fraction of the worldwide total, controlling U.S. emissions alone would not solve the problem of greenhouse gas build-up. In the future, the accumulation of CO_2 and other greenhouse gases may well be determined by the less developed nations, where the population and standard of living are rapidly increasing.

- Other Greenhouse Gases

Methane is the primary constituent of natural gas and, in general, is about 25 times more effective in trapping infrared radiation than CO_2. Some common emission sources include leakage of natural gas from pipelines and venting from oil and gas wells. Methane may also be emitted from coal mining and processing, landfills, rice paddies, biomass burning, and animals (especially cattle and dairy cows). Fossil fuel production activities account for about 15 percent of the total emissions of methane.

Chlorofluorocarbons are a class of chemicals used widely in industrial sectors as refrigerants, propellants, and solvents. CFCs are about 20,000 times more effective in trapping infrared radiation than CO_2. Power plants, however, do not emit CFCs.

The main sources of nitrous oxide are microbial processes within soil and water. Nitrous oxide is about 230 times more effective as a greenhouse gas than CO_2. It is also generated during fossil fuel combustion and biomass burning, but recent measurements indicate that emissions from fossil fuel combustion are low.

Climatic Changes

The greenhouse effect appears to be well supported, but it is not certain that enhanced warming is actually occurring. If it is occurring, the extent of warming, and its specific ramifications, are also uncertain. Climate change due to the greenhouse effect would affect the entire planet, impacting man and the natural ecosystems. Projections of the regional results of global warming are highly uncertain because of the crude treatment of biological and hydrological processes on land and especially the neglect of deep ocean effects in existing climate models. The most recent global climate models suggest that, if CO_2 concentrations were to double from pre-industrial levels, there might be an ultimate increase in the global average surface temperature of 1.5° to 5.5°C. Based on the scenarios studied, if no policies to limit greenhouse gas emissions are undertaken, the equivalent doubling of CO_2 could occur as early as 2030 to 2040 (EPA 1989c).

Reliable predictions for local or regional responses of climate variables such as temperature and rainfall are not currently available. However, several possible effects may occur over the next several decades (Schneider 1989) as a result of warming:

- longer growing seasons in high latitudes;

- wetter springtimes in high and middle latitudes;

- drier midsummer conditions in mid-latitude areas;
- an increased probability of extreme heat waves and reduced probability of extreme cold waves;
- an increased likelihood of summer vegetation fires in drier/hotter regions; and/or
- increased sea levels over the next 100 years.

Such changes, should they occur, could have significant ramifications for the residents of Maryland. For example, hotter summers and milder winters would increase electricity demand in summer but ease it in winter. An increase in sea level would amplify the effects of storms on coastal cities such as Ocean City and would impact coastal planning. Increased drought is possible, but is less certain than predicted increases in temperature and rise in sea level. Drought may cause adverse effects on water supplies, agriculture, and wetlands.

Current observations do not conclusively prove that the expected global warming from the observed increase in greenhouse gases has indeed begun. However, if greenhouse gases continue to build in the atmosphere, global warming could eventually take place. Most researchers believe that there is a better than even chance that the climate will significantly change in the future due to human activities (Schneider 1989); however, uncertainties about this change abound. Today researchers cannot reliably predict the magnitude or timing of the change or what might be expected in specific regions of the globe.

Responses

Currently no U.S. regulations specifically address the greenhouse issue, although there are over a dozen pieces of legislation being considered by Congress. Many investigators are emphasizing that, particularly in light of the continued industrialization of developing countries, global warming is a worldwide issue that should be addressed internationally. However, some states are already responding by setting aggressive goals such as a 20 percent reduction in CO_2 emissions by the year 2000. International treaties responding to global climate issues are also being considered.

In spite of the uncertainties and due to the potential consequences, policies are being formulated to address environmental and economic concerns, while responding to the global warming issue. The steps that have been identified as likely to lessen the progress of global warming will also aid in reducing other pollutant emissions. These suggestions include the promotion of conservation within the utility as well as other sectors and a shift in fuel use toward natural gas and non-fossil fuel alternatives.

Some suggestions to slow down global warming include:

- shift fuel use from coal to oil and natural gas;
- promote energy conservation and the use of solar heating;
- set standards of high efficiency for appliances, lights, automobiles, and buildings;
- endorse mass transit programs;
- allow utilities to market conservation;
- promote effective land use planning;
- develop tree planting programs;
- impose fuel emissions fees to reflect actual environmental costs; and
- reevaluate the use of nuclear power.

I. Other Issues

The preceding sections have focused primarily on the occurrence, control, and consequences of air pollutant emissions from power plants. This section focuses on a few of the less well-developed issues that may be of significance in the future. These issues include: visibility degradation, crop loss, impacts to pristine (Class I) areas, and the use of small and non-utility electric power generators.

Visibility Degradation

Visibility degradation is described as loss of visual range or obscuration of distant features. It is objectively evaluated by directly measuring visual range. However, subjective measures such as the number of very clear days per year or the number of days on which important scenic features are obscured may be of more interest to the general public.

By objective measures, visibility in the northeastern United States steadily deteriorated between 1948 and 1970. Mean visibility decreased 60 percent during this period. Improved visibility has been noted in northeastern states (including Maryland) in recent years and is attributed to reductions in SO_x emissions and ambient sulfate aerosol. In the Ohio River Valley and some eastern locations, visibility degradation is certainly correlated with sulfur emissions and sulfate aerosol, but degradation in other areas has been associated with NO_x in power plant plumes and with the formation of particulate matter during photochemical oxidation of organic compounds.

The possibility that power generation, a major source of sulfate precursors, causes or contributes to degradation of visibility in Maryland cannot be discounted. Not only do power plants contribute a substantial amount of the state's loading of SO_x, but blowing particulate material from fugitive sources and cooling tower mist may contribute to local visibility degradation.

Crop Loss

Numerous reports of crop loss associated with air pollutants may be found in the literature (Davis and Wilhour 1976; Irving 1983; Shriner *et al.* 1990). Ozone, sulfur oxides, and toxic particulate emissions have all been linked with decreased growth and yield in food and fiber crops and trees. Of these, the most significant effects are associated with ozone, which causes crop loss at concentrations less than the NAAQS. This issue has not been recently addressed in Maryland in either the general air quality context or in relation to power plant emissions.

Impact on Class I Areas

The ability of air pollutants to cause damage is of particular concern in pristine areas of the country, such as national parks and wilderness areas. Class I areas, including most national parks, receive special protection under federal PSD review requirements. The allowable increments for all pollutants in Class I areas are much lower than for other areas (Table 3-2), and special provisions in the regulations require participation of the local Federal Land Manager in all permitting decisions that might impact Class I lands. The Clean Air Act Amendments of 1977 established guidelines for the designation of federal lands as Class I areas. The intent of Congress was to protect and preserve "visibility and those scenic, cultural, biological, and recreational resources of an area that are affected by air quality" for future generations of Americans.

No Class I areas are located in Maryland. The closest Class I areas in the surrounding states are the Shenandoah National Park in Virginia, the Dolly Sods and Otter Creek National Wildlife Refuges in West Virginia, and the Brigantine National Wildlife Refuge in New Jersey.

The Federal Land Manager has the responsibility of protecting air quality related values (AQRVs), such as visibility, in the Class I areas. The required additional impacts analysis of a new source's PSD permit is intended to provide the Federal Land Manager with information regarding potential impacts on Class I areas. The Federal Land Manager can bar the issuance of a PSD permit, regardless of whether the Class I PSD increments are being met, if it can be demonstrated that the proposed source (or modification) would adversely impact the AQRVs of such lands.

At the present time, available evidence suggests that emissions from Maryland power plants do not contribute significantly to degradation of air quality in Shenandoah National Park or any other Class I areas.

Small and Non-Utility Generators

Multiple small utility and non-utility generators could have environmental impacts far different from those of a single large generator producing the same amount of electricity. Although the emissions from a number of small sources might be distributed in space, the maximum ground level impacts could be greater than those produced by a single large generator. Stacks of small generators would tend to be shorter than those of a large source. Some of the electricity might be obtained from existing facilities having less effective emission controls than those required for new sources. For new small generators, control requirements may not be as stringent as for larger units. Furthermore, some cogenerators, e.g., municipal waste incinerators, may present environmental issues that large utility generators do not.

Until recently, little attention has been paid to any adverse cumulative impacts that might stem from the addition of small generators. A comparative analysis of the environmental impacts of such generators versus those of large utility generators producing equivalent electricity could be valuable in assessing the overall environmental impacts.

J. Summary and Conclusions

Recent years have seen a major shift in environmental concerns related to power plant emissions to the atmosphere. Until the past few years, the major concerns focused on the NAAQS and PSD increment consumption provisions of the Clean Air Act. Of these provisions, only two seem to remain as unresolved issues: the potential contribution of power plants to ozone formation, and fugitive dust emissions from coal-fired power plants. New issues such as global warming and toxic pollutants have been receiving increasing attention from the community at large, as well as from the regulators. Furthermore, there is increasing focus on emissions controls regardless of their effect on ambient air concentrations.

It appears that power plant-induced ground level concentrations of SO_x and NO_x, even when considering future increases in electricity generation and the impacts of all power plants combined, are generally too small to be of major concern in Maryland with regard to human health. Increases due to new sources will tend to be low because of the more stringent application of BACT. The recent acid rain provisions of the Clean Air Act will reduce emissions from existing sources, and will likely result in lower ground level concentrations. The major issues concerning power plant emissions of SO_x and NO_x will, therefore, center not on ground level concentrations of the pollutants, but on the control of emissions. For new facilities, the major atmospheric issues are likely to revolve around the determination of suitable BACT. For existing plants, the issues regarding reductions mandated by the Clean Air Act Amendments are likely to receive the most attention.

Even though hydrocarbon emissions from power plants are small, Maryland NSINA regulations may place severe restrictions on power plants constructing in non-attainment areas for ozone. Currently, most strategies for reducing ozone formation have centered on reducing hydrocarbon emissions. However, in some locations, reduction of NO_x emissions may be more effective. It is important to determine the role of NO_x in the formation of ozone in Maryland. It may be that concerns regarding ozone formation will join those on acid precipitation as important reasons for controlling NO_x emissions. Further study is needed on this issue.

PM10 has replaced TSP in regulations related to ambient levels of particulates because smaller particles can have more significant health effects. Ground level concentrations of particulate matter due to emissions from power plant stacks are usually low and of little concern. However, PM10 non-attainment in some areas of Maryland might dictate additional restrictions on particulate emissions from existing or new power plants. In contrast to stack emissions, fugitive dust emissions from coal-fired facilities could be significant, depending on the controls used and the location of the sources. Fugitive particulates from new coal-fired sources would be a significant issue during licensing because of the difficulty of estimating the quantity of emissions (particularly PM10), and the cost of controls. Better methods are needed to estimate fugitive PM10 emissions from power plant sources and the effectiveness of various controls on them.

Since much of the toxic material originating from power plants is found in particulates, effective strategies for reducing stack and fugitive particulate emissions would serve to reduce toxic emissions as well. Although preliminary evidence indicates that inhalation of toxics originating at power plant stacks is not a significant issue, the effects of indirectly ingesting such toxics are more uncertain. Further study is needed to ascertain the impacts of power plant stack and fugitive emissions through the food chain. Public concern has brought the issue of toxic air emissions to the forefront in licensing procedures.

The possibility of global warming due to the greenhouse effect is a significant worldwide environmental issue. However, there is considerable uncertainty over the rate of warming and its consequences. Control strategies for reducing CO_2 emissions include energy conservation and the use of alternate energy sources such as solar and nuclear energy. Energy conservation and the use of solar or nuclear energy could have the important added benefits of conserving resources and reducing overall pollutant emissions.

Maryland power plants are considering meeting some of their electrical power needs by obtaining power from small and non-utility generators. The environmental impacts of small generators may be far different from those of larger utility generators furnishing equivalent power. The environmental impacts of such actions have not been investigated, and the adequacy of current regulations to address the environmental differences has not been determined.

K. References

Babcock and Wilcox. 1989. Staged combustion for reduced NOx emissions from an atmospheric fluidized-bed combustor. Prepared by the Babcock and Wilcox Company, for the Electric Power Research Institute, June 1989.

Ames, J., T. Myers, L. Reid, D. Whitney, S. Golding, S. Hayes and S. Reynolds. 1985. SAI Airshead Model Operations Manuals - Vol. I - User's Manual. U.S. Environmental Protection Agency, Research Triangle Park, NC. EPA-600/8-85-007a. (NTIS # PB 85-191567).

BACT/LAER Clearinghouse. A compilation of control technology determinations. Report prepared by Emission Standards Division, U.S. EPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC. PB89-225411.

Burton, C.S. and G.Z. Whitten. 1988. Efficacy of locally-implemented NOx emissions reductions as a means of attaining the existing Federal ozone NAAQS: Criteria for identifying candidate areas and methods for judging acceptable strategies. Special report prepared for the Utility Air Regulatory Group by SAI, Inc. San Rafael, CA. SYSAPP-88/058.

Calabrese, E.J. and E.M. Kenyon. 1989. The perils of state air toxics programs. Environmental Science and Technology 23:1323-1328.

CBRM (Maryland Department of Natural Resources, Chesapeake Bay Research and Monitoring Division). 1989. Solid waste issues associated with sulfur dioxide emission control. Prepared by the Maryland Department of Natural Resources, Cheasapeake Bay Resources and Monitoring Division, Annapolis, MD. AD-89-3.

Davis, D., G. Smith and G. Klauber. 1974. Trace gas analysis of power plant plumes via aircraft measurement: O3, NOx and SO2 chemistry. Science 186: 733-736.

Davis, D., and R. Wilhour. 1976. Susceptibility of woody plants to sulfur dioxide and photochemical oxidants. A literature review. U.S. Environmental Protection Agency, Washington, D.C. EPA 600/3-76-102.

Entropy. 1988. Stationary source sampling report: Reference No. 5831. Report prepared by Entropy Environmentalists, Inc., Research Triangle Park, NC, for Potomac Electric Power Company, Washington, DC.

EPA. (United States Environmental Protection Agency). 1981. Air pollution control orientation course. SI:422, Third Edition, Unit 2, "Effects of Air Pollution". Prepared by Northrop Services, Inc., Research Triangle Park, NC. EPA-450/2-81-017b.

EPA. 1986. Air quality criteria for ozone and other photochemical oxidants. Volumes I-IV. Prepared by Environmental Criteria and Assessment Office, Research Triangle Park, NC. EPA-600/8-84-020-AF-EF.

EPA. 1987. Improving new source review implementation. Memo from J. Craig Potter, Assistant Administrator for Air and Radiation, to Regional Administrator Regions I-X.

EPA. 1989a. The analysis of air toxic emissions, exposure, cancer risk and controllability in five urban areas. Volume I-Base year analysis and results. Prepared by Office of Air Quality Planning and Standards, Research Triangle Park, NC. EPA-450/2-89-012A.

EPA. 1989b. Estimating air toxics emissions from coal and oil combustion sources. Prepared by Office of Air Quality Planning and Standards, Research Triangle Park, NC. EPA-450/2-89-001.

EPA. 1989c. Policy options for stabilizing global climate. Volume I. Draft report prepared by U.S. EPA Office of Policy, Planning and Evaluation, Washington, D.C.

FERC (Federal Energy Regulatory Commission). 1977-1988. FERC Form No. 1 for Maryland Utilities.

Hansen, J., I. Fung, A. Lacis, D. Rind, S. Lebedeff, R. Ruedy, and G. Russell. 1988. Global climate changes as forecast by Goddard Institute of Space Studies Three Dimensional Model. Journal of Geophysical Research 93:9341-9364.

Heck, W.W., R.M. Adams, W.W. Cure, A.S. Heagle, E. Heggestad, R.J. Kohut, L.W. Kress, J.O. Rawlings and O.C. Taylor. 1983. A reassessment of crop loss from ozone. Environmental Science & Technology, 17: 573A-581A.

Houghton, R. and G. Woodwell. 1989. Global climate change. Scientific American Volume 260, Number 4. April 1989.

Irving, P. 1983. Acidic precipitation effects on crops: A review and analysis of research. J. Environmental Quality. 12(4): 442-453.

Makanasi, J. 1988. "Reducing NOx Emissions", Power, September 1988, p. S-1.

Martin, R.R., and W. M. Johnson. 1984. NOx Control in Fire Heaters. The John Zink Company. March, 1984.

Maryland Handbook on Environmental Law, "Regulation of Air Resources" Chapter II, pp. 13-30. 1988. Baltimore, MD and Washington, DC., Piper and Marbury.

MDE (Maryland Department of the Environment). 1988. Maryland state yearly air quality data report for 1988. Prepared by the Maryland Department of the Environment, Air Management Administration, Annapolis, MD.

MDE. 1989. Maryland Emissions Inventories for 1984 - 1987. Prepared by the Maryland Department of the Environment, Air Management Administration, Annapolis, MD.

Meszler, D. 1990. Model output from Mobile-4 runs made using the default mode to generate estimates of emissions. Personal communication from D. Meszler, MDE, Annapolis, MD, to S. Kamen, Versar, Inc., Columbia, MD, 3 January 1990.

Meyer, E. 1990. Personal communication from E. Meyer, EPA, Model Applications Section, Office of Air Quality Planning and Standards, Research Triangle Park, NC to S.A. Campbell, S.A. Campbell and Associates, Columbia, MD, 8 January 1990.

Pedersen, W. 1987. Air pollution control. In: Environmental Law Handbook, 9th Edition. pp. 292-329. Rockville, Maryland, Government Institutes, Inc.

Perhac, R. 1989. A critical look at global climate and greenhouse gases. Power Engineering, September 1989.

PPER (Maryland Department of Natural Resources, Power Plant and Environmental Review Division). 1989. Risk assessment study of the Dickerson site, Volumes I, II, and III. Report prepared by Versar, Inc. ESM Operations, Columbia, MD, Environmental Resources Management, Inc., Exton, PA and Annapolis, MD, S.A. Campbell and Associates, Columbia, MD, and R. Nilsson, Stockholm, Sweden, for the Maryland Department of Natural Resources, Power Plant and Environmental Review Division, Annapolis, MD. PPSE-SH-4.

PPRP. 1988. Power plant cumulative environmental impact report. Prepared by the Maryland Department of Natural Resources, Power Plant Research Program. Annapolis, MD. PPRP-CEIR-6.

Schneider, S. 1989. The changing climate. Scientific American, Volume 261, Number 3, September 1989.

Seinfeld J. 1989. Urban air pollution: state of the science. Science 243: 745.

Sexton, K. and Westberg. 1983. Photochemical ozone formation in urban and point source plumes. Environ. Sci. Technol. 17: 224-227.

Shriner, D., W. Heck, S. McLaughlin, D. Johnson, J. Joslin, and C. Peterson. 1990. Response of vegetation to atmospheric deposition and air pollution. Prepared for National Acid Deposition Assessment Program, Washington, D.C. ORNL/ESD Publicaiton No. 3452.

Simpson, D. 1989. Total vehicle miles traveled in Maryland 1980-1988. Personal communication from D. Simpson, Maryland Department of Transportation, to S. Kamen, Versar, Inc., Columbia, MD, 19 December 1989.

Trueblood, R.C., C. Wedig and R.J. Gendreau. 1989. Efficiency of fabric filters and ESPs in controlling trace metals emissions from coal-burning facilities. Presented at Conference on Air Quality Issues Pertaining to Power Production, Enfield, CT, 1989.

Van Royen, R.G. McInnes, V.L. Putsche and K.C. Jameson. 1989. Methods for establishing emissions inventory for combustion sources. Presented at Conference on Air Quality Issues Pertaining to Power Production, Enfield, CT, 1989.

Walter, E.G. 1988. The potential effects of plume interactions at Dickerson on atmospheric transformations of volatile organic emissions and on ozone formation. Presented as testimony on behalf of Maryland Department of Natural Resources in the Matter of Potomac Electric Power Companys' Application for a Certificate of Public Convenience and Necessity for Station H, Case 8063, Phase I. January 6, 1988.

Wang D., F. Borman and D.F. Karnosky. 1986. Regional tree growth reductions due to ambient ozone: evidence from field experiments. Environ. Sci. Technol., 20: 1122-1125.

L. Glossary

Air Management Administration. 1989. Maryland state yearly air quality data report - 1988. Maryland Department of the Environment, Air Management Administration, Baltimore, MD.

Atmospheric fluidized bed combustion. Refers to the combustion of fuel in a "fluidized" bed. A fluidized bed consists of a bottom level in a combustor that is filled with granular particles of sand, limestone, or ash. Air blown up through this bottom level suspends the particles and thus "fluidizes" the bed material. This process can serve both as a furnace and an air pollution control device. A material is added to the bed to react with and capture pollutants.

Attainment area. An area where ambient levels of a given criteria pollutant is below the National Ambient Air Quality Standards (NAAQS). Attainment means meeting the NAAQS for that pollutant.

Baghouse. An air pollution control device used to reduce dust and particulate matter emissions from stacks. Baghouses consist of multiple collecting bags (similar in concept to vacuum cleaner bags) suspended inside a protective casing.

Class I area. Pristine area (e.g., certain national parks) as designated by the Clean Air Act, in which air quality and air quality related values are determined to be significant attributes.

Coal gasification. A technology in which coal is converted into a gas, treated for particulate and sulfur removal, and then routed to combustion turbines or elsewhere. Coal gasification can be used as an alternative to conventional coal-fired electric power generation with post-combustion control.

Emissions offsets. A process by which emissions from a new source are counteracted or "offset" by decreases in emissions from existing sources.

Electrostatic precipitator (ESP). An emissions control device that reduces dust and other particulate matter emissions to the atmosphere by attracting particles in the exhaust gas to charged collection plates or tubes.

Flue gas desulfurization (FGD). An emissions control technology that uses an alkaline mixture to absorb sulfur dioxide in the flue gas, producing a sodium- or calcium-sulfur by-product.

Fugitive emissions. Those emissions that are not collected and routed through a chimney, smokestack, or vent at a power plant.

Global warming. A theory suggesting that over time, worldwide temperatures will increase due to the enhancement of the greenhouse effect.

Greenhouse effect. Trapping of heat by the atmosphere. As the Earth intercepts sunlight, a fraction of the sunlight is absorbed by the atmosphere and the Earth's surface. The absorbed solar energy is re-emitted at a lower frequency as heat, which may be trapped in the atmosphere due to clouds and trace gases. This effect results in an atmosphere that is warmer than would be expected for a planet located 93 million miles from the Sun.

Increments. Increases in ambient pollutant concentrations above baseline levels. Increment limits, established under PSD regulations, prevent the degradation of air quality at locations currently attaining NAAQS.

Lowest achievable emission rate. The most stringent emissions limitation achieved by a similar source anywhere in the country, regardless of cost.

National Ambient Air Quality Standards (NAAQS). Limits on the maximum concentration of pollutants in the outdoor air, established by EPA to protect public health and welfare with an ample margin of safety.

National Emissions Standards for Hazardous Air Pollutants (NESHAPs). Standards, both pollutant- and source-specific, established to protect health from pollutants that are deemed to pose a significant threat to public health and that are not regulated under ambient air quality standards.

NCDC. 1989. Local climatological data, annual summary with comparative data for Baltimore, MD (Baltimore-Washington International Airport). National Climatic Data Center Asheville, NC.

New Source Performance Standards (NSPS). Standards that establish a minimum level of control required for a particular type of source.

New Sources Impacting on a Non-attainment Area (NSINA). Maryland State regulations designed to protect the environment by imposing stringent requirements on new sources of air pollution in the more polluted areas of the State.

Non-attainment area. An area where the ambient level of a criteria pollutant exceeds the NAAQS for the pollutant. An area may be designated non-attainment for one pollutant and still be designated attainment for others.

Ozone. A gaseous compound (consisting of three atoms of oxygen) that is formed in the atmosphere by a variety of photochemical mechanisms, particularly during the oxidation of atmospheric hydrocarbons in the presence of sunlight and NO_x.

Prevention of Significant Deterioration (PSD). A federal program established to prevent deterioration of air quality in areas of the country with relatively good air quality (i.e., areas in attainment with NAAQS).

Quiet combustor. A control technology that uses modifications to the combustion zone of a natural gas turbine to lower temperatures and reduce the amount of NO_x formed.

Selective Catalytic Reduction (SCR). A post-combustion method of air pollution control, designed to remove NO_x from the flue gas formed during combustion.

Small utility generators. Producers of electricity with a total capacity of less than 100 MW.

State Implementation Plan. A federally approved plan developed by each state to describe how State laws and regulations will be implemented to ensure compliance with federal air quality requirements.

CHAPTER 4

AQUATIC IMPACT

A. Introduction

The rivers, lakes, and estuaries comprising the aquatic environment of Maryland serve as sources of cooling water, receiving bodies for effluents, and sites for hydroelectric generation. Power generation activities impact the aquatic environment in several ways: they can disturb biotic structures or processes which can potentially affect food supplies, release toxic chemicals, and change the aesthetic quality of recreational areas.

The Chesapeake Bay and its tributaries serve as the major source of cooling water for electric generation in Maryland and also as receiving water bodies for power plant effluents. Most Maryland steam power plants use once-through cooling systems to remove excess heat from the condensers. Such systems continuously draw "new" water into the plant from a source water body, heat it 5° to 17°F as it passes through the condenser, and discharge it into a receiving water body. Closed-cycle cooling, which is used at three major Maryland power plants, "recycles" water in a cooling tower and draws new water only to make up for evaporative losses and to clean working parts of cooling towers. Water withdrawals for closed-cycle systems are 2 to 25 percent of those for once-through systems, although a much greater percentage of the water withdrawn is consumed through evaporation.

Hydroelectric power plants utilize the potential energy of impounded water to generate electricity. The construction, filling, and operation of dams (for hydroelectric power or for other purposes) may change water quality and the physical characteristics of upstream and downstream habitats, and alter the migration patterns of anadromous fish. Some hydroelectric facilities in Maryland are installed where impoundments already exist; in such cases, no dam construction impacts are attributable to the power facility.

All these activities affect a complex environment. The Chesapeake Bay is one of the largest and most productive estuaries in the world, supporting a complex food web that produces large quantities of fish and shellfish. The Bay's food web includes microscopic algae, called phytoplankton; small animals, called zooplankton; dead and decaying matter, called detritus, and the microorganisms that decompose it; biota that live on the bottom, called benthic organisms; forage fish such as anchovies and menhaden; larger fish, like white perch, striped bass, and bluefish; and crabs. Maryland's rivers and streams also support complex assemblages of organisms, comprising food webs comparable to those found in the Chesapeake Bay.

This chapter presents the cumulative impact assessment for the aquatic environment. It discusses detailed information from current research into power plant impacts, and summarizes studies covered in earlier CEIRs. For details of these earlier studies, readers should refer to previous CEIRs (PPSP 1975, 1978, 1982, 1984, 1986; PPRP 1988) or the original sources cited therein.

B. Sources and Nature of Impact

Water Withdrawal and Consumption

Approximately 1,440 million gallons per day (mgd) of water is withdrawn for each 1,000 MW of generating capacity with once-through cooling; much of this water is not consumed, however, but returned to the aquatic environment. Surface water withdrawals as reported to the Maryland Water Resources Administration (WRA) by Maryland power plants (non-utility as well as utility owned) for 1988 are shown in Table 4-1.

In 1985, Maryland withdrew about 6,710 mgd of water for all uses combined, 1,410 mgd of fresh water and 5,300 mgd of saline water (Solley *et al.* 1988). In that year, about 5,030 mgd of saline water (95 percent of total saline withdrawals) were used for steam electric cooling along with 399 mgd of fresh water (28 percent of the total fresh water withdrawals).

In general, the availability of water in Maryland is considered good (Viessman and DeMoncada 1980). Due to the availability of saline water from the Chesapeake Bay, saline water withdrawals are a much greater proportion of the Maryland total than in other states of the mid-Atlantic region and around the country. In the U.S. as a whole, water withdrawals for generation of electricity accounted for about 37 percent of all freshwater withdrawals in 1975, second only to agriculture in water use (Viessman and DeMoncada 1980).

Steam electric plant cooling utilized nearly 69 percent of the total freshwater consumed in the state. Freshwater "consumed" is the portion of water withdrawn that is not returned to the aquatic environment, usually being lost to the atmosphere. This is a much greater proportion than in the mid-Atlantic region (25 percent) or in the U.S. as a whole (4.7 percent) (Solley *et. al.* 1988). Power plant water consumption represents about 2 percent of the total amount of water withdrawn from the Bay each year (Corps of Engineers 1984). This means that about 0.18 percent of the volume of water in the Chesapeake Bay is consumed each year for power plant cooling. This amount is also equivalent to about 0.22 percent of the annual average freshwater inflow to the Chesapeake Bay (for its entire watershed) or 4.3 percent of the "7Q10" flow, which is the seven-day low freshwater inflow expected to occur once every ten years. The Potomac River plants (R.P. Smith and Dickerson) consume an estimated 1.5 percent of the 7Q10 flow at Point of Rocks.

Three major Maryland power plants (Brandon Shores, Chalk Point, and Vienna) use closed-cycle cooling, which requires new water only to replace evaporative losses and to clean working parts of the cooling towers (blowdown). Water requirements for closed-cycle systems are 2 to 25 percent of those for once-through systems, but as much as half of the water withdrawn is lost to evaporation. Power plants with once-through cooling, by contrast, lose about 0.7 to 2 percent of the

Table 4-1
Surface water withdrawals at Maryland steam plants

Power Plant	Cooling System Type	Water Body	Water Type	Plant Withdrawal (mgd) Max Permitted	1988 Avg.
Brandon Shores	cooling towers	Patapsco	saline	50	13
BRESCO	once-through	Patapsco	saline	62	32
Calvert Cliffs	once-through	Chesapeake Bay	saline	3,500	2,895
Chalk Point	*	Patuxent	saline	720	603
C.P. Crane	once-through	Seneca Creek	saline	475	353
Dickerson	once-through	Potomac	fresh	400	368
Gould Street	once-through	Patapsco	saline	75	46
Morgantown	once-through	Potomac	saline	1,500	1,216
Riverside	once-through	Patapsco	saline	200	91
R.P. Smith	once-through	Potomac	fresh	(no permit)	48
Vienna	cooling towers	Nanticoke	fresh	4.3	1.3
Wagner	once-through	Patapsco	saline	940	813
Westport	once-through	Patapsco	saline	150	23
Total				8,076.3	6,502.3

*Units 1 and 2 use once-through cooling while units 3 and 4 use cooling towers.

Source: WRA.

water withdrawn (Corps of Engineers 1984; SRBC 1989). Units 3 and 4 at Chalk Point utilize closed-cycle cooling systems, which require 24.5 mgd of makeup water for each cooling tower. Evaporative losses consume approximately 8.6 mgd for each tower, 35 percent of the makeup water withdrawn. Blowdown utilizes 15.8 mgd; this amount is indirectly returned to the discharge canal from settling ponds (UE&C 1989).

As electric power demand increases and obsolete plants are replaced, it is expected that waste heat will be dissipated increasingly by wet cooling towers, for all steam electric generating processes. The gradual replacement of once-through cooling with closed-cycle cooling towers means an increase in consumptive use and a decrease in water withdrawals. A summary of projected surface water withdrawal and consumptive use for proposed Maryland power plants is shown in Table 4-2.

The U.S. Army Corps of Engineers in 1984 projected an increase in freshwater consumption rates due to power production in the Chesapeake Bay basin to about 800 mgd by the year 2020. This represents about 31 percent of the seven-day low freshwater flow expected to occur once every 10 years based on historical records. The electric power industry would then become the second largest consumptive user of fresh water in the Chesapeake Bay basin by the year 2020 (Corps of Engineers 1984). More recent information indicates that freshwater consumption by power plants will be substantially less than previously projected. In the Susquehanna River basin, the Corps of Engineers (1984) projected freshwater consumption to be 528 mgd by the year 2020; average consumptive use in the basin is currently estimated to remain at 71 mgd at least through 2001 (SRBC 1989). There may, however, be increasing pressure to locate future generating sites on estuaries or the ocean in order to conserve fresh water.

Biological, Water Quality, and Thermal Impacts

As water is drawn through a steam or hydroelectric power plant and returned to the receiving water body, aquatic biota may be injured or killed in the plant structures or by plant-related environmental alterations. These interactions and the ensuing stresses encountered by aquatic biota are briefly described below; more detail was presented in previous CEIRs. Different organisms are susceptible to damage from different types of interaction, as shown in Table 4-3.

- Types of Impacts for Steam Electric Stations

For steam electric stations, impacts can be classified in four major categories: entrapment, impingement, entrainment, and discharge effects. Figure 4-1 illustrates where these impacts occur.

Entrapment

Entrapment is the accumulation of fish and crabs (brought in with cooling water flows) in the intake region (Area A in Figure 4-1; plant intake regions are not always clearly delineated). There they may be exposed to water of low dissolved

Table 4-2
Projected water withdrawal and consumptive use at proposed Maryland power plants

Proposed Power Plant	Water Withdrawal	Water Consumption	Percent Consumed
Perryman[a]	7.30 mgd	4.18 mgd	57.3
Nanticoke [b]	11.52 mgd	10.37 mgd	90.0
Station H [c]	10.47 mgd	7.98 mgd	76.2
Total	29.29 mgd	22.53 mgd	76.9

All values presented here assume 100% capacity.

Notes and Sources:

(a) Includes cooling tower, combustion turbines, and combined cycle steam turbines (BG&E 1989)

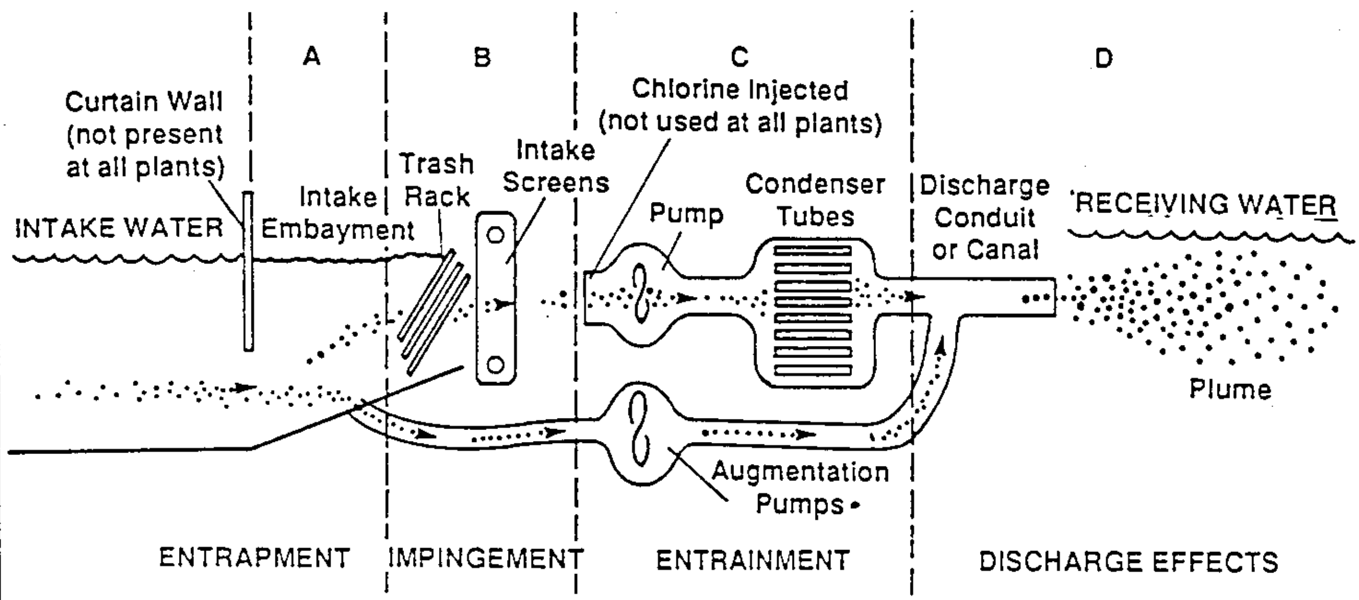
(b) Four 150 MW fluidized bed combustion units with cooling towers; based on 1.15 MGD discharge (RGH 1989)

(c) Includes Elements I, II, and III (proposed Station H, cooling towers, and gasification process) (ERM 1989)

Table 4-3
Major types of aquatic effects of steam electric and hydroelectric power plant operations

Source of Effects	Primary Susceptible Organisms	Type of Stress: Low DO	Mechanical	Thermal	Chemical	Habitat Alteration
STEAM ELECTRIC FACILITIES						
Entrainment						
	Phytoplankton [a]		X	X	X	
	Zooplankton [b]		X	X	X	
	Ichthyoplankton [c]	X	X	X	X	
	Adult and juvenile fish	X	X	X	X	
Entrapment	Adult and juvenile fish and crabs	X				
Impingement	Adult and juvenile fish and crabs		X	X [d]	X [d]	
Discharge	Benthos [e]	X		X	X	X
	Adult and juvenile fish [f]	X		X	X	
HYDROELECTRIC FACILITIES						
Creation of Impoundment	All biota	X				X
Entrainment	Adult and juvenile fish	X	X			
Discharge	Benthos [e]	X				X
	Adult and juvenile fish [f]	X				X
	Ichthyoplankton [c]	X				X

[a] Minute plants present in the water.
[b] Weak swimming animals in the water.
[c] Eggs and larvae of fish.
[d] Only applicable for power plants where impinged biota are returned to the receiving water with discharge waters.
[e] Organisms living in or on the bottom, including shellfish.
[f] Discharge effects on mobile taxa, such as fish, crabs, or plankton, whose behavior and distributions may be strongly influenced by hydrodynamic conditions are extremely difficult to detect..



*Present at Chalk Point plant, but no longer in use.

Figure 4-1. Path of water flow through a power plant using once-through cooling and zones of effects on organisms oxygen content that is drawn in with intake flows, which can weaken or kill them. They may also become weak from prolonged swimming against intake flows and eventually die or become impinged.

Impingement

Larger organisms may become trapped on barriers protecting internal plant structures (e.g., intake screens, barrier nets) (Area B, Figure 4-1). They may become physically damaged and thus more susceptible to disease and less able to compete when returned to the receiving water body. The methods used to remove impinged organisms from barriers and return them to the receiving water body determine, to a large degree, the numbers of organisms killed.

Entrainment

Smaller organisms such as plankton and young fish may be drawn through the plant cooling system and auxiliary pumps. Their contact with cooling system structures and their exposure to high-velocity water, heated effluents, and chemicals used to prevent biofouling frequently causes physical damage and death. Larger organisms can also become entrained by unscreened augmentation pumps, as was the case at Chalk Point before its pumps were shut down (Area C, Figure 4-1). Entrainment and impingement are the primary direct mechanisms through which power plants adversely affect Maryland's aquatic habitats (MMES 1985a). Although fewer organisms are entrained by closed-cycle cooling systems, the high retention time causes essentially 100 percent mortality.

Discharge Effects

Discharge effects are the behavioral and physiological changes (including death) that result from the exposure of aquatic biota to heated effluents, chemicals used to control biofouling (e.g., chlorine), and other toxic discharges. The relative importance of these effects is plant- and site-specific and will be discussed in detail in later sections. Discharges may also modify the overall physical and chemical properties of the water downstream (e.g., salinity regime, sediment characteristics), thus changing the kinds and abundance of organisms at the discharge site. The biological effects of exposure to thermal effluents depend upon the maximum temperature reached, the magnitude of the change, and the duration of exposure. Thermal mortality is generally a major concern when discharge temperature exceeds 35°C (95°F). Chlorine, toxic to most biota in the ppb to ppm range, is a major concern when the concentration in plant effluents is greater than 0.2 ppm. Concentrations of pollutants in water discharged from cooling towers (blowdown) can be from five to 200 times as high as in once-through cooling water. Because less water is discharged in blowdown release, discharge effects occur in a smaller area.

- Types of Impacts for Hydroelectric Facilities

The development and operation of hydroelectric facilities can cause three types of impacts: alterations of water quality, fluctuations and reductions in flow, and prevention of fish passage. Figure 4-2 illustrates where these impacts occur.

Alterations of Water Quality

Hydroelectric generation can affect turbidity, dissolved oxygen (DO) concentration, nutrient concentrations, and water temperature both upstream and downstream of the dam (Areas A and E, Figure 4-2). Changes in turbidity are usually associated with sediment clearing, i.e., dredging or the deliberate discharge of water through mud gates. Turbidity is a special concern when sedimentation of the impoundment frequently recurs.

Alterations in DO, nutrient concentrations, and water temperature are likely to arise in large, stratified impoundments, particularly during summer when the surface water becomes warmer, reducing vertical mixing. Depending upon the layer of the impoundment from which water entering the turbines is withdrawn, downstream aquatic habitats may experience abnormal changes in water temperature, unacceptable concentrations of nutrients, and low DO concentration. Low DO concentrations can harm a wide variety of aquatic biota (Davis 1975). Techniques such as turbine venting used to mitigate DO conditions in the discharge from a hydroelectric facility increase the possibility of nitrogen supersaturation, which can lead to gas bubble disease in downstream fish.

Fluctuations in Water Level and Flow Reductions

Unnatural water level fluctuations occur in impoundments and in downstream aquatic habitats when hydroelectric facilities are operated in a peaking mode, i.e., not continually but in response to peak demand for electricity. In addition, some streamflow is sometimes diverted away from the natural streambed for small-scale hydroelectric projects. Fluctuations in water level and flow may interfere with recreational use of the water body, and directly affect the abundance of food organisms important to fish growth and survival (Hynes 1970; Weisberg and Janicki 1985).

Prevention of Fish Passage

Hydroelectric development can prevent the movement of resident and anadromous fishes past the dam unless a fish ladder or fish lift is installed (Areas C and D, Figure 4-2). Entrainment through turbines may also kill many fish, depending on the type of turbine, the proportion of flow diverted through the turbine, and the size of fish passing downstream (Turbak *et al.* 1981). Loss of freshwater spawning and nursery habitat due to blockage of migration routes is frequently cited as a major factor contributing to declines in anadromous fish populations (e.g., Walburg and Nichols 1967, Chesapeake Executive Council 1988).

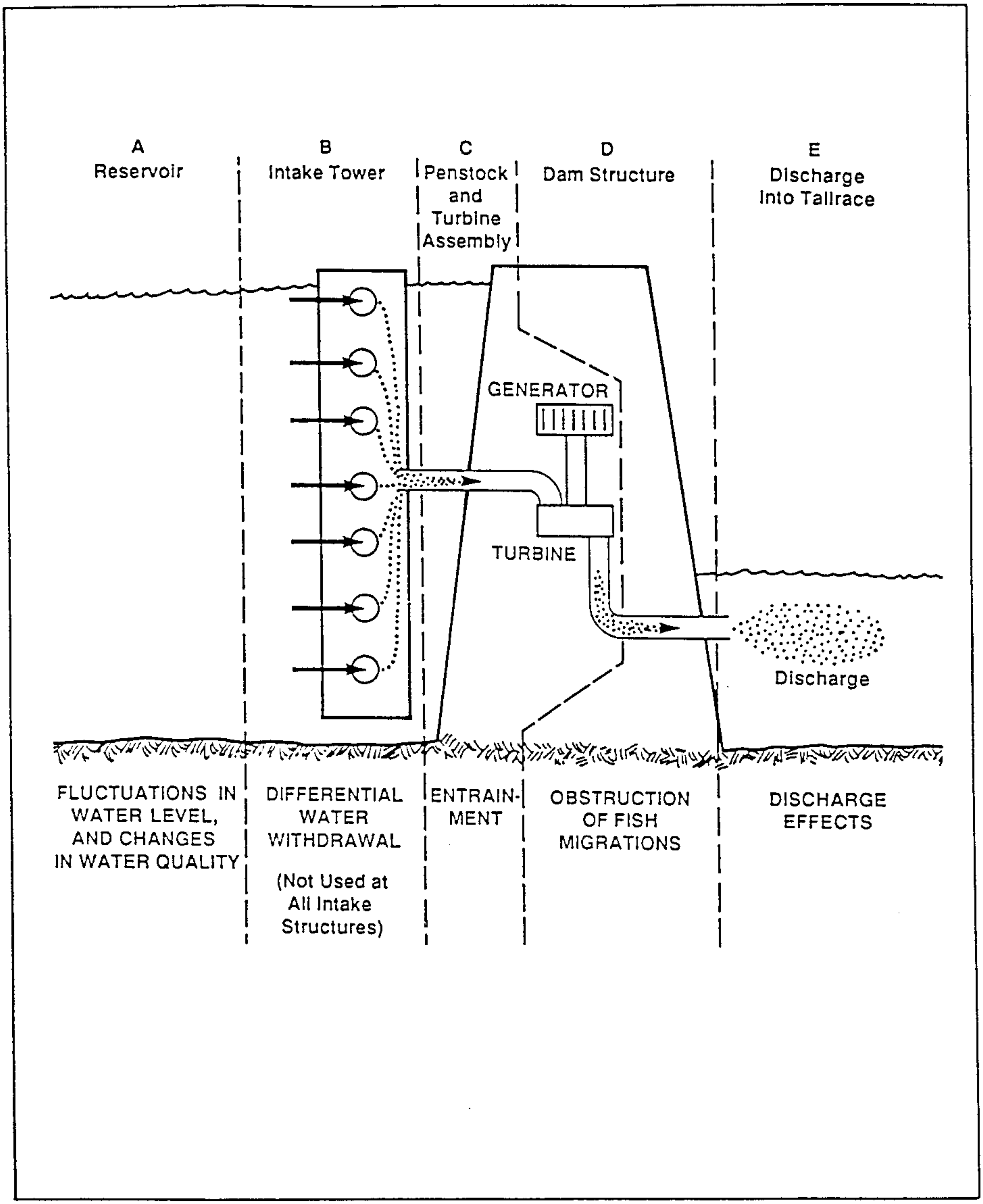


Figure 4-2. Path of water flow through a hydroelectric power plant, and zones of effect on organisms

• Environmental Concerns

Mortalities caused by power plant operations can result in population declines if they are not offset by compensating mechanisms such as increases in growth, fecundity, and/or survival. Losses of phytoplankton and zooplankton are generally recouped quickly because they grow and reproduce rapidly (with generation times of hours to days). Organisms of higher taxonomic levels have much longer generation times, and power plant-related mortalities to these biota are much more likely to result in population declines. Fish, crabs, and many benthic organisms generally spawn once a year; however, some fish may not reproduce until they are several years of age.

The impacts of steam electric generation (i.e., entrainment, entrapment, impingement, and discharge effects) are of major concern for spawning and nursery areas of commercially important or "representative important species," particularly fish (Clark and Brownwell 1973; Jensen 1977; Cada *et al.* 1982). Mortality to a large proportion of each year's spawn or nursery stock can adversely impact regional populations and harvests. Similarly, hydroelectric plant impacts on anadromous fish (i.e., blockage of spawning migrations and destruction of a large percentage of juvenile populations in turbines) can eliminate populations of them in a river system. Localized changes in biotic distribution or abundance (those occurring near the plant's discharge) are less important to ubiquitous species that have relatively broad spawning and nursery areas.

Although direct effects are more likely to be measured, the operation of power plants can also produce indirect effects. Construction of impoundments for hydroelectric power plants can have profound effects on food web dynamics of rivers and streams by changing the kinds and abundances of biota in the impounded area. Water level and flow fluctuations also affect the composition and abundance of biota in habitats downstream of hydroelectric facilities.

C. Aquatic Habitats

The Chesapeake Bay and the streams and rivers that flow into it are composed of distinct and definable habitat types. Estuarine habitat types are defined by salinity, which is the most important environmental variable in controlling biotic distributions (Lippson *et al.* 1979). Flow characteristics determine freshwater riverine habitat types (Hynes 1970). Each habitat has unique functions in producing or supporting important resources, although the biotic components of some habitats overlap and the area of each habitat varies seasonally (with the exception of nontidal fresh waters).

Habitat Types

Aquatic habitat types can be defined using salinity characteristics (Lippson *et al.* 1979):

Habitat	Salinity Ranges
Marine	30 to 35 ppt (parts per thousand)
Polyhaline	18 to 30 ppt
Mesohaline	5 to 18 ppt
Oligohaline	0.5 to 5 ppt
Tidal fresh	0 to 0.5 ppt
Nontidal fresh (riverine)	0 ppt

Figures 4-3 and 4-4 illustrate the general seasonal locations of these habitats. There are no operational or planned steam generating plants in polyhaline or marine habitats in Maryland. The major ecological functions of the other habitats are described below.

- Mesohaline

This medium-salinity zone accounts for most of the aquatic habitat in Maryland (Lippson 1973). Its habitats are the primary areas of shellfish production (i.e., softshell clams, blue crabs, and oysters), and benthic populations are frequently very productive here. Mesohaline habitats also produce most of the estuarine forage fish (e.g., anchovies, menhaden, silversides) and serve as important feeding areas for large predatory fish (e.g., white perch, bluefish, striped bass). The mesohaline salinity zone is sometimes separated into two habitats: high (salinity of 10-18 ppt) and low (salinity of 5-10 ppt). The high mesohaline habitat is important in nursery activities of shellfish, particularly oysters. The low mesohaline habitat is the primary nursery for juvenile blue crabs and many young-of-the-year fish (e.g., spot, bluefish).

- Oligohaline

Much of the suspended sediment and detritus that is trapped by the Chesapeake Bay's complex circulation pattern is deposited in this low-salinity (brackish water) zone, providing an important component of the food web. Nutrient concentrations and primary productivity are also high in the oligohaline zone. These environments support resident fish populations and serve as spawning and nursery grounds for a few fish, including striped bass and white perch. Some forage fishes (e.g., silversides) use oligohaline areas as spawning and nursery grounds, and a few migratory species (e.g., menhaden) feed on its productive plankton populations.

- Tidal Fresh

These segments of estuaries are under tidal influence but see no significant salt intrusion. They provide spawning and nursery habitat for anadromous fishes,

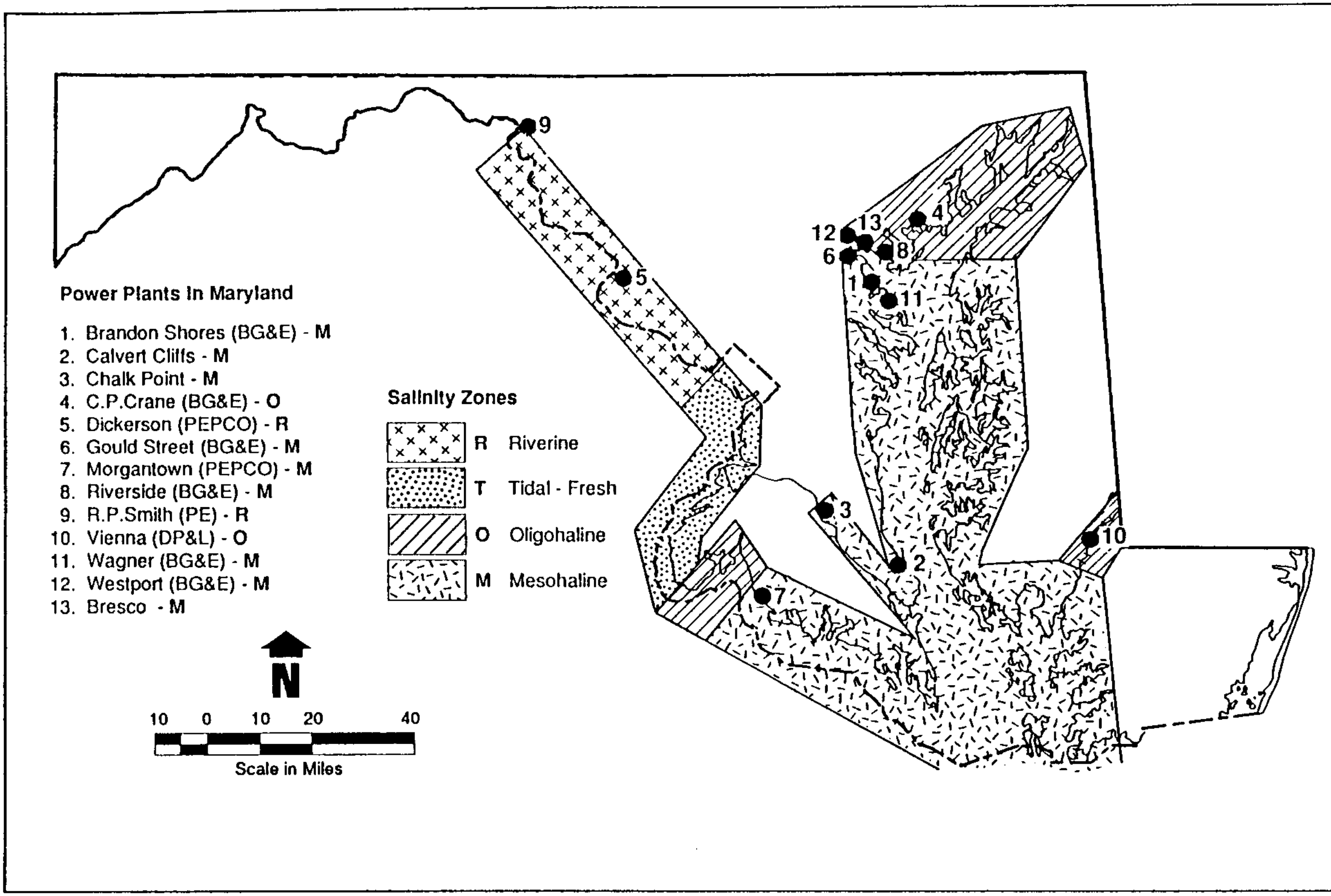


Figure 4-3. Salinity zones of the Chesapeake Bay during summer/fall seasons

15415 71

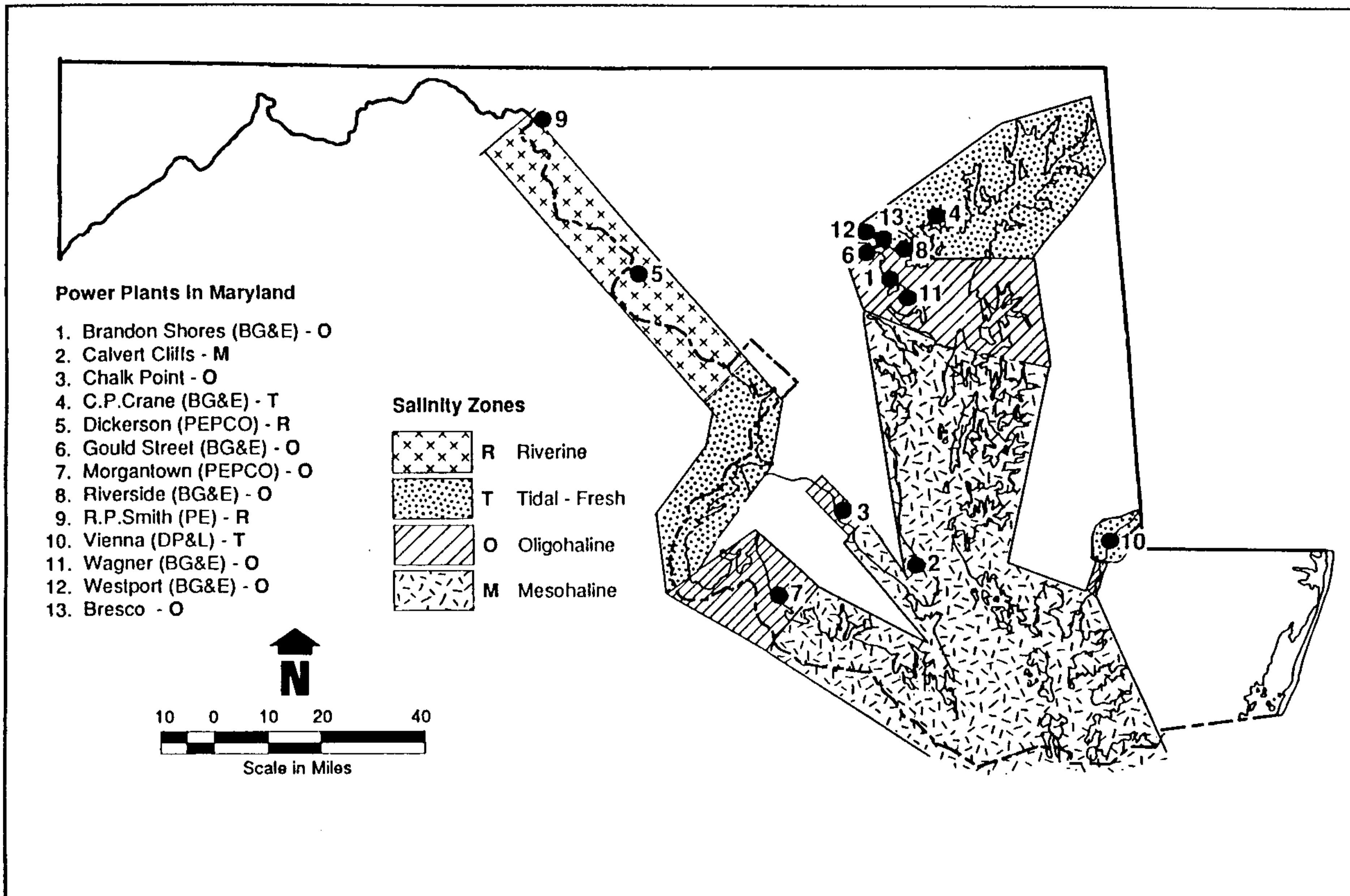


Figure 4-4. Salinity zones of the Chesapeake Bay during the winter/spring seasons

particularly striped bass and white perch, and also support the larvae and juveniles of these species during early development. Some resident fish (e.g., white catfish) spend their entire life cycles in this habitat zone. Large quantities of suspended sediment, detritus, and nutrients are also trapped in this low-salinity zone by estuarine circulation patterns.

- Nontidal Fresh (Rivers and Lakes)

Nontidal riverine habitats in Maryland serve as the major spawning and nursery areas for many anadromous and semianadromous fish (e.g., shad, river herrings, yellow perch). Rivers also support resident fish populations, many of which (e.g., trout, smallmouth bass) are actively pursued by sport fishermen. All of the large lakes in the state are artificial reservoirs, constructed and managed for specific purposes such as flood control, augmentation of low river flows, municipal water supplies, hydroelectric power, and cooling of thermal effluents. Such uses can harm the aquatic habitat for fish species of recreational importance.

Power Plant Locations

The estuarine salinity zones move seasonally in response to rainfall and resulting changes in freshwater inflow. Table 4-4 indicates the salinity zones of the Chesapeake Bay during the winter/spring season, the zones in which Maryland steam generating plants are located, and the generating capacity of each plant.

Table 4-5 summarizes the characteristics and locations of hydroelectric power plants in Maryland, comparing peak capacity, annual generation, water use rates at peak power output, and impoundment volumes. The Conowingo plant on the Susquehanna River is the only large-scale hydroelectric facility in Maryland. Nine small-scale hydroelectric facilities (i.e., less than 30 MW capacity) are operational, and one more is under construction. All are located in nontidal fresh water.

D. Regulatory Considerations

Steam Generating Power Plants

The intake, use, and discharge of water by Maryland steam power plants is regulated through State Surface Water Appropriation and Use Permits and National Pollutant Discharge Elimination Systems (NPDES) permits. These permits reflect federal and state constraints on the amount of water and the type of intake used, as well as the chemical and physical characteristics of effluents.

Because it is not possible or cost-effective to assess power plant effects on all of the species inhabiting aquatic environments, state regulations governing thermal discharges provide for the evaluation of plant impacts on selected representative important species (RIS). These species, because of their abundance, distribution, ecological roles (e.g., food web linkage), or economic importance, are representative or essential to the maintenance of balanced indigenous populations

Table 4-4
Steam electric power plant locations in Maryland (by salinity regime and season)

	Net Capacity (MW)	Winter/Spring				Summer/Fall			
		Riverine	Tidal-fresh	Oligo-haline	Meso-haline	Riverine	Tidal-fresh	Oligo-haline	Meso-haline
Brandon Shores	620 [a]			X					X
BRESCO	50 [b]			X					X
Calvert Cliffs	1,650				X				X
Chalk Point	1,955			X					X
C.P. Crane	390		X					X	
Dickerson	556	X				X			
Gould Street	103			X					X
Morgantown	1,412			X					X
Riverside	493			X					X
R.P. Smith	114	X				X			
Vienna	150		X					X	
Wagner	1,002			X					X
Westport	244			X					X
Total Capacity by zone (MW)		670	540	5,879	1,650	670	0	540	7,529

[a] One 620 MW unit is in operation at Brandon Shores, and one 640 MW unit is under construction.
[b] BRESCO (Baltimore Southwest Resource Recovery Facility) began operations in 1985.

Table 4-5
Licensed and/or operational hydroelectric facilities in nontidal fresh waters in Maryland

Facility	Date Operational	River	Peak Capacity (kW)	Annual Generation (MWh)	Turbine Capacity At Peak Output (cfs)	Normal Impoundment Capacity (Acre-feet)
Brighton	1985	Patuxent River	480	2,685	130	19,000
Conowingo	1926	Susquehanna River	512,000	1,738,000	85,000	310,000
Deep Creek	1925	Deep Creek	20,000	29,000	600	93,000
Gilpin Falls	1984	Northeast Creek	396	2,700	56	8
Gore's Mill	1950s	Little Falls	10	N/A	N/A	4
Jennings Randolph	Under Construction	North Branch Potomac River	13,846	55,000	900	94,700
Parker Pond	1950s	Beaverdam Creek	40	N/A	N/A	130
Potomac River #3	1922	Potomac River	600	1,588	334	1,075
Potomac River #4	Early 1900s	Potomac River	1,000	4,338	940	7,300
Potomac River #5	1919	Potomac River	1,120	6,851	940	4,900
Wilson Mill	1983	Deer Creek	23	N/A	N/A	5

of shellfish, fish, and wildlife. Because changes in their abundance or distribution are regarded as signs of system-wide alterations, they are used as indicators.

The impact of once-through cooling systems on aquatic habitats is evaluated in conjunction with the NPDES permit process and the Code of Maryland Regulations (COMAR) 26.08.03. Under these regulations, an initial evaluation of impact is based on the amount of water used and the size of the thermal plume with respect to physical characteristics of the receiving water body (mixing zone criteria) and the importance of the area as a spawning and nursery site. Mixing zone criteria are indicators of the receiving water body's ability to dilute effluents; failure to pass them indicates a large potential for discharge effects. The importance of the area as a spawning and nursery habitat indicates the potential biological and geographical extent of entrainment and impingement impacts. If the plant fails to pass these screening criteria, a more detailed evaluation of its biological impacts is required. Table 4-6 outlines the types of screening criteria and summarizes the status of those Maryland power plants that are subject to thermal discharge criteria. The utility may request alternate effluent limitations (exceeding those defined by mixing zone specifications in COMAR 26.08.03.03) based upon the findings of the detailed biological studies.

Because impinged organisms are generally either the major reproductive units of certain populations or older, more valuable stages of others, Maryland thermal regulations require that impingement losses be estimated and that actions to minimize them (e.g., modifications to intake structures or operating practices) be evaluated. Estimates of the monetary value of impingement losses are used to evaluate the cost-effectiveness of actions required to reduce impingement.

Actions required to mitigate entrainment losses have no similar financial definition, but are required to be commensurate with the consequences of entrainment losses to regional RIS populations, ecosystem functioning, and economically important fishery resources. Management actions required to mitigate discharge impacts are similarly unrestricted, including any that may be required to preserve balanced indigenous populations in the receiving water body.

As identified in the Maryland Register, 6 October 1989, MDE has proposed to repeal existing Regulations .03 to .05 and to adopt new ones under COMAR 26.08.03 - Discharge Limitations. Although much of the content is identical, the organization of the new regulations will clarify their intent and implementation. Some specific changes include: allowing the establishment of mixing zones on a case-by-case basis (if applicable); establishing a low-volume waiver from the intake structure requirements; requiring that thermal variances be reviewed along with new NPDES permits or permit renewals; and eliminating the RIS list and substituting a definition by functional characteristics.

<u>Hydroelectric Power Plants</u>

Because small-scale hydroelectric facilities fall under federal regulatory jurisdiction, the State of Maryland does not license them. However, under

Table 4-6
Status of power plants under Maryland thermal discharge criteria

Plant	Mixing Zone Criteria	Spawning and Nursery Area of Consequence	Alternate Effluent Limitations	Regulatory Status
BRESCO	Fails	PPER recommended approval with additional studies required to support 1994 permit renewal	PPER recommended approval	Approved with ichthyoplankton and fisheries studies required in 1990.
Calvert Cliffs	Passes	PPER recommended approval	N/A	Approved 12/81
Chalk Point	Fails	Fails	Presently being evaluated	Mitigation studies completed; decision pending
C.P. Crane	Fails	PPER recommended approval	PPER recommended approval	Approved 9/84
Dickerson	Fails (under some flow conditions)	PPER recommended approval	PPER recommended approval	Approved 2/82
Gould Street	Passes	Passes	N/A	Approved 7/82
Morgantown	Passes	PPER recommended approval	PPER recommended approval	Approved 8/81
Riverside	Passes	Passes	N/A	Approved 7/82
R.P. Smith	Fails (under some flow conditions)	PPER recommended approval	PPER recommended approval	Approved 5/82
Wagner	Fails	Presently being evaluated	Presently being evaluated	Biological studies completed; decision pending. NPDES renewal in 1991.
Westport	Passes	Passes	N/A	Approved 7/82

provisions of the Fish and Wildlife Coordination Act, the concerns of state and local resource agencies must be addressed in the federal licensing process. PPER has been designated the lead agency within DNR for coordinating the review of small-scale hydroelectric facility applications. The Federal Energy Regulatory Commission (FERC) has adopted procedures for exempting certain projects (primarily small projects for which the applicant possesses property rights) from federal jurisdiction. Since such projects need not address environmental concerns of state and federal agencies in the licensing process, monitoring for compliance is DNR's responsibility.

Although no state license or permit is required specifically to operate a hydroelectric power facility, COMAR 26.08.05.03 requires that owners and operators of dams on state waters cooperate with DNR to prevent adverse effects on downstream water quality and aquatic habitat. Several state permits, such as the water appropriation permit and Waterway Construction Permit (both granted by WRA), are usually required. Dam owners and operators must also consult with other resource agencies, such as the Scenic River Review Board, the Maryland Geological Survey, and the Maryland Historical Trust. More details on the permits and consultations required for licensing and permitting of small-scale hydroelectric facilities are provided in the Inventory of Maryland Dams and Assessment of Hydropower Resources (Weisberg *et al.* 1985).

One of the first steps in PPER's licensing review for proposed small hydroelectric projects is preparation of a site description based on information submitted by the applicant. Site descriptions provide information on the water quality, biological resources, and recreational activities near proposed projects, as well as engineering information on the type, size, and operation of the proposed facility. These site descriptions are used to identify potential environmental impacts while proposed projects are in the planning stage. The developer then may modify the proposed project to minimize expected impacts, or conduct additional studies to precisely define potential impacts. The environmental review procedure has been or is being applied to 14 projects over the last eight years: Atkisson, Brighton, Daniels, Deep Creek, Dickey, Duckett, Gilpin Falls, Jennings Randolph, Little Falls, Pine Grove, Potomac Dam No. 3, Potomac Dam No. 4, Rocky Gorge, and Savage River.

E. Aquatic Impact Assessment for Steam Generating Power Plants

The only additional evaluations of aquatic impacts conducted since the publication of CEIR-6 were at BRESCO, Chalk Point, and Wagner. Information from previous CEIRs is briefly summarized here and updated with the most recent findings of studies available through the end of 1989.

Mesohaline Power Plants

The three largest plants in Maryland -- Calvert Cliffs, Chalk Point, and Morgantown -- are located in this zone. Each uses once-through cooling. Detailed studies of these plants were summarized in previous CEIRs. Recent studies for