C. ALTERNATIVES THAT EXCLUDE OR DETER FISH FROM ENTERING THE INTAKES

Intakes withdrawing surface waters for domestic or industrial purposes, including cooling water use at electric generating stations, generally employ some means of excluding debris from the water. Where the source water includes aquatic life, consideration is given to means of excluding organisms from the intakes as well. Standard devices for excluding debris, such as fixed or traveling screens, may entrap (impinge) larger organisms, while not excluding smaller ones. The method selected to exclude debris and aquatic life depends upon the volume of water to be withdrawn, the amount and nature of the materials and organisms to be excluded, the costs of the options available and the benefits of the exclusion. The following sections evaluate several options considered by the DEC to be potentially appropriate for further excluding aquatic life from the cooling water intakes at the Hudson River Stations.

1. Ristroph Modified Vertical Traveling Water Screens

a. *Technology Review*

Vertical traveling water screens have been standard equipment for exclusion of debris at water intake structures. These machines consist of a continuous series of mesh-covered panels mounted between two endless chains that are rotated by a head shaft. A steel frame supports the screens in a position extending from the bottom of the intake to the deck above the water surface. Floating and suspended debris is collected on the panels and carried by the rotation of the chains to a sluice. A spray system washes the debris from the mesh into a sluice for collection and disposal or return to the water body.

Several types of vertical traveling screens are used at the cooling water intakes of power stations. They differ in their orientation to the intake and the flow path of water through them (Figure VIII-6). Conventional screens are oriented with the screen face across the intake entrance and the flow of water is directly through the face. Water passes first through the outer face and subsequently through the inner face as the screen rotates. The outer face provides essentially all of the filtration. Dual-flow screens are turned 90° in the intake. In the most common design, so-called double entry single exit screens, the flow passes simultaneously through both screen faces. This design effectively prevents debris trapped on the screen surface from being carried over the top and into the intakes. Since two faces are providing filtration, rather than the filtration occurring through a single face in the

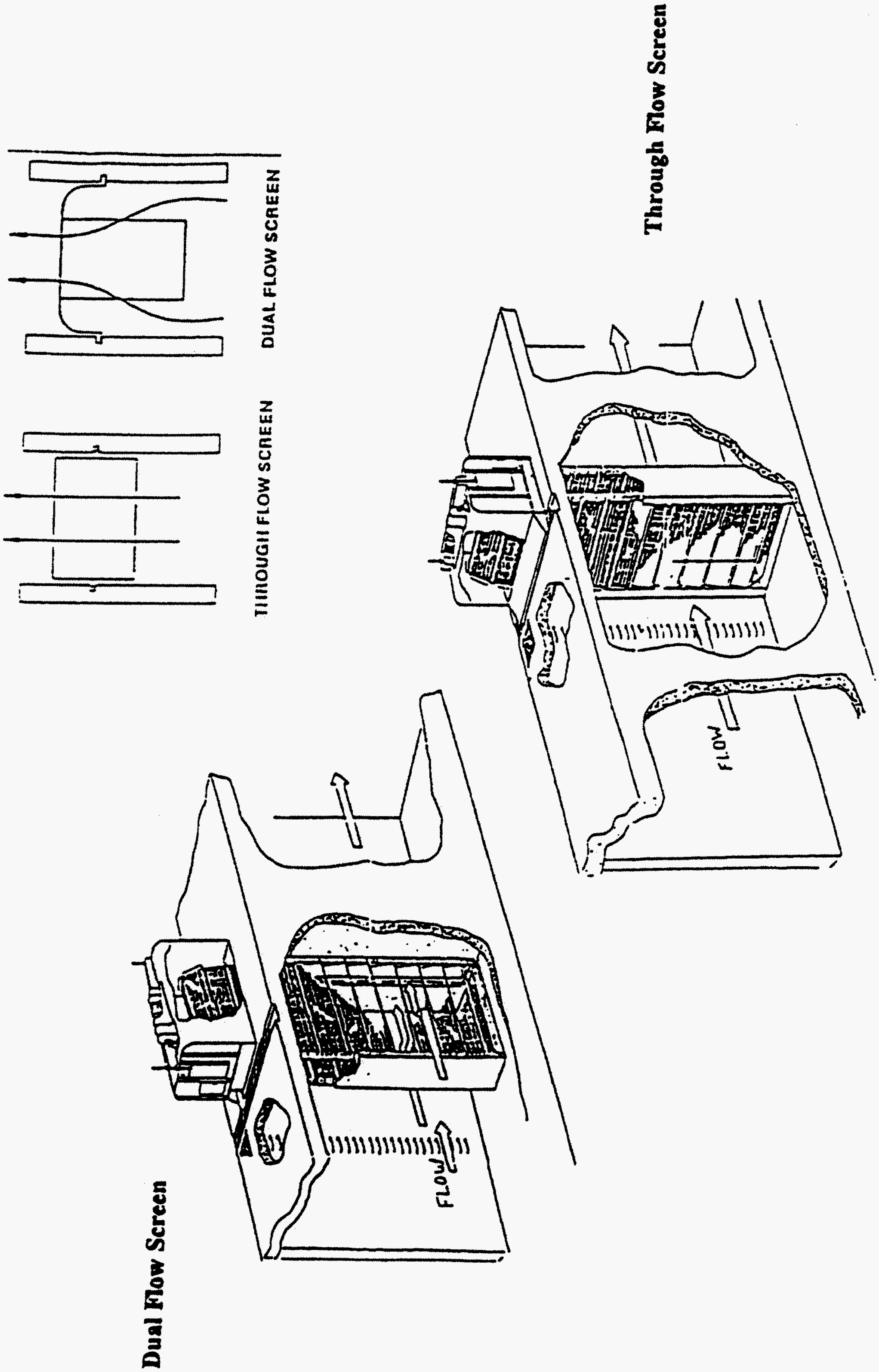

Figure VIII-6. General arrangement of dual flow and through flow traveling water intake screens within intake bays.

conventional orientation, the size of the screens can be reduced and the lighter screens operated with less wear.

The design and operation of these machines may be modified to enhance the survival of fish that become trapped (impinged) on the screen mesh and to return them to the water body. The mesh size may be selected to either collect or allow passage (entrainment) of organisms based upon their relative sensitivities to entrainment and impingement. The principal features of a modified vertical travelling screen include: 1) structural and mechanical upgrades to enable continuous rotation; 2) screen material designed to minimize abrasion; 3) fish collection buckets mounted on the bottom edge of each screen panel; 4) dual low pressure fish spray, high pressure debris spray wash systems; 5) troughs or sluices to collect fish separately from debris washed from the screens; and 6) conduits to return the collected fish to the water body.

Continuous or frequent intermittent rotation of the screens ensures that fish are removed immediately or in short order from the screen surface for return to a safe location. As the screens are rotated out of the water, fish slide across and drop off the mesh and collect in the pool of water in the bucket. As each panel rotates past a low-pressure spray, the fish are gently washed into a sluice mounted on the intake deck. The sluice carries the fish to a point of discharge from which re-circulation into the intake is expected to be minimal. Screens incorporating all or most of the features described above are generally referred to as Ristroph screens. Continuous rotation may be the single most important element contributing to the increased post-impingement survival reported from these systems.

The basic Ristroph features were optimized for use on conventional vertical traveling screens at the Indian Point Units 2 & 3 Stations (Fletcher 1990). Screens incorporating the modified-Ristroph features are currently in place at both Indian Point Units 2 & 3. The modifications to the conventional vertical traveling screens at Indian Point Units 2 & 3 were subsequently evaluated for adaptation to the dual-flow (double entry, single exit) screen design. The adaptation of the features to dual-flow screens at the Arthur Kill Generating Station is fully described in Con Edison 1996. When enhancing the fish-handling characteristics of dual-flow screens, additional consideration should be given to the water flow patterns through the screen faces. It may be necessary to provide flow-straightening devices to ensure that water velocities are fairly uniform across the screen faces. Tests to evaluate the importance of flow-straightening devices at Arthur Kill were inconclusive (Con Edison 1996), but other studies suggest they may be important in some installations (Fletcher 1994).

Studies have demonstrated that incorporation of Ristroph features into both conventional and dual-flow screen systems can provide increased survival of fish after impingement (Fletcher 1990; Con Edison 1996). Results of post-impingement survival tests from modified dual-flow screens at the Arthur Kill Station and from modified conventional screens at Indian Point Units 2 & 3 indicate similar survival rates. Survival rates for many species from modified and unmodified screens are presented in the original reports. Results are presented here for only five species collected from both facilities at similar time periods (September and October) and in large enough numbers to make meaningful comparisons (Table VIII-11).

Post-impingement survival is species- and size-specific and many factors influence it. These include environmental factors, such as the temperature and salinity of the water, and characteristics of the intakes at which the screens are installed. Important intake characteristics include water velocity in front of and through the screens and the proximity of the fish collection point to a return point for the fish to the water body. Therefore, it is difficult to extrapolate results from one situation to another.

b. Engineering Aspects, Applicability and Costs

i. Indian Point Units 2 & 3

Modified Ristroph conventional traveling screens are in place at Indian Point Units 2 & 3 (Section IV) and are not considered further here.

ii. Roseton Units 1 & 2

Roseton Units 1 & 2 currently has six conventional screens and two modified dual-flow screens. The conventional screens are rotated continuously and fish and debris returned to the river. The dual-flow screens were installed for testing and contain most of the modified Ristroph features incorporated at the Arthur Kill Station. One has an added a flow straightening device (Section IV).

Testing of the conventional screens has produced post-impingement survival rates that are lower for some species than rates from the tests of the modified Ristroph screens at Indian Point Units 2 & 3 (LMS, 19901). Testing of the dual-flow screens at Roseton Units 1 & 2 suggests that post-impingement survival rates of most species are higher than the rates from the conventional screens, but not consistently as high as rates from the modified Ristroph screens at Arthur Kill or Indian Point Units 2 & 3 (NAI, 1995). This may be due to unfavorable water flow characteristics through these screens. In order to fit the dual-flow screens into the intakes without major structural changes to the intakes, the screen area was reduced, resulting in somewhat higher water velocities and irregular flow patterns at the screen faces.

Installation of eight conventional vertical traveling screens with the Indian Point Units 2 & 3 features is considered here as an alternative to retaining the existing screens however, cost estimates are not presently available. Replacement of the conventional screens with

Table VIII-11

SURVIVAL (%) OF FISH 8 HOURS AFTER COLLECTION FROM FLETCHER-MODIFIED CONVENTIONAL TRAVELLING SCREENS AT THE INDIAN POINT UNIT 2 STATION AND FLETCHER-MODIFIED DUAL FLOW SCREENS AT THE ARTHUR KILL STATION

SPECIES	INDIAN POINT	ARTHUR KILL
American Shad	65.1	77.8
Blueback Herring	74.4	82.7
Striped Bass	90.7	87.9
Atlantic Tomcod	82.6	96.3
White Perch	86.3	88.1

Results taken from Con Edison, 1996

reduced-size dual flow screens is not considered further here because the environmental benefits are uncertain without further testing and the costs of modifying the intakes to accommodate larger dual flow screens is prohibitive.

iii. Bowline Point Units 1 & 2

Bowline Point Units 1 & 2 currently have six conventional vertical travelling screens. The screens are rotated continuously and fish and debris returned to the river. Testing of the screens has produced post-impingement survival rates that are lower for some species than rates from the Fletcher-modified conventional screens at Indian Point Units 2 & 3. Deployment of the barrier net at the existing Bowline Point Units 1 & 2 intake provides a significant reduction in impingement and does not require further investigation of the feasibility of installing Ristoph screens.

c. Environmental Aspects

The only environmental change that might result from the replacement of the existing cooling water intake screens at Bowline Point Units 1 & 2 and Roseton Units 1 & 2 would be some reduction in fish mortality due to impingement, if the new screens resulted in increased post-impingement survival. However impingement-related losses are already relatively minor at both stations, particularly at Bowline Point Units 1 & 2 where a barrier net is in place. Projected improvements related to either modified Ristroph dual-flow or conventional screens must be inferred from studies elsewhere and extrapolations are uncertain. The uncertainty is greater for Roseton Units 1 & 2 because environmental conditions, particularly salinity, differ more greatly from those at Indian Point Units 2 & 3 than do conditions at Bowline Point Units 1 & 2.

2 Fine-Mesh Screens

Aquatic organism retention on the surface of an intake screen (impingement) or the organism's ability to pass through the screen's mesh opening (entrainment) are functions of the hydraulic conditions upstream and at the face of the screen, the size and configuration of the screen mesh opening, and the size and configuration of the aquatic organisms. Physical exclusion by a screen occurs when the mesh size of the screen is smaller than the organism susceptible to entrainment; hydrodynamic exclusion results from a low through-slot velocity, which limits extrusion of the organism through the mesh. The strategy for the use of fine-mesh screens is to employ them at generating facilities that have high through-plant entrainment mortality, due to high condenser temperatures or other physical stresses, while maximizing screen recovery and survival.

Organism entrainment can be modified by altering the screen mesh size, i.e., lower entrainment will result when the mesh size is smaller than the entrainable organism's smallest dimension and the through-mesh velocity is not high enough to result in through-mesh organism extrusion; and higher entrainment will occur with larger mesh openings. However, when entrainment is reduced through the use of smaller mesh openings the direct result is impingement of the smaller-sized organisms.

a. Technology Review

I General

Several studies have been conducted to determine the effect of screen mesh size and through-mesh velocity on the size (total length), life stage, and abundance of fish larvae entrained. In general, laboratory and field studies have found that mesh opening size directly influences the size of the organism retained (the smaller the mesh size, the smaller the organism retained). However, the reduction in entrainment effected by fine mesh screens is substantially greater than can be accounted for by physical exclusion alone (Browne et al. 1981; EAI 1981).

Schneeberger and Jude (1981), in a study designed to predict the exclusion capabilities of small-mesh screens on Great Lakes fish larvae, concluded that body dimensions (maximum depth, average cross-sectional area) in relation to screen mesh size was the primary determinant of screen efficiency. They determined that body depth exceeded body width and that to predict potential organism entrainment or impingement, the cross-sectional dimensions were best compared to total body length. Several other studies designed to evaluate the effects of screen mesh size on larval fish entrainment and screen retention have concluded that body depth is the more accurate morphometric measurement related to screen retention and entrainment (Tomljanovich et al. 1978; EAI 1981; Edwards et al. 1981; Taft et al. 1981; Fletcher 1990). For all studies the actual size of fish larvae retained on the screens was smaller than projected from the mesh opening, with the primary reasons for increased retention of the smaller larvae related to the swimming and sensory capabilities of the larvae, water velocities, and the orientation of the larvae on the screen mesh.

A few laboratory and field studies have been conducted to determine the effects of screen mesh size and through-mesh velocity on the size (total length), life stage, and abundance of fish larvae entrained or impinged. Edwards et al. (1981) conducted a laboratory study on marine fish larvae, designed to determine screen retention on 0.5-, 1.0-, 1.8-, and 3.3-mm mesh test panels. The study concluded that in general, square mesh retained smaller larvae than equivalent size slot mesh, and that smaller mesh retained a greater percentage of the smaller larvae. Laboratory studies conducted on freshwater, estuarine, and marine fish larvae, using 0.5-, 1.0-, 1.5-, and 2.0-mm mesh, concluded that screen retention was directly related to body depth and that the small mesh retained a larger percentage of the smaller larvae (Taft et al. 1981).

The results of post-entrainment and post-impingement survival testing and evaluations of the influence of screen mesh size on both have been variable. Laboratory studies on freshwater larvae have found that post-impingement survival is species-specific, with some species exhibiting high mortality and others experiencing relatively high survival (Edwards et al. 1981; Taft et al. 1981; McLaren and Tuttle 1999). For some species, survival increased with age (length). NAI (1989) found lower overall post-impingement survival on the smaller mesh screens, but concluded the lower survival was due to the high mortality of small larvae, which were retained in greater proportions by the smaller size mesh. Fletcher (1990) reviewed several larval screen retention studies and noted that overall mortality did not correlate significantly with mesh size, but was more dependent on species and age (size). He also noted a direct relationship between debris retention and mortality; smaller mesh retained more debris, with a resultant higher mortality due to the larvae becoming entangled in the debris. McLaren and Tuttle (1999) reporting the results of a multi-year study on modified through-flow traveling screens with 9.5-mm and 1.0-mm mesh concluded that fine-mesh screens retained a significantly greater number of organisms, with larval post-impingement survival highly species-specific EAI (1980) monitored post-entrainment survival at the Danskammer Point Generating Station on the Hudson River and found that post-yolk-sac striped bass and white perch larvae survival generally increased with increased length. However, for alewife, blueback herring, and American shad the effect of length on survival was variable. Post-yolk-sac larvae experienced a higher survival than did later life stages. EAI (1979) also concluded that entrainment survival of larger larvae (following entrainment at traveling screens with 3.0-mm mesh) was comparable to impingement survival on the smaller mesh screens, which indicated there was no benefit to the installation of the smaller mesh on the screens. In his review of fine-mesh screen studies Fletcher (1990) found that, with few exceptions, mortality of impinged fish larvae decreased with age. Schneeberger and Jude (1981) concluded that because larger larvae have greater post-impingement and natural survival, it may be desirable to preferentially protect larger larvae from entrainment by selecting screen mesh sizes that would exclude (retain) large larvae and entrain small ones.

ii. Test Flume Study

The potential for fine-mesh screens (1.0 to 3.0-mm mesh) to reduce losses of the early life stages of fish by entrainment was evaluated by Fletcher (1992). The study was conducted in an hydraulic flume outfitted with a Ristroph screen. The objectives of the testing were to evaluate the effectiveness of hydraulic spoilers to reduce water vortexing within fish buckets or screen basketsand to evaluate means of increasing the survival of larval fish collected on screens of various mesh sizes. Tests were performed with larval striped bass.

Results indicate that the retention and survival of early life stages of striped bass exposed to modified Ristroph screen baskets outfitted with fine mesh are influenced by several variables, including fish length, mesh size, approach velocity, and exposure time. Data suggest that the use of 1.0-mm mesh to minimize striped bass entrainment is impractical for larvae of 6.0 mm or less in total length, since most larvae of this size are entrained through this mesh, and those that are retained on the mesh experience high impingement mortality. Retention of 8.4-mm larvae on 1.0-mm mesh was moderate to high (67 to 89%), and initial survival was 100% for those recovered in the fish bucket. Fish that remained impinged experienced high mortality. Latent mortality was substantial, and these results suggest that 8.4-mm striped bass are also probably too small and delicate for safe recovery from fine-mesh screens. Collection efficiency of 12.8mm striped bass on 2.0-mm mesh averaged 70.9% (319 out of 450 fish) over three test velocities (15, 30, and 45 cm/s). This level of retention, coupled with an adjusted mortality of approximately 36% (averaged over the three test velocities), indicates that about 45% of the exposed larvae might benefit form fine-mesh screens. Collection efficiency of 15.9-mm striped bass exposed to 2.0-mm mesh screens exceeded 97.5% (396 out of 406 fish), and survival, adjusted for handling effects, was greater than 93%. Additional tests with 15.9- and 22.0-mm striped bass using 3.0-mm mesh showed somewhat lower retention on the screens.

b Engineering Aspects, Applicability and Costs

Fine-mesh screens generate higher head losses for a given flow compared to screens equipped with larger sized mesh. This results from the lower percentage of open area of the mesh, which in turn creates higher through-screen flow velocities. Also, the finer mesh collects more debris than the standard size mesh, resulting in more rapid clogging or "blinding" of the screen mesh face. However, it should be noted that Fletcher (1990) reported that small-opening mesh screens clean more easily than large or standard mesh screens due to low debris stapling or mesh entanglement. The increased hydraulic losses associated with fine-mesh screening material places greater demands on the screen support structural components, mechanical components, and spray wash systems compared to conventional size mesh. Thus, more detailed engineering studies would be required prior to development of full-scale screen system designs that would be capable of operating reliably with fine mesh screen panels at Bowline Point Units 1 & 2, Indian Point Units 2 & 3 and Roseton Units 1 & 2. Consideration would be given to the use of removable fine-mesh overlay panels instead of permanent replacement panels.

Installation of fine-mesh screens would significantly increase debris loading. From an operational standpoint the increased debris loading associated with fine-mesh screens could reduce plant efficiency and reliability by requiring stepped-up screen cleaning and maintenance and by degrading condenser performance if screens had to be taken out of service and the associated pumps shut down.

Costs for installation of fine-mesh screens at any of the stations cannot be estimated reliably until the further biological (see below) and engineering evaluations are completed.

c. Environmental Aspects

The most important environmental effect of reducing the intake screen mesh size would be changes in the numbers of fish lost to entrainment and impingement. The potential for reducing entrainment effects by installing fine-mesh screens at the Indian Point Units 2 & 3, Bowline Point Units 1 & 2 and Roseton Units 1 & 2 Stations was examined during the technical workshops convened by the DEC to review the preliminary DEIS. The relative contributions of various size striped bass, white perch and river herring (alewife and blueback herring combined) larvae and early juveniles to conditional entrainment (mortality were estimated and compared with information available on post-impingement survival of larvae from fine-mesh screen studies). The results indicated that reductions, if any, in total entrainment and impingement conditional mortality would probably be relatively small because the post impingement survival is relatively low and their contribution to conditional entrainment mortality is relatively high. Striped bass less than 11mm long contributed about 50% of the CEMRs at Indian Point Units 2 & 3 and Bowline Point Units 1 & 2 and about 80% of that at Roseton Units 1 & 2, while white perch less than 11 mm long contributed about 90% of the CEMRs at all stations. For both species post-entrainment survival is relatively high. The contribution of herring larger than 11 mm to CEMRs at all stations was somewhat higher (up to 75% at Bowline Point Units 1 & 2), but post impingement survival would probably be low. Further field and laboratory studies of both post-entrainment and post-impingement survival would be needed to determine the mesh size that would optimize entrainment and impingement effects. Trade-offs among species would have to be considered when selecting a screen mesh size because both entrainment and impingement survival rates are species- and size-specific.

3. Cylindrical Wedge-Wire (Johnson) Screens

a. Technology Review

Cylindrical wedge-wire screens are essentially arrays of large-diameter pipes with small perforations (slots) through which water can be withdrawn. The size (number, length and arrangement of the pipes) of the array depends upon the volume of water required, the size of the slots and the desired velocity of the water through the slots. Slot size is selected, in part, on the basis of the sizes of particles, including aquatic life, to be excluded from the intake water. The smaller the size of each slot, the larger must be the array of pipes to provide adequate open area through which water can enter.

These screens have some potential to reduce entrainment, as well as impingement, at water intakes (SAIC, 1994). Cylindrical wedge-wire screening systems are generally designed to provide sufficient surface area to accommodate the required flow volumes at through-slot velocities of 0.5 fps (15 cm/s) or less. The velocity of water approaching the slots declines rapidly with increasing distance from the screen and becomes negligible at several inches from the surface (SAIC, 1994). These low approach velocities apparently are largely responsible for enabling even some weakly swimming organisms to avoid entrainment and impingement. Other design parameters, which influence the effectiveness of these systems, are the size of the slots, the orientation of the cylinders relative to the direction of the ambient currents, and the relative velocities of the through-slot and ambient currents.

Both the design of the system and the biology of the exposed organisms affect the degree to which wedge-wire screens would reduce entrainment and impingement at any intake. From a biological perspective, the morphometrics (length x girth), swimming ability and behavior of the organisms to be excluded from the intake are important. Most studies have been done in laboratory test facilities using small slot dimensions (1 to 3 mm) and through-slot velocities of less than 0.5 fps. Results have been variable. Using a barge-mounted test facility in an intake canal in Maryland, Weisberg et al. (1987) reported that 1 mm, 2 mm and 3 mm slot screens reduced entrainment of bay anchovy larger than 15mm TL, by 98.7%, 80.0% and 84.8% respectively, relative to an unscreened port. Exclusion by all three slot sizes was about 50% for anchovy of 5 to 7 mm TL, but the numbers of eggs and larvae less than 5 mm TL entrained was only slightly reduced or actually increased by up to two orders of magnitude relative to those entrained through an unscreened port. Field studies at the Campbell Station on Lake Michigan provided few statistically significant differences in the numbers of plankton entrained through 2 mm and 9.5 mm screens, although up to 40% more fish were entrained through the 9.5 mm slots (Weisberg et al, 1987).

Although cylindrical wedge-wire screens have been used successfully for many years for withdrawal of ground water, more recent application to surface water intakes has been largely under circumstances where the potential for clogging is low or the cost of installing redundant systems is modest. Use by the electric power industry in the United States has been largely restricted to withdrawal of fresh make-up water for closed-cycle cooling systems. However, at the RESCO Plant on the Hudson River in Peekskill New York, wedge-wire screens have been in place since 1985 to provide up to 38,000 gpm of once-through cooling water flow for a small (60 mw) generating unit (EA 1986).

Clogging of the perforations and consequent loss of flow is a concern with these systems. Installation of fine-mesh cylindrical screens is limited at offshore marine locations because of the propensity for clogging by marine growth and debris and the difficulty of providing an effective cleaning mechanism at such locations. Where screens can be located close to shore, air backwash systems may be used to remove debris. In these systems, a large volume of air under high pressure (100 psi) is discharged periodically into the interior of each screen. The bursts of air remove debris accumulated on the outer surface. However, the air bursts may not effectively remove biological growth, debris accumulation on the inner surface, or fine materials wrapped around the screen mesh. Mechanical or even hand cleaning may be required. The frequency of cleaning must be evaluated site-specifically before an appropriate system can be designed. Under some conditions frazil ice must also be considered a potential source of flow interruptions. Frazil ice may form very rapidly during cold, clear, windy nights in water bodies with no ice cover. Wedge wire screens with small slot dimensions are particularly vulnerable.

b Engineering Aspects, Applicability and Costs

i. Indian Point Units 2 & 3

Two conceptual configurations of wedge-wire screening systems were developed and evaluated for Indian Point Units 2 & 3 in the early1980s, but these and other screening options were rejected in favor of Ristroph modified travelling screens (Con Ed 1984). One configuration involved installation of an array of screens on a bulkhead that would be constructed along the shoreline. The second involved installation of the screens offshore on a header system. Conceptual designs for both arrays were developed (Figure VIII-7 and VIII-8) to provide up to 840,000 gpm of water flow through 9.5 mm slots at an average through-slot velocity of 0.35 fps and a maximum velocity of 0.5 fps. Any reduction in slot dimension or through-slot velocity would increase the size of the installation and the cost.

Both the reliability and biological effectiveness of these systems for application at Indian Point Units 2 & 3 was considered uncertain. Before any system could be adopted, substantial modeling of river flows and in-situ testing of prototypes, including the effectiveness of pneumatic cleaning systems, would be required to ensure that the system would reliably provide the required cooling water flows. Periods of slack tide were expected to produce particularly troublesome conditions. Consideration would also have to be given to potential navigation hazards associated with some configurations, particularly those extending well offshore.

The design, model testing, prototype testing and final installation of a wedge wire screen system at Indian Point Units 2 & 3 was anticipated to take approximately 4½ to 5 years, barring unanticipated difficulties. Nuclear Regulatory Commission reviews might delay the schedule.

The cost of developing and installing the bulkhead-mounted wedge wire screen system at either unit was estimated to be about $22 million at a projected service date of March 1989. The cost of developing and installing the offshore design was $27 million at a projected September 1989 service date. These estimates reflected an assumption that installation

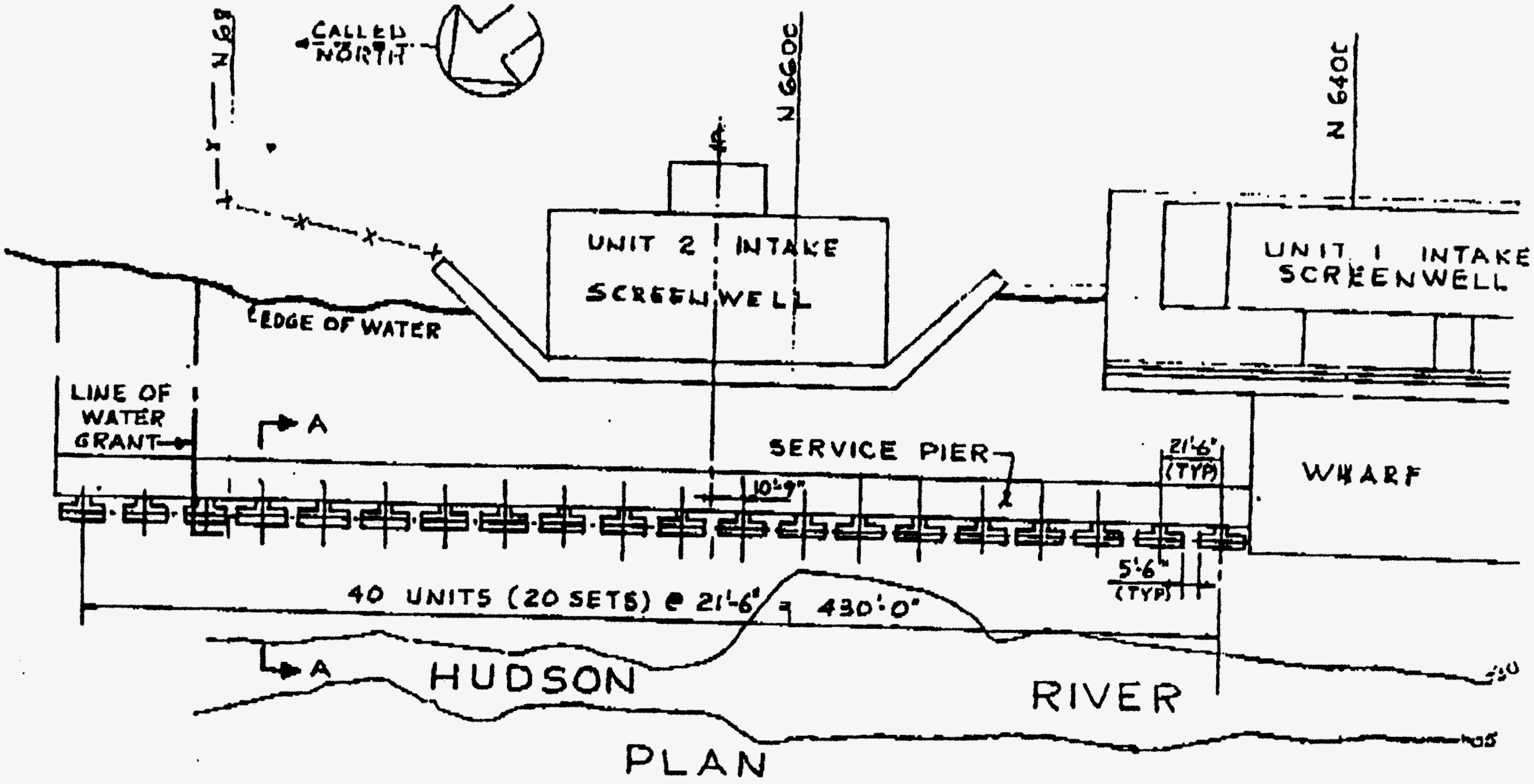

Figure VIII-7. Preliminary concept design for a bulkhead mounted wedgewire screen intake.

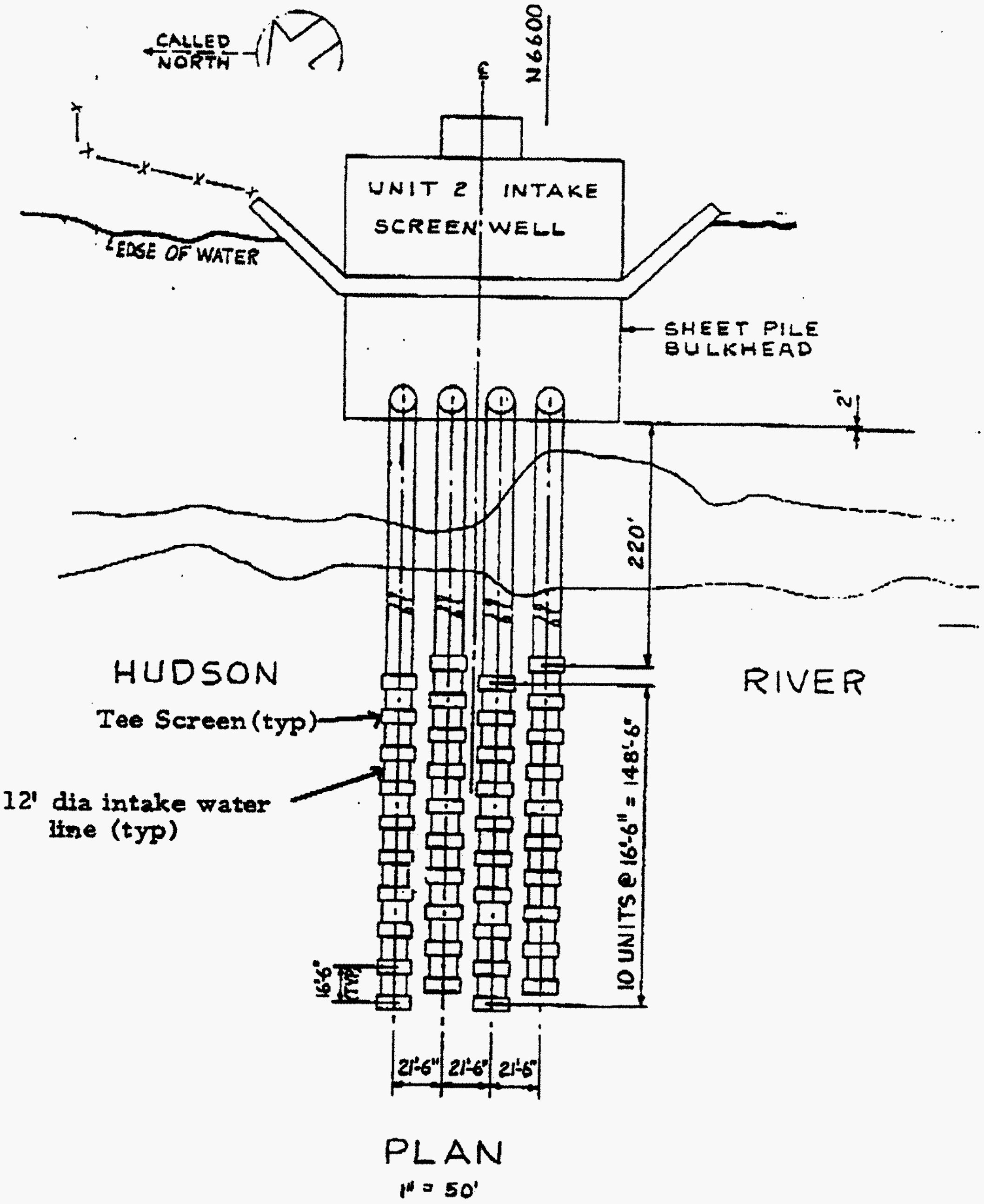

Figure VIII-8. Preliminary concept design for an offshore wedgewire screen intake structure.

could be coordinated with refueling outages. That assumption may no longer be valid and considerable additional costs for replacement power might arise.

ii. Bowline Point Units 1 & 2 and Roseton Units 1 & 2

Conceptual designs and cost estimates have not been prepared for the Bowline Point Units 1 & 2 or Roseton Units 1 & 2 Stations; however, costs at these sites would probably approach the same order of magnitude as the estimated Indian Point Units 2 & 3 costs.

c. Environmental Aspects

Although data from other smaller installations and from laboratory testing indicate that impingement would likely be largely eliminated, the effects on entrainment are uncertain (EA 1986, Weisberg et al. 1987). Additional studies would be required to estimate the extent to which the numbers of various life stages of fish entrained through systems of various slot sizes would be lower, if at all, than the densities currently entrained at the Bowline Point Units 1 & 2, Roseton Units 1 & 2, and Indian Point Units 2 & 3 Stations. Studies that provide the bases for ETM estimates of conditional mortality indicate that densities of some species and life stages currently entrained are lower than their average densities in the river (Appendix VI-1-B). These differences may be due to avoidance of the intakes or to lower abundances near the intakes than at other locations. To the extent that the lower densities in the intakes are due to lower abundances near the intakes, relocation of the intakes might inadvertently increase the numbers of individuals entrained and killed. Further examination of densities of entrainable organisms in the current and anticipated withdrawal zones for each of the stations would be required, including tests of prototypes with different slot dimensions.

Further consideration would also have to be given to the contribution of various sizes of entrained organisms to the estimates of conditional mortality associated with the existing screening systems at each station to determine the extent to which conditional mortality might be reduced. Since smaller organisms would continue to be entrained through even the smaller slot sizes of wedge-wire screens and the post-entrainment survival of larger individuals entrained through the existing systems is relatively high for many species, reductions in conditional mortality, if any, may not be directly proportional to reductions in total numbers entrained.

The extensive waterfront construction including installation of a bulkhead for the waterfront array and underwater piping for the offshore array may create permitting issues. Careful staging of the offshore work would be required to avoid interference with navigation and potential effects on fish spawning and movements.

4. Barrier Nets

In some cases it is practical to prevent aquatic organisms from approaching an intake by deploying various nets or screens, which allow water to pass through but prevent passage of organisms larger than the size of the mesh. These barriers are deployed so that the velocity of the water through the mesh is so low that fish and other animals that cannot pass through the net can swim away from it to avoid impingement or entanglement. .

a. Technology Review

Physical exclusion systems may consist of either media filters or coarse screen material, both of which rely on the combination of a low-velocity withdrawal through openings small enough to prevent passage of aquatic life above a selected size. The primary engineering concerns associated with such systems are loss of flow due to clogging and dislodgement of the barrier. The primary biological concern is impingement. In order to achieve through-net velocities low enough to largely avoid impingement (less than 0.5 fps), these systems must have very large surface areas. For example, the through-screen velocity of a typical conventional intake screen is often on the order of 1 fps. In order to achieve a water velocity on the order of 0.1 fps through a barrier net surrounding a screened intake with a through-screen velocity of 1 fps, the cross sectional area of the net would have to be about 10 times greater than that of the screens, if the mesh sizes of the net and screens were the same.

Selection of the net construction material and mesh size are primarily determined by site-specific factors, such as geology, water velocity, and debris-loading potential (clogging and biofouling); and biological factors, including species, size, and spatial and temporal distribution patterns (Leidy and Ott 1986). The deployment of a barrier net is dependent on intake configuration and the physical characteristics of the water body at the proposed site. Barrier nets are currently employed at freshwater- and estuarine-sited facilities, but not at marine facilities, due primarily to hydraulic conditions and biofouling potential. Overall, the evaluation of barrier net systems indicates that site-specific parameters are very restrictive. In certain applications, however, a barrier net system can be effective at mitigating biological impacts associated with water withdrawals.

Barrier nets have been installed to reduce impingement. At several installations, deployment is limited to specific seasons when fish exposure to the intakes is very high compared to other seasons. At the Bowline Point Units 1 & 2 Plant, a 9.5-mm mesh nylon net installed during the fall through spring period has resulted in a reduction in the impingement rate of up to 99% for some species (NAI 1997). The cooling water intake is on Bowline Pond, a small embayment of the river that offers protection from boat traffic and high tidal currents. The barrier net is deployed in a V-configuration approximately 15 m from the intake structure, where water currents approaching the net under full circulating water pump operation at the intake are approximately 0.5 fps (15 cm/s). Barrier net installations at other cooling water intake structures and at the entrances to intake canals have also greatly reduced impingement (Newman et al. 1981; Stober et al. 1983; White et al. 1984; Bengeyfield 1992; LMS 1998).

b. Engineering Aspects, Applicability, and Costs

Factors to be considered in determining whether a barrier net can be deployed at a site include water velocity (plant induced and tidal currents), debris-loading potential (clogging and biofouling), bottom type, and water depth. A barrier net is best deployed in low velocity areas where a complete seal can be maintained. Theoretically, low approach velocities lower the risks of fish being impinged in the net and of rapid clogging of the net by entrained debris (Michaud 1991). Thus data on environmental conditions (storms, and wave or tidal variability) are necessary to properly design and determine the best deployment technique. Debris loading and biofouling must remain at a minimum to maintain the net's filtering capacity and site-specific conditions should be considered, such as bottom sediment type, impact on recreational or commercial boat traffic, and potential storm damage.

Bowline Point Units 1 & 2

Bowline Point Units 1 & 2 currently deploy a barrier net and the continuation of this mitigation measure has been proposed.

Indian Point Units 2 and 3 and Roseton Units 2 & 3

At Roseton Units 1 & 2 and Indian Point Units 2 & 3 barrier nets would be required to withstand tidal currents of 60 to 65 cm/s. Seasonal debris loading would be the most significant deterrent to the use of a barrier net at Roseton Units 1 & 2 and Indian Point Units 2 & 3. During the spring following ice-out, large quantities of debris, especially leaf litter and marsh grasses are present in the river. These materials could clog a barrier net; if exposed to strong tidal currents, a barrier net could be torn free from its anchor points. It is currently considered impractical to install a barrier net at the Indian Point Units 2 & 3 station due to the proximal positioning of water intakes to strong tidal currents, the water depth (30 to 40 ft near shore), the proximity of the main river channels, and the seasonally high debris loading. Since the net would necessarily surround or be in proximity to the service water intakes that support critical safety systems at the Indian Point Units 2 & 3 stations, the NRC would need to review the possibility that those systems could be compromised by net failures.

Based on engineering and environmental considerations, a barrier net is not considered feasible for deployment at the Indian Point Units 2 & 3 Generating Station.

At Roseton Units 1 & 2 the intake structure is located shoreward of an oil dock, which might provide some protection from water currents and recreational boating if a barrier net were to be positioned in between. However, sedimentation is considerable in this area and could cause significant problems in recovery of a deployed net. Accordingly, it may also be impractical to install a barrier net at this station. The engineering of the net and deployment method would require field investigations to obtain information on bottom geology, currents and sedimentation, and physical modeling to evaluate the proposed designs. Engineering, design, and modeling costs are estimated to be $500,000.

c. Environmental Aspects

The effectiveness of a barrier net in reducing impingement would be contingent upon the seasons during which it could be maintained in place. Other environmental effects of deploying a barrier net include potential disturbance of bottom sediments and restrictions on public use of the water body and on commercial and private boat traffic.

Since the Bowline Point Units 1 & 2 barrier net is deployed in Bowline Pond, which is entirely within the property boundaries of the facility, there have been no instances of public complaints over loss of use of the pond area enclosed by the net, or of boating incidents. The lack of public concern is due in part to the fall-through-spring deployment period, generally marked by low recreational water use, and to the debris boom that provides a physical barrier to the net itself. The deployment of a barrier net inside the oil dock at Roseton Units 1 & 2 would have minimal impact on public use of the area. In addition, deployment inside the oil dock would result in no impacts on commercial shipping and only minimal impacts on recreational boating. Some of the impacts on fish populations due to the relatively high water velocities in the area could be mitigated by net design, though there may be some fish loss due to net contact. However, deposition of silt and sand is considerable in the vicinity of the Roseton Units 1 & 2 intake structure (especially on the north side). Barrier net lead lines could be buried and this would make it difficult to recover any net deployed there. Additional studies would be required to better establish the effects on sediments and shore-zone currents and what steps could be undertaken to mitigate them.

At the Roseton Units 1 & 2 Generating Station the location for a barrier net would be in the Hudson River probably between the shoreline intake structure and the oil dock. Currents and sedimentation in the area of net deployment require additional studies and extensive engineering to determine whether or not it is feasible to design a net and deployment method that could be used in the Hudson River rather than in a protected bay like Bowline Pond. A barrier net could not be deployed during cold weather due to ice conditions in the

Newburgh Bay area. Results of annual impingement studies (NAI 1998) indicate that the most effective period of barrier net deployment at Roseton Units 1 & 2 would be from August through November, thus negating the ice condition problem.

5. Fine-Mesh Barrier Systems

Large-mesh barrier nets have been shown to be an effective technique at mitigating impingement impacts. A fine-mesh barrier system has the potential to reduce the current levels of entrainment of smaller organisms, including ichthyoplankton.

a. Technology Review

Orange and Rockland Utilities, Incorporated (ORU) began evaluation of a 3.0-mm mesh barrier net as a means of limiting ichthyoplankton entrainment at the Bowline Point Units 1 & 2 Generating Station (LMS 1994, 1996a). Bay anchovy larvae represent the dominant ichthyoplankton in the vicinity of Bowline Point Units 1 & 2 and account for 80% of the organisms entrained. Over 90% of the bay anchovy entrained at Bowline Point Units 1 & 2 are post yolk-sac larvae (LMS 1994). Three-millimeter mesh was determined to be the best mesh size to limit bay anchovy entrainment based on physical exclusion alone, following a review and analysis of the size (length, body depth) of these larvae. The fine-mesh barrier net was first deployed around the Bowline Point Units 1 & 2 cooling-water intake structure during 1993 and 1994 using the same configuration as the fall-winter-spring-deployment of the 9.5-mm mesh net; however, the fine-mesh net was deployed using nine wooden piles.

The effectiveness of the fine-mesh barrier net was determined through a comparison of ichthyoplankton abundance estimates from plankton net tows outside of the net and pump samples from inside the net. The conclusions of the 1993 and 1994 evaluation studies (LMS 1994, 1996a) are presented below:

- A 3.0-mm mesh net could be deployed during the summer period when the concentration of bay anchovy larvae is at its seasonal peak.
- Clogging and biofouling of the net mesh was a significant problem. Biofouling during 1994 completely blocked the flow of water through the mesh resulting in two of the nine support piles snapping at the mudline.
- Underwater cleaning of the net using high-pressure spray guns was achievable; however, the time required to clean a small section limits this as a viable maintenance technique. It was determined that the most efficient cleaning technique

would be through net removal. Net-removal cleaning was under evaluation when the pressure on the clogged net snapped the support pile and terminated the study.

- The dominant ichthyoplankton species present during the evaluation period was the bay anchovy; however, abundance levels during both study years were low and the period of presence in the study area was very short. The low abundance levels and short period of presence in the study area limited the ability to determine the effectiveness of the fine-mesh barrier net.

Southern Energy is currently evaluating the Gunderboom System, a porous filter fabric, as a means of limiting entrainment at the Lovett Generating Station. The Lovett Station is located on the Hudson River north of Stony Point. It has three generating units utilizing Hudson River water in a once-through condenser cooling water system. The research and development program has evaluated several different boom designs at the Lovett Unit 3 intake and one boom design that included all three intake structures (LMS 1996b, 1997, 1998a, 1998b). Boom effectiveness at limiting entrainment is determined by comparing ichthyoplankton abundance collected inside and outside the boom using pumps. The Gunderboom deployed at Unit 3 during 1995 became clogged shortly after deployment, which resulted in the submergence of the top of the boom. However, the boom was maintained in place for over two months during which time it was determined to be 80% effective at limiting ichthyoplankton entrainment. A three-unit boom was deployed during 1996; however, the boom failed within hours of deployment and was removed before any sampling could be conducted. A prototype boom was deployed during 1997 to evaluate a new dead weight anchoring system and an air-purge cleaning system. The dead-weight anchoring system was effective in the soft sediments found in the vicinity of Lovett, and the air-purge cleaning system was effective at maintaining the filtering capacity. A modified boom was deployed at Unit 3 from 11 June to 4 September 1998. Diver inspections of the boom were conducted approximately every two weeks. During the 6 August inspection an open area that could not be completely closed was found. Once it was determined that the open area could not be closed, the ichthyoplankton sampling program was terminated. During the period the Gunderboom was intact (mid-June through mid-July), ichthyoplankton densities at the intake with the Gunderboom (Unit 3) averaged 76% lower than those at the intake without the Gunderboom (Unit 4) (ASA 1999).

b. Engineering Aspects, Costs and Applicability

The evaluation of a fine-mesh barrier net and the Gunderboom System indicate that it might be possible to deploy a fine-mesh barrier system at some Hudson River locations. The current design of the Gunderboom System under evaluation permits the use of an automated airburst cleaning system that has been shown to be effective at maintaining the filtering capacity of the boom. For a fine-mesh barrier net, it is projected that the minimum maintenance (cleaning) schedule would be weekly, with the proposed cleaning method requiring net removal. This costs of this level of required maintenance virtually eliminate this from further consideration.

i. Bowline Point Units 1 & 2

The Bowline Point Units 1 & 2 fine-mesh barrier net evaluation studies (LMS 1994, 1996a) included measuring current velocities throughout the pond, monitoring the rate of biofouling on various mesh size test panels, and reviewing information on ichthyoplankton in Haverstraw Bay and Bowline Pond.

ii. Indian Point Units 2 & 3

Given the site conditions present at the Indian Point Units 2 & 3 Nuclear Generating Station, including deep water close to the intake structure, location of navigation channel, high seasonal debris loading, and high river currents, the use of a fine-mesh barrier system for ichthyoplankton entrainment mitigation is not considered feasible. In addition, for nuclear generating stations, the cooling/service water systems are critical nuclear components, requiring Nuclear Regulatory Commission (NRC) review and approval for any proposed modification, such as the installation of an intake barrier system. Any potential for a barrier system to interfere with plant operations, i.e., blockage of intake, would cause the NRC to reject the proposed modification.

iii. Roseton Units 1 & 2

At the Roseton Units 1 & 2 Generating Station, the location of the intake structure shoreward of the oil and coal barge unloading platform offers some protection from river currents and the navigation channel. However, high seasonal debris loading and proximity to the oil and coal vessels unloading fuel and disturbing sediments as they maneuver into position limits the feasibility of barrier system deployment at Roseton Units 1 & 2.

c. *Environmental Aspects*

The primary use of a fine-mesh barrier system would be for reducing (ichthyoplankton) entrainment. Further study is required before the effectiveness of a fine-mesh barrier system can be predicted. Since the majority of ichthyoplankton are present during the warmer water periods, a primary concern for the use of a fine-mesh system is clogging and biofouling. No ichthyoplankton impingement has been observed on the deployed Gunderboom. However, laboratory studies are currently underway to evaluate the potential for impingement.

Other environmental effects of deploying a physical exclusion system include potential disturbance of bottom sediments, restrictions on public use of the water body, and interference with commercial and private boat traffic.

6. Behavioral Systems

Behavioral devices are intended to either deflect or attract fishes away from a water intake. They have been designed to produce visual, physical, and acoustic stimuli, individually and in combinations.

a. Technology Review

Comprehensive reviews of behavioral devices were done by Lawler, Matusky & Skelly Engineers LLP (LMS 1988, 1992), Stone & Webster Engineering Corporation (SWEC 1986, 1994), and Popper and Carlson (1998). Electrical barriers, air bubble curtains, hanging chains, underwater strobe lights, mercury lights, incandescent lights, water jet curtains, and sound were considered. Systems using light and sound have produced the most effective barriers. However, high turbidity and strong currents reduce the potential effectiveness of underwater lights in the Hudson River. Therefore, acoustic systems are the only devices likely to be effective in reducing fish exposure to the cooling water intakes at Bowline Point, Units 1 & 2 Roseton Units 1 & 2 and Indian Point Units 2 & 3.

Sound System

Various means of producing underwater sound have been evaluated as means of moving fish from less favorable to more favorable locations. Mechanically produced low-frequency sound has been evaluated as a technique to reduce alewife impingement at the Pickering Nuclear Generating Station on Lake Ontario (Haymes and Patrick 1986), but the mechanical devices suffered from poor reliability and required extensive maintenance (SWEC 1986). Low-frequency pneumatic devices were evaluated at an offshore test structure in Lake Ontario (EPRI 1989a) and at the intake of the Roseton Units 1 & 2 Generating Station (EPRI 1989b). No consistent deterrent capability was found for the pneumatic devices and they also were subject to frequent breakdown.

Because of the many problems associated with mechanical sound-generating devices (primarily operational reliability), investigators tested devices that generate sound electronically. High-frequency sound produced by electronic systems has been tested on caged fish species including alewives, blueback herring, and white perch (Dunning et al. 1992, Nestler et al. 1992). Alewives in a cage exhibited an immediate and strong avoidance response to pulsed broadband sound between 117 and 133 kHz at a source level above 156 dB//μPa (Dunning et al. 1992). The avoidance response continued throughout the longest test period, two hours. Blueback herring in a cage had an immediate and long-lasting response to high frequency sound (Nestler et al. 1992). A full-scale sound deterrent system using pulsed broadband sound between 122 and 128 kHz at a source level of 190 dB//μPa was evaluated at the James A. FitzPatrick Nuclear Power Plant (JAF) on Lake Ontario (Ross et al. 1993 and Ross et al. 1996). When the system was operating, the density of fish near the JAF intake decreased by as much as 96%, and the number of alewives impinged decreased by as much as 87%. The sound system was effective at keeping fish away from the intake structure during the day and at night, with an effective exclusion range exceeding 80 m.

Electronically produced low-frequency sound elicited a strong avoidance response from caged white perch and striped bass during the day, but only a weak response at night (ESEERCO 1991). Low-frequency sound was tested on several salmon and trout species at the Ludington Pumped Storage facility on Lake Michigan and at a hydroelectric facility on the St. Josephs River (Loeffelman et al. 1991). Tests of low-frequency sound systems have resulted in responses too inconsistent to warrant installation near turbine or cooling water intakes. Mechanical devices that produce low-frequency sound have also elicited a significant avoidance response from white perch in captivity, but failed to consistently elicit a strong response from fish near power plant intakes (EPRI 1989b).

High-frequency sound generated by acoustic deterrent systems has been determined to be effective at moving alosids (alewife, blueback herring) away from intakes; however, neither low- nor high-frequency sound systems have been shown to be effective at moving any other fish species from such locations.
Since the devices rely on the abilities of fish to detect and swim away from the sounds they have not been shown to be effective at reducing the exposure of small weakly swimming organisms, such as fish larvae, to intakes. Therefore, they cannot be considered for reducing entrainment at the Bowline Point Units 1 & 2, Roseton Units 1 & 2 and Indian Point Units 2 & 3 intakes.

b. Engineering Aspects, Applicability, and Costs

At Bowline Point Units 1 & 2, Roseton Units 1 & 2, and Indian Point Units 2 & 3 sound might be used to reduce impingement of alewives, blueback herring and American shad. The location and design of acoustic deterrence systems at the four plants would have to be based on knowledge not currently available about fish movements, water currents, bottom topography, and the levels of background and reflected noise near the intakes (Ross et al. 1993).

The cost of an acoustic deterrence system would be based on the level of effort required to: 1) collect information on fish movements, water currents, bottom topography, and levels of background and reflected noise near the intakes to determine where to put sound projectors, 2) design, fabricate, and install the system, 3) confirm the system's effectiveness, and 4) maintain the system. It is likely that the level of effort will vary from plant to plant and depend on regulatory requirements. At JAF, the cost of items 1 through 3 was over $2 million and the cost of item 4 is on the order of $25 thousand per year.

c. Environmental Aspects

High frequency sound might be used to reduce impingement of blueback herring, alewives and American shad at all four stations. Sound has not been shown to be effective at reducing entrainment of any species. With the barrier net in place at Bowline Point Units 1 & 2 and modified Ristroph screens at Indian Point Units 2 & 3, conditional mortality due to impingement of shad, herring and alewives is not expected to exceed 0.1% at either station under the proposed operating plans. At Roseton Units 1 & 2 conditional mortality due to impingement is also expected to be less than 0.1% for shad and herring and only about 0.2% for alewives. However, Central Hudson proposes to continue to evaluate the use of sound in conjunction with the existing screens. If a system proves likely to be as effective as the system installed at the JAF Station, and is installed at Roseton Units 1 & 2, the conditional mortality rates identified above would be further reduced by 80 to 90%.

No environmental effects other than impingement reduction would be expected to occur if sound systems were installed. Results from caged studies indicate that broadband high-frequency sound did not produce any visible signs of damage to alewives or aberrant behavior in alewives and other fishes that occasionally were exposed (Dunning et al. 1992). Results from JAF indicate that alewives near the intake strongly avoided sounds at intensities about one-sixteenth the sound pressure level used by Hastings et al. (1996) to produce limited and inconsistent damage to the ears of the oscar *Astronotus ocellatus*. Thus, a well designed acoustic deterrent system is not likely to cause damage to the ears of alewives that are capable of swimming away from high-frequency sound or other species temporarily exposed.

D. OTHER ALTERNATIVES

1. District Heating and Cooling

District heating and cooling would use steam from the existing Bowline Point Units 1 & 2, Indian Point Units 2 & 3, and Roseton Units 1 & 2 stations as a source of steam for heating and/or cooling systems in the areas surrounding the stations. This section evaluates the technical and economic feasibility of this alternative. Due to the fact that the steam for district heating and cooling would have to be taken from a point in the Rankine cycle where the energy content of the steam is still relatively high, the extraction point would occur prior to the point at which the steam enters the turbine. Thus shunting the steam to a district heating system would not capture "waste heat" that would otherwise have been transferred to the Hudson River, but instead would use heat energy that otherwise would have been used to generate electricity. Unless the steam sent to the district heating/cooling system replaces energy that would have been supplied through electricity, this alternative would not reduce the need for generation from these facilities and even the very modest reductions in the amount of heat the facilities introduce into the estuary would not be realized.

a. Technology Review

A district heating and cooling (DHC) alternative for Roseton Units 1 & 2, Indian Point Units 2 & 3, and Bowline Point Units 1 & 2 is fully described in Appendix VIII-4. The DHC study evaluated the potential to reduce waste heat in three ways: export of heat in the form of processed steam for industrial or institutional users; export of comfort heat and/or hot water heat to potential industrial or institutional customers; and development of potential district cooling systems. District heating has been used successfully in urban areas with nearby customers. The potential to provide a positive benefit of this nature to the neighboring community while reducing the discharge of heat to the river might make this alternative attractive if it were feasible. However, the three power stations under consideration are located in rural or suburban communities that do not offer large customer bases. The demand for district heating and cooling in those communities would be so small that reductions in heat rejection to the river and cooling water use would be minimal. As described in greater detail below, the potential environmental benefit to the Hudson River does not warrant the expenditures required. The demand for a district cooling system near any of the power plants was determined to be even less than that for district heating; thus the cooling option was not evaluated further.

b. Engineering Aspects and Applicability

Engineering studies indicate that it is possible, although it would be expensive, to retrofit each of the power plants. However, the practicality of the DHC alternative is dependent on the availability of potential customers for process steam or heating in the service area surrounding the power stations. If customers are available, engineering factors must then be considered. These include, e.g., the feasibility of modifications to allow for district heating, conduits for transmission and distribution systems, and an evaluation of the impact of loss of generating capacity associated with retrofitting existing turbines.

Analyses of the potential service area around each plant indicated that there were no customers for process steam in the vicinity of the Indian Point Units 2 & 3 station, and although there were several potential customers for comfort heating or district hot water heating, only a small portion of the total heat load could be transferred in this manner. The Bowline Point Units 1 & 2 Generating Station survey identified several potential customers for steam and five school buildings that might be serviced with comfort heating and domestic hot water. The Roseton Units 1 & 2 Generating Station survey indicated three potential process-steam customers and 11 other potential district-heating customers.

c. Environmental Aspects

The environmental incentives for implementing district heating or cooling would be to reduce cooling water withdrawals and discharges to the Hudson River. A reduction in heat discharge would also be accomplished. Because the demand for district heating and cooling in the areas surrounding the power plant is small, the impact on temperatures in the Hudson River is equally small. As described below in greater detail, district heating and cooling would result in only a small reduction in discharge temperatures at any of the three power stations.

i. Bowline Point Units 1 & 2

The current maximum cooling water temperature rise for Bowline Point Units 1 & 2 due to condenser heat is about 17.15°F. If steam were exported to U.S. Gypsum, a likely recipient, the temperature rise would be 16.93°F, a reduction of 0.22°F. By installing a district hot water heating system the temperature rise would be 16.83°F, a reduction of 0.32°F. If both systems were implemented together, and simultaneously operated at peak loads, the total reduction in circulating water discharge temperature would be 0.54°F. The district heating peak occurs for only a few months a year in winter when the mean river temperature is approximately 40°F. During the summer months only the U.S. Gypsum process system would use steam close to its peak demand, so the combined effect would be to reduce circulating water discharge temperature by only about 0.35°F.

Unit 2 accounts for 50% of the circulating water used at the Bowline Point Units 1 & 2 site. When the temperature reduction is considered as part of the overall site discharge from the Bowline Point Units 1 & 2 station, the average temperature reduction would be less than 0.27°F at peak loads and only 0.18°F during the summer months.

ii. Indian Point Units 2 & 3

Indian Point Units 2 & 3 would have the same district heating customers. Therefore, either unit, but not both, would be modified. For the purpose of this analysis Unit 2 was selected; results would be identical for Unit 3.

The current maximum cooling water temperature rise for Indian Point Unit 2 due to condenser heat is about 16.3°F. If steam were supplied to a comfort and hot water district heating system, the temperature rise would be 16.15°F. Based on Indian Point Unit 2 circulating water flow, such a system would reduce the circulating water temperature by 0.15°F. Since both Indian Point Units 2 and 3 discharge circulating water into a common canal, the combined water temperature would be reduced by 0.07°F.

In summer months the district heating system would provide domestic hot water but not comfort heating to customers. Summer domestic hot water load is usually 15% of the winter peak heating load. Therefore, the reduction in combined circulating water temperature from both Units 2 & 3 is estimated at 0.01°F during the summer months and essentially no reduction in flow.

iii. Roseton Units 1 & 2

The current maximum temperature rise for Roseton Units 1 & 2 Generating Station due to condenser heat is about 16.21°F. If steam were exported to process steam customers, the temperature rise would be 16.06°F, a reduction of 0.15°F. If both systems were implemented, the total reduction in circulating water discharge temperature would be 0.23°F during simultaneous operation at peak loads. This peak load would occur for a few months a year in winter. During the summer months only process steam customers would use steam. Under these conditions the combined effect of the steam export and district heating systems would be to reduce circulating water discharge temperature by about 0.17°F.

d. Economic Considerations

The cost of implementing district heating and cooling would be very high, given the insignificant reduction in waste heat that could be achieved. A summary of capital costs, operating costs, and potential revenue associated with each of the three power plants is given in Appendix VIII-4.

2. Importation of Power

Importation of power is a component of the proposed action and of the alternatives considered because service area power needs must be accommodated in all cases. Regional power shortfalls caused by outages and flow reductions at Hudson River plants must be compensated for by power production elsewhere.

A corollary to importation of power is export of environmental impacts. The identity and extent of those impacts cannot be defined without knowledge of the source of the imported power and the focus of environmental impact. As described in Section IV, the New York Power Pool historically balanced power production and distribution in New York State to assure reliable low-cost energy to the ratepayer. The sources of imported power change on a minute-by-minute basis and are dependent on many factors, including availability of generating units and bulk transmission lines, and individual company and total statewide load levels. This process is changing as New York State moves into deregulation of the electric utility industry. With the development of wholesale energy markets and retail electric competition (retail access), more and more customers will be able to obtain energy from a multitude of energy suppliers. The boundaries of traditional utility franchises, as they relate to energy production, will no longer exist. Thus, as the source of imported power is variable, so will be the location and extent of impacts associated with it; however, to the extent that imported power would be generated at plants with once-through cooling, there could be incremental impingement, entrainment, and thermal plume impacts at those facilities, such as the ones set forth in Section VI for facilities described herein. The impacts that accrue to the locations where replacement power is produced cannot be identified or evaluated.

3. Multiple Choice Alternative

a. Introduction

NYSDEC requested that the utilities also evaluate a four-pronged alternative that was designed to reduce the levels of entrainment and impingement mortality through retirement of units, incorporation of closed-cycle cooling at existing units, or construction of new facilities with once-through cooling. The four prongs would offer the utilities a choice of the following strategies:

1. Operation of the nuclear units (Indian Point Units 2 & 3) until the end of their Nuclear Regulatory Commission licenses under the conditions set forth in the 1981 Settlement Agreement. Con Edison and NYPA would agree now not to seek extension of their NRC licenses past the expiration of their current terms in 2013 and 2015, respectively. SENY and Central Hudson would agree to continue to operate Bowline Point Units 1

& 2 and Roseton Units 1 & 2 under Settlement Agreement conditions and to retire the units in approximately 2015.

2. The immediate start of construction of closed-cycle cooling for the existing units.
3. The initiation of applications under Public Service Law Article 10 to re-power the stations at these sites with generating units designed for closed-cycle cooling. Operation of each of the present plants could continue under Settlement Agreement terms until each Article 10 process was completed.
4. The institution of 32-week outages each year for all units at Bowline Point Units 1 & 2, Indian Point Units 2 & 3 and Roseton Units 1 & 2 in order to eliminate entrainment mortality.

b. Evaluation of alternatives

Elements of these strategies have already been evaluated in Section VIII.B and that evaluation will not be repeated here. For example, the second strategy (construction of cooling towers) was examined in Section VIII.B.3 and elements of strategy number 4 (prescribed outages) were evaluated in Section VIII.B.1. The practicality of other elements of these strategies is evaluated as follows:

i. Forego future operation

New York State has just entered into an era of deregulated electrical generation, in which the future use of any existing unit for generation of electricity will be determined by the ability of that facility to produce lower cost electricity and provide it reliably. The degree to which new power plants will be constructed and operated to provide electricity in competition with the Bowline Point Units 1 & 2, Indian Point Units 2 & 3, and Roseton Units 1 & 2 plants on a reliable basis cannot be forecast with certainty, particularly 13 to 15 years into the future. It requires accurate forecasts of fuel costs, operating costs, market conditions, and interim developments in generation and transmission of electricity. Furthermore, this strategy assumes that the effects of the existing plants on the Hudson River must be reduced, a conclusion not supported by Section VI of this DEIS. Thus, the utilities believe that deciding at this time to forego the future operation of the Bowline Point Units 1 & 2, Indian Point Units 2 & 3, and Roseton Units 1 & 2 plants is not prudent nor does it support the economic development initiative of New York State.

ii. Re-power with closed-cycle cooling

The decision to close an operating power plant and replace it with another assumes that the new plant will supply more economic and marketable electricity over the expected life of the existing plant. As described above in relation to the first strategy, such a decision is subject to forecasts of future fuel prices, useful life of the existing plants, construction and operating costs, market conditions, and other effects of interim power plant and transmission development. Given these uncertainties, the utilities believe that this decision should be made after the effects of deregulation when energy prices in New York State are known from experience.

iii. Complete elimination of entrainment mortality through outages

In section VIII.B.1, the alternative of a one-unit 32-week outage at each station was described. The best estimate that can be made for this strategy's effects on air emissions and economics would be to double the estimates for Scenario D. However, this would not completely capture the effects of 32-week outages at all six units. On July 6, 1999, the New York Control Area (NYCA) reached a peak load of 30,311 MW even after implementation of emergency operating procedures for voltage reductions and massive appeals for voluntary customer load reductions. Two major generating facilities were forced out of service that day (Oswego No. 5 and 9-Mile No. 2, totaling 1,918 MW of capacity). Even with only two major units out of service, the NYCA experienced low voltages and a Major Emergency was declared by the New York Power Pool. Had another 4,000 MW plus of generating capacity on the Hudson River not been available that day in New York State, extensive load shedding would have occurred.

Currently the loads within New York State must acquire enough Installed Capacity to match the New York Control Area (NYCA) load plus 22%. This is to meet the reliability criteria that there is sufficient generation installed so that the probability of loss of load due to a generation deficiency is no more than one day in 10 years. For example, using the 1999 actual summer pool peak of 30,311 MW, NYCA would require about 37,000 MW of installed capacity. Using the reported capacity identified in the 1999-6-107 Load & Capacity Data "Yellow Book" as of January 1999, which included over 4,000 MW of Hudson River capacity, over 3,300 MWs of additional capacity would be required. Eliminating or reducing the Hudson River capacity would drive this number even higher, to maintain the required reliability level.

E. NO ACTION

Consideration of a "no action alternative" is inapplicable to the subject applications for renewal of SPDES permits for operating plants. DEC is required by law to act on the applications, i.e., to grant them according to the terms of the applications, to grant them with conditions, or to deny them.

F. PERMIT DENIAL

A DEC determination not to reissue permits for the Bowline Point Units 1 & 2, Roseton Units 1 & 2, and Indian Point Units 2 & 3 generating stations would prohibit the plants from discharging effluent to the Hudson River. Since the plants are dependent on water use and discharge for operation, final permit denial would effectively require that the plants shut down within the period for compliance specified in the permit. This would eliminate the environmental effects resulting from the operation of these stations, but translate some or all to unknown other sites where replacement power would be generated.

On July 6, 1999, the New York Control Area (NYCA) reached a peak load of 30,311 MW even after implementation of emergency operating procedures for voltage reductions and massive appeals for voluntary customer load reductions. Two major generating facilities were forced out of service that day (Oswego No. 5 and 9-Mile No. 2, totaling 1,918 MW of capacity). Even with only two major units out of service, the NYCA experienced low voltages and a Major Emergency was declared by the New York Power Pool. Had another 4,000 MW plus of generating capacity on the Hudson River not been available that day in New York State, extensive load shedding would have occurred.

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G. OTHER ACTIONS

Preceding subsections describe actions that might be taken to directly reduce the number of aquatic organisms killed by the operation of the Bowline Point Units 1 & 2, Roseton Units 1 & 2, and Indian Point Units 2 & 3 Stations. This section describes action that might be taken to directly or indirectly offset, rather than directly reduce, power plant effects on certain aquatic resources. Rectification, reduction, and compensation may in appropriate circumstances be employed to offset environmental effects or impacts from existing facilities or operations or to anticipate their potential occurrence. These approaches to mitigation are generally implemented through restoration, enhancement, or protection of the resources impacted by the proposed action.

The potential resource restoration, enhancement, and protection (REP) activities to offset the potential for power plant impacts on the Hudson River estuary could be resource directed or habitat directed. An example of resource-directed activities would be stocking the river with hatchery-reared fish. Habitat-directed activities could include a wide variety of possibilities, such as power-plant-related wetland restoration or enhancement, elimination of barriers to fish utilization of tributaries and tidal channels, or enhancement of subtidal spawning and nursery habitat in the littoral areas of the Hudson River estuary proper.

1. Resource-Directed Activities

a. *Fish Stocking*

Individual fish that do not survive entrainment or impingement can be replaced with those spawned from Hudson River fish, reared in a hatchery or pond, and stocked into the Hudson River.. In practice, the eggs spawned for hatchery use represent only a small percentage of the total eggs produced by the species. However, the protection provided during the rearing process enhances the survival of the young by orders of magnitude over their counterparts in the river.

Fish hatcheries have a long history in the United States, dating back a century or more. For example, in the Hudson River during the 1800s, Seth Green cultured American shad larvae for stocking with the apparent intent of maintaining or improving the intense shad fishery of that time. This work continued until 1935. More recent decades have seen the expansion of the scientifically based use of hatcheries for mitigation and restoration. For example, hatcheries for salmonids (including coho and chinook salmon, brown and steelhead trout) have been used extensively to mitigate the effects of water withdrawals and hydropower projects, and to restore anadromous fish to areas where their populations had declined.

Dozens of anadromous fish hatcheries are in operation in the states of California, Idaho, Oregon, New York, and Washington, among others.

Hatcheries have also been used widely to protect and enhance stocks of striped bass. Under the coordination of the U.S. Fish and Wildlife Service (USFWS) and the Atlantic States Marine Fisheries Commission (ASMFC), state and federal hatcheries have cultured and stocked several million striped bass fingerlings since 1985, with the objective of restoring seriously declining Chesapeake Bay populations and protecting the Atlantic coastal stocks of this species. Striped bass hatchery and stocking programs have also been conducted in the Sacramento-San Joaquin and Santee-Cooper rivers. The Hudson River utilities operated a striped bass hatchery on the Hudson River from 1983 through 1991 as a requirement of the 1981 and 1987 SPDES permits and from 1992 through 1995 as a condition of several Consent Orders agreed to by the utilities, the DEC, and environmental advocacy groups.

Hatcheries offer the additional indirect benefit of being interesting to the public and may offer environmental education programs that contribute to the development of social concern and commitment to protect natural resources. This is particularly true for intensive culture facilities, whose fish tanks and educational displays may be observed throughout the rearing season.

b. Candidate Species and Approaches

Three Hudson River fish species are candidates for hatchery rearing and stocking because of their resource value and potential to be reared using intensive culture: striped bass, Atlantic sturgeon, and American shad.

i. Striped Bass

Techniques for artificial propagation of the species are well established and have been refined and tested specifically for Hudson River striped bass through research and production efforts conducted by the utilities since 1973.

Under hatchery protocol, total estimated survival from egg to fingerling stockout is typically in the range of 2-10%, about 10,000 to 100,000 times greater than that expected in the wild.

ii. Atlantic Sturgeon

Atlantic sturgeon have become the focus of the most recent USFWS population restoration work directed at Atlantic coast anadromous fishes. Much of the preliminary work was conducted to develop cultural techniques for fry and juveniles produced from captured adult wild broodstock. The current emphasis of USFWS is on developing captive broodstock maturation techniques.

These programs were initiated in 1977 at South Carolina's Waddell Mariculture Center as a joint federal/state project. Research into the development of cultural techniques for captured wild fish ended in 1992 with the completion of the work at Waddell and a shift to broodstock maturation studies. These studies have been conducted at the federal fish hatchery in Orangeburg, South Carolina, with staff trained by sturgeon culturists at the University of California's Davis Aquaculture Program. Other federally funded projects will be conducted at the Cortland (New York) Fish Nutrition Laboratory to refine knowledge of sturgeon diet and at the University of Florida in Gainesville to study hormonal activity in maturing broodfish.

North American sturgeon were first used successfully in fish culture when Seth Green obtained and stripped ripe Hudson River broodstock captured by commercial fisheries in 1875. By 1912, the several states that were participating in sturgeon culture work had abandoned their efforts, due in large part to the inability to control ovulation and spermiation of the adult broodfish. The recent focus of USFWS on these issues will improve the quality of sturgeon culture. ASMFC's Management Plan for Atlantic Sturgeon suggests that aquaculture and artificial stocking are feasible solutions for restoring wild sturgeon stocks, which should encourage Atlantic coastal states to consider developing additional sturgeon restoration or enhancement projects.

iii. American Shad

Recent efforts to develop American shad culturing techniques to restore the Susquehanna stock (St. Pierre 1976) have led to the development of successful techniques for intensive culture of larval shad through the juvenile stage (Wiggins et al. 1985). Most of the preliminary work was done at the USFWS Fish Cultural Station in Lamar, Pennsylvania, or at the Pennsylvania Fish Commission's Benner Springs Fish Research Station in Bellafonte, Pennsylvania.

Preferred techniques have yielded excellent survival ratios throughout the intensive culture period, with a survival rate of approximately 60% reported from hatch to 70 days posthatch (Howey 1985). Shad may be raised in circular tanks and fed brine shrimp nauplii, making them compatible with the existing hatchery facility at Verplanck.

Restoration of shad into coastal river systems has been under consideration by USFWS, the Merrimac River Technical Committee for Restoration Efforts in Massachusetts and New Hampshire, and the Department of Marine Resources in Maine.

2. Habitat-Directed Activities

a. Rationale

Habitat-directed REP is a scientifically sound and socially desirable means to enhance or restore resource value. One habitat-directed REP possible in the Hudson River estuary involves construction, restoration, or enhancement of those tidal wetlands and subtidal aquatic vegetation beds in the littoral zone that provide habitat for species subject to power plant effects. This would increase available spawning and nursery habitat for fish and increase the contribution of these habitats to the primary and secondary productivity of the ecosystem. Another possible habitat-directed REP involves removal of impediments to fish migration and spawning in tributary streams and tidal channels. This would also increase the availability of spawning habitat and therefore the successful reproduction of those fish species using these areas to spawn. A number of fish species currently subject to power plant impacts could be expected to benefit from restoration and enhancement of associated habitats, including striped bass, shad, white perch, and herring.

b. Tidal Wetlands and Submerged Aquatic Vegetation

Wetlands (e.g., marshes, tidal flats, and associated tidal creeks) and submerged aquatic vegetation (SAV) serve three major ecological functions: (1) hydrological control, i.e., floodwater retention and groundwater recharge; (2) water quality maintenance, i.e., removal of sediment, excess nutrients, and contaminants; and (3) food chain support, i.e., production of a large quantity of food suitable for juvenile fish and protective habitat for diverse populations of organisms (Adamus and Stockwell 1983). The food chain and protective habitat function is of particular importance in estuarine areas.

The wetlands and SAV make important contributions to effective ecosystems. Their restoration and enhancement is a valuable tool for environmental management, which minimizes the effects of losses in production of fish and other aquatic organisms (Jorgensen and Mitsch 1989). Such mitigation involves the restoration or enhancement of altered or degraded wetlands that have lost some of their natural function and value. Restoration and enhancement are widely used for mitigation of degraded wetlands (Ferrigno et al. 1986; Shisler 1989). Considering that wetlands and SAV provide significant habitat and food for fish and invertebrates in the Hudson River estuary, their restoration and enhancement could be effective tools for minimizing the effects of fish losses by increasing their productivity.

Although the wetland and SAV areas are smaller in the Hudson River estuary than in many other East Coast estuaries, wetlands together with SAV in associated subtidal areas can be expected to play a significant role in energy transfer through the food web to fish, especially in localized, critical nursery habitats. In addition, recent concerns about the long-term influence of reduced nutrients and zebra mussel infestation on the energy dynamics of the Hudson River imbue wetlands/SAV restoration and enhancement with greater strategic significance in Hudson River estuary management plans.

c. *Tributary Streams and Tidal Channels*

Several species of estuarine fish, including river herring, white perch, and black bass, spawn in freshwater tributaries and tidal channels, whose access may be blocked by dams or sedimentation, thus limiting potential spawning habitat. For example, tributary streams used by river herring along the Atlantic coast have been dammed or otherwise blocked for industrial, transportation, irrigation, recreational, or flood control purposes for many decades. In recent decades there has been growing interest in programs to provide passageways around impediments for spawning runs. Several states, including Maine, Massachusetts, New Hampshire, and Rhode Island, have taken action since the 1960s at over 100 locations to increase available stream-spawning habitat by removing blockages or constructing passageways. Locally, recent surveys identified more than 50 impediments to anadromous fish-run tributaries of the New York/New Jersey harbor watershed, and prioritized sites for possible mitigation (Durkas 1992).

Removal of impediments to tributary and tidal channel access could increase spawning habitat for freshwater spawning fish in the Hudson River estuary. It could also increase accessibility for a wide variety of species to the productivity and refuge afforded by backwater wetlands. In some cases removal of sediment traps and reconstruction of bottom contours may restore bottom substrate conditions suitable for the spawning of centrarchids, including the black bass. Restoration of access would therefore enhance the production and abundance of small fish, including juvenile herring, which are food for a variety of predators. Predators include species of recreational and commercial importance that do not directly utilize freshwater streams and channels for spawning, such as striped bass, weakfish, and bluefish. It would also offer increased spawning opportunity to offset power-plant-related losses of herring and white perch.

d. *Candidate Sites and Approaches*

Several recent initiatives on the part of regulatory bodies and other public and private groups indicate increasing recognition of the values and functions of critical habitat within the Hudson River ecosystem. The State of New York has designated 39 Significant Tidal Habitats on the Hudson River. These sites, which are to be protected and restored where possible (DOS 1990), include a variety of habitat types (marshes, embayments, tributaries, and littoral and open-water zones) between the Troy Dam and the New York/New Jersey border (Table VIII-8).

A DEC legislative initiative to enhance protection of tidal wetlands was rejected in 1991. Nevertheless, DEC's Division of Marine Resources intends to seek budgetary approvals to enhance protection through regulatory change, and will consider adopting a mitigation policy for tidal wetlands. DEC is also working with regional conservation groups to identify ecologically significant underwater lands to transfer to DEC jurisdiction for protection. With the objective of identifying restoration needs, DEC has included filled lands as well as lands currently under water in its definition of "underwater lands" (DEC 1992).

Through funding from CHG&E the Hudson River utilities have already contributed voluntarily to the fledgling restoration efforts being coordinated by the Museum of the Hudson Highlands. This program is a cooperative effort among museum staff and federal, state, private, and local interest groups to improve habitat at Cornwall coalyard, Sloop Hill, Danskammer Cove, Constitution Marsh, and Manitou Marsh. Potential restoration opportunities were also identified by the DOS Coastal Management Program and more recently by DEC (DEC 1993).

Public interest in the concept of restoring and protecting the Hudson River ecosystem is currently high. Several state and Federal programs have established restoration and protection goals and objectives. Implementation of habitat-directed REPs to mitigate power plant effects would be consistent with the goals of the Hudson River Estuary Management Program, Hudson River National Estuarine Research Reserve, New York State Coastal Management Program, and the New York-New Jersey Harbor Estuary Program. To date, these programs have established broad objectives and general locations worthy of protection or in need of restoration. Prior to any design or implementation efforts, further planning would be required to characterize REP sites, determine feasible restoration options, evaluate their possible environmental benefits and impacts, and determine their potential for ameliorating power plant impacts. Restoration actions likely to be evaluated include:

- Establishment of emergent or submergent vegetation
- Destruction of intruding vegetation and reestablishment of natural vegetation of higher habitat value
- Removal of barriers, reopening of tide channels, and installation of fish passage facilities
- Hydrologic alterations to support restoration of appropriate water quality, sediment, or vegetation characteristics

Planning and implementation of REP to mitigate power plant effects would require close coordination with ongoing management programs as well as local public involvement.

3. Costs and Benefits

If mitigation beyond that provided by the proposed action is desired, specific REP actions can be developed to provide those benefits. The cost of the REP actions is dependent upon the level of benefits to be provided. Therefore, no attempt has been made to evaluate in detail the costs and benefits of the REP activities described above, with the exception of the utilities' striped bass hatchery. After full amortization of construction costs, annual operating costs for the striped bass hatchery owned by the Utilities in Verplank, NY were on the order of $300,000 when the system last operated. They vary somewhat with realized levels of fish production; the length of the spawning and rearing seasons; and, most important, the need for repair or replacement of major system components.

H. Conclusions

In the evaluation of alternative technologies for potential use at Roseton Units 1 & 2, Indian Point Units 2 & 3, Bowline Point Units 1 & 2, several criteria were considered:

1. Technical feasibility: Is the technology commercially available and do practical, technical, and engineering considerations allow the use of the technology at the specific site in question?

2. Biological effectiveness: Does the technology reduce or eliminate the potential for adverse environmental impact to the aquatic ecosystem?

3. Other environmental effects: Does the technology have significant environmental side effects which might lessen its potential for net environmental benefits?

4. Cost: Is the cost of installing the technology at the site economically practical and not out of proportion to the anticipated environmental benefits?

These factors are summarized for each of the alternatives considered in Tables VIII-12, 13, and 14. The provisions for fish protection in the Proposed Action, consisting of cooling water flow management, intake technologies and continued research, represents a suitable balance of economic, social, and environmental interests and would not adversely affect species diversity or species abundance within the fish communities in the Hudson River.

Table VIII-12
SUMMARY OF ALTERNATIVES FOR RENEWAL OF SPDES PERMIT FOR ROSETON UNITS 1 & 2.

Alternative		Effects on Fish			Water Quality & Consumption	Aesthetics	Land Use	NY Statewide		Costs
		Entrainment CMR	Impingement CMR	Population Effects				Air Emissions (1000 T/yr)	Fuel Use	F=Fishery P=Electrical Production
Proposed Action		SB: 0.033 WP: 0.064 AT: 0.016 BA: 0.010 AS: 0.004 RH: 0.032 SS: 0.012 FPP: 17.6	SB: <0.001 WP: 0.001 AT: <0.001 BA: <0.001 AS: <0.001 BH: <0.001 AW: 0.002 SS: <0.001	Negligible reductions in equilibrium populations of striped bass and American shad; no reduction of Atlantic tomcod	Best use of water maintained. Evaporation: 3,600 gpm	None	None	NOx: 64 SO2: 175 CO: 21 CO2: 42,283 Part.: 62	Oil: 11.6 (10^6 Bbls) Gas 165.1 (10^{12} CF) Coal: 9.6 (10^6 Tons) U: 347.6 (10^{12} BTU)	F: <$19,000yr P: 0
Prescribed Outages And Permit Flow Rates	A-Independent Scheduling of previous permit outages within window	SB:0.03 WP:0.06 AT:0.02 BA:0.01 AS: RH:0.03 SS:	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	NOx: +0.1% SO2: +0.3% CO: +0.0% CO2: +0.0% Part.: +0.1%	Oil: -0.3% Gas -0.4% Coal: +0.3% U: 0.0%	F: <$19,000/yr P: $972/,000yr
	B-Independent Scheduling of previous permit outages at any time	SB:0.03 WP:0.06 AT:0.02 BA:0.01 AS: RH:0.03 SS:	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	NOx: +0.1% SO2: +0.3% CO: +0.0% CO2: +0.0% Part.: +0.1%	Oil: -0.3% Gas -0.4% Coal: +0.3% U: 0.0%	F: <$19,000/yr P: $972,000/yr
	C-Dependent Scheduling of previous permit outages at any time	SB:0.03 WP:0.06 AT:0.02 BA:0.01 AS: RH:0.03 SS:	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	NOx: +0.1% SO2: +0.3% CO: +0.0% CO2: +0.0% Part.: +0.1%	Oil: -0.3% Gas -0.4% Coal: +0.3% U: 0.0%	F: <$19,000/yr P: $972,000/yr
	D-32-week one-unit outage	SB:0.023 WP:0.045 AT:0.010 BA:0.007 AS:0.003 RH:0.022 SS:0.008	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	NOx: +1.1% SO2: +2.5% CO: -0.4% CO2: +0.3% Part.: +0.8%	Oil: -2.7% Gas -3.3% Coal: +2.6% U: 0.0%	F: 0 P: $7.8 million/yr

Table VIII-12
SUMMARY OF ALTERNATIVES FOR RENEWAL OF SPDES PERMIT FOR ROSETON UNITS 1 & 2.

Alternative		Effects on Fish			Water Quality & Consumption	Aesthetics	Land Use	NY Statewide		Costs F=Fishery P=Electrical Production
		Entrainment CMR	Impingement CMR	Population Effects				Air Emissions (1000 T/yr)	Fuel Use	
Efficient Flow		Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	Similar to Proposed Action	Similar to Proposed Action	F: < $19,000/yr P: Unknown
Wet/Dry Cooling Towers		SB:0.004 WP:0.004 AT:0.001 BA:<0.001 AS:<0.001 RH:0.001 SS:0.003	Essentially eliminated	None	Consumptive use of 9,000 gpm; concentrated blowdown discharge 20,000 gpm.	Potential visual effects from river; some plume effects	Disturbance of 6 acres	NOx: +0.1% SO2: +0.1% CO: +0.1% CO2: +0.1% Part.: +0.0%	Oil: +0.5% Gas +0.3% Coal: 0.0% U: 0.0%	F: $0 P: $132-184 million
Intake Technologies	Ristroph Screens	Similar to Proposed Action	Uncertain reduction in impingement mortality	Similar to Proposed Action	Similar to Proposed Action	None	None	Similar to Proposed Action	Similar to Proposed Action	F: <19,000/yr P: Unknow
	Cylindrical Wedge-wire Screens	Reduction in entrainment mortality is uncertain and would depend on species and mesh size	Reduction in Impingement mortality is uncertain.	Similar to Proposed Action	Similar to Proposed Action	None	None	Similar to Proposed Action	Similar to Proposed Action	F: <19,000/yr P: Unkown
	Fine-Mesh Screens	Reduction in entrainment mortality – fewer organisms entrained.	Increase in impingement mortality –more organisms impinged.	Similar to Proposed Action	Similar to Proposed Action	None	None	Similar to Proposed Action	Similar to Proposed Action	F: <19,000/yr P: Unknown
	Barrier Nets	Not Feasible to Deploy								
	Fine-Mesh Barrier Nets	Not Feasible to Deploy								
	Behavioral Systems	Similar to Proposed Action	Reductions in impingement mortality are uncertain	Similar to Proposed Action	Similar to Proposed Action	None	None	Similar to Proposed Action	Similar to Proposed Action	F: <$19,000/yr P: Unknown

Table VIII-12
SUMMARY OF ALTERNATIVES FOR RENEWAL OF SPDES PERMIT FOR ROSETON UNITS 1 & 2.

Alternative		Effects on Fish			Water Quality & Consumption	Aesthetics	Land Use	NY Statewide		Costs
		Entrainment CMR	Impingement CMR	Population Effects				Air Emissions (1000 T/yr)	Fuel Use	F=Fishery P=Electrical Production
Importation of Power		Not feasible to replace with imported power.								
District Heating		Not feasible. No change in impact from proposed action.								
Multiple Choice Alternative	1 – Fixed 40-year end of life of units. Retirement in 2013 and 2015.	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	Similar to Proposed Action	Similar to Proposed Action	F: <$19,000/yr P: Unknown
	2 – Cooling Towers	See Cooling Tower Alternative Above								
	3 – Repower	Not able to evaluate at this time								
	4 – 32-week Outages	SB:0 WP:0 AT:0 BA:0 AS:0 RH:0 SS:0	Slightly less that Proposed Action	None	Similar to Proposed Action	Possible impacts if new generation sources or transmission facilities required	Possible need for increased power plant construction and/or transmission capability	NOx: +2.2% SO2: +5.0% CO: -0.8% CO2: +0.6% Part.: +1.6%	Oil: -5.4% Gas -6.6% Coal: +2.6% U: 0.0%	F: 0 P: $15.6 million annually

Table VIII-13

SUMMARY OF ALTERNATIVES FOR RENEWAL OF SPDES PERMIT FOR INDIAN POINT UNITS 2 & 3.

Alternative		Effects on Fish			Water Quality & Consumption	Aesthetics	Land Use	NY Statewide		Costs
		Entrainment CMR	Impingement CMR	Population Effects				Air Emissions (1000 T/yr)	Fuel Use	F=Fishery P=Electical Production
Proposed Action		SB:0.107 WP:0.044 AT:0.140 BA:0.132 AS:0.002 RH:0.008 SS:0.032 FPP:73.2	SB:<0.001 WP:0.002 AT:0.002 BA:<0.001 AS:<0.001 BH:0.001 AW:0.001 SS:<0.001	Negligible reductions in equilibrium populations of striped bass and American shad; no reduction of Atlantic tomcod	Best use of water maintained. Evaporation: 8,900 gpm	None	None	NOx: 64 SO2: 175 CO: 21 CO2: 42,283 Part.: 62	Oil: 11.6 (10^6 Bbls) Gas 165.1 (10^{12} CF) Coal: 9.6 (10^6 Tons) U: 347.6 (10^{12} BTU)	F: <$25,000/yr P:$590,000/yr
Prescribed Outages And Permit Flow Rates	A-Independent Scheduling of previous permit outages within window	SB:0.08 WP:0.03 AT:0.14 BA:0.11 AS: RH:0.01 SS:	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	NOx: +1.4% SO2: +1.2% CO: +0.4% CO2: +1.1% Part.: +0.5%	Oil: +0.9% Gas +1.6% Coal: +1.1% U: -2.1%	F: <$25,000/yr P:$14.3 million/yr
	B-Independent Scheduling of previous permit outages at any time	SB:0.06 WP:0.03 AT:0.14 BA:0.11 AS: RH:0.01 SS:	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	NOx: +1.4% SO2: +1.2% CO: +0.4% CO2: +1.1% Part.: +0.5%	Oil: +0.9% Gas +1.6% Coal: +1.1% U: -2.1%	F: <$25,000/yr P:$14.3 million/yr
	C-Dependent Scheduling of previous permit outages at any time	SB:0.06 WP:0.03 AT:0.14 BA:0.12 AS: RH:0.01 SS:	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	NOx: +1.4% SO2: +1.2% CO: +0.4% CO2: +1.1% Part.: +0.5%	Oil: +0.9% Gas +1.6% Coal: +1.1% U: -2.1%	F: <$25,000/yr P:$14.3 million/yr
	D-32-week one-unit outage	SB:0.067 WP:0.028 AT:0.090 BA:0.076 AS:0.001 RH:0.006 SS:0.020	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	NOx: +7.5% SO2: +8.5% CO: +2.3% CO2: +5.9% Part.: +2.5%	Oil: +5.0% Gas +8.4% Coal: +5.6% U: -11.3%	F: <$25,000/yr P:$73 million/yr

Table VIII-13
SUMMARY OF ALTERNATIVES FOR RENEWAL OF SPDES PERMIT FOR INDIAN POINT UNITS 2 & 3.

Alternative		Effects on Fish			Water Quality & Consumption	Aesthetics	Land Use	NY Statewide		Costs
		Entrainment CMR	Impingement CMR	Population Effects				Air Emissions (1000 T/yr)	Fuel Use	F=Fishery P=Electical Production
Efficient Flow		SB:0.124 WP:0.052 AT:0.160 BA:0.149 AS:0.002 RH:0.011 SS:0.038	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	Similar to Proposed Action	Similar to Proposed Action	F: <$25,000/yr P: 0
Wet/Dry Cooling Towers		SB:0.012 WP:0.003 AT:0.012 BA:0.005 AS:<0.001 RH:<0.001 SS:0.004	Essentially eliminated	Similar to Proposed Action	Consumptive use of 24,000 gpm; concentrated blowdown discharge 24,000 gpm.	Substantial visual effects from river; some plume effects	30+ acres clearing of forested land; fill in river; 66,000 lb/mo salt deposition;	NOx: +1.2% SO2: +1.6% CO: +0.2% CO2: +0.8% Part.: +0.3%	Oil: +0.7% Gas +0.8% Coal: +0.7% U: 0.0%	F: 0 P: $584-$843 million depending on end of life
Intake Technologies	Ristroph Screens	Similar to Proposed Action								
	Cylindrical Wedge-wire Screens	Reduction in entrainment mortality is uncertain and would depend on species and mesh size	Impingement mortality would be reduced to low levels	Similar to Proposed Action	Similar to Proposed Action	None	None	Similar to Proposed Action	Similar to Proposed Action	F: < $25,000/yr P: $44-$55 million (in 1989)
	Fine-Mesh Screens	Reduction in entrainment mortality is uncertain	Reduction in impingement mortality uncertain.	Similar to Proposed Action	Similar to Proposed Action	None	None	Similar to Proposed Action	Similar to Proposed Action	F: < $25,000/yr P:Unknown
	Barrier Nets	Not Feasible to Deploy								
	Fine-Mesh Barrier Nets	Not Feasible to Deploy								
	Behavioral Systems	No change from Proposed Action	Reductions in impingement mortality are uncertain	Similar to Proposed Action	Similar to Proposed Action	None	None	Similar to Proposed Action	Similar to Proposed Action	F: < $25,000/yr P: Unknown

Table VIII-13
SUMMARY OF ALTERNATIVES FOR RENEWAL OF SPDES PERMIT FOR INDIAN POINT UNITS 2 & 3.

Alternative		Effects on Fish			Water Quality & Consumption	Aesthetics	Land Use	NY Statewide		Costs
		Entrainment CMR	Impingement CMR	Population Effects				Air Emissions (1000 T/yr)	Fuel Use	F=Fishery P=Electical Production
Importation of Power		Not feasible to replace with imported power								
District Heating		Not feasible. No change in impact from proposed action.								
Multiple Choice Alternative	1 - Fixed 40-year end of life of units. Retirement in 2013 and 2015.	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	None	None	F: < $25,000/yr P: $590,000/yr
	2 - Cooling Towers	See Cooling Tower Alternative Above								
	3 – Repower	Not Feasible for Nuclear Units								
	4 – 32-week Outages	SB:0 WP:0 AT:0 BA:0 AS:0 RH:0 SS:0	Slightly Less than Proposed Action	None	Similar to Proposed Action	Possible impacts if new generation sources or transmission facilities required	Possible need for increased power plant construction and/or transmission capability	NOx: +15.0% SO2: +17.0% CO: +4.6% CO2: +11.8% Part.: +5.0%	Oil: +10.0% Gas +16.4% Coal:+11.2% U: -22.6%	F: 0 P: $292 million/yr

Table VIII-14
SUMMARY OF ALTERNATIVES FOR RENEWAL OF SPDES PERMIT FOR BOWLINE POINT UNITS 1 & 2.

Alternative		Effects on Fish			Water Quality & Consumption	Aesthetics	Land Use	NY Statewide		Costs F=Fishery P=Electrical Production
		Entrainment CMR	Impingement CMR	Population Effects				Air Emissions (1000 T/yr)	Fuel Use	
Proposed Action		SB: 0.006 WP: 0.002 AT: 0.089 BA: 0034 AS: 0.00 RH: 0.00 SS: 0.00 FPP: 22.1	SB:0.00 WP: 0.00 AT: 0.00 BA: 0.00 AS: 0.00 BH: 0.00 AW: 0.00 SS: 0.00	Negligible reductions in equilibrium populations of striped bass and American shad; no reduction of Atlantic tomcod	Best use of water maintained. Evaporation: 3,600 gpm	None	None	NOx: 64 SO2: 175 CO: 21 CO2: 42,283 Part.: 62	Oil: 11.6 (10^6 Bbls) Gas 165.1 (10^{12} CF) Coal: 9.6 (10^6 Tons) U: 347.6 (10^{12} BTU)	F: <$2,000/yr P: $10,000-$15,000/yr
Prescribed Outages And Permit Flow Rates	A-Independent Scheduling of previous permit outages within window	SB:0.01 WP:0.00 AT:0.08 BA:0.03 AS: RH:0.00 SS:	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	NOx: +0.3% SO2: +0.7% CO: +0.0% CO2: +0.1% Part.: +0.2%	Oil: +0.1% Gas -0.9% Coal: +0.5% U: 0.0%	F: <$2,000/yr P: $1.9 million/yr
	B-Independent Scheduling of previous permit outages at any time	SB:0.01 WP:0.00 AT:0.06 BA:0.04 AS: RH:0.00 SS:	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	NOx: +0.3% SO2: +0.7% CO: +0.0% CO2: +0.1% Part.: +0.2%	Oil: +0.1% Gas -0.9% Coal: +0.5% U: 0.0%	F: <$2,000/yr P: $1.9 million/yr
	C-Dependent Scheduling of previous permit outages at any time	SB:0.00 WP:0.00 AT:0.08 BA:0.03 AS: RH:0.00 SS:	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	NOx: +0.3% SO2: +0.7% CO: +0.0% CO2: +0.1% Part.: +0.2%	Oil: +0.1% Gas -0.9% Coal: +0.5% U: 0.0%	F: <$2,000/yr P: $1.9 million/yr
	D-32-week one-unit outage	SB:0.004 WP:0.002 AT:0.041 BA:0.024 AS:0.000 RH:0.001 SS:0.002	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	NOx: +1.0% SO2: +3.0% CO: -0.1% CO2: +0.3% Part.: +0.8%	Oil: +0.3% Gas -3.7% Coal: +2.0% U: 0.0%	F: <$2,000/yr P: $7.7 million/yr

Table VIII-14
SUMMARY OF ALTERNATIVES FOR RENEWAL OF SPDES PERMIT FOR BOWLINE POINT UNITS 1 & 2.

Alternative		Effects on Fish			Water Quality & Consumption	Aesthetics	Land Use	NY Statewide		Costs
		Entrainment CMR	Impingement CMR	Population Effects				Air Emissions (1000 T/yr)	Fuel Use	F=Fishery P=Electrical Production
Efficient Flow		Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	Similar to Proposed Action	Similar to Proposed Action	F: <$2,000/yr P: 0
Wet/Dry Cooling Towers		SB:0.001 WP:0.002 AT:0.005 BA:<0.001 AS:<0.000 RH:0.000 SS:0.001	Essentially eliminated	None	Consumptive use of 9,000 gpm; concentrated blowdown discharge 20,000 gpm.	Potential visual effects from river; some plume effects	Disturbance of 6 acres	NOx: +0.1% SO2: +0.0% CO: +0.0% CO2: +0.1% Part.: +0.0%	Oil: +0.1% Gas +0.2% Coal: 0.0% U: 0.0%	F: 0 P: $138-$234 million
Intake Technologies	Ristroph Screens	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	Similar to Proposed Action	Similar to Proposed Action	F: <$2,000/yr P: Substantial
	Cylindrical Wedge-wire Screens	Reduction in entrainment mortality is uncertain and would depend on species and mesh size	Impingement mitigated with barrier net	Similar to Proposed Action	Similar to Proposed Action	None	None	Similar to Proposed Action	Similar to Proposed Action	F: <$2,000/yr P: Unknown
	Fine-Mesh Screens	Reduction in entrainment mortality – fewer organisms entrained.	Impingement mitigated with barrier net	Similar to Proposed Action	Similar to Proposed Action	None	None	Similar to Proposed Action	Similar to Proposed Action	F: <$2,000/yr P: Unknown
	Barrier Nets	Barrier nets are part of the Proposed Action								
	Fine-Mesh Barrier Nets	Uncertain benefit and feasibility for this facility	Impingement mitigated with barrier net	Similar to Proposed Action	Similar to Proposed Action	None	None	Similar to Proposed Action	Similar to Proposed Action	F: <$2,000/yr P: Unknown
	Behavioral Systems	Similar to Proposed Action	Impingement mitigated with barrier net	Similar to Proposed Action	Similar to Proposed Action	None	None	Similar to Proposed Action	Similar to Proposed Action	F: <$2,000/yr P: Unknown

Table VIII-14
SUMMARY OF ALTERNATIVES FOR RENEWAL OF SPDES PERMIT FOR BOWLINE POINT UNITS 1 & 2.

Alternative		Effects on Fish			Water Quality & Consumption	Aesthetics	Land Use	NY Statewide		Costs
		Entrainment CMR	Impingement CMR	Population Effects				Air Emissions (1000 T/yr)	Fuel Use	F=Fishery P=Electrical Production
Importation of Power		Not feasible to replace with imported power.								
District Heating		Not feasible. No change in impact from proposed action.								
Multiple Choice Alternative	1 – Fixed 40-year end of life of units.	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	Similar to Proposed Action	None	None	Similar to Proposed Action	Similar to Proposed Action	F: < $2,000/yr P: Unable to evaluate
	2 – Cooling Towers	See Cooling Tower Alternative Above								
	3 – Repower	Not able to evaluate at this time.								
	4 – 32-week Outages	SB:0 WP:0 AT:0 BA:0 AS:0 RH:0 SS:0	Slightly less than Proposed Action	None	Similar to Proposed Action	None	None	NOx: +2.0% SO2: +6.0% CO: -0.2% CO2: +0.6% Part.: +1.6%	Oil: +0.3% Gas -7.4% Coal: +4.0% U: 0.0%	F: 0 P: $15.4 million annually