Water Impacts

In addition to affecting air quality, construction and operation of power plants have impacts on both Maryland's surface water and ground water resources.

Surface Water Impacts

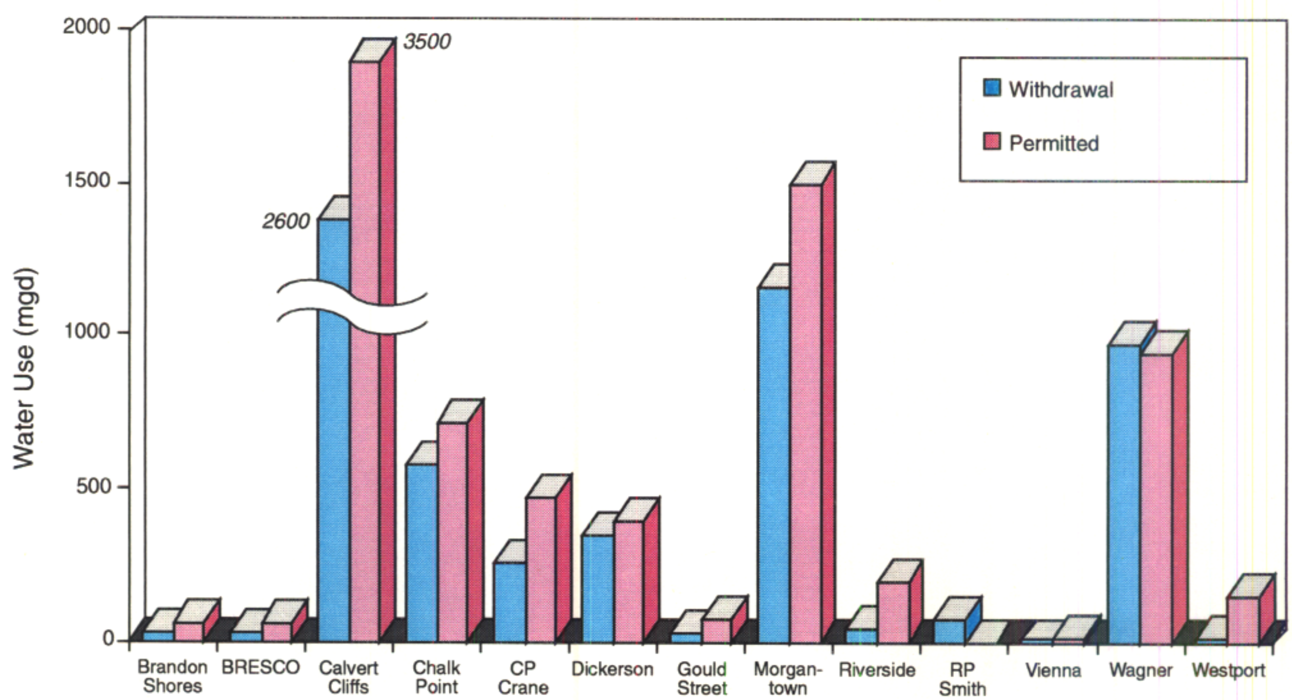
Steam-generating power plants use large volumes of water for cooling. In Maryland, the Chesapeake Bay is the major source of this water. The Bay also receives most of the **effluents,** or wastewater discharge, from power plants in the state. Both withdrawal and discharge of water at power plants can adversely affect surface waters. Hydroelectric power plants also use vast amounts of water. These plants use impounded water produced by the damming of rivers to generate electricity. Inundation of land, blockage of rivers, and changes in water quality may result from construction and operation of these facilities.

This section focuses on the nature and extent of surface water impacts from these two types of power plants found in Maryland.

Water Withdrawal and Consumption

Steam-generating power plants need water to cool operating equipment. In a **once-through cooling system**, water is drawn continuously into a power plant from a **source water body** and is used to draw the heat from the power plant condensers. This heated water is then discharged into a **receiving water body**

Figure 2-4
Surface Water Withdrawals (mgd) 1991



(usually the same as the source). Once-through cooling systems require large volumes of water — a fossil fuel fired plant with once-through cooling uses about 1.4 million gallons of cooling water per day for each megawatt of electricity produced. Nuclear power plants, such as the Calvert Cliffs plant, generate more waste heat than fossil fuel plants and therefore must use more water per megawatt for once-through cooling.

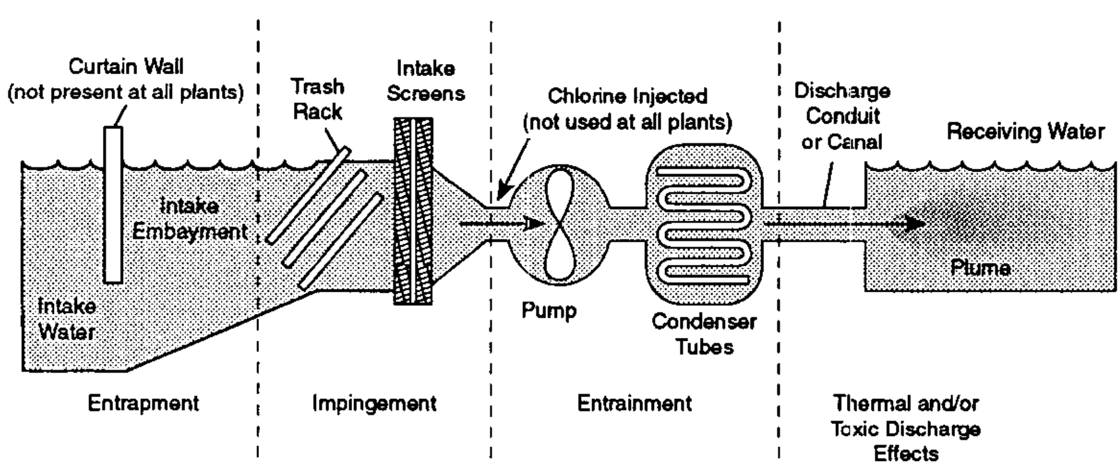
With the exception of Brandon Shores, Vienna, and two of the four units at Chalk Point, all of Maryland's steam-generating power plants use once-through cooling systems. Figure 2-4 shows water use rates of power plants in Maryland, given in millions of gallons per day (mgd). The Department of Natural Resources grants a surface water appropriation to each power plant based on a forecast of the plant's water needs over a period of several years. This permitted withdrawal, also shown on Figure 2-4, represents the estimated maximum amount of water that each plant will withdraw.

Closed-cycle systems (in use at three major Maryland power plants: Brandon Shores, Chalk Point, and Vienna) recycle cooling water and require only 2 to 25 percent of the water needed for once-through cooling systems. However, as much as half of the water withdrawn is **consumed** (used and not returned) due to evaporation. Steam electric plants in Maryland use nearly 70 percent of the total freshwater consumed in the state by all sources. As older power plants are replaced, more closed-cycle systems, as well as **dry cooling towers,** may be used to dissipate waste heat at new power plants. Use of closed-cycle systems will result in decreases in total amounts of water withdrawn (and discharged), but could also increase the amount of water consumed due to evaporation.

Impacts of Steam Electric Power Plants

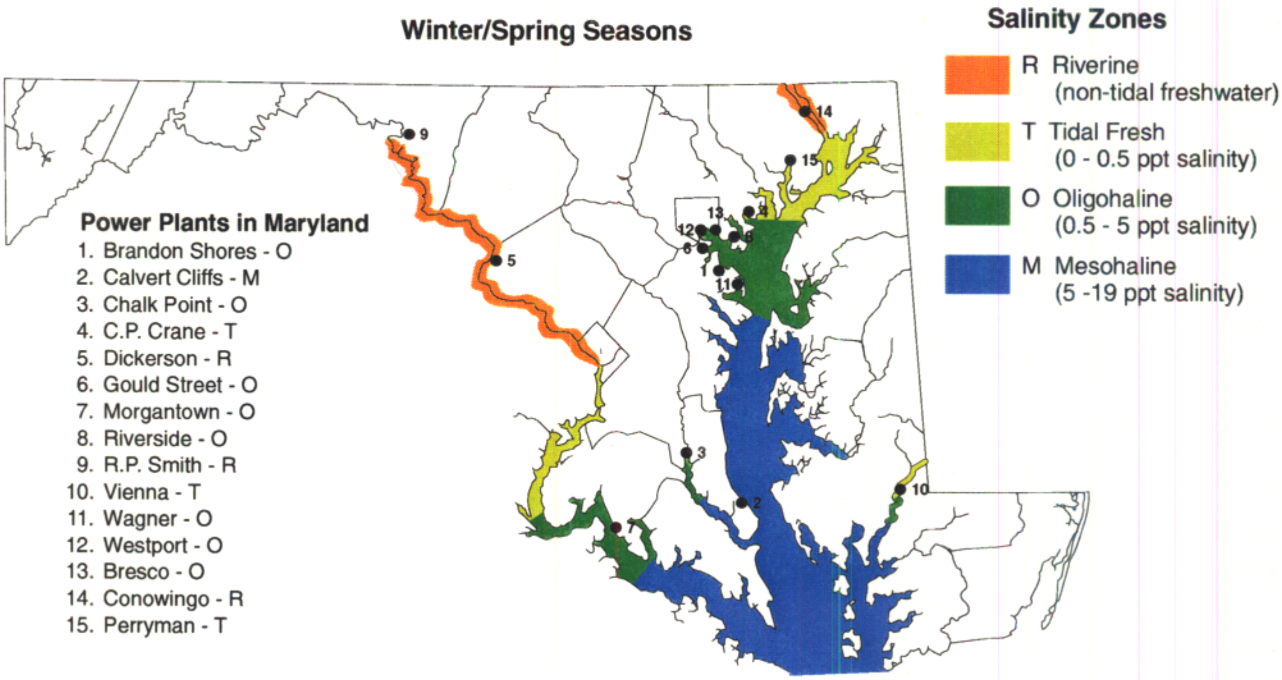
In Maryland, most cooling water is drawn from the Chesapeake Bay or one of its tributaries. Although there is ample water available in the Bay for cooling

Figure 2-5
Water Flow Through a Power Plant Using Once-through Cooling

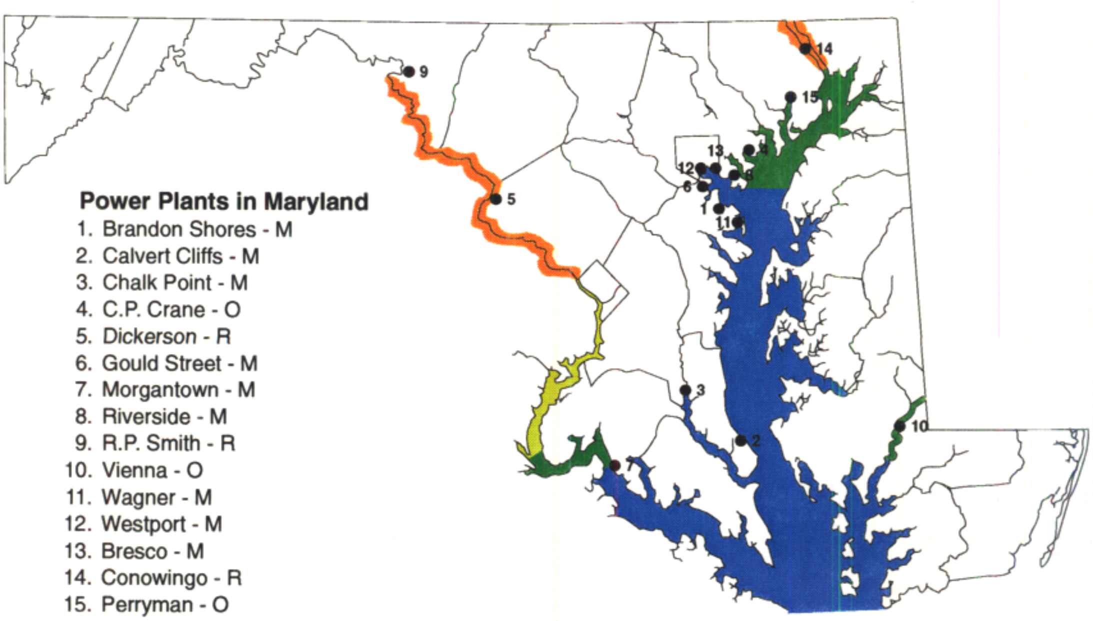


Salinity Zones of the Maryland Chesapeake Bay

Winter/Spring Seasons



Summer/Fall Seasons



purposes, adverse environmental effects can result from withdrawing, heating, and discharging such large volumes of water. The ways in which aquatic organisms are impacted by power plant operations include entrapment, impingement, entrainment, and discharge effects (see Table 2-1). Figure 2-5 illustrates where these impacts occur.

Table 2-1
Ways in Which Aquatic Organisms are Impacted by Power Plants

Entrapment	Accumulation of fish and crabs (brought in with cooling water) in the intake region; exposure to water of low dissolved oxygen content drawn in with intake flows can weaken or kill organisms; prolonged swimming against intake flows may also weaken or lead to impingement of organisms.
Impingement	Trapping of larger organisms on barriers protecting internal power plant structures, such as intake screens, barrier nets; physical damage leads to disease or inability to compete with other organisms; some methods used for returning organisms to receiving water can lessen impacts.
Entrainment	Drawing in of plankton and young fish through plant cooling systems; contact with cooling system structures, high-velocity water, heated effluents, and biofouling chemicals causes damage and death.
Discharge Effects	Changes in behavior and physiology (including death) as a result of exposure to heated effluents, biofouling chemicals (e.g., chlorine), and other toxic discharges; modification of physical and chemical properties in the discharge area may lead to habitat changes and changes in organisms that can live there.

PPRP and Maryland's utilities have evaluated impacts at 13 major power plants in the state over the last two decades, conducting several dozen studies on the nature and extent of entrainment, impingement, and discharge effects. These studies were used to evaluate the relative impacts of power plant operations on the aquatic environment in the state, with special emphasis on the Chesapeake Bay. Some studies were also used as the basis for modifying operating procedures at the plants to minimize impacts and to provide dollar cost estimates of unavoidable losses in aquatic biota.

Several **habitat types** exist in the Chesapeake Bay, defined by salinity zones; each supports a different mix of biological communities. The impact of power plant operations will also vary among habitat types, since species react differently to the stresses of entrainment, impingement, and discharge effects. Results of PPRP's many impact studies are summarized below by salinity zone.

Mesohaline Zone

Results of studies at all power plants in the **mesohaline** zone, which is a primary shellfish production area, show that there have been no cumulative impacts to aquatic resources to date. Although large entrainment losses of some types of aquatic organisms, known as phytoplankton and zooplankton, have been measured frequently, no consistent depletions in numbers of organisms have been found. This is most likely due to the fact that these small organisms have short generation times (hours to days), and therefore populations recover quickly from entrainment. The only power plant in this type of habitat that may affect riverwide fish spawning and nursery areas is Chalk Point, and this potential loss is being mitigated with a **fish hatchery** program. Power plants in the mesohaline zone impinge large numbers of juvenile fish and crabs. However, fish and crab losses do not cause measurable depletions in these species because of the large size and wide distribution of their populations. Discharge effects in this zone generally are localized. Although power plant discharges may attract or repel fish and crabs, they do not adversely affect fish migration, spawning, or growth.

Tidal Fresh - Oligohaline Zones

Studies indicate that entrainment losses from power plants in these zones, which are spawning areas for some fish such as striped bass and white perch, are small and do not affect regional populations. Many organisms in these habitats survive impingement; the major species that are impinged are abundant throughout Maryland's tidal waters. Impingement losses are too small to have a detectable effect on regional fish populations. Although operations at the C.P. Crane power plant measurably affect salinity and temperature of the receiving water body, these changes do not significantly affect aquatic resources in this zone.

Riverine (Non-tidal Freshwater) Zone

Studies in this habitat zone, which is a major spawning area for many types of fish, have shown that, in general, entrainment and impingement impacts are small. There are some discharge effects in this habitat, but they are localized. None of the studies have identified long-term cumulative impacts of these facilities.

Reducing Aquatic Impacts

Numerous **intake technologies** and modifications to **operating practices** have been developed to reduce entrainment or impingement impacts at steam electric power plants. However, relatively few have the ability to reduce both entrainment and impingement impacts. PPRP has investigated the applicability of several intake technologies to Maryland's power plants and ecosystems.

Intake technologies can be classified into three categories: **physical barriers, behavioral barriers**, and **collection**. Physical barriers, such as screens or nets, are the most successful for reducing both entrainment and impingement.

Barrier nets are generally economical to install and maintain, particularly for retrofitting at older plants. Nets reduce impingement effectively in both estuarine and freshwater habitats. Chalk Point has a barrier net across the mouth of its intake canal, but physical limitations at other Maryland power plants, such as Morgantown or Calvert Cliffs, may prevent installation there. Wedge-wire screens are moderately expensive to retrofit into existing power plants or to install into new plants. Their fine wire mesh generally keeps entrainment low and essentially eliminates impingement. Wedge-wire screens are successfully employed on the Delaware River and are currently being incorporated in the design of a proposed power plant in Maryland.

Behavioral barriers, such as air bubble curtains and sound, are designed to cause fish to avoid intake flows. These barriers have been found to be moderately effective in reducing impingement of schooling fish, but are unsuccessful for protecting other types of fish from impingement, or at reducing entrainment and impingement of fish in early life stages.

Collection of organisms after impingement is only partially effective at reducing impingement losses. Some of the collected organisms, particularly those in early life stages and juveniles, are sensitive to handling and abrasion and suffer high post-impingement mortality. If impinged organisms are returned to the receiving water body near the intake structure, they may be susceptible to reimpingement. Morgantown has redesigned its fish return system to be capable of returning fish to either side of the intake structure depending on the direction of the tide, thus reducing the potential for reimpingement.

Modification of plant operations is frequently the most cost-effective approach to reducing many aquatic impacts. Two operating practices that PPRP has evaluated are modifications to **intake screen wash cycles** and the use of **auxiliary tempering pumps**. To clean intake screens of impinged debris and organisms, intake screens at Maryland power plants are rotated on a frequency of anywhere from once per day to continuously. Increasing the frequency of rotation does not alter the rate of impingement, but it can have the beneficial effect of reducing mortalities associated with impingement by reducing the amount of time organisms are exposed to scavengers (e.g., crabs) and conditions leading to suffocation. Auxiliary tempering pumps were used at Chalk Point to decrease the effects of thermal and chemical water discharges. Studies by both PEPCO and PPRP, however, showed that turning off the pumps would reduce entrainment and impingement while not increasing downstream mortalities significantly. PEPCO has now discontinued use of the pumps.

Impacts of Hydroelectric Facilities

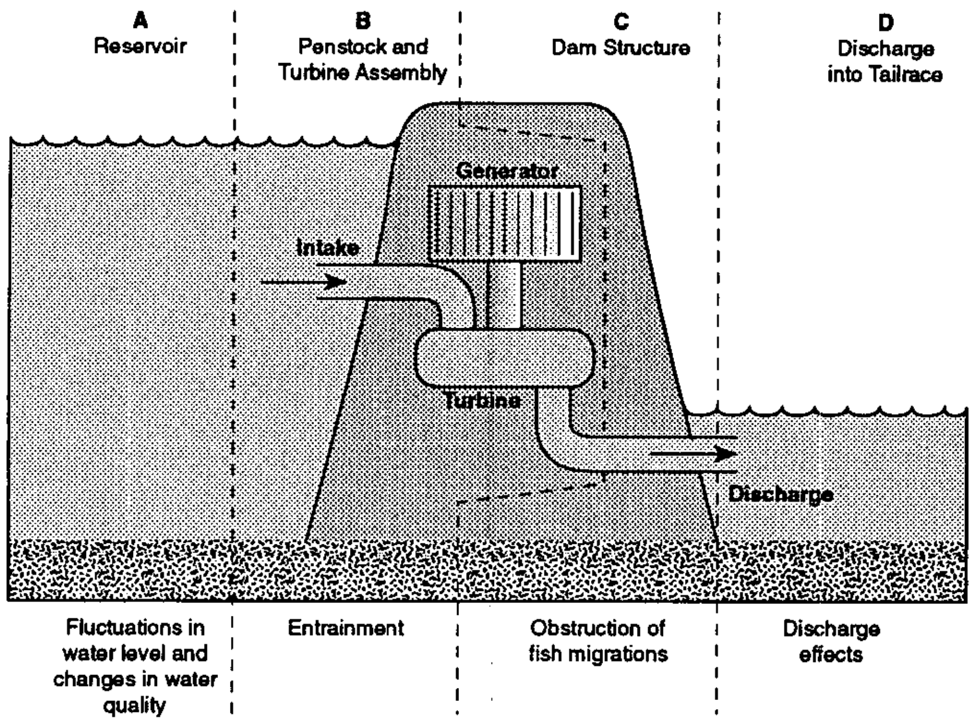
Ten hydroelectric projects are operating in Maryland. The largest facility in Maryland is the Conowingo Hydroelectric Station, with a capacity of 512 MW. The second largest is Deep Creek Station, with a capacity of 20 MW. Eight smaller projects around the state have a combined capacity of 36 MW. The development and operation of hydroelectric facilities can cause three types of impacts:

Alterations of Water Quality – Hydroelectric generation can affect water clarity, dissolved oxygen (DO) concentration, and water temperature both upstream and downstream of the dam (Areas A and D in Figure 2-6).

Fluctuations in Water Level and Flow Reductions – Operating hydroelectric facilities in a **peaking mode** (that is, not continually but in response to peak demand for electricity) produces unnatural water level fluctuations in impoundments and in aquatic habitats downstream of dams (Areas A and D, Figure 2-6). Small-scale hydroelectric projects may also divert some streamflow away from the natural streambed. Fluctuations in water level and flow may interfere with recreational use of the water body and reduce the abundance of food important to fish growth and survival.

Prevention of Fish Passage – Hydroelectric development can prevent the movement of fishes past the dam (Areas B and C, Figure 2-6). Entrainment through turbines may kill many fish, depending on the type of turbine, the proportion of flow diverted through the turbine, and the size of fish passing downstream.

Figure 2-6
Water Flow Through a Hydroelectric Power Plant



In Maryland, there are two general concerns about fish passage through hydroelectric facilities: 1) interruption of the migratory patterns of fish (primarily herrings and striped bass) that swim upstream to reproduce; and 2) fish mortality in the turbines, which can reduce resident fish populations. Studies to date on fish passage at small facilities in Maryland have only been conducted where resident fish were of concern. These studies indicated that there is some turbine-related mortality of fish. However, the magnitude of this effect varies between sites, suggesting the need for evaluation at each project. It has also been found that turbine-related mortality may not be sufficient to cause a significant impact on the entire fish population but may be great enough to have a measurable impact on the recreational fishery.

Smaller-scale hydroelectric projects in Maryland undergo a review process that allows for early involvement by state resource agencies. By this means, PPRP has been able to work with developers to mitigate potential impacts before a hydroelectric plant is constructed. Where potential impacts could not be addressed fully before construction, monitoring programs to measure the degree of impact have been required of the developer or conducted by PPRP.

PECO operates the largest hydroelectric facility in Maryland at the Conowingo Dam on the Susquehanna River. Significant stocks of resident and anadromous fish species, such as channel catfish, white perch, striped bass, and river herring, occur downstream of the dam. Historically, the Susquehanna River supported large spawning runs of anadromous species such as American shad. Sport fishermen regularly visit the region, and surveys suggest that the area has been one of the most intensively fished locations in the state.

Dam operations at Conowingo control water levels and flows in downstream aquatic habitats, thereby directly affecting the abundance and type of food organisms available for fish. During peak electricity demand periods in the summer, water that is released from the impoundment often has low DO concentrations, which can cause poor water quality downstream of the dam. The dam has also prevented anadromous fish from reaching spawning areas upstream. After many years of negotiation, the Federal Energy Regulatory Commission (FERC), the State of Maryland, and PECO reached agreement in 1988 to address these problems in three broad areas:

- *Water Quality: PECO evaluated several methods to improve DO in water released from Conowingo and selected turbine venting as the most feasible. PPRP conducted studies in cooperation with PECO to select the most appropriate DO monitoring locations below the dam. PECO incorporated the results of this study into its procedures to ensure that the dam's releases meet Maryland's DO standard. Ongoing PPRP monitoring indicates that this method is effective.*

- *Water Flow and Downstream Habitat: As a result of studies which showed that a minimum flow could improve fish habitat below the dam, PECO agreed to provide minimum flows all year. The amount of flow is seasonal, varying from a high of 10,000 cubic feet per second (cfs) in the spring to 3,500 cfs in the winter. Providing minimum flows year round represents a significant cost to the utility because it requires shifting some power generation to nights and weekends when the demand for electricity and economic payback is significantly lower. PPRP is studying the effects of continuous flows during the winter months (December through February) to determine if the biological resources at risk during those months require continuous flows.*

- *Anadromous Fish Restoration: PECO installed an experimental fish lift at Conowingo in response to concerns about restoring anadromous fish runs upstream of the dam. By 1989, PECO had collected more than 8,000 adult shad at the lift. Most of the fish were transported by truck to upstream spawning grounds because passage is not yet possible at the dams upstream of Conowingo. Due to the success of the experimental fish lift, PECO, FERC, and the resource agencies agreed on permanent fish passage at Conowingo. Construction of the new east side fish lift was completed*

Deep Creek Hydroelectric Station: An Environmental and Economic Balancing Act

The Deep Creek hydroelectric project is a 20-MW facility located in Garrett County and owned by the Pennsylvania Electric Company (Penelec). Deep Creek Lake, a 3,900-acre impoundment created specifically for hydroelectric generation in the 1920s and owned by Penelec, has evolved as the centerpiece of tourism in western Maryland. Discharges from the Deep Creek project enter Maryland's only designated "wild" river, the Youghiogheny, which supports a developing trout fishery, a number of rare or endangered plants and animals, and one of the most challenging whitewater runs in the United States.

In 1988, Penelec initiated renewal of the Deep Creek facility's license with the Federal Energy Regulatory Commission (FERC). As the coordinating agency for the state, PPRP was involved at the outset of the relicensing and consultation process. PPRP identified issues of concern and conducted necessary environmental studies in close cooperation with Penelec. The relicensing presents an opportunity — not available in 25 years — to develop a plan for controlling the timing and quantity of water released from the project to enhance lake and river natural and recreational resources. This requires finding balanced solutions to a variety of technically complex problems, because the interests of various users of Deep Creek Lake's resources are often conflicting.

In late 1991, Penelec was released from FERC jurisdiction (effective in 1994) and is currently pursuing a surface water appropriations permit from DNR. PPRP has continued its involvement, providing technical expertise to produce an equitable plan for future water and resource management at the project. Permit terms now being finalized include conditions to balance the following suite of conflicting natural resource and recreational concerns: 1) reservoir operations to make lake-based recreational opportunities more dependable and extend further into fall, 2) operation of the project to increase the number and dependability of whitewater boating opportunities, 3) mitigation of a long-standing dissolved oxygen problem in project discharges, 4) maintenance of a continuous minimum flow in the river to increase trout habitat, and 5) timing of generation during summer to maintain coldwater habitat for trout on a year-round basis. When implemented, these changes to the Deep Creek Lake project will produce substantial economic, environmental, and recreational benefits to one of Maryland's most valuable natural resources.

Restoration of American Shad to the Susquehanna River: An Environmental Success Story

American shad and other anadromous species historically made extensive migrations up the Susquehanna River during their spawning season. In the 19th century, these annual spawning runs were comprised of several million shad each year. Hydroelectric dams built early this century closed the Susquehanna to runs of shad and other migratory fishes. Studies and negotiations since the 1940s, culminating in a 1992 agreement between government agencies and utilities, have resulted in a gradual restoration of shad runs in the Susquehanna River:

- In 1970, utilities upstream of Conowingo Dam agreed to fund collection and stocking of shad eggs annually.
- In 1972, Philadelphia Electric Company (PECO) completed construction of an experimental fish lift at the west side of Conowingo Dam.
- In 1976, a dedicated shad hatchery was constructed with utility funding and fry and fingerling stockings began.
- In 1984, a long-term fish restoration agreement was reached with the upstream utilities, and in 1988 PECO agreed to construct permanent fish passage facilities at Conowingo.
- By 1990, the upper Bay shad population reached more than 100,000, and in 1992, more than 25,000 shad were transported above the dam.
- In the spring of 1991, the permanent (east) lift at Conowingo began operating; the cost of this state-of-the-art facility was $11.5 million.
- In 1992, Safe Harbor Water Power Corporation (SHWPC) and Pennsylvania Power & Light (PP&L) agreed to provide passage by 1997 at Holtwood and Safe Harbor Dams; Metropolitan Edison agreed to provide passage at York Haven Dam within the following three years.
- With fish passage available at all four dams, up to 3 million returning American shad may be transported to their historic upstream spawning grounds.

Over the past 20 years PECO has spent $10 million for studies and lift operation and SHWPC, PP&L, and Metropolitan Edison an additional $13 million on its passage facilities. Construction of upstream passage is estimated to cost between $18 and $37 million. This program is an excellent example of cooperation and long-term commitment between state and federal agencies and private utility companies who share a common goal of restoring migratory fish runs to the Susquehanna River.

in the spring of 1991, in time for the spring shad run. PECO collected 27,227 and 25,721 American shad in the 1991 and 1992 runs respectively, illustrating the success of shad restoration efforts (Figure 2-7).

A major breakthrough was reached in October 1992 in enhancing the recovery of the American shad and other migratory species that live in the Chesapeake Bay and the Susquehanna River. After many years of negotiations with the State of Maryland, the U.S. Fish and Wildlife Service, the Pennsylvania Fish and Boat Commission, and other groups, Safe Harbor Water Power Corporation and Pennsylvania Power & Light have agreed to build fish passage facilities at their hydroelectric facilities in Pennsylvania, both upstream of Conowingo Dam on the Susquehanna River. Metropolitan Edison (a subsidiary of General Public Utilities), which operates the York Haven Dam further upstream, will construct a third passage facility at a future point, according to the agreement. This agreement is the result of protracted industry and governmental cooperation and will sustain and ensure the restoration of the American shad populations in the Chesapeake Bay and the Susquehanna River. The fish passage facilities will allow shad and other migratory species of fish to travel over the dams during their annual upriver journey from the Atlantic Ocean via the Bay. The facilities are scheduled to be completed in 1996, in time for the spring 1997 migration. Negotiations have been going on for more than a decade; the current settlement will replace the 1984 agreement.

Ground Water Impacts

Some power plants in Maryland use surface waters for cooling and other operations (see previous discussion in Surface Water Impacts); other plants use ground water. The impacts on the quantity and quality of the state's ground water resources from the siting, operation, and expansion of power plants continue to be a prominent issue in Maryland. The significant quantity of ground water used by power plants in the state has created concerns about lowering of water levels in critical