Unfortunately, the record for this station is incomplete because of instrumentation problems (3). No water-level trend is evident from this short record.

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[1]The data used to prepare this figure are interim in nature, but are included because they represent the best data presently available.

[2]There is some question as to whether the Morgantown wells draw from the Patapsco or the Patuxent aquifers, although it can be stated with certainty that they draw from the Potomac Group. It is generally held that goundwater is pumped from the Patapsco aquifer (3).

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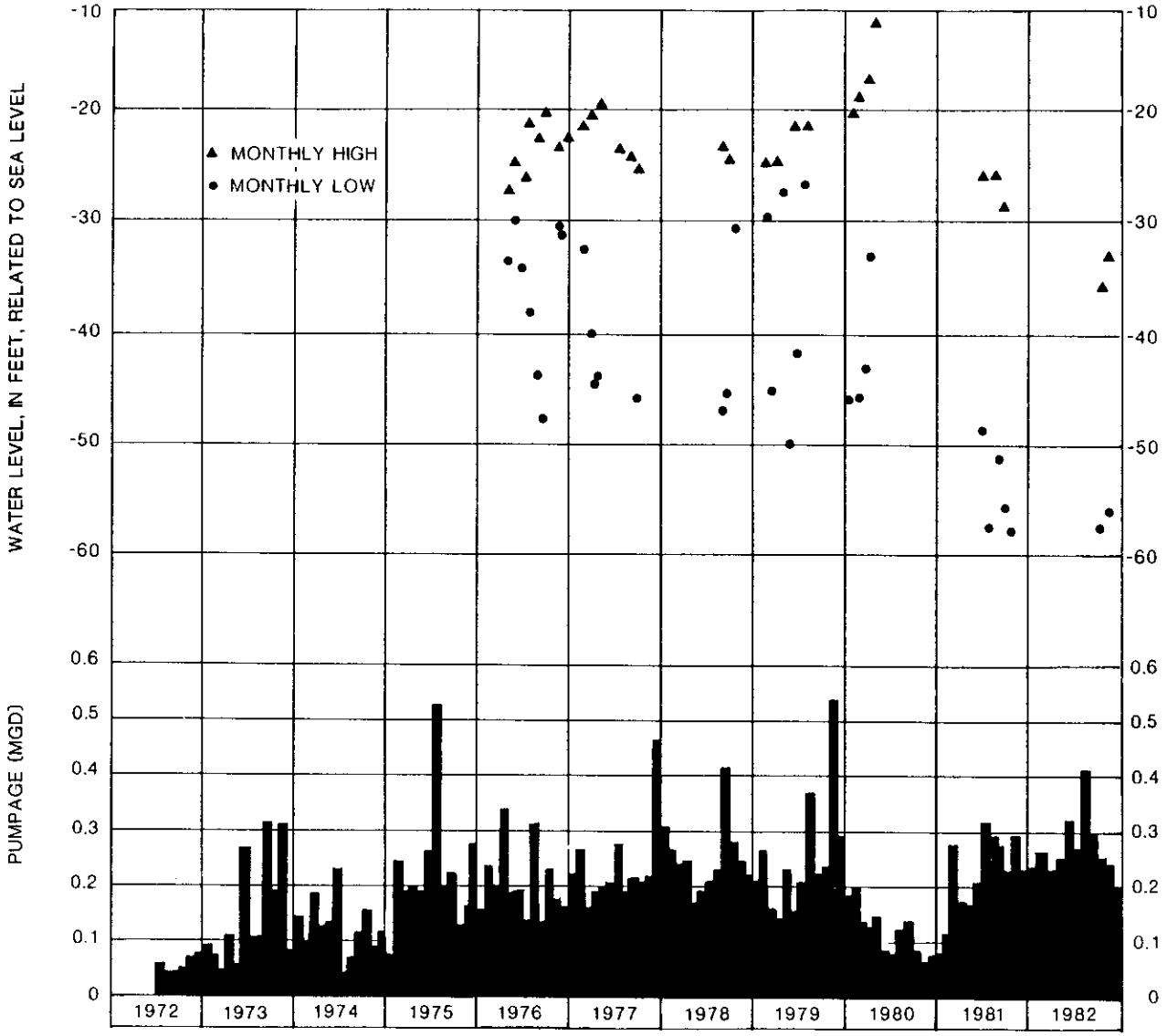

FIGURE VIII-2. GROUNDWATER PUMPAGE AND WATER LEVELS AT THE CALVERT CLIFFS POWER PLANT FROM FIRST OPERATION THROUGH 1982.

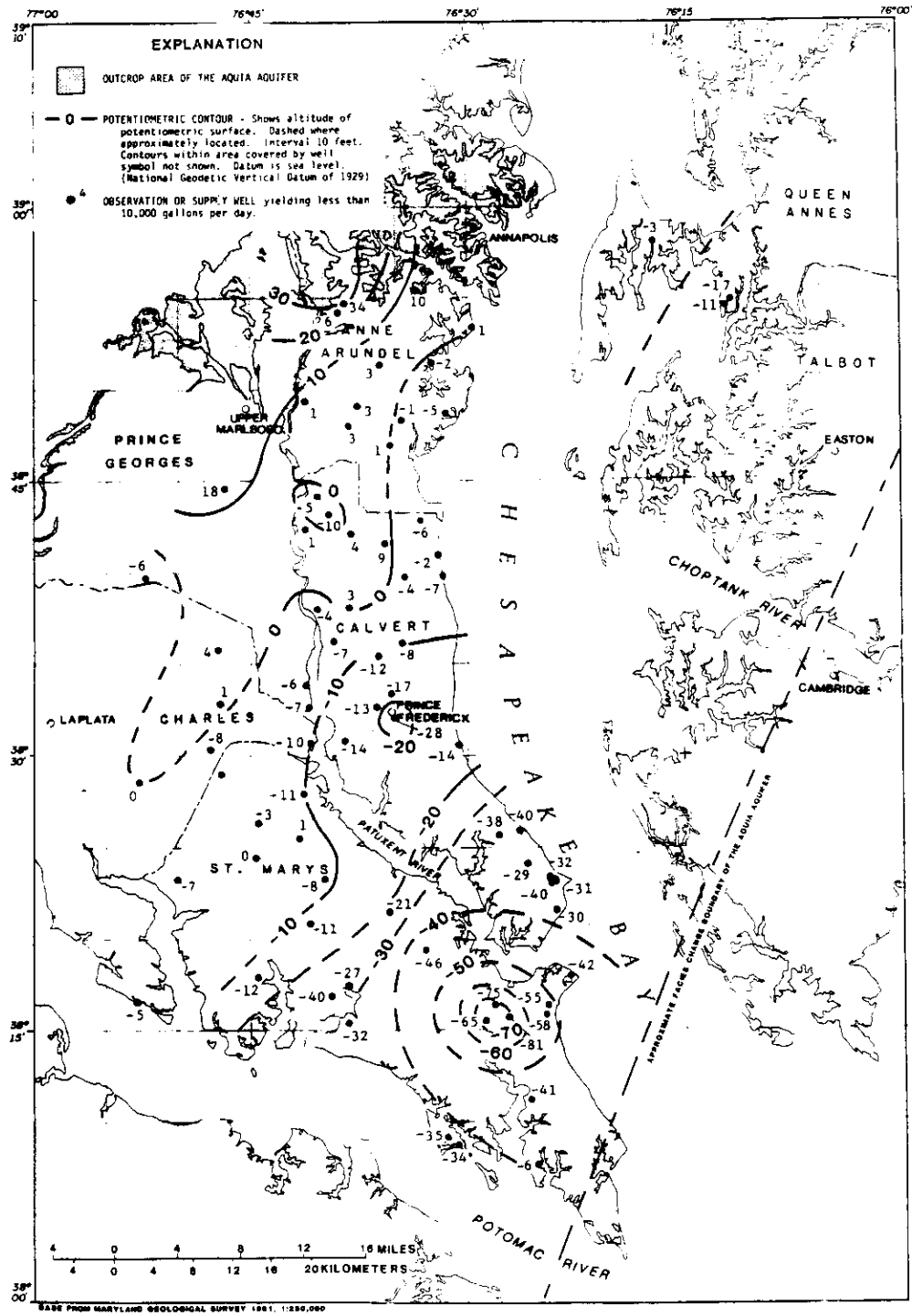

Figure VIII-3. Preliminary map showing the potentiometric surface of the Aquia aquifer in southern Maryland, September 1982.

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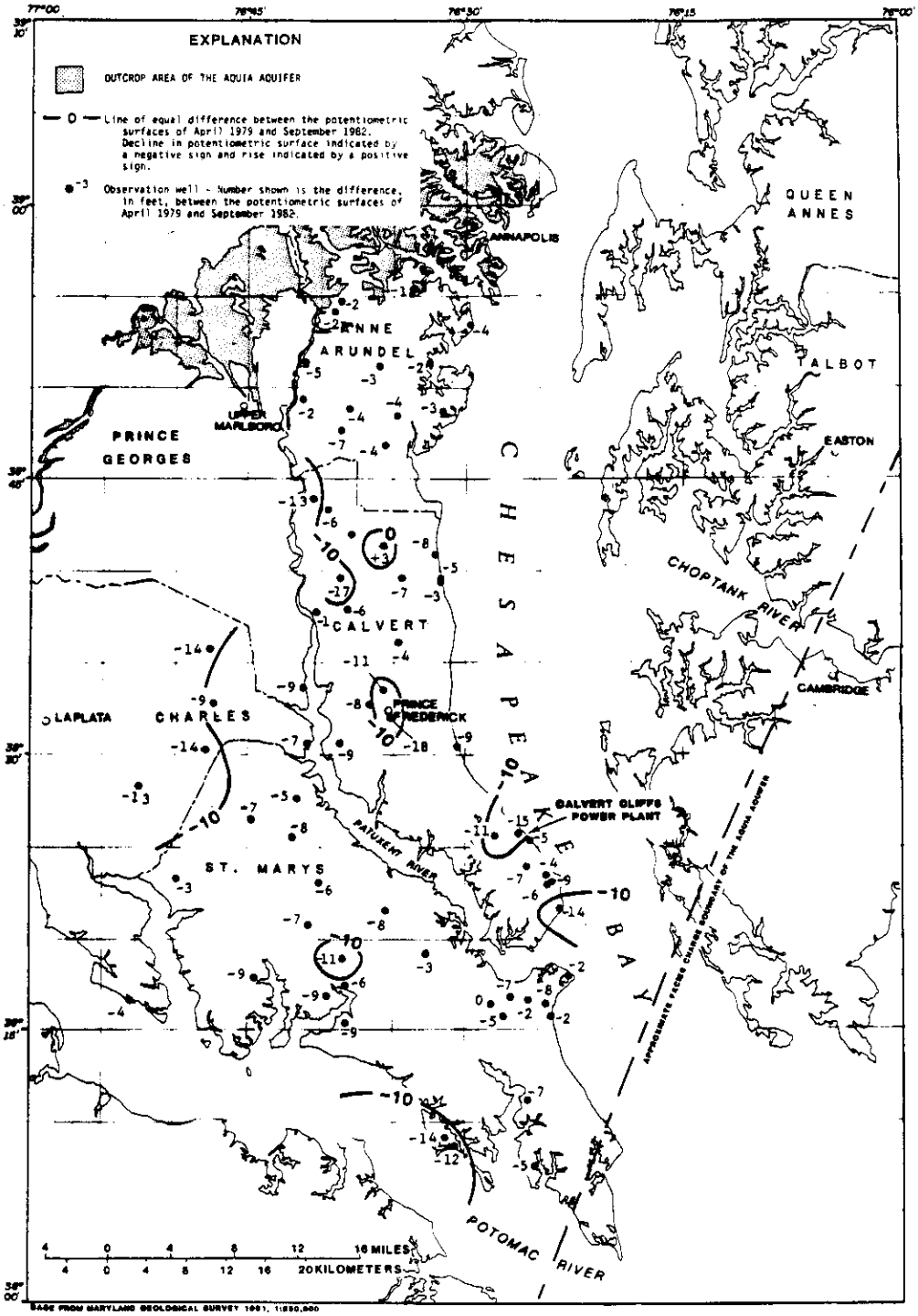

Figure VIII-4. Preliminary map showing the difference between the potentiometric surfaces of the Aquia aquifer of April 1979 and September 1982 in southern Maryland.

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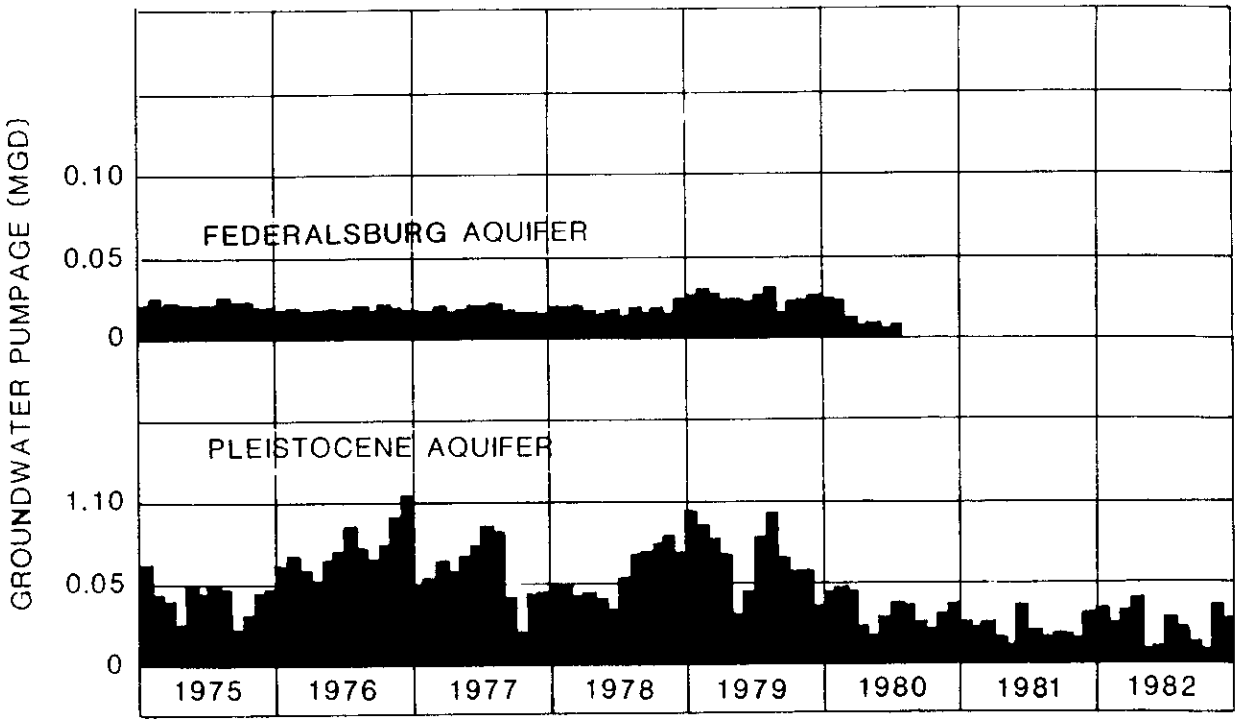

FIGURE VIII-5. GROUNDWATER PUMPAGE AT THE VIENNA POWER PLANT, BY AQUIFER, FROM 1975 TO 1982

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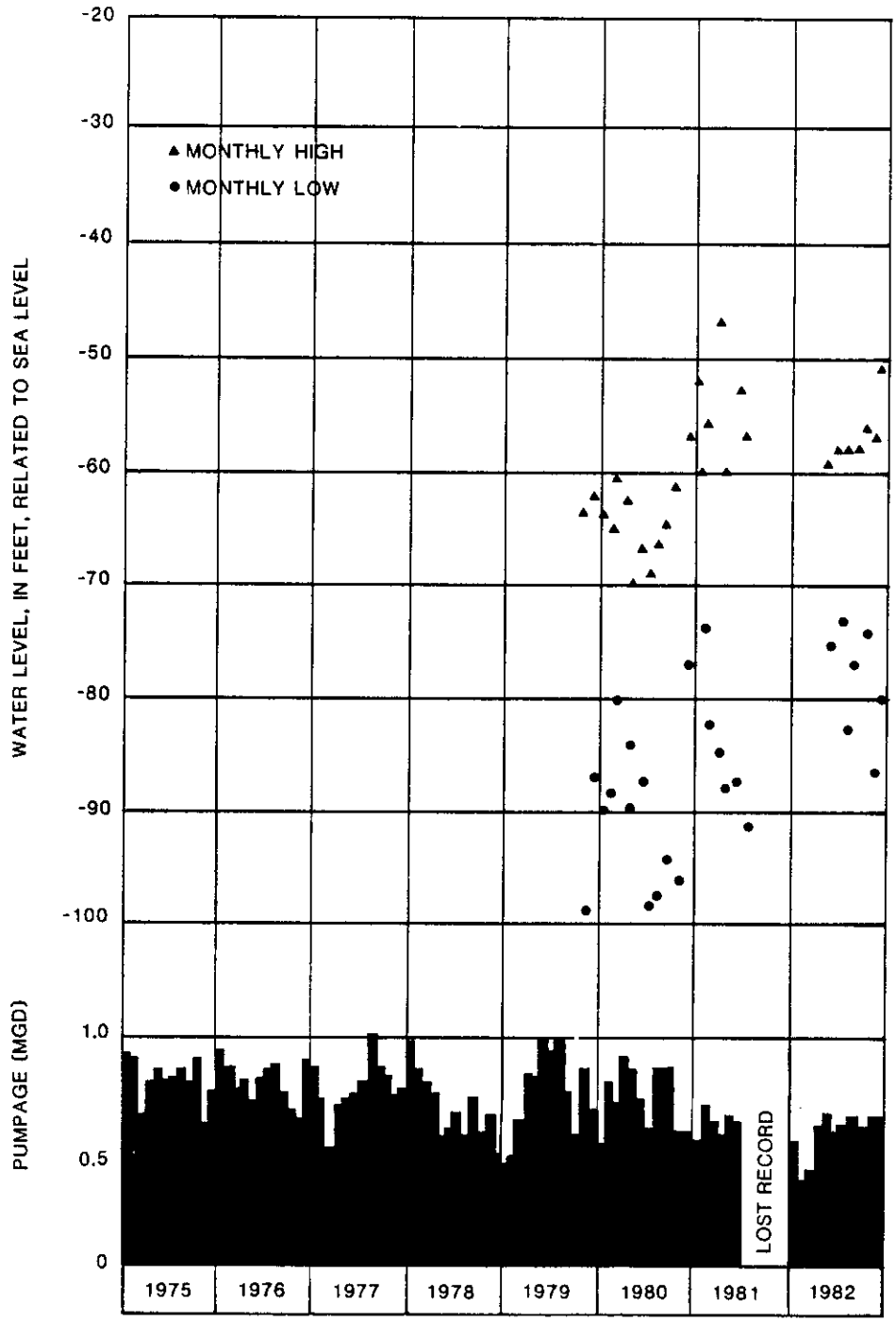

FIGURE VIII-6 GROUNDWATER PUMPAGE AND WATER LEVELS IN OBSERVATION WELL AT THE MORGANTOWN POWER PLANT FROM 1975 THROUGH 1982

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The Chalk Point Power Plant, located on the Patuxent River, withdraws water from the Patapsco and Magothy aquifers. There are no other large groundwater users in the immediate vicinity of the plant. During 1981 and 1982, Chalk Point pumped an average of 570,000 gpd from five wells in the Magothy aquifer, and an average of 240,000 gpd from one well in the Patapsco aquifer.[1] Figure VIII-7 shows pumping rates and observation well data for both aquifers. The water level in the Magothy aquifer has generally declined since the plant began operating in 1963, reaching a level of 37 feet below sea level (as measured 1 mile from pumping wells) during 1982 (Figure VIII-8). The water level in the Patapsco aquifer has also declined, as can be seen from Figure VIII-9.

The potentiometric surface map for the Magothy aquifer (Figure VIII-10) shows a cone of depression in the vicinity of Chalk Point. As is also apparent, cones of depression exist in other high use areas, e.g., Annapolis and Waldorf. The difference in potentiometric surfaces from September 1975 to September 1982 is shown in Figure VIII-11. While the Northern portion of the aquifer shows only minor water level changes, the Southern portion is characterized by a significant decline.

Some concern has been expressed that declining water levels in the Aquia aquifer are due to pumpage at Chalk Point. This is despite the fact that Chalk Point's production wells are screened in the Magothy and Patapsco aquifers. However, as can be seen from Figure VIII-7, the minimal changes in Aquia water levels in response to changes in pumpage from the Magothy indicate that the Aquia is separated from the Magothy by effective confining beds (5).

The groundwater withdrawal permit for Chalk Point will expire on March 7, 1984, and PEPCO will be required to apply for a new permit. It is anticipated that PEPCO will also request an increase in the permitted average and maximum daily appropriations for withdrawals from the Maghothy. The increased appropriation will be necessary in order to operate all four units at full power. PEPCO had originally intended to meet this demand by drilling an additional well into the Patapsco aquifer (6); however, this is now not likely because of poor water quality in the Patapsco (7). PEPCO now hopes to meet this demand by increased withdrawals from the Magothy.

In 1978, PPSP initiated a study to quantify the amount of groundwater used in an operating power plant, to determine the in-plant breakdown of water usage, and to investigate methods for reducing groundwater consumption. The Chalk Point Power Plant was selected for this study because, of all Maryland power

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[1]The pumpage for 1982 was misreported in the Biannual Water Withdrawal Reports due to a miscalibrated meter. The data used herein are corrected data as supplied by the Potomac Electric Power Company (4).

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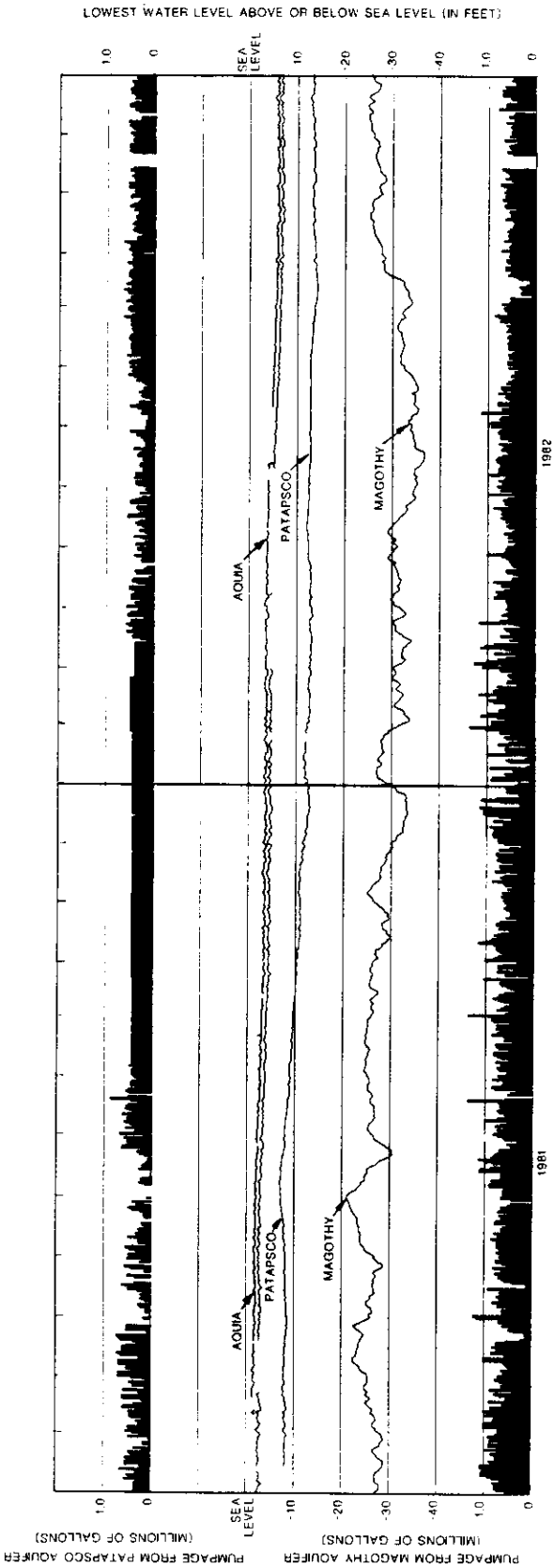

FIGURE VIII-7. PUMPAGE AND WATER LEVELS FOR THE PATAPSCO, MAGOTHY, AND AQUIA AQUIFERS AT CHALK POINT IN 1981 AND 1982

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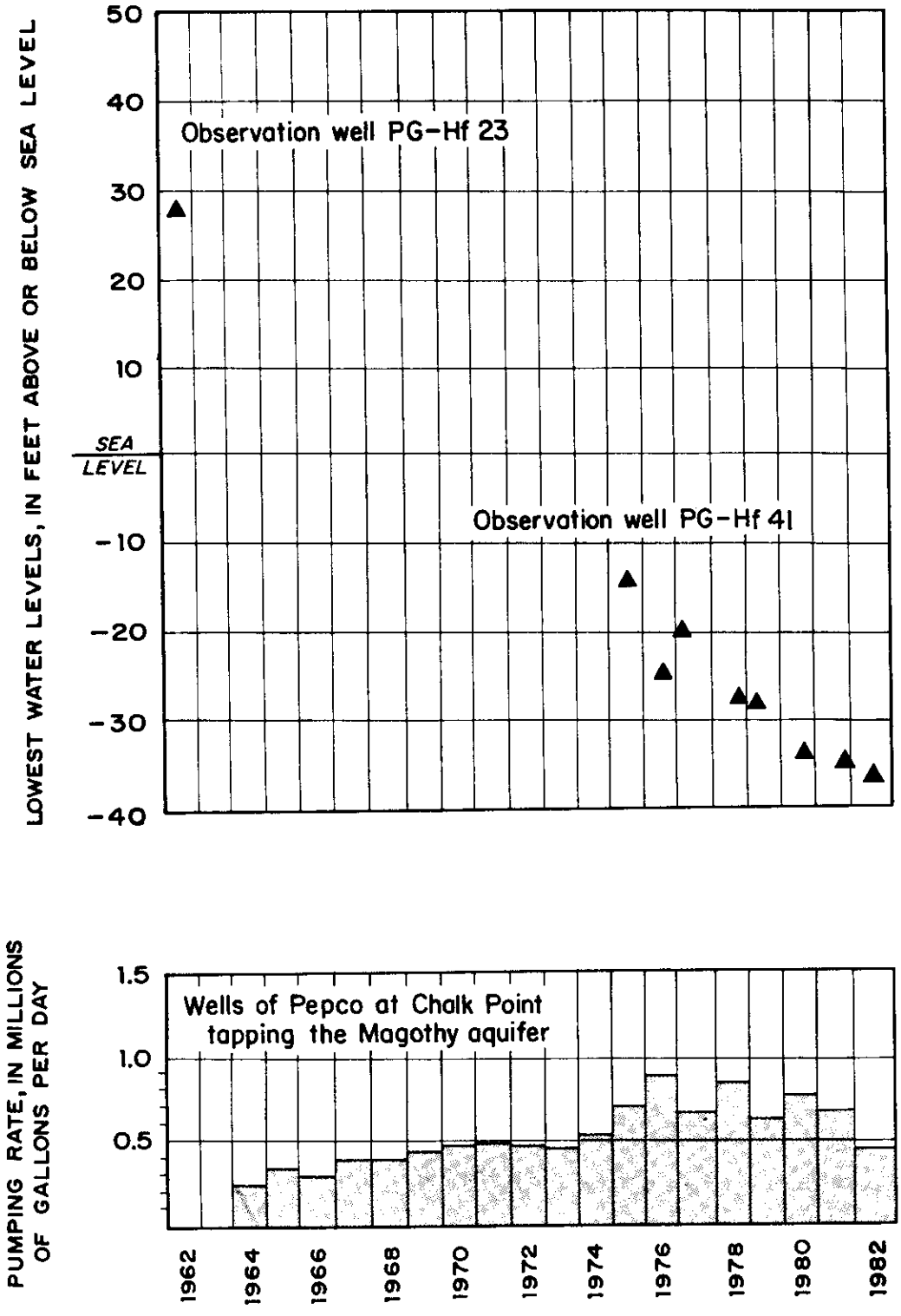

Figure 8. The relationship between the annual low water levels and the average annual pumpage at Chalk Point (1962-1982).

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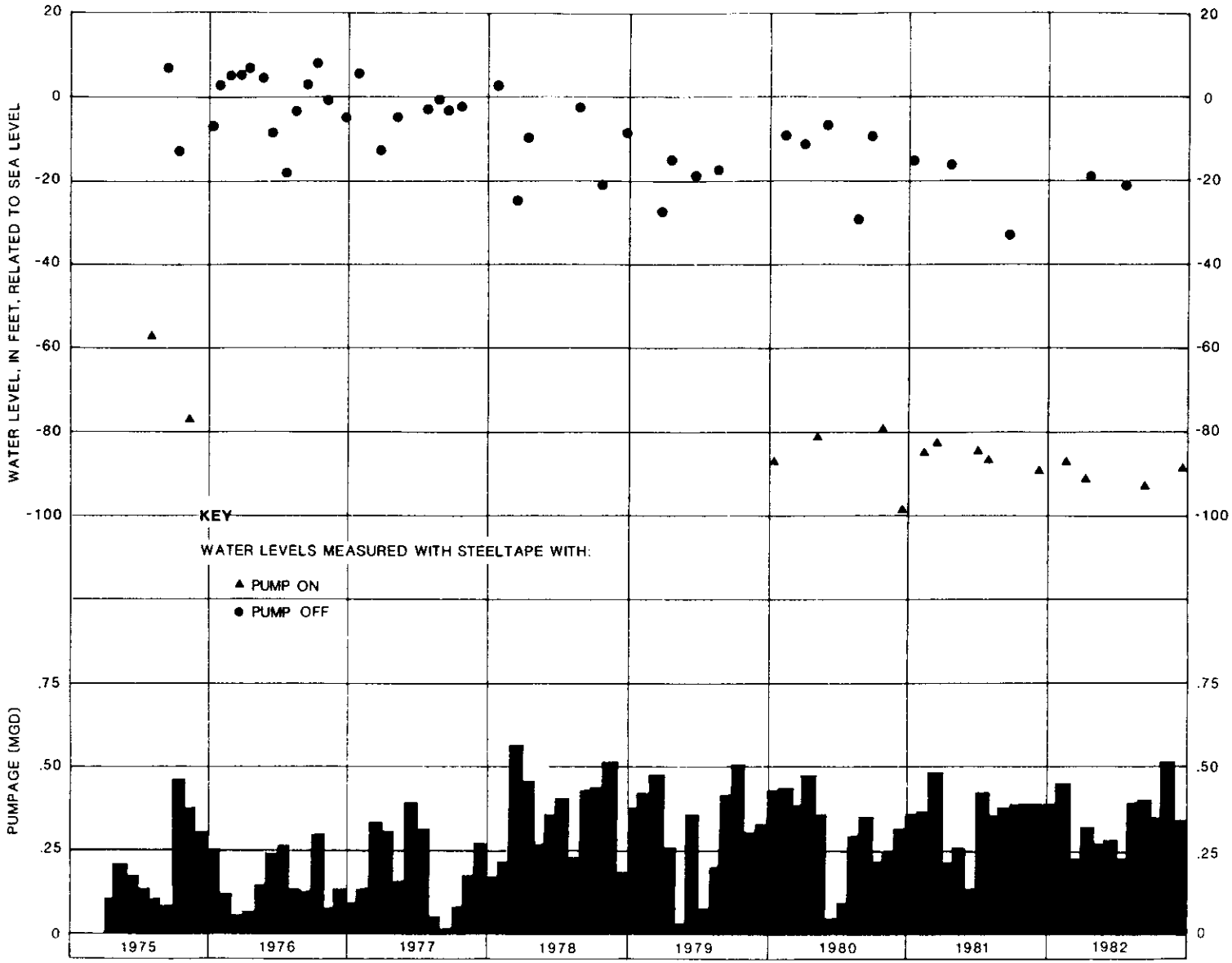

FIGURE VIII -9. GROUNDWATER PUMPAGE AND WATER LEVELS FOR THE PATAPSCO AQUIFER AT THE CHALK POINT POWER PLANT

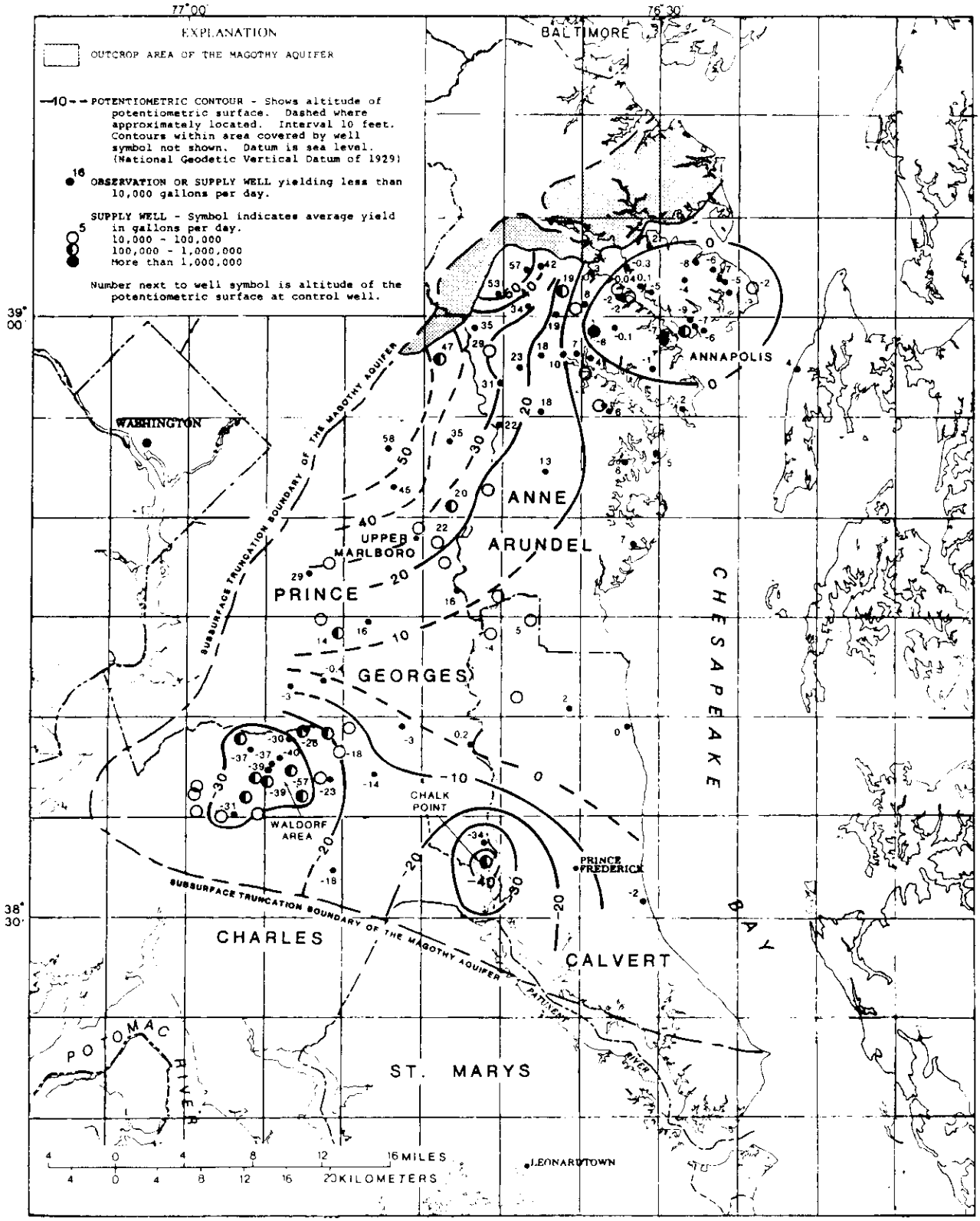

Figure VIII-10. Map showing the potentiometric surface of the Magothy aquifer in southern Maryland, September 1982.

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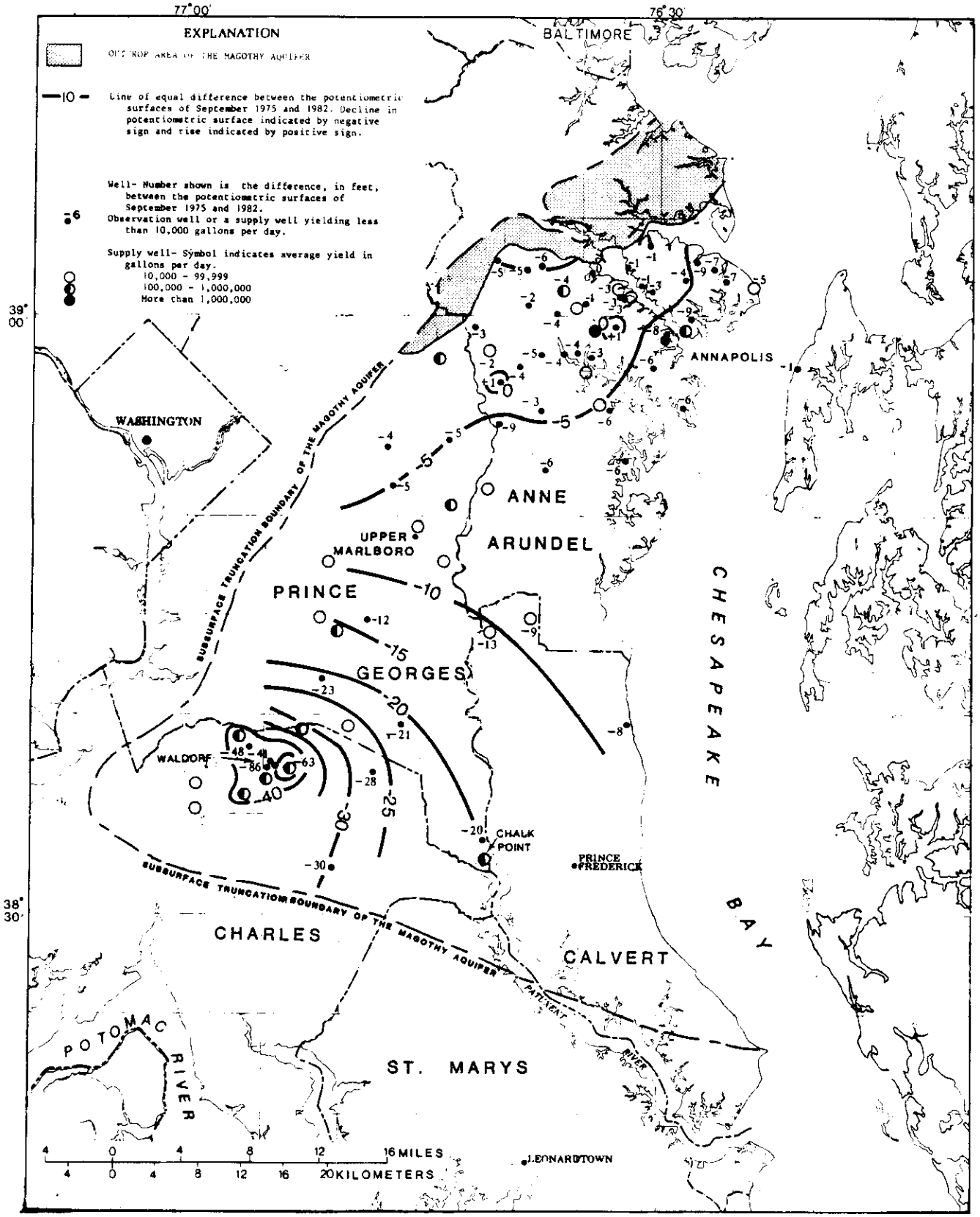

Figure VIII-11. Map showing the difference between the potentiometric surfaces of the Magothy aquifer of September 1975 and September 1982 in southern Maryland.

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plants, it is the largest groundwater user, and because it has two different fuel sources (coal and oil). For the study period, Units 1 and 2 used an average of 484,000 gpd. The breakdown of in-plant usage is shown in Figure VIII-12 (8). The study also indicated that groundwater consumption may be reduced by approximately 20 percent with detailed water management and water recovery systems.

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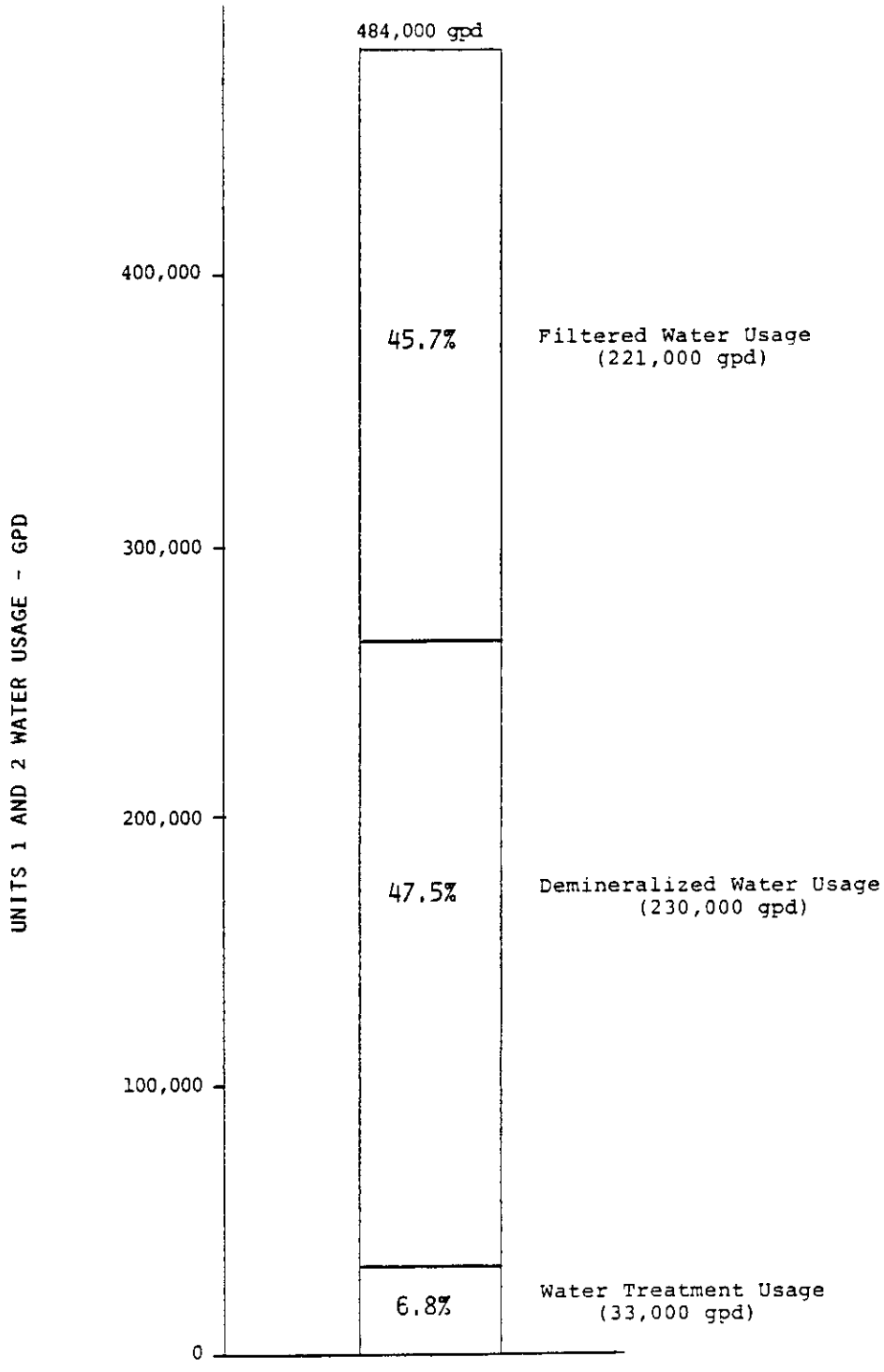

Figure VIII-12. Water usage at Chalk Point Units 1 and 2 as averaged over a ywo-year period.

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APPENDIX A

MARYLAND DEPARTMENT OF STATE PLANNING PROJECTIONS

Chapters I and II of this report emphasize the central role of load forecasting projections in generation expansion planning. Reliable load forecasts are essential if future adequacy of service is to be assured while avoiding excess capacity. For that reason, the Power Plant Siting Program (PPSP), in conjunction with the Maryland Department of State Planning (DSP), has conducted a program of independent load forecasts since the mid-1970s.

The PPSP/DSP forecasts are based upon econometric models of the demand for electricity in the service areas of the Maryland utilities. These models quantify the effects of various economic, demographic and other factors (explanatory variables) upon the demand for electricity. Thus to forecast future power demands, it is necessary to formulate assumptions concerning the future values of these explanatory variables. The econometric models and their use in the PPSP/DSP load forecasting program was discussed in detail in the previous CEIR. In this appendix two of the inputs to the models, employment and population, will be discussed.

Two of the most important variables explaining historical power demands are employment and population. Employment is the best available measure of economic activity in various sectors of the economy, while population is used to explain the number of residential electric customers.DSP currently publishes long-range projections of employment and population for Baltimore City and all Maryland counties, and these projections have been used in all PPSP/DSP load forecast studies.[1] This appendix discusses the DSP projections program. It begins by examining recent economic and demographic trends in Maryland. Following the discussion of historical trends, the DSP projections are presented. To put these projections in perspective, they are compared to available projections of the U.S. The final section consists of a brief review of the methodologies employed by DSP in preparing its projections.

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[1]The DSP projections relate only to the Maryland portions of the service areas of Maryland utilities. Other sources of information were utilized to obtain employment and population projections for the non-Maryland portions. The Maryland portion accounts for approximately 50 percent of PEPCO, 100 percent of BG&E, 25 percent of DP&L and 20 percent of APS.

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A. Historical Employment and Population Trends

Population and employment have grown moderately though steadily in Maryland over the past two decades, although employment growth has slowed noticeably during the last three years as a result of a severe recession. In addition to these aggregate trends, some important sectoral and geographic shifts have occurred. Employment and population have ceased to grow (or growth have slowed substantially) in some areas of the state and have accelerated in others. Certain employment sectors have prospered while others have stagnated.

Employment

Employment trends in Maryland have to a considerable extent mirrored that of the U.S., which is not surprising considering the State's highly diversified economy. Comparisons with the U.S. are shown in Tables A-1 and A-2. Table A-1 presents Maryland and U.S. total employment 1967 through 1980, and Table A-2 is a comparison of the employment structure of the U.S. and Maryland in 1970 and 1980.

The trends in Maryland and the U.S. shown on Table A-1 are quite similar, suggesting that Maryland has been subject to the same sorts of economic and demographic forces as the rest of the nation. During the period 1967 through 1980, Maryland comprised between 2.01 and 2.07 percent of U.S. employment; and total employment in Maryland and the U.S. grew by an identical annual rate of 2.1 percent. The subperiods, indicate some small differences in trends. Since 1975 employment growth in Maryland has been slightly slower than the U.S. -- 2.5 percent per year versus 2.8 percent per year. This may result from the fact that 1975 was a severe recession year, and Maryland appears to be somewhat less sensitive to business downturns than the rest of the nation.[1] During early 1983 the Maryland unemployment rate was 8.2 percent compared to a U.S. employment rate in excess of 10 percent (5).

Some important differences between Maryland and the U.S. do emerge in examining the structure of employment. As shown in Table A-2, large differences exist in the relative importance of government (excluding military) and manufacturing. In 1980 manufacturing accounted for only 12.7 percent of total Maryland employment compared to 21.6 percent nationally, while government accounted for 23.4 percent of Maryland employment compared to 17.3 percent for the U.S. Manufacturing has declined over the past decade in both Maryland and the U.S., but the decline is much sharper in Maryland. The trade, services and government

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[1] Government, a very stable source of employment, accounts for a much larger percentage of employment in Maryland than nationwide. Manufacturing, which often tends to fluctuate with the business cycle, accounts for a much smaller percentage of employment in Maryland than in the nation as a whole.

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Table A-1. Total Employment in Maryland and the United States, 1967-1980 [a] (Thousands)

Year	Maryland	United States	Maryland as a Percent of U.S.
1967	1,501.5	74,372	2.02%
1970	1,623.8	78,627	2.07
1975	1,745.0	84,783	2.06
1976	1,762.7	87,485	2.01
1977	1,816.8	90,546	2.01
1978	1,911.0	94,373	2.02
1979	1,966.8	96,945	2.03
1980	1,973.4	97,270	2.03
	Annual Rates of Growth		
1967-1975	1.9%	1.7%	--
1970-1980	2.0	2.2	--
1975-1980	2.5	2.8	--
1967-1980	2.1	2.1	--

(a) Data from Ref. 1 and 2.

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Table A-2. Employment Structure in Maryland and the United States, 1970 and 1980[a] (Percent)

Sector	Maryland		United States	
	1970	1980	1970	1980
Agriculture	2.6%	2.2%	3.9%	3.5%
Mining	0.1	0.1	0.9	1.1
Construction	6.6	6.3	4.9	4.7
Manufacturing	17.7	12.7	26.3	21.6
Transportation, Communications & Utilities	5.6	4.7	6.1	5.5
Trade	21.5	22.3	20.4	21.7
F.I.R.E. (b)	4.9	5.3	5.0	5.5
Services	19.2	22.9	15.7	19.1
Government (excluding military)	21.8	23.4	17.1	17.3

(a) Data from Ref. 1, 3 and 4.

(b) Finance, insurance and real estate.

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sectors in Maryland have offset the decline in manufacturing. The largest of those increases is in the service sector which increased from 19.2 to 22.9 percent of total State employment over the 1970 to 1980 period.

Regional employment trends within the State are presented in Table A-3, which gives total and manufacturing employment in 1970 and 1980 for the five principal regions in the State. With some minor exceptions, these regions correspond closely to the Maryland portions of the service areas of the five largest electric utilities in the State. The counties comprising and utilities serving these regions are as follows:

Baltimore -- In addition to the City of Baltimore, the region includes Anne Arundel, Baltimore, Carroll, Harford and Howard counties. Nearly all of this area is served by Baltimore Gas & Electric Company (BG&E) which also serves small portions of certain other surrounding counties.

Washington Suburban -- This region is defined to be Montgomery and Prince George's counties, the two Maryland counties contiguous to the District of Columbia. The majority of residents in these two counties receive electric service from Potomac Electric Power Company (PEPCO).

Western Maryland -- This region consists of Allegany, Garrett, Frederick and Washington counties. Almost all of this area is served by the Potomac Edison Company (PE), a subsidiary of the Allegheny Power System (APS). These counties account for about 60 percent of Potomac Edison (the remainder being contiguous areas of Virginia and West Virginia) and about 20 percent of APS, which extends over more than 80 counties in five states.

Southern Maryland -- This region includes Calvert, Charles and St. Mary's counties and is largely served by Southern Maryland Electric Cooperative (SMECO).

Eastern Shore -- The counties comprising Maryland's Eastern Shore include Caroline, Cecil, Kent, Queen Anne's, Talbot, Dorchester, Somerset, Wicomico and Worchester. With the exception of Cecil County which is served by Conowingo Power Company, nearly all of this area is served at either wholesale or retail by Delmarva Power & Light Company (DP&L).

Statewide, total employment between 1970 and 1980 increased by 2.0 percent per year; over that same period manufacturing employment declined by 1.2 percent annually (1). The Baltimore region accounts for more than half the State's total employment and two-thirds the manufacturing employment, but has grown at a considerably slower pace than the State -- 1.4 percent per year. This performance is entirely attributable to Baltimore City which lost 21,000 jobs overall and 31,000 manufacturing jobs between 1970 and 1980. The Baltimore suburban counties, particu-

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Table A-3. Employment by Region in Maryland, 1970 and 1980[a] (Thousands)

Region	1970 No.	1970 % of State	1980 No.	1980 % of State	Annual Rate of Growth (b) 1970-1980
Baltimore					
Total	951.4	58.6%	1,092.8	55.4%	1.4%
Manufacturing	197.2	72.1	162.9	67.0	-1.9
Washington Suburban					
Total	401.7	24.7	568.3	28.8	3.5
Manufacturing	16.2	5.9	23.7	9.8	3.9
Western Maryland					
Total	115.8	7.1	135.5	6.9	1.6
Manufacturing	31.9	11.7	29.7	12.2	-0.7
Southern Maryland					
Total	39.6	2.4	49.1	2.5	2.2
Manufacturing	1.1	0.4	1.5	0.6	3.2
Eastern Shore					
Total	115.3	7.1	127.8	6.5	1.0
Manufacturing	27.0	9.9	25.2	10.4	-0.7

(a) Data from Ref. 1.

(b) Refers to annual rate of growth in percentage employed.

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larly, Howard and Anne Arundel counties, exhibited rapid growth. The Washington suburban region shows the most rapid growth over this period, gaining approximately 170,000 new jobs. Although manufacturing grew by nearly 4 percent per year, that represents a total gain of only 7,500 jobs. Manufacturing in the Washington suburbs is less than 5 percent of that region's total employment. Southern Maryland experienced growth slightly in excess of the statewide average, but Western Maryland and the Eastern Shore lagged behind the State. All five regions, however, did experience positive and at least moderate growth during the 1970s.

Population

Unlike employment, population is not subject to the vagaries of the business cycle. Statewide changes in total population tend to be very stable on a year-to-year basis. Nonetheless, over a sufficiently long period of time (such as two decades) important trends can be detected. Moreover, for smaller geographic areas (e.g., counties) large and important changes can occur within the period of a few years.

Table A-4 presents U.S. and Maryland population growth over the period 1960 through 1980, and Table A-5 breaks down Maryland 1970 and 1980 population into the five regions described in the previous section. The first table indicates that population in Maryland has grown somewhat more rapidly than the U.S. (1.5 percent versus 1.2 percent), and as a result, Maryland's share of the U.S. has increased from 1.72 percent to 1.86 percent. Within that 20-year period, however, there are two distinctly different subperiods. During the 1960s Maryland population increased by 2.3 percent, nearly double the national rate of 1.3 percent. Both Maryland and the U.S. experienced a population slowdown in the 1970s. That slowdown was mild for the nation as a whole (1.3 percent to 1.0 percent) but very sharp in Maryland (2.3 to 0.7 percent). Maryland's share of U.S. population has been declining since the mid 1970s.

The population trends differ considerably among the various major regions in Maryland and even within regions. The Baltimore region and the Washington suburbs account for more than 80 percent of the State's population. As shown on Table A-5, both regions experienced slow population growth (0.5 percent per year), below the statewide rate of growth. Southern Maryland achieved the most rapid rate of growth (3.8 percent per year) largely as a result of the increased suburban development in Charles County. Western Maryland and the Eastern Shore grew at a moderate 1.3 and 1.4 percent annual rate, respectively. Perhaps the most startling trend was the reduction in population in Baltimore City which lost approximately 15 percent of its population in the 1970s. The Baltimore region also contains the state's most rapidly growing county, Howard County, which nearly doubled its population in the 1970s.

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Table A-4. Maryland and United States Population, 1960-1980(a)
(Thousands)

Year	Maryland	United States	Maryland as a Percent of U.S.
1960	3,113	180,671	1.72%
1970	3,924	205,056	1.91
1976	4,172	217,554	1.92
1977	4,195	219,761	1.91
1978	4,212	222,096	1.90
1979	4,223	224,569	1.88
1980	4,225	227,156	1.86
		Annual Rates of Growth	
1960-1970	2.3%	1.3%	--
1970-1980	0.7	1.0	--
1960-1980	1.5	1.2	--

(a) Data from Ref. 2, 4, 11 and 12.

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Table A-5. Population in Maryland
by Region, 1970 and 1980 (a)
(Thousands)

Region	1970 Number	1970 Percent of Maryland	1980 Number	1980 Percent of Maryland	Annual Rate of Growth
Baltimore	2,071	52.8%	2,174	51.6%	0.49%
Washington Suburban	1,185	30.2	1,244	29.5	0.49
Southern Maryland	116	2.9	167	4.0	3.75
Western Maryland	294	7.5	334	7.9	1.28
Eastern Shore	258	6.5	297	7.0	1.39
State	3,924	100.0	4,225	100.0	0.70

(a) Data from Ref. 2 and 11.

Population and Employment Compared

Population and employment interact in a complex manner. Increases in population tend to increase labor supply and thus, ultimately, total employment as firms make use of the increased labor pool. Moreover, population increases tend to increase the demand for goods and services. Since some of these goods and services are likely to be locally produced, that will also tend to increase employment. On the other hand, an increase in employment opportunities in the state tends to encourage an in-migration of job seekers. These job seekers and their families add to the state's population.

We therefore would expect to find a close relationship between population and employment trends, and in general that is the case. However, there are also some important differences which require some explanation. Table A-6, which presents employment/population ratios, facilitates the comparison. The table indicates that significant increases in the employment/population ratio occurred during the 1970s which reflects the fact that employment during that decade grew considerably faster than population. (Recall from the discussion earlier in this chapter that Maryland and the U.S. population grew by 0.7 and 1.0 percent per year, respectively, while annual employment growth for both exceeded 2 percent.)

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Table A-6. Employment/Population Ratios[a] 1970 and 1980 (Percent)

	1970	1980	Percent Change
United States	38.4%	42.7%	+11.2%
Maryland	39.3	45.4	+15.5
Regions			
Baltimore Region	45.9	50.3	+ 9.5
Washington Suburbs	33.9	45.7	+34.8
Southern Maryland	34.2	29.4	-14.2
Western Maryland	39.4	40.5	+ 2.8
Eastern Shore	44.6	43.1	- 3.4

(a) Excludes military employment. Data from Ref. 1 and 10.

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The reasons for these disparate trends are fairly clear. During the decade of the 1970s the age structure of the population was changing. Nationwide, the percentage of the population of working age (16 to 64 years of age) increased from 60 percent in 1970 to 64.4 percent in 1980 (4). A similar trend occurred in Maryland. A critical factor is that the percentage of individuals of working age desiring employment (referred to as the labor force participation rate) has also increased. In Maryland it increased from 59.9 percent in 1970 to 64.5 percent in 1980 (11). One particularly important factor explaining this trend was the increased desire of women to join the labor force. Female labor force participants in Maryland increased by 4.1 percent per year compared to a 1.9 percent annual increase in the number of women over 16 years of age and compared to a total population increase in Maryland of 0.7 percent per year. A final factor, unemployment, provided a small offset to these trends. The Maryland and U.S. unemployment rates increased by approximately two percentage points between 1970 and 1980, partially due to the difficulty in creating enough jobs to employ a rapidly increasing labor force.

Commuting patterns may dominate employment/population relationships for some small regions. The Washington suburbs exhibited a relatively low ratio in 1970 but by 1980 exceeded the Maryland and U.S. average. (See Table A-6.) The low 1970 ratio can be explained by the tendency for many residents of these two counties to commute to jobs in the District of Columbia. During the 1970s most of the Washington area employment expansion occurred in the suburbs thus reducing the amount of net commuting out of Maryland. It appears that increased suburbanization has created precisely the opposite effect in Southern Maryland. The decrease in that region's employment/population ratio reflects the fact that residents of those counties have increased their propensity to commute to jobs out of the region.

B. DSP Projections

DSP publishes projections of employment and population to the year 2000 for each county in the State. The projections are provided at a very high level of detail. County-level population is projected by sex, race and age cohorts, and employment in each county is projected by major industry group. In the manufacturing sector the projections are presented at the two-digit Standard Industrial Classification (SIC) code level. The previous sections demonstrate why it is important to obtain and study sectoral or cohort detail rather than merely the aggregates.

This section presents the statewide and regional projections published by DSP for employment and population. To put these projections in perspective, they are compared to projections of the U.S. economy published by the Bureau of Economic Analysis (BEA), U.S. Department of Commerce, and Wharton Econo-

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metric Forecasting Associates, a commercial forecasting service. It should be noted that the DSP state-level projections are partially based upon the projections published by BEA.

The U.S., Maryland and multicounty regional projections of employment, population and the employment/population ratio are shown on Table A-7 for the years 1990 and 2000. The 1980 historical figures are shown for purposes of comparison. Table A-8 presents the projected annual average rates of growth for employment and population for the periods 1980-1990, 1990-2000 and 1980-2000. The relative growth rates for employment and population directly determine the change in the employment/population ratio.

On the basis of available projections Maryland is expected to lag slightly behind the rest of the nation. Maryland's population growth is expected to approximate the national population growth, but its employment growth is projected to be noticeably slower. The growth rates for the major regions of the state are generally expected to be similar to the statewide figures. A major exception is Southern Maryland which is expected to exhibit relatively rapid population growth but virtually no employment growth. Another interesting result is the marked slowdown in employment growth in the Washington suburbs compared to the very rapid pace of the 1970s.

The population projections for the U.S., Maryland and the five regions imply a rate of increase very much in line with the experience of the 1970s. However, the employment projections represent a sharp break from past trends. Employment growth is projected to fall from 2 percent (or more) per year in the 1970s to 1.2 or 1.3 percent per year for the U.S. and 0.7 percent per year for Maryland. This suggests that forecasters are not expecting the working age segment to grow more rapidly than population as a whole or the labor force participation rate to increase significantly. Thus only very small changes in the employment/population ratio are expected for the 1980s and 1990s. (See Table A-7.)

Manufacturing is of particular interest to the PPSP/DSP load forecasting program since manufacturing tends to use far more energy per employee than other types of business. This sector is also of interest because of both its long-run decline in Maryland and its sensitivity to the business cycle. Table A-9 presents projections of manufacturing's share of total employment for 1980, 1990 and 2000 for the U.S., Maryland and each major region in Maryland. The last column in that table provides the projected annual average growth in manufacturing 1980-2000. BEA projects that U.S. manufacturing will decline only slightly compared to the rest of the economy. Wharton, however, is projecting considerably less growth, both relatively and absolutely, for manufacturing.

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Table A-7. Projections of Employment and Population for Maryland and the United States, 1980-2000[a]
(Thousands)

Area	1980[b] Population	1980[b] Employment	1980[b] E/P	1990 Population	1990 Employment	1990 E/P[c]	2000 Population	2000 Employment	2000 E/P[c]
U.S. (BEA)[d]	227,658	97,270	42.7%	242,979	113,849	46.9%	259,845	122,209	47.0%
U.S. (Wharton)[d]	227,658	97,270	42.7	251,380	111,977	44.5	269,670	126,286	46.8
Maryland	4,225	1,973	46.7	4,517	2,140	47.4	4,850	2,285	47.1
Regions									
Baltimore	2,174	1,093	50.3	2,296	1,174	51.1	2,424	1,238	51.1
Washington Suburban	1,244	568	45.7	1,319	627	47.6	1,445	686	47.5
Southern Maryland	167	49	29.4	214	49	22.7	255	51	20.1
Western Maryland	334	136	40.5	366	150	40.9	384	159	41.3
Eastern Shore	297	128	43.1	323	141	43.6	342	151	44.1

(a) Data from Ref. 1, 10, 12, 13 and 14.

(b) Actuals; all employment figures exclude military.

(c) Employment/population ratio.

(d) BEA and Wharton employment projections are adjusted to be consistent with the 1980 actuals shown above.

Table A-8. Projected Annual Rates of Growth for Employment and Population[a] (Percent)

Area	1980-1990 Population	1980-1990 Employment	1990-2000 Population	1990-2000 Employment	1980-2000 Population	1980-2000 Employment
U.S. (BEA)	0.7%	1.6%	0.7%	0.7%	0.7%	1.2%
U.S. (Wharton)	1.0	1.4	0.7	1.2	0.9	1.3
Maryland	0.7	0.8	0.7	0.7	0.7	0.7
Regions						
Baltimore	0.6	0.7	0.5	0.5	0.6	0.6
Washington Sub.	0.6	1.0	0.9	0.9	0.8	1.0
Southern MD	2.5	0.0	1.8	0.4	2.1	0.2
Western MD	0.9	1.0	0.5	0.6	0.7	0.8
Eastern Shore	0.8	1.0	0.6	0.7	0.7	0.8

(a) Data from Table A-7.

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Table A-9. Manufacturing's Share of Total Employment[a] (Percent)

Area	1980	1990	2000	1980-2000 Annual Growth Rate
U.S. (BEA)[b]	20.7%	19.8%	19.3%	0.9%
U.S. (Wharton)[c]	18.9	17.5	15.7	0.4
Maryland	12.7	11.7	10.9	0.1
Regions				
Baltimore	14.9	14.1	13.0	-0.1
Washington Suburban	4.2	4.5	4.6	1.4
Southern Maryland	3.1	3.3	3.1	0.3
Western Maryland	21.8	20.3	18.9	0.1
Eastern Shore	19.7	17.9	16.7	0.0

(a) Data from Ref. 1, 12, 13 and 14.

(b) 1980 figures and growth rate are based upon BEA historical figures for 1978.

(c) 1980 figures and growth rate are based upon Wharton historical figures for 1982.

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DSP is projecting that manufacturing employment will exhibit almost no growth over the next two decades and will decline significantly compared to total employment. However, even the DSP projection of virtually zero growth is a major improvement over the experience of the 1970s when manufacturing declined by more than one percent per year.

A closer inspection of the DSP manufacturing projections reveals further insights of interest to those forecasting power demands. Although DSP projects no decline in manufacturing employment, it does project declines for several of the more energy intensive sectors such as primary metals, textiles, chemicals, rubber and plastics. On the other hand, DSP is projecting a 33 percent growth over the next 20 years in printing and publishing, an industry that does not require large quantities of electric power per employee (1).

C. The DSP Projections Methodology

DSP has developed formal analytical methodologies to forecast population and employment to the year 2000. This section briefly describes those methodologies, and the manner in which they are implemented by DSP's Planning Data Office. DSP currently utilizes computerized, highly structured models to generate its projections. However, it is important to understand that the process of developing the projections also involves a large element of judgment regarding some of the key inputs and assumptions to the models.

Population[1]

The DSP process of developing population projections involves two stages. The first stage involves obtaining state and county by county population totals which is accomplished in cooperation with federal, Maryland regional and county planning agencies. The second stage uses these county-level total population figures as "control totals" to develop the detailed county-level age cohort, sex and race projections. A computerized cohort survival model, which is briefly described later in this section, is used for that purpose.

The first stage begins with the long-range projection of Maryland total population published by BEA in 1980. The BEA projection of Maryland population was adjusted for the final results of the 1980 Census of Population (not available at the time the BEA projections were prepared). In addition, the BEA projections were adjusted upwards by 1 percent for 1985 and 1990 and by 2.5 percent for the year 2000. These adjustments had the effect of maintaining Maryland's share of U.S. population at

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[1]This section is based substantially upon two DSP memoranda dated June 15, 1981 and December 10, 1982.

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1.82 percent in 1990 and 1.80 percent in the year 2000 rather than having it fall to 1.76 percent in the year 2000 without these adjustments.

Based upon judgment, analyses of past population trends, and anticipated local developments, a set of county-level projections of total population is developed. These county figures are then adjusted so that their total equals the statewide population figure for Maryland determined earlier (i.e., the modified BEA projections described above). The process of developing the county population totals involves discussions with regional planning agencies throughout the State. DSP recognizes seven planning regions (collapsed to five in the earlier discussion in this Appendix) within the State of Maryland. DSP coordinates its projections activities with the Baltimore Regional Planning Council (Regional Population Committee), the Metropolitan Washington Council of Governments (Cooperative Forecasting Subcommittee), and regional planning offices in the other five regions of the State.

The production of the latest DSP projections involved the following sequence of events. Preliminary projections based on 1980 census results were prepared in the fall of 1980. Input was obtained from the Baltimore Regional Planning Council in the spring of 1981, and interim projections (county totals only) were made available in June 1981. DSP's Final Interim Projections (with age, race and sex detail based upon additional census based age-specific data) were released in October 1982. These results went through a regional review process during the winter of 1982/1983. In the spring of 1983 the Council of Governments' projections were obtained for Montgomery and Prince George's counties. This latest information resulted in upward revisions to the 1990 and 2000 population projections for both the two counties and the State. This change represents an upward adjustment to the State total for year 2000 of nearly 2 percent (approximately 85,000). The final DSP population projections are scheduled for publication in the summer of 1983.

The second stage of the methodology, the cohort survival analysis, begins by developing population detail concerning age, sex and race by jurisdiction for the previous decade. These figures are available for the two census years, 1970 and 1980, but must be developed for intercensal years. The Maryland Center for Health Statistics provides births and deaths by sex, race, age of the mother (in the case of births) and sex, race and age of the deceased (in the case of deaths) for the intercensal period. The 1970 and 1980 census detail, along with the vital statistics for the intervening periods, permits total population change in each county over the ten years to be disaggregated into its components -- births, deaths and net migration. These three components are also obtained by age, race, and sex.

Once the baseline data are established it is necessary to apply fertility, mortality and migration assumptions to the various age, race and sex cohorts. The fertility assumptions for

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each county are based upon the age and race cohort-specific fertility actually experienced during the 1979-1981 period. These fertility rates are assumed to change in accordance with the rate of change in fertility projected by the Census Bureau for the U.S. A similar approach was followed for the mortality assumptions. The methodology provides special recognition and separate treatment of "group quarters" under the age of 65 (i.e., military, college dormitory, institutionalized population), since that part of the population is not readily determined by the usual cohort survival methods.

The final and perhaps most difficult part of the methodology involves net migration (by race, sex and age cohort). Using the information described above, migration rates for each county (with race, sex and age detail) are estimated for the period 1970-1980. (Net migration is, in essence, a residual after accounting for the population changes attributable to fertility and mortality given the fact that the 1970 and 1980 total population figures are known.) The procedure for obtaining projected migration rates involves comparing the population figures (by cohorts) that would result from assuming zero net migration with the county total population figures established earlier in the first stage. Based upon this comparison, the historical migration rates are appropriately modified.

In summary, the cohort survival model begins with the detailed 1980 census figures and calculates population for the years 1985, 1990, 1995 and 2000 in each county by age cohort, sex and race. The calculations require the following inputs:

1. 1980 baseline data for households and "group quarters";

2. fertility rates;

3. mortality (i.e., survival) rates; and

4. migration rates.

Employment[1]

The DSP methodology develops projections of county-level employment for 54 major industry groups for the years 1985, 1990, 1995 and 2000. In doing so, it adheres to the Standard Industrial Classification (SIC) code established by the federal government. The employment projections are calculated by the use of a computerized model.

The DSP methodology employs "economic base" theory. This approach identifies certain key sectors of the economy as base or export industries, and the region's other industries are

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[1]This section is based substantially upon the methodological discussion found in Employment in Maryland, Trends and Projections, 1967-2000, Maryland Department of State Planning, July 1982.

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directly or indirectly linked to the base sectors. Thus the nonbase industries may be thought of as principally serving the local or regional market. Employment in the base industries is determined by the total market demand for the goods and services of those industries. Expansion in the base sectors, in turn, causes a simultaneous expansion in the other, nonbase sectors of the economy. The DSP model identifies agriculture, mining, manufacturing and federal government as the base industries and construction, transportation, utilities, trade, services, state and local government, finance and real estate as the local or nonbase industries.

Changes in the level of economic activity in a given base industry for a given county depend upon two factors -- that industry's share of total national output (i.e., interindustry competition) and that region's ability to maintain or to increase its share of the national market for that good (i.e., interregional competition). Obviously, the level of employment in that industry will also be affected by the overall rate of expansion of the aggregate national economy.

The model further recognizes that nonbasic activity within a county or region may be partially export (to nearby regions) and partially local (referred to as "residentiary"). The export portion of nonbase employment along with the base employment "drives" the expansion of the regional economy.

Projecting expansion in these export sectors (base and revant part of nonbase) is thus the key to developing employment projections for all sectors. State-level employment in each export sector is projected by analyzing historical ratios or relationships between State employment in a given sector and national employment in that sector. The county-level projections are then based upon a similar analysis of historical county-State employment ratios for each export industry.

The DSP projections of export sector employment (which generates local growth) require both an analysis of historical national/State and State/county employment ratios and a set of national-level employment projections. The DSP employment model relies upon the BEA long-range projections of U.S. employment by major industry group for that purpose. These projections were published by BEA in 1980. The historical national, State and county employment data for the period 1967 through 1980 were also obtained from BEA. DSP adjusts the BEA employment figures in order to allocate the self-employed (treated by BEA only as an aggregate) to the 54 industry sectors.

The Maryland shares of U.S. employment and the county shares of Maryland employment are projected by use of time-series regression methods. For each of the export industries (base and relevant part of nonbase), employment shares are calculated for each historical year and regressed against time. These regression equations are developed for the State as a whole and for each Maryland county. The functional form of each

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regression equation is either linear, exponential or logistic, depending upon whether the ratios have been relatively stable, declining or rising over time. Employment by export industry for Maryland can then be calculated as the projected employment share percentage multiplied times national employment in that industry as projected by BEA. The county-level figures may then be calculated in a similar fashion based upon the State-level results obtained in the previous step.

The export sector projections ultimately determine employment in the residentiary sectors of the local economies. The method for translating future export employment into future residentiary employment involves a trend analysis. At the State-level the ratio of residentiary employment in a given industry to total State export employment is computed for each historical year. Trend analyses using linear, exponential or logistic regression models are performed. Once again, the form of the regression depends upon whether the ratio is stable, increasing or declining over time. The same procedure is then followed for each county. The resultant projected ratios are then multiplied times projected export employment to obtain the future employment values for the residentiary component in each industry. Total employment in each nonbase industry is the sum of residentiary and export portions of that industry.

The set of analytical procedures described above produces an initial set of employment projections. The results are then examined and modified in light of existing knowledge concerning local economic and industry conditions. Finally, scaling adjustments are made to the results to reconcile the sum of the county results to statewide totals.

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