VOLUME 3

Submission to the Regional Water Quality Control Board

Agenda Item 6 - Poseidon Resources Corporation, Proposed Carlsbad Desalination Project (Order No. R9-2006-0065, NPDES No. CA0109223).

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Comments Submitted by Latham & Watkins LLP, January 26, 2009 – February 11, 2009 San Diego Regional Board Meeting, Item 6 - Poseidon Resources Corporation, Proposed Carlsbad Desalination Project (Order No. R9-2006-0065, NPDES No. CA0109223)

Tab No. and Citation	Annotation
A. If maximum intake velocity <= 0.5 fps, impingement mortality will be minimized to acceptable levels	
A. National Pollutant Discharge Elimination System: Regulations Addressing Cooling Water Intake Structures for New Facilities, 66 Fed. Reg. 65256, 65274 (December 18, 2001) (to be codified at 40 C.F.R. pts. 9, 122, 123, 124, 125) (2009)	Final EPA Rule, which explains that "intake velocity is one of the key factors that can affect the impingement of fish and other aquatic biota" and notes that 0.5 fps is an approach velocity threshold recommended in Federal documents; cites studies supporting the proposition that 0.5 fps is the recommended intake velocity threshold.
B. EPA Requirements Applicable to Cooling Water Intake Structures for New Facilities Under Section 316(B) of the Act, 40 C.F.R. §§ 125.84(b)(2), 125.84(c)(1) (2009)	Phase I Rule, which provides that a maximum intake velocity of 0.5 ft/s or less minimizes adverse environmental impacts associated with impingement mortality to acceptable levels.
C. EPA Requirements Applicable to Cooling Water Intake Structures for New Facilities Under Section 316(B) of the Act, 40 C.F.R. §§ 125.94(a)(1)(ii) (2009)	Phase II Rule (suspended), which provides that an intake velocity of 0.5 ft/s or less minimizes impingement impacts to such an extent that no further technological or mitigation measures are necessary to protect fish species.
D. John Boreman et al., *Impacts of Power Plant Intake Velocities on Fish*, in Topical Briefs: Fish and Wildlife Resources and Electric Power Generation, No. 1 (Power Plant Project, Office of Biological Services, Fish and Wildlife Service, U.S. Department of the Interior) (1977)	Topical brief cited by EPA in Final Rule addressing cooling water intake structures for new facilities (66 Fed. Reg. 65256, 65274) in support of the proposition that the EPA has relied on the 0.5 fps approach velocity threshold as guidance to protect fish from impingement.

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E. A.G. Christianson et al., *Reviewing Environmental Impact Statements- Power Plant Cooling Systems, Engineering Aspects* (National Thermal Pollution Research Program, Pacific Northwest Environmental Research Laboratory, EPA-660/2-73-016) (1973)	EPA Report cited by EPA in Final Rule addressing cooling water intake structures for new facilities (66 Fed. Reg. 65256, 65274) in support of the proposition that the EPA has relied on the 0.5 fps approach velocity threshold as guidance to protect fish from impingement.
F. John C. Sonnichsen, Jr. et al, *A Review of Thermal Power Plant Intake Structure Designs and Related Environmental Considerations* (Hanford Engineering Development Laboratory, HEDL–TME 73–24, UC–12) (1973)	Report containing studies of fish swimming speeds and endurance, which formed the basis for EPA's conclusion that 0.5 fps is the recommended intake velocity threshold to protect
G. A.W.H. Turnpenny, *The Behavioral Basis of Fish Exclusion from Coastal Power Station Cooling Water Intakes*, in RESEARCH REPORT- CENTRAL ELECTRICITY (Vol. RD/L/2201/R88) (1988)	Research Report cited by EPA in Final Rule addressing cooling water intake structures for new facilities (66 Fed. Reg. 65256, 65274) in support of the proposition that the EPA has relied on the 0.5 fps approach velocity threshold as guidance to protect fish from impingement.
H. King, W. Instructional Memorandum RB-44: *Review of NPDES (National Pollutant Discharge Elimination System) permit applications processed by the EPA (Environmental Protection Agency) or by the State with EPA oversight.*' In: U.S. Fish and Wildlife Service Navigable Waters Handbook.	Instructional Memorandum cited by EPA in Final Rule addressing cooling water intake structures for new facilities (66 Fed. Reg. 65256, 65274) in support of the proposition that the EPA has relied on the 0.5 fps approach velocity threshold as guidance to protect fish from impingement.
I. Electric Power Research Institute, Inc., *Catalog of Assessment Methods for Evaluating the Effects of Power Plant Operations on Aquatic Communities* (EPRI, TR-112013) (1999)	Report cited by EPA in Final Rule addressing cooling water intake structures for new facilities (66 Fed. Reg. 65256, 65274) in support of the proposition that the EPA has relied on the 0.5 fps approach velocity threshold as guidance to protect fish from impingement.

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Tab No. and Citation	Annotation
J. Electric Power Research Institute, Inc., *Evaluation of Biocriteria as a Concept Approach, and Tool for Assessing Impacts of Impingement and Entrainment Under § 316(b) of the Clean Water Act* (EPRI, TR-114007) (2000)	Report cited by EPA in Final Rule addressing cooling water intake structures for new facilities (66 Fed. Reg. 65256, 65274) in support of the proposition that the EPA has relied on the 0.5 fps approach velocity threshold as guidance to protect fish from impingement.
K. Electric Power Research Institute, Inc., *Technical Evaluation of the Utility of Intake Approach Velocity as an Indicator of Potential Adverse Environmental Impact under § 316(b)* (EPRI, TR-1000731) (2000)	Report cited by EPA in Final Rule addressing cooling water intake structures for new facilities (66 Fed. Reg. 65256, 65274) in support of the proposition that the EPA has relied on the 0.5 fps approach velocity threshold as guidance to protect fish from impingement.
B. Scientists Customarily Apply a 50% Confidence Level When Calculating APF and Apply No Mitigation Ratio	
L. John Steinbeck et al, *Assessing Power Plant Cooling Water Intake System Entrainment Impacts* (California Energy Commission, CEC-700-2007-010) (2007)	Report relied upon by Dr. Mayer in support of the proposition that scientists customarily apply a 50% confidence level when calculating APF and apply no mitigation ratio.
C. The 2005 rainy season did not alter the predominately salt water environment of Agua Hedionda Lagoon	
M. Hany Elwany et al, *Agua Hedionda Lagoon Hydrodynamic Studies* (Tenera Environmental Technical Report, CE No. 05-10) (2005)	Supports Jenkins's conclusion that the 2005 rainy season did not alter the predominately salt water environment of Agua Hedionda Lagoon.
N. Scott A. Jenkins & Joseph Wasyl, *Coastal Processes Effects of Reduced Flows at Agua Hedionda Lagoon* (Study submitted to Tenera Environmental and Poseidon Resources) (2006)	Supports Jenkins's conclusion that the 2005 rainy season did not alter the predominately salt water environment of Agua Hedionda Lagoon.

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Tab No. and Citation	Annotation
O. Tetra Tech, Inc., *Agua Hedionda Watershed Water Quality Analysis and Recommendations Report* (Report submitted to City of Vista) (2007)	Supports Jenkins's conclusion that the 2005 rainy season did not alter the predominately salt water environment of Agua Hedionda Lagoon.
P. NWS, 2009, "National Weather Service Daily Climate Reports," http://www.wrh.noaa.gov/sgx/obs/rtp/carlsbad.html	Supports Jenkins's conclusion that the 2005 rainy season did not alter the predominately salt water environment of Agua Hedionda Lagoon.
Q. Curriculum Vitae of David L. Mayer, PhD. – President / Principal Scientist – Tenera Environmental Inc.	

A

Federal Register

Tuesday,
December 18, 2001

Part II

Environmental Protection Agency

40 CFR Parts 9, 122, et al.

National Pollutant Discharge Elimination System: Regulations Addressing Cooling Water Intake Structures for New Facilities; Final Rule

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Parts 9, 122, 123, 124, and 125

[FRL–7105–4]

RIN 2040–AC34

National Pollutant Discharge Elimination System: Regulations Addressing Cooling Water Intake Structures for New Facilities

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final rule.

SUMMARY: Today's final rule implements section 316(b) of the Clean Water Act (CWA) for new facilities that use water withdrawn from rivers, streams, lakes, reservoirs, estuaries, oceans or other waters of the United States (U.S.) for cooling purposes. The final rule establishes national technology-based performance requirements applicable to the location, design, construction, and capacity of cooling water intake structures at new facilities. The national requirements establish the best technology available, based on a two-track approach, for minimizing adverse environmental impact associated with the use of these structures.

Based on size, Track I establishes national intake capacity and velocity requirements as well as location- and capacity-based requirements to reduce intake flow below certain proportions of certain waterbodies (referred to as ''proportional-flow requirements''). It also requires the permit applicant to select and implement design and construction technologies under certain conditions to minimize impingement mortality and entrainment. Track II allows permit applicants to conduct site-specific studies to demonstrate to the Director that alternatives to the Track I requirements will reduce impingement mortality and entrainment for all life stages of fish and shellfish to a level of reduction comparable to the level the facility would achieve at the cooling water intake structure if it met the Track I requirements.

EPA expects that this final regulation will reduce impingement and entrainment at new facilities. Today's final rule establishes requirements that will help preserve aquatic organisms and the ecosystems they inhabit in waters used by cooling water intake structures at new facilities. EPA has considered the potential benefits of the rule; these include a decrease in expected mortality or injury to aquatic organisms that would otherwise be subject to entrainment into cooling water systems or impingement against screens or other devices at the entrance of cooling water intake structures. Benefits may also accrue at population, community, or ecosystem levels of ecological structures. The preamble discusses these benefits to the extent possible in qualitative terms.

DATES: This regulation shall become effective January 17, 2002. For judicial review purposes, this final rule is promulgated as of 1:00 p.m. Eastern Standard Time (EST) on January 2, 2002, as provided in 40 CFR 23.2.

ADDRESSES: The public record for this rule is established under docket number W–00–03. Copies of comments received, EPA responses, and all other supporting documents (except for information claimed as Confidential Business Information (CBI)) are available for review in the EPA Water Docket, East Tower Basement, Room EB–57, 401 M Street, SW., Washington, DC 20460. The record is available for inspection from 9:00 a.m. to 4:00 p.m. Monday through Friday, excluding legal holidays. For access to the docket materials, please call (202) 260–3027 to schedule an appointment.

FOR FURTHER INFORMATION CONTACT: For additional technical information contact Deborah G. Nagle at (202) 260–2656. For additional biological information contact Debbi Hart at (202) 260–0905. For additional economic information contact Ghulam Ali at (202) 260–9886. The e-mail address for the above contacts is *rule.316b@epa.gov.*

SUPPLEMENTARY INFORMATION:

What Entities Are Regulated by This Action?

This final rule applies to new greenfield (defined by example in section I. of this preamble) and stand alone facilities that use cooling water intake structures to withdraw water from waters of the U.S. and that have or require a National Pollutant Discharge Elimination System (NPDES) permit issued under section 402 of the CWA. New facilities subject to this regulation include those that have a design intake flow of greater than two (2) million gallons per day (MGD) and that use at least twenty-five (25) percent of water withdrawn for cooling purposes. Generally, facilities that meet these criteria fall into two major groups: new steam electric generating facilities and new manufacturing facilities. If a new facility meets these conditions, it is subject to today's final regulations. If a new facility has or requires an NPDES permit but does not meet the two MGD intake flow threshold or uses less than 25 percent of its water for cooling water purposes, the permit authority will implement section 316(b) on a case-by-case basis, using best professional judgment. This final rule defines the term ''cooling water intake structure'' to mean the total physical structure and any associated constructed waterways used to withdraw water from a water of the U.S. The cooling water intake structure extends from the point at which water is withdrawn from the surface water source up to and including the intake pumps. Today's rule does not apply to existing facilities including major modifications to existing facilities that would be ''new sources'' in 40 CFR 122.29 as that term is used in the effluent guidelines and standards program. Although EPA has not finished examining the costs of technology options at existing facilities, the Agency anticipates that existing facilities would have less flexibility in designing and locating their cooling water intake structures than new facilities and that existing facilities might incur higher compliance costs than new facilities. For example, existing facilities might need to upgrade or modify existing intake structures and cooling water systems to meet requirements of the type contained in today's rule, which might impose greater costs than use of the same technologies at a new facility. Retrofitting technologies at an existing facility might also require shutdown periods during which the facility would lose both production and revenues, and certain retrofits could decrease the thermal efficiency of an electric generating facility. Site limitations, such as lack of undeveloped space, might make certain technologies infeasible at existing facilities. Accordingly, EPA does not intend that today's rule or preamble serve as guidance for developing section 316(b) requirements for existing facilities. Permit writers should continue to apply best professional judgment in making case-by-case section 316(b) determinations for existing facilities, based on existing guidance and other legal authorities. EPA will address existing facilities fully in Phase II and Phase III rulemakings.

The following table lists the types of entities that EPA believes are potentially subject to this final rule. This table is not intended to be exhaustive; rather, it provides a guide for readers regarding entities likely to be regulated by this action. Other types of entities not listed in the table could also be regulated. To determine whether your facility is regulated by this action, you should carefully examine the applicability criteria at § 125.81 of the rule. If you have questions regarding the applicability of this action to a particular entity, consult one of the persons listed in the preceding **FOR FURTHER INFORMATION CONTACT** section.

Category	Examples of regulated entities	Standard Industrial Classification (SIC) Codes	North American Industry Classification System (NAICS) Codes
Federal, State and Local Government.	Operators of steam electric generating point source dischargers that employ cooling water intake structures.	4911 and 493	221111, 221112, 221113, 221119, 221121, 221122, 221111, 221112, 221113, 221119, 221121, 221122.
Industry	Operators of industrial point source dischargers that employ cooling water intake structures.	See below	See below.
	Steam electric generating	4911 and 493	221111, 221112, 221113, 221119, 221121, 221122, 221111, 221112, 221113, 221119, 221121, 221122.
	Agricultural production	0133	111991, 11193.
	Metal mining	1011	21221.
	Oil and gas extraction (excluding offshore and coastal subcategories).	1311, 1321	211111, 211112.
	Mining and quarrying of nonmetallic minerals.	1474	212391.
	Food and kindred products	2046, 2061, 2062, 2063, 2075, 2085	311221, 311311, 311312, 311313, 311222, 311225, 31214.
	Tobacco products	2141	312229, 31221.
	Textile mill products	2211, 2261	31321.
	Lumber and wood products, except furniture.	2415, 2421, 2436, 2493	321912, 321113, 321918, 321999, 321212, 321219.
	Paper and allied products	2611, 2621, 2631, 2676, 2679	3221, 322121, 32213, 322121, 322122, 32213, 322291.
	Chemical and allied products	28 (except 2822, 2835, 2836, 2842, 2843, 2844, 2861, 2895, 2893, 2851, and 2879).	325 (except 325182, 32591, 32551, 32532).
	Petroleum refining and related industries.	2911, 2999	32411, 324199.
	Rubber and miscellaneous plastics products.	3011, 3069	326211, 31332, 326192, 326299.
	Stone, clay, glass, and concrete products.	3241	32731.
	Primary metal industries	3312, 3313, 3315, 3316, 3317, 3334, 3339, 3353, 3357.	324199, 331111, 331112, 331492, 331222, 332618, 331221, 22121, 331312, 331419, 331315, 331521, 331524, 331525.
	Fabricated metal products, except machinery and transportation equipment.	3421, 3499	332211, 337215, 332117, 332439, 33251, 332919, 339914, 332999.
	Industrial and commercial machinery and computer equipment.	3523, 3531	333111, 332323, 332212, 333922, 22651, 333923, 33312.
	Transportation equipment	3724, 3743, 3764	336412, 333911, 33651, 336416.
	Measuring, analyzing, and controlling instruments; photographic, medical, and optical goods; watches and clocks.	3861	333315, 325992.
	Electric, gas, and sanitary services	4911, 4931, 4939, 4961	221111, 221112, 221113, 221119, 221121, 221122, 22121, 22133.
	Educational services	8221	61131.
	Engineering, Accounting, Research, Management, and Related Services.	8731	54171.

Supporting Documentation

The final regulation is supported by two major documents:

1. *Economic Analysis of the Final Regulations Addressing Cooling Water Intake Structures for New Facilities* (EPA–821–R–01–035), hereafter referred to as the *Economic Analysis.* This document presents the analysis of compliance costs, barrier to entry, and energy supply effects. In addition, the document provides an assessment of potential benefits.

2. *Technical Development Document for the Final Regulations Addressing Cooling Water Intake Structures for New Facilities* (EPA–821–R–01–036), hereafter referred to as the *Technical Development Document.* This document presents detailed information on the methods used to develop unit costs and describes the set of technologies that may be used to meet the rule's requirements.

How To Obtain Supporting Documents

You can obtain the *Economic Analysis* and *Technical Development Document* from the Agency's 316(b) website (http://www.epa.gov/ost/316b). The documents are also available from the National Service Center for Environmental Publications, P.O. Box

42419, Cincinnati, OH 45242–2419; telephone (800) 490–9198 and the Water Resource Center , U.S. EPA, 1200 Pennsylvania Avenue, N.W. (RC 4100), Washington D.C. 20460 (202) 260–2814.

Organization of This Document

I. Scope of This Rulemaking

Today's final rule establishes technology-based performance requirements applicable to the location, design, construction, and capacity of cooling water intake structures at new facilities under section 316(b) of the Clean Water Act. The rule establishes the best technology available for minimizing adverse environmental impact associated with the use of these structures. Today's final rule also partially fulfills EPA's obligation to comply with a consent decree entered in the United States District Court, Southern District of New York in *Riverkeeper Inc., et al.* v. *Whitman*, No. 93 Civ. 0314 (AGS). (For a more detailed discussion of the consent decree, see II.C.2).

This final rule applies to new greenfield or stand alone facilities: (1) that use a newly constructed cooling water intake structure, or a modified existing cooling water intake structure whose design capacity is increased that withdraws water from waters of the U.S.; and (2) that has or is required to have a National Pollutant Discharge Elimination System (NPDES) permit issued under section 402 of the CWA. Specifically, the rule applies to you if you are the owner or operator of a facility that meets all of the following criteria:

- Your greenfield or stand alone facility meets the definition of new facility specified in § 125.83 of this rule;
- Your new facility uses a newly constructed or modified existing cooling water intake structure or structures, or your facility obtains cooling water by any sort of contract or arrangement with an independent supplier who has a cooling water intake structure;
- Your new facility's cooling water intake structure(s) withdraw(s) water from waters of the U.S. and at least twenty-five (25) percent of the water withdrawn is used for contact or noncontact cooling purposes;
- Your new facility has a design intake flow of greater than two (2) million gallons per day (MGD); and
- Your new facility has an NPDES permit or is required to obtain one.

If a new facility meets these conditions, it is subject to today's final regulations. If a new facility has or requires an NPDES permit but does not meet the two MGD intake flow threshold or the twenty-five percent cooling water use threshold, it is not subject to permit conditions based on today's rule; rather, it is subject to permit conditions implementing section 316(b) of the CWA set by the permit director on a case-by-case basis, using best professional judgment.

A. What Is a New Facility?

A new facility subject to this regulation is any facility that meets the definition of ''new source'' or ''new discharger'' in 40 CFR 122.2 and 122.29(b)(1), (2), and (4); commences construction after January 17, 2002; and uses either a newly constructed cooling water intake structure, or an existing cooling water intake structure whose design capacity is increased; or obtains cooling water by any sort of contract or arrangement with an independent supplier who has a cooling water intake structure. The term ''commence construction'' is defined in 40 CFR 122.29(b)(4).

As stated above, this rule applies to only ''greenfield'' and ''stand-alone'' facilities. A greenfield facility is a facility that is constructed at a site at which no other source is located, or that totally replaces the process or production equipment at an existing facility (see 40 CFR 122.29(b)(1)(i) and (ii)). A stand-alone facility is a new, separate facility that is constructed on property where an existing facility is located and whose processes are substantially independent of the existing facility at the same site (see 40 CFR 122.29(b)(1)(iii)). An example of total replacement is as follows: The power plant or manufacturer demolishes the power plant or manufacturing facility and builds a new plant or facility in its place. The pumps of the existing cooling water intake structure are replaced with new pumps that increase design capacity to accommodate additional cooling water needs, but the intake pipe is left in place. In this situation, the facility would be a new facility. Modifications to an existing cooling water intake structure that do not serve the cooling water needs of a greenfield or stand-alone facility in 40 CFR 122.2 and 122.29(b)(1), (2), and (4) (i.e., a facility that meets the definition of new source or new discharger and commences construction after the effective date of the rule) do not constitute a new facility subject to this rule. Thus, the definition of new facility under this rule is narrower than the definition of new source under section 306 of the CWA.

The definition of new facility also requires that the greenfield or stand-alone facility use ''a newly constructed cooling water intake structure or an existing cooling water intake structure whose design capacity is increased to accommodate the intake of additional cooling water.'' This means a facility that would otherwise be a ''new facility'' would *not* be treated as a new facility under this rule if it withdraws water from an existing cooling water intake structure whose design capacity has not been increased to accommodate the intake of additional cooling water. Routine maintenance and repair, such as replacement of pumps that does not increase the capacity of the structure, cleaning in response to biofouling, and repair or replacement of moving parts at a cooling water intake that is part of a greenfield or stand-alone facility, and that occur simply for operation and maintenance purposes, would not be a modification of that intake structure. One way to distinguish whether replacement of the pipes or the pumps is for maintenance and repair purposes or whether it is to accommodate construction of a new facility is to determine whether the replacement increases the original design capacity. Today's rule specifies that changes to a cooling water intake structure are considered modifications for purposes of this rule only if such changes result in an increase in design capacity. Thus, routine maintenance or repair of the cooling water intake structure, including the pumps, that does not result in an increase in design capacity does not modify a cooling water intake structure. However, if a change is made to the cooling water intake structure, including the pumps, that increases design capacity to any extent, then the cooling water intake structure has been modified; use of this structure by a greenfield or stand-alone facility would make the facility a new facility subject to this rule.

B. What Is a Cooling Water Intake Structure?

For the purposes of this rule a ''cooling water intake structure'' is defined as the total physical structure and any associated constructed waterways used to withdraw water from waters of the U.S. The cooling water intake structure extends from the point at which water is withdrawn from waters of the U.S. up to and including the intake pumps. EPA has defined ''cooling water'' as water used for contact or noncontact cooling, including water used for equipment cooling, evaporative cooling tower makeup, and dilution of effluent heat content. The Agency has specified that the intended use of cooling water is to absorb waste heat from production processes or auxiliary operations. In addition, for the final rule EPA has amended the definition of cooling water to ensure that the rule does not discourage the reuse of cooling water as process water. As such, heated cooling water that is subsequently used in a manufacturing process is considered process water for the purposes of calculating the percentage of a new facility's intake flow that is used for cooling purposes.

C. What Cooling Water Use and Design Intake Flow Thresholds Result in a New Facility Being Subject to This Final Rule?

This rule applies to new facilities that (1) withdraw cooling water from waters of the U.S. and use at least twenty-five (25) percent of the water withdrawn for cooling purposes and (2) have a cooling water intake structure with a design intake capacity of greater than or equal to two (2) million gallons per day (MGD) of source water. See 40 CFR 125.81 of this rule. The percentage of total water withdrawn that is used for cooling purposes is to be measured on an average monthly basis over a period of one year. See 40 CFR 125.81(c) of this rule. A new facility meets the 25 percent cooling water use threshold if, on the basis of the new facility's design when measured over a period of one year, any monthly average percentage of cooling water withdrawn is expected to equal or exceed 25 percent of the total water withdrawn. Waters of the U.S. include the broad range of surface waters that meet the regulatory definition at 40 CFR 122.2, which can include lakes, ponds, reservoirs, nontidal rivers or streams, tidal rivers, estuaries, fjords, oceans, bays, and coves.

Some commenters questioned whether the discussion of cooling ponds in the preamble to the proposal (65 FR 49067, col. 2) meant that EPA considers cooling ponds to be ''waters of the United States.'' EPA did not intend that discussion to change the regulatory status of cooling ponds. Cooling ponds are neither categorically included nor categorically excluded from the definition of ''waters of the United States'' at 40 CFR 122.2. EPA interprets 40 CFR 122.2 to give permit writers discretion to regulate cooling ponds as ''waters of the United States'' where cooling ponds meet the definition of ''waters of the United States.'' The determination whether a particular cooling pond is or is not ''waters of the United States'' is to be made by the permit writer on a case-by-case basis, informed by the principles enunciated in *Solid Waste Agency of Northern Cook County* v. *US Army Corps of Engineers,* 531 U.S. 159 (2001).

D. Does This Rule Apply to My Facility If It Does Not Have a Point Source Discharge Subject to an NPDES Permit?

Today's final rule applies only to new facilities as defined in § 125.83 that have an NPDES permit or are required to obtain one because they discharge or might discharge pollutants, including storm water, from a point source to waters of the United States. Requirements for minimizing the adverse environmental impact of cooling water intake structures will continue to be applied through NPDES permits.

E. What Requirements Must I Meet Under the Final Rule?

Today's final rule establishes a two-track approach for regulating cooling water intake structures at new facilities. Track I establishes uniform requirements based on facility cooling water intake capacity. Track II provides dischargers with the opportunity to establish that alternative requirements will achieve comparable performance. The regulated entity has the opportunity to choose which track it will follow. The Track I and Track II requirements are summarized below.

Under Track I, new facilities with a design intake flow equal to or greater than 10 MGD, must meet the following requirements:

(1) Cooling water intake flow must be at a level commensurate with that achievable with a closed-cycle,

recirculating cooling system; (40 CFR 125.84(b)(1))

(2) Through-screen intake velocity must be less than or equal to 0.5 feet per second; (40 CFR 125.84(b)(2))

(3) Location- and capacity-based limits on proportional intake flow must be met (for fresh water rivers or streams, intake flow must be less than or equal to 5 percent of the mean annual flow; for lakes or reservoirs, intake flow may not disrupt natural thermal stratification or turnover pattern (where present) of the source water except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies); for estuaries or tidal rivers, intake flow must be less than or equal to 1 percent of the tidal excursion volume; for oceans, there are no proportional flow requirements); (40 CFR 125.84(b)(3)) and

(4) Design and construction technologies for minimizing impingement mortality and entrainment must be selected and implemented if certain conditions exist where the cooling water intake structure is located. (40 CFR 125.84(b)(4) and (5))

Under Track I, new facilities with a design intake flow equal to or greater than 2 MGD, but less than 10 MGD, must meet the following requirements:

(1) Through-screen intake velocity must be less than or equal to 0.5 feet per second; (40 CFR 125.84(c)(1))

(2) Location- and capacity-based limits on proportional intake flow must be met (for fresh water rivers or streams, intake flow must be less than or equal to 5 percent of the mean annual flow; for lakes or reservoirs, intake flow may not disrupt natural thermal stratification or turnover pattern (where present) of the source water except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies); for estuaries or tidal rivers, intake flow must be less than or equal to 1 percent of the tidal excursion volume; for oceans, there are no proportional flow requirements); (40 CFR 125.84(c)(2)) and

(3) Design and construction technologies for minimizing impingement mortality must be selected if certain conditions exist where the cooling water intake structure is located 125.84(c)(3); and design and construction technologies for minimizing entrainment must be selected and implemented. (40 CFR 125.84(c)(4))

Under Track II, new facilities must meet the following requirements:

(1) Employ technologies that will reduce the level of adverse environmental impact to a comparable level to that which would be achieved under the Track I requirements (as demonstrated in a Comprehensive Demonstration Study); (40 CFR 125.84(d)(1))

(2) The same proportional intake flow limitations as in Track I, based on the intake source water, must be met; (40 CFR 125.84(d)(2)).

Section IV.B and V. of this preamble provides a more detailed discussion of the requirements included under this two-track approach. The two-track approach provides new facilities with a well-defined set of requirements that constitute best technology available (BTA) for minimizing adverse environmental impact and can be implemented relatively quickly. This approach also provides flexibility to operators who believe alternative or emerging technologies would be just as effective at reducing impingement and entrainment.

II. Legal Authority, Purpose and Background of Today's Regulation

A. Legal Authority

Today's final rule is issued under the authority of sections 101, 301, 304, 306, 308, 316, 401, 402, 501, and 510 of the Clean Water Act (CWA), 33 U.S.C. 1251, 1311, 1314, 1316, 1318, 1326, 1341, 1342, 1361, and 1370. This rule partially fulfills the obligations of the U.S. Environmental Protection Agency (EPA) under a consent decree in *Riverkeeper Inc., et al.* v. *Whitman,* United States District Court, Southern District of New York, No. 93 Civ. 0314 (AGS).

B. Purpose of Today's Regulation

Section 316(b) of the CWA provides that any standard established pursuant to section 301 or 306 of the CWA and applicable to a point source must require that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available (BTA) for minimizing adverse environmental impact. Today's final rule defines a cooling water intake structure as the total physical structure, including the pumps, and any associated constructed waterways used to withdraw water from waters of the U.S. Cooling water absorbs waste heat from processes employed or from auxiliary operations on a facility's premises. Single cooling water intake structures might have multiple intake bays. Today's final rule establishes requirements applicable to the location, design, construction, and capacity of cooling water intake structures at new facilities that withdraw at least two (2) million gallons per day (MGD) and use at least twenty-five (25) percent of the water they withdraw for cooling purposes. Today's final rule establishes best technology available for minimizing adverse environmental impact associated with the intake of water from waters of the U.S. at these structures. See part III for further discussion of the environmental impact associated with cooling water intake structures.

C. Background

1. The Clean Water Act

The Federal Water Pollution Control Act, also known as the Clean Water Act (CWA), 33 U.S.C. 1251 *et seq.*, seeks to ''restore and maintain the chemical, physical, and biological integrity of the nation's waters.'' 33 U.S.C. 1251(a). The CWA establishes a comprehensive regulatory program, key elements of which are (1) a prohibition on the discharge of pollutants from point sources to waters of the U.S., except as authorized by the statute; (2) authority for EPA or authorized States or Tribes to issue National Pollutant Discharge Elimination System (NPDES) permits that regulate the discharge of pollutants; and (3) requirements for EPA to develop effluent limitation guidelines and standards and for States to develop water quality standards that are the basis for the limitations required in NPDES permits.

Today's final rule implements section 316(b) of the CWA as it applies to ''new facilities'' as defined in this rule. 316(b) addresses the adverse environmental impact caused by the intake of cooling water, not discharges into water. Despite this special focus, the requirements of section 316(b) are closely linked to several of the core elements of the NPDES permit program established under section 402 of the CWA to control discharges of pollutants into navigable waters. For example, section 316(b) applies to facilities that withdraw water from the waters of the United States for cooling through a cooling water intake structure and are point sources subject to an NPDES permit. Conditions implementing section 316(b) are included in NPDES permits and will continue to be included in NPDES permits under this final rule.

Section 301 of the CWA prohibits the discharge of any pollutant by any person, except in compliance with specified statutory requirements. These requirements include compliance with technology-based effluent limitation guidelines and new source performance standards, water quality standards, NPDES permit requirements, and certain other requirements.

Section 402 of the CWA provides authority for EPA or an authorized State or Tribe to issue an NPDES permit to any person discharging any pollutant or combination of pollutants from a point source into waters of the U.S. Forty-four States and one U.S. territory are authorized under section 402(b) to administer the NPDES permitting program. NPDES permits restrict the types and amounts of pollutants, including heat, that may be discharged from various industrial, commercial, and other sources of wastewater. These permits control the discharge of pollutants primarily by requiring dischargers to meet effluent limitations and other permit conditions. Effluent limitations may be based on promulgated federal effluent limitation guidelines, new source performance standards, or the best professional judgment of the permit writer. Limitations based on these guidelines, standards, or best professional judgment are known as technology-based effluent limits. Where technology-based effluent limits are inadequate to ensure compliance with water quality standards applicable to the receiving water, more stringent effluent limits based on applicable water quality standards are required. NPDES permits also routinely include monitoring and reporting requirements, standard conditions, and special conditions.

Sections 301, 304, and 306 of the CWA require that EPA develop technology-based effluent limitation guidelines and new source performance standards that are used as the basis for technology-based minimum discharge requirements in wastewater discharge permits. EPA issues these effluent limitation guidelines and standards for categories of industrial dischargers based on the pollutants of concern discharged by the industry, the degree of control that can be attained using various levels of pollution control technology, consideration of various economic tests appropriate to each level of control, and other factors identified in sections 304 and 306 of the CWA (such as non-water quality environmental impacts including energy impacts). EPA has promulgated regulations setting effluent limitation guidelines and standards under sections 301, 304, and 306 of the CWA for more than 50 industries. See 40 CFR parts 405 through 471. Among these, EPA has established effluent limitation guidelines that apply to most of the industry categories that use cooling water intake structures (e.g., steam electric power generation, iron and steel manufacturing, pulp and paper manufacturing, petroleum refining, chemical manufacturing).

Section 306 of the CWA requires that EPA establish discharge standards for new sources. For purposes of section 306, new sources include any source that commenced construction after the promulgation of applicable new source performance standards, or after proposal of applicable standards of performance if the standards are promulgated in accordance with section 306 within 120 days of proposal. CWA section 306; 40 CFR 122.2. New source performance standards are similar to the technology-based limitations established for existing sources, except that new source performance standards are based on the best available demonstrated technology instead of the best available technology economically achievable. New facilities have the opportunity to install the best and most efficient production processes and wastewater treatment technologies. Therefore, Congress directed EPA to consider the best demonstrated process changes, in-plant controls, and end-of-process control and treatment technologies that reduce pollution to the maximum extent feasible. In addition, in establishing new source performance standards, EPA is required to take into consideration the cost of achieving the effluent reduction and any non-water quality environmental impacts and energy requirements. As stated above, a ''new source'' under CWA section 306 applies to a broader set of facilities than the group of facilities subject to this rule.

2. Consent Decree

Today's final rule partially fulfills EPA's obligation to comply with an amended Consent Decree entered in the United States District Court, Southern District of New York, in *Riverkeeper Inc., et al.* v. *Whitman,* No. 93 Civ 0314 (AGS), a case brought against EPA by a coalition of individuals and environmental groups. The consent decree as entered on October 10, 1995, provided that EPA propose regulations implementing section 316(b) by July 2, 1999, and take final action with respect to those regulation by August 13, 2001. Under subsequent orders and an amended consent decree, EPA has divided the rulemaking into three phases and is working under new deadlines. In addition to taking final action on this rule governing new facilities by November 9, 2001, EPA must propose regulations for, at a minimum, existing power plants that use large volumes of cooling water by February 28, 2002, and take final action 18 months later. EPA must propose regulations for, at a minimum, smaller-flow power plants and factories in four industrial sectors (pulp and paper making, petroleum and coal products manufacturing, chemical and allied manufacturing, and primary metal manufacturing) by June 15, 2003.

3. What Prior EPA Rulemakings Addressed Cooling Water Intake Structures?

In April 1976 EPA published a rule under section 316(b) that addressed cooling water intake structures. 41 *FR* 17387 (April 26, 1976), proposed at 38 *FR* 34410 (December 13, 1973). The rule added a new § 401.14 to 40 CFR Chapter I that reiterated the requirements of CWA section 316(b). It also added a new part 402, which included three sections: (1) § 402.10 (Applicability), (2) § 402.11 (Specialized definitions), and (3) § 402.12 (Best technology available for cooling water intake structures). Section 402.10 stated that the provisions of part 402 applied to ''cooling water intake structures for point sources for which effluent limitations are established pursuant to section 301 or standards of performance are established pursuant to section 306 of the Act.'' Section 402.11 defined the terms ''cooling water intake structure,'' ''location,'' ''design,'' ''construction,'' ''capacity,'' and ''Development Document.'' Section 402.12 included the following language:

> The information contained in the Development Document shall be considered in determining whether the location, design, construction, and capacity of a cooling water intake structure of a point source subject to standards established under section 301 or 306 reflect the best technology available for minimizing adverse environmental impact.

In 1977, fifty-eight electric utility companies challenged these regulations, arguing that EPA had failed to comply with the requirements of the Administrative Procedure Act (APA) in promulgating the rule. Specifically, the utilities argued that EPA had neither published the development document in the **Federal Register** nor properly incorporated the document into the rule by reference. The United States Court of Appeals for the Fourth Circuit agreed and, without reaching the merits of the regulations themselves, remanded the rule. *Appalachian Power Co.* v. *Train*, 566 F.2d 451 (4th Cir. 1977). EPA later withdrew part 402. 44 *FR* 32956 (June 7, 1979). 40 CFR 401.14 remains in effect.

4. How Is Section 316(b) Being Implemented Now?

Since the Fourth Circuit remanded EPA's section 316(b) regulations in 1977, NPDES permit authorities have made decisions implementing section 316(b) on a case-by-case, site-specific basis. EPA published draft guidance addressing section 316(b) implementation in 1977. See *Draft Guidance for Evaluating the Adverse Impact of Cooling Water Intake Structures on the Aquatic Environment: Section 316(b) P.L. 92–500* (U.S. EPA, 1977). This draft guidance describes the studies recommended for evaluating the impact of cooling water intake structures on the aquatic environment and recommends a basis for determining the best technology available for minimizing adverse environmental impact. The 1977 section 316(b) draft guidance states, ''The environmental-intake interactions in question are highly site-specific and the decision as to best technology available for intake design, location, construction, and capacity must be made on a case-by-case basis.'' (Section 316(b) Draft Guidance, U.S. EPA, 1977, p. 4). This case-by-case approach also is consistent with the approach described in the 1976 development document referenced in the remanded regulation.

The 1977 section 316(b) draft guidance suggests the general process for developing information needed to support section 316(b) decisions and presenting that information to the permitting authority. The process involves the development of a site-specific study of the environmental effects associated with each facility that uses one or more cooling water intake structures, as well as consideration of that study by the permitting authority in determining whether the facility must make any changes for minimizing adverse environmental impact. Where adverse environmental impact is present, the 1977 draft guidance suggests a stepwise approach that considers screening systems, size, location, capacity, and other factors.

Although the draft guidance describes the information that should be developed, key factors that should be considered, and a process for supporting section 316(b) determinations, it does not establish national standards based on the best technology available for minimizing adverse environmental impact. Rather, the guidance leaves the decisions on the appropriate location, design, capacity, and construction of each facility to the permitting authority. Under this framework, the Director determines whether appropriate studies have been performed and whether a given facility has minimized adverse environmental impact. The Director's determinations of whether the appropriate studies have been performed or whether a given facility has minimized adverse environmental impact have often been subject to challenges that can take a long time to resolve and may impose significant resource demands on permitting agencies, the public, and the permit applicant.

5. Proposed New Facility Rule

On August 10, 2000, EPA published proposed requirements for cooling water intake structures at new facilities to implement section 316(b) of the Clean Water Act. EPA proposed a tiered approach for reducing adverse environmental impact, with three degrees of stringency based on EPA's view of the relative vulnerability of each category of waterbody. EPA received numerous comments and data submissions concerning the proposal. See 65 *FR* 49060.

6. Notice of Data Availability

On May 25, 2001, EPA published a Proposed Rule Notice of Data Availability (NODA). This notice presented a summary of the data EPA had received or collected since proposal, an assessment of the relevance of the data to EPA's analysis, some modified technology options suggested by commenters, and an alternative regulatory approach suggested by a trade group representing the utility industry as well as EPA's ideas about how it might modify this suggested approach. See 66 *FR* 28853. On July 6, 2001, EPA reopened the comment period for certain documents and issues related to those documents. See 66 *FR* 35572.

7. Public Participation

EPA has worked extensively with stakeholders from the industry, public interest groups, State agencies, and other Federal agencies in the development of this final rule. In addition to comments received during the comment periods of the original proposal, the NODA, and the reopened comment period for certain documents referenced in the NODA, EPA conducted two public meetings: in June 1998, in Arlington, Virginia (63 *FR* 27958) and in September, 1998, in Alexandria, Virginia (63 *FR* 40683). In addition, in September 1998, EPA staff participated in a technical workshop sponsored by the Electric Power Research Institute on issues relating to the definition and assessment of adverse environmental impact. EPA staff have participated in other industry conferences, met upon request on numerous occasions with industry representatives, and met on a number of occasions with representatives of environmental groups. EPA has also met with stakeholders, attended conferences and held workshops concerning topics related to the existing source rulemaking effort.

In the months leading up to publication of the proposed rule, EPA conducted a series of stakeholder meetings to review the draft regulatory framework for the proposed rule and invited stakeholders to provide their recommendations for the Agency's consideration. EPA managers have met with the Utility Water Act Group, Edison Electric Institute, representatives from an individual utility, and with representatives from the petroleum refining, pulp and paper, and iron and steel industries. EPA conducted meetings with environmental groups attended by representatives from between 3 and 15 organizations. EPA also met with the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA) and, with the assistance of ASIWPCA, conducted a conference call in which representatives from 17 states or interstate organizations participated. After publication of the proposed rule, EPA continued to meet with stakeholders at their request. These meetings are summarized in the record.

III. Environmental Impact Associated With Cooling Water Intake Structures

The proposed rule provided an overview of the magnitude and type of environmental impacts associated with cooling water intake structures, including several illustrative examples of documented environmental impacts at existing facilities (see 65 *FR* 49071 through 4). The majority of biological impacts associated with intake structures are closely linked to water withdrawals from the various waters in which the intakes are located.

Based on preliminary estimates from a questionnaire sent to more than 1,200 existing power plants and factories, industrial facilities in the United States withdraw more than 279 billion gallons of cooling water a day from waters of the U.S. The withdrawal of such large quantities of cooling water affects vast quantities of aquatic organisms annually, including phytoplankton (tiny, free-floating photosynthetic organisms suspended in the water column), zooplankton (small aquatic animals, including fish eggs and larvae, that consume phytoplankton and other zooplankton), fish, crustaceans, shellfish, and many other forms of aquatic life. Aquatic organisms drawn into cooling water intake structures are either impinged on components of the cooling water intake structure or entrained in the cooling water system itself.

Impingement takes place when organisms are trapped against intake screens by the force of the water passing through the cooling water intake structure. Impingement can result in starvation and exhaustion (organisms are trapped against an intake screen or other barrier at the entrance to the cooling water intake structure), asphyxiation (organisms are pressed against an intake screen or other barrier at the entrance to the cooling water intake structure by velocity forces that prevent proper gill movement, or organisms are removed from the water for prolonged periods of time), and descaling (fish lose scales when removed from an intake screen by a wash system) and other physical harms.

Entrainment occurs when organisms are drawn through the cooling water intake structure into the cooling system. Organisms that become entrained are normally relatively small benthic,[1] planktonic,[2] and nektonic[3] organisms, including early life stages of fish and shellfish. Many of these small organisms serve as prey for larger organisms that are found higher on the food chain. As entrained organisms pass through a plant's cooling system they are subject to mechanical, thermal, and/or toxic stress. Sources of such stress include physical impacts in the pumps and condenser tubing, pressure changes caused by diversion of the cooling water into the plant or by the hydraulic effects of the condensers, sheer stress, thermal shock in the condenser and discharge tunnel, and chemical toxemia induced by antifouling agents such as chlorine. The mortality rate of entrained organisms varies by species and can be high under normal operating conditions.[4][5] In the case of either impingement or entrainment, a substantial number of aquatic organisms are killed or subjected to significant harm.

In addition to impingement and entrainment losses associated with the operation of the cooling water intake structure, EPA is concerned about the cumulative overall degradation of the aquatic environment as a consequence of (1) multiple intake structures operating in the same watershed or in the same or nearby reaches and (2) intakes located within or adjacent to an impaired waterbody. Historically, impacts related to cooling water intake structures have been evaluated on a facility-by-facility basis. The potential cumulative effects of multiple intakes located within a specific waterbody or along a coastal segment are largely unknown (one relevant example is provided for the Hudson River; see discussion below). There is concern, however, about the effects of multiple intakes on fishery stocks. As an example, the Atlantic States Marine Fisheries Commission has been requested by its member States to investigate the cumulative impacts on commercial fishery stocks, particularly overutilized stocks, attributable to cooling water intakes located in coastal regions of the Atlantic.[6] Specifically, the study will focus on revising existing fishery management models so that they accurately consider and account for fish losses from intake structures.

EPA analyses suggest that over 99 percent of the existing facilities with cooling water withdrawal that EPA surveyed in its section 316(b) survey of existing facilities are located within 2 miles of waters that are identified as impaired and listed by a State or Tribe as needing development of a total maximum daily load (TMDL) to restore the waterbody to its designated use. EPA notes that the top four leading causes of waterbody impairment (siltation, nutrients, bacteria, and metals) affect the aquatic life uses of a waterbody. The Agency believes that cooling water intakes potentially contribute additional stress to waters already showing aquatic life impairment from other sources such as industrial discharges and urban stormwater.

EPA is also concerned about the potential impacts of cooling water intake structures located in or near habitat areas that support threatened, endangered, or other protected species. Although limited information is available on locations of threatened or endangered species that are vulnerable to impingement or entrainment, such impacts do occur. For example, EPA is aware that from 1976 to 1994, approximately 3,200 threatened or endangered sea turtles entered enclosed cooling water intake canals at the St. Lucie Nuclear Generating Plant in Florida.[7] The plant developed a capture-and-release program in response to these events. Most of the entrapped turtles were captured and released alive; however, approximately 160 turtles did not survive. More recently, the number of sea turtles being drawn into the intake canal increased to approximately 600 per year; this increase led to a requirement for barrier nets to minimize entrapment.

Finally, in the proposed rule EPA expressed concern about environmental impacts associated with the construction of new cooling water intake structures. Three main factors contribute to the environmental impacts: displacement of biota and habitat resulting from the physical placement of a new cooling water intake structure in an aquatic environment, increased levels of turbidity in the aquatic environment, and effects on biota and habitat associated with aquatic disposal of materials excavated during construction. Existing programs, such as the CWA section 404 program, National Environmental Policy Act (NEPA) program, and programs under State/Tribal law, include requirements that address many of the environmental impact concerns associated with the construction of new intakes (see Section VII. G for applicable Federal statutes). EPA recognizes that impacts related to construction of cooling water intake structures can occur and defers to the regulatory authority provided within the above-listed programs to evaluate the potential for impacts and minimize their extent.

In the proposed rule and NODA, EPA provided a number of examples of impingement and entrainment impacts that can be associated with existing facilities. It is important to note that these examples were *not* meant to predict effects at new facilities but rather to illustrate that the number of organisms impinged and entrained by a facility can be substantial. EPA also

[1] Refers to bottom dwellers that are generally small and sessile (attached) such as mussels and anemones, but can include certain large motile (able to move) species such as crabs and shrimp. These species can be important members of the food chain.

[2] Refers to free-floating microscopic plants and animals, including the egg and larval stages of fish and invertebrates that have limited swimming abilities. Plankton are also an important source of food for other aquatic organisms and an essential component of the food chain in aquatic ecosystems.

[3] Refers to free-swimming organisms (e.g., fish, turtles, marine mammals) that move actively through the water column and against currents.

[4] Mayhew, D.A., L.D. Jensen, D.F. Hanson, and P.H. Muessig. 2000. A comparative review of entrainment survival studies at power plants in estuarine environments. *Environmental Science and Policy* 3:S295–S301.

[5] EPRI. 2000. Review of entrainment survival studies: 1970–2000. Prepared by EA Engineering Science and Technology for the Electric Power Research Institute, Palo Alto, CA.

[6] Personal communication, telephone conversation between D. Hart (EPA) and L. Kline (ASMFC), 2001.

[7] Florida Power and Light Company. 1995. Assessment of the impacts at the St. Lucie Nuclear Generating Plant on sea turtle species found in the inshore waters of Florida.

notes that these are examples of the types of impacts that may occur without controls, that these examples are not representative of all sites whose facilities use cooling water intake structures, and that these examples may not reflect subsequent action that may have been taken to address these impacts on a site-specific basis. With these notes, EPA provides the following examples, illustrating that the impacts attributable to impingement and entrainment at individual facilities may result in appreciable losses of early life stages of fish and shellfish (*e.g.,* three to four billion individuals annually [8]), serious reductions in forage species and recreational and commercial landings (*e.g.,* 23 tons lost per year [9]), and extensive losses over relatively short intervals of time (*e.g.,* one million fish lost during a three-week study period [10]).

Further, some studies estimating the impact of impingement and entrainment on populations of key commercial or recreational fish have predicted substantial declines in population size. This has lead to concerns that some populations may be altered beyond recovery. For example, a modeling effort evaluating the impact of entrainment mortality on a representative fish species in the Cape Fear estuarine system predicted a 15 to 35 percent reduction in the species population.[11]

In addition, studies of entrainment at five Hudson River power plants during the 1980s predicted year-class reductions ranging from six percent to 79 percent, depending on the fish species.[12] An updated analysis of entrainment at three of these power plants predicted year-class reductions of up to 20 percent for striped bass, 25 percent for bay anchovy, and 43 percent for Atlantic tom cod, even without assuming 100 percent mortality of entrained organisms.[13] The New York Department of Environmental Conservation concluded that these reductions in year-class strength were ''wholly unacceptable'' and that any ''compensatory responses to this level of power plant mortality could seriously deplete any resilience or compensatory capacity of the species needed to survive unfavorable environmental conditions.''[14]

The following are summaries of other, documented examples of impacts occurring at existing facilities sited on a range of waterbody types. Also, see the discussion of the benefits of today's final rule in Section IX.

Brayton Point Generating Station. The Brayton Point Generating Station is located on Mt. Hope Bay, in Somerset, Massachusetts, within the northeastern reach of Narragansett Bay. Because of problems with electric arcing caused by salt drift and lack of fresh water for the closed-cycle recirculating cooling water system, the company converted Unit 4 from a closed-cycle, recirculating system to a once-through cooling water system in July 1984. The modification of Unit 4 resulted in a 41 percent increase in coolant flow, amounting to an intake flow of approximately 1.3 billion gallons per day and increased thermal discharge to the bay.[15] An analysis of fisheries data by the Rhode Island Division of Fish and Wildlife using a time series-intervention model showed an 87 percent reduction in finfish abundance in Mt. Hope Bay coincident with the Unit 4 modification.[16] The analysis also indicated that, in contrast, species abundance trends have been relatively stable in adjacent coastal areas and portions of Narragansett Bay that are not influenced by the operation of Brayton Point station.

San Onofre Nuclear Generating Station. The San Onofre Nuclear Generating Station (SONGS) is located on the coastline of the Southern California Bight, approximately 2.5 miles southeast of San Clemente, California.[17] The marine portions of Units 2 and 3, which are once-through, open-cycle cooling systems, began commercial operation in August 1983 and April 1984, respectively.[18] Since then, many studies evaluated the impact of the SONGS facility on the marine environment.

In a normal (non-El Niño) year, an estimated 121 tons of midwater fish (primarily northern anchovy, queenfish, and white croaker) are entrained at SONGS, of which at least 57 percent are killed during plant passage.[19] The fish lost include approximately 350,000 juveniles of white croaker, a popular sport fish; this number represents 33,000 adult individuals or 3.5 tons of adult fish. Within 3 kilometers of SONGS, the density of queenfish and white croaker in shallow-water samples decreased by 34 and 36 percent, respectively. Queenfish declined by 50 to 70 percent in deepwater samples.[20] A subsequent EPA review of the SONGS 316(b) demonstration concluded that although the plant incorporated technologies for minimizing adverse environmental impact, operations at SONGS cause adverse impacts to organisms in the cooling water system and to biological populations and communities in the vicinity of the intake and discharge locations for the plant.[21] These effects included mortality of fish, especially losses of millions of eggs and larvae, that are taken into the plant with cooling water and creation of a sometimes turbid plume that affects kelp, fish, and invertebrates in the San Onofre kelp bed.[22]

Pittsburg and Contra Costa Power Plants. The Pittsburg and Contra Costa Power Plants are located in the San Francisco Estuary, California. Because the San Francisco Bay Delta ecosystem has changed dramatically over the past century, several local species (e.g., Delta smelt, Sacramento splittail, chinook salmon, and steelhead) have been listed as threatened or endangered. Facility estimates for one of these species,

[8] EPA Region IV. 1979. Brunswick Nuclear Steam Electric Generating Plant of Carolina Power and Light Company, historical summary and review of section 316(b) issues.

[9] EPA Region IV. 1986. Findings and determination under 33 U.S.C. 1326, In the Matter of Florida Power Corporation Crystal River Power Plant Units 1, 2, and 3, NPDES permit no. FL0000159.

[10] Thurber, N.J and D. J. Jude. 1985. Impingement losses at the D.C. Cook Nuclear Power Plant during 1975–1982 with a discussion of factors responsible and possible impact on local populations. Special report no. 115 of the Great Lakes Research Division, Great Lakes and Marine Waters Center, University of Michigan.

[11] EPA Region IV. 1979. Brunswick Nuclear Steam Electric Generating Plant of Carolina Power and Light Company, historical summary and review of section 316(b) issues.

[12] Boreman J. and P. Goodyear. 1988. Estimates of entrainment mortality for striped bass and other fish species inhabiting the Hudson River Estuary. *American Fisheries Society Monograph* 4:152–160.

[13] Consolidated Edison Company of New York. 2000. Draft environmental impact statement for the state pollutant discharge elimination system permits for Bowline Point, Indian Point 2 & 3, and Roseton steam electric generating stations.

[14] New York Department of Environmental Conservation (NYDEC). 2000. Internal memorandum provided to the USEPA on NYDEC's position on SPDES permit renewals for Roseton, Bowline Point 1 & 2, and Indian Point 2 & 3 generating stations.

[15] Metcalf & Eddy. 1992. Brayton Point station monitoring program technical review. Prepared for USEPA.

[16] Gibson, M. 1995 (revised 1996). Comparison of trends in the finfish assemblages of Mt. Hope Bay and Narragansett Bay in relation to operations of the New England Power Brayton Point station. Rhode Island Division of Fish and Wildlife, Marine Fisheries Office.

[17] Southern California Edison. 1988. Report on 1987 data: marine environmental analysis and interpretation, San Onofre Nuclear Generating Station.

[18] Ibid.

[19] Swarbrick, S. and R.F. Ambrose. 1989. Technical report C: entrapment of juvenile and adult fish at SONGS. Prepared for Marine Review Committee.

[20] Kastendiek, J. and K. Parker. 1989. Interim technical report: midwater and benthic fish. Prepared for Marine Review Committee.

[21] SAIC. 1993. Draft review of Southern California Edison, San Onofre Nuclear Generating Station (SONGS) 316(b) demonstration. Prepared for USEPA Region IX.

[22] Ibid.

chinook salmon, indicate that the Pittsburg and Contra Costa intakes have the potential to impinge and entrain up to 36,567 chinook salmon each year.[23] Based on restoration costs, EPA estimates that losses for this species alone can be valued at $25–40 million per year.

Power Plants with Flows Less Than 500 MGD. The following information from facility studies documents impingement and entrainment losses for facilities with lower flows than the previous examples:

1. The Pilgrim Nuclear Power Station, located on Cape Cod Bay, Massachusetts, has an intake flow of 446 MGD.[24] The average annual total losses of fish (all life stages) was 26,800 due to impingement and 3.92 billion due to entrainment[25]

2. The Coleman Power Plant, located on the Ohio River in Henderson, Kentucky, has an intake flow of 337 MGD[25] and combined average impingement and entrainment losses of 702,630,800 fish per year (30,800 impinged and 702,600,000 entrained).[26]

Existing and historical studies like those described in this section may provide only a partial picture of the severity of environmental impact associated with cooling water intake structures. Most important, the methods for evaluating adverse environmental impact used in the 1970s and 1980s, when most section 316(b) evaluations were performed, were often inconsistent and incomplete, making detection and consideration of all impacts difficult in some cases, and making cross-facility comparison difficult for developing a national rule. For example, some studies reported only gross fish losses; others reported fish losses on the basis of species and life stage; still others reported percent losses of the associated population or subpopulation (e.g., young-of-year fish). Recent advances in environmental assessment techniques provide new and in some cases better tools for monitoring impingement and entrainment and detecting impacts associated with the operation of cooling water intake structures.[27 28] EPA acknowledges that these new assessment techniques may in some cases provide additional rather than better tools and perspectives.

IV. Summary of the Most Significant Revisions to the Proposed Rule

A. Data Updates

1. Number and Characteristics of New Facilities

Chapter 5 of the *Economic Analysis* provides a detailed discussion of the data and methodology used to estimate the number of new electric generating facilities and new manufacturing facilities subject to the final section 316(b) new facility rule. This section provides a summary of primary revisions to the analyses since the proposal. The section discusses new combined-cycle facilities, new coal facilities, and new manufacturing facilities separately.

a. New Combined-Cycle Facilities

The general approach for estimating the number of new combined-cycle facilities subject to the final section 316(b) new facility rule has not changed since proposal. However, and as discussed in the notice of data availability (NODA), EPA has used new data, which have become available since the proposal, to update the analysis. As a result, the number of new combined-cycle facilities now projected to be in scope of this rule has increased from 24 in the proposed rule analysis to 69 in the updated analysis for the final rule.

(1) Proposed Rule

For the proposal analysis, EPA used a three-step approach to estimating the number of new combined-cycle facilities: (1) Determination of future combined-cycle capacity additions; (2) estimation of the percentage of all regulated combined-cycle facilities that are in-scope; and (3) estimation of the number of new facilities. EPA used the *Annual Energy Outlook 2000* (AEO2000), prepared and published by the Energy Information Administration (EIA) of the U.S. Department of Energy, as the basis for the projected number of new in-scope combined-cycle facilities. The AEO2000 forecast 131 gigawatts (GW) of new combined-cycle capacity to begin operation between 2001 and 2020. Since the AEO does not have any information on the number of new facilities, their size, or their cooling water characteristics, EPA used the January 2000 version of Resource Data International's NEWGen Database to determine the in-scope percentage of new combined-cycle facilities and their facility and cooling water characteristics.

In the January 2000 NEWGen database, 94 of 466 projects met the following screening criteria: (1) New facility; (2) located in the United States; (3) active project (*i.e.,* not canceled or tabled); (4) anticipated date of initial commercial operation after August 13, 2001; and (5) steam electric prime mover. All 94 facilities were included in the analysis of new combined-cycle facilities. EPA then consulted permitting authorities, other public agencies, and company websites to obtain data on the planned facility cooling water use. EPA obtained sufficient data to assess the in-scope status for 56 of the 94 facilities. Seven of the 56 facilities, or 12.5 percent, were found to be in scope of the proposed rule; 49 were found to be out of scope. To estimate the total number of new in-scope combined-cycle facilities projected to begin operation between 2001 and 2020, EPA applied the average facility size of the seven in-scope NEWGen facilities (723 MW) and the in-scope percentage (12.5 percent) to EIA's forecast of new combined-cycle capacity additions. EPA made the conservative assumption that all new combined-cycle capacity would be built at new facilities rather than at existing facilities. These calculations resulted in an estimate of 24 new in-scope combined-cycle facilities over the 2001–2020 period (see also Exhibit 1 below).

(2) Final Rule

For the final rule analysis and as discussed in the NODA, EPA used the same general methodology but obtained updated information. In particular, EPA used the forecast of capacity additions from the U.S. Department of Energy's *Annual Energy Outlook* (AEO2001) and the February 2001 NEWGen Database. AEO2001's forecast of new combined-cycle capacity additions between 2001 and 2020 was 204 GW, compared with 131 GW in the AEO2000. Similarly, the February 2001 NEWGen Database contains considerably more new energy projects than the version used for the proposed rule analysis: The database contains 941 new projects, of which 361 met the screening criteria discussed above. Of the 361 facilities, 320 are combined-cycle facilities. To increase the number of facilities upon which facility and cooling water use characteristics are based, EPA excluded the anticipated date of initial commercial operation as a screening criterion. The analysis for the final rule

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[23] Southern Energy. 2000. Habitat conservation plan for the Pittsburg and Contra Costa Power Plants.

[24] Edison Electric Institute. 1994. EEI Power Statistics Database. Prepared by the Utility Data Institute.

[25] Data compiled by EPA from annual reports of impingement and entrainment losses from the Pilgrim Nuclear Power Station for the years 1991–1999.

[26] Hicks, D.B. 1977. Statement of findings for the Coleman Power Plant, Henderson, Kentucky.

[27] Schmitt, R.J. and C.W. Osenberg. 1996. *Detecting Ecological Impacts.* Academic Press, San Diego, CA.

[28] EPRI. 1999. Catalog of assessment methods for evaluating the effects of power plant operations on aquatic communities. TR–112013, EPRI, Palo Alto, CA.

therefore includes all facilities that meet the other four screening criteria, even if a facility will already have begun construction when the rule is promulgated and will therefore not be subject to the final rule.

EPA again consulted permitting authorities, other public agencies, and company websites to obtain data on the facilities' planned cooling water use. EPA obtained sufficient data to assess the cooling water characteristics for 199 of the 320 combined-cycle facilities. Of the 199 facilities, 57, or 28.6 percent, were found to be in scope of the final rule; 142 were found to be out of scope. The average size of all 199 facilities with cooling water information was approximately 741 MW. The average size of the 57 in-scope facilities was 747 MW. EPA made one other revision in estimating the total number of new in-scope combined-cycle facilities projected to begin operation between 2001 and 2020: Instead of assuming that all new combined-cycle capacity would be built at new facilities, EPA used information on combined-cycle capacity additions at existing facilities from the NEWGen Database to determine the actual share of capacity that will be built at new facilities. The database showed that 88 percent of new combined-cycle capacity is proposed at new facilities. EPA used the Department of Energy's estimate of new combined-cycle capacity additions (204 GW) and multiplied it by the percentage of capacity that will be built at new facilities (88 percent) to determine that 179 GW of new capacity will be constructed at new facilities. EPA then divided this value by the average facility size (741 MW) to determine that there would be a total of 241 potential new combined-cycle facilities (both in scope and out of scope of today's final rule). Finally, on the basis of EPA's estimate of the percentage of facilities that meet the two (2) MGD flow threshold (28.6 percent), EPA now estimates there will be 69 new in-scope combined-cycle facilities over the 2001–2020 period. Exhibit 1 summarizes the data differences for combined-cycle facilities between the proposal and the final rule analyses.

EXHIBIT 1.—SUMMARY OF COMBINED-CYCLE FACILITY RESEARCH (2001 TO 2020)

Information category	Proposed rule analysis	Final rule analysis
AEO2000 combined-cycle capacity additions	135 GW[a]	
AEO2001 combined-cycle capacity additions		204 GW
Percentage of combined-cycle capacity additions from new facilities	100%	88%
Capacity additions from new facilities	135 GW	179 GW
Average size of all combined-cycle facilities	723 MW	741 MW
Total number of new combined-cycle facilities	187	241
In-scope percentage	12.5%	28.6%
Number of new in-scope combined-cycle facilities	24	69
Average size of in-scope combined-cycle facilities	723 MW	747 MW

[a] Includes 4 GW of new coal capacity additions for 2001–2010.

The final step in the costing analysis for the final rule was to project cooling water characteristics of the 69 new in-scope combined-cycle facilities on the basis of the characteristics of the 57 in-scope NEWGen facilities. EPA developed six model facility types based on three main characteristics: (1) The facility's type of cooling system (once-through or recirculating system); (2) the type of water body from which the intake structure withdraws (freshwater or marine water); and (3) the facility's steam-electric generating capacity. The model facility characteristics were then applied to the 69 projected new combined-cycle facilities. EPA estimated that 64 new in-scope combined-cycle facilities will employ a recirculating system and only five will employ a once-through system. Of the 64 facilities with a recirculating system, 58 will withdraw from a freshwater body and six will withdraw from a marine water body. All five facilities with a once-through system are projected to withdraw from a marine water body.

b. New Coal Facilities

The general approach for estimating the number of new coal facilities subject to this final rule has not changed since proposal. However, as discussed in the NODA, EPA has used new data, which have become available since the proposal, to update the analysis. As a result, the number of new coal facilities projected to be in scope of this rule, decreased slightly, from 16 in the proposed rule analysis to 14 in the final rule analysis. However, most of the new in-scope coal facilities are now expected to begin operation earlier than under the proposal analysis.

(1) Proposed Rule

For the years 2001–2010, the AEO2000 projected limited new coal-fired steam electric generating capacity. In addition, the January 2000 NEWGen Database included no new coal-fired generating facilities. EPA therefore did not project any new coal facilities for 2001–2010. For the years 2011–2020, EPA used EIA's projected new capacity addition from coal-fired facilities, 17 GW, and information from the following sources to estimate the number and cooling water characteristics of new coal-fired power facilities subject to the rule: Form EIA–767 (Steam Electric Plant Operation and Design Report, Energy Information Administration, U.S. Department of Energy, 1994, 1997); Form EIA–860 (Annual Electric Generator Report, Energy Information Administration, U.S. Department of Energy, 1994, 1997); and Power Statistics Database (Utility Data Institute, McGraw-Hill Company, 1994). EPA estimated that 16 new coal facilities of 800 MW each would be subject to the proposed section 316(b) new facility rule and would begin operation between 2011 and 2020. Of these, 12 were projected to operate a recirculating system in the baseline, while four were projected to operate a once-through system.

(2) Final Rule

EPA used a similar methodology for the final rule analysis but obtained updated information and added data from the section 316(b) industry survey of existing facilities *(Industry Screener Questionnaire: Phase I Cooling Water Intake Structures, Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures, and Industry Short Technical Questionnaire: Phase II Cooling Water Intake Structures).* To be consistent with the analysis for combined-cycle facilities, EPA used the forecast of capacity additions from the

AEO2001, which predicts 22 GW of new coal capacity between 2001 and 2020. In contrast to the proposal analysis, EPA considered the entire 2001–2020 period for the final rule analysis. In addition, EPA used information from the section 316(b) industry survey to determine the average size, in-scope percentage, and cooling water characteristics of new coal plants. The three surveys identified 111 unique coal-fired facilities that began commercial operation between 1980 and 1999. The facilities have a combined generating capacity of 53 GW, with an average of 475 MW each. The surveys further showed that 45 of the 111 facilities, or 40.5 percent, would be in scope of today's final rule if they were new facilities. These 45 facilities have an average generating capacity of 763 MW.

Information in the February 2001 version of the NEWGen Database on capacity additions at new and existing facilities showed that approximately 76 percent of new coal capacity will be built at new facilities. Applying this percentage (76 percent), as well as the average facility size (475 MW) and the in-scope percentage (40.5 percent), to EIA's forecast of new coal capacity additions resulted in 14 new in-scope coal facilities, with an average capacity of 763 MW, over the 2001–2020 period. Exhibit 2 summarizes the data differences for coal facilities between the proposal and the final rule analyses.

EXHIBIT 2.—SUMMARY OF COAL FACILITY RESEARCH

	Proposed rule analysis (2011–2020)	Final rule analysis (2001–2020)
AEO2000 coal capacity additions	17 GW	
AEO2001 coal capacity additions		22 GW
Percentage of coal capacity additions from new facilities	82%	76%
Capacity additions from new faciliteis	14 GW	17 GW
Average size of all coal facilities	800 MW	475 MW
Total number of new coal facilities	18	35
In-scope percentage	99.0%	40.5%
Number of new in-scope coal facilities	16	14
Average size of in-scope coal facilities	800 MW	763 MW

EPA projected cooling water characteristics of the 14 new in-scope coal facilities using data for recently-constructed plants from the section 316(b) industry survey. Similar to the combined-cycle facility analysis, EPA developed eight model facility types based on three main characteristics: (1) The facility's type of cooling system (once-though or recirculating system); (2) the type of water body from which the intake structure withdraws (freshwater or marine water); and (3) the facility's steam-electric generating capacity. The model facility characteristics were then applied to the 14 projected new coal facilities. EPA estimated that 10 new in-scope coal facilities will employ a recirculating system and three will employ a once-through system. One coal facility has a recirculating cooling pond and will exhibit characteristics more like a once-through facility. Of the10 facilities with a recirculating system, nine will withdraw from a freshwater body and only one facility will withdraw from a marine water body. All three facilities with a once-through system and the one facility with a cooling pond are projected to withdraw from a freshwater body.

c. Manufacturing Facilities

The general methodology used to estimate the number of new manufacturing facilities subject to the final section 316(b) new facility rule has not changed since proposal. However, on the basis of comments, EPA has altered some estimates and used new data to update the analysis. As a result, the number of new manufacturing facilities projected to be in scope of this rule has decreased from 58 at proposal to 38 in the final rule analysis.

(1) Proposed Rule

In the proposal analysis, EPA used three industry-specific estimates to project the number of new in-scope manufacturing facilities: (1) Industry growth forecasts; (2) the estimated percentage of the projected capacity growth accounted for by new facilities; and (3) data on the cooling water use at existing facilities. EPA used the projected growth of value of shipments in each industry to estimate likely future growth in capacity. A number of sources provided growth forecasts, including the annual U.S. Industry & Trade Outlook, *AEO2001,* and other sources specific to each industry. EPA assumed that the growth in capacity will equal growth in value of shipments, except where industry-specific information supported alternative assumptions. Not all industry growth, however, is expected to occur at new facilities: Some of the projected growth in capacity may result from increased utilization of existing capacity or capacity additions at existing facilities. Where information on the share of growth from new facilities was available, EPA used these data. For example, EIA projected that all increases in petroleum shipments will result from expanded capacity at existing facilities. Where this information was not available, EPA made the conservative estimate that 50 percent of the projected growth in capacity will be attributed to new facilities. Finally, EPA assumed that the cooling water use characteristics of new facilities in each industry, including the in-scope percentage, would be similar to those of existing facilities. Cooling water use data for existing facilities came from the *Industry Screener Questionnaire: Phase I Cooling Water Intake Structures.* To calculate the total number of new in-scope manufacturing facilities, EPA applied the industry-specific growth rate and the percentage of capacity growth from new facilities to the sample-weighted number of in-scope screener facilities in each industry.

(2) Final Rule

For the final rule analysis, EPA updated the projected growth in value of shipments for each industry using the most recent data available. On the basis of comments, three changes were made to the percentage of projected capacity growth that is attributed to new facilities. First, the American Chemistry Council stated that EPA overestimated the number of new in-scope chemical facilities in the proposal analysis because the percentage of growth that comes from new facilities (50 percent) was overstated. The comment did not provide a more accurate estimate. EPA therefore revised this estimate for the chemical industry to 25 percent, which reduced the number of new chemical facilities by half. (The *Economic Analysis* documents the effect of using an alternative assumption of 37.5 percent, the midpoint between the proposal analysis estimate and the final rule analysis estimate, in analyzing the economic impacts of this rule.) Second, the petroleum industry commented that the assumption of no new petroleum refineries over the next 20 years is invalid. Even though the AEO2001 projects no new refineries in the United States, to be conservative EPA nevertheless revised this estimate and included two new in-scope petroleum refineries in the final rule analysis. Third, the American Forest & Paper Association stated that one or two new greenfield paper mills will be built over the next decade. EPA added two new in scope paper mills over the 20-year analysis period in response to this comment. In addition, EPA updated the water use characteristics of the projected new facilities by using data from the *Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures instead of the Screener Questionnaire.* In the proposal analysis, EPA erroneously used the average daily intake flow rate, instead of the design intake flow rate, to determine whether a facility meets the two MGD flow threshold and is subject to the rule. Since the average intake flow is either lower than or equal to the design intake flow, this error likely underestimated the number of new in-scope manufacturing facilities. For the analysis of the final rule, EPA used the design intake flows reported in the section 316(b) industry survey.

Overall, because of the revisions described above, EPA's estimate of the number of new in-scope manufacturing facilities dropped from 58 at proposal to 38 in the cost analysis for this final rule.

2. Revisions to the Costing Estimates

Chapter 2 of the *Technical Development Document* provides a detailed description of the data and methodology used to develop compliance cost estimates for the final regulation. This section provides a summary of the main revisions in the costing inputs since the proposal.

At the time of the proposal, EPA included cost estimates for plume abatement at 50 percent of the electric generating facilities anticipated to install recirculating wet cooling towers to comply with the rule. This was an error. As described in the NODA (66 FR 28866 and 28867), EPA has since refined its estimates of cooling tower costs on a national basis to reflect plume abatement costs at a significantly lower proportion of facilities. EPA determined, on the basis of further research and information received from vendor manufacturers, that plume abatement measures were installed at only 3 to 4 percent of recent wet cooling tower projects. Therefore, the costing estimates for the final rule reflect this change.

At the time of the proposal, EPA included cost estimates for pumping of recirculating cooling water in the towers based on a flow rate equal to 15 percent of a comparable once-through cooling flow (based on the flow of make-up water). As explained in the NODA (66 FR 28866), this was an error. EPA has since refined its costing estimates to include the entire cooling flow. EPA's cost estimates for both capital and O&M costs for the final rule reflect appropriately sized pumps to recirculate the full design cooling water flow. The in-tower cooling water flow is now based on the level of cooling necessary for the condenser and the plants' cooling needs.

Since proposal, EPA has included costs from additional projects in the calculation of its costing estimates for recirculating wet cooling towers. EPA obtained further ''turn-key'' vendor project costs that have been incorporated into the specific costing equations used to calculate the capital and operation and maintenance (O&M) costs of the final rule. Turn-key project costs represents all costing elements necessary to estimate engineering costs, such as vendor overhead, equipment, wiring, foundations and contingencies. EPA included these project costs in the calculation of the costing equations in order to increase the number of real-world projects upon which the final cost estimates are based.

EPA has refined its estimates of O&M costs for recirculating wet cooling towers since proposal. At the time of proposal, EPA estimated economy of scale for O&M costs for recirculating, wet cooling towers as their size increases. EPA based this estimate primarily on the economy of scale savings for wastewater treatment systems as wastewater flow increases. The overall effect of this approach showed that for very large cooling towers, a savings of nearly two-thirds was achieved compared with smaller cooling towers. On the basis of comments received and further research, EPA has refined its estimates of O&M costs and economies of scale. The cost estimates presented for the final rule reflect this revision to the analysis.

In the final rule, EPA has included cost estimates for energy penalties due to operating power losses from recirculating cooling tower systems. Further information on this subject can be found in Section IV.A.3 of this preamble, below.

3. Energy Penalty Estimates for Recirculating Wet Cooling and Dry Cooling Towers

Since proposal, as discussed in the NODA (66 FR 28866), EPA has included in its estimates of O&M costs the performance penalties that may result in reductions of energy or capacity produced because of adoption of recirculating cooling tower systems. The cost estimates for the final rule include consideration of these penalties. The final rule cost estimates account for the energy penalty at facilities that are projected to install recirculating wet cooling tower systems in lieu of once-through cooling systems. EPA's cost estimates for dry cooling regulatory alternatives account for the appropriate energy penalty of this technology at each facility projected to install such a system.

For the final rule, EPA's costing methodology for performance penalties is based on the concept of lost operating revenue due to a mean annual performance penalty. EPA estimated the mean annual performance penalty for each tower technology as compared with once-through or recirculating wet cooling systems (where applicable for the dry cooling analysis). EPA then applied this mean annual penalty to the annual revenue estimates for each facility projected to install a recirculating cooling tower technology as a result of the rule or a regulatory option. EPA considers these revenue losses as representative of the cost to the facility for either replacing the power lost via the market or expanding the capacity of the new power plant.

Chapter 3 of the *Technical Development Document* discusses performance penalties in more detail.

4. Significant Changes to the Economic Analysis a. Revisions to Costing Analysis

EPA has made a methodological change for estimating the cost for today's rule. For the proposal, EPA directly estimated the incremental cost of the rule without estimating the baseline cost. This made it difficult to identify the magnitude of changes in relevant components of a system of a facility and their individual costs. For the final rule, EPA separately estimated the baseline costs and the cost after meeting the requirements of the rule.

Thus, the incremental cost attributed to the rule is derived from the difference between the baseline cost and the cost after compliance with the requirements of the rule.

For the proposal, EPA estimated the cost of the rule to be $12 million. This estimate was in part based on the assumption that 90 percent of the coal facilities would be within the scope of the rule. Since the publication of the proposal, EPA has analyzed additional information regarding coal facilities. This information shows that 40.5 percent of the coal facilities would be within the scope of the rule. EPA also revised the baseline characteristics for these facilities. For the final rule, EPA estimates that 71 percent of new in-scope coal facilities would have recirculating cooling towers independent of the rule. For combined-cycle facilities, EPA used the January 2000 version of the NEWGen database at proposal to estimate the proportion of the facilities that would be within the scope of the proposal. In view of the changes in the energy market, EPA is using a more current version (February 2001) of the NEWGen database for the final analysis. Consequently, EPA is revising the in-scope percentage for combined-cycle facilities to 28.6 percent for the final analysis, instead of 12.5 percent used for the proposal.

For the proposal, EPA used the average flow from the section 316(b) industry survey, screener questionnaire for existing manufacturing facilities to estimate the technology and O&M costs for new manufacturing facilities. EPA believes that the average flow would underestimate the costs because costs mostly depend on design of a facility. Therefore, EPA is using the design flow for estimating the cost for manufacturing facilities for the final rule. For the proposal, EPA assumed that 50 percent of the growth in product demand in the chemical industry would be met from new facilities. Commenters pointed out that this assumption leads to an overestimation of the number of new facilities and EPA agrees. Therefore, EPA has revised this assumption to 25 percent for the analysis supporting today's rule.

EPA has also examined the cost of the rule as a percentage of (annual) revenue for purposes of determining whether the options are economically practicable. The worst-case, or upper-limit, cost estimate for the rule is between 3.3 to 5.2 percent of estimated revenues (for three coal facilities), between 1 and 3 percent for an additional six facilities, and less than 1 percent for the rest of the facilities. EPA concludes that those costs are economically practicable and will not pose a barrier to entry for new facilities. The initial compliance cost of the rule (i.e., capital costs and permitting costs) as a percentage of construction cost of an electric generation facility is 3.4 percent for one coal facility, between 1.0 and 3.0 percent for an additional seven facilities, and less than 1.0 percent for the rest of the electric generation facilities. EPA finds that these are relatively low compliance costs. EPA does not consider that the cost of the rule would be a barrier to entry for new facilities and also finds that cost to be economically practicable.

5. Air Emissions Increases as a Result of Certain Regulatory Options

For the final rule, and as discussed in the NODA, EPA includes estimates of annual air emissions increases for certain pollutants from new power plants as a result of certain regulatory options considered. EPA developed estimates for air emissions increases for SO_2, NO_X, CO_2, and Hg for the regulatory options based on near-zero intake (dry cooling) and for those based on uniform national requirements of flow reduction commensurate with closed-cycle recirculating wet cooling systems (wet cooling towers) or with wet-cooling systems in Track I of a two-track rule. EPA anticipates, because of measurable performance penalties associated with cooling tower systems (see Section IV.A.3 of this preamble), that, depending on the regulatory option, air emissions nationally could increase from all or a small subset of new power plants as a result of the installation of cooling tower systems. EPA estimates the marginal air emissions increases by assuming that the energy lost by the facility cannot be replaced through additional fuel consumption at that facility, but rather, the energy will be replaced by the entire grid as a whole. Thus, the replacement energy necessary to compensate for the performance penalty is generated by the mix of fuels present in the entire grid. This is because, in EPA's view and on the basis of comments received, power plants are not always capable of compensating for an energy shortfall due to a performance penalty of a recirculating cooling tower by increasing their fuel consumption. Even though the estimated mean annual performance penalty for recirculating wet cooling towers is small, EPA estimates that facilities designed for once-through cooling would not always be designed with sufficient excess capacity to compensate for the performance penalties caused by recirculating wet cooling tower installations as a result of this rule. Therefore, EPA determines that marginal increases in air emissions due to performance penalties are best represented by estimating that the entire grid will replace the energy loss. EPA's estimates of marginal increases of air emissions are presented in Exhibit 3.

EXHIBIT 3.—ESTIMATES OF MARGINAL INCREASES OF AIR EMISSIONS FOR RECIRCULATING WET COOLING TOWERS [a]

	Capacity (MW)	Annual CO_2 (tons)	Annual SO_2 (tons)	Annual NO_X (tons)	Annual Hg (lbs)
National Emissions from Electricity Generation	828,631	2,575,814,488	13,581,673	6,437,710	86,722
Air Emission Increases if Plants Compensate With Increased Fuel Consumption					
National Electricity Generation Air Emissions Increases for Wet Cooling.		712,886 (.0028%)	1,543 (.0011%)	1,518 (.0024%)	23 (.0026%)
Air Emission Increases if Plants Purchase Replacement Power From Market					
National Electricity Generation Air Emissions Increases for Wet Cooling.		485,860 (.0019%)	2,561 (.0019%)	1,214 (.0019%)	16 (.0019%)

[a] This analysis assumes that annual emissions from energy generation are constant from 1998 to 2020, even though generation is projected to increase steadily over the next twenty years. Therefore, these estimates are slightly overstated.

B. Regulatory Approach

1. Proposed Rule

EPA proposed flow, velocity, and other design and construction technologies requirements based on the type of waterbody in which the intake structure is located and, for certain types of waters, the location of the intake in the water body. EPA proposed to group surface water into four categories: freshwater rivers and streams, lakes and reservoirs, estuaries and tidal rivers, and oceans. For each of these waterbody types, EPA divided the waterbody into sections based on the defined ''littoral zone.'' At proposal, littoral zone was defined as any nearshore area in a freshwater river or stream, lake or reservoir, or estuary or tidal river extending from the level of highest seasonal water to the deepest point at which submerged aquatic vegetation can be sustained (i.e., the photic zone extending from shore to the substrate receiving one (1) percent of incident light); where there is a significant change in slope that results in changes to habitat or community structure; and where there is a significant change in the composition of the substrate (e.g., cobble to sand, sand to mud). In oceans, the littoral zone encompassed the photic zone of the neritic region. The photic zone is that part of the water that receives sufficient sunlight for plants to be able to photosynthesize. The neritic region is the shallow water or nearshore zone over the continental shelf.

In general, the closer the intake structure was to the littoral zone, the more stringent the proposed best-technology-available requirements for minimizing adverse environmental impact became. For example, an intake structure located within the littoral zone would have required the most stringent capacity and velocity controls as well as the use of other design and construction technologies. EPA also proposed the most stringent requirements for best technology available for minimizing adverse environmental impact in all parts of tidal rivers and estuaries because of the potential for high biological productivity in these waters.

2. Notice of Data Availability

In the NODA, EPA sought comment on various versions of a two-track approach resulting from comments received on the proposal. Under this approach, a facility would choose to pursue one of two tracks. In general (based on size), Track I would establish national technology-based performance requirements, whereas Track II would allow the facility to conduct site-specific studies to demonstrate to the permit director that alternative technologies or approaches could reduce impingement and entrainment to the same or a greater degree than the Track I technology-based performance standards. See 66 *FR* 28868 to 28872.

3. Final Rule

In this rule, EPA is establishing a two-track technology-based approach that does not distinguish between waterbody types or the location of the intake structure within the waterbody type. Track I establishes capacity (for facilities with a design intake flow equal to or greater than 10 MGD), velocity, and capacity- and location-based proportional flow requirements to reduce impingement and entrainment of fish, shellfish, eggs, and larvae and requires the applicant to select and implement design and control technologies to minimize impingement and entrainment in certain areas. Track I applicants with intake flow between 2 and 10 MGD do not have to comply with a capacity limitation but then must use technologies to reduce entrainment at all locations. Track II allows a facility to conduct a comprehensive demonstration study to show that alternative controls will achieve comparable performance. The two-track approach balances the goal of providing regulatory certainty and fast permitting for new facilities with the goal of allowing flexibility by including a performance-based alternative. Track I streamlines the permitting process, providing a high degree of certainty that a facility will obtain a National Pollutant Discharge Elimination System (NPDES) permit without delays. In EPA's view, Track II provides an incentive for the development of innovative technologies that will represent best technology available for minimizing impingement and entrainment from cooling water intake structures.

V. Basis for the Final Regulation

A. Major Options Considered for the Final Rule

EPA considered and analyzed several technology-based regulatory options to determine the best technology available for minimizing adverse environmental impact for new facilities. All of these options were analyzed and compared with the current requirements applied to NPDES permits for existing facilities with cooling water intake structures. Although the Agency considered numerous regulatory options during rule development, the primary options considered in development of today's final rule include: (1) Technology-based performance requirements for different types of waters, with intake capacity limits based on closed-cycle recirculating wet cooling systems required only in estuaries, tidal rivers, the Great Lakes, and oceans; (2) national technology-based performance requirements for all waterbodies, with flow reduction commensurate with the level achieved with closed-cycle recirculating wet cooling; (3) national technology-based performance requirements for all waterbodies with a near-zero intake level (based on dry cooling); [29] and (4) a case-by-case, site-specific approached based on the 1977 draft guidance document.[30] In addition to these options, EPA also considered variations on each of the technology-based options using on a two-track permitting approach. The two-track options include one presented by industry for consideration. The two-track approach establishes a specific set of technology-based performance requirements that a permittee can implement that reflect best technology available for minimizing adverse environmental impact; this approach also provides permittees with flexibility to demonstrate that an alternative set of requirements achieves a comparable level of performance.

For all the options except for those based on dry cooling, EPA also considered requiring a design through-screen velocity of 0.5 ft/s, location- and capacity-based flow restrictions proportional to the size of the waterbody (such as a requirement for streams and rivers allowing no more than 5 percent withdrawal of the mean annual flow), and design and construction technologies to minimize impingement mortality and entrainment. In addition, EPA considered requiring post-operational monitoring of impinged and entrained organisms, monitoring of the through-screen velocity, and periodic visual inspections of the intake structures.

1. Technology-Based Performance Requirements for Different Types of Waterbodies

Under this option, EPA would establish requirements for minimizing adverse environmental impact from cooling water intake structures based on

[29] EPA also examined subcategorization strategies for the dry cooling based option, on the basis of regional distribution of facilities, size of facilities, and type of facility (i.e., steam electric power plants versus manufacturing facilities).

[30] U.S. Environmental Protection Agency. 1977. *Draft guidance for evaluating the adverse impact of cooling water intake structures on the aquatic environment: section 316(b) P.L. 92–500.*

the type of waterbody in which the intake structure is located, the location of the intake in the waterbody, the volume of water withdrawn, and the design intake velocity. EPA would also establish additional requirements or measures for location, design, construction, or capacity that might be necessary for minimizing adverse environmental impact. Under this option, the best technology available for minimizing adverse environmental impact would constitute a technology suite that would vary depending on the type of waterbody in which a cooling water intake structure is located and the location of the cooling water intake structure within the waterbody. EPA would set technology-based performance requirements; the Agency would not mandate the use of any specific technology.

Under this option, EPA considered only requiring intake flow reduction commensurate with the level that can be achieved using a closed-cycle recirculating wet cooling system for intakes located in estuaries, tidal rivers, oceans, and the Great Lakes. For all other waterbody types, the only capacity requirements would be proportional flow reduction requirements. In all waterbodies, velocity limits and a requirement to study, select, and install design and construction technologies would apply. EPA determined that the annual compliance cost to industry for this option would be $36.3 million. EPA found that the regulatory implementation burden would be of an acceptable level but that the delay in permitting of new facilities could be up to 6 months if all new facilities were required to complete a baseline biological characterization study prior to submitting an application for a permit. This study would detail the potential design and construction technologies that would apply to all new facilities and would be required beyond the flow reduction requirements for facilities located in estuaries, tidal rivers, oceans, and the Great Lakes. This option was, in part, rejected due to the potential of delays in permitting. More significantly, this option was rejected because closed-cycle recirculating cooling water systems are available and economically practicable across all waterbody types.

2. National Technology-Based Performance Requirements for All Waterbodies

a. Flow Reduction Commensurate With the Level Achieved by Closed-Cycle Recirculating Wet Cooling Systems

EPA also considered a regulatory option for new facilities based primarily on intake-flow reduction from all cooling water intake structures commensurate with the level that can be achieved using a closed-cycle recirculating cooling water system. This option does not distinguish between facilities on the basis of the waterbody from which they withdraw cooling water. In addition to reducing design intake velocity and complying with capacity- and location-based proportional flow requirements, all facilities need to complete a baseline biological characterization study prior to submitting the application for a permit. This study would detail the design and construction technologies necessary to maximize the survival of impinged adult and juvenile fish and to minimize the entrainment of eggs and larvae. The applicant would also need to comply with any additional requirements established by the Director as reasonably necessary to minimize impingement and entrainment as a result of the effects of multiple cooling water intake structures in the same waterbody, seasonal variations in the aquatic environment affected by the cooling water intake structures controlled by the permit, or the presence of regionally important species. EPA did not determine the annual compliance cost to industry for this option. EPA found that the permit writer's regulatory implementation burden would be of an acceptable level. EPA adopted this option, in part, as Track I of the two-track approach.

b. Intake Capacity Reduction Commensurate with the Level Achieved by Use of a Dry Cooling System

EPA considered a regulatory option for new facilities based primarily on intake flow reduction from all cooling water intake structures commensurate with zero or very low-level intake (dry cooling). This option does not distinguish between facilities on the basis of the waterbody from which they withdraw cooling water. Dry cooling systems use either a natural or a mechanical air draft to transfer heat from condenser tubes to air. EPA determined that the annual compliance cost to industry for this option would be at least $490 million. EPA also found that the permit writer's regulatory implementation burden would be of an acceptable level and there would be no delay in the permitting of new facilities. The option would require no baseline biological characterization study prior to submission of the application for a permit, due to the requirement of near-zero intake.

In addition, EPA analyzed three subcategorization strategies for the final rule based on the dry cooling technology. EPA considered establishing zero or very low-level intake requirements only for steam electric power plants locating in cold northern climates. See Section V.C.1. EPA also separately analyzed a zero or very low-level intake requirement for steam electric power plants of small capacity (those with total capacity less than 500 MW). See Section V.C.1. For both of these subcategorization strategies, all facilities not complying with dry cooling technology-based performance requirements would comply with the national requirement of capacity reduction based on closed-cycle recirculating wet cooling. The dry cooling subcategories would require no baseline biological characterization study prior to submission of the application for permit, because of the requirement of near-zero intake. EPA found that the permit writer's regulatory implementation burden would be of an acceptable level and there could be a delay of up to 6 months in the permitting of new facilities under the dry cooling based subcategories. EPA discusses why it is not adopting the dry cooling approach for subcategories based on size and/or climate in Section V.C. below.

3. Two-Track Options

For each of the regulatory options outlined above that requires reduction of flow commensurate with the level achieved with closed-cycle recirculating cooling systems, EPA also considered a number of two-track options. The two-track options provide flexibility to the permittee in that the facility may choose to comply by meeting the specific technology-based performance requirements defined in the ''fast track'' (Track I), or by demonstrating that a level of performance would be achieved comparable to the level that would be achieved under the Track I requirements under the ''demonstration track'' (Track II).

Under one of the two-track options (referred to as the ''preferred two-track'' option), EPA considered a fast-track based on a commitment by the facility to employ a suite of technologies that would represent best technology available for minimizing adverse environmental impact. The technologies considered include reduction in capacity commensurate with that achievable by use of a closed-cycle recirculating cooling water system; a velocity limitation of less than or equal to 0.5 ft/s; and location where intake capacity would be no more than five (5) percent of the mean annual flow of a freshwater stream or river, no more than one (1) percent of the tidal excursion volume of a tidal river or estuary or where the intake capacity would not disrupt the natural stratification and turnover patterns of a lake or reservoir. Applicants also would be required to conduct baseline biological characterization monitoring; these data would be used to determine which design and construction technologies are needed on a case-by-case basis. EPA also considered allowing the permit applicant to specify design and construction technologies and to require monitoring so that the performance of these technologies could be evaluated in a subsequent NPDES permit. In order to speed up the issuance of the first permit at the new facility, EPA considered waiving any mandatory baseline biological characterization monitoring under Track I. In this case, the applicant would have the opportunity to rely on and present historical or literature information to support its selection of design and construction technologies. Under this approach, applicants would propose what design and construction requirements are most appropriate to reduce impingement and entrainment or to maximize impingement survival resulting from water withdrawn as make-up water at these facilities. The biological characterization information would support the design and construction technologies that the permittee chose to implement. The Director could revisit these design and construction technologies at the time of permit renewal. (Most design and construction technologies can be implemented without stopping operation at the facility.) As an alternative to the case-by-case designation of design and construction technologies, EPA also considered designating the following two design and construction technologies as part of a fast-track, best technology available suite of technologies: a fine mesh traveling screen with a fish return system, variable speed pumps, and a low pressure spray; or a submerged wedgewire fine mesh screen.

Under Track II, a facility would need to conduct a comprehensive demonstration study that documents that an alternative suite of technologies can be used by the facility to reduce impingement mortality and entrainment for all life stages of fish and shellfish to achieve a level of reduction comparable to the level that would be achieved under Track I. The estimated annual compliance cost to facilities for the preferred two-track option is $47.7 million.

EPA also considered a less stringent variation of the two-track option above, in which Track I would not require cooling water intake structures located in fresh rivers or streams and lakes or reservoirs to reduce capacity to a level commensurate with that achievable by use of a closed-cycle cooling system. EPA did not select this option because other available technologies that are economically practicable achieve greater reduction in impingement and entrainment.

EPA also considered a third two-track option as suggested by industry. Under this option, an applicant choosing Track I would install ''highly protective'' technologies in return for expedited permitting without the need for pre-operational or operational studies in the source waterbody. According to the commenters, these technologies would ''exceed the section 316(b) standards'' because they would ''avoid adverse environmental impact,'' defined as proven population or ecosystem impacts. Such fast-track technologies might include technologies that reduce intake flow to a level commensurate with a wet closed-cycle cooling at that site and that achieve an average approach velocity (measured in front of the cooling screens or the opening to the cooling water intake structure) of no more than 0.5 ft/s, or any technologies that achieve a level of protection from impingement and entrainment within the expected range for a closed-cycle cooling (with 0.5 ft/s approach velocity) given the waterbody type where the facility is to be located. This option was intended to allow facilities to use standard or new technologies that have been demonstrated to be effective for the species, type of waterbody, and flow volume of the cooling water intake structure proposed for their use. Examples of candidate technologies include (a) wedgewire screens, where there is constant flow, as in rivers; (b) traveling fine mesh screens with a fish return system designed to minimize impingement and entrainment; and (c) aquatic filter barrier systems, at sites where they would not be rendered ineffective by high flows or fouling. The operator of a proposed new facility would elect which set of technologies to install and validate its performance as necessary. In return, the permitting agency would not require additional section 316(b) protective measures for the life of the facility.

Under the industry approach, Track II would provide an applicant who does not want to commit to any of the above technology options with an opportunity to demonstrate that site-specific characteristics, including the local biology, would justify another cooling water intake structure technology, such as once-through cooling. For these situations, the applicant could demonstrate to the permitting agency, on the basis of site-specific studies, either that the proposed intake would not create an appreciable risk of adverse environmental impact or, if it would create an appreciable risk of adverse environmental impact, that the applicant would install technology to ''minimize'' adverse environmental impact. Such demonstrations would recognize that some entrainment and impingement mortality can occur without creating ''adverse environmental impact,'' but, where there is an appreciable risk of adverse environmental impact (e.g., population effects), the technology that would ''minimize'' it would be the technology that maximized net benefits. EPA determined that the annual compliance cost to industry for this option would be $24.9 million. EPA discusses why it is not accepting the industry's two-track approach in full in Section V.D below.

EPA also considered a waterbody-based two track option. Under this option, Track I would require, depending on the waterbody type, screens, fish return systems, or reduction in capacity to a level commensurate with that achievable by use of a closed-cycle cooling system. The delineation of waterbody types would correlate with greater or lesser potential for impingement and entrainment. Under Track II , a permit applicant would be able to demonstrate how alternative technology performance measures would reduce impingement mortality and entrainment for all life stages of fish and shellfish to a level of reduction comparable to the level that would be achieved under Track I.

EPA did consider a two-track option based on dry cooling. EPA did not promulgate this option for reasons discussed at Section V.C. of this preamble for not adopting dry cooling as best technology available for minimizing adverse environmental impact. In addition, there are very limited alternatives for achieving a dry cooling-level reduction in impingement and entrainment in a second track. EPA did not select this option because other available technologies that are economically practicable achieve significant reduction in impingement and entrainment at far lower cost.

B. Why EPA Is Establishing EPA's Preferred Two-Track Option as the Best Technology Available for Minimizing Adverse Environmental Impact?

For new facilities subject to this rule, EPA finds that the preferred two-track option represents the best technology available for minimizing adverse environmental impact. With respect to new facilities, the technologies used as the basis for this option are commercially available and economically practicable for the industries affected as a whole, and have acceptable energy impacts. EPA estimates that only nine electric generators who were planning to install a once-through cooling system will have to install recirculating wet cooling towers as a result of this rule. The energy impacts associated with these nine facilities is estimated to comprise only 0.026 percent of total new electric generating capacity. Similarly, the technologies used as the basis for this option also have acceptable non-aquatic environmental impacts. The non-aquatic environmental impacts associated with increased air emissions (SO_2, NO_2, CO_2, and Hg) is very small. The increased SO_2, NO_X, CO_2, and Hg attributed to the nine facilities that would be required to install recirculating wet cooling towers in lieu of once-through cooling systems is negligible in comparison to the total annual air emissions from new power plants. EPA finds that the requirements contained in the preferred two-track approach meet the requirement of section 316(b) of the CWA that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact. The components of the two-track approach are illustrated in Appendix 1 to this preamble.

1. What Are the Performance Requirements for the Location, Design, Construction, and Capacity for Cooling Water Intake Structures?

Under the final rule, EPA has adopted a two-track approach. Under Track I, for facilities with a design intake flow equal to or greater than 10 MGD, the capacity of the cooling water intake structure is restricted, at a minimum, to a level commensurate with that which could be attained by use of a closed-cycle recirculating system. Then for facilities with a design intake flow equal to or greater than 2 MGD, the design through-screen intake velocity is restricted to 0.5 ft/s and the total quantity of intake is restricted to a proportion of the mean annual flow of a freshwater river or stream, or to maintain the natural thermal stratification or turnover patterns (where present) of a lake or reservoir except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies), or to a percentage of the tidal excursions of a tidal river or estuary. In addition, an applicant with intake capacity greater than 10 MGD must select and implement an appropriate design and construction technology for minimizing impingement mortality and entrainment if certain conditions exist. (Applicants with 2–10 MGD flows are not required to reduce capacity but must install technologies for reducing entrainment at all locations.) Under Track II, the applicant has the opportunity to demonstrate that impacts to fish and shellfish, including important forage and predator species, within the watershed will be comparable to these which you would achieve were you to implement the Track I requirements for capacity and design velocity. See § 125.84(b)(1) and (2). Proportional flow requirements also apply under Track II.

a. Capacity

In Track I, all new facilities with cooling water intake structures having a design intake flow equal to or greater than 10 MGD must:

Reduce the total design intake flow to a level, at a minimum, commensurate with that which can be attained by a closed-cycle recirculating cooling water system using minimized make-up and blowdown flows.

Reducing the cooling water intake structure's capacity is one of the most effective means of reducing entrainment (and impingement). Capacity includes the volume of water that can be withdrawn through a cooling water intake structure over a period of time. Limiting the volume of the water withdrawn from a waterbody typically reduces the number of aquatic organisms in that waterbody that otherwise would be entrained. Under Track I, EPA requires that all new facilities, with intake flows equal to or greater than 10 MGD, limit their flow to a level commensurate with that which could be attained by use of a closed-cycle recirculating cooling water system using minimized make-up and blowdown flows. *See* § 125.84 (b)(1).

Closed-cycle, recirculating cooling water systems are known to reduce the amount of cooling water needed and in turn to directly reduce the number of aquatic organisms entrained in the cooling water intake structure. For the traditional steam electric utility industry, facilities located in freshwater areas that have closed-cycle recirculating cooling water systems can, depending on the quality of the make-up water, reduce water use by 96 to 98 percent from the amount they would use if they had once-through cooling water systems. Steam electric generating facilities that have closed-cycle recirculating cooling water systems using salt water can reduce water usage by 70 to 96 percent when make-up and blowdown flows are minimized.[31]

Manufacturing facilities that reuse and recycle water withdrawn from a water of the U.S. in a manner that reduces intake flow to a level commensurate with that which can be attained by a closed-cycle, recirculating cooling water system that has minimized make-up and blow down flows will be in accordance with the rule. *See* § 125.86(b)(1). For purposes of this regulation, EPA considers reuse and recycling at manufacturing facilities to be equivalent to closed-cycle, recirculating cooling water systems at steam-electric power plants.

Although EPA has not projected that any once-through electric generating facilities with an intake capacity of less than 10 MGD will be built in the next 20 years, EPA acknowledges that projecting the numbers and characteristics of facilities over long timeframes may lead to uncertainties in EPA's analysis. (*See* Sections 5.1.4 and 5.2.4 of the Economic Analysis for a discussion of uncertainties and limitations in EPA's baseline projections of new facilities.) In the event that such facilities might be built in the future (for example, as a stand-alone, combined-cycle, cogeneration facility associated with a manufacturer), EPA has concluded that the application of the intake capacity requirements in the selected option is not economically practicable for facilities with the smallest cooling water intake structures, those that withdraw less than 10 MGD. Based on EPA's estimate, the compliance cost-to-revenue ratio for combined-cycle facilities with these flows is 4.9 to 8.8 percent or higher. Even if these facilities installed a closed-cycle recirculating cooling system to reduce dynamic flow below the regulatory threshold for this rule and avoided all other costs of the rule, their cost-to-revenue ratio still would be from 2 to 3.2 percent or more (and they

[31] The lower range would be appropriate where State water quality standards limit chloride to a maximum increase of 10 percent over background and therefore require a 1.1 cycle of concentration. The higher range may be attained where cycles of concentration up to 2.0 are used for the design.

still might have to bear additional cost to comply with requirements the Director establishes on a case-by-case basis). EPA's analysis shows that the costs for all such facilities generally would be far above the range of impacts for facilities above 10 MGD, which have, compliance cost to-revenue ratios at or below 0.5 percent for more than 70 facilities, between 2 and 3 percent for only six facilities, and above 3 percent for only 3 facilities. EPA believes that the economic impact of complying with the rule would be disproportionate for electric generating facilities with flows below 10 MGD. Thus, the Agency is exercising its discretion under section 316(b) of the CWA to determine what is economically practicable and is creating specific requirements in Track I available to facilities with flows between 2 and 10 MGD. *See* § 125.84(c). These facilities are required to meet the same velocity, proportional flow, and the design and construction technology requirements for impingement that apply in § 125.84(b). *See* § 125.84(c)(1), (2) and (3). However, they are not required to reduce intake flow commensurate with use of a closed-cycle recirculating cooling system. Instead, they are required use design and construction technologies for minimizing entrainment at all locations. *See* 125.84(c)(4). EPA believes that the requirements of § 125.84(c) are an economically practicable way for these facilities to reduce impingement mortality and entrainment. EPA has made similar decisions in establishing technology-based effluent limitations guidelines and standards under 301 and 306, see e.g., Texas Oil & Gas Ass'n v. U.S. EPA, 161 F.3d 923, 940 (5th Cir. 1998) (Court upheld EPA's subcategorization for Cook Inlet based upon disproportionate economic impact).

b. Design and Construction Technologies

i. Velocity

Intake velocity is one of the key factors that can affect the impingement of fish and other aquatic biota. In the immediate area of the intake structure, the velocity of water entering a cooling water intake structure exerts a direct physical force against which fish and other organisms must act to avoid impingement or entrainment. EPA considers velocity to be an important factor that can be controlled for minimizing adverse environmental impact at cooling water intake structures. Because velocity can be minimized through appropriate design of the intake structure relative to intake flow, it is most easily addressed during the design and construction phase of a cooling water intake structure. Alternatively, the facility can install certain hard technologies (e.g., wedgewire screens and velocity caps) to change the configuration of the structure so that the effects of velocity on aquatic organisms are minimized.

Under Track I, for a facility with a design intake flows equal to or greater than 2 MGD, the final regulation requires that the maximum design through-screen velocity at each cooling water intake structure, be no more than 0.5 ft/s. See § 125.84(b)(2). The design through-screen velocity is defined as the value assigned during the design phase of a cooling water intake structure to the average speed at which intake water passes through the open area of the intake screen (taking fouling into account) or other device against which organisms might be impinged or through which they might be entrained.

To develop an appropriate minimum velocity requirement at cooling water intake structures that will be effective in contributing to the overall reduction in impingement, EPA reviewed available literature, State and Federal guidance, and regulatory requirement. EPA found that an approach velocity of 0.5 ft/s has been used as guidance in at least three Federal documents.[32 33 34] The 0.5 ft/s approach velocity threshold recommended in the Federal documents is based on a study of fish swimming speeds and endurance performed by Sonnichsen et al. (1973).[35] This study was based on an unknown number of individuals from about 30 different species of fish and eels, with many of the data for adult fish. The three Federal documents recommending a 0.5 ft/s intake velocity often referred to one another or had no references. The lack of abundant and diverse data led EPA to adopt a safety factor to ensure an appropriate level of protection for aquatic organisms. This study concluded that appropriate velocity thresholds should be based on the fishes' swimming speeds (which are related to the length of the fish) and endurance (which varies seasonally and is related to water quality). The data presented showed that the species and life stages evaluated could endure a velocity of 1.0 ft/s. To develop a threshold that could be applied nationally and is effective at preventing impingement of most species of fish at their different life stages, EPA applied a safety factor of two to the 1.0 ft/s threshold to derive a threshold of 0.5 ft/s. This safety factor, in part, is meant to ensure protection when screens become partly occluded by debris during operation and velocity increases through portions of the screen that remain open. EPA compiled the data from three studies on fish swim speeds (University of Washington study, Turnpenny, and EPRI) into a graph. The data suggest that a 0.5 ft/s velocity would protect 96 percent of the tested fish. EPA recognizes that there may be specific circumstances and species for which the 0.5 ft/s requirement might not be sufficiently effective. When issuing NPDES permits, the permit directors will need to comply with any applicable requirements under the Endangered Species Act (ESA). Both the National Marine Fisheries Service and the California Department of Fish and Game have developed fish screen velocity criteria.[36 37 38] Under section 510 of the Clean Water Act (CWA) States may impose additional requirements pursuant to State law. When EPA issues an NPDES permit, States may condition the permit pursuant to their certification authority under section 401 of the CWA.

Two velocities are of importance in the assessment and design of cooling water intake structures: the approach velocity and the through-screen or through-technology velocity. The approach velocity is the velocity measured just in front of the screen face or at the opening of the cooling water intake structure in the surface water source, and is biologically the most important velocity. The design through-screen or through-technology velocity is the velocity measured through the screen face or just as the organisms are

[32] Boreman, J. 1977. Impacts of power plant intake velocities on fish. Power Plant Team, U.S. Fish and Wildlife Service.

[33] Christianson, A. G., F. H. Rainwater, M.A. Shirazi, and B.A. Tichenor. 1973. Reviewing environmental impact statements: power plant cooling systems, engineering aspects, U.S. Environmental Protection Agency (EPA), Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon, Technical Series Report EPA–660/2–73–016.

[34] King, W. Instructional Memorandum RB–44: Review of NPDES (National Pollutant Discharge Elimination System) permit applications processed by the EPA (Environmental Protection Agency) or by the State with EPA oversight.'' In: U.S. Fish and Wildlife Service Navigable Waters Handbook.

[35] Sonnichsen, J.C., Bentley, G.F. Bailey, and R.E. Nakatani. 1973. A review of thermal power plant intake structure designs and related environmental considerations. Hanford Engineering Development Laboratory, Richland, Washington, HEDL–TME 73–24, UC–12.

[36] National Marine Fisheries Service Northwest Region. 1995. Juvenile Fish Screen Criteria.

[37] National Marine Fisheries Service, Southwest Region. 1997. Fish Screening Criteria for Anadromous Salmonids. Published on the Internet at *http://swr.ucsd.edu/hcd/fishscrn.htm* (access date).

[38] California Department of Fish and Game. 1997. Fish screening criteria.

passing through the opening into another device (e.g., entering the opening of a velocity cap). The through-screen velocity is always greater than the approach velocity because the net open area is smaller.

For this final rule, EPA uses the design through-screen velocity as a component of best technology for minimizing adverse environmental impact. EPA anticipates that design through-screen velocity will be simpler to calculate, and monitor (via measurement of head loss) and be more accurate than measuring approach velocity. The approach velocity is a point function. When the cross-section of an intake structure is large, the approach velocity will not be the same at all points across all points in a single cross-section. The approach velocity varies depending on where it is measured: how far from the surface, how far in front of the screen, or the location across the screen. Approach velocity also varies with the number of measurements taken; is 1 taken, or 10? Furthermore, it is much easier to design the intake structure to achieve a specific through-screen velocity. EPA notes that design through-screen velocity will be easier to implement because a number of technologies use it as the standard measure for intake design. In conjunction with the design intake velocity requirement, EPA requires new facilities to monitor the head loss across the screens or other technology on a quarterly basis. See § 125.87(b). EPA requires that head loss across the screens (or other appropriate measurements for technologies other than intake screens) be monitored and correlated with intake velocity once the facility is operating.

ii. Other Design and Construction Technologies

The final rule requires facilities withdrawing more than 10 MGD that choose Track I to select and install design and construction technologies for minimizing impingement mortality and/or entrainment if they locate in certain areas where fish or shellfish resources need additional protection. *See* § 125.84(b)(4) and (5). Facilities withdrawing between 2 and 10 MGD may meet a different set of Track I requirements. *See* § 125.84(c). If they choose to do so, the rule specifies that they must meet the same design and construction requirements to reduce impingement as applies to facilities withdrawing greater than 10 MGD. However, to reduce entrainment, instead of requiring a reduction in intake flow commensurate with use of a closed-cycle recirculating cooling water system, the rule requires these facilities to select and install design and construction technologies at all locations. *See* § 125.84(c)(3) and (4).

EPA is requiring these technologies in Track I because they are technically available, economically practicable and they effectively further reduce impingement mortality and entrainment at new facilities that choose to locate in areas where fish and shellfish resources need additional protection. EPA notes that facilities with closed-cycle recirculating cooling systems can still withdraw large volumes of cooling water, particularly if they operate in brackish or other waters where high rates of recirculation cannot be achieved, and may still impinge or entrain large numbers of aquatic organisms. Thus, EPA believes that facilities that choose to locate in areas where fish and shellfish need additional protection should install these technologies to further reduce impingement mortality and entrainment.

In the Track I requirements at § 125.84(c), which apply to facilities with cooling water intakes between 2 and 10 MGD that choose not to meet the capacity reduction requirements in § 125.84(b), the rule requires these facilities to meet the same design and construction requirements for minimizing impingement mortality as are required for facilities withdrawing greater than 10 MGD, *See* § 125.84(c)(3). These impingement requirements apply if the facility locates where fish and shellfish resources need additional protection. Facilities between 2 and 10 MGD that choose not to meet the capacity reduction requirements in § 125.84(b), however, must install design and construction technologies for reducing entrainment at all locations. *See* § 125.84(c)(4). EPA makes this distinction because, for economic practicality reasons, today's rule does not require smaller new facilities to reduce intake flow commensurate with a closed-cycle recirculating cooling system. In this case, EPA believes that use of design and construction technologies is an alternative, economically practicable and technically available means for reducing entrainment.

Today's rule does not require facilities choosing Track II to install design and construction technologies as specified under 125.84(b)(4) and (5) or 125.84(c)(3) and (4). EPA believes that such facilities will use these technologies, at least in part, to meet the Track II comparability requirements at 125.84(c)(1) and thus achieve comparable performance.

As used in these provisions, ''minimize'' means to reduce to the smallest amount, extent, or degree reasonably possible. *See* § 125.83. Technologies that minimize impingement mortality and entrainment of all life stages of fish and shellfish at a location might include, but are not limited to, intake screens, such as fine mesh screens and aquatic filter barrier systems, that exclude smaller organisms from entering the cooling water intake structure; passive intake systems such as wedgewire screens, perforated pipes, porous dikes, and artificial filter beds; and diversion and/or avoidance systems that guide fish away from the intake before they are impinged or entrained. In some cases, technologies that might be used to achieve the 0.5 ft/s velocity standard at § 125.85(b)(2) and § 125.85(c)(1), such as passive intake systems, might also minimize impingement mortality and entrainment.

Some technologies minimize impingement mortality by maximizing the survival of impinged organisms. These technologies include, but are not limited to, fish-handling systems such as bypass systems, fish buckets, fish baskets, fish troughs, fish elevators, fish pumps, spray wash systems, and fish sills. These technologies either divert organisms away from impingement at the intake structure, or collect impinged organisms and protect them from further damage so that they can be transferred back to the source water at a point removed from the facility intake and discharge points.

Some additional design and construction technologies have feasibility issues limiting their use to certain types of locations. Some have not been used on a widespread basis above certain intake flow rates. The effectiveness of these technologies also may vary depending on factors such as the speed and variability in direction of currents in a waterbody, the degree of debris loading at a location, etc. Because of these issues, EPA has not established a national performance standard for these technologies more specific than to require the applicant to study literature and available physical and biological data on their proposed location, and then to select and install technology(ies) that minimize impingement mortality and entrainment. (As stated above, ''minimize'' is defined as a reduction ''to the smallest amount, extent or degree reasonably possible.'')

In Track I of the final rule, EPA does not require an applicant that installs design and construction technology(ies) to seek the approval of the Director regarding which design and construction technology(ies) it selects, nor does EPA require the applicant to conduct biological monitoring prior to submitting its application. Rather, to avoid permitting delays Track I only requires the applicant to gather and present historical information and/or literature to support its decision on which design and construction technology(ies) to implement at the new facility. *See* § 125.86(b)(4).

Because an applicant does not need the Director's approval of its design and construction technology(ies) prior to the first permit, EPA has included a provision that requires the Director to determine, at each permit reissuance, whether design and construction technologies at the facility are minimizing impingement mortality and/ or entrainment, *See* § 125.89(a)(2). This provision is intended to ensure that the applicant selects and installs appropriate technology(ies).

The framework of these provisions balances a number of factors. One is EPA's interest in ensuring that applicants seeking their first permit under Track I can quickly obtain one without delay and, if they wish, without engaging in a dialogue with the Director about whether additional design and construction technologies are needed at their site, or which technologies will reasonably reduce impingement mortality and entrainment at the location. In this case, an applicant may wish to install some of the more highly protective additional design and construction technologies, to minimize any opportunity for disagreement with the Director at permit reissuance about whether the applicant chose technologies that ''minimize'' impingement mortality and entrainment at their location.

Alternatively, an applicant under § 125.84(b) who is willing to take the time to engage in a dialogue with the Director prior to the first permit under Track I may be able to obtain the Director's concurrence on a finding that the proposed intake will not be located in an area where fish or shellfish resources need additional protection. *See* § 125.84(b)(4) and (5) for a list of such areas. In this case, the applicant may not need to install any additional design and construction technologies. In the event that the location of the intake structure is such that additional technologies are required, an applicant who is willing to take the time to consult with the Director prior to the first permit under Track I may be able to obtain the Director's concurrence that technologies that are less costly than the most highly-protective ones available are sufficient for its location. (EPA again notes that ''minimize'' is defined as a reduction ''to the smallest amount, extent or degree reasonably possible.'')

EPA believes the above framework reasonably balances its interest in minimizing permit delays with its interest in ensuring that applicants willing to take more time and engage in a dialogue with the Director may have an opportunity to reduce their costs. As a general matter, EPA strongly encourages permit applicants to consult with the Director prior to selecting and installing design and construction technology(ies). Today's rule, however, requires no such consultation, and, as discussed elsewhere in this preamble, EPA's costing analysis conservatively assumes that permittees will install additional design and construction technologies at all locations.

EPA recognizes that the condition of biological resources at a location may change over time. The requirement for the Director to review the applicant's design and construction technologies at permit reissuance provides an opportunity for any appropriate changes in the design and construction technologies used at the location. *See* § 125.89(a)(2).

c. Location

Although EPA recognizes that the location of a cooling water intake structure can be a factor that affects the environmental impact caused by the intake structure, today's final rule, apart from the proportional flow requirements, does not include specific national requirements for new facilities based on location of the cooling water intake structure. In EPA's view, the optimal design requirement for location is to place the inlet of the cooling water intake structure in an area of the source waterbody where impingement and entrainment of organisms are minimized by locating intakes away from areas with the potential for high productivity (taking into account the location of the shoreline, the depth of the waterbody, and the presence and quantity of aquatic organisms or sensitive habitat). EPA received significant and convincing comments arguing against the specific proposed requirements and feasibility for locations based on waterbody type and location within the waterbody. Among other things, commenters argued that EPA's proposed requirements would be difficult to implement and relied on generalizations about types of waterbodies that were too simplistic. See section VI.C for further discussion of comments and EPA's responses regarding location. This topic is discussed further in Chapter 5 of the *Technical Development Document.*

Although today's rule does not specifically establish location requirements, several components of the two-track approach inherently consider location as a factor. Under Track I, location is a consideration when the applicant selects and implements the design and construction technologies for minimizing impingement and entrainment and maximizing impingement survival. In addition, EPA estimated that in order to meet the proportional flow requirements in Track I and Track II, facilities may need to site in locations that can support their water withdrawals or find other alternatives, such as, obtaining water from ground water, grey water, or a public water supply system. Under Track II, the new facility may choose location as a key component for minimizing impingement and entrainment. Under Track II, an applicant has the opportunity to conduct site-specific studies to demonstrate that alternative technologies or configurations, including the relocation of an intake to areas of less sensitivity, will reduce impingement mortality and entrainment for all life stages of fish and shellfish to a level of reduction comparable to the level that would be achieved were the applicant to implement the technology-based performance requirements in Track I.

In addition, this new facility rule also regulates location as a performance characteristic of new facilities to minimize entrainment and other adverse environmental impacts that are likely to occur as a result of the withdrawal of makeup water even where a facility uses recirculating systems. Historically, some previous CWA section 316(b) studies conducted for permits proceedings have considered potential impacts from facilities whose cooling water intake flow is large in proportion to the source water flow or tidal volume.[39] [40] [41] Under this rule, §§ 125.84(b)(3), 125.84(c)(2), and 125.84(d)(2), EPA establishes proportional flow requirements for new facility cooling water intake structures located in freshwater rivers and streams, lakes and reservoirs, and estuaries and

[39] Lewis, Randall B. and Greg Seegert. Entrainment and Impingement Studies at two Power Plants on the Wabash River in Indiana. Power Plants & Aquatic Resources: Issues and Assessment. *Environmental Science & Policy.* Volume 3, Supplement 1. September 2000.

[40] Public Service Indiana. 316(b) Demonstration for the Cayuga and Wabash River Generating Stations. Prepared by Dames and Moore, Cincinnati, Ohio. August 30, 1997.

[41] Public Service Company of Indiana. A 316(b) Study and Impact Assessment for the Cayuga Generating Station. Prepared by EA Science and Technology, Northbrook, IL. April 1988.

tidal rivers, requiring that the total design intake flow from all cooling water intake structures at a facility withdrawing:

• From a freshwater river or stream must be no greater than five (5) percent of the source waterbody mean annual flow;

• From a lake or reservoir must not disrupt the natural thermal stratification or turnover pattern (where present) of the source water except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies);

• From estuaries or tidal rivers must be no greater than one (1) percent of the volume of the water column in the area centered about the opening of the intake with a diameter defined by the distance of one tidal excursion at the mean low water level.

EPA finds these proportional flow limitations to represent limitations on capacity and location that are technically available and economically practicable for the industry as a whole. EPA examined the performance of existing facilities based on section 308 questionnaire data in terms of proportional flow in order to determine what additional value could be used as a safeguard to protect source waters against entrainment, especially in smaller waterbodies or in waterbodies where the intake is disproportionately large as compared to the source water body. (In practice, EPA expects that these requirements would require a facility to relocate or obtain water from another source, e.g., a public water supply or groundwater, only in smaller waterbodies, because no new facilities in larger waterbodies that use wet recirculating cooling systems would ever run afoul of these requirements.) In order to assess the performance of new facilities in meeting these requirements, EPA examined the performance of existing facilities and determined that 90 percent of existing facilities in freshwater rivers and streams and 92 percent of existing facilities in estuaries or tidal rivers meet these requirements. Based on documents included in the record, EPA also believes that most existing facilities meet the proportional flow requirement for lakes and reservoirs. EPA expects that new facilities would have even more potential to plan ahead to select locations and design intake capacity that meet these requirements. EPA recognizes that these requirements are conservative in order to account for the cumulative impact of multiple facilities' intakes. The 1 percent value for estuaries reflects that the area under influence of the intake will move back and forth near the intake and that withdrawing 1 percent of the volume of water surrounding the intake twice a day over time would diminish the aquatic life surrounding the intake. The 5 percent value for rivers and streams reflects an estimate that this would entrain approximately 5 percent of the river or stream's entrainable organisms and a policy judgment that a greater degree of entrainment reflects an inappropriately located facility. Because they are overwhelmingly achievable for new facilities, EPA believes they are appropriate to this new facility rule.

Proportional flow limitations are one way to provide protection for aquatic life and enhancement of commercial and recreational uses of source waters. Larger proportionate withdrawals of water may result in commensurately greater levels of entrainment. Entrainment impacts of cooling water intake structures are closely linked to the amount of water passing through the intake structure, because the eggs and larvae of some aquatic species are free-floating and may be drawn with the flow of cooling water into an intake structure. Sizable proportional withdrawals from a stream or river might also change the physical character of the affected reach of the river and availability of suitable habitat, potentially affecting the environmental or ecological value to the aquatic organisms. In lakes or reservoirs, the proportional flow requirement limits the total design intake flow to a threshold below which it will not disrupt the natural thermal (and dissolved oxygen) stratification and turnover pattern (where present) of the source water except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies). See § 125.84(b)(3)(ii). The proportional flow requirement for lakes and reservoirs would primarily protect aquatic organisms in small to medium-sized lakes and reservoirs by limiting the intake flow to a capacity appropriate for the size of the waterbody. In estuaries and tidal rivers, EPA's proportional flow requirement uses a volume that relates specifically to the cooling water intake structure and the area it influences (see § 125.83). Organisms in this area of influence travel back and forth with the tides and so may be exposed to the intake multiple times. The proportional flow requirement for estuaries and tidal rivers will limit the withdrawal of a sizable proportion of the organisms within the area of influence, commensurately reducing the entrainment of aquatic organisms.

d. Additional and Alternative Best Technology Available Requirements

At § 125.84(e), the final rule recognizes that a State may, under sections 401 or 510 of the CWA, ensure the inclusion of any more stringent requirements relating to the location, design, construction, and capacity of a cooling water intake structure at a new facility that are necessary to ensure attainment of water quality standards, including designated uses, criteria, and antidegradation requirements.

EPA interprets the CWA to authorize State and Tribal permit authorities to require more stringent limitations on intake where necessary to protect any provision of State law, including State water quality standards. Commenters have asserted that EPA does not have such authority under CWA section 301(b)(1)(C), arguing that authority is limited to controls on discharges of pollutants. Leaving that question open, there is ample authority under CWA sections 510 and 401, as is consistent with the goals of the CWA articulated in section 101 of the CWA, to provide EPA ample authority for such a provision. Section 510 of the CWA provides, in relevant part:

> Except as provided in this Chapter, nothing in this chapter shall (1) preclude or deny the right of any State or political subdivision therefore * * * to adopt or enforce * * * (B) any requirement respecting control or abatement of pollution * * * except that if an * * * other limitation * * * or standard of performance is in effect under this chapter, such State * * * may not adopt or enforce any * * * other limitation * * * or standard of performance which is less stringent than the * * * other limitation * * * or standard of performance under this chapter.

EPA interprets this to reserve for the States the authority to implement requirements that are more stringent than the Federal requirements under state law. PUD No. I of Jefferson *County* v. *Washington Dep't of Ecology,* 511 U.S. 700, 705 (1994). (As recognized by section 510 of the Clean Water Act, 33 U.S.C. 1370, States may develop water quality standards more stringent than required by this regulation.). Further, section 401(d) of the CWA provides, in relevant part,

> Any certification provided under this section shall set forth any effluent limitations and other limitations, and monitoring requirements necessary to assure that any applicant for a Federal license or permit will comply with any applicable effluent limitations and other limitations, under section 1311 or 1312 of this title, standard of performance under 1316 of this title, or prohibition, effluent standard, or

pretreatment standard under section 1317 of this title, and with any other appropriate requirement of state law set forth in such certification, and shall become a condition on any Federal license or permit subject to the provisions of this section.''

In *PUD No. I of Jefferson County* v. *Dep't of Ecology,* 511 U.S. 700, 711 (1994), the Supreme Court held that this provision is not ''specifically tied to a 'discharge'.'' (''The text refers to the compliance of the applicant, not the discharge. Section 401(d) thus allows the State to impose 'other limitations' on the project in general to assure compliance with various provisions of the Clean Water Act and with ''any other appropriate requirement of State law.'') Thus, section 401(d) provides states with ample authority in their 401 certifications to require EPA to include any more stringent limitations in order to meet the requirements of state law. These two sections of the CWA further the objectives of the act to ''restore and maintain the chemical, physical, and biological integrity of the nation's waters,'' the interim goal to protect water quality and are consistent with the CWA policy to ''recognize, preserve, and protect the primary responsibility and rights of States to prevent, reduce, and eliminate pollution'' and ''to plan the development and use * * * of water resources.'' CWA sections 101(a) and (b).

2. What Technologies Are Available To Meet the Regulatory Requirements

a. Track I: Capacity

The technical availability of the two-track option is demonstrated by information in EPA's record showing that each component of Track I, the ''fast-track'' option, can be achieved through the use of demonstrated technologies. Intake capacity reduction commensurate with use of a wet closed-cycle recirculating cooling system as required by § 125.84(b)(1) can be achieved using a recirculating wet cooling tower or cooling pond. Such a closed-cycle recirculating cooling system is a commonly practiced technology among the new facilities controlled by this rule. The Technical Development Document shows that 67 percent of new in-scope facilities (10 new coal-fired power plants, 64 new combined-cycle power plants, and 7 manufacturing facilities) would install a closed-cycle recirculating cooling system independently of this rule.

While manufacturers use closed-cycle recirculating cooling systems to a lesser extent than do electric power generators, manufacturers also have opportunities to recycle or reuse their cooling water to reduce their water intake capacity. To examine the extent to which new manufacturing facilities are likely to reuse and recycle cooling water, the Agency reviewed the engineering databases that support the effluent limitations guidelines for several categories of industrial point sources. In general, this review identified extensive use of recycling or reuse of cooling water in documents summarizing industrial practices in the late 1970s and early 1980s, as well as increased recycling and reuse of cooling water in the 1990s. For example, the reuse of cooling water in the manufacturing processes was identified in the pulp and paper and chemicals industries, in some cases as part of the basis for an overall zero discharge requirement (inorganic chemicals). Other facilities reported reuse of a portion of the cooling water that was eventually discharged as process wastewater, with some noncontact cooling water discharged through a separate outfall or after mixing with treated process water.

For manufacturing facilities, flow reduction techniques differ between facilities and industry sectors. Facilities use unheated noncontact cooling water for condensing of excess steam produced via cogeneration; they use unheated contact and noncontact cooling water for in-process needs; and they frequently reuse process waters and wastewaters for contact and noncontact cooling.

The chemical and allied products sector and the petroleum refining sector demonstrate similar cooling water practices. Both sectors utilize cooling water for condensing of excess steam from cogeneration and for critical process needs. Most process cooling water is noncontact cooling water and generally is not reused as process water (though it may be recirculated). Paper and allied products facilities generally reuse cooling water and cogenerated steam throughout their processes (though the level to which this occurs differs among facilities). Primary metals industries utilize cooling water for contact and noncontact cooling and for condensation of steam from onsite electric power generation. Contrary to the other sectors, the primary metals industries have no general purpose for cogenerated steam in their processes.

In general, the cooling requirement for cogeneration in these manufacturing sectors is less than for the same power generated by utility and nonutility power plants. Regardless of this fact, this rule requires that the intake of water used for this purpose (and not reused as process water) must be minimized according to the same technology-based performance requirements as for other steam electric generating facilities. The condensing of excess steam from cogeneration is the same process at manufacturers as at utility and nonutility power plants. Therefore, EPA does not distinguish between requirements for this activity.

For the purposes of this regulation, EPA considers the withdrawal of water for use and reuse as both process and cooling water analogous to the reduction of cooling water intake flows achieved through the use of a recirculating cooling water system. For example, some facilities transfer excess process heat to a water stream and subsequently reuse the heated stream for other process purposes. In this case there is considerable conservation of water and energy by the reuse of cooling water. Alternatively, some facilities often withdraw water first for a process application and subsequently reuse it as cooling water. EPA encourages such practices and, in turn, considers these techniques analogous to flow reduction for the purposes of meeting the capacity reduction requirements of this rule. To meet the intake capacity requirements at § 125.84(b)(1) a new manufacturing facility must, to the maximum extent practicable, reuse and recycle cooling water withdrawn for purposes other than steam electric condensing. Cooling water intake used for the purposes of condensing of exhaust steam from electricity generation must be reduced to a level commensurate with that which can be attained by a closed-cycle recirculating cooling water system using minimized make-up and blowdown flows. EPA concludes that for manufacturers the capacity requirement meets the criterion of best technology available commercially at an economically practicable cost.

b. Track I: Velocity

EPA examined the technical feasibility of the required through-screen velocity of 0.5 ft/s. This requirement relies on the appropriate design of the intake structure relative to intake flow to reduce velocity or installation of certain hard technologies (e.g., wedgewire screens and velocity caps) to change the configuration of the structure so that the effects of velocity on aquatic organisms are minimized. EPA's record demonstrates that these designs and technologies are widely used in the industries subject to this rule. Since there are a number of intake technologies currently in use that are designed to meet a 0.5 ft/s through-screen velocity, the technologies that can achieve the Track I velocity technology-based performance requirement meet the criterion of best technology available commercially at an economically practicable cost.

The Agency also reviewed the data from the section 316(b) industry survey with respect to the velocity requirement § 125.84(b)(2). The preliminary results suggest that more than two-thirds of combined cycle and coal-fired electric generating facilities built within the past 15 years would meet the velocity requirement. These currently operating facilities demonstrate that a design intake velocity of 0.5 ft/s is achievable and provides for sufficient cooling water withdrawal.

c. Track I: Other Design and Construction Technologies

EPA also examined the technology availability of the design and construction requirements at § 125.84(b)(4) and (5) in the final rule. While EPA costed this requirement based on the assumption that a facility would install cylindrical wedgewire screen, or fish return systems on traveling screens, EPA's record demonstrates that there are a number of potentially effective design and construction intake technologies available for installation at cooling water intake structures for minimizing adverse environmental impact. The intake technologies that new facilities may consider are in one of four categories that include, but are not limited to,

• Intake screen systems: single-entry, single-exit vertical traveling screens; modified traveling screens (Ristroph screens); single-entry, single-exit inclined traveling screens; single-entry, double-exit vertical traveling screens; double-entry, single-exit vertical traveling screens (dual-flow screens); horizontal traveling screens; fine mesh screens mounted on traveling screens; horizontal drum screens; vertical drum screens; rotating disk screens; and fixed screens.

• Passive intake systems: wedgewire screens, perforated pipes, perforated plates, porous dikes, artificial filter beds, and leaky dams.

• Diversion or avoidance systems: louvers, velocity caps, barrier nets, air bubble barriers, electrical barriers, light barriers, sound barriers, cable and chain barriers, aquatic filter barrier systems, and water jet curtains.

• Fish handling systems: fish pumps, lift baskets, fish bypasses, fish baskets, fish returns, fish troughs, and screen washes.

d. Track II: Alternative Technologies

EPA also notes that certain facilities following Track II may be able to demonstrate reduction of impingement mortality and entrainment for all life stages of fish and shellfish to a level of reduction comparable to the level that would be achieved under Track I using lower-cost alternative technologies. Under 125.84(d), new facilities that choose to comply under Track II must reduce impacts to fish and shellfish, including important forage and predator species, within the watershed to a level comparable to that which would be achieved were they to implement the requirements of § 125.84(b)(1), and (2) under Track I.[42] EPA does not consider this requirement to mandate exactly the same level of reduction in impingement and entrainment as would be achieved under Track I. Rather, given the numerous factors that must be considered to determine the required level of reduction in impingement and entrainment for Track II and the complexity inherent in assessing the level of performance of different control technologies, EPA believes it is appropriate for a new facility following Track II to achieve reductions in impingement and entrainment that are 90 percent or greater of the levels achieved under Track I. EPA believes this approach is reasonable for the several reasons.

New facility determinations regarding flow or impingement and entrainment under Track I or Track II are, by necessity, estimates based on available data as well as certain assumptions. Such estimates have substantial value but cannot reasonably be expected to achieve a high level of precision. This is particularly true where, as here, impingement and entrainment rates must be correlated with reductions in flow (which are themselves estimated), reductions in intake velocity, and other design and construction requirements. It also is important to recognize that the efficacies of different design and construction technologies also are based on estimates that are inexact due to data limitations, variations in ambient conditions, and the presence or absence of different species, among other factors.

Available data suggests that alternative design and construction technologies for cooling water intake structures can achieve the level of reduction in impingement and entrainment required under Track II. For example, technologies such as fine and wide-mesh wedgewire screens, as well as aquatic filter barrier systems, have been shown to reduce mortality from impingement by up to 99 percent or greater compared with conventional once-through systems. In addition, other types of barrier nets may achieve reductions in impingement of 80 to 90 percent, and modified screens and fish return systems, fish diversion systems, and fine mesh traveling screens and fish return systems have achieved reductions in impingement mortality ranging from 60 to 90 percent greater than conventional once-through systems. Similarly, although there is less available full scale performance data regarding entrainment, aquatic filter barrier systems, fine mesh wedgewire screens, and fine mesh traveling screens with fish return systems have in certain places been shown to achieve 80 to 90 percent greater reduction in mortality from entrainment compared with conventional once-through systems. Examples of effective use of technologies that reduce impingement and/or entrainment include:

• Studies from 1996 to 2001 at Lovett Station (New York) show no obvious impingement/contact mortality using aquatic filter barrier systems;

• Fine mesh (0.5 mm) screen performance to reduce entrainment has consistently improved at Big Bend Units 3 and 4 (Florida) with better surveillance and maintenance, including biweekly cleaning of screens to prevent biofouling. The operator's 1988 monitoring data show an efficiency in screening fish eggs (primarily drum and bay anchovy) exceeding 95 percent. For fish larvae (primarily drum, bay anchovies, blennies, and gobies), it was about 86 percent. Latent survival of fish eggs has improved to 65 to 80 percent for drum, and 66 to 93 percent for bay anchovy;

• At the Brunswick Station (North Carolina), 1 mm fine mesh screens have been used on two of four traveling screens (only when temperatures are less than 18 degrees C). Total reduction of fish entrained by the fine mesh versus conventional screens has been found to be 84 percent;

• Wedgewire screens with slot sizes of one, two, and three millimeter were studied by the State of Maryland at the Chalk Point Station. One millimeter screens led to 80 percent exclusion of all species, including larvae. For fish

[42] These Track I provisions require that the new facility reduce its intake flow, at a minimum, to a level commensurate with that which can be attained by a closed-cycle recirculating cooling water system; desgin and construct each cooling water intake structure to a maximum through-screen design intake velocity of 0.5 ft/s; and select and implement design and construction technologies (e.g., wedgewire screens, fine mesh screens, fish handling and return systems, barriers nets, acquatic filter barrier systems) to minimize impingement and entrainment of all life stages of fish and shellfish and to maximize survival of impinged life stages of fish and shellfish.

with greater than 10 mm length, entrainment was eliminated.[43]

Several additional factors suggest that these performance levels can be improved upon. First, some of the cooling water intake structure technology performance data reviewed is from the 1970's and 1980's and does not reflect recent developments and innovation (e.g., aquatic filter barrier systems, sound barriers). Second, the conventional barrier and return system technologies characterized above have not been optimized on a widespread level to date, as would be encouraged by this rule. Such optimization can be best achieved by new facilities, which can match site conditions to available technologies. Third, EPA believes that many facilities could achieve further reductions (estimated 15–30 percent) in impingement and entrainment by providing for seasonal flow restrictions, variable speed pumps, and other innovative flow reduction alternatives.

e. Track II: Location

New facilities seeking to comply under Track II can use the location of their cooling water intake structures to achieve further reductions in impingement and entrainment. Location of the cooling water intake structure can be addressed during the planning and design phases of new facility construction. At that time, it may be possible to choose a particular waterbody type and a specific location on that waterbody where (considering the proposed capacity of the cooling water intake structure) the potential for impingement and entrainment is relatively low. The optimal design requirement for cooling water intake structure location is to place the inlet in an area of the source waterbody where impingement and entrainment of organisms are minimized, i.e., taking into account: the physical and chemical characteristics of the waterbody; the presence and location of sensitive habitats; and the composition, abundance, and spatial/temporal presence of aquatic organisms. It is well known that there are certain areas within every waterbody with increased biological productivity, and therefore where the potential for impingement and entrainment of organisms is greater (e.g., littoral zone in lakes, shore zone in rivers, nearshore coastal waters in oceans). Examples include the following.

- Near the Fort Calhoun Station on the Missouri River, transect studies in 1974 to 1977 indicated higher densities of fish larvae along the cutting bank of the river adjacent to the Station's intake structure and lower densities at the mid-channel location. While densities of fish larvae changed throughout the three month data collection period, the densities collected from the mid channel remained substantially less than those in the cutting bank location.[44]
- Catches of young striped bass from Suisun Bay near the Pittsburg Power Plant (May to July 1976) ranged from 0.062/m^3 to 0.496/m^3 in the center channel, and from 0.082/m^3 to 0.648/m^3 along the north shore. Weekly mean densities for striped bass were 0.215/m^3 in the center channel, and 0.320/m^3 along the north shore.[45]
- A study of densities in the Connecticut River in 1972 showed that fish tended to be more abundant in the more shallow areas near the east shore. Distributions of fish also changed depending upon the time of day and the depth in the water column.[46]

Biologically productive and/or sensitive areas that should be avoided during the intake siting process are those that serve to promote: the congregation and growth of aquatic organisms; the propagation of the early life stages of aquatic organisms (e.g., planktonic stages); and any life stage of a threatened or endangered species. Examples of these sensitive areas would include (but are not limited to) critical nursery areas, spawning grounds, important migratory pathways, refuge areas, and essential fish habitats. Other factors to consider in the intake siting process include the proximity to: aquatic sanctuaries/refuges; national parks, seashores and monuments; wilderness areas; areas of environmental concern or outstanding natural resource waters; and coral reefs. Conversely, potential examples of less-sensitive areas may include: areas outside of the limnetic zone (i.e., no light penetration); areas of significant oxygen depletion; and areas proven to have low densities of organisms.

f. Track II: Restoration

The purpose of section 316(b) is to minimize adverse environmental impact from cooling water intake structures. Restoration measures that result in the performance comparable to that achieved in Track I further this objective while offering a significant degree of flexibility to both permitting authorities and facilities.

EPA recognizes that restoration measures have been used at existing facilities implementing section 316(b) on a case-by-case, best professional judgment basis as an innovative tool or as a tool to conserve fish or aquatic organisms, compensate for the fish or aquatic organisms killed, or enhance the aquatic habitat harmed or destroyed by the operation of cooling water intake structures. Under Track II, this flexibility will be available to new facilities to the extent that they can demonstrate performance comparable to that achieved in Track I. For example, if a new facility that chooses Track II is on an impaired waterbody, that facility may choose to demonstrate that velocity controls in concert with measures to improve the productivity of the waterbody will result in performance comparable to that achieved in Track I. The additional measures may include such things as reclamation of abandoned mine lands to eliminate or reduce acid mine drainage along a stretch of the waterbody, establishment of riparian buffers or other barriers to reduce runoff of solids and nutrients from agricultural or silvicultural lands, removal of barriers to fish migration, or creation of new habitats to serve as spawning or nursery areas. Another example might be a facility that chooses to demonstrate that flow reductions and

[43] EPA acknowledge that there are a limited number of large facilities where alternative technologies have been used. However, the use of fine mesh screens at Brunswick and big Bend have shown performance levels exceeding 70–80 percent. Similarly, fine mesh wedgewire screens at Logan have used to reduce entrainment by 90 percent. While these sites draw water from tidally influenced rivers, they should be equally transferable to large, fresh water rivers in the midwest. In fact, reliability and likely performance should be better than a site such as Big Bend where the bifouling would be a greats issue. The ''actual'' examples are supported by laboratory testing showing the viability of fine mesh screens that was performed at Delmara Research, TVA, and the proposed Seminole Plant in Florida. These tests found entrainment reductions using fine mesh screens of greater than 90 percent. the use of an aquatic filter barrier system (i.e. gunderboom) at the Lovett Station in New York is entirely transferable to a large, Midwestern river system. This system is now providing consistently greater than 80 percent reductions in entrainment and has the potential to exceed 90 percent. The areas where aquatic filter barrier systems might not be effective/feasible include ocean locations with high waves, limited access areas, and places where navigation could be effected. Note that feasibility should be similar to other barrier net systems, which have been installed at a number of Great Lake sites, e.g., Ludington.

[44] King, R.G. 1977. Entrainment of Missouri River fish larvae Fort Calhoun Station. In: Jensen, L.D. (Ed.), *Fourth National Workshop on Entrainment and Impringement* EA Communications, Melville, NY, pp.45–56.

[45] Stevens, D.E. and B.J. Finlayson. 1977. Mortality of young striped bass entrained at two power plants in the Sacramento-San Joaquin Delta, California, In: Jensen, L.D. (Ed.), *Fourth National Workshop on Entrainment and Impingement.* EA Communications, Melville, NY, pp. 57–69.

[46] Marcy, B.C. 1974. Vulnerability and survival of young Connecticut River entrained at a nuclear power plant. In: Jensen, L.D. (Ed.), *Entrainment and Intake Screening: Proceedings of the Second Entrainment and Intake Screening Workshop.* Electric Power Research Institute Publication No. 74–049–00–5, Palo Alto, CA, pp. 281–288.

less protective velocity controls, in concert with a fish hatchery to restock fish being impinged and entrained with fish that perform a similar function in the community structure, will result in performance comparable to that achieved in Track I.

EPA recognizes that it may not always be possible to establish quantitatively that the reduction in impact on fish and shellfish is comparable using the types of measures discussed above as would be achieved in Track I, due to data and modeling limitations. Despite such limitations, EPA believes that there are situations where a qualitative demonstration of comparable performance can reasonably assure substantially similar performance. EPA is thus providing, in § 125.86, that the Track II Comprehensive Demonstration Study should show that either: (1) The Track II technologies would result in reduction in both impingement mortality and entrainment of all life stages of fish and shellfish of 90 percent or greater of the reduction that would be achieved through Track I (quantitative demonstration) or, (2) if consideration of impacts other than impingement mortality and entrainment is included, the Track II technologies will maintain fish and shellfish in the waterbody at a substantially similar level to that which would be achieved under Track I (quantitative or qualitative demonstration).

g. Track I and II: Proportional Flow

Finally, EPA examined the technical feasibility of the proportional flow reduction requirements at §§ 125.84(b)(3), 125.84(c)(2), and 125.84(d)(2) of the rule. EPA based this requirement, in addition to the closed-cycle recirculating cooling water technologies discussed above, on the use of groundwater, municipal sources of water, treated wastewater (grey water), and on locating facilities on waterbodies that can meet the proportional flow requirements.

EPA analyzed the potential siting implications of the proportional flow requirements and determined that within the United States approximately 131,147 river miles have sufficient flow to support the water usage needs of large manufacturing facilities withdrawing up to 18 MGD of water without exceeding the proportional flow limitations in this rule. Approximately 53,964 river miles could support a large non-utility power-producing facility withdrawing 85 MGD, and approximately 14,542 river miles could support a large utility plant requiring 700 MGD without exceeding of the proportional flow limitations in this rule. Under today's final rule, new facilities needing additional cooling water in other areas would need to supplement withdrawals from waters of the U.S. with other sources of cooling water or redesign their cooling systems to use less water.

As another gauge of the siting impacts of the flow requirement for new facilities, the Agency determined, from a 1997 database of the Energy Information Agency and a 1994 Edison Electric Institute database, that 89 percent of existing non-nuclear utility facilities could be sited at their current location under today's final requirements if they also operated in compliance with the capacity reduction requirements at § 125.84(b)(1). (Please note that the Agency does not intend to prejudge or signal in any way whether its final rule for existing facilities will or will not include capacity limitations commensurate with a level that could be attained by a recirculating cooling water system. EPA conducted this analysis to determine whether today's proportional flow requirements would unreasonably limit siting alternatives for new facilities only.)

Finally, to further examine the potential siting implications of today's rule for new facilities, the Agency reviewed data on water use by existing facilities in arid regions of the country. The Agency found that 80 percent of the existing facilities in Arizona, California, Nevada, New Mexico, Oklahoma, and Texas do not use waters of the U.S. in their operations, indicating that new facilities in these areas would similarly use waters other than waters of the U.S. in their operations. Therefore, today's final rule would not affect these facilities if they were being constructed as new facilities subject to the rule.

3. Why Is the Two-Track Option Economically Practicable?

EPA has determined that the two-track option is economically practicable for the industries affected by the rule. For the two-track option that does not distinguish between waterbody types, the cost of compliance to the industry is expected to be no more than $47.7 million annually. Because the Agency cannot predict precisely which track the projected facilities would choose and what the compliance response for Track II facilities would be, EPA estimated the costs based on the assumption that each new facility that does not plan to install a recirculating system in the baseline would choose to conduct the studies required of Track II but then implement the requirements of Track I. This is the most conservative cost estimate because it assumes the highest cost a facility could potentially incur. Presumably, the facilities will choose the most economically favorable track, which would imply that the lowest cost is most representative. For example, at Section VIII.B.3. below, EPA describes how a permit applicant locating a facility with a once-through cooling system in certain waters such as large rivers and reservoirs may be able to demonstrate reduction of impingement mortality and entrainment to a level of reduction comparable to the level that would be achieved if they complied with the Track I requirements. However, the expediency of permitting through Track I may result in reductions in financing costs and market advantages that may outweigh the potential technology cost savings of Track II. The cost estimates above do not incorporate any savings occurring from the increased certainty of Track I faster permitting and reduction in finance costs. As stated above, for new in-scope power plants, EPA's record shows that 64 new combined-cycle facilities and 10 new coal-fired facilities would install a closed-cycle recirculating cooling water system independently of the rule. As discussed in the *Economic Analysis,* for those that would not otherwise install a recirculating cooling system, EPA has determined that the capital costs of such an installation would be economically practicable and would not create a barrier to entry. By barrier to entry, EPA means the requirements would not present costs that would prevent a new facility from being built. For those facilities that would not otherwise install a recirculating cooling system, EPA estimates that the annualized cost of such an installation is $19.1 million for a large coal-fired plant (3,564 MW), $3.8 million for a medium coal-fired plant (515 MW), and $0.7 million for a small coal-fired plant (63 MW). For a large combined-cycle facility (1,031 MW), installation of a recirculating cooling water system would cost approximately $3.2 million annually.

EPA finds that the final rule is economically practicable and achievable nationally for the industries affected because a very small percentage of facilities within the industries are expected to be affected by the regulation and the impact on those that would be affected would be small. For today's final rule, EPA used the compliance cost/revenue test as a basis for determining that the requirements on a national level are economically practicable. EPA used the compliance cost/revenue test to assess economic achievability by comparing the magnitude of annualized compliance costs with the revenues the facility is expected to generate. Under this test, EPA has determined that on average, the rule will constitute 0.3, 1.2, and 0.14 percent of projected annual revenue for new combined-cycle power plants, coal-fired power plants, and manufacturing facilities, respectively. The cost to-revenue ratio is estimated to range from 0.7 percent to 5.2 percent of revenues for steam electric generating facilities and less than 0.1 percent to 0.5 percent of annual revenues for manufacturing facilities. None of the 38 projected new manufacturing facilities was estimated to incur annualized compliance costs greater than 1 percent of annual revenues. Based on EPA's analysis, the steam electric generating facilities projected to be in scope of this rule are able to afford these economic impacts. In general, the Agency concludes that economic impacts on the electric generating industry from this final rule would be economically practicable, because the facilities required to comply with the requirements would be able to afford the technologies necessary to meet the regulations.

Finally, since the analysis for new facilities entails some uncertainty because it reflects a projection into the future, EPA is maintaining in the final rule a provision in the regulation authorizing alternative requirements where data specific to the facility indicate that compliance with the requirement at issue would result in costs wholly out of proportion to the costs EPA considered in this analysis. See § 125.85 of this rule.

Considering the economic impacts on the electric generating industry as a whole, today's final rule only applies to those electric generating facilities that generate electricity with a steam prime mover and that meet certain requirements (e.g., have or need to have an NPDES permit, withdraw equal to or greater than 2 MGD from waters of the U.S.). As summarized in Exhibit 1 and Exhibit 2 above, an analysis of the NEWGen database shows that only 69 out of the 241 new combined-cycle facilities (28.6 percent) would be subject to this rule, and only 14 out of 35 new coal-fired facilities (40.5 percent).

For the manufacturer industry sectors with at least one new facility that is subject to this final rule, an analysis of the data collected using the Agency's section 316(b) Industry Detailed Questionnaire for existing facilities indicates that only 472 of the 1,976 nationally estimated existing facilities have an NPDES permit and directly withdraw cooling water from waters of the U.S. Of these 472 facilities, only 406 facilities are estimated to withdraw more than two (2) MGD. Of these 406 facilities, only 296 facilities are estimated to use more than 25 percent of their total intake water for cooling water purposes. Thus, this finding of economic practicability is further supported because only 15 percent of the manufacturing industry sectors will incur costs under this rule. According to EPA's analysis, economic impacts on the manufacturing facilities from this final rule would be economically practicable because the facilities projected to be in scope of this rule would be able to afford the technologies necessary to meet the regulations.

C. Why EPA Is Not Adopting Dry Cooling as the Best Technology Available for Minimizing Adverse Environmental Impact?

In establishing best technology available for minimizing adverse environmental impact the final rule, EPA considered an alternative based on a zero-intake flow (or nearly zero, extremely low flow) requirement commensurate with levels achievable through the use of dry cooling systems. Dry cooling systems (towers) use either a natural or a mechanical air draft to transfer heat from condenser tubes to air. In conventional closed-cycle recirculating wet cooling towers, cooling water that has been used to cool the condensers is pumped to the top of a recirculating cooling tower; as the heated water falls, it cools through an evaporative process and warm, moist air rises out of the tower, often creating a vapor plume. Hybrid wet-dry cooling towers employ both a wet section and dry section and reduce or eliminate the visible plumes associated with wet cooling towers.

In evaluating dry cooling-based regulatory alternatives, EPA analyzed a zero or nearly zero intake flow requirement based on the use of dry cooling systems as the primary regulatory requirement in either (1) all waters of the U.S. or (2) tidal rivers, estuaries, the Great Lakes, and oceans. The Agency also considered subcategorization strategies for the new facility regulation based on size and types of new facilities and location within regions of the country, since these factors may affect the viability of dry cooling technologies.

EPA rejects dry cooling as best technology available for a national requirement and under the subcategorization strategies described above, because the technology of dry cooling carries costs that are sufficient to pose a barrier to entry to the marketplace for some projected new facilities. Dry cooling technology also has some detrimental effect on electricity production by reducing energy efficiency of steam turbines and is not technically feasible for all manufacturing applications. Finally, dry cooling technology may pose unfair competitive disadvantages by region and climate. Further, the two-track option selected is extremely effective at reducing impingement and entrainment, and while the dry cooling option is slightly more effective at reducing impingement and entrainment, it does so at a cost that is more than three times the cost of wet cooling. Therefore, EPA does not find it to represent the ''best technology available'' for minimizing adverse environmental impact. EPA recognizes that dry cooling technology uses extremely low-level or no cooling water intake, thereby reducing impingement and entrainment of organisms to dramatically low levels. However, EPA interprets the use of the word ''minimize'' in CWA section 316(b) to give EPA discretion to consider technologies that very effectively reduce, but do not completely eliminate, impingement and entrainment as meeting the requirements of section 316(b) the CWA.

Although EPA has rejected dry cooling technology as a national minimum requirement, EPA does not intend to restrict the use of dry cooling or to dispute that dry cooling may be the appropriate cooling technology for some facilities. This could be the case in areas with limited water available for cooling or waterbodies with extremely sensitive biological resources (e.g., endangered species, specially protected areas). An application of dry cooling will virtually eliminate use of cooling water and impingement and entrainment, in almost all foreseeable circumstances, would reduce a facility's use of cooling water below the levels that make a facility subject to these national minimum requirements.

1. Barrier to Entry

EPA has determined that higher capital and operating costs associated with dry cooling may pose barrier to entry for some new sources in certain circumstances. (In general, barrier to entry means that it is too costly for a new facility to enter into the marketplace). A minimum national requirement based on dry cooling systems would result in annualized compliance cost of greater than 4 percent of revenues for all of 83 projected electric generators within the scope of the rule. For 12 generators, costs would exceed 10% of revenues. EPA's economic analysis demonstrates that a regulatory alternative based on a national minimum dry cooling-based requirement would result in annualized compliance costs to facilities of over $490 million, exceeding the annual costs of a regulation based on recirculating wet cooling towers by more than 900 percent ($443 million annually).

Because the technology can cause inefficiencies in operation under certain high ambient temperature conditions and because of the greater capital and operating costs of the dry cooling system compared with the industry standard of using recirculating closed-cycle wet cooling systems, requiring dry cooling as a minimum national requirement could, in some cases, also result in unfair competitive advantages for some facilities. Thus, while at least one state has required dry cooling, EPA does not believe it is appropriate to mandate this requirement on a national basis. In EPA's view the disparity in costs and operating efficiency of the dry cooling systems compared with wet cooling systems is considerable when viewed on a nationwide or regional basis. For example, under a uniform national requirement based on dry cooling, facilities in the southern regions of the U.S. would be at an unfair competitive disadvantage to those in cooler northern climates, far more than if the rule were not based on such a requirement. Even under the regional subcategorization strategy for facilities in cool climatic regions of the U.S., adoption of a minimum requirement based on dry cooling could impose unfair competitive restrictions for new facilities. This relates primarily to the elevated capital and operating costs associated with dry cooling. Adoption of requirements based on dry cooling for a subcategory of facilities under a particular capacity would pose similar competitive disadvantages for those facilities. Furthermore, EPA is concerned that requiring dry cooling for a subcategory of new facilities would create a disincentive to building a new combined-cycle facility (with associated lower flows) in lieu of modifying existing facilities, which may have greater environmental impacts. Dry cooling systems can cost as much as three times more to install than a comparable wet cooling system. For example, the Astoria Energy LLC Queens application filed with the State of New York indicated that a dry cooling system would cost $32 million more to install than a hybrid wet-dry cooling system for a proposed 1,000-MW plant. Operating costs would be $30 million more for the dry cooling system than the hybrid wet-dry system.[47] The State of New York estimates that use of a dry cooling system at the 1,080-MW Athens Generating Company facility would cost approximately $1.9 million more per year, over 20 years, than a hybrid wet-dry cooling system. The total dry cooled projected cost would be approximately $500 million. Because dry cooling systems are so much larger than wet cooling systems, these systems' operation and maintenance require more parts, labor, etc. Costs of this magnitude, when imposed upon one subcategory of facilities but not another, provide a disparate competitive environment, especially for deregulated energy markets. New facilities are competing against the many combined-cycle and coal-fired facilities already in the marketplace or slated for substantial expansion that use wet, closed-cycle cooling systems or even once-through cooling systems. The potential economic impact should EPA not similarly require dry cooling for some or all existing facilities might cause some firms to, at the least, delay their entry into the marketplace until they better understand the regulatory environmental costs faced by their competitors.

2. Energy Penalty and Other Non-Aquatic Impacts

Given the performance penalty of dry cooling versus wet cooling, the incremental air emissions of dry cooling as compared with wet cooling, provide additional support for why EPA is rejecting dry cooling. Dry cooling technology results in a performance penalty for electricity generation that is likely to be significant under certain climatic conditions. By ''performance penalty'' EPA means that dry cooling technology requires the power producer to utilize more energy than would be required with recirculating wet cooling to produce the same amount of power. EPA concludes that performance penalties associated with dry cooling tower systems pose a significant feasibility problem in some climates. As discussed in Chapter 3 of the *Technical Development Document*, EPA estimates the mean annual performance penalty of a dry cooling system relative to recirculating wet cooling towers at 1.7 and 6.9 percent for combined-cycle and coal-fired facilities, respectively. Peak-summer energy shortfalls for dry cooling towers as compared to wet towers can exceed 2.7 and 9.3 percent for combined cycle and coal-fired facilities, respectively. These performance penalties could have significant technical feasibility implications. For example, dry cooling facilities have as a design feature turbine back pressure limits that often trigger a plant shut down if the back pressure reaches a certain level. Peak summer effects of inefficiency of dry cooling can and do cause turbine back pressure limits to be exceeded at some demonstrated plants which in turn experience shutdown conditions when the back pressure limits are reached. In addition, these performance penalties could pose potential power supply and reliability issues if dry cooling were required on a nationwide or regional basis. For example, EPA estimates that in hot climates dry cooling equipped power plants experience peak summer energy penalties of 3.4 to 4.3 percent for combined cycle plants and 14.8 to 19.4 percent for coal fired plants, as compared to once-through cooling systems. These peak summer penalties represent significant reductions in production at power plants in periods when demand is greatest. Compared to the selected option which a large majority of new facilities were planning to install independent of this rule, all 83 electric generators would be required to install dry cooling technology. The energy impacts (power losses) associated with these 83 facilities is estimated to comprise 0.51 percent of total new electric generating capacity (i.e., a reduction in new design generating capacity of 1,904 MW). These energy impacts raise the concern that on a large scale, dry cooling technology may affect electricity supply reliability. This significant reduction in electricity production is another reason EPA has not selected dry cooling as the best technology available for minimizing adverse environmental impacts on a nationwide or regional basis.

Because of the performance penalty, power producers using dry cooling produce more air emissions per kilowatt-hour of energy produced. Nationally, EPA estimates that a minimum requirement based on dry cooling would cause significant air emissions increases over wet cooling systems. EPA projects for the dry cooling alternative that CO_2, NO_X, SO_2, and Hg emissions would increase by 8.9 million, 22,300, 47,000, and 300 pounds per year, respectively. See Chapter 3 of the *Technical Development Document* for more information on EPA's air emissions analysis, including a discussion of the coincidence between maximum air emissions and the periods of the most severe air pollution problems. These additional non-aquatic

[47] Astoria Energy LLC Queens Facility Application.

environmental impacts (in the form of air emissions) further support EPA's determination that dry cooling does not represent best technology available for minimizing adverse environmental impact on a national or region-specific basis.

3. Cost-Effectiveness

EPA also considered the incremental costs and impingement and entrainment reduction between the selected option and dry cooling. Dry cooling, while very effective in reducing impingement and entrainment, is very expensive to implement. EPA understands that dry cooling can virtually eliminate the need for cooling water and therefore dramatically reduces impingement and entrainment. However, EPA has determined that the costs associated with implementing dry cooling are ten times as expensive as wet cooling. EPA has shown that the selected option, requiring facilities to reduce their intake flows to a level commensurate with that which can be attained by a closed-cycle, recirculating cooling water system, would reduce the amount of water withdrawn for cooling purposes by 70 to 98 percent. In addition, EPA has shown that this would result in corresponding reductions in impingement and entrainment. Further, the record shows that other requirements in the rule, such as velocity and proportional flow limits and the requirement to implement design and construction technologies, would result in additional reductions in impingement and entrainment. Based on the information available in the record, EPA estimates that the selected option may result in reduction of impingement to levels that could possibly exceed 99 percent. Estimated reductions in entrainment could also be substantial on a case-by-case basis (70 to 95 percent). Because EPA's selected option is very effective in reducing impingement and entrainment and is one-tenth the cost, EPA believes that it is reasonable to reject dry cooling as a nationally applicable minimum in all cases.

4. Technical Feasibility of Dry Cooling for Manufacturers

EPA considers that dry cooling technologies for manufacturing cooling water intake structures, as a whole, pose significant engineering feasibility problems. The primary feasibility issue is that dry cooling requires nearly zero water intake and many manufacturers reuse cooling water in their process. This dual use for process and cooling water prevents the application of dry cooling. In addition, many manufacturers require cooling water at an available temperature that is not reliably met by utilizing dry cooling. However, in some specific circumstances, EPA is aware of several demonstrated cases of dry cooling for cogeneration plants that are associated with manufacturers.

D. Why EPA Is Not Accepting the Industry Two-Track Approach in Full

While EPA is adopting the general two-track framework suggested by a trade association representing the electric generating industry, EPA is not accepting all aspects of this approach. The primary differences between the approach that EPA is promulgating and the approach industry suggested are: (1) The final two-track approach defines a different level of environmental performance as ''best available technology for minimizing adverse environmental impact'' for the ''fast track'' and (2) the final two-track approach contains a different way of measuring equivalence with the environmental performance of the ''fast track'' in the second track. In short, EPA prefers a more concrete and objective measure of best technology available for minimizing adverse environmental impact for the new facility rule than does the measure suggested by the industry proposal.

Under EPA's approach, best technology available for minimizing adverse environmental impact for new facilities would be the level of impingement and entrainment reduction achievable by (1) technology that reduces intake capacity in a manner comparable to that of a recirculating wet cooling tower; (2) technologies that reduce design through-screen velocity to reduce impingement, as explained in Section V.B.1.c of this preamble; (3) the applicant's selected design and construction technologies for minimizing impingement and entrainment and maximizing impingement survival; and (4) capacity and location-based technology requirements for limiting flow withdrawal to a certain proportion of a waterbody. By contrast, the industry proposal asserts that ''closed cycle cooling and low intake velocity reduces entrainment and impingement to such low levels that adverse environmental impact is avoided, thereby not just meeting, but exceeding, the section 316(b) standard of protection.''

Further, the industry proposal states that wedgewire screens, traveling fine mesh screens, and aquatic filter barrier systems, either alone or in combination, are sufficient, at least in certain types of waterbodies, in that they ''may provide a level of protection within the same range'' and thus should be determined to ''in almost every case avoid adverse environmental impact, thereby exceeding the requirements of section 316(b).'' While EPA's approach does not preclude the use of these alternative technologies if they demonstrate impingement and entrainment reductions equivalent to those of the suite of technologies it has described as ''best technology available for minimizing adverse environmental impact,'' in EPA's view the record does not show that using just one of the technologies listed above in order to qualify for expedited fast-track permitting is equivalent in reducing impingement and entrainment in a manner that reflects best technology available for minimizing adverse environmental impact. While barrier methods are effective at reducing impingement, EPA's record shows that they are currently not as effective at reducing entrainment as EPA's preferred option. This is because larvae and very small organisms can still pass through the barrier and may be entrained. While industry asserts that entrainment does not lead to mortality, there is conflicting evidence in the record on this topic, some of which indicates that in fact a large percentage of organisms can perish or be severely harmed when entrained. For these reasons, EPA does not find that the record supports the notion that the technologies listed by industry in its two-track proposal as ''exceeding the requirements of section 316(b)'' are as effective at reducing impingement and entrainment as the suite of technologies EPA has found to be technically available and economically practicable to the industries affected as a whole. For further discussion of entrainment and the performance of a variety of cooling water intake structure technologies, see Section III of this preamble and Chapter 5 of the *Technical Development Document*.

The industry two-track approach is based on industry's argument that the CWA compels EPA to determine section 316(b) limits on a case-by-case basis examining first whether the cooling water intake structure causes population or ecosystem effects before requiring any technology, because, industry asserts, this is the only plausible interpretation of the phrase ''adverse environmental impact.'' EPA does not believe that the language of the statute compels this interpretation. Instead, EPA believes it is reasonable to interpret section 316(b)'s requirement to establish ''best technology available for minimizing adverse environmental impact'' to authorize EPA to promulgate technology-based performance requirements analogous to those derived for point sources under sections 301 (existing sources) and 306 (new sources) for minimizing a suite of adverse environmental impacts, including impingement and entrainment, diminishment of compensatory reserve, and stresses to populations, communities of organisms, and ecosystems. The controls required today appropriately reflect technologies that for new facilities are available and economically practicable, that do not have unacceptable non-aquatic environmental impacts (including impacts on the energy supply across the United States), and that reduce impingement and entrainment of aquatic organisms in a manner that will help support, maintain, and protect aquatic ecosystems. EPA wants to be very clear that this decision relates only to new facilities. In making the upcoming decisions regarding existing facilities in Phases II and III, EPA will carefully weigh all of the relevant factors, many of which are different for existing facilities than for new facilities.

In addition, while EPA agrees that a two-track approach is an effective way to implement CWA section 316(b) for new facilities, EPA does not believe that a population-based approach for defining both the fast track and equivalent performance in the second track is a workable solution for new facilities.

With respect to the ''fast track'' suggested by industry, EPA does not have a record indicating that the technologies cited by industry (such as a fish return system alone) are the best technologies available for reducing impingement and entrainment. Moreover, even if population were the only endpoint, the record does not support the assertion that the technology cited by industry would qualify for the fast track because it can be uniformly predicted across the nation not to have population impacts (assuming one can agree upon what are the relevant species of concern) for all new facilities nationally in any location. At the same time, EPA has identified technologies that for new facilities (which, unlike existing facilities, do not have retrofitting costs) that are technically available and economically practicable. Therefore for new facilities, EPA believes it is reasonable to require such technologies on a national basis to reduce impingement and entrainment.

With respect to the second track, EPA does not prefer the population approach for new facilities, because the time and complexity of conducting population studies properly is generally inconsistent with making fast and reliable permitting decisions, an issue of particular importance for permitting new facilities. EPA's record shows that in order to study and demonstrate proper population studies, the permitting approval process would be adversely delayed for some new facilities. Specifically, because of the complexity of biological studies, it is very difficult to assess the cause and effect of cooling water intake structures on ecosystems or on important species within an ecosystem. An overwhelming majority of scientists have stated that biological studies can take multiple years because of the complex nature of biological systems. Moreover, unlike in the laboratory, where conditions are controlled, a multitude of confounding factors make biological studies very difficult to perform and make causation, in particular, difficult to determine. All of these issues take time to assess. EPA estimates that a credible job of studying these issues could take up to 3 years to complete. While some of this study can be conducted prior to start-up of the plant, this could cause delays in many situations. For these reasons, EPA does not believe that a population approach makes sense for new facilities.

VI. Summary of Major Comments on the Proposed Rule and Notice of Data Availability (NODA)

A. Scope/Applicability

Comments on the scope and applicability of the new facility rule address several issues, including the definition of a new facility, the definition of a cooling water intake structure (including the twenty-five (25) percent cooling water use threshold), the proposed threshold for cooling water withdrawals (i.e., 2 MGD), and the requirement for a facility to hold a NPDES permit.

1. New Facility Definition

EPA proposed to define a ''new facility'' as any building, structure, facility, or installation that meets the definition of a ''new source'' or ''new discharger'' in 40 CFR 122.2 and 122.29(b)(1), (2), and (4); commences construction after the effective date of the final rule; and has a new or modified cooling water intake structure. See proposed 40 CFR 125.83; 65 *FR* 49116.

Numerous commenters supported EPA's determination that the new facility rule should apply only to greenfield and stand-alone facilities but questioned whether EPA had clearly and effectively limited applicability of the proposed rule to such facilities. Some commenters indicated that the proposed regulatory definition of new facility, which references the existing NPDES new source and new discharger definitions, is confusing. For example, some commenters asserted that defining the total replacement of an existing process as a new facility is not consistent with application of the rule only to greenfield or stand-alone facilities. Commenters indicated that the regulation should make it very clear that the new facility rule applies only to greenfield and stand-alone facilities. To clarify the definition of new facility, some commenters encouraged EPA to include language or examples from the proposed preamble in the final regulatory language. Several commenters requested that EPA more explicitly clarify that a new cogeneration plant installed to serve an existing facility would not be considered a new facility under this rule.

The Agency believes that most new facilities subject to this rule will be considered new sources as defined in 40 CFR 122.2 and 122.29(b)(1), (2), and (4) and subject to new source performance standards for effluent discharges.[48] Under 122.29(b), a source is a new source if it meets the definition of new source in 122.2 (effectively, it discharges or may discharge pollutants, and its construction commenced after promulgation—or proposal in specified circumstances—of a new source performance standard) and it meets any of three conditions. The first is that the source is constructed at a site at which no other source is located (40 CFR 122.29(b)(1)(i)). The second is that the source totally replaces the process or production equipment that causes a discharge at an existing facility (40 CFR 122.29(b)(1)(ii)). The third is that the new source's processes are substantially independent of any existing source at the same site (40 CFR 122.29(b)(1)(iii)). EPA stated in the proposed rule that the new facility rule applies to greenfield facilities, described as facilities that meet the first and second conditions above, and stand-alone facilities, which are those that meet the third condition, provided these facilities meet other applicable conditions (*i.e.,* commencement of construction after the effective date of the final rule, new or

[48] Although the Agency believes that most new facilities subject to this rule will be considered new sources, EPA has included the reference to the definition of new discharger at 122.2 to address any new facility that may commence construction prior to the promulgation of a new source performance standard. The Agency notes that the definition of new discharger in 122.2 only applies to facilities not defined as a new source.

modified CWIS). Thus, the Agency believes the language of the regulation does make it clear that the rule applies to greenfield and stand-alone facilities or those whose processes are substantially independent of an existing facility at the same site. As commenters requested, EPA has added some examples to the regulatory section of the rule to serve as guidance regarding the definition of new facility under this final rule.

Several commenters also questioned whether repowering an existing facility would trigger applicability of the new facility requirements. These commenters pointed out that repowering is a common practice that often results in a gain in efficiency (*i.e.,* both increased power output and a reduced need for cooling water withdrawals). Commenters expressed concern that, although repowering an existing facility is distinct from building a greenfield or stand-alone facility, repowering could be interpreted as subject to the new source definition and thereby subject to the new facility rule. Some also asserted that the proposed rule included an arbitrary distinction between completely replacing an existing facility and repowering that facility. By defining the complete replacement of a facility as a new facility but allowing repowering to be defined as an existing facility, these commenters argued, the proposed rule creates an incentive to use less efficient technology for the redevelopment of older sites. Commenters also noted that the proposed rule would regulate a new, greenfield facility and the complete replacement of an existing facility (*i.e.,* a brownfield site) in a similar manner, which creates a disincentive to redevelop or modernize brownfield sites.

The definition of a new facility in the final rule applies to a facility that is repowered only if the existing facility has been demolished and another facility is constructed in its place, and modifies the existing cooling water intake structure to increase the design intake capacity. To the extent commenters assert some inequity of treatment between new facilities and certain existing facilities, EPA will address this comment when it addresses what substantive requirements apply to existing facilities. Further, changes to an existing facility that do not totally replace the process or production equipment that causes a discharge at an existing facility (*e.g.,* partial repowering), and those that do not result in a new separate facility whose processes are substantially independent of any existing source at the same site, do not result in the facility being defined as a new facility, regardless of whether these changes result in the use of a new or modified cooling water intake structure that increases existing design capacity. EPA does not agree that by not addressing most repowering under this rule the Agency is creating an incentive to use less efficient technology. Both the power-generating and manufacturing industries routinely seek greater efficiency when repowering. This is illustrated by the increased use over the past 10 years of combined-cycle technology, which requires significantly less cooling water for a given level of power generation and is a more efficient process than older technologies.

Several commenters supported EPA's definition of new facility as proposed. In contrast to concerns discussed above, some commenters expressed apprehension that the new facility definition would not capture all appropriate facilities. These commenters observed that an existing facility could rebuild its whole facility behind the cooling water intake structure and not be subject to the requirements applicable to a new facility. These commenters asserted that if an operator completely rebuilds an existing facility that facility should be subject to the new facility requirements.

EPA can foresee one instance in which the concern raised by this commenter may be well founded. In this rule EPA has defined a new facility in a manner consistent with existing NPDES regulations, with a limited exception. EPA generally deferred regulation of new sources constructed on a site at which an existing source is located (see 40 CFR 122.29(b)(3)) until the Agency completes analysis of its survey data on existing facilities. However, in addition to meeting the definition of a new source, today's rule requires that a new facility have a new cooling water intake structure or use an existing intake structure that has been modified to increase the design capacity. Thus, it might be possible to completely demolish an existing source, replace it with a smaller-capacity new source, and not be regulated under today's rule as a new facility. This facility would then be an existing facility an as such the requirements applicable to such a facility will be addressed in Phase II and III.

Several commenters requested that EPA define facilities deemed to be substantially independent for purposes of applying the new source criteria under 40 CFR 122.29 as those that could be practicably located at a separate site. Commenters maintained that such an approach is justified because EPA has based the proposed new facility requirements on the assumption that each owner or operator has the option to choose the location of his or her new facility and that such location would be selected to allow the owner or operator to best comply with the intake structure location and operation requirements.

With regard to defining when a facility is substantially independent under 40 CFR 122.29, EPA does not believe it is feasible to project under what circumstances owners and operators are free to select any location they desire for a new facility. For this reason, EPA takes the facility as it is planned for purposes of determining whether it is a new facility. In today's rule EPA does not believe it is appropriate to define the phrase ''substantially independent'' as used in 122.29(b)(1)(iii) as facilities that could be practicably located at a separate site. Section 122.29(b)(1)(iii) in the existing NPDES regulations already provides that ''[i]n determining whether . . . processes are substantially independent, the Director shall consider such factors as the extent to which the new facility is integrated with the existing plant; and the extent to which the new facility is engaged in the same general type of activity as the existing source.'' EPA does not think it is feasible for the permit authority to judge whether the facility could have been elsewhere for the purpose of determining whether the facility is subject to the new facility rules. Commenters also requested that EPA define what actions constitute routine maintenance to an existing cooling water intake, so that the distinction between changes that constitute maintenance and those that constitute a modification to an existing intake is made clearer.

EPA has not defined ''routine maintenance'' in the final rule because clarifying what constitutes routine maintenance is not vital to the definition of new facility. Under the new facility rule, to be considered a new facility a facility must be a new source or new discharger and use a newly constructed cooling water intake structure or a modified existing cooling water intake structure whose design intake has been increased. Thus, changes to a cooling water intake structure at an existing facility that is not a new source or new discharger are not subject to this rule. In addition, at facilities that are new sources or new dischargers but may use an existing cooling water intake structure, EPA has clarified in the final rule that the facility is subject to this rule only where changes to the intake result in an increase in design capacity. At facilities that are new sources or new dischargers, changes to an intake structure that do not result in an increase in design capacity do not result in that facility being subject to this rule.

Finally, some commenters expressed concern about the status of facilities that are under construction or have recently been constructed. These commenters suggested that such facilities should not be defined as new facilities. Others asserted that it is unfair to define a facility that has submitted a permit application but has not started construction as a new facility.

The Agency chose the commencement of construction date because it was generally consistent with the term ''new source'' in the existing NPDES permitting regulations and it should provide adequate notice and time for facilities to implement the technological changes required under the rule. The date a facility commences construction is clarified at 40 CFR 122.29(b)(4). This provision describes certain installation and site preparation activities that are part of a continuous onsite construction program; it includes entering into specified binding contractual obligations. Thus, under today's rule facilities that are constructed or commence construction within the meaning of 40 CFR 122.29(b)(4) prior to or on the effective date of the final rule are not new facilities. Those that commence construction after the effective date of this rule and meet the other regulatory thresholds defined in § 125.81 are subject to the requirements of this rule.

2. Definition of Cooling Water Intake Structure

EPA proposed that the term ''cooling water intake structure'' means the total physical structure and any associated constructed waterways used to withdraw cooling water from waters of the U.S., provided that at least twenty-five (25) percent of the water withdrawn is used for cooling purposes. See, proposed 40 CFR 125.83; 65 *FR* 49116. In the NODA the Agency requested comments on two additional alternatives. See, 66 *FR* 28854.

Most of the comments addressing the definition of cooling water intake structure focused on the 25 percent threshold for cooling water use. These comments are summarized and addressed under Section VI.A.3, below. EPA has placed the 25 percent threshold in the applicability requirements of the final rule to clarify the definition of cooling water intake structure. Intakes below this threshold are not subject to today's national rule; however, permit writers should determine any appropriate section 316(b) requirements for structures withdrawing less than 25% of intake flow for cooling purposes on a case-by-case basis.

Some commenters suggested that cooling water intake structures should not be defined in a way that would include the pumps in the cooling water system. Commenters maintained that pumps are part of the cooling water system, not part of the intake, and they assert that the Agency has authority under section 316(b) only over cooling water intake structures. Commenters noted that changing pumps is part of the normal routine of maintenance and repair performed at facilities that use water for cooling and that such activity should not trigger applicability of the new facility rule.

In the final rule EPA has clarified the definition of cooling water intake structure to explicitly include the first intake pump or series of pumps. The explicit inclusion of the intake pumps in the cooling water intake structure definition reflects the key role pumps play in determining the capacity (i.e., dynamic capacity) of the intake. These pumps, which bring in water, are an essential component of the cooling water intake structure since without them the intake could not work as designed. Section 316(b) authorizes EPA to impose limitations on the volume of the flow of water withdrawn through a cooling water intake structure as a means of addressing ''capacity.'' *In re Brunswick Steam Electric Plant*, Decision of the General Counsel No. 41 (June 1, 1976). Such limitations on the volume of flow are consistent with the dictionary definition of ''capacity,''[49] the legislative history of the Clean Water Act,[50] and the 1976 regulations.[51] *Id.* Indeed, as Decision of the General Counsel No. 41 points out, the major environmental impacts of cooling water intake structures are those affecting aquatic organisms living in the volumes of water withdrawn through the intake structure. (Statement of Mr. Buckley, Senate consideration of the Report of the Conference Committee [discusses intake from once-through systems]. A Legislative History of the WPCA Amendments of 1972, 93rd Cong., 1st Sess., Committee Print at 196, 197). Therefore, regulation of the volume of the flow of water withdrawn also advances the objectives of section 316(b).

3. Applicability Criteria: Requirement to Withdraw Water From a Water of the U.S., the Twenty-Five (25) Percent Cooling Water Use Threshold, and the Two (2) MGD Intake Flow Threshold

As was proposed, the final new facility rule applies to any new facility that (1) has or is required to have an NPDES permit; (2) proposes to use a cooling water intake structure to withdraw water from waters of the U.S.; (3) uses at least twenty-five (25) percent of the water withdrawn for cooling purposes; and (4) has a design intake flow of greater than two (2) million gallons per day (MGD). See proposed 40 CFR 125.81 and 125.83; 65 *FR* 49116.

Commenters raised several concerns regarding the proposed 25 percent threshold. A number of commenters asserted that EPA did not provide a rational basis in its record for proposing that use of 25 percent of intake flow for cooling purposes should determine whether an intake structure is a cooling water intake structure. Commenters asserted that it is inappropriate to base the 25 percent cooling water use threshold on the number of cooling water intake structures or amount of cooling water flow this threshold would make subject to this rule. Several commenters observed that no single threshold can be applied to all intakes to accurately distinguish cooling water intakes from other intakes. If EPA is determined to use a single threshold in this definition, numerous commenters favored a threshold of 50 percent cooling water use, which commenters stated is the de facto threshold used under the existing definition of a cooling water intake structure found in 1977 draft guidance. However, some commenters maintained that for an intake to be defined as a cooling water intake structure the vast majority (i.e., 75–100 percent) of water withdrawn must be used for cooling.

As discussed above, in the final rule EPA has placed the 25 percent threshold in the applicability section to clarify the applicability of the rule. Permit writers may determine that an intake structure that withdraws less than 25% of the intake flow for cooling purposes should be subject to section 316(b) requirements, and set appropriate requirements on a case-by-case basis, using Best Professional Judgment. Although cooling water intake structures that fall below the 25% threshold are not subject to today's national rule, today's rule does not inhibit permit writers, including those

[49] ''Cubic contents; volume; that which can be contained.'' *Random House Dictionary of the English Language*, cited in Decision of the General Counsel No. 41.

[50] Legislative History of the Water Pollution Control Act Amendments of 1972, 93d Cong., 1st Sess., at 196–7 (1973).

[51] 40 CFR 402.11(c)(definition of ''capacity''), 41 *FR* 17390 (April 26, 1976).

at the Federal, State, or Tribal level, from addressing such cooling water intake structures as deemed necessary.

EPA chose 25 percent as a reasonable threshold for the percent of flow used for cooling purposes in conjunction with the two MGD total flow threshold discussed below to ensure that almost all cooling water withdrawn from waters of the U.S. is addressed by the requirements in this rule for minimizing adverse environmental impact. EPA estimates that approximately 68 percent of manufacturing facilities that meet other thresholds for the rule and 93 percent of power-generating facilities that meet other thresholds for the rule use more than 25 percent of intake water for cooling. In contrast, approximately 49 percent of new manufacturing facilities use more than 50 percent of intake water for cooling. EPA does not believe it is reasonable to exclude from regulation nearly half of those manufacturing facilities that use large volumes of cooling water and, as a result, impinge and entrain aquatic organisms. EPA also considered it important to cover as many of the facilities as possible in order to create regulatory certainty for new facilities and for States and Tribes that must permit these new facilities. EPA predicts this will leave four (4) percent of the electric power generating facilities and thirty-two (32) percent of manufacturing facilities to the discretion of the permit writer. EPA believes that new facilities that use less than 25 percent of water withdrawn for cooling are most effectively addressed by States and Tribes on a best professional judgement (BPJ) basis, rather than under a national rule, since BPJ provides a certain degree of flexibility for a permit writer to consider available technologies and unique factors posed by new facilities that are below the threshold.

Several manufacturers commented that the rule as proposed may create a disincentive to manufacturing operations increasing efficiency through reducing process water use, since such reductions increase the percentage of cooling water used. These commenters observed that since process water is reused for cooling and cooling water may be heated and reused as process water, flexibility is needed in the rule so these practices are not discouraged or penalized. They also stated that process water cannot be reused in a manner consistent with closed-loop cooling. Some commenters also stated that the final rule should address situations in which the percentages of water used for cooling and as process water are not constant, or where the withdrawal of cooling water is intermittent.

In the final rule EPA has amended the definition of cooling water intake structure to ensure that the rule does not discourage the reuse of cooling water as process water. EPA has amended the proposed definition of cooling water intake structure to specify that cooling water that is used in a manufacturing process, either before or after it is used for cooling, is considered process water for purposes of calculating the percentage of a new facility's intake flow that is used for cooling and whether that percentage exceeds 25 percent. In addition, EPA also has added guidance to the regulation that clarifies how the 25 percent threshold should be applied to new facilities that do not maintain a constant ratio of cooling water to process water. See § 125.81(c) of this rule. This guidance provides that the threshold requirement that at least 25 percent of water withdrawn be used for cooling purposes is to be measured, on the basis of facility design, on an average monthly basis over a period of 1 year (any 12-month period). It further clarifies that a new facility meets the 25 percent cooling water threshold if any monthly average, over a year, for the percentage of cooling water withdrawn equals or exceeds 25 percent of the total water withdrawn.

Numerous commenters asserted that the two MGD threshold is too low and is not supported by a credible justification. Some commenters stated that the two MGD cutoff is overly conservative given that many facilities determined to be causing no adverse impact have considerably greater flows. For example, these commenters note that the State of Maryland uses a 10 MGD threshold, which commenters state would capture 99.67 percent of all existing cooling water flows if applied on a national basis. Several commenters supported the use of Maryland's approach. Others stated that the proposed rule contained insufficient data to be science-based (i.e., based on the level of withdrawal above which adverse environmental impact occurs). Commenters also observed that many of the environmental impact data EPA presented in the proposed rule focused on major power plants with flows much greater than two MGD, which does not support the proposition that adverse impacts occur at small facilities with lower flows. Rather, the commenters suggest, the threshold appears to be designed merely to capture a certain percentage of flow. If so, commenters assert this threshold is arbitrary and not based on sound science. Some of these commenters asserted that cooling water intake structure impact data support thresholds exceeding 500 MGD. A few commenters maintained that it is not appropriate to apply a single threshold to all waterbody sizes. Several supported the two MGD threshold. Several commenters also supported higher thresholds, including 5, 10, 25, and 100 MGD. Some commenters maintained that section 316(b) requirements should apply to all cooling water intake structures and that therefore no flow threshold is necessary.

EPA chose the two MGD threshold because this threshold addresses the majority of new facilities and therefore provides the States and Tribes with a national rule that can be easily applied to a majority of permitting decisions they face in order to implement the legal requirements of CWA section 316(b). All cooling water intake flow results in the potential for impingement and entrainment. Thus, all facilities must address section 316(b) requirements in the same fashion. Therefore, where EPA's record demonstrates that the requirements are technically available, economically practicable, and not have unacceptable non-water quality environmental impacts, including energy impacts, the Agency believes that it is appropriate for the new facility rule to address the majority of cooling water intake structure facilities. In doing so, EPA resolves for permit writers what the requirements are for new facilities.

On the basis of data for facilities with cooling water intake structures built in the past 10 years, EPA estimates that 58 percent of the manufacturers, 70 percent of the nonutilities, and 100 percent of the utilities will be regulated under the two MGD threshold. At the two MGD threshold, 62 percent of all in-scope facilities using surface water and 99.7 percent of the total flow will be covered. Estimated total flow is approximately 9 billion gallons per day. EPA did not select a significantly higher threshold, such as 15 or 25 MGD, because these thresholds would exclude most utility, nonutility and manufacturing facilities from regulation. At a threshold of 15 MGD, 32 percent of the manufacturers, 29 percent of the nonutilities, and 50 percent of the utilities would be covered, as would 97.3 percent of the total flow. The total flow covered remains relatively high, because the large flows from a small number of utility facilities dominate the total flow. While at a threshold of 25 MGD, 94.9 percent of the total flow would still be covered, many more facilities would not be covered. Only 18 percent of manufacturers, 17 percent of nonutilities, and 50 percent of utilities would be covered. Thus, 72 percent of manufacturers, 83 percent of nonutilities, and 50 percent of utilities, withdrawing up to 25 MGD would need to be addressed on a Best Professional Judgement basis. The Agency is concerned about the regulatory uncertainty for regulated new facilities and the burden on State and tribal permit writers to ensure appropriate requirements for these facilities. EPA also believes that the two MGD threshold reduces the burden on States and Tribes responsible for implementing section 316(b) requirements because, as a national threshold, it reduces the burden associated with site-specific determination of appropriate 316(b) limits. The lower threshold may also reduce delays for permit applicants by providing certain national standards.

EPA did not select a 5 or 10 MGD threshold because of the percentage of projected new nonutility and manufacturing facilities that would be excluded from regulation under these thresholds and concern that future trends in intake flow levels would, under these regulatory options, leave most new facilities using cooling water exempt from national regulation and subject to case-by-case determinations by permit agencies. At a threshold of 5 MGD, only 40 percent of nonutility facilities would be covered under this rule. Under a threshold of 10 MGD, 38 percent of manufacturing and 28 percent of nonutility facilities would be covered. EPA did examine the State of Maryland's 10 MGD standard but did not find information that would support the use of this standard on a national basis. In addition, the trend in power generation is toward, on a per facility/per unit of output basis, a general reduction in cooling water intake flow levels over time. Combined-cycle gas turbines require less water per unit of electricity generated than coal-fired or nuclear facilities. For example, a 750 MW combined-cycle facility with evaporative cooling towers is estimated to require approximately 7 to 8 MGD and under a 10 MGD threshold would not be subject to this national rule. The Agency believes that, given the objective of section 316(b), it is undesirable to exclude such a large plant from this rule. As reductions in cooling water intake flow levels occur, the two MGD threshold also ensures that this rule can serve the State, Tribes, and permit applicants by assuring that permits for new facilities comply with 316(b).

EPA does not agree that the intake flow threshold in the applicability portion of this rule must be based on prior determinations of the degree of environmental impact caused by a specific facility or specific cooling water intake structure. Section 316(b) applies to any facility that uses a cooling water intake structure and is a point source subject to standards imposed under CWA section 301 or 306. EPA has included a flow threshold to provide some reasonable limit on the scope of the national requirements imposed under today's rule. The Agency believes those new facilities with withdrawals that are at or below a two MGD threshold will generally be smaller operations that may face issues of economic affordability and are therefore more appropriately addressed on a case-by-case basis using BPJ. Moreover, as discussed in Section III, EPA does not agree that adverse environmental impact associated with cooling water intake structures is solely a population-based phenomenon. Rather, there can be numerous measures of such impacts, including assessments of fish and aquatic organism population impacts. Given the language of section 316(b) and the issues associated with determining adverse impacts, EPA does not view the examples of cooling water impacts discussed in the proposed rule and NODA as limiting the applicability of this rule to new facilities that have the opportunity to employ widely used, economically practicable measures that will, at a minimum, reduce injury to large numbers of fish and aquatic life and may result in benefits at higher levels of ecological structures.

Finally, commenters stated that large facilities that use closed cooling water systems may still require withdrawals of more than 2 MGD. These commenters asserted that it is unfair to subject these facilities to additional regulation after they have reduced their intake flow by 90 percent or more.

EPA agrees that very large facilities that use closed cooling water systems may still require withdrawals of more than two (2) MGD. As discussed elsewhere in this preamble, EPA determined that reducing intake capacity commensurate with use of a closed-cycle recirculating cooling system is not economically practicable for facilities withdrawing between 2 and 10 MGD. However, EPA does not agree that it is unfair to subject these facilities to further requirements necessary to reduce impingement and entrainment. Section 316(b) requires that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact. While reductions in total intake flow may represent the single most significant improvement for new facilities with cooling water intake structures, large flows withdrawn for make-up (i.e., to replace evaporative loss and blow down) can still cause significant impingement and entrainment. Additional controls on intake velocity, flow relative to the source waterbody, and design and construction technologies proposed by the facility also represent important aspects of a cooling water intake structure that must, under section 316(b), be addressed. As discussed elsewhere in this preamble and in the *Technical Development Document and Economic Analysis,* these additional measures are both widely employed and affordable. EPA does not believe that a determination of ''best technology available for minimizing adverse environmental impact'' for new facilities can omit these low-cost, effective technologies. Also see Section VIII of this preamble for a discussion that explains the percentage of new facilities already meeting the final rule requirements and the low cost of these requirements.

4. NPDES Permit

The proposed rule would apply only to new facilities that are or will be subject to an NPDES permit. See, proposed 40 CFR 125.81; 65 *FR* 49116. Comments received on this proposed requirement generally focus on the new facilities that withdraw cooling water from waters of the U.S. but do not hold an NPDES permit.

Some commenters asserted that EPA should not use the 316(b) rulemaking to regulate cooling water intake structures that are not owned by the NPDES-permitted facility. Commenters indicated that such an approach was beyond the authority provided by 316(b) and would make the rule unnecessarily complex.

The final rule applies only to new facilities that hold an NPDES permit or are required to obtain a permit. The Agency continues to believe that most new facilities that will be subject to this rule will control the intake structure that supplies them with cooling water and will discharge some combination of their cooling water, wastewater, and stormwater to a water of the U.S. through a point source regulated by an NPDES permit. Under this scenario, the requirements for the cooling water intake structure will be applied in the facility's NPDES permit.

In the event that a new facility's only NPDES permit is a general permit for storm water, EPA anticipates that the Director will write an individual NPDES permit containing requirements for the facility's cooling water intake structure.

Such 316(b) requirements could also be included in the general permit.

B. Environmental Impact Associated With Cooling Water Intake Structures

The proposed rule requested comment on the scope and nature of environmental impacts associated with cooling water intakes. Many comments were directed generally toward entrainment and impingement impacts, with some discussion of impacts caused by intake construction activities. The majority of comments, however, concentrated on defining adverse environmental impact and the approaches that were most relevant for characterizing adverse environmental impact, including assessments of population modeling and bioassessment approaches.

1. Entrainment, Impingement, and Construction Impacts

In the proposed rule, EPA requested comment on the types of impacts attributable to cooling water intake structures (65 *FR* 49072). Most of the comments focused on discussion of entrainment and impingement impacts and the impacts associated with construction of new cooling water intake structures.

One commenter suggested that the EPA should have scientific analyses to support the statement that entrainment mortality is high. The commenter also stated that, on the basis of recently conducted entrainment studies, through-plant change in temperature was the controlling factor for entrainment mortality and that entrainment impacts could be minimized through use of a cooling water system designed for high volume, low-velocity flow, which would minimize temperature differential. The commenter also noted that high-volume, low-velocity-flow cooling water systems would be specifically eliminated by the proposed 316(b) regulation.

EPA notes that entrainment studies indicate that through-plant mortality rates of young fish are determined by numerous factors. Different species have different tolerance to passage through a cooling system, and mortality rates may differ among life stages of the same species. A summary of mortality data from five Hudson River power plants found that mortality rates could be substantial.[52] The report cited species-specific mortality rates that varied by life stage for bay anchovy (93 to 100 percent), Atlantic tomcod (0 to 64 percent), herrings (57 to 92 percent), white perch (41 to 55 percent), and striped bass (18 to 55 percent). The study emphasized that the reliability of these estimates was questionable and that various sources of potential bias may have caused the estimated rates to be lower than the actual mortality rates. The Electric Power Research Institute (EPRI) sponsored a recent review of 36 entrainment survival studies, the majority of which were conducted in the 1970s.[53] [54] The summarized mortality rates described by EPRI were in substantial agreement with patterns reported in the Hudson River summary, specifically that anchovies and herrings had the highest mortality rates (greater than 75 percent), and that temperature change seemed to be an important determining factor. Thus, EPA believes scientific studies document that entrainment mortality for some species can be quite high.

EPA recognizes that Track I of the final rule precludes the use of high-volume, flow cooling water systems. However, in today's rule, under Track II, an intake with the capacity needed to support a high-volume, once-through cooling system that is shown through studies to reduce impingement mortality and entrainment for all life stages of fish and shellfish to achieve a level of reduction comparable to the level that would be achieved by applying Track I technology-based performance requirements at a site would meet the requirements of the rule.

Another commenter suggested that many of the more significant impingement episodes occur in conjunction with environmental phenomena such as low dissolved oxygen and rapid temperature declines. According to the commenter, these phenomena cause the death of many fish that are then ultimately collected on intake screens. EPA acknowledges that episodes of low dissolved oxygen and rapid temperature declines can result in fish losses, but does not concur that this is consistently documented as a significant or sole cause of fish impingement mortalities.

Another commenter recommended that EPA require antifouling measures at the construction and operational stages to minimize intake attractiveness to local fish, diving birds, and marine mammals. As stated previously, EPA defers controls for minimizing adverse impacts due to construction of new cooling water intake structures to the authority of existing Federal, State, and Tribal programs established for this purpose. EPA believes it is incumbent upon the individual facilities to implement antifouling measures during operations that are appropriate for the specific characteristics of their waterbody. As an example, antifouling measures for freshwater systems will be different from measures used for ocean intakes. (See Section VI.E.3.a. below for more information on fouling controls).

Finally, one commenter suggested that cooling water intake structures affect many components of an ecosystem, not just individual species. Thus, the regulation should consider indirect effects on predators resulting from losses of prey species and overall ecosystem effects when evaluating environmental impacts. EPA has taken primarily a technology-based approach to this national rule. EPA believes that this rule will reduce impacts to predators by dramatically reducing entrainment and impingement of prey species and will therefore protect ecosystems as a whole. In addition, this rule recognizes that States and Tribes can be more stringent as is consistent with section 510 of the CWA.

EPA also received comments on the documented examples of impingement and entrainment impacts discussed in the proposed rule. Several commenters argued that it was inaccurate for EPA to equate the taking of aquatic organisms with environmental impact because there was little evidence that intakes, new or existing, would cause or were causing adverse impacts. In contrast, other commenters asserted that, given the tremendous quantity of water that utilities withdraw and the large number of organisms impinged and entrained by intakes, it was clear that the cooling process had an adverse impact on aquatic ecosystems. EPA believes that the examples of environmental impact provided in the proposed rule are illustrative of the types of effects associated with cooling water intakes.

Several commenters objected to the use of specific facilities as representative examples of environmental impact. They argued that EPA focused on a few high-profile, high-intake facilities and in some cases used outdated information or misinterpreted results. EPA believes it used the best

[52] Boreman, J., L.W. Barnthouse, D.S. Vaughan, C.P. Goodyear, S.W. Christensen, K.D. Kuman, B.L. Kirk, and W. Van Winkle. 1982. the Impact of Entrainment and Impingement on Fish Populations in the Hudson River Estuary: Volume I, Entrainment Impact Estimates for Six Fish Populations Inhabiting the Hudson River Estuary. Prepared for the U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research by the Oak Ridge National Laboratory. ORNL/NUREG/TM–385/V1.

[53] EPRI. 2000. Review of entrainment survival studies: 1970–2000. Report No. 1000757. Prepared by EA Engineering Science & Technology.

[54] Some of the studies summarized in EPRI (2000) are the same ones considered by Boreman et al. (1982). See EPRI (2000) for complete citations of 36 original studies.

information available for the proposed rule and the final rule. There are few, if any, recent data documenting entrainment or impingement rates at the majority of existing facilities. Many of the available reports are for larger facilities (for which environmental impact concerns were greatest) and contain analyses conducted 20 to 25 years ago. Several of the examples cited in the proposed rule were based on historical data and EPA acknowledges that the data may not reflect current impingement or entrainment rates at the facility, particularly if technologies and other operational measures for reducing entrainment and impingement have been implemented since the original study. However, in most cases updated information was not available. To the extent possible, EPA has supplemented the facility information in the record for this final rule to include smaller facilities and updated information.

Finally, several commenters suggested that there was no need to address construction impacts in the 316(b) rule because there were existing Federal, State, and local provisions designed to minimize the impacts caused by construction activities. Another commenter stated that it was likely that the majority of new generation, once-through cooling facilities will be using existing cooling water intake structures and that it was doubtful that a new once-through facility would be constructed in an area where significant habitat could be disrupted. In contrast, another commenter stated that the regulation should address impacts associated with new cooling water intake structure construction, even if impacts were not recurring.

Under today's rule, EPA will minimize construction impacts by requiring appropriate intake design and construction technologies. EPA recognizes that other Agencies have a prominent role in evaluating and minimizing impacts related to construction activities and acknowledges that existing Federal, State, and Tribal programs include requirements that address many of the environmental impact concerns associated with the construction of new intakes. EPA believes that implementation of appropriate design and construction technologies and existing program requirements will minimize the environmental impacts of construction.

2. Adverse Environmental Impact

The proposed rule discussed six potential definitions for adverse environmental impact: (1) A level of impingement and entrainment that is recurring and nontrivial, perhaps defined as the impingement or entrainment of 1 percent or more of the aquatic organisms in the near-field area as determined in a 1-year study; (2) entrainment or impingement damage as a result of the operation of a specific cooling water intake structure, including a determination of the magnitude of any short-term and long-term adverse impacts; (3) any impingement or entrainment of aquatic organisms; (4) a biocriteria approach based on a comparison of the abundance, diversity, and other important characteristics of the aquatic community at the proposed intake site with similar biological metrics at defined reference sites; (5) evaluation of impacts to protected species, socially, recreationally, or commercially important species, and community integrity (including community structure and function); and (6) impacts likely to interfere with the protection and propagation of a balanced indigenous population of fish, shellfish, and wildlife. The proposed rule also invited comment on whether adverse environmental impact should be defined more broadly to include non-aquatic environmental impacts (e.g., air emissions, noise, introductions of non-indigenous species) associated with technology-based requirements (see Section VI.B.2.e. below). In the NODA, EPA presented another population-based approach proposed by industry for defining adverse environmental impact—''Adverse environmental impact is a reduction in one or more representative indicator species that (1) creates an unacceptable risk to the population's ability to sustain itself, to support reasonably anticipated commercial or recreational harvests, or to perform its normal ecological function, and (2) is attributable to the operation of the cooling water intake''—and invited comment on this definition as well as refinements to three of the definitions discussed in the proposed rule. See, 66 *FR* 28859–28863.

Numerous commenters stated that defining adverse environmental impact was critical to the 316(b) regulation because the program is fundamentally based on minimizing environmental impact. Further, commenters suggested that, without a solid definition of adverse environmental impact, the Agency's ability to interpret, implement, and enforce 316(b)-related actions would be seriously hampered.

EPA recognizes that since enactment of 316(b), scientists, environmentalists, lawmakers, and regulators have disagreed on an exact definition for adverse environmental impact. Further, the many studies conducted to date and arguments put forward on this issue have done little to resolve the current lack of consensus among the concerned parties. Given this background, EPA has determined to address adverse environmental impacts as discussed below.

a. What Constitutes Adverse Environmental Impact Under This Final Rule?

EPA acknowledges that there are multiple types of adverse environmental impact including impingement and entrainment; reductions of threatened, endangered, or other protected species; damage to ecologically critical aquatic organisms, including important elements of the food chain; diminishment of a population's potential compensatory reserve; losses to populations, including reductions of indigenous species populations, commercial fishery stocks, and recreational fisheries; and stresses to overall communities or ecosystems as evidenced by reductions in diversity or other changes in system structure or function.

In the preamble to the proposed rule, EPA discussed several other options for interpreting adverse environmental impact. One option would be to look to section 316(a) of the Clean Water Act for guidance. Section 316(a) addresses requirements for thermal discharge and provides that effluent limitations associated with such discharge should generally not be more stringent than necessary to ''assure the protection and propagation of a balanced indigenous population of shellfish, fish, and wildlife in and on that body of water.'' The same language is repeated in section 303(d) with reference to total maximum daily load (TMDL) listing requirements for waters impaired by thermal discharge. These statutory provisions indicate that Congress intended this requirement to be used in evaluating the environmental impacts of thermal discharges. Some have suggested that, since thermal discharges are usually paired with cooling water intake, it may be reasonable to interpret the Clean Water Act to apply this requirement in evaluating adverse environmental impact from cooling water intake structures as well.

Commenters have argued that the CWA compels EPA to determine that the objective of section 316(b) must be linked to the 316(a) goal to ensure protection and propagation of a balanced indigenous population of shellfish, fish, and wildlife. EPA does not agree that the CWA compels EPA to interpret adverse environmental impact as that term is used in section 316(b) in the Act by reference to the phrase ''balanced indigenous population'' under section 316(a). Because Congress used different terms in section 316(b) than in section 316(a), EPA does not believe the Agency is required to adopt such an interpretation. When Congress includes particular language in one section of a statute but omits it in another section of the same act, it is generally presumed that Congress acted intentionally and purposely in the disparate inclusion or exclusion. *Bates* v. *U.S.*, 522 U.S. 23 (1997). The usual canon of statutory interpretation is that when Congress uses different language in different sections of a statute, it does so intentionally. *Florida Public Telecommunications Ass'n, Inc.* v. *F.C.C.*, 54 F.3d 857 (D.C. Cir. 1995). Instead, EPA believes, consistent with EPA's ecological risk assessment guidelines, that it is reasonable to interpret adverse environmental impact as including impingement and entrainment, diminishment of compensatory reserve, stresses to the population or ecosystem, harm to threatened or endangered species, and impairment of State or authorized Tribal water quality standards. The Agency has long maintained that adverse environmental impact from cooling water intake structures must be minimized to the fullest extent practicable,[55] even in cases where it can be demonstrated that the requirement applicable under section 316(a) is being met.[56 57] Thus, the objective of section 316(b) includes population effects but is not limited to those effects. EPA's interpretation of ''adverse environmental impact'' is discussed in more detail below.

b. Approach to Defining Adverse Environmental Impact

EPA received numerous comments on its proposed rule asserting that the proper endpoint for assessing adverse environmental impact is at the population level, that some of EPA's proposed alternative definitions of adverse environmental impact would essentially protect ''one fish,'' and that EPA's alternative for defining adverse environmental impact as recurring and nontrivial impingement and entrainment was vague or would lead to excessive and costly efforts to protect a very few fish that would not result in ecologically relevant benefits. EPA's record at proposal demonstrated that cooling water intake structures do not kill, impinge, or entrain just ''one fish,'' or even a few aquatic organisms. The NODA published by EPA provides further examples of cooling water intake structures that kill or injure large numbers of aquatic organisms. For example, EPA provided information on aquatic organism conditional mortality rates for the Hudson and Delaware rivers that demonstrated significant mortality due to cooling water intake structures. EPA considered this information, as well as information in Section III on impingement and entrainment survival and impact, as it deliberated options for the final rule and how adverse environmental impact should be defined. Further, EPA considered documents that discussed potential consequences associated with the loss of large numbers of aquatic organisms. These potential consequences included impacts on the stocks of various species, including any loss of compensatory reserve due to the deaths of these organisms, and the overall health of ecosystems. Given all of these considerations, EPA determined that there are multiple types of undesirable and unacceptable adverse environmental impacts, including entrainment and impingement; reductions of threatened, endangered, or other protected species; damage to critical aquatic organisms, including important elements of the food chain; diminishment of a population's compensatory reserve; losses to populations, including reductions of indigenous species populations, commercial fishery stocks, and recreational fisheries; and stresses to overall communities or ecosystems as evidenced by reductions in diversity or other changes in system structure or function.

EPA also invited commenters to submit for consideration additional studies that documented either significant impacts or lack of significant impacts from cooling water intake structures. Several commenters submitted reports on manufacturing and power plant facilities that purported to demonstrate minimal impact from cooling water intake. One commenter submitted three documents for EPA's review. Another commenter submitted information on the Neal Complex facility located on the Missouri River near Sioux City, Iowa. The commenter described a 10-year (1972–82) study that focused on evaluating the operational impacts of the Neal facility, sited on a heavily channelized segment of the Missouri River. The commenter asserted that study results indicated little if any detrimental impact to the Missouri River ecosystem caused by facility operations. EPA reviewed the information summarized by the commenter and finds fault with several of the statements and conclusions cited in the comment. This is discussed further in EPA's response to comments document.

c. Assessment of Population Modeling Approach

Some commenters asserted that impacts on individual organisms or subpopulations are not ecologically relevant and recommended that EPA define adverse environmental impact as follows: ''Adverse environmental impact is a reduction in one or more representative indicator species that (1) creates an unacceptable risk to the population's ability to sustain itself, to support reasonably anticipated commercial or recreational harvests, or to perform its normal ecological function, and (2) is attributable to the operation of the cooling water intake structure.'' Under this approach, EPA would define unacceptable risk by using a variety of methods that fisheries scientists have developed for estimating (1) the level of mortality that can be imposed on a fish population without threatening its capacity to provide ''maximum sustainable yield'' (MSY) on a long-term basis, as developed under the Magnuson-Stevens Fishery Conservation and Management Act, and (2) the optimum population size for maintaining maximum sustainable yield.

In evaluating such comments, EPA considered the premises underlying MSY and the models used by National Marine Fisheries Service (NMFS) to derive MSY. Because the concept of MSY is based on harvesting adult fish, EPA generally questions whether this approach is directly relevant to egg, larvae, and juvenile losses associated with intakes. EPA also notes that the models used to estimate MSY do not directly incorporate any additional stressors (such as losses from entrainment and impingement) to managed stocks other than fishing pressure. Further, it is important to note that NMFS does not always manage stocks to their calculated MSY. In many cases, particularly if there is a concern over protecting habitat or critical ecosystems, NMFS regulates fisheries based on their ''optimum yield,'' which is less than the MSY. According to the Magnuson-Stevens Fisheries Conservation and Management Act, ''the

[55] *In re Brunswick Steam Electric Plant*, Decision of the General Counsel No. 41, June 1, 1976.

[56] *In re Public Service Co. of New Hampshire*, (Seabrook Station Units 1 and 2) (Decision of the Administrator) 10 ERC 1257, 1262 (June 17, 1977).

[57] *In re Central Hudson Gas and Elec. Corp.*, Decision of the General Counsel No. 63, July 29, 1977.

term 'optimum' with respect to the yield from a fishery, means the amount of fish which * * * is prescribed as such on the basis of the MSY from the fishery, as reduced by any relevant economic, social, or ecological function * * *''

EPA also considered the relative long-term success of ongoing fishery management practices implemented by the National Marine Fisheries Service and others. Despite the availability of state-of-the-art fish population models and considerable experience managing fisheries, NMFS recently classified 34 percent of their managed fishery stocks as over-utilized.[58] EPA agrees with fisheries experts and resource managers that there is unavoidable uncertainty associated with managing fish populations.[59 60 61 62] As a recent NMFS advisory panel expressed it, ''Uncertainty and indeterminancy are fundamental characteristics of the dynamics of complex adaptive systems. Predicting the behaviors of these systems cannot be done with absolute certainty, regardless of the amount of scientific effort invested.''[63] Consistent with its own Guidelines for Ecological Risk Assessment, EPA agrees with the conclusions of the NMFS panel that ''Given the high variability associated with ecosystems, managers should be cognizant of the high likelihood for unanticipated outcomes. Management should acknowledge and account for this uncertainty by developing risk-averse management strategies that are flexible and adaptive.'' As the panel concluded, ''The modus operandi for fisheries management should change from the traditional mode of restricting fishing activity only after it has demonstrated an unacceptable impact, to a future mode of only allowing fishing activity that can be reasonably expected to operate without unacceptable impacts.'' EPA and other fishery scientist support the concept of a precautionary approach,[64] particularly when dealing with complex systems, as described below.

EPA recognizes that the limitations of existing population models, including models used to manage fisheries, may be related to our overall limited understanding of the complexity of aquatic ecosystems and the long-term effects of anthropogenic activities[65 66]. As proposed in a recent journal article, many of the adverse impacts identified for coastal ecosystems, such as estuarine eutrophication, loss of kelp beds, coral reef die-offs, and introductions of invasive species, were initiated by historical overfishing.[67] Losses or extinctions of large vertebrate predators and filter-feeding bivalves such as oysters caused by overfishing have, over time, resulted in species replacements and significantly limited or ceased interactions between the overfished populations and other coastal community species. Historical overfishing and ecological extinctions precede both modern ecological investigations and the collapse of several marine ecosystems in recent times, ''raising the possibility that many more marine ecosystems may be vulnerable to collapse in the near future.''[68] Further, because modern ecological studies do not typically consider the long-term historical record, existing fishery resource baselines may be inaccurate, and ''Even seemingly gloomy estimates of the global percentage of fish stocks that are overfished are almost certainly far too low.''[69] Thus, EPA is concerned that historical overfishing increased the sensitivity of coastal ecosystems to subsequent disturbance, making them more vulnerable to human impact and potential collapse. Based on the long-term record of anthropogenic impacts to coastal ecosystems, their documented degradation, and their potential sensitivity to additional anthropogenic disturbance, as well as the admitted uncertainty associated with managing coastal fishery populations, EPA firmly believes that protective, risk-averse measures are warranted to prevent further declines or collapses of coastal and other aquatic ecosystems. EPA views impingement and entrainment losses to be one of many potential forms of disturbance that should be minimized to avoid further degradation.

Further, it remains unclear whether it is possible or sufficient to use single species population assessment models to assess impacts on multiple species, as is often necessary in evaluating impingement and entrainment by cooling water intake structures. NMFS now recognizes that improvement in fisheries management will require a comprehensive, ecosystem-based approach and recently convened an advisory panel to develop principles and approaches for ecosystem-based fishery management. In its report to Congress, the advisory panel noted that such an approach will ''require managers to consider all interactions that a target fish stock has with predators, competitors and prey species; the effects of weather and climate on fisheries biology and ecology; the complex interactions between fishes and their habitat; and the effects of fishing on fish stocks and their habitat.''[70] EPA supports the ecosystem-based approach to fisheries management advanced by NMFS and recognizes that this approach will require an in-depth understanding of species interactions. Because the ecosystem-based approach is currently evolving, EPA believes it is unlikely that most existing single species population models can accurately account for multiple-species interactions.

EPA also considered information addressing the issue of compensation—an increase that may potentially occur in survival, growth, or reproduction of a species triggered by reductions in population size[71 72]—and its application to the section 316(b) rulemaking. In particular, EPA sought comment on a memorandum discussing compensation and the quantity of data required to calculate compensation factors (DCN #2–020C). This document states that the use of compensation factors is typically

[58] National Marine Fisheries Service. 1999. Our living oceans. Report on the status of U.S. living marine resources. U.S. Department of Commerce, NOAA tech. memo. NMFS–F/SO–41.

[59] Hilborn, R., and C.J. Walters. 1992. *Quantitative fisheries stock assessment: choice, dynamics, and uncertainty.* Chapman and Hall.

[60] Hilborn, R., E.K. Pikitch, and R.C. Francis. 1993. Current trends in including risk and uncertainty in stock assessment and harvest decisions. *Canadian Journal of Fisheries and Aquatic Sciences* 50:874–880.

[61] Hutchings, J.A., and R.A. Meyers. 1994. What can be learned from the collapse of a renewable resource? Atlantic cod, Gadus morhus, of Newfoundland and Labrador. *Canadian Journal of Fisheries and Aquatic Sciences* 51:2126–2146

[62] National Research Council. 1998. *Improving fish stock assessments.* National Academy Press, Washington, D.C.

[63] National Marine Fisheries Service Ecosystem Principles Advisory Panel. 1998. *Ecosystem-based fishery management. A report to Congress.*

[64] Dayton, P.K. 1998. Reversal of the burden of proof in fisheries management. *Science* 279:821–822.

[65] Fogarty, M.J., A.A. Rosenberg, and M.P. Sissenwine. 1992. Fisheries risk assessment: sources of uncertainty. A case study of Georges Bank haddock. *Environ. Sci. Technol.* 26:440–446.

[66] Ludwig, D., R. Hilborn, and C. Walters. 1993. Uncertainty, resource exploitation, and conservation: lessons from history. *Science* 260:17 and 36.

[67] Jackson, J.B.C., M.X. Kirby, W.H. Berger, K.A. Bjorndal, L.W. Botsford, B.J. Bourque, R.H. Bradbury, R. Cooke, J. Erlandson, J.A. Estes, T.P. Hughes, S. Kidwell, C.B. Lange, H.S. Lenihan, J.M. Pandolfi, C.H. Peterson, R.S. Steneck, M.J. Tegner, and R.R. Warner. 2001. *Science* 293(5530):629–638.

[68] Ibid.

[69] Ibid.

[70] NMFS Ecosystem Principles Advisory Panel. 1998. *Ecosystem-based fishery management. A report to Congress.*

[71] Rose, K.A., J.H. Cowan, Jr., K.O. Winemiller, R.A. Myers, and R. Hilborn 2001. In press. Compensatory density-dependence in fish populations: importance, controversy, understanding, and prognosis. In press, *Fish and Fisheries.*

[72] Goodyear, C.P. 1980. Compensation in fish populations. In *Biological monitoring of fish*, ed. C.H. Hocutt and J.R. Stauffer, pp. 253–280. Lexington Books, Lexington, MA.

limited to cases in which fishery managers have extensive data on a fish population and that specific, numerical compensation values generally are not used in the absence of robust data sets (i.e., a minimum of 15–20 years of data suggested). Moreover, fish stocks for which these robust data sets exist are generally the highly exploited commercial and recreational stocks,[73] and few data exist for most nonharvested species. This memorandum also noted that in the absence of sufficient data various proxies are typically used to avoid quantitatively determining compensation.

In general, commenters asserted that compensation is a well-documented property of population regulation and that, despite 30 years of studies, there was no evidence that power plant impacts alone could reduce a population's compensatory reserve. Other comments specific to the memorandum concurred that, in the absence of sufficient data, compensation may be indirectly assessed using spawner-recruit models and that more than 100 marine and estuarine shellfish populations are currently managed by NMFS and other fisheries commissions using these proxies. One commenter provided information pertaining to new scientific studies of compensatory reserve and large databases containing fisheries information that are currently under development. The commenter asserted that use of meta-analysis—defined as the process of combining and assessing findings from several separate research studies that bear upon a common scientific problem—in conjunction with expanded fishery data sets will greatly increase the number of species for which scientists can estimate compensatory reserves. The commenter maintained that more and better estimates of compensatory reserve will be developed by the end of the decade, and requested that EPA take this trend into consideration. In contrast, another commenter asserted that industry abuses compensation theories and density-dependent models to support their contention that killing millions of fish is not ecologically relevant nor does it equate to an adverse environmental impact. The commenter further contended that there was a lack of scientific support for density-dependent models and provided references from peer-reviewed journals that critique and challenge the scientific underpinnings of these models.

EPA believes that a population's potential compensatory ability is affected by all stressors encountered within the population's natural range, including takes attributed to individual or multiple cooling water intake structures. Thus, even if there is little evidence that cooling water intakes *alone* reduce a population's compensatory reserve, EPA is concerned that the multitude of stressors experienced by a species can potentially adversely affect its ability to recover.[74] Moreover, EPA notes that the opposite effect may occur when populations are low, a phenomenon known as ''depensation.'' Depensation refers to decreases in recruitment as stock size declines.[75] Because depensation can lead to further decreases in the abundance of populations that are already seriously depleted, recovery may not be possible even if stressors are removed. In fact, there is some evidence that depensation may be a factor in some recent fisheries collapses.[76 77 78]

Because EPA's mission includes ensuring the sustainability of communities and ecosystems, EPA must comprehensively evaluate all potential threats to resources, and work towards eliminating or reducing identified threats. EPA believes that cooling water intakes do pose a threat to some fishery stocks and through this rule is seeking to minimize that threat. EPA also acknowledges that spawner-recruit proxies are currently used by several agencies to manage fishery stocks. However, as indicated in the record, these proxies are used in the absence of robust data sets. EPA does not believe that simply because an approach is currently in place, it constitutes the best approach. Given the uncertainty associated with managing fish stocks and the degree of stock overutilization despite long-term management efforts (see earlier discussion in Section VI.B.2.c.), EPA is concerned about the relative accuracy of these proxies and their overall ability to protect fishery stocks. EPA does not discourage development of new data sets, population models, or other scientific investigations that will improve estimates of compensatory reserve or other parameters that are needed to understand fishery dynamics. In fact, it is EPA's belief that these developments are ongoing due to the acknowledgment—direct or otherwise—that existing data and models are inadequate. Under the consent decree schedule, EPA is required to promulgate today's rule based on its interpretation of current science and EPA agrees with all comments discussed above that there are some weaknesses and potential inaccuracies inherent to existing estimations of compensation. EPA strongly supports additional research efforts and the development of expanded fisheries data sets that can be used to fill information gaps and improve our understanding of the complex relationships associated with aquatic ecosystems, fishery populations, and anthropogenic activities and, ultimately, assist NMFS and other agencies in wisely managing fishery resources. Because fishery resources are so precious, EPA further contends that compensation studies and models currently under development—including the data on which they are based—should be subject to peer review and other measures that will ensure their scientific rigor.

EPA also evaluated information submitted by the Utility Water Act Group (UWAG) and the Electric Power Research Institute (EPRI), both in their comments and in studies provided to the Agency after the comment period. In summary, these comments and documents asserted that entrainment of very large numbers of eggs, larvae, and early juvenile-stage fish does not necessarily meaningfully affect populations of the entrained species and that substantial percentages of the organisms of many species may survive entrainment. Further, these comments and documents asserted or were intended to support the assertion that impingement survival was high for many species and that impingement often impacts low-value, forage species when they are naturally prone to seasonal die-off regardless of cooling water intake structures. One of these comments asserted that EPRI and some

[73] Myers, R.A., J. Bridson, and N.J. Barrowman. 1995. Summary of worldwide stock and recruitment data. *Canadian Technical Reports in Fisheries and Aquatic Science* 2024:1–327.

[74] Hutchings, J.A. and R.A. Myers. 1994. What can be learned from the collapse of a renewable resource? Atlantic cod, *Gadus morhus*, of New Foundland and Labrador. *Canadian Journal of Fisheries and Aquatic Sciences* 51:2126–2146.

[75] Goodyear, C.P. 1977. Assessing the impact of power plant mortality on the compensatory reserve of fish populations. Pages 186–195 in W. Van Winkle, ed., *Proceedings of the Conference on Assessing the Effects of Power-Plant Induced Mortality on Fish Populations.* Pergamon Press, New York, NY.

[76] Myers, R.A., N.J. Barrowman, J.A. Hutchings, and A.A. Rosenberg. 1995. Populations dynamics of exploited fish stocks at low population levels. *Science* 26:1106–1108.

[77] Hutchings, J.A. and R.A. Myers. 1994. What can be learned from the collapse of a renewable resource? Atlantic cod, *Gadus morhus*, of New Foundland and Labrador. *Canadian Journal of Fisheries and Aquatic Sciences* 51:2126–2146.

[78] Liermann, M. and R. Hilborn. 1997. Depensation in fish stocks: A hierarchic Bayesian meta-analysis. *Can J. Fish. Aquat. Sci.* 54:1976–1985.

of the best fishery scientists in the world have never identified a site where definitive or conclusive aquatic population or community level impacts have occurred from operation of cooling water intake structures as described by EPA in the proposed rule.

In response to comments that entrainment of very large numbers of eggs, larvae, and other life stages of fish do not meaningfully affect populations of entrained species, EPA believes that there is evidence that some fish stocks have been adversely affected by cooling water intakes. For example, Atlantic Coast States have expressed concern over declines in winter flounder populations and have requested that the Atlantic States Marine Fisheries Commission conduct a study of the cumulative effects of cooling water intakes on winter flounder abundance. In addition, NMFS documented in several fishery management plans that cooling water intake structures are one of the threats that may adversely affect fish stocks and their habitats (DCN# 2–024M, 2–024N, and 2–024O). EPA also is concerned that an extensive data set, encompassing 20 or more years of monitoring data, is usually required to adequately assess whether or not populations are being affected by intakes. These long-term data sets are not currently available for many species, and thus it is very difficult to confidently state that entrainment has a negligible impact on *any* fish population. EPA also notes that the potential compensatory reserve of some fishery stocks can be depleted beyond the point of recovery [79] and that the compensatory reserve of many species entrained or impinged by intakes is unknown. For all of these reasons, EPA believes that the potential for entrainment impacts exists, and that additional scientific data are needed to evaluate entrainment impacts on all affected fish and shellfish populations.

In response to assertions that many organisms survive entrainment, EPA maintains that studies show that through-plant mortality rates of young fishes vary depending on numerous factors. [80] Different species have different tolerance to passage through a cooling system, and mortality rates may differ among life stages of the same species. A summary of mortality data from five Hudson River power plants showed that mortality rates could be substantial.[81] The report cited species-specific mortality rates that varied by life stage for bay anchovy (93 to 100 percent), Atlantic tomcod (0 to 64 percent), herrings (57 to 92 percent), white perch (41 to 55 percent), and striped bass (18 to 55 percent). The study further emphasized that the reliability of these estimates was questionable and that various sources of potential bias may have caused the estimated rates to be *lower* than the actual mortality rates. EPRI sponsored a recent review of 36 entrainment survival studies, the majority of which were conducted in the 1970s. [82] [83] The summarized mortality rates described by EPRI were in substantial agreement with patterns reported in the Hudson river summary, namely that anchovies and herrings had the highest mortality rates (greater than 75 percent), and that thermal regimes seemed to be important determining factors.

Similar to entrainment survival, EPA notes that studies show impingement survival is dependent on species characteristics such as and life history stage, swimming ability, etc.[84] Impingement survival is also dependent on the type of technology in place and the operational aspects of the intake. EPA is aware that in some cases, with appropriate technologies in place, impingement survival may be substantial for some species.[85] EPA is also aware that impingement survival studies suggest that impingement survival is low for some species such as small bay anchovy and Atlantic menhaden during summers in Atlantic Coast estuaries.[86] EPA does not believe that loss of such forage species should be viewed as having limited importance simply because they have minimal or no commercial or recreational value. From a more holistic, ecological perspective, forage species can have great importance in their role as prey for higher trophic levels, including many commercially and recreationally important fish species. In today's rule, EPA seeks to minimize impingement losses for *all* affected species.

d. Biological Assessment Approach

Biological assessments and criteria are recognized as important methods for gathering relevant ecological data for addressing attainment of biological integrity and designated aquatic life uses.[87] EPA invited comment on the following discussion and documents that identified potential constraints on using these methods to determine adverse environmental impact from the operation of cooling water intake structures. First, biological assessment and criteria methods are still being developed for large rivers and the Great Lakes, two large waterbody types where many cooling water intake structures are located. Second, although biological assessment and criteria guidance has been published by EPA for small streams and wadeable rivers, lakes and reservoirs, and estuaries and coastal marine waters, many States and authorized Tribes have yet to apply these criteria in large waterbodies where cooling water intake structures will be located. Most work to date by the States to use these methods was applied to small streams and wadeable rivers where relatively few cooling water intake structures are located. In addition, although bioassessments and criteria are valuable for evaluating the biological condition of a waterbody, in complex situations where multiple stressors are present (e.g., point source discharges, non-point source discharges, harvesting, runoff, hydromodifications, habitat loss, cooling water intake structures, etc.), it is not well understood how to identify all the different stressors affecting the biology in a waterbody and how best to apportion the relative contribution to the biological impairment of the stressors from each source within a watershed. Thus, it is the opinion of EPA that the existing guidance for conducting biological assessments (particularly within large river systems and the Great Lakes) and the quantity of biocriteria data compiled at the State/Tribal level are insufficient at this time to apply a biocriteria approach to

[79] Hutchings, J.S. and R.A. Myers. 1994. What can be learned from the collapse of a renewable resource? Atlantic cod, *Gadus morhus,* of New Foundland and Labrador. *Canadian Journal of Fisheries and Aquatic Sciences* 51:2126–2146.

[80] EPRI. 2000. Review of entrainment survival studies: 1970–2000. Report No. 1000757. Prepared by EA Engineering Science & Technology.

[81] Boreman, J., L.W. Barnthouse, D.S. Vaughan, C.P. Goodyear, S.W. Christensen, K.D. Kumar, B.L. Kirk, and W. Van Winkle. 1982. The impact of entrainment and impingement on fish populations in the Hudson River Estuary: volume I, Entrainment impact estimates for six fish populations inhabiting the Hudson River Estuary. Prepared for the U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research by the Oak Ridge National Laboratory. ORNL/NUREG/TM–385/V1.

[82] Electric Power Research Institute. 2000. *Review of entrainment survival studies: 1970–2000.* No 1000757. Prepared by EA Engineering Science & Technology.

[83] Some of the studies summarized in EPRI (2000) are the same ones considered by Boreman *et al.* (1982). See EPRI (2000) for complete citations of 36 original studies.

[84] EPRI. 2000. Technical evaluation of the utility of intake approach velocity as an indicator of potential adverse environmental impact under Clean Water Act section 316(b). Report No. 100731, EPRI, Palo Alto, CA.

[85] Ibid.

[86] Ibid.

[87] Davis, W.S. and T.P. Simon, eds. 1995. *Biological assessment and criteria: tools for water resource planning & decision making.* Lewis Publishers, Boca Raton, FL.

evaluation of cooling water intakes nationally.

EPRI also questioned the applicability of bioassessments for 316(b) analyses. Specifically, EPRI developed a document that examined the suitability of multimetric bioassessment for regulating cooling water intake structures under section 316(b) of the CWA.[88] In its conclusion, EPRI stated that biocriteria are well suited for assessing community-level effects, but are not designed as indices for measuring population-level effects without additional analyses; that assumptions about the structure and function of ecosystems embedded in the biocriteria approach appear to conflict with current understanding of ecosystems as dynamic, nonequilibrium systems structured on multiple time and space scales; and that issues such as significant uncertainty related to identification of reference conditions remain unresolved, particularly for large, open systems such as estuaries and coastal marine waters.

e. Non-Aquatic Environmental Impacts

EPA invited comment in the proposal on whether adverse environmental impact should be defined broadly to consider non-aquatic adverse environmental impacts in addition to aquatic impacts (65 *FR* 49075). EPA also discussed the water quality and non-water quality impacts of cooling towers (both wet and dry) in the proposal (see 65 *FR* 49075 and 65 *FR* 49081). In the NODA, EPA outlined its methodology for estimating marginal increases in air emissions from electric generating facilities due to the adoption of wet or dry cooling towers (66 *FR* 28867).

Some commenters asserted that EPA failed to consider potential adverse environmental impacts associated with evaporative cooling towers. One commenter stated that evaporative cooling towers carry some potential for localized impact apart from their extraction of cooling water, because they may discharge bacterial slimes, fungi, and a variety of organisms which colonize the tower but are not otherwise native to the local ecosystem. The commenter added that such organisms can be suppressed by the use of biocides that may be discharged with the effluent. In addition, the commenter claimed that evaporative towers may concentrate nutrients such as phosphates and, when brackish or marine water is used, discharge salt spray drift. Additionally, one commenter stated that although there is no express statutory support in section 316(b) for limiting consideration to aquatic impacts (see 33 U.S.C. 1326(b)) they believe that the analysis of such impacts can be appropriate. Further, the commenter encouraged EPA to consider non-aquatic impacts which relate to cooling towers. Other commenters stated that Congress' mandate for environmental impact is broader than the entrainment and impingement impacts upon which EPA has focused in the proposed regulation. The commenters urged EPA to consider the following effects of the cooling tower technology: (1) Increased air emission due to the "energy penalty" exacted by closed-cycle cooling, or dry cooling; (2) noise; (3) visible plumes that (a) are unaesthetic, and (b) contribute to increased fogging and icing on nearby roadways; and (4) salt drift. The commenters added further that of all the technologies associated with cooling condenser water, once-through cooling is the only technology that is not associated with increased air emissions. According to the comments, the other cooling water technologies either directly emit contaminants into the air and/or indirectly result in an increase of fuel use and air emissions due to the loss of electrical generation capacity by the power used to operate these technologies. The comments stated that, in essence, the proposed regulations pre-determine that air and noise impacts are more acceptable than impacts to aquatic resources and water quality. The comments added that the locations least likely to be able to comply with the requirements, like those in urban areas, are also the most likely to have impaired air quality. One commenter maintained that for recirculated systems, cooling tower blowdown must be stored in evaporation ponds or treated prior to discharge, resulting in potential for groundwater impacts and disturbance of terrestrial habitats. Additional commenters stated that there could be unintended air pollution consequences for manufacturers from the 316(b) rule due to adoption of cooling towers. The forest products industry projects an increase in SO_2, NO_X, PM, and CO_2 emissions due to increased energy demand to run their mills. Other commenters stated that EPA must ensure that new cooling water technologies do not increase fossil fuel use by manufacturers.

Conversely, some commenters stated that the primary environmental concern with intake structures should be those focused on the aquatic environment. They added that while non-aquatic concerns are valid and should be considered secondarily, the main effect of these facilities is to the aquatic communities and the decision-making process should reflect this priority. Further, one commenter recommended that the regulation, (and probably more specifically the guidance), allow States, authorized Tribes, permitting authorities, and facility operators to have sufficient flexibility to consider non-aquatic impacts that may result from activities related to the design, construction, location, and operation of an intake structure and other alternative technologies identified as having a harmful effect on air, lands, and other natural resources when making section 316(b) decisions. One commenter claimed that a large array of environmental laws and regulations already exist to address non-water environmental impacts. Some commenters asserted that the potential for localized impact from wet cooling towers is relatively minor given the substantial improvements in entrainment and impingement and the elimination of thermal impacts associated with wet cooling as compared to once-through cooling.

For the final rule, EPA presented estimates of marginal annual increases in air emissions associated with installing recirculating wet cooling towers in lieu of once-through cooling systems. The Agency compared projected emissions under the rule to projected emissions absent the rule. Because EPA projects that, regardless of the outcome of the rule (that is, absent the regulations) a majority of power plants would have recirculating wet cooling towers and a minority would have once-through or dry cooling systems, the number of in-scope facilities contributing to increased air emissions is small. Regardless, EPA estimates that the following annual air emissions increases will occur as consequence of the rule: 2,560 tons of SO_2, 1,200 tons of NO_X, 485,900 tons of CO_2, and 16 pounds of Hg. These increases represent a change of less than 0.02 percent of annual emissions from power plants in the United States. Air emissions for manufacturing facilities projected within the scope of the rule are projected to not increase. This is due to the fact that EPA projects manufacturers to utilize reuse and recycling of cooling water to meet the flow reduction requirements in lieu of recirculating wet cooling towers. For the other regulatory options analyzed for the final rule, EPA presented annual air

[88] EPRI. 2000. Evaluation of biocriteria as a concept, approach, and tool for assessing impacts of impingement and entrainment under ;§ 316(b) of the Clean Water Act. Report No. TR–114007, EPRI, Palo Alto, CA.

emissions estimates in Chapter 3 of the *Technical Development Document.*

To a large degree, issues brought forth by commenters regarding non-aquatic impacts of cooling towers were highly site-specific. For instance, in the cases where visible plumes from evaporative cooling towers was a significant issue for the public and other stakeholders on the local level, alternative or additional technologies have been adopted in response to stakeholder sentiment. The two-track regulatory framework adopted by EPA in the final rule allows for this local, site-specific decision-making process. In the case where facilities, or public stakeholders, determine that an alternative technology to a traditional flow reducing type (such as recirculating wet cooling towers or cooling ponds) is necessary, the two-track methodology provides the flexibility for an equivalent aquatic environmental impact minimization to occur without producing a non-aquatic impact.

In general, EPA has concluded that at a national level the primary impacts of this rule will be aquatic in nature, and focus on impingement and entrainment affects. Nevertheless, at a local level, it is possible that air quality impacts, non-impingement and entrainment aquatic effects, or energy impacts could be significant and potentially justify a different approach to regulating cooling water intake structures. Moreover, the cost impact of the rule, under certain local conditions, could be wholly disproportionate to costs anticipated by EPA on a national level. EPA believes that it is prudent to make an alternative regulatory mechanism available to the permitting authority to address such situations, and to be used at the permitting authority's discretion. EPA is sensitive to the large resource burden which such flexibility could place on the permitting authority, if this mechanism were abused by permit applicants. Therefore, EPA is placing the burden of demonstration of the need to pursue such alternative regulatory limits entirely on the permit applicant.

In this final rule for new facilities, where EPA is concerned about certainty and speed of permitting, EPA has selected impingement and entrainment as the metric for performance. EPA has considered the non-impingement and entrainment environmental impacts of the new facility rule and has found them to be acceptable on a national level. EPA is currently developing proposed regulations to establish the best technology available for minimizing adverse environmental impact from intake structures associated with existing facilities. The studies EPA has done of non-impingement and entrainment impacts in the case of new facilities would not govern in that context. Accordingly, the standard and procedures EPA develops for assessing adverse environmental impact from intake structures at existing facilities may well be quite different, and nothing in this rulemaking should preclude EPA from coming to the conclusion that a different approach for regulating cooling water intake structures at existing facilities is warranted.

3. Additional Information Indicating that Impingement and Entrainment May Be a Non-Trivial Stress on a Waterbody

In addition to reviewing the merits of a population approach to assessing adverse environmental impact, EPA considered information suggesting that impingement and entrainment, in combination with other factors, may be a nontrivial stress on a waterbody. EPA recognizes that cooling water intake structures are not the only source of human-induced stress on aquatic communities. These stresses include, but are not limited to, nutrient loadings, toxics loadings, low dissolved oxygen content of waters, sediment loadings, stormwater runoff, and habitat loss. While recognizing that a nexus between a particular stressor and adverse environmental impact may be difficult to establish with certainty, the Agency identified methods for evaluating more generally the stresses on aquatic communities from human-induced perturbations other than fishing. Of particular importance is the recognition that stressors that cause or contribute to the loss of aquatic organisms and habitat may incrementally impact the viability of aquatic resources. EPA examined whether waters meet their designated uses, whether fisheries are in stress, and whether waters would have higher water quality or better support their designated uses if EPA established additional requirements for new cooling water intake structures. EPA considered use of this type of information as one approach for evaluating adverse environmental impact.

EPA prepared a memorandum (Dabolt, T. EPA. April 18, 2001, revised July 2001. Memo to file Re: 316(b) analysis-relationship of location to cooling water intake structures to impaired waters) documenting that 99 percent of existing cooling water intake structures at facilities that completed EPA's section 316(b) industry survey are located within two miles of locations within waterbodies identified as impaired and listed by a State as needing development of a total maximum daily load (TMDL) to restore the waterbody to its designated use. All of the leading sources of waterbody impairment—nutrients, siltation, metals, and pathogens—can affect aquatic life. In the 1998 National Water Quality Inventory, inability to support aquatic life uses was one of the most frequently cited water quality concerns.

EPA recognizes, however, that these data do not establish that cooling water intake structures are the cause of adverse environmental impact in any particular case and that there may be other reasons for the presence of impaired waters near cooling water intake structures, such as the frequent location of facilities with cooling water intake structures near other potential sources of impairment (*e.g.,* industrial point sources, urban stormwater). Nonetheless, this analysis suggests that many cooling water intake structures are sited within or adjacent to impaired waters, and that intakes potentially contribute to existing stress on waterbodies and their resident biota.

EPA also summarized information from a number of sources indicating overutilization of about 34 percent of the fishery stocks whose known status is tracked by and under National Oceanic and Atmospheric Administration's (NOAA) purview (54 out of 160 stock groups) and which rely on tidal rivers, estuaries, and oceans for spawning, nursery, or adult habitat. An additional 45 stocks under NOAA purview are of unknown status (about 22 percent of the fisheries managed by NOAA) because of incomplete assessments. In addition, NOAA documents in a number of their fishery management plans that cooling water intake structures, particularly once-through cooling water systems that withdraw large volumes of water, cause adverse environmental impacts due to significant impingement of juveniles and entrainment of eggs and larvae. EPA believes that stress due to overutilization may be relevant to assessing cumulative impacts of multiple stressors, including cooling water intake structures.

C. Location

The proposed rule outlined a framework in which intakes located in certain sections of a waterbody would be subject to varying levels of restrictions. Specifically, intakes located within the broadly defined littoral zone or in especially sensitive waterbodies (estuaries and tidal rivers) would face additional restrictions on intake flows and intake velocity. Intakes located outside these higher priority waters would be subject to decreased levels of regulation. See the proposed rule for a detailed discussion of the framework set forth. (Section VIII.A.2., pages 49083 to 49085.)

Numerous comments were received on the proposed requirements for location, nearly all of which opposed the proposal. In the most general sense, many commenters agreed with the concept of protecting waters that are more productive. However, most commenters also argued that the proposed approach was scientifically and technically flawed and would be extremely difficult to implement. The comments can be divided into several generic categories: importance of location for an intake, general comments on the use of the littoral zone as a regulatory concept, and specific comments regarding the littoral zone definitions for each waterbody type.

In the NODA, EPA further explored the issue of intake location by soliciting comments on a revised definition of littoral zone and revised requirements for several waterbody types including the Great Lakes, and for waters not designated to support aquatic life use.

Comments on the NODA generally reiterated issues raised in the comments on the proposed rule. Commenters agreed that location is an important factor in assessing the impacts of cooling water intake structure, but that creating a regulatory framework to specifically address locational issues would be extremely difficult.

After reviewing the available data and comments regarding intake location, EPA has elected not to vary requirements for new facilities on the basis of whether a cooling water intake structure is located in one or another broad category of waterbody type or in a broadly defined zone of higher productivity or sensitivity within certain types of waterbody. Instead, EPA has promulgated technology-based performance requirements for new facilities that defines best technology available for minimizing adverse environmental impact in all waterbody types. This prescription for best technology available for minimizing adverse environmental impact recognizes the site-specific nature of biology and other locational factors by allowing the permit applicant in Track I to select and implement certain design and construction technologies after a review of available information on the site. Facilities that choose not to follow the specific technology-based performance requirements in Track I may opt for Track II and, after site-specific study, seek to demonstrate equivalent protection of the aquatic resources in a given waterbody from impingement and entrainment by using alternative technologies or approaches.

While EPA continues to believe that it could have established different requirements based on general information about the productivity of water bodies, EPA decided for the new facility rule that introducing separate requirements for different water bodies was unnecessary in light of the strong record support that the track I requirements are technically available and economically practicable for new facilities and in light of the flexibility provided by Track II where the applicant demonstrates that it can use different technologies to reduce impacts to fish and shellfish to a level comparable to the level that would be achieved if they implemented Track I requirements at their site.

EPA did not vary the performance requirements based on waterbody type because it found problems in defining and implementing a littoral zone approach (as discussed below) and found that reducing impingement mortality and entrainment on fresh water bodies to a comparable level as in estuaries and oceans to be technically feasible and economically practicable.

1. Importance of Intake Location

Several commenters agreed with EPA that location is an important factor in assessing the impact of a cooling water intake structure. One commenter added that location is also critical to the technical feasibility of the facility, because the site characteristics with respect to hydrology, land area available, and other factors can greatly influence the viability of a facility. Other commenters supported the waterbody-specific approach, but in the context that adverse environmental impact is a site-specific or even species-specific phenomenon. Another commenter disagreed with the proposed delineation of waterbody types, stating that adverse impacts can be found at all waterbody types and both in and outside the littoral zone. Therefore, equal protection should be afforded to all waters under the regulation. One commenter opposed the approach involving waterbody types, since defining distinct types is difficult, and noted that a site-specific approach would be more appropriate. Another commenter argued that the effectiveness of intake technologies varies by location, thereby supporting a site-specific approach.

EPA agrees that location is an important factor in addressing cooling water intake structure impacts, and, in Track I, permit applicants must select and implement certain design and construction technologies after considering site-specific conditions. In Track II, permit applicants have complete flexibility to address site-specific conditions, provided they can reduce impacts to fish and shellfish to a level comparable to the level that would be achieved if they implemented Track I requirements at their site.

2. General Comments on the Use of the Littoral Zone Concept

Many commenters made general statements of opposition to the use of the concept of littoral zone as part of the proposed rule, each for a variety of reasons. Most of the comments expressed concern over one or more of the following issues: The proposed definition and approach is too broad and untenable; the conditions used to define the littoral zone can vary greatly on an annual basis; the proposal is poorly supported by the scientific literature; and the proposal is a poor proxy for biological productivity and ignores ecological complexity and site-specific conditions. In general, commenters acknowledged that some areas of a waterbody are more sensitive to cooling water intake structure impacts but disagreed with EPA's approach for defining the concept. For example, the term ''area of high impact,'' proposed in the NODA, represented an improvement over the term ''littoral zone,'' but commenters noted that the proposed term still lacked a clear definition. One commenter further noted that a site-specific approach would allow for a more thorough analysis of a waterbody and account for these sensitive areas. Another commenter argued that the approach was inappropriate, because EPA does not have the authority to establish less restrictive requirements in some waterbodies.

EPA recognizes that most commenters, albeit for a variety of sometimes conflicting reasons, do not support use of a littoral zone or similarly broad concept to specify requirements for best technology available for minimizing adverse environmental impact. EPA instead has adopted a two-track framework in which permit applicants can fully address site-specific factors in proposing what technologies or alternatives they will use to reduce impingement and entrainment to levels readily achievable with use of low-cost, widely used technologies.

3. Specific Comments on the Definition or Applicability of the Littoral Zone

a. Littoral Zone—Oceans

Most commenters opposed the proposed definition and use for oceanic littoral zones. Generally, commenters saw it as too broad, vague, and unsupported by scientific literature, although one commenter did disagree with a reduced level of protection for oceanic waters. Some commenters noted that the entire continental shelf could be interpreted as the littoral zone under the proposed definition. Other commenters disagreed with the usage of salinity as a defining criterion, noting that many environmental factors (e.g., seasonality, tides, weather) can influence the salinity levels and therefore alter the geographic location of the littoral zone. One commenter added that some estuarine waters could possibly be classified as oceanic waters, thus reducing the level of protection required by the regulation. Commenters were also asked to comment on a proposed fixed distance from shore as a definition of the littoral zone. Some commenters did support a fixed distance (from 200 to 500 meters offshore) but most commenters opposed the proposed definition, because of the need to recognize site-specific characteristics, such as biological resources, areas of high productivity, and waterbody size and configuration, at each facility. Many of the same comments opposing the fixed-distance approach are echoed in the general comments about the inadequacy of the littoral zone approach noted above.

For the reasons discussed above, EPA has adopted an alternative regulatory structure and will not in this rule set nationally defined areas within oceans where different requirements apply for best technology available for minimizing adverse environmental impact.

b. Littoral Zone—Freshwater Rivers

Only a few of the comments received addressed freshwater rivers and streams, but those few comments raised concerns over the proposed definition of the littoral zone. One commenter noted that, generally, the flow, turbidity, and seasonality at a site can greatly affect the vegetation and light penetration, thereby affecting the extent of the littoral zone. This commenter also added that riverine intakes are often shoreline intakes and noted that the definition would be difficult to apply to intakes because of hydrologic factors such as meanders and shoreline construction techniques. Another commenter submitted additional data and analysis supporting the concept that freshwater lakes and rivers are less vulnerable to the effects of impingement and entrainment than other types of waterbodies.

Today's final rule adopts a different regulatory framework—a two-track approach—and does not set different requirements for best technology available for minimizing adverse environmental impact for different parts of freshwater rivers. Instead, under Track II, an applicant may conduct site-specific studies and possibly determine that a different cooling water intake structure location within the waterbody would reduce impingement mortality and entrainment to a level of reduction comparable to the level achieved under Track I requirements at a lower cost. If so, the applicant is free to propose an alternative location for its intake in its permit application.

c. Littoral Zone—Lakes and Reservoirs

One commenter noted that site-specific factors must be considered when locating a cooling water intake structure. The commenter argued that it was not necessarily true that intakes located in the littoral zone of lakes or reservoirs impact more species or species having higher economic value compared to intakes sited offshore. The commenter also stated that based on its experience, the dominant species entrained and impinged within lake systems were forage species (e.g., gizzard shad, alewife, smelt) regardless of intake location.

EPA agrees that it is important to consider site-specific factors when identifying the most appropriate location for a cooling water intake structure. As discussed above, under a Track II approach, an applicant may conduct site-specific studies to determine where best to site its intake (inshore or offshore) as long as it can be proven that the chosen location would reduce the level of impingement mortality and entrainment of all stages of fish and shellfish to a level of reduction comparable to the level the facility would achieve under the Track I requirements. However, EPA does not agree that the susceptible life history stages of lake forage species (such as those listed by the commenter) are as likely to be impinged or entrained at an offshore intake as an intake located inshore. Basic life history information for many forage species documents that spawning events and juvenile stages often occur in nearshore lake waters. As an example, young-of-the-year gizzard shad form schools and are usually found close inshore within shallow waters overlying mud bottom (Dames & Moore, 1977). Similarly, although adult alewifes typically inhabit deep, pelagic waters of landlocked lakes, they migrate to harbors and nearshore waters to spawn in spring and early summer.

d. Littoral Zone—Estuaries and Tidal Rivers

Commenters were more divided in their comments on estuaries and tidal rivers. Some commenters generally supported the proposed definition of an estuary and the increased level of protection for these waters. Others noted that the proposed definition greatly oversimplified its ecological function, since not all areas within an estuary are equally productive. Another commenter noted that the proposed rule applied the greatest level of restrictions to the waterbody type with the greatest heterogeneity. Several commenters expressed concern over the use of salinity as a delineation tool, noting the tendency for the 30 ppm gradient to move within the waterbody.

Based on facility size, EPA is setting the same performance-based technology requirements for tidal rivers and estuaries as for all other waterbodies under Track I of the final rule. To the extent that site-specific characteristics of a proposed facility location make the Track I requirements more or less effective at reducing impingement and entrainment, the facility choosing to pursue Track II will have a site-specific goal for evaluating the efficacy of alternative technologies and approaches.

4. Waters Not Designated To Support Aquatic Life Uses

In the NODA, EPA requested comment on the issue of less stringent requirements for facilities located on waterbodies that are not designated to support aquatic life. One commenter supported less stringent requirements than proposed, requesting that facilities located on waters not designated to support aquatic life be exempt from the 316(b) regulations. This commenter also noted that such an exemption would not necessarily be permanent, since States have the authority to reclassify waters to again support aquatic life. Another commenter did not support the proposed approach. A third commenter argued that the CWA does not allow for exemptions from technology-based requirements on the basis of the designated use of the receiving waters. Some commenters submitted specific examples of impaired waterbodies and listed nutrient enrichment as one of the causes of impairment.

Today's final rule does not establish less stringent requirements for waterbodies not designated to support aquatic life use. However, to the extent that the lack of an aquatic life use would result in Track I requirements achieving limited reductions in impingement and entrainment at a site, a permit applicant willing to conduct site-specific studies under Track II might be able to demonstrate that alternative technologies or approaches would reduce the level of impingement mortality and entrainment to a level of reduction comparable to the level the facility would achieve if it met the Track I requirements at that location. EPA addressed use impairment and the stress that cooling water intake structures may add to impaired waterbodies at VI. B. above.

D. Flow and Volume

Under the proposed rule, EPA proposed limitations on intake flow and volume for new facilities that varied depending on the type of waterbody upon which the facility is to be located. Specifically, intake flows at facilities whose cooling water intake structure withdraws from freshwater lakes and rivers would be limited to the lower of five (5) percent of the source water body mean annual flow or twenty-five (25) percent of the 7Q10. Facilities located on lakes and reservoirs would be limited to intake flows that do not disrupt, alter the natural thermal stratification or turnover pattern (where present) of the source water except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies). Intakes in tidal rivers and estuaries would be limited to no more than one (1) percent of the volume of the water column in the area centered about the opening of the intake, with a diameter defined by the distance of one tidal excursion at the mean low water level. The additional requirement of intake flow commensurate with that of a closed-cycle recirculating cooling water system was proposed for intakes located in either estuaries and tidal rivers or the littoral zone of any waterbody.

EPA requested comment on each proposed limitation by waterbody type, unique situations such as the Great Lakes, and the introduction of more stringent flow requirements for intakes in estuaries, tidal rivers, and littoral zones.

In general, commenters opposed the proposed flow and volume limitations. They argued that EPA did not present a link between intake flows and adverse impact, that the limits are based on questionable grounds, and that EPA lacked the authority to enact such limits, and against specific items in each proposed waterbody limitation.

On the basis of the supporting data presented in the proposed rule and the NODA, Track I and Track II of today's final rule maintain the proposed flow limitations with some changes. EPA believes the record contains ample evidence to support the proposition that reducing flow and capacity reduces impingement and entrainment, one measure of adverse environmental impact, and may reduce stress on higher levels of ecological structure including population and communities. (See, #2–029, 2–013L–R15 and 2–013J). EPA also has determined that a capacity- and location-based limit on withdrawals in certain waterbody types is an achievable requirement that will have little or no impact on the location of cooling water intake structures projected to be built over the next 20 years.

1. Relation of Flow and Capacity to Impact

Several commenters disagreed with EPA's contention that a high intake flow volume necessarily corresponds to higher rates of adverse environmental impact. Commenters pointed to several facilities with relatively high intake volumes that reported no significant loss of aquatic life due to entrainment or impingement. The commenters asserted that, collectively, these cooling systems showed no significant impact on the recovery of impaired aquatic species or on the overall health of the aquatic population. By contrast, some commenters faulted EPA's proportional flow requirements for failing to account for cumulative impacts in waterbodies that have been previously designated as sensitive. In their view, such waters would suffer a disproportionate impact from high intake volumes than would less sensitive waters. Relying heavily on a flow-based requirement would ignore this potentially ecologically harmful effect.

Many commenters also disagreed with the notion that flow-induced entrainment automatically equates to adverse impact. Commenters argued that any intake flow would likely result in some entrainment loss but that this does not substantially harm the biological community of the source water. To support this, commenters provided examples that demonstrate healthy sport and commercial fishing populations in close proximity to large power plants. Citing these examples, commenters argued that EPA's proposed best technology available requirements based on entrainment and impingement are overly restrictive and cost prohibitive. Instead, commenters proposed basing the 316(b) requirements more on the overall health and viability of the surrounding aquatic environment than on rates of entrainment and impingement.

On the other hand, some commenters supported EPA's assertion that volume and impact are directly proportional. One commenter provided statistical evidence from several cooling system studies that demonstrated higher rates of entrainment and impingement when intake volumes were increased.

Several commenters questioned EPA's emphasis on reducing intake flow to minimize impact while ignoring other influential factors, such as life history strategy, distribution throughout the water column, and adaptations to external stresses, among others, that can result in high entrainment and impingement mortality rates. The commenters argued that such factors can often be mitigated by structural design or location modifications without incurring the expense associated with a reduction in the overall volume of water withdrawn. Similarly, other commenters noted that EPA failed to address technologies and design modifications that could achieve the desired effect—reduction in entrainment and impingement losses—while still maintaining a high rate of withdrawal.

EPA believes the record contains ample evidence to support the proposition that reducing flow and capacity reduces impingement and entrainment, one measure of adverse environmental impact, and may reduce stress on higher levels of ecological structure including population and communities. (*See* DCN #2–029 in the record for this rule (compilation of swim speed data), which demonstrates the potential vulnerability of many fish species to impingement. The documents DCN #2–013L–R15 and 2–013J support the proposition that flow is related to entrainment.) The widespread use of capacity-reduction technology at almost all proposed new electric generating facilities and by a substantial number of new manufacturers makes capacity reduction an appropriate component of best technology available for minimizing adverse environmental impact at new facilities. EPA disagrees with commenters that other factors influential to impingement and entrainment have been ignored. Both Track I and Track II of the final rule allow for site-specific evaluations in determining the appropriate technologies to be implemented. For example, the Design and Construction Technology Proposal Plan required in Track I and the Evaluation of Potential

Cooling Water Intake Structure Effects in Track II allow for site specific consideration of factors other than flow to minimize impacts from impingement and entrainment. Cumulative impacts are addressed on a case-by-case basis by each permitting authority.

2. Basis for Flow Proportional Limits

Numerous commenters rejected the justification for the flow requirement proposed by EPA as being too vague and untenable. Specifically, commenters questioned the proposed goal of a ''99 percent level of protection'' for aquatic communities and how it relates to levels of protectiveness in other water quality-based programs. Many commenters believed both ''99 percent'' and ''level of protection'' were vague and called on EPA to provide more explicit definitions in the final rule. Other commenters questioned the gain in overall aquatic health that can be achieved by setting the requirement at such a high level. Several commenters cited other federal programs and publications, such as the *Water Quality Standards Handbook,* in support of their claim that EPA has no precedent on which to base its proposed requirement. Other programs have demonstrated that a lower target protection level is still adequately protective of the viability of the total aquatic environment. Commenters noted that a high standard would increase compliance costs significantly while producing no measurable improvement in the overall health of the source waterbody and called on EPA to better justify its support of the proposed requirement.

While EPA believes this final rule will significantly increase protection for aquatic communities, the Agency has determined that the proportional flow requirements represent limitations on capacity and location that are technically available and economically practicable for the industry as a whole. EPA examined the performance of existing facilities based on data from the section 316(b) industry survey in terms of proportional flow to determine what additional value could be used as a safeguard to protect against impingement and entrainment, especially in smaller waterbodies, where multiple intakes are located on the same waterbody, or in waterbodies where the intake is disproportionately large as compared to the source water body. As discussed in Section V.B.1.c. above, EPA found most existing facilities meet these requirements. EPA expects that new facilities would have even more potential to plan ahead and select locations that meet these requirements. EPA recognizes that some measure of judgment was involved in establishing the specific numeric limits in these requirements and that these requirements are conservative in order to account for multiple intakes affecting a waterbody. In particular, the 1 percent value for estuaries reflects that the area under influence of the intake will move back and forth near the intake and withdrawing 1 percent of the volume of water surrounding the intake twice a day over time would diminish the aquatic life surrounding the intake. The 5 percent value mean annual flow reflects an estimate that this would entrain approximately 5 percent of the river or stream's organisms and a policy judgment that such a degree of entrainment reflects an inappropriately located facility. Nevertheless, because they address important operation situations and appear to be highly achievable for new facilities, EPA believes they are appropriate to this rule.

These requirements are expected to have little or no impact on the location of cooling water intake structures projected to be built over the next 20 years as new facilities have the opportunity to choose sites that meet their specific design and cooling water needs before construction begins.

E. Velocity

1. Design Through-Screen Velocity as a Standard Measure

Under the proposed rule, any intake located in a freshwater or tidal river, stream, estuary, or ocean or within or near the littoral zone of a lake or reservoir would have to meet a maximum intake velocity requirement: a design through-screen intake velocity of 0.5 feet per second (ft/s).

EPA requested comment on the appropriateness of design through-screen velocity as a standard measure with 0.5 ft/s as the intake velocity, and the utility and appropriateness of a nationally based velocity requirement for the 316(b) regulations. Comments addressed these topics, as well as a range of other issues: problems with biofouling, issues better addressed through a site-specific approach, applicability to offshore oil and gas facilities, and applicability to existing facilities.

Generally, industry commenters thought the 0.5 ft/s requirement to be overprotective and not supported by the scientific literature. On the other hand, states and public interest groups commenters agreed with this requirement. Commenters also gave examples of several situations in which the velocity requirement would be inappropriate. Comments on the NODA generally reiterated issues raised in the comments on the proposed rule.

Numerous commenters questioned the proposed intake velocity requirement on several grounds. Many of the comments suggested that the proposed requirement is based on limited scientific data and undocumented or unsupported government policies. Commenters generally cited the age of the data used to support the requirement, the small number of scientific studies upon which the requirement is based, and the unclear origins of existing government policies that advocate using the 0.5 ft/s requirement. Other commenters stated that the requirement is very conservative and still may not prevent adverse environmental impact. A number of commenters pointed to other factors that affect impingement and entrainment, such as light, turbidity, temperature, and fish behavior. Other commenters suggested alternative requirements, including 1.0 ft/s, an allowable range of velocity from 0.5 ft/s to 1.0 ft/s, a species-specific velocity requirement dependent on the species composition of nearby waters, and a case-by-case velocity limit. Several other commenters further noted that a number of existing facilities with intake velocities exceeding 0.5 ft/s have been determined to be in compliance with 316(b) or to have minimal impacts to fish populations. Other commenters questioned the record support for determining the safety factor used in deriving the proposed velocity requirement. Some commenters supported the velocity requirement, with one commenter noting that it is well-established as a protective requirement and is consistent with the levels of protection required under other existing regulations.

Several commenters expressed concern over the use of design through-screen velocity as the proposed requirement. Some pointed out that approach velocity has been the accepted standard for measuring velocity and questioned the lack of justification for proposing a different methodology. One commenter noted that a specific measure of velocity may be better suited for the design of a particular intake (e.g., through-screen velocity for a wedgewire screen and sweeping velocity for an angled screen). Another commenter opposed the use of design through-screen velocity, arguing that it is difficult to measure and does not represent the velocity that fish must detect in order to avoid impingement. Others noted that a through-screen velocity of 0.5 ft/s would, by definition, require an approach velocity of less than 0.5 ft/s. A commenter also questioned the appropriateness of using through-screen velocity, because intake screens can easily become clogged or fouled, having a dramatic effect on velocity and water flows at and through the screen. Other commenters supported the use of design through-screen velocity, noting that it has long been the industry and regulatory standard for measuring intake velocity. Several commenters suggested methods for measuring approach velocity.

Finally, several commenters drew comparisons with existing velocity requirements used by NMFS Northwest Region. Some of these comments requested that the proposed requirement be fully consistent with the existing NMFS requirements. Others noted that the proposed requirements are actually more stringent than the NMFS requirements when compared using a flow vector analysis, contrary to the Agency's statement that the proposed requirements were less stringent than NMFS requirements.

Given the compilation of supporting data presented in the proposed rule and the NODA, Track I of today's final rule maintains the proposed intake velocity requirement of 0.5 ft/s through-screen velocity. The 0.5 ft/s through-screen requirement is well supported by existing literature on fish swim speeds and will also serve as an appropriately protective measure. EPA believes a requirement that protects almost all fish and life stages is particularly appropriate to provide a margin of safety when, as is common, screens become occluded by debris during the operation of a facility and velocity increases through the portions of a screen that remain open. EPA notes that more than 70 percent of the manufacturing facilities and 60 percent of the electricity generating facilities built in the past 15 years have met this requirement and believes the requirement is an appropriate component of best technology available for minimizing adverse environmental impact at new facilities.

As documented by the data collected for the NODA, EPA believes the 0.5 ft/s requirement is scientifically based, technically sound, protective of aquatic resources, and technically available and economically practicable as demonstrated by the fact that it is frequently achieved at recently built facilities. As discussed below, the requirement is well supported by existing literature on fish swim speeds and will also serve as an appropriate protective measure, since the data suggest that a 0.5 ft/s intake velocity would protect 96 percent of the tested fish. EPA notes that if the permit applicant does not want to meet the specific Track I velocity requirement, the applicant can, under Track II, conduct site-specific studies and seek to demonstrate comparable reduction of impingement mortality and entrainment. This may allow facilities to install cooling water intake structures with greater that 0.5 ft/s velocities if they can demonstrate that they would have the same reduction of impingement and entrainment as Track I standards which include the 0.5 ft/s limitation on velocity. Additionally, past permitting decisions were made using the best judgment at the time of the decision. These permitting decisions should not be interpreted to signify best technology available in future decisions.

The NODA presented further data on fish swim speeds. The velocity of water entering a cooling water intake structure exerts a direct physical force against which fish and other organisms must act to avoid impingement and entrainment. An analysis of swim speed data demonstrates that many fish species are potentially unable to escape the intake flow and avoiding being impinged. EPA received or collected data from EPRI (see W–00–03 316(b) Comments 2.11), from a University of Washington study that supports the current National Marine Fisheries Service velocity requirement for intake structures, and from references included in comments from the Riverkeeper (see Turnpenny, 1988, referenced in W–00–03 316(b) Comments 2.06; document found in DCN #2–028B in the record for this rule). These data were compiled into a graph (Swim Speed Data, DCN #2–029 in the record of this rule). The data suggest that a 0.5 ft/s velocity would protect 96 percent of the tested fish.

In developing the intake velocity requirement, EPA assumed a flat screen with the intake flow directly perpendicular to the face of the screen, because this is a typical arrangement for a cooling water intake structure. However, angled screens, such as those described in the NMFS requirements, are used in some intake designs, and EPA does not wish to discourage any intake designs. Under § 125.84(e), the Director may require additional controls (such as the NMFS requirements) to complement the protection afforded by the velocity requirement. EPA also developed the velocity requirement with a highly protective intake velocity in mind, regardless of the intake configuration. As a result, EPA's requirements may be more stringent than existing requirements required by NMFS or other agencies.

EPA recognizes that approach velocity has been a measurement technique for intake velocity in the past. However, many recently constructed facilities have been designed to meet through-screen intake velocity limitations. Additionally, EPA notes that design through-screen velocity will be simpler to measure and therefore be easier to implement on a national level for both regulators and facilities than approach velocity. New facilities can be designed with consideration given to the through-screen velocity requirement, and designs can be altered accordingly. Intake velocity will also be simpler to measure, as facility engineers can simply calculate the intake velocity on the basis of intake flow and the intake screen area, as opposed to the more complex data gathering process involved in measuring approach velocities near an intake screen. EPA also recognizes that the approach velocity will be less than 0.5 ft/s. The intake velocity requirement is intended to be a highly protective requirement. Regardless of the intake structure design or the presence of sufficient detection or avoidance cues, the intake velocity is low enough to protect of a majority of fish species. For these reasons, the final rule maintains the requirement to measure intake velocity on a design through-screen basis.

2. Appropriateness of a National Velocity Requirement

Numerous comments were received regarding the appropriateness of a national-scale requirement for intake velocity. Many commenters expressed concern that a national requirement would be an unnecessary burden on facilities. Specifically, some commenters noted that a site-specific framework for the 316(b) rule and velocity requirement would be preferable, as it would best account for site-specific details, some of which may affect the rates of impingement and entrainment. Other commenters questioned using a national requirement; given the variability in environmental conditions and fish swim speeds, these commenters said making a national approach is inappropriate to suitably cover the range of organisms found in a given water body. Some commenters noted that the velocity requirement might preclude the future use or implementation of some highly effective technologies. One commenter noted that several studies have suggested little or no correlation between flow and impingement or entrainment; the commenter argued that, therefore, a relationship between impingement or entrainment and intake velocity does not exist.

As documented by the data collected for the NODA, the 0.5 ft/s requirement is scientifically based, is protective of aquatic resources with a reasonable margin of safety, and is met by many recently built facilities. EPA believes it is an appropriate component of best technology available for minimizing adverse environmental impact at new facilities. Permit applicants who wish to build a facility using higher intake velocities have the option, under Track II, to conduct site-specific studies and seek to demonstrate that their alternative will reduce impingement mortality and entrainment to a level of reduction comparable to the level the facility would achieved if it met the Track I requirements, including the velocity limit of 0.5 ft/s.

While EPA acknowledges that multiple factors may affect impingement and entrainment at a given intake, EPA believes that there is ample evidence contained in the record to support a correlation between velocity and/or flow and impingement and entrainment. As stated in the preamble to the rule, intake velocity is one of the key factors affecting the impingement of fish and other aquatic biota. The velocity of water entering a cooling water intake structure exerts a direct physical force against which fish and other organisms must act to avoid impingement and entrainment. The compilation of swim speed data (DCN #2–029 in the record of the rule) demonstrates that many fish species are potentially unable to escape the intake flow and avoid being impinged. The record also supports the proposition that flow is related to entrainment.[89]

Finally, EPA chose a national requirement in order to provide a consistent standard for facilitating implementation given the technical availability and economic practicability of the requirement.

3. Other Comments Concerning the Velocity Proposal

a. Biofouling at Intakes

Several commenters submitted that an intake velocity of 0.5 ft/s may lead to increased difficulties with biofouling at facility intakes, especially at offshore oil and gas extraction facilities. Another commenter noted that with an increase in biofouling facilities would need to increase treatment efforts. Frequently, these efforts involve adding chemical treatments to water flows and may have subsequent adverse impacts on water quality. Another management strategy noted by a commenter is to maintain sufficiently high intake velocities to preclude colonization by fouling organisms. One commenter also expressed concern over the implications of biofouling at fine mesh screens and the potential for these protective technologies to become quickly fouled. One commenter supported the velocity requirement, noting that commercially available alloys have been shown to be highly effective in repelling biofouling organisms.

EPA recognizes that maintaining sufficiently high intake velocities is one possible solution for minimizing settlement by biofouling organisms. However, further research by the Agency suggests that this is not the most effective technique. Often, intake velocities are designed to be as low as possible to reduce the impingement and entrainment of aquatic organisms. Additionally, the intake systems of many facilities are unprepared to support such high intake velocities and would possibly require modifications in order to maintain such velocities. An analysis of facility survey data at existing facilities suggested that only 33 (3.4 percent) of 978 surveyed facilities have intake velocities of sufficient magnitude (greater than 5 ft/s) to inhibit biofouling. Fortunately, a variety of viable alternative technologies and management strategies for dealing with biofouling are available. Examples of these options include the use of construction materials that inhibit attachment of organisms, mechancial cleaning, and chemical and/or heat treatments. While no one strategy has been shown to be universally applicable, there are certainly affordable and implementable options. Maintaining a high intake velocity has not been shown to be the most effective way to control biofouling, since other methods have been shown to be more effective at a lower cost, especially in the context of new facilities. A facility that has yet to be constructed can integrate biofouling control technologies into its design and minimize the impacts of biofouling on normal operations.

b. Concerns Better Addressed by a Site-Specific Approach

Several commenters raised other concerns about the proposed velocity requirement, pointing to a variety of issues that they argue could be more easily addressed on a site-specific level. Some commenters noted that intakes located on large or fast-moving waterbodies may have difficulty maintaining the proposed intake velocity. For example, an intake located in a river moving at 3.0 ft/s may be unable to maintain a constant 0.5 ft/s intake velocity because of the ambient flow. As for the biota near the intake, the commenters submitted that these organisms have adapted to a higher-velocity environment and do not necessarily require protection under a velocity requirement. Other commenters noted that the direction of flow near an intake can have a substantial effect on the intake velocity and detection by fish. For example, the intake velocity at an intake subject to tidal movements or a longshore current may be affected. Another commenter expressed concern that the intake velocity is meaningful only if measured where the screen is the first component of the cooling water intake structure encountered by an organism, such as with a wedgewire screen. Intake canals, trash racks, and other cooling water intake structure components pose a threat by potentially entrapping fish that are unable to locate an escape route. One commenter noted that experimental technologies, such as strobe lights, sound, or intake velocities greater than 0.5 ft/s (up to 10 ft/s for some technologies) may not be developed because of the restrictions on intakes. One commenter observed that a reduction in intake velocity may also reduce the amount of cooling water taken in by a facility. The commenter observed that reducing the cooling capacity of the cooling system may adversely affect facility safety and efficiency.

For faster-moving waterbodies and in other situations where a permit applicant may wish to use a higher intake velocity, facilities may opt to follow Track II and seek to demonstrate that reductions in impingement mortality and entrainment would be comparable to the level achieved with the Track I requirements. Given the data EPA has seen on the protective nature of the 0.5 ft/s requirement (see DCN #2–028 in the Docket for the rule), EPA does not foresee a significant issue regarding entrapping fish and will continue in Track I to specify design through-screen velocity as the measure for determining compliance with the velocity requirement. EPA also notes that facilities wishing to employ developmental technologies may follow Track II and demonstrate a comparable level of protection.

For new facilities, EPA does not anticipate that cooling system safety for nuclear-fueled facilities will be an issue

[89] The documents DCN# 2–013L–R15 (Goodyear. 1997. Mathematical Methods to Evaluate Entrainment of Aquatic Organisms by Power Plants) and DCN# 2–013J (EPRI. 1999. Catalog of Assessment Methods for Evaluating the Effects of Power Plant Operations on Aquatic Organisms.) in the record of the rule both support this premise.

because any requirements can be addressed through facility design. New facilities have the opportunity to address and mitigate safety and efficiency issues during the design of the facilities. The fact that 79 percent of power generating plants and 46 percent of manufacturing facilities built within the last five years meet the Track I velocity requirement demonstrates that facilities designed in accordance with this requirement can incorporate any necessary features to ensure proper functioning of the cooling system.

F. Dry Cooling

In the proposed rule EPA requested comment on regulatory alternatives based wholly or in part on a zero-intake flow (or nearly zero, extremely low-flow) requirement commensurate with levels achievable through the use of dry cooling systems. See, 65 *FR* 49080–49081. EPA rejected dry cooling as best technology for minimizing adverse environmental impact for the reasons discussed in Section V.C above.

Some commenters, citing several examples, responded that dry cooling systems must be the best technology available for minimizing adverse environmental impact because they reduce intake volume and the killing of aquatic organisms to extremely low levels. These comments claim that dry cooling is an available and demonstrated technology. They focus on several demonstrated cases of dry cooling and discuss its use for a range of fuel sources, ownership categories, climates, and electric generating capacity. The comments claim that dry cooling technology in the United States has been growing rapidly since the early 1980s and represents approximately 27 percent of new capacity since 1985. Additionally, commenters in favor of the dry cooling alternative state, on the basis of recent construction trends, that the best technology available for the New England region is dry cooling systems. The commenters provide examples of 15 steam electric stations currently operating, under construction, or recently approved for construction using dry cooling in New England. These projects range in capacity from 24 MW to 1500 MW, with an average capacity of 480 MW and a total capacity of 7200 MW. Commenters supporting the dry cooling alternative claim that the technology frees the industry user groups from unnecessarily restrictive requirements to site facilities adjacent to or short distances from waterbodies or other sources of cooling water and eliminates discharges (of both thermal pollution and water conditioning chemicals) to these waterbodies. This freedom from water dependency, the comments assert, allows new power plants to locate in close proximity to the end users of electricity, thereby decreasing energy loss due to transmission, and to use alternative sources of water such as treated wastewater effluents, municipal supplies, and groundwater. EPA rejected dry cooling for the reasons discussed at V.C above.

Some commenters asserted that dry cooling systems are not necessary for minimizing adverse environmental impact nor do they qualify as the best technology available. They assert that dry systems are not considered to be a viable, cost-effective design choice unless there are unique circumstances and conditions associated with either the site or the market climate for the project. The comments recommend that adoption of dry cooling systems be left to the permittee's judgment and not be a uniform requirement. The physical space requirements, the commenters assert, severely limit the siting options available to new facilities. They oppose the imposition of dry cooling in southern climates, where, they claim, there is an abundance of high volume surface water available for cooling. Additionally, the commenters claim that dry cooling has not been shown necessary for minimizing adverse environmental impact. They also contest claims made by other commenters on the proposal that dry cooling has been demonstrated for a variety of climates and generating capacities. These commenters counter claims made by other commenters on the proposal that dry cooling is a demonstrated technology for large-size power plants. EPA has rejected dry cooling as best technology available for the reasons discussed at V.C above.

Other commenters discuss dry cooling technologies at manufacturing facilities. The commenters challenge the viability of dry cooling systems in manufacturing facilities that cool process fluids to ambient levels (e.g., below 100 degrees F) or do not condense steam. They claim that the dual use of process and cooling water prevents the application of dry cooling. EPA agrees that dry cooling technologies for manufacturing cooling waters pose engineering feasibility problems. EPA rejects dry cooling as a basis for a national requirement for new manufacturing facilities (as discussed in Section V.C above) but points to several demonstrated cases of dry cooling for cogeneration plants at or adjacent to manufacturing facilities as encouragement for cogenerating plants to consider the technology on a site-specific basis.

The cost of dry cooling systems is discussed in a variety of comments. Generally, all commenters discuss elevated capital and operating and maintenance (O&M) costs in comparison with similar capacity recirculating wet cooling towers. An analysis of modeled new combined-cycle plants in five regions of the United States was submitted with one comment. This analysis estimated that capital and total O&M costs for dry cooling systems exceed those for wet cooling systems by greater than 75 percent, regionally and nationally. Other commenters generically assert that the capital and operating costs of the technology significantly exceed those of recirculating wet cooling towers of comparable capacity. Even commenters in favor of dry cooling as the best technology available acknowledge that the cost of a dry cooling system can be as much as three times that of a comparable wet cooling system. However, these commenters also contest that the cost of the technology is clearly not wholly disproportionate to the environmental benefit gained. These commenters in favor of dry cooling as the best technology available claim that the capital cost and O&M costs of air-cooled structures at combined-cycle electric generating plants represent a small fraction, only 2 to 3 percent (using EPA's proposal cost estimates), of the estimated annual revenues for those facilities. These commenters state that because newer combined-cycle plants need cooling only for the steam portion of their cycle (only about one-third of their total capacity), they can be cooled with a much smaller dry cooling system than a comparably sized, steam-only generating plant. Thus, these commenters claim, the increased cost for dry cooling is considerably smaller than it would have otherwise been for conventional all-steam plants. These commenters add that they believe the costs of installing dry cooling as the best technology available at a fraction of a cent per kilowatt hour, would not be felt or even noticed by consumers. EPA discusses the costs of dry cooling extensively in Chapter 4 of the *Technical Development Document.* EPA agrees with commenters that elevated costs of the technology as compared with other cooling technologies pose a significant implementation problem for new facilities. Specifically, as discussed in Section V.C above, the compliance costs of dry cooling based requirements would result in annualized compliance cost of greater than 4 percent of revenues for all 83 electricity generators, and of greater than 10% of revenue for 12 of the 83 generators.

The performance of dry cooling systems is addressed in many comments. Some comments point to lower performance than wet cooling systems and greater sensitivity to climatic conditions as being crucial for evaluating the efficacy of the technology. These comments claim that depending on climatic conditions, certain locations in the country will have a higher probability of incurring energy penalties. These commenters cite performance drawbacks to dry cooling systems due to operation at elevated turbine backpressures or reductions in energy production in locations with high daily or seasonal dry-bulb temperatures. One commenter provided results from a modeling exercise simulating energy inefficiency impacts at dry cooling facilities in a variety of climatic conditions. The results from the commenter's analysis showed summer peak performance shortfalls (*i.e.,* peak energy penalties) of greater than 30 percent for dry cooling facilities. Additionally, the commenters estimate that the energy penalty would vary considerably throughout the United States because of climactic conditions. Conversely, some commenters claim that the energy penalty from some dry cooling facilities in some areas is equivalent to that calculated by New York State officials for the Athens Generating Company facility, where they estimated a 1.4 to 1.9 percent reduction in overall plant electrical generating capacity as a consequence of using a dry cooling system versus a hybrid wet'dry system.[90] The commenters add that, in their view, energy conservation measures can more than offset any potential minor loss of efficiency from dry cooling. The commenters claim that the building of modern generating facilities provides significant efficiency gains that dwarf any potential loss due to the cooling system design. These commenters claim that transmission losses exceed the energy penalty associated with the dry cooling system; further, they assert that because dry cooling makes it possible to locate away from major bodies of water and closer to energy users, a facility can be more than compensated for the energy penalty. Finally, the commenters state that a 1 to 2 percent loss for the sake of greater protection of water resources is comparable to other efficiency penalties EPA requires of the electric industry for reductions in NO_X and SO_2 emissions. The performance penalties of dry cooling systems play a significant role in EPA's decision to reject dry cooling as the best technology available. See Section V.C above for further discussion.

Hybrid wet and dry cooling systems are addressed in several comments. One commenter contends that the viability of hybrid systems for large-scale cooling operations (e.g., at a power plant with capacity greater than 500 MW) is uncertain. The commenter identifies site-specific performance advantages of hybrid systems over dry cooling, noting that the most common type of hybrid system is designed to eliminate visible plumes from wet cooling towers. These comments additionally claim that hybrid plume abatement systems are not water-conserving systems and that their costs are greater than wet cooling tower systems. EPA considers hybrid cooling systems not to be adequately demonstrated for power plants of the size projected to be within the scope of the rule. As such, EPA has not adopted the technology as a component of the best technology available requirements of today's rule. However, EPA recognizes that there is distinct potential for the use of hybrid cooling systems, especially in cases where plume abatement is concerned.

Some commenters claim that air emissions from electricity generation would increase because of energy penalties from dry cooling systems. These commenters state that an energy penalty creates a need for replacement power, which must be met by even more new generating capacity resulting in an increased potential for environmental impacts (such as increased air emissions). The comments add further that estimating those emissions would project the costs of power production and the mix of generating capacities (e.g., coal-fired, nuclear) available at the time of anticipated demand. Other commenters take the view that increased air emissions due to dry cooling systems are not a concern. EPA is concerned about the degree to which dry cooling-based requirements would increase air emissions associated with electricity generation. In the cases where performance penalties are high (i.e., in hot climates or during hot climatic periods), the increases in air emissions due to the potential adoption of dry cooling-based requirements are of concern to the Agency. This issue is further discussed in Section V.C in the context of EPA's rejection of dry cooling.

For the final rule EPA concludes that dry cooling systems are not the best technology available for minimizing environmental impact. EPA recognizes that dry cooling systems can achieve significant reductions in the impingement and entrainment of aquatic organisms compared with other cooling systems, especially once-through systems. Additionally, EPA acknowledges that the technology has been demonstrated as a viable cooling alternative for certain power plant applications under certain circumstances. EPA notes, however, that few of the plants constructed with the technology have been built with cooling systems of a size comparable to what would be required at several of the planned coal-fired systems EPA projects within the scope of the rule. The dry cooling technology presents flexibility to power plants, especially those of small size, those locating in arid regions, and those with water scarcity issues, or those wishing to avoid NPDES permitting issues. However, the technology presents several clear disadvantages that prohibit its adoption as a minimum national requirement or as a minimum requirement for subcategories of facilities. Although EPA recognizes that the technology—by using extremely low-level or no cooling water intake—reduces impingement and entrainment of organisms to dramatically low levels, EPA interprets the use of the word ''minimize'' in CWA section 316(b) to give EPA discretion to consider technologies that reduce but do not completely eliminate impingement and entrainment as meeting the requirements of section 316(b) the CWA.

A minimum national requirement based on dry cooling systems would result in annualized compliance cost of greater than 4 percent of revenues for all 83 electricity generators, and of greater than 10% of revenue for 12 of the 83 generators. Because the technology can cause inefficiencies in operation during peak summer periods and in hot climates, adoption as a minimum national requirement would also impose unfair competitive disadvantage for facilities locating in hot climates, more so than a traditional recirculating wet cooling tower or once-through cooling system. For the subcategory of facilities in cool climatic regions of the United States, adoption of a requirement based on dry cooling for these facilities would also impose unfair competitive restrictions. The competitive disadvantages relate primarily to the capital and operating costs of the dry cooling system. Additionally, adoption of requirements based on dry cooling for

[90] State of New York, Department of Environmental conservation. 1999. Initial post hearing brief, Athens Generating Company, L.P. Case no. 97–F–1563.

a subcategory of facilities with a capacity under a particular level or by fuel type would pose similar competitive disadvantages for those facilities. EPA's record demonstrates that dry cooling systems generally cost as much as three times more to install and construct than a comparable wet cooling system. Dry cooling system O&M costs range from less than or comparable to those for wet systems to two or more times higher. In addition, dry systems generally impose an energy penalty as compared with wet cooling systems. EPA estimates the annual average energy penalty to be 3 percent over a recirculating wet cooling tower system.

Further, EPA considers the degree of energy inefficiency associated with dry cooling to be counter to the performance of the best technology available candidate technology. EPA's record shows an annual average energy penalty for dry cooling of approximately 3 percent relative to recirculating wet cooling towers. This energy penalty represents the typical performance of a dry cooling system in northern climates, extended to the rest of the national climates. However, the peak summer performance is expected to decrease significantly in certain hot climates. EPA estimates that, for a newly constructed and designed facility, the peak summer shortfall could exceed the annual penalty by an additional 3 percent. This value could increase significantly as the facility ages; it hinges on regular and thorough maintenance.

EPA concludes that the air emissions increases from power plants due to adoption of a requirement based on dry cooling would be counter to the performance of a best technology available candidate technology. Changes in energy consumption associated with dry cooling would result in changed fuel consumption and therefore could result in greater air emissions from power plants using dry cooling than would occur if the plants used wet cooling. EPA estimates that the average annual air emissions for the power plants in scope of the final rule with a dry cooling alternative for CO, NO_X, SO_2, and Hg emissions would be greater than if the plants used wet cooling. See Section VI.B.2.e. See Chapter 3 in the *Technical Development Document* for more information on EPA's air emissions analysis.

G. Implementation-Baseline Biological Characterization

In the proposed regulations, the Agency proposed that all facilities perform a source water baseline biological characterization to establish an initial baseline for evaluating potential impact from the cooling water intake structure before the start of operation. The study required that information be collected over a 1-year period. This information was needed to determine the kinds, numbers, life stages, and duration of aquatic organisms in the vicinity of the cooling water intake structure. The Director would use the findings of the study to evaluate the efficacy of the location, flow, and velocity requirements and to define the need for design and construction technologies. The regulations would have also required facilities to conduct impingement monitoring over a 24-hour period once per month and entrainment monitoring over a 24-hour period no less than biweekly during the period of peak reproduction and larval abundance. After two years, the permitting agency would be allowed to reduce the frequency of impingement and entrainment monitoring. EPA's July 2000 information collection request estimated costs for the Source Water Baseline Biological Characterization at an average of $32,000. Monitoring was estimated at approximately $38,000 annually for entrainment and $13,000 annually for impingement. The NODA provided updated costs for both the source water baseline characterization and post operational monitoring.

1. Need for the Source Water Baseline Biological Characterization

Numerous commenters from both the States and the industry agreed that the source water baseline biological characterization was reasonable to determine the condition of the aquatic system. Other commenters questioned the need for a 1-year study that would provide information of limited utility because of the variation that natural populations exhibit from year to year. Some commenters were concerned that the baseline year may not be representative of the average characteristics of the organisms and that comparing subsequent monitoring with the baseline may provide erroneous conclusions.

Some commenters expressed their concern that the requirement to perform the baseline biological characterization would delay issuance of an NPDES permit and that the time required to develop the study in cooperation with and with approval from the permitting authority would increase the development time by 3 to 6 months. They estimated that the time to perform the study would be approximately 18 to 21 months. In particular, the electric utility industry stated that the additional time may result in construction delays that would threaten the availability or price structure of electricity in certain areas.

In addition, some commenters stated that there may be no need for a study if highly protective technology such as closed-cycle cooling is proposed to be used by the permittee, especially if the facility is located on a large waterbody.

Some commenters suggested that the studies be required only if alternative requirements were requested and not if the strict technology-based requirements are adopted. One commenter questioned the need for reevaluating the baseline biological characterization for the next permit term.

In response to these comments, EPA has modified the baseline biological characterization requirements in the rule to allow for the use of existing data, both for the initial permit issuance and reissuance. In today's final rule, Track I specifies highly protective technology-based performance requirements and does not require a permit applicant to conduct monitoring prior to submitting an application. The applicant must gather existing information on the site and select design and construction technologies that will minimize impingement and entrainment and maximize impingement survival. Under Track II, the applicant must conduct a considerably more rigorous study if he or she seeks to demonstrate that alternatives to the Track I requirements will reduce the level of impingement mortality and entrainment to a level of reduction comparable to the level the facility would achieve if it met the Track I requirements at a site.

2. Cost of Source Water Baseline Biological Characterization

Numerous commenters stated not only that the proposed sample collection was time consuming but also that the analysis and identification of the samples of aquatic insects and ichthyoplankton were extremely labor intensive. Some commenters suggested that the studies be required only if alternative requirements were requested and not if the strict technology-based requirements were adopted.

Numerous commenters stated that existing qualitative information is already available on aquatic species at many sites located on major waterbodies. At these sites, little additional information would be provided by an additional year of sampling in the vicinity of a proposed cooling water intake structure. These commenters would like the Agency to prepare additional guidance as to when existing information would be appropriate. Another commenter questioned the acceptability of existing information that is more than 5 years old, because of changes in water quality, species composition, and other variables.

One commenter stated that the study should be tailored to the needs of the site. The commenter stated that some static or controlled environments might require a less rigorous study, while more complex and changing environments might require a more rigorous study to fully characterize the site. Other commenters stated that the requirements in the regulation were ambiguous.

Commenters were concerned that the costs estimated for the proposed rule, at an average of $32,000, were unrealistically low and that a more reasonable estimate might be $100,000. Some commenters stated that the estimate for a proper characterization study would be 10 times the original estimate. One commenter stated that the $32,000 may be low even for a paper study, stating that a simple study with the barest scope of work would cost in excess of $50,000 while impingement and entrainment monitoring would cost approximately $100,000–$150,000 per year.

Some commenters stated that the costs EPA estimated were too low in light of the accuracy that would be needed to determine whether significant adverse environmental impact exists and whether further mitigative measures or technologies must be used and that the characterization will also serve as the benchmark against which future performance is measured. One commenter stated that the accuracy needed would require stratified sampling.

Some commenters stated that the costs presented in the NODA for post-operational monitoring were still too low. They stated that at a minimum multi-species assessments for decisionmaking would cost approximately $50,000.

EPA believes that the post-operational monitoring cost is accurate. This cost was developed to reflect the extent of the monitoring required, which is noticeably less than previous 316(b) monitoring requirements. It is likely that the commenter is referring to these previous monitoring requirements when making comments as to the cost of these efforts. For example, previous studies may have required extensive impingement and entrainment monitoring and detailed taxonomic studies. The post operational monitoring required by this rule is expected to be less burdensome, requiring only monthly surveys for impingement and entrainment and possibly species identification. This level of effort is considerably less than the monitoring conducted under previous section 316(b) studies and is therefore less costly.

3. Impingement and Entrainment Monitoring

Some commenters requested that impingement and entrainment monitoring not be required if the strict technology-based requirements were adopted by a facility. They thought that installing the technology should be adequate to show compliance and to demonstrate that the objectives of section 316(b) had been met. Other commenters suggested that postoperational monitoring be implemented on a site-by-site basis where there is evidence that unanticipated potential impacts could occur or where habitat restoration has restored aquatic populations.

EPA disagrees with commenters who advocate no impingement and entrainment monitoring during the permit for permittees who opt to meet the Track I requirements. The Track I requirements for design through-screen velocity and for selecting and installing design and construction technologies that minimize impingement mortality and entrainment require the permittee to install and operate technologies that require periodic maintenance and operation in a prescribed manner. Periodic monitoring is appropriate. The permit director also must determine for each permit renewal whether additional design and construction technologies are necessary, and impingement and entrainment monitoring will provide information needed for this determination. See 125.89(a)(2).

H. Cost

1. Consideration of Facility Level Costs

EPA received comments on the proposal regarding its facility level cost estimates for the proposed requirements and a number of the regulatory alternatives. The issues addressed by commenters covered a range of topics, which EPA summarizes below.

Some commenters claim that EPA has not considered or addressed all environmental costs and impacts of the regulatory alternatives. The commenters state that EPA has not considered the operating efficiency losses of wet and dry cooling tower systems. They claim that both auxiliary power requirements and performance penalties may result in reductions in capacity and in the quantity of energy to end-users. The commenters state that replacing this power from other higher-cost sources will result in social costs for which EPA has not accounted. As a result of performance penalties, according to the commenters, the quantity of fuel required to generate the same quantity of energy increases. They add that recirculating cooling towers may result in the following additional environmental impacts, for which EPA has not accounted: visibility impacts from recirculating cooling towers, local climate change from wet cooling tower plumes, wildlife losses (e.g., birds colliding with towers), fish losses due to loss of heated aquatic plumes to over-wintering habitats, increased air emissions from sources replacing lost power, and increased impediments to waterway navigation due to icing in northern regions.

EPA initially responded by providing information in the NODA regarding this subject and outlined its intent to account for some additional costs in the final rule (66 *FR* 28866 and 28867). The cost estimates for the final rule include consideration of performance penalties and other environmental issues highlighted by the commenters. The final rule accounts for the ‘‘energy penalty’’ for facilities that are projected to install recirculating wet cooling tower systems in lieu of once-through cooling systems. EPA estimated marginal performance penalties, the costs to replace the lost power due to these penalties, and the increased air emissions of the penalties. Additionally, visibility impacts from cooling towers, local climate change from wet cooling tower plumes, wildlife losses (*e.g.,* birds colliding with towers), fish losses due to loss of heated aquatic plumes to support over-wintering habitats, and increased impediments to waterway navigation due to icing in northern regions are considered local impacts that can be addressed through the use of Track II or, in some cases, through design modifications of the recirculating wet cooling tower. EPA has provided costs for plume abatement (2 percent of the number of cooling towers) to address cooling tower emissions and considers the other impacts to be negligible and best addressed on a site-specific basis.

Some commenters criticize EPA's approach to estimating capital and operating costs of recirculating wet cooling towers. The commenters claim that EPA has significantly underestimated the costs of a recirculating wet cooling tower by considering only the cost of the cooling tower without the additional cost of other necessary cooling system equipment such as wiring, foundations, noise attenuation treatment, the cost of construction and other equipment. They claim also that EPA's estimates understate makeup water costs for wet cooling towers. The commenters add that EPA's cost multipliers for recirculating wet cooling towers are questionable and not consistent with a number of engineering texts. With respect to O&M costs, they question EPA's estimates for economies of scale. For dry cooling towers, the commenters object to EPA's methodology of making a direct cost comparison between dry cooling systems and wet cooling systems. They claim that EPA's approach for estimating capital and O&M costs for dry cooling towers is flawed because it relies on cooling water flow as the cost basis. In addition, they state that EPA does not provide cost equations or curves for dry cooling systems. One commenter claims that winterization costs of dry cooling systems were not considered by EPA and that EPA therefore has underestimated the system's costs.

EPA fully documented the bases for recirculating wet cooling tower cost estimates in the NODA (66 *FR* 22866 and 22867). EPA disagrees with many of the comments regarding flaws in estimating capital and operating costs for cooling towers. The *Technical Development Document* and comment response document discuss EPA's costing estimates and consideration of the variety of issues asserted by commenters, such as documentation of equipment costs, foundations, noise attenuation, and the cost of construction. EPA has also considered the comments regarding makeup water costs. The estimates of costs for this rule reflect a realistic and accurate basis for makeup water usage in wet cooling towers. These issues are discussed further in Chapter 2 of the *Technical Development Document.* With respect to EPA's estimates of O&M economies of scale, EPA revised its estimates based on comments received and further analysis. EPA conducted a thorough review of its data and the public comments. Although the comments did not persuasively describe errors in EPA's economies of scale estimates, they did prompt EPA to reconsider the concept. EPA's further research revealed that there are economies of scale associated with certain components of O&M, but that use of economies of scale for total O&M costs would not be appropriate. As such, EPA's estimates for operation and maintenance costs for wet cooling towers have been refined to reflect no economies of scale. See Chapter 2 of the *Technical Development Document* for further discussion.

In the NODA, EPA included further documentation to support its estimates of the costs of dry cooling systems (both for capital and O&M components). Despite the comments received expressing concern over the methodology employed by EPA to estimate the costs, EPA continues to view its empirical models as robust, accurate, and well suited for the purposes of the final rule. EPA acknowledges that basing cost curves for dry cooling systems on cooling flow is unconventional. However, the model is based on empirical data and accurately estimates the costs of dry cooling systems. Regarding the subject of winterization, EPA's costs inherently include this technological aspect as it is an incorporated design feature in modern dry cooling systems upon which the empirical models are correlated. See Chapter 4 of the *Technical Development Document* for further information regarding EPA's costing methodology for dry cooling.

One commenter questions EPA's estimates regarding the ''design approach value'' used in plant cooling systems. The commenter recommends that EPA adopt an approach value of 8°F instead of 10°F. The commenter claims that EPA has understated the size of the cooling towers with its approach value estimate. EPA provided significant documentation in the NODA regarding its estimates of cooling system design approach values. Specifically, data demonstrate that a 10 degree design approach for a wet cooling tower is acceptable industry practice. Chapter 3 of the *Technical Development Document* discusses this subject further and presents EPA's supporting data.

Comments from manufacturers express concern over potential energy losses due to abandoning the use of waste heat for process water heating. They expressed concern that the proposed rule would discourage the practice of process and cooling water reuse. The commenters assert that if these potential energy loss costs were added to the other costs of the proposed rule, that the total cost could be substantially higher, possibly by several million dollars. Thus, the commenters state, the proposed rule could pose a significant and perhaps insurmountable hurdle for construction of new manufacturing facilities. EPA considered these comments and is adopting a definition of cooling water for the final rule (see § 125.83) that addresses these concerns. At § 125.86(b)(1)(ii), EPA also specifies that the amount of water withdrawn for cooling purposes that is reused or recycled in subsequent industrial processes is equivalent to closed-cycle recirculating cooling water for the purposes of meeting the Track I capacity-reduction, requirements at § 125.84(b)(1). However, the amount of cooling water that is not reused or recycled must be minimized. Therefore, the commenters' concerns that costs could be substantially higher, possibly by several million dollars have been addressed in the final rule.

Further, some commenters claim that EPA has not considered the costs of a sufficient number of regulatory alternatives or alternative technologies. EPA included, in Section VIII of this preamble and the *Economic Analysis* (Chapter 10), cost information on the range of regulatory alternatives considered for the final rule.

One commenter on the NODA described the costs associated with potential delays in permit approvals. The commenter stated that should permitting delays extend the construction period, the associated costs would accumulate at a monthly rate associated with the finance costs associated with down-payments on equipment, the lost income from sales of electricity, and the cost of purchasing replacement power. For regulatory alternatives that have projected permitting delay, EPA has incorporated the commenter's suggestion to the extent possible. For the final rule, EPA is basing the regulatory option on a two-track compliance option that, under the ''fast track,'' has no associated delay in permitting. In addition, EPA has not accounted for cost savings of the rule over the current, resource intensive, case-by-case regulatory approach. In that sense, the final rule overestimates compliance costs.

Another commenter to the NODA provided a case-study example for converting the Indian Point Units 2 and 3 to closed-cycle cooling water systems or dry cooling systems. The results show a small cost impact for closed-cycle cooling water systems and a modest cost impact for dry cooling, according to the commenter. In terms of the cost for producing power, the incremental cost for the installation and use of a closed-cycle cooling water system, according to the commenter's analysis is 0.01 to 0.03 cents per kWh. The commenter's analysis shows incremental costs for the installation and use of a hybrid cooling system between 0.14 and 0.19 cents per kWh and 0.21 to 0.27 cents per kWh for dry cooling. EPA evaluated the case-study analysis presented by the commenter for this retrofit situation and finds the costs to be relatively applicable (as the costing analysis was based on EPA's proposal cost estimates, EPA notes that some costing methodology revisions are not reflected in the commenter's analysis). EPA disagrees with several cost-related estimates made in the commenter's analysis, and therefore determines that the cost impacts of dry cooling technologies on the price of electricity is somewhat understated. See response to comment document for further discussion of this case-study analysis and EPA's technical review of the study.

2. Need For More Complete Assessment

A number of industry respondents criticized the economic analysis supporting the rule arguing that it has underestimated the cost of the proposal. Several comments noted that the technology cost, along with the baseline biological characterization, has been underestimated. A few comments asserted that EPA has not considered additional alternatives in selecting the preferred option to comply with requirements of the Executive Order 12866. Industry commenters noted that EPA has not selected the best technology available on a cost-benefit basis. Commenters also noted that the environmental cost of the technologies has not been reflected in the *Economic Analysis.* EPA recognizes that it selected best technology available for minimizing adverse environmental impact on the basis of what it determined to be an economically practicable cost for the industry as a whole. EPA did this by considering the cost of the rule as compared with the revenue of a facility, as well as the cost compared to the overall construction costs for a new facility. This approach is analogous to the economic achievability analyses it conducts for other technology-based rules under sections 301 and 306 of the CWA which use very similar language to section 316(b) and to which section 316(b) refers, and is consistent with the legislative history of section 316(b) of the CWA. At the same time, the record does contain analysis of the costs for a number of the regulatory alternatives considered under the rule.

After reviewing these comments, EPA has revised the *Economic Analysis.* As discussed in the NODA, EPA has gathered additional cost information to verify its cost estimates. It has collected additional information on benefit or the efficacy of the technologies used in the costing exercise. EPA has used more recent forecasts to estimate the number of electric generation facilities. The energy penalty associated with certain technology options, which was not included in the economic analysis for the proposal, has been included in the final economic analysis. EPA considered the costs for a number of alternatives to the requirements in today's final rule.

3. Accuracy of the Estimates

A number of commenters questioned the accuracy of the cost estimates. One commenter (Electric Power Supply Association) stated that EPA's estimates of the cost of the rule are based on several critical and arguable assumptions: (1) The rate of new facility development in the coming years, (2) the proportion of new facilities that would employ cooling water intake structures, (3) the costs of adopting one technology versus another, and (4) the cost of scientific and engineering studies. The combined effect of these assumptions, it is claimed, is that EPA underestimated the cost of the rule by as much as one-hundred-fold. Another commenter claimed that the cost of the rule would be more than five times higher than the EPA's estimates. The Utility Water Act Group (UWAG) estimated the cost of installing a cooling tower alone at $6,366.7 million for recirculating wet cooling towers and $11,245.3 million for dry cooling, assuming 100 percent of the combined-cycle facilities would be required to install towers.

EPA considers these estimates to be unreasonable. After careful review of comments received and additional analyses, EPA estimates the annualized compliance cost of the final rule to be $47.7 million. This cost estimate includes a revised forecast for new electric generation capacity, a revised technology baseline for regulated facilities, a revised estimate of the number of regulated manufacturing facilities, and inclusion of costs for a comprehensive demonstration study in Track II. The example costs presented by UWAG were, as described by the commenter, not directly comparable to EPA's cost estimates. The commenter included a significant equipment cost in its analysis—that of the steam condenser—that clearly is not applicable to the incremental costs of this rule, as all new facilities would install a steam condenser regardless of this rule. In addition, several estimates for design variables differ from those used by EPA and significantly bias the capital and operation and maintenance costs upward. EPA analyzes and discusses the UWAG example for costs in the response to comment document.

4. Energy Supply

Some industry respondents, including the Utility Water Act Group, argued that the section 316(b) proposal would be a significant threat to the national energy supply, would prohibit location of new power plants in most places, and would serve as a barrier to entry in the electric generation market. EPA disagrees with these assertions based on the siting impact analysis discussed at Section V.B.2., the relatively low cost of the rule as a proportion of revenues (as discussed in Section VIII), and the energy impact analysis described in Section X.J.

Some of the commenters stated or implied that the cost of the rule would have a significant impact on meeting growth in energy demand. EPA disagrees with this assertion because the compliance cost of the final rule is an insignificant component of not only new facility revenue but also the construction cost of a new plant. Thus, the cost of the rule is too small to affect the electric generation market. The cost of the final rule is so low primarily because 93 percent of the projected new in-scope combined-cycle facilities, which are responsible for most of the new electric generation capacity, have already planned to install recirculating wet cooling towers in the baseline. Therefore, they will incur, in addition to permit application cost, only a cost associated with selecting and implementing a design and construction technology such as a wedgewire screen or a fish return system on a traveling screen. In addition, estimates show that most new in-scope coal facilities also plan to install cooling towers independently of this rule. Thus, the rule requirements will not have any significant effect on the energy supply. Had EPA chosen dry cooling technology as the best technology available for minimizing adverse environmental impact, the energy impact would have been significant (i.e., upwards of 0.51 percent reduction (1,904 MW) of the projected new generating capacity).

Commenters asserted that the requirements of the rule could adversely affect the reliability of the electric power system, potentially increasing the risk of brownouts or blackouts or a curtailment of load provided to a particular user. EPA disagrees with this assertion. While Track I requirements (for facilities with intake flows equal to or greater than10 MGD) to reduce capacity commensurate with the use of a closed-cycle, recirculating cooling system and to select and install design and construction technologies would result in an additional use of electric power at a power plant not already planning to use these technologies, the magnitude of the electric use compared with total electric supply at the national level is negligible (approximately 0.03 percent (100 MW) of projected new capacity). Only four coal-fired and five combined-cycle plants are projected to install recirculating wet cooling towers because of the rule. Moreover, the magnitude of electricity required in the operation of design and construction technologies, such as a fish return system, is very small. Finally, future facilities are not necessarily required to install cooling towers; under Track II they have an option to conduct site-specific studies and seek to demonstrate that other technologies will reduce impacts to fish and shellfish to a level comparable to the level that would be achieved at their site with the Track I requirements for intake capacity and velocity. Thus, the efficiency issue associated with the recirculating wet cooling towers, raised in some comments, overemphasizes the effect on the power supply at the national level. Similarly, EPA does not believe that other requirements of the rule, such as the velocity limit and proportional flow requirements, will adversely affect efficiency at power plants. The Track I velocity requirements of the rule can be met by design changes including enlarging the opening of the cooling water intake structure and screens without reducing the flow and hence without influencing the cooling efficiency. The proportional flow limits in the rule would also be largely met by power plants without any discernible impact on their efficiency or net energy supply. As discussed in section V.B.1.c. above, EPA found that most existing facilities meet these requirements. The proportional limitation can be met during design by siting on an alternative waterbody or by choosing alternative technologies, for example. Additionally, see Section V.B.1. for a discussion of proportional flow limits.

Commenters expressed concern that the regulatory requirements would result in delays in the construction of the new power plants, thus affecting the power supply and electricity prices. However, under Track I in the final rule, facilities can build a power plant without any required pre-permit monitoring.

Some industry commenters asserted that the requirements of the rule could be a hindrance to cogeneration. EPA disagrees with this conclusion. Contrary to the assertion, Track I in the final rule provides incentives for cogeneration because it considers reuse of cooling water as process water and vice versa as equivalent to recirculation. Thus, a cogeneration facility can reuse cooling water as process water or vice versa and eliminate the need to install a recirculating wet cooling tower to save costs or reduce the size of any tower needed to meet the Track I intake capacity requirement.

5. Forecast for New Utility and Nonutility Electric Generators

Most comments on the forecast of new utility and nonutility electric generators claimed that EPA underestimated the number of new generators in scope of the proposed section 316(b) new facility rule. Commenters cited several reasons for the alleged underestimate: (1) The use of an incomplete, outdated, or biased database as the basis of the estimate; (2) an underestimation of the number of facilities that will operate a CWIS; (3) an underestimation of the size of new facilities; and (4) the use of new capacity forecasts that are based on conservative assumptions regarding anticipated growth in demand for electricity. Two commenters claimed that the underestimation may be five-fold. Commenters also suggested that EPA underestimated the intake flow of regulated (in scope) facilities and the number of new generators that will use a once-through cooling system. One commenter claimed that the proposed section 316(b) new facility rule would cause additional delays in bringing new electricity supply on line.

EPA used the most current and complete data available at the time to develop the projected number of new electric generators. To address the above comments, EPA updated and expanded its research as new data have become available. In support of the final section 316(b) new facility rule, EPA used the February 2001 version of the NEWGen database. Compared to the January 2000 NEWGen database used for proposal, the newer version contains more than twice the number of new projects (941 compared to 466). EPA researched more than three times as many greenfield combined-cycle facilities (320 compared to 94) and obtained cooling water source information on almost four times the number of facilities (199 compared to 56). While EPA recognizes the fast pace of changes in the electricity generation industry, EPA believes that the substantial increase in the number of greenfield electric generators analyzed will address concerns commenters had voiced. In addition, the much larger number of facilities identified as being in scope of the final section 316(b) new facility rule (57 compared to seven) will provide a more robust and representative basis for estimating the characteristics (including size and cooling system type) and costs of new greenfield generators. Finally, EPA is using the Department of Energy's (DOE) updated Annual Energy Outlook 2001 as the basis for its total new capacity forecast. The 2001 Outlook is based on higher economic growth (in the reference case, 3.0 percent) and electricity demand (in the reference case, 1.8 percent) compared to the Annual Energy Outlook 2000 (2.2 percent and 1.4 percent, respectively). It should be noted that, for both the proposed and the final section 316(b) new facility rule, EPA's projection of new electric generators is based on forecasts made by the DOE's Energy Information Administration (EIA), not forecasts made by EPA.

6. Forecast for New Manufacturers

EPA received few comments on the number of new manufacturers estimated for the proposed rule. One main concern was that the proposed regulations could adversely impact offshore and coastal oil and gas drilling operations. At proposal, EPA had not considered or projected impacts on this industrial category. Among other concerns, these commenters stated that: (1) offshore and coastal oil and gas drilling facilities have much more limited technology options for addressing any adverse environmental impact of cooling water intake than land-based facilities; (2) under current regulations (40 CFR 435.11), existing mobile oil and gas extraction facilities are considered new sources when they operate on new development wells and could be required to perform costly retrofits in order to comply with the 0.5 fps velocity requirement if they become subject to the proposed requirements for cooling water intake structures at new facilities; and (3) higher cooling water intake velocities are necessary in marine waters to control biofouling of cooling water intake structures.

EPA also received comments suggesting that certain industry segments should be exempted from the final section 316(b) new facility rule. One commenter claimed that EPA intended to exclude the wood products segment of the forest products industry from the proposed section 316(b) new facility rule because the proposal analysis did not explicitly analyze this segment. This commenter suggested this segment should be exempted because facilities generally use little water. Another commenter claimed that EPA has overestimated the number of new greenfield chemical facilities. This commenter stated that the actual number of new chemical facilities is very low and that therefore, according to OMB guidelines, regulation of that industry segment is not justified.

In response to these industry comments, EPA will propose and take final action on regulations for new offshore and coastal oil and gas facilities, as defined at 40 CFR 435.10 and 40 CFR 435.40, in the Phase III section 316(b) rule. EPA is deferring regulation of these facilities due to the unique engineering, cost, and economic issues associated with offshore and coastal drilling rigs, ships, and platforms. EPA will not categorically exempt new facilities in those land-based industry segments from the final section 316(b) new facility rule for any of the reasons suggested by commenters. EPA analyzed those industries that are most likely to experience adverse industry-level economic effects, based on their large-volume cooling water use. Any facility that meets the in-scope requirements set forth in § 125.81 will have to comply with the rule, irrespective of the number of in scope facilities in that segment, the industry's general cooling water characteristics, or whether the industry segment was explicitly analyzed in the proposal analysis. Should facilities in these other industrial categories face compliance costs wholly disproportionate to those EPA considered and found to be economically practicable in today's economic analysis, they can seek alternative requirements in accordance with the provisions at § 125.85.

I. Benefits

1. Cooling Water Intake Structure Impact Analysis Component of the Benefits Analysis for the Proposed Section 316(b) New Sources Rule

Comments related to EPA's cooling water intake structure impact analysis in Chapter 11 of the new sources EEA were received from two industry commenters. The comments focused on four main topics: (1) Potential population-level consequences of impingement and entrainment, (2) potential compensatory responses of fish populations to mortality of early life stages, (3) potential impingement and entrainment survival, and (4) species and habitats that may be particularly sensitive to cooling water intake structure impacts.

Both commenters argued that EPA should have evaluated the impingement and entrainment numbers presented in Chapter 11 of the EEA in relation to the total population of affected species, and one commenter commissioned a fisheries scientist to conduct such an analysis. EPA believes that a population-level analysis of the data presented in Chapter 11 is inappropriate for several reasons. First, as stated by EPA in its presentation of the data in Chapter 11, the purpose of the data compilation was to provide information on the relative magnitude of impingement and entrainment, not to evaluate potential secondary effects on the affected populations. Thus, EPA did not attempt to assemble the other types of data that the commenter noted would be required to evaluate potential effects of these losses on the populations of affected species. Such data include survival rates of early life stages, growth rates, reproductive rates, population size at the time of impingement and entrainment, and potential carrying capacity of the population in the surrounding waterbody. EPA notes that in most cases the studies that EPA examined did not provide such data.

EPA also notes that the data uncertainties and potential biases associated with the impingement and entrainment data presented in Chapter 11 of the *Economic Analysis* (discussed by EPA in Section 11.2) should be taken into account in any analysis of the data, including evaluation of potential population-level effects. As EPA noted in Chapter 11, there is insufficient information in many of the source documents to determine how impingement and entrainment estimates may have been influenced by choices of which species to study, differences in collection and analytical methods among studies or across years, or changes in a facility over time. EPA is concerned that the consequences of such data uncertainties and biases are even greater for population-level analyses than they are for an analysis of individuals. As EPA noted, the data are not a statistical sample; therefore, "the data should be viewed only as general indicators of the potential range of impingement and entrainment losses." As one of the commenters acknowledges, "EPA's estimates were used primarily to understand the relative proportion of different species impinged and entrained."

Both commenters argued that analyses involving long-term predictions of fish populations must include estimates of potential density-dependence (compensation). Again, EPA wishes to emphasize that the data presented in Chapter 11 were not intended for a population-level analysis and are not suitable for such an evaluation. Thus, the argument that compensation must be considered is irrelevant in the context of EPA's EEA.

One of commenters argued that the annual impingement and entrainment rates summarized by EPA do not equate to harm or losses of organisms, because many organisms survive impingement and entrainment. While some organisms may survive impingement and entrainment, the reliability of estimated entrainment mortality rates has been questioned because of various measurement uncertainties and sources of potential bias. [91] Even if the results of existing studies are accepted, the data indicate that under normal operating conditions entrainment mortality can be quite high for many species. Depending on temperature conditions within the intake and the life stage involved, studies of Hudson River species found that entrainment mortality ranged from 93 to 100 percent for bay anchovy, 0 to 64 percent for Atlantic tomcod, 57 to 92 percent for herrings, 41 to 55 percent for white perch, and 18 to 55 percent for striped bass. [92] A recent industry-sponsored review of 36 entrainment survival studies found that anchovies and herrings have the highest entrainment mortality, generally in excess of 75 percent. [93]

The two commenters disagreed with EPA's conclusion that the littoral zone is a more sensitive area. EPA is no longer including consideration of the littoral zone in its final rule. See discussion in Section VI.C.

One commenter objected that EPA did not provide the original worksheets used by EPA to compile the impingement and entrainment data provided in Chapter 11 of the EEA, arguing that this would have facilitated an independent analysis by making it easier to "quickly identify the studies used." However, EPA notes that all data sources are provided in footnotes to the tables and full citations are provided in the references section at the end of Chapter 11. The methods used to compile and summarize these data are

[91] Boreman, J., L.W. Barnthouse, D.S. Vaughan, C.P. Goodyear, S.W. Christensen, K.D. Kumar, B.L. Kirk, and W. Van Winkle. 1982. The Impact of Entrainment and Impingement on Fish Populations in the Hudson River Estuary: Volume I, Entrainment Impact Estimates for Six Fish Populations Inhabiting the Hudson River Estuary. Prepared for the U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research by the Oak Ridge National Laboratory. ORNL/NUREG/TM–385/VI.

[92] Boreman, J., L.W. Barnthouse, D.S. Vaughan, C.P. Goodyear, S.W. Christensen, K.D. Kumar, B.L. Kirk, and W. Van Winkle. 1982. the Impact of Entrainment and Impingement on Fish Populations in the Hudson River Estuary: Volume I, Entrainment Impact Estimates for Six Fish Populations Inhabiting the Hudson River Estuary. Prepared for the U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research by the Oak Ridge National Laboratory. ORNL/NUREG/TM–385/VI.

[93] Electric Power Research Institute. Review of Entrainment Survival Studies: 1970–2000. Prepared by EA Engineering Science & Technology. December 2000.

provided in Section 11.2 of the chapter, along with a discussion of data uncertainties and potential biases.

Another technical issue raised by this commenter concerned the waterbody classification of two of the facilities in EPA's impingement and entrainment tables. For the waterbody classifications, EPA relied on the industry's 1995 Utility Data Institute database because results from EPA's section 316(b) industry survey were not yet available. This database indicated ''river'' for the waterbody type on which the intakes of Hudson River facilities are located. EPA agrees with the commenter that this is misleading, since the portion of the Hudson River where the intakes are located is a tidal river. For analysis supporting today's final rule, facility categorization for all facilities is based on the plant's response to the question on waterbody type in the Agency's section 316(b) industry survey administered for the existing facility rule. EPA has revised its data tables to place data from studies on Hudson River facilities under the ''estuary and tidal river'' classification. Similarly, EPA agrees with the commenter that although the intake of the Monroe plant is on the Raisin River, the facility is more appropriately classified as a Great Lakes facility because of the fish species involved. EPA has therefore revised its tables so that impingement and entrainment data for this facility are now included with data for the Great Lakes. However, as noted above, the final rule does not distinguish among waterbody types, so such classifications do not have a direct effect on the final regulations.

2. Responses to Comments on the Economic Valuation Components of the Benefits Analysis for the Proposed Section 316(b) New Sources Rule

The comments on the new sources benefits analysis (economic component) were all fairly generic in their statements and fairly consistent in their arguments. The main thrust throughout most of the relevant comments was to point out that the Agency had not developed a quantitative benefits analysis and, as such, it had failed to conform to its own guidance and the requirements of Executive Order 12866. Some comments noted that the benefits analysis did not generate relevant quantitative information that could be used to facilitate an informative comparison of benefits and costs, and several comments encouraged EPA to complete its benefits analysis. Industry comments have also repeatedly pointed out that the Agency should perform a site-specific benefits analysis. In addition, several of the comments addressed aspects of how a benefits analysis should be performed. Specifically, comments described (1) what the steps of benefits analysis need to be (identify, quantify, and then value benefits), (2) the use of best practices in applying ''benefits transfer'' techniques for developing plausible monetary values to apply, and (3) the need to properly consider baseline conditions.

As clearly noted and acknowledged in Chapter 11 of the EEA, ''EPA was unable to conduct a detailed, quantitative analysis of the proposed rule because much of the information needed to quantify and value potential reductions in impingement and entrainment at new facilities was unavailable'' (EEA, p. 11–1). The chapter then proceeds to detail the types of information that would be required to do the analysis for new sources (the chapter also offers some examples using available data to illustrate potential benefits based on site-specific studies of some existing facilities.)

The comments received are accurate in the sense that they point out what the Agency acknowledges at the outset, namely, that a quantitative benefits analysis was not feasible for the proposed rule for new facilities. The comments received, however, do not offer data or methods that would enable the Agency to overcome these constraints. In fact, a main thrust of industry's comments has been that the Agency is required to do a site-specific benefits analysis, given the site-specific nature of a benefits analysis.

Because the gaps still exist in the types of information required to conduct a more comprehensive benefits analysis, the Agency has been unable to appreciably expand upon the economic portions of its benefits analysis for today's final rule. However, EPA is developing a more comprehensive assessment of benefits for its upcoming rulemaking for existing facilities, because some of the key data limitations can be more readily overcome when baseline conditions for the facilities and the impacted aquatic ecosystems can be identified and studied (these perspectives are not available for new sources with unknown locations).

Finally, EPA notes that the Agency's Guidelines for Preparing Economic Analysis are, as the title states, ''guidelines'' and not strict requirements. Consistent with these guidelines and standard professional best practices, it is the Agency's intent to develop economic analyses that are as complete and reliable as is feasible for its rulemakings. However, it is neither required nor prudent for EPA to develop empirical estimates of benefits where data limitations or other critical constraints preclude doing so in a credible and reliable manner.

3. Comments on the Relevance and Estimation of Nonuse Values

Two comments were received that questioned the applicability of nonuse benefits to the section 316(b) rulemaking and critiqued EPA's discussion of how such nonuse values might be estimated based on existing literature.

These comments point out that the issue of nonuse values (also known in some literature as ''passive use'' values) has sometimes been controversial, which the Agency recognizes. Further, the comments accurately note that there are limited methods available for measuring nonuse values, and that the accuracy of these methods can be debated because there are no observable market transactions or other ways to infer values by using the revealed preferences of the American people.

EPA recognizes that challenges associated with the estimation of nonuse values have been widely discussed in the economics literature as well as in the context of regulatory analysis and damage case litigation. However, consistent with the broadly accepted view in the economics profession, the Agency believes that nonuse values are likely to exist and apply for many (if not all) of the beneficial ecological outcomes that stem from EPA regulatory actions, including enhancements to aquatic systems as can be anticipated from the proposed section 316(b) rulemaking. There is no convincing evidence to suggest that nonuse values strictly apply to only a small set of environmental resources or only to irreversible changes in the condition of those resources. Further, even if nonuse values were thought to apply only under limited circumstances, the proposed section 316(b) rule is likely to have beneficial impacts on species and resources of concern (*e.g.,* threatened or endangered fish species) and thereby meet even a narrowly defined applicability test.

EPA agrees with the comments in terms of recognizing that there are no clear preference methods available for estimating nonuse values. Nonetheless, there are a number of stated preference methods that can be and have been successfully applied to develop credible estimates of nonuse values. Research using some of the early applications of the contingent valuation method (CVM, which is one type of stated preference method that has been applied by economists for nonuse value estimation) indicated that nonuse estimates derived from inadequately designed CVM survey instruments may not be wholly reliable. Nonetheless, the body of research on stated preferences that has evolved over the past several years provides a broadening array of tools and methodological refinements that overcome many of the limitations inherent in some of the earlier applications of contingent valuation methods. EPA believes that well-designed, fully tested, and properly implemented stated preference approaches can provide useful and credible measures of nonuse values.

EPA would like to engage in a large-scale primary research effort to develop and apply state-of-the-art stated preference methods to the issue of estimating nonuse values for the ecological outcomes anticipated from section 316(b) regulatory options. However, the Agency lacks the budgetary resources, time, and appropriate authorities to pursue such research. Accordingly, the EEA discusses the viable alternative approach. Chapter 11 presents two types of benefits transfer approaches that the Agency has relied upon in past regulatory analyses and describes the findings of studies used in these exercises. While no estimates of nonuse benefits are made in the EEA, the discussion provided by the Agency establishes the appropriate concepts, approaches, and caveats that would be associated with the benefits transfer approach that would need to be used if the Agency were to develop such estimates.

J. Engineering and Economic Analysis Limitations

Some commenters argued that the industry profiles presented in the proposed rule were inaccurate. One commenter noted that, in particular, the pulp and paper industry has changed substantially since the early 1990's, the time period upon which EPA industry profile assumptions are based.

EPA's economic analysis is based on the forecasts for new facilities. To the extent that forecasts are uncertain, the estimates for costs are uncertain. The economic analysis is based on the 20-year forecast, while the life of the facility is assumed to be 30 years for annualizing costs. Facility life spans could differ from the 30-year life span, and as a result the annualized cost to these facilities could also differ. To estimate the number of new facilities for the chemical sector, EPA assumed, on the basis of comments that the estimate of 50 percent used at proposal was too high, that 25 percent of growth in product demand would be met from the new facilities. However, data were not readily available to verify this assumption. As a sensitivity analysis, EPA also calculated costs by assuming that 37.5 percent of the growth in new capacity in the chemicals sectors would occur at new facilities. In addition, for manufacturing facilities, EPA used the growth rates projected for three to five years to forecast growth over the 20-year time period.

In estimating costs, EPA assumed that new manufacturing facilities that would become operational over the 20-year period would be uniformly distributed over time. Actual growth could differ from this predicted pattern. The economic analysis is based on five major industry groups that account for the vast majority of cooling water withdrawal in the U.S. Some facilities in other industries may withdraw cooling water in excess of 2 MGD and may incur some costs to comply with the requirements of the rule. Such costs are not reflected in the economic analysis because of lack of reliable and readily available data. To the extent that facilities in other industries are affected, EPA believes that the costs and economic impacts would be similar to those considered by EPA and found to be economically practicable.

Numerous commenters argued that the cost estimates in the economic analysis are inaccurate, resulting in the underestimation of the total cost of the rule. Commenters disagreed with the cost analysis for many aspects of the rule, including but not limited to monitoring, operations and maintenance, contingency costs, and capital costs.

To the extent possible, EPA used information on the specific characteristics of planned new plants for which information is available to project the baseline characteristics of facilities affected by the rule.

Some commenters questioned the applicability and appropriateness of the economic analysis in relation to new (greenfield) facilities and existing facilities.

The estimates do not cover substantial modification of existing facilities. These facilities are not covered by the rule; hence, estimates for these facilities are not reflected in this analysis.

K. EPA Authority

Numerous commenters raised issues with regard to EPA's authority to implement section 316(b) in the proposed new facility rule. Commenters asserted that EPA's authority is limited to regulating CWISs and that by regulating dynamic flow, EPA is actually placing operational restrictions on the cooling system which in their view, are not part of a CWIS. Further, they argue that Congress did not give EPA authority to decide how much water a facility should withdraw, and thus, EPA may not regulate the gallons per day withdrawn, but must be limited to regulating physical and behavioral barriers located at the interface between the intake structure and the water body and separation and removal processes located between the point of withdrawal and the cooling water pumps. By these definitions, supply pumps and all other elements of the cooling water system are not intake structure technologies. Thus, commenters asserted EPA has no legal authority to require wet cooling or dry cooling.

In response, EPA emphasizes that it is not requiring wet cooling, but that it is establishing performance-based technology requirements on the dynamic flow of the cooling water intake structure that reduce impingement and entrainment at a level that is achieved by using closed-cycle cooling. Section 316(b) authorizes EPA to impose limitations on the location, design, construction and capacity of CWISs. EPA interprets the statute to authorize it to regulate that volume of the flow of water withdrawn through a cooling water intake structure as a means of addressing "capacity." *In re Brunswick Steam Electric Plant,* Decision of the General Counsel No. 41 (June 1, 1976). Such limitations on the volume of flow are consistent with the dictionary definition of "capacity" [94], the legislative history of the Clean Water Act [95], and the 1976 regulations. [96] *Id.* Indeed, as Decision of the General Counsel No. 41 points out, the major environmental impacts of cooling water intake structures are those affecting aquatic organisms living in the volumes of water withdrawn through the intake structure. Therefore, regulation of the volume of the flow of water withdrawn also advances the objectives of section 316(b).

Commenters also stated that EPA's proposed proportional flow withdrawal requirements lack a legal foundation since the references to location and capacity in section 316(b) refer to the CWIS itself, not the whole cooling system, and Congress did not authorize

[94] "Cubic contents; volume; that which can be contained." Random House Dictionary of the English Language, cited in Decision of the General Counsel No. 41.

[95] Legislative History of the Water Pollution Control Act Amendments of 1972, 93d Cong., 1st Sess., at 196–7 (1973).

[96] 40 CFR 402.11(c) (definition of "capacity"), 41 *FR* 17390 (April 26, 1976).

EPA to limit the siting of new facilities that use cooling water. To the extent that new facilities comply with this requirement by employing a wet cooling system or by obtaining water from other sources, EPA believes that this is within EPA's authority to regulate capacity, as stated above. Because the major environmental impacts of cooling water intake structures are those affecting aquatic organisms living in the volumes of water withdrawn through the intake structure, in the limited circumstances where the volume of water withdrawn would exceed the proportional flow requirements and the facility would need to locate elsewhere to meet the requirement, EPA believes this regulation of location also advances the objectives of section 316(b).

Some commenters argued that section 316(b) is no more stringent than section 316(a) and thus section 316(b) compels EPA to interpret ''adverse environmental impact'' as an impact with a demonstrated impact on a ''balanced indigenous population.'' EPA does not agree that the CWA compels EPA to interpret ''adverse environmental impact'' as that term is used in section 316(b) in the Act by reference to the phrase ''balanced indigenous population'' under section 316(a). The CWA is silent with respect to what is meant by ''adverse environmental impact'' under section 316(b), whereas the CWA specifically mentions ''balanced indigenous population'' as a variance under section 316(a). The main guiding principles for statutory interpretations were articulated in *Chevron, U.S.A., Inc. v. Natural Resources Defense Council, Inc.*, 467 U.S. 838, 843 (1984). There the court stated, if the statute is silent or ambiguous with respect to the specific issue, the question for the court is whether the agency's answer is based on a permissible construction of the statute. The court need not conclude that the agency construction was the only one it permissibly could have adopted to uphold the construction, or even the reading the court would have reached if the question initially had arisen in a judicial proceeding. Thus, if a statute is ambiguous and an agency's interpretation of the statute is reasonable, a court must defer to the agency. Here, EPA's interpretation of the statute is reasonable and furthers the purposes of the CWA. This interpretation is further supported because Congress used different terms in section 316(b) than it used in section 316(a). Congress did not refer to a ''balanced indigenous population'' in section 316(b) of the CWA. Where Congress includes particular language in one section of a statute, but omits it in another section of the same act, it is generally presumed that Congress acted intentionally and purposely in the disparate inclusion or exclusion. *Bates* v. *U.S.,* 522 U.S. 23 (1997). *See also Florida Public Telecommunications Ass'n, Inc.* v. *F.C.C.,* 54 F.3d 857 (D.C. Cir. 1995). Further, section 316(a) and section 316(b) address two different issues. Section 316(a) addresses the discharge of heated water while section 316(b) address the withdrawal of huge volumes of water. Thus, it is reasonable to view the two different sections of the statute as addressing different environmental problems in different ways. *In re Brunswick Steam Electric Plant,* Decision of the General Counsel No. 41 (June 1, 1976). For purposes of implementing section 316(b) in the new facility rule, EPA thinks it is reasonable to interpret the phrase adverse environmental impacts as including a range of impacts, including impingement and entrainment, diminishment of compensatory reserve, stresses to the population or ecosystem, harm to threatened or endangered species, impairment of state water quality standards, see Section V, above.

Some commenters stated that section 316(b), which focuses on intakes, not discharges, does not authorize EPA to establish a rule authorizing States to set additional cooling water intake structure requirements to meet state water quality standards. EPA addresses this issue in Section V.B. above.

L. Restoration

In the proposed rule EPA requested comments on a variety of mandatory, discretionary, and voluntary regulatory approaches involving restoration measures (65 *FR* 49089). Many commenters supported a role for restoration or mitigation. These commenters stated that restoration is a well-accepted concept that should have a voluntary role in section 316(b) determinations and constitutes an appropriate means for sources to reduce the potential for causing adverse environmental impact to below the level of regulatory concern, or reduced regulatory concern. Commenters further stated that restoration should not be mandatory and that EPA lacks authority to require it but should not preclude restoration measures from playing an important role in section 316(b) permitting decisions. These same commenters stated that restoration should not be considered the best technology available for minimizing adverse environmental impact because it is not a technology that addresses the location, design, construction, or capacity of a cooling water intake structure.

Other commenters strongly opposed restoration measures as substitute for direct controls, arguing that they are not the ''best technology available for minimizing adverse environmental impact,'' but the commenters thought restoration measures may have a role in compensating for past harms to the aquatic environment or as an additional consideration above the protections offered by direct controls. Another commenter added that restoration measures, in the context of section 316(b), are generally unworkable and that the only measurable restoration method would be offsetting, in which an applicant would stop use of an older intake facility that does more harm than the proposed one.

Some commenters also stated that restoration should be included in permitting considerations when it is determined that dry cooling is not feasible. In this case, the facility should use a wet closed-cycle recirculating system and restoration should be considered. These commenters also suggested that, if restoration is allowed, there should be consultation with other State and Federal resource agencies to avoid inconsistent approaches. Finally, commenters stated that section 316(b) does not authorize mandatory restoration.

Today's final rule for new facilities includes restoration measures as part of Track II. EPA is not including restoration in Track I because this track is intended to be expeditious and provide certainty for the regulated community and a streamlined review process for the permitting authority. To do this for new facilities, EPA has defined the best technology available for minimizing adverse environmental impact in terms of reduction of impingement and entrainment, an objective measure of environmental performance. By contrast, restoration measures in general require complex and lengthy planning, implementation, and evaluation of the effects of the measures on the populations of aquatic organisms or the ecosystem as a whole.

EPA is including restoration measures in Track II to the extent that the Director determines that the measures taken will maintain the fish and shellfish in the waterbody in a manner that represents performance comparable to that achieved in Track I. Applicants in Track II need not undertake restoration measures, but they may choose to undertake such measures. Thus, to the extent that such measures achieve performance comparable to that achieved in Track I, it is within EPA's authority to authorize the use of such measures in the place of the Track I requirements. This is similar to the compliance alternative approach EPA took in the effluent guidelines program for Pesticide Chemicals: Formulating, Packaging and Repackaging. There EPA established a numeric limitation but also a set of best management practices that would accomplish the same numeric limitations. See 61 FR 57518, 57521 (Nov. 6, 1997). EPA believes that section 316(b) of the Clean Water Act provides EPA with sufficient authority to authorize the use of voluntary restoration measures in lieu of the specific requirements of Track I where the performance is substantially similar under the principles of *Chevron USA* v. *NRDC,* 467 U.S. 837, 844–45 (1984). Here, Congress is silent concerning the role of restoration technologies in the statute and in the legislative history, either by explicitly authorizing or explicitly precluding their use. EPA also believes that appropriate restoration measures or conservation measures that are undertaken on a voluntary basis by a new facility to meet the requirements of the rule fall within EPA's authority to regulate the ''design'' of cooling water intake structures. *Bailey* v. *U.S.,* 516 U.S. 137 (1995)(In determining meaning of words used in a statute, court considers not only the bare meaning of the word, but also its placement and purpose in the statutory scheme.)

This interpretation of the statute fits well within the purpose of section 316(b) of the CWA. The purpose of section 316(b) is to minimize adverse environmental impact from cooling water intake structures. Restoration measures that result in the performance comparable to that achieved in Track I further this objective while offering a significant degree of flexibility to both permitting authorities and facilities.

EPA recognizes that restoration measures have been used at existing facilities implementing section 316(b) on a case-by-case, best professional judgment basis as an innovative tool or as a tool to conserve fish or aquatic organisms, compensate for the fish or aquatic organisms killed, or enhance the aquatic habitat harmed or destroyed by the operation of cooling water intake structures. Under Track II, this flexibility will be available to new facilities to the extent that they can demonstrate performance comparable to that achieved in Track I. For example, if a new facility that chooses Track II is on an impaired waterbody, that facility may choose to demonstrate that velocity controls in concert with measures to improve the productivity of the waterbody will result in performance comparable to that achieved in Track I. The additional measures may include such things as reclamation of abandoned mine lands to eliminate or reduce acid mine drainage along a stretch of the waterbody, establishment of riparian buffers or other barriers to reduce runoff of solids and nutrients from agricultural or silvicultural lands, removal of barriers to fish migration, or creation of new habitats to serve as spawning or nursery areas. Another example might be a facility that chooses to demonstrate that flow reductions and less protective velocity controls, in concert with a fish hatchery to restock fish being impinged and entrained with fish that perform a similar function in the community structure, will result in performance comparable to that achieved in Track I.

EPA recognizes that it may not always be possible to establish quantitatively that the reduction in impact on fish and shellfish is comparable using the types of measures discussed above as would be achieved in Track I, due to data and modeling limitations. Despite such limitations, EPA believes that there are situations where a qualitative demonstration of comparable performance can reasonably assure substantially similar performance. EPA is thus providing, in § 125.86, that the Track II Comprehensive Demonstration Study should show that either: (1) The Track II technologies would result in reduction in both impingement mortality and entrainment of all life stages of fish and shellfish of 90 percent or greater of the reduction that would be achieved through Track I (quantitative demonstration) or, (2) if consideration of impacts other than impingement mortality and entrainment is included, the Track II technologies will maintain fish and shellfish in the waterbody at a substantially similar level to that which would be achieved under Track I (quantitative or qualitative demonstration).

EPA does not intend the foregoing discussion or today's rule to be authoritative with respect to any ongoing permit proceedings for existing facilities or previously issued existing facility permits, which should continue to be governed by existing legal authorities. EPA will address the issue of restoration further in Phase II and Phase III.

VII. Implementation

Under the final rule, section 316(b) requirements would be implemented through the NPDES permit program. These regulations establish application, monitoring, recordkeeping, and reporting requirements for new facilities. The regulations also require the Director to review application materials submitted by each new facility and include the requirements and monitoring and recordkeeping requirements in the permit.

EPA will develop a model permit and permitting guidance to assist Directors in implementing these requirements. In addition, the Agency will develop implementation guidance for owners and operators that will address how to comply with the application requirements, the sampling and monitoring requirements, technology plans, and the recordkeeping and reporting requirements in these regulations.

A. When Does the Rule Become Effective?

This rule becomes effective thirty (30) days from the date of publication. After the effective date of the regulation, new facilities are required to submit the application data for cooling water intake structures required under these regulations.

B. What Information Must I Submit to the Director When I Apply for My New or Reissued NPDES Permit?

The NPDES application process under 40 CFR 122.21 requires that facilities submit information and data 180 days prior to the commencement of a discharge. If you are the owner or operator of a facility that meets the new facility definition, you will be required to submit the information that is required under 40 CFR 122.21 and § 125.86 of today's final rule with your initial permit application and with subsequent applications for permit reissuance. The Director will review the information you provide and will confirm whether your facility is a new facility and establish the appropriate requirements to be applied to the cooling water intake structure(s).

At 40 CFR 122.21, today's rule requires all owners or operators of new facilities to submit three general categories of information when they apply for an NPDES permit. The general categories of information include (1) physical data to characterize the source water body in the vicinity where the cooling water intake structures are located, (2) data to characterize the design and operation of the cooling water intake structures, and (3) existing data (if they are available) to characterize the baseline biological condition of the source waterbody. All applicants must also submit a statement specifying whether they will comply with either Track I or Track II

(§ 125.86(a)(1)), and source waterbody flow information (§§ 125.86(b)(3) or 125.86(c)(1)). If you are a Track I applicant, you must also submit (1) data to show you will meet the Track I flow and velocity requirements and (2) a design and construction technology plan demonstrating that you have selected design and construction technologies necessary to minimize impingement mortality and/or entrainment if you are located where such technologies are necessary. If you are a Track II applicant, you must also submit a comprehensive demonstration study with detailed information on source waterbody and intake structure characteristics, and a verification monitoring plan. Applicants seeking an alternative requirement under § 125.85 must submit data that demonstrate that their compliance costs would be wholly out of proportion to the costs considered by EPA in establishing the requirements of §§ 125.84(a) through (e) or that compliance with the rule would cause significant adverse impacts on local air quality, local water resources or local energy markets.

The following describes the application requirements for all new facilities and the requirements specific to Tracks I and II in more detail.

1. All New Facilities

a. Source Water Physical Data

All new facilities must provide the source water physical data required at 40 CFR 122.21(r)(2) in their permit applications. These data are needed to characterize the facility and evaluate the type of waterbody and species affected by the cooling water intake structure. This information will also be used by the permit writer to evaluate the appropriateness of the design and construction technologies selected by the applicant for use at their site in subsequent permit proceedings. Specific data items that must be submitted include (1) a narrative description and scale drawings showing the physical configuration of all source waterbodies used by the facility, including areal dimensions, depths, salinity and temperature regimes, and other documentation; (2) an identification and characterization of the source waterbody's hydrological and geomorphological features, as well as the methods used to conduct any physical studies to determine the intake's zone of influence and the results of such studies; and (3) locational maps.

b. Cooling Water Intake Structure Data

All new facilities must submit the cooling water intake structure data required at 40 CFR 122.21(r)(3) to characterize the cooling water intake structure and evaluate the potential for impingement and entrainment of aquatic organisms. Information on the design of the intake structure and its location in the water column will allow the permit writer to evaluate which species or life stages would potentially be subject to impingement and entrainment. A diagram of the facility's water balance would be used to identify the proportion of intake water used for cooling, make-up, and process water. The water balance diagram also provides a picture of the total flow in and out of the facility, allowing the permit writer to evaluate compliance with the Track I flow reduction requirements (if applicable). Specific data on the intake structure include (1) a narrative description of the configuration of each of your cooling water intake structures and where it is located in the waterbody and in the water column; (2) latitude and longitude in degrees, minutes, and seconds for each of your cooling water intake structures; (3) a narrative description of the operation of each of your cooling water intake structures, including design intake flows, daily hours of operation, number of days of the year in operation, and seasonal changes, if applicable; (4) a flow distribution and water balance diagram that includes all sources of water to the facility, recirculating flows, and discharges; (5) engineering drawings of the cooling water intake structure.

c. Source Water Baseline Biological Characterization Data

All new facilities must submit the source water baseline biological characterization data required in 40 CFR 122.21(r)(4) with their permit application. This information will characterize the biological community in the vicinity of the cooling water intake structure as well as the operation of the cooling water intake structures. The Director may use this information in subsequent permit renewal proceedings to determine if the applicant's design and construction technology plan should be revised. This supporting information must include existing data (if available), which may be supplemented with new field studies if the applicant so chooses. The applicant must submit the following specific data (1) a list of the data that are not available and efforts made to identify sources of the data; (2) if available, a list of species (or relevant taxa) in the vicinity of the cooling water intake structure, and identification of the species and life stages that would be most susceptible to impingement and entrainment (including both nekton and meroplankton) (Species identified should include the range of species in the system including the forage base); (3) if available, identification and evaluation of the primary period of reproduction, larval recruitment, and period of peak meroplankton abundance for relevant taxa; (4) if available, information sufficient to provide data representative of the seasonal and daily biological activity in the vicinity of the cooling water intake structure; (5) if available, identification of all threatened or endangered species that might be susceptible to impingement and entrainment at your cooling water intake structures; (6) documentation of any public participation or consultation with Federal or State agencies undertaken in collecting the data; (7) if the above data are supplemented with data collected in actual field studies, a description of all methods and quality assurance procedures for data collection, sampling, and analysis, including a description of the study area; identification of the biological assemblages to be sampled or evaluated (both nekton and meroplankton); and data collection, sampling, and analysis methods. The sampling or data analysis methods used must be appropriate for a quantitative survey and based on a consideration of methods used in other biological studies performed within the same source waterbody. The study area should include, at a minimum, the area of influence of the cooling water intake structure.

d. Source Water Flow Data

All facilities must demonstrate compliance with the source water flow requirements in §§ 125.84(b)(3) and (c)(2). Information to show that a new facility is in compliance with these requirements must be submitted to the Director in accordance with §§ 125.86(b)(3) and (c)(1).

If your facility is located on a freshwater river or stream, you must submit data that supports that you are withdrawing less than five (5) percent of the annual mean flow. The documentation might include either publicly available flow data from a nearby U.S. Geological Survey (USGS) gauging station or actual instream flow monitoring data that the facility has collected itself. The waterbody flow should be compared with the total design flow of all cooling water intake structures at the new facility.

If your cooling water intake structure is withdrawing water from an estuary or a tidal river, you need to calculate the tidal excursion and provide the flow data for your facility and the supporting calculations. The tidal excursion distance can be computed using three different methods ranging from simple to complex. The simple method involves using available tidal velocities that can be obtained from the Tidal Current Tables formerly published by the National Ocean Service of the National Oceanic and Atmospheric Administration (NOAA) and currently printed and distributed by private companies (available at bookstores or marine supply stores). The midrange method involves computing the tidal excursion distance using the Tidal Prism Method. [97] The complex method involves the use of a two-dimensional or three-dimensional hydrodynamic model. The simplest method to use is the following:

(1) Locate the facility on either a NOAA nautical chart or a base map created from the USGS 1:100,000 scale Digital Line Graph (DLG) data available on the USGS website. These DLG Data can be imported into a computer-aided design (CAD) program or geographic information system (GIS). If these tools are unavailable, 1:100,000 scale topographic maps (USGS) can be used.

(2) Obtain maximum flood and ebb velocities (in meters per second) for the waterbody in the area of the cooling water intake structure from NOAA Tidal Current Tables.

(3) Calculate average flood and ebb velocities (in meters per second) over the entire flood or ebb cycle by using the maximum flow and ebb velocities from 2 above.

$$\text{Velocity}_{\text{Average Flood}} = \text{Velocity}_{\text{Maximum Flood}} * \frac{2}{\pi} \qquad \text{(Equation 1)}$$

$$\text{Velocity}_{\text{Average Ebb}} = \text{Velocity}_{\text{Maximum Ebb}} * \frac{2}{\pi} \qquad \text{(Equation 2)}$$

(4) Calculate the flood and ebb tidal excursion distance using the average flood and ebb velocities from 3 above.

$$\text{Distance}_{\text{Flood Tidal Excursion}} = \text{Velocity}_{\text{Average Flood}} * 6.2103 * 3600\ \frac{s}{hr} \qquad \text{(Equation 3)}$$

$$\text{Distance}_{\text{Ebb Tidal Excursion}} = \text{Velocity}_{\text{Average Ebb}} * 6.2103 * 3600\ \frac{s}{hr} \qquad \text{(Equation 4)}$$

(5) Using the total of the flood and ebb distances from above, define the diameter of a circle that is centered over the opening of the cooling water intake structure.

(6) Define the area of the waterbody that falls within the area of the circle (see Appendix 2 to Preamble). The area of the waterbody, if smaller than the total area of the circle might be determined either by using a planimeter or by digitizing the area of the waterbody using a CAD program or GIS. For cooling water intake structures located offshore in large waterbodies, the area of the waterbody might equal the entire area of the circle (see D in Appendix 3 to Preamble). For cooling water intake structures located flush with the shoreline, the area might be essentially a semicircle (see C in Appendix 3 to Preamble). For cooling water intake structures located in the upper reaches of a tidal river, the area might be some smaller portion of the area of the circle (see A in Appendix 3 to Preamble).

(7) Calculate the average depth of the waterbody area defined in 6 above. Depths can easily be obtained from bathymetric or nautical charts available from NOAA. In many areas, depths are available in digital form.

(8) Calculate a volume by multiplying the area of the waterbody defined in 6 by the average depth from 7. Alternatively, the actual volume can be calculated directly with a GIS system using digital bathymetric data for the defined area.

If your cooling water is withdrawn from a lake or reservoir, you must submit information such as a narrative description of the waterbody thermal stratification and any supporting documentation and engineering calculations to show that your cooling water intake structure meets the requirement not to alter the natural thermal stratification or turnover pattern (where present) of the source water except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies). Typically, this natural thermal stratification will be defined by the thermocline, which may be affected to a certain extent by the withdrawal of cooler water and the discharge of heated water into the system. This information demonstrates to the permit writer that you are maintaining the thermal stratification or turnover pattern (where present) of the source water except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies) such that it maintains appropriate habitat for the biological makeup of the waterbody.

2. Track I Facilities

a. Flow Reduction Information

New facilities larger than 10 MGD that choose Track I must submit the data on flow reduction required in § 125.86(b)(1) with their permit applications. New facilities between 2 and 10 MGD that choose to comply with the Track I requirements at § 125.84(b) must also submit this data. The information required includes a narrative description of the water balance of the closed-cycle recirculating cooling water system for the facility and an

[97] Diana, E., A.Y. Kuo, B.J. Neilson, C.F., Cerco, and P.V. Hyer. 1987. *Tidal prism model manual,* Virginia Institute of Marine Science, Gloucester Point, VA.

engineering demonstration that the intake flows have been minimized to the maximum extent reasonably possible. You should also consider all feasible methods to re-use blowdown in other plant operations. New facilities between 2 and 10 MGD that choose to comply with the Track I requirements at § 125.84(c) must submit data that shows that the facility's total design water intake flow is less than 10 MGD. *See* § 122.21(r)(3)(iii).

b. Velocity Information

New facilities that choose Track I must submit the data on velocity required in § 125.86(b)(2) with their permit applications. The information required includes a narrative description of the design, structure, equipment, and operation used to meet the performance requirement and any engineering calculations used to calculate design through-screen velocity.

c. Design and Construction Technology Plan

If you select Track I, § 125.86(b)(4) and (b)(5) require you to include a Construction Technology Plan in your application that demonstrates that your facility has selected and will implement the design and construction technologies necessary to minimize impingement mortality and/or entrainment when certain conditions exist at the site. If you select Track I and choose to comply with the requirements of § 125.84(c) (which are available to facilities between two and ten MGD) you much install technologies to reduce impingement at some locations and you must install technologies to reduce entrainment at all sites. *See* § 125.84(c)(3) and (4). Examples of such technologies that may be appropriate for your site include, but are not be limited to (1) fish-handling and return systems, (2) wedgewire screens, (3) fine mesh screens, (4) barrier nets, and (5) aquatic filter barrier systems. The Agency recognizes that selection of the specific technology or group of technologies for your site will depend on individual facility and waterbody conditions.

In the application, you need to describe the technology(ies) you will implement at your facility to meet the requirements in § 125.84(b)(4) and (5) or § 125.84(c)(3) and (4), the basis for their selection, and the expected level of performance. During subsequent permit terms, the Director may require you to implement additional or different design and construction technologies if the initial technologies you selected and implemented do not meet the requirement of minimizing impingement mortality and entrainment.

3. Track II Facilities

a. Comprehensive Demonstration Study

If you select Track II, § 125.86(c)(2) requires you to perform and submit to the Director the results of a Comprehensive Demonstration Study, including data and detailed analyses to demonstrate that you will reduce the impacts to fish and shellfish to levels comparable to the level you would achieve were you to implement the Track I requirements at § 125.84(b)(1), and (2). To meet the ''comparable level'' requirement, you must demonstrate that you have reduced both impingement mortality and entrainment of all life stages of fish and shellfish to 90 percent or greater of the reduction that would be achieved through Track I, or if your demonstration includes consideration of impacts other than impingement mortality and entrainment, that the measures taken will maintain the fish and shellfish in the waterbody at a substantially similar level to that which would be achieved through Track I. Your proposed technologies may specifically include the reuse of spent cooling water as industrial process water and the associated reductions in process water withdrawals from the source waterbody as a means for reducing intake capacity and impingement and entrainment.

The Comprehensive Demonstration Study has four parts:

• A proposal for how information will be collected;
• A Source Water Biological Study;
• An evaluation of potential cooling water intake structure effects; and
• A Verification Monitoring Plan.

These plans and evaluations must be submitted to the Director with the permit application.

Under § 125.86(c)(2)(iii)(B), you may submit data from previous biological studies performed in the vicinity of the proposed or actual intake if the data are no more than 5 years old so that they reasonably represent existing conditions. You must demonstrate that such existing data are fully representative of the current conditions in the vicinity of the intake and provide documentation showing that the data were collected by using established and reliable quality assurance procedures.

Before performing the study you must submit to the Director a plan stating how information will be collected to support the study. This plan must provide (1) a description of the proposed technology(ies) to be evaluated; (2) a list and description of any historical studies characterizing the physical and biological conditions in the vicinity of the proposed or actual intakes and their relevancy to the proposed study; (3) a summary of any public participation or consultation with Federal or State agencies undertaken in development of the plan; and (4) a sampling plan for data that will be collected in actual field studies in the source waterbody that documents all methods and quality assurance procedures for data collection, sampling, and analysis. The study area for such field studies must include, at a minimum, the area of influence of the cooling water intake structure and at least 100 meters beyond. The area of influence is the portion of water subject to the forces of the intake structure such that a particle within the area is likely to be pulled into the intake structure.

You must submit the results of a Source Water Biological Study in accordance with § 125.86(c)(2)(iv)(A). This characterization must include (1) a taxonomic identification and characterization of aquatic biological resources (nekton and meroplankton) to provide a summary of historic and contemporary aquatic biological resources; a determination and description of the target populations of concern (those species and life stages that would be most susceptible to impingement and entrainment); and a description of the abundance and temporal and spatial characterization of the target populations based on the collection of multiple years of data to capture the seasonal and daily biological activity in the vicinity of the cooling water intake structure; (2) an identification of all threatened or endangered species that might be susceptible to impingement and entrainment by the cooling water intake structures; and (3) a description of additional chemical, water quality, and other anthropogenic stresses on the source waterbody. The Director might coordinate a review of your list of threatened or endangered species with the U.S. Fish and Wildlife Service and/or National Marine Fisheries Service staff to ensure that potential impacts to threatened or endangered species have been addressed.

The study must evaluate the potential for cooling water intake structure effects in accordance with § 125.86(c)(2)(iv)(A). This evaluation must include (1) a statement of the baseline against which the comparative analyses will be made. The impingement and entrainment baselines must be calculated for the facility by assuming a design of a once-through cooling water system employing a trash rack and traveling screens; (2) an engineering estimate of the efficacy of proposed technologies in reducing impacts to fish and shellfish to a level comparable to the level that would be achieved by meeting the Track I requirements at the site. To demonstrate that the technologies meet the ''comparable level'' requirement, the demonstration must show that both impingement and entrainment of all life stages of fish and shellfish have been reduced to 90 percent or greater of the reduction that could be achieved through Track I, or, if impacts other than impingement mortality and entrainment are considered, that the measures taken will maintain the fish and shellfish in the waterbody at a substantially similar level to that which would be achieved through Track I. The efficacy projection must include a site-specific evaluation of technology suitability for reducing impingement and entrainment based on design, location, and operational specification applied to the characterization and a site-specific evaluation of any additional measures based on the physical, chemical, and biological characteristics of the site; and (3) a characterization of impingement and entrainment survival estimates of the proposed alternative technology based on case studies in the vicinity of the cooling water intake structure and/or site-specific technology prototype studies, and a characterization of fish and shellfish propagation and survival based, for example, on case studies documenting the efficacy of any additional measures performed at similar sites.

To demonstrate that you will reduce impingement mortality and entrainment to a level of reduction comparable to the level that you would achieve if you implemented Track I requirements at your site, you will need to develop a conceptual engineering design of a hypothetical recirculating water system for your facility, including the estimated intake flow. The estimated intake flow should take into account an optimized system in which the volume of intake flow/blowdown is minimized to the maximum extent feasible. The conceptual design should also include proposed design and construction technologies that would be used to minimize impingement mortality and entrainment pursuant to § 125.84(b)(4) and (5). Finally, you should estimate the expected level of impingement and entrainment associated with the hypothetical intake structure for all species found in substantial numbers in source waterbody in the vicinity of the intake structure. In estimating entrainment, 100 percent mortality may be assumed to preclude the need to perform entrainment survival studies.

You must then calculate and document the expected level of performance of the proposed alternative technologies for all species found in significant numbers in the source waterbody in the vicinity of the intake structure. Such documentation may consist of pilot-scale testing at the proposed facility, *representative* performance data from *comparable* facilities, or both. In preparing the documentation you should specifically show that the pilot-scale or comparable facility data address the following factors that may affect technology performance:

- Physical and chemical watershed conditions (temperature, freezing and thawing, tidal conditions, wave action, sediment and debris, flow, etc.);
- Biological watershed conditions (individual species, life stages, predator species, seasonality, etc.);
- Engineering feasibility and long-term reliability, and
- Operation and maintenance issues.

Available data suggests that alternative design and construction technologies for cooling water intake structures can achieve the level of reduction in impingement mortality and entrainment required under Track I. Technologies such as fine and wide-mesh wedgewire screens, as well as aquatic filter barrier systems, have been shown to reduce mortality from impingement by up to 99 percent or greater compared with conventional once-through systems. In addition, other types of barrier nets may achieve reductions of 80 to 90 percent, and modified screens and fish return systems, fish diversion systems, and fine mesh traveling screens and fish return systems have achieved reductions in impingement mortality ranging from 60 to 90 percent greater than conventional once-through systems. Similarly, with regard to entrainment, although there is less available full scale performance data, aquatic filter barrier systems, fine mesh wedgewire screens, and fine mesh traveling screens with fish return systems have been shown to achieve 80 to 90 percent greater reduction in mortality from entrainment compared with conventional once-through systems. Several additional factors suggest that these performance levels can be improved upon. First, some of the cooling water intake structure technology performance data reviewed is from the 1970's and 1980's and does not reflect recent developments and innovation (e.g., aquatic filter barrier systems, sound barriers). Second, these conventional barrier and return system technologies have not been optimized on a widespread level to date, as would be encouraged by this rule. Such optimization can be best achieved by new facilities, which can match site conditions to available technologies. Third, EPA believes that many facilities could achieve further reductions (estimated 15–30 percent) in impingement and entrainment by providing for seasonal flow restrictions, variable speed pumps, and other innovative flow reduction alternatives. Finally, new facilities seeking to comply under Track II can choose the specific location of their cooling water intake structures to further optimize the level of reduction in impingement mortality and entrainment (i.e., locate the cooling water intake structure outside of biologically productive or sensitive areas to the extent this would serve to reduce environmental impact). For additional discussion, *see* Section V.B.2.

Finally, new facilities complying under Track II must submit a Verification Monitoring Plan in accordance with § 125.86(c)(2)(iv)(A). The plan must include information on how the facility will conduct a monitoring study to verify the full-scale performance of the proposed technologies and of any additional measures. The plan must describe the frequency of monitoring and the parameters to be monitored. The Director will use the verification monitoring to verify that you are meeting the level of impingement and entrainment expected and that fish and shellfish are being maintained at the level expected. The Director will then determine whether to approve the use of the suite of alternative technologies in subsequent permit issuance. Verification monitoring must start during the first year that the cooling water intake structure begins operation and continue for a sufficient period of time to demonstrate that the facility is reducing impingement mortality and entrainment to a level of reduction comparable to the level the facility would have been achieved by implementing the flow reduction and design velocity requirements of Track I.

4. Data To Support a Request for Alternative Requirements

If, pursuant to § 125.85(a), you request that an alternative requirement less stringent than those specified in § 125.84 be required in your permit, § 125.85(b) places the burden on you to show that your compliance costs are wholly out of proportion to the costs EPA considered during development of the requirements at issue, or that compliance with the national standard will result in significant adverse impact to local air quality, local water resources, or local energy markets. Compliance costs that EPA considered were subdivided into one-time costs and recurring costs. Examples of one-time costs include capital and permit application costs. Examples of recurring costs include operation and maintenance costs, permit renewal costs, and monitoring, recordkeeping, and reporting costs.

C. How Will the Director Determine the Appropriate Cooling Water Intake Structure Requirements?

The Director's first step would be to determine whether the facility is covered by this rule If the answer is yes to all the following questions, the facility must comply with the requirements of this final rule.

(1) Is the facility a "new facility" as defined in § 125.83?

(2) Does the new facility withdraw cooling water from waters of the U.S.; *OR* does the facility obtain cooling water by any sort of contract or arrangement with an independent (supplier or multiple suppliers) of cooling water if the supplier(s) withdraw(s) water from waters of the U.S. and is not a public water system?

(3) Is at least 25 percent of the water withdrawn by the facility used for cooling purposes?

(4) Does the new facility have a design intake flow of greater than 2 million gallons per day (MGD)? [98]

(5) Does the new facility discharge pollutants to waters of the U.S., including storm water-only discharges, such that the facility has or is required to have an NPDES permit?

If these final regulations are applicable to the applicant, the second step would be to determine the locational factors associated with the new facility's cooling water intake structure. The Director would first review the information that the new facility provided to validate the source waterbody type in which the cooling water intake structure is located (freshwater stream or river, lake or reservoir, estuary or tidal river, or ocean). (As discussed above, the applicant would need to identify the source waterbody type in the permit application and provide the appropriate documentation to support the waterbody type classification.) The Director would review the supporting material the applicant provided in the permit application. The Director would also review the engineering drawings and the locational maps the applicant provided, documenting the physical placement of the cooling water intake structure.

For Track I facilities, the Director's next step would be to review the design requirements for intake flow and velocity. For a new facility with an intake flow equal to or greater than 10 MGD that is required to reduce its intake flow to a level commensurate with that which could be attained by a closed-cycle recirculating cooling water system, the Director would review the narrative description of the closed-cycle recirculating cooling water system design and any engineering calculations to ensure that the new facility is complying with the requirement and that the make-up and blowdown flows have been minimized. If the flow reduction requirement is met by reusing or recycling water withdrawn for cooling purposes, the Director must review documentation that the amount of cooling water that is not reused or recycled has been minimized.

The velocity requirement is based on the design through-screen or through-technology velocity as defined in § 125.83. For Track I facilities, the maximum design velocity would always be 0.5 ft/s. To determine whether the new facility meets the maximum design velocity requirement, the Director would review the narrative description of the design, structure, equipment, and operation used to meet the velocity requirement. The Director would also review the design calculations that demonstrate that the maximum design velocity would be met. In reissuing permits, the Director would review velocity monitoring data to confirm that the facility is not exceeding the initial design velocity calculated at the start of commercial service.

Under Track I, the Director would then review the applicant's Design and Construction Technology Plan (if the applicant is located in an area where such technologies are required) and the applicant's Source Water Baseline Biological Characterization data. During each permit renewal, the Director would then review monitoring data, application data, and other supporting information to determine whether the applicant needs to implement additional or different design and construction technologies (see discussion of § 125.89(a)(2) below).

Under Track II, the Director would receive and should review the applicant's proposed plan for preparing the Comprehensive Demonstration Study. When the applicant proposes to rely on existing studies, the Director would assess the data quality and the relevance to the proposed facility. When new biological surveys are proposed, the Director would determine whether they fully characterize the waterbody potentially impacted by impingement and entrainment. Where pilot-scale demonstrations are proposed, the Director would evaluate whether they are generally representative of full-scale operations. After the study is completed, the Director would review the applicant's analysis, specifically to determine whether the proposed alternative technology(ies) will reduce impingement mortality and entrainment to a level of reduction comparable to the level that the facility would achieve if it complied with the Track I requirements for reducing intake capacity and design velocity, or if the proposed measures in conjunction with the proposed technologies will maintain the fish and shellfish in the waterbody at a substantially similar level to that which would be achieved. The Director would also review the facility's Technology Verification Plan for post-operational monitoring to demonstrate that the technologies are performing as predicted.

The proportional flow requirement applicable to all facilities is based on waterbody type. To determine whether the new facility meets the flow requirement, the Director would first verify the new facility's determination of the waterbody flow for the respective waterbody type (e.g., annual mean flow and low flow for freshwater river or stream). The Director would review the source-water flow data the facility provided in the permit application. The Director should consider using available USGS data (for freshwater rivers and streams) to verify the flow data in the permit application. Then the Director would review any supporting documentation and engineering calculations that demonstrate that the new facility would meet the flow requirements. To verify the flow data the new facility provides for an estuary or a tidal river, the Director would review the facility's calculation of the tidal excursion.

The final regulations at § 125.84(e) require compliance with any more stringent requirements relating to the location, design, construction, or capacity of a cooling water intake structure or monitoring requirements at a new facility that a Director deems necessary to comply with any provision of State law, including state water quality standards, including designated

[98] If the answer is no to these flow parameters and yes to all the other questions, the Director would use best professional judgment on a case-by-case basis to establish permit conditions that ensure compliance with section 316(b).

uses, criteria, and antidegradation provisions.

D. What Will I Be Required to Monitor?

At § 125.87, today's final rule requires biological monitoring and visual or remote inspections at all facilities. Track I facilities and Track II facilities that rely on specified velocity levels as part of their alternative technology(ies) are also required to monitor screen head loss and velocity.

Both Track I and Track II facilities must conduct biological monitoring for impingement and entrainment to assess the presence, abundance, life stages, and mortality (eggs, larvae, post larvae, juveniles, and adults) of aquatic organisms (fish and shellfish) impinged or entrained during operation of the cooling water intake structure. These data would also be used by the permitting authority in subsequent permit terms to determine whether additional or modified design and construction technologies are reasonably necessary (see discussion of § 125.89(a)(2) in D. below). The facility would be required to conduct impingement and entrainment sampling over a 24-hour period no less than once per month when the cooling water intake structure is in operation and report results to the Director annually. After two years, the Director may approve an applicant's request for less frequent biological monitoring if the facility provides data to support the request showing that less frequent monitoring would still allow for the detection of any seasonal and daily variations in the species and numbers of individuals that are impinged or entrained. The Director should approve a request for reduced frequency in biological monitoring only if the supporting data show that the technologies are consistently performing as projected under all operating and environmental conditions and less frequent monitoring would still allow for the detection of any future performance fluctuations.

Under § 125.87(b), Track I facilities are required to monitor the head loss across the intake screens to obtain a correlation of those values with the design intake velocity (Track I) or other specified velocity (Track II) at minimum ambient source-water surface elevation (according to best professional judgment based on available hydrological data). The maximum head loss across the screen for each cooling water intake structure must be used to determine compliance with the velocity requirement in § 125.84(b)(2) and (c)(1). The data collected by monitoring this parameter would provide the Director with additional information after the design and construction of the cooling water intake structure to demonstrate that the facility is operating and maintaining the cooling water intake structure in a manner such that the velocity requirement continues to be met. The Agency considers this the most appropriate parameter to monitor, because, although the facility might be designed to meet the requirement, proper operation and maintenance is necessary to maintain the open area of the screen and intake structure, ensuring that the design intake velocity is maintained. Head loss can easily be monitored by measuring and comparing the height of the water in front of and behind the screen or other technology. Track I facilities that use devices other than screens would be required to measure the actual velocity at the point of entry through the device. Velocity can be measured with velocity meters placed at the entrance into the device.

Weekly visual or remote inspections are required to provide a mechanism for both the new facility and the Director to ensure that any technologies that have been implemented for minimizing adverse environmental impact are being maintained and operated in a manner that ensures that they function as designed. EPA has promulgated this requirement so that facilities that develop plans and install technologies could not operate them improperly so that adverse environmental impact is not minimized to the extent expected. The Director would determine the actual scope and implementation of the visual inspections based on the types of technologies installed at your facility. For example, inspections could be as simple as observing bypass and other fish handling systems to ensure that debris has not clogged the system and rendered it inoperable.

E. How Will Compliance Be Determined?

This rule will be implemented by the Director placing conditions consistent with this rule in NPDES permits. Compliance with permit conditions implementing this rule require the following data and information:

• Data submitted with the NPDES permit application to show that the facility is in compliance with location, design, construction, and capacity requirements (§ 125.86).

• Compliance monitoring data and records, including those for impingement and entrainment monitoring, to show that impingement and entrainment impacts are being minimized (§ 125.87(a)).

• Through-screen or through-technology velocity monitoring data and records to show that the facility is being operated and maintained as designed to continue to meet the velocity requirement (§ 125.87(b)).

• Records from visual or remote inspections to show that technologies installed are being operated properly and function as they were designed (§ 125.87(c)).

Facilities are required to keep records and report the above information in a yearly status report in § 125.88. In addition, Directors may perform their own compliance inspections as deemed appropriate in accordance with 40 CFR 122.41.

F. What Are the Respective Federal, State, and Tribal Roles?

Section 316(b) requirements are implemented through NPDES permits. As discussed in Section II.A today's final regulations would amend 40 CFR 123.25(a)(36) to add a requirement that authorized State programs have sufficient legal authority to implement today's requirements (40 CFR part 125, subpart I). Therefore, today's final rule potentially affects authorized State and Tribal NPDES permit programs. Under 40 CFR 123.62(e), any existing approved section 402 permitting program must be revised to be consistent with new program requirements within one year from the date of promulgation, unless the NPDES-authorized State or Tribe must amend or enact a statute to make the required revisions. If a State or Tribe must amend or enact a statute to conform with today's final rule, the revision must be made within two years of promulgation. States and Tribes seeking new EPA authorization to implement the NPDES program must comply with the requirements when authorization is requested.

In addition to updating their programs to be consistent with today's rule, States and Tribes authorized to implement the NPDES program would be required to implement the cooling water intake structure requirements following promulgation of the final regulations. The requirements must be implemented upon permit issuance and reissuance. Duties of an authorized State or Tribe under this regulation include

• Verification of a permit applicant's determination of source waterbody classification and the flow or volume of certain waterbodies at the point of the intake;

• Verification that the intake structure maximum flow rate is less than the maximum allowable as a proportion of waterbody flow for certain waterbody types;

• Verification that a Track I permit applicant's design intake velocity calculations meet applicable regulatory requirements;

• Verification that a Track I permit applicant's intake design and reduction in capacity are commensurate with a level that can be attained by a closed-cycle recirculating cooling water system that has minimized make-up and blowdown flows;

• Verification that a Track II permit applicant's Comprehensive Demonstration Study demonstrates that the proposed alternative technologies will reduce the impacts to fish and shellfish to levels comparable to those the facility would achieve if it met the Track I requirements;

• Development of draft and final NPDES permit conditions for the applicant implementing applicable section 316(b) requirements pursuant to this rule; and

• Ensuring compliance with permit conditions based on section 316(b) requirements.

EPA will implement these requirements where States or Tribes are not authorized to implement the NPDES program.

G. Are Permits for New Facilities Subject to Requirements Under Other Federal Statutes?

EPA's NPDES permitting regulations at 40 CFR 122.49 contain a list of Federal laws that might apply to federally issued NPDES permits. These include the Wild and Scenic Rivers Act, 16 U.S.C. 1273 *et seq.*; the National Historic Preservation Act of 1966, 16 U.S.C. 470 *et seq.*; the Endangered Species Act, 16 U.S.C. 1531 *et seq.*; the Coastal Zone Management Act, 16 U.S.C. 1451 *et seq.*; and the National Environmental Policy Act, 42 U.S.C. 4321 *et seq.* See 40 CFR 122.49 for a brief description of each of those laws. In addition, the provisions of the Magnuson-Stevens Fishery Conservation and Management Act, 16 U.S.C. 1801 *et seq.*, relating to essential fish habitat might be relevant. Nothing in this final rulemaking authorizes activities that are not in compliance with these or other applicable Federal laws.

H. Alternative Requirements

Today's rule establishes national requirements for new facilities. EPA has taken into account all the information that it was able to collect, develop, and solicit regarding the location, design, construction, and capacity of cooling water intake structures at new facilities. EPA concludes that these requirements reflect the best technology available for minimizing adverse environmental impact on a national level. In some cases, however, data that could affect the economic practicability of requirements might not have been available to be considered by EPA during the development of today's rule. Therefore, EPA is including § 125.85 to allow for adjustment of the requirements of § 125.84 in certain limited circumstances.

Section 125.85 would allow the Director, in the permit development process, to set alternative best technology available requirements that are less stringent than the nationally applicable requirements. Under § 125.85(a), any interested person may request that alternative requirements be imposed in the permit. Section 125.85(a) provides that alternative requirements that are less stringent than the requirements of § 125.84 would be approved only if the Administrator determines that compliance with the requirement at issue would result in compliance costs wholly out of proportion to the costs considered during development of the requirement at issue or in significant adverse impacts on local air quality, local water resources or local energy markets; the alternative requirement requested is no less stringent than justified by the wholly out of proportion cost or significant adverse impact; and the alternative requirements will ensure compliance with other applicable provisions of the Clean Water Act and any applicable requirements of State law.

Because new facilities have a great degree of flexibility in their siting, in how their cooling water intake structures are otherwise located, and in the design, construction, and sizing of the structure, cost is the primary factor that would justify the imposition of less stringent requirements as part of the alternative requirements approach. This is because other factors affecting the location, design, construction, and capacity of cooling water intake structures at new facilities can be addressed by modifications that may have cost implications. EPA notes that alternate discharge standards are not allowed in the somewhat analogous case of the new source performance standards that EPA establishes under section 306 of the CWA for the discharge of effluent from new sources in particular industrial categories. However, because EPA is acting under a separate authority in this rule, section 316(b) of the CWA, and because section 316(b) of the CWA is silent concerning this issue, EPA believes it is reasonable to interpret section 316(b) to give EPA discretion to establish alternative requirements for new facility cooling water intake structures. EPA takes this position because this final rule would establish requirements for cooling water intake structures at any type of new facility in any industrial category above the flow threshold.[99] Thus, in some instances it might be possible that the costs of complying with today's final requirements would be wholly out of proportion to the costs EPA considered and determined to be economically practicable. As discussed in the *Economic Analysis* Chapter 7, EPA has analyzed the cost of compliance with today's final requirements for all facilities projected to be built in the reasonably foreseeable future, as well as other types of facilities that might be built at later dates (such as large base-load steam electric generating facilities that do not use combined-cycle technology) and concludes that these compliance costs would be economically practicable for all types of facilities the Agency considered. However, should an individual new facility demonstrate that costs of compliance for a new facility would be wholly out of proportion to the costs EPA considered and determined to be economically practicable, the Director would have authority to adjust best technology available requirements accordingly.

Under § 125.85(a), alternative requirements would not be granted based on a particular facility's ability to pay for technologies that would result in compliance with the requirements of § 125.84. Thus, so long as the costs of compliance are not wholly out of proportion to the costs EPA considered and determined to be economically practicable, the ability of an individual facility to pay in order to attain compliance with the rule would not support the imposition of alternative requirements.

EPA has allowed for alternative requirements where the facility demonstrates, to the satisfaction of the Director, that at a local level, the air quality impacts, non-impingement and entrainment aquatic effects, or energy impacts of complying with the requirements of § 125.84 are significant and justify a different approach to regulating cooling water intake structures.

Section 125.85(a) specifies procedures to be used in the establishment of alternative requirements. The burden is

[99] Except for facilities in the offshore and coastal subcategories of the oil and gas extraction point source category as defined under 40 CFR 435.10 and 40 CFR 435.40.

on the person requesting the alternative requirement to demonstrate that alternative requirements should be imposed and that the appropriate requirements of § 125.85 (a) have been met. The person requesting the alternative requirements should refer to all relevant information, including the support documents for this rulemaking, all associated data collected for use in developing each requirement, and other relevant information that is kept on public file by EPA.

VIII. Economic Analysis

The total estimated annualized compliance costs of today's final rule is $48 million.[100] This estimate includes incremental costs incurred by new facilities that begin operation between 2001 and 2020. Facilities not already meeting section 316(b) requirements incur several types of costs under today's final rule. One-time costs of the rule include capital technology costs and costs for the initial permit application. Recurring costs include operating and maintenance (O&M) costs, permit renewal costs, and costs for monitoring, record keeping, and reporting. EPA's cost estimates are presented in Chapters 6 and 7 of the *Economic Analysis* and in the *Technical Development Document*.

Today's final rule provides for a two-track approach to comply with the rule's requirements. Facilities that already plan to install a closed-cycle cooling system in the baseline are assumed to choose Track I, the "fast track." These facilities will incur only the costs of installing fish baskets and a fish return system if they would not have already elected to install these technologies independent of the rule. EPA records document that the screens were sized to reduce the velocity. Facilities that do not plan to install a closed-cycle cooling system in the baseline are assumed to choose Track II. These facilities will install alternative technologies of their choice that will reduce impingement mortality and entrainment to a level of reduction comparable to the level the facility would achieve if it met the Track I requirements. The alternative technologies considered in the cost analysis are further discussed in Chapter 5 of the Technical Development Document.

Chapter 2 of the *Technical Development Document* outlines EPA's approach to estimating the facility-level costs associated with this rule. EPA estimated costs for a series of model facilities, based on their cooling system type (once-through or recirculating system), the type of water body from which the intake structure withdraws (freshwater or marine water), and a measure of the facility's size (generating capacity for steam-electric generating capacity plants and design intake flow for manufacturers). Model facility characteristics were derived from specific new facilities predicted to be built based on Resource Data International's NEWGen Database, and from existing facilities based on responses to the section 316(b) industry survey of existing facilities (see discussion below) and U.S. Department of Energy information. EPA estimated compliance costs for the 121 new facilities estimated to begin operation between 2001 and 2020, based on model facility characteristics and the requirements of today's final rule. EPA amortized capital cost estimates over 30 years.[101] EPA projected construction of 121 new facilities over the next 20 years after promulgation of the final rule.

A. Electric Generation Sector

For the period 2001 through 2020, EPA estimates that 83 new electric generation facilities will be subject to today's final rule.[102] EPA identified these facilities based on three main data sources: (1) The U.S. Department of Energy's *Annual Energy Outlook 2001* (AEO2001); (2) Resource Data International's NEWGen Database (February 2001 version); and (3) the section 316(b) industry survey of existing facilities. Because the facilities are new facilities that have not yet been built, EPA necessarily had to project certain aspects of the facilities. Hence, the facilities are model facilities. For more information on EPA's facility modeling, see Chapter 5 of the *Economic Analysis*.

EPA estimated facility-level costs for the 83 new electric generation facilities found to be within the scope of this rule by comparing each facility's projected baseline characteristics with the incremental requirements of the rule. If a facility already planned to fulfill any of the applicable requirements independent of the rule, the cost estimates did not include any costs for meeting that requirement. For example, EPA estimates that 74 of the 83 proposed new generating facilities already plan to build a recirculating wet cooling tower, so only 9 facilities are assumed to incur costs for complying with the flow reduction requirement at § 124.84(b)(1) of the final rule.

EPA used annual forecasts of new capacity additions from the AEO2001 to predict how many of the 83 new generating facilities will begin operation in each year between 2001 and 2020. EPA then distributed the new facilities estimated to install a cooling tower evenly over the years with projected new facilities. For example, EPA estimates that three of the 14 new in-scope coal-fired facilities are planning to build a once-through system in the baseline. The cost analysis therefore assumes that the 1st, 6th, and 11th coal-fired facility to begin operation will incur costs of a recirculating wet cooling tower. An additional coal facility which plans to have a cooling pond was treated as having a once-through system in the baseline and was also costed with a cooling tower.[103] This facility was assumed to be the 2nd to begin operation. EPA's assumptions on when new Track I coal facilities will begin operation leads to an overestimate of the total costs of this rule because higher cost facilities are over represented among the coal facilities beginning operation early in the 20-year analysis period. Additionally, EPA estimates that five of the 69 new in-scope combined-cycle facilities would install a recirculating wet cooling tower as a result of the rule. The cost analysis therefore assumes that the 1st, 16th, 30th, 44th, and 58th combined-cycle facility to begin operation will incur costs of a recirculating wet cooling tower.

Total annualized costs for the 83 new facility electric generators are estimated to be $34.7 million (using a 7 percent discount rate). The lowest annualized compliance cost for any electric generator is estimated to be

[100] The estimated annualized compliance costs are presented as a single cost to represent the highestpotential implementation costs to industry. For example, although such costs are based on estimates of howmany facilities will choose compliance under Track I and Track II, even facilities estimated to follow TrackII have been assumed to ultimately have to install closed-cycle recirculating cooling water systems.

[101] The amortization period was selected to correspond to the estimated useful life of the technologiesrequired for compliance with this rule. EPA conducted a sensitivity analysis using a 15-yearamortization period (see Chapter 7 of the *Economic Analysis*).

[102] See Section IV.A. above or Chapter 5 of the *Economic Analysis* for underlying estimates and methods used for estimating the cost of the rule.

[103] In some states, a cooling pond is considered a water of the U.S. In these states, a plant with such a cooling system would have to comply with the recirculating requirements of the final section 316(b) New Facility Rule. In those states where a cooling pond is not considered a water of the U.S., a plant would not have to comply with the recirculating requirements of this rule. The costing analysis made the conservative assumption that facilities with a cooling pond would have to comply with the recirculating requirements. These recirculating facilities with cooling ponds were therefore costed as if they had a once-through system in the baseline.

approximately $170,000; the lowest annualized cost per megawatt of generating capacity is estimated to be $153. The highest annualized cost is estimated to be $19.1 million; the highest cost per megawatt of generating capacity is estimated to be $11,640. Sixty-nine facilities are expected to have relatively low annualized compliance costs (below $200,000 per facility), while 8 facilities will have annualized costs exceeding $1 million per facility.[104] The other facilities would have costs between $200,000 and $1 million per facility.

B. Manufacturing Sector

For the period 2001 through 2020, EPA projected that 38 new manufacturing facilities will incur costs to comply with today's final rule. All of these facilities are model facilities estimated based on industry growth rates (derived from the U.S. Industry and Trade Outlook 2000 and industry-specific sources, such as Kline's Guide to the Chemical Industry) and responses to the section 316(b) industry survey. Facility-specific operational characteristics of the cooling water intake structures, economic and financial characteristics of the projected new facilities, and waterbody type and other locational information were not available. EPA assumed that the characteristics of new facilities in a given 4-digit SIC code will be similar to the characteristics of existing facilities in that same SIC code. Compliance costs were therefore calculated based on the characteristics of existing facilities by SIC code, source water type, cooling system type, and flow, using data from the section 316(b) industry survey of existing facilities. EPA used the same unit costs and methods as for new electric generators.

Total annualized costs for the 38 new manufacturing facilities are estimated to be $13.0 million. The lowest annualized compliance cost for any facility is approximately $175,000; the highest annualized cost is $1.6 million; the average annualized costs for the remaining 36 manufacturing facilities centers around $494,000 per facility. Five of the manufacturing facilities incur annualized costs less than $200,000 per facility, and one chemicals facility incurs annualized costs exceeding $1 million.

Exhibit 4 provides a summary of the estimated annualized compliance costs for today's final rule.

EXHIBIT 4.—NATIONAL ANNUALIZED COSTS OF COMPLIANCE WITH THE SECTION 316(B) NEW FACILITY REGULATION

[in $2000, millions]

Industry category	Number of projected new in-scope facilities	Capital and permit application costs	Recurring costs	Total annualized compliance costs
Electric Generators:				
Combined-Cycle	69	$3.7	$9.6	$13.3
Coal-Fired	14	4.1	17.3	21.4
Total Generators	83	7.8	26.9	34.7
Manufacturing Facilities:				
SIC 26 Pulp & paper	2	0.2	0.3	0.5
SIC 28 Chemicals	22	2.7	4.1	6.8
SIC 29 Petroleum	2	0.3	0.5	0.8
SIC 331 Iron & steel	10	1.9	2.8	4.6
SIC 333/335 Aluminum	2	0.1	0.1	0.2
Total Manufacturing	38	5.2	7.8	13.0
All Projected New Facilities	121	12.9	34.7	47.7

C. Economic Impacts

The estimated annualized compliance costs would represent a small portion of the estimated revenues for almost all of the new facilities subject to today's rule. Costs as a percentage of baseline revenues would be less than 1 percent for all but nine of the facilities. Of these nine facilities, only 3 would experience costs as a percentage of baseline revenues of 3 percent or more.[105] EPA's discussion of cost impacts is presented in Chapter 7 of the *Economic Analysis.* Impacts at the industry level are expected to be very limited because the projected number and total capacity of the new facilities that are within the scope of today's final rule are generally small compared with the industry as a whole. Because EPA does not expect many facilities to be affected and does not expect the costs of the rule to create a barrier to entry or to create a significant change in productivity, EPA does not expect today's final rule to cause significant changes in industry productivity, competition, prices, output, foreign trade, or employment. The baseline revenues and the modest costs for each facility subject to today's rule are sufficient to preclude any barriers to entry.

EPA therefore expects the final rule to be economically practicable for the industries as a whole. The rule is not expected to result in any significant impact on generation and distribution of electricity, because most of the electric generation facilities are expected to meet most of the rule's requirements in the baseline. Only a small percentage of the total number of facilities in each of the manufacturing sectors will be affected by the final rule. EPA therefore concludes that this rule will not result in a significant impact on industries or the economy.

D. Cost and Economic Impacts of Other Alternatives

In addition to today's final rule, EPA estimated the costs and economic impacts of several alternative regulatory options. The first alternative option that EPA considered would be to apply the Track I requirements of today's final rule only to facilities withdrawing from

[104] The higher-cost electric generators are expected to begin operation in the years 2004, 2005 (two facilities), 2007 (two facilities), 2010, 2013, and 2017.

[105] Three coal facilities would have annualized costs between 3.3 percent and 5.2 percent of revenues. Sixelectric generators would have annualized costs greater than 1 but less than 3 percent of revenues.

estuaries, tidal rivers, Great Lakes, and oceans. Under this option, the definition and number of new facilities subject to the rule would not change, but some facilities would incur less stringent compliance requirements. EPA estimates that the total annualized compliance costs for this alternative would be $36.3 million. The second alternative option considered by EPA would impose more stringent compliance requirements on the electric generating segment of the industry. It is based wholly or in part on a zero intake-flow (or nearly zero, extremely low-flow) requirement, commensurate with levels achievable through the use of dry cooling systems. New manufacturing facilities would not be subject to these stricter requirements but would have to comply with the requirements of today's final rule. EPA estimated costs for this alternative by assuming that the dry cooling standard would apply to electric generators on all waters of the U.S. The costs of this option are estimated to be $490.7 million per year.

The first alternative regulatory option considered by EPA would have lower total costs than today's final rule. A regulatory framework based on dry cooling towers for some or all electric generators is the most expensive option. Compared with today's final rule, this option would impose an additional cost of $443 million, or $6,910 per megawatt of generating capacity, on the electric generating sector.

IX. Potential Benefits Associated With Reducing Impingement and Entrainment

To provide an indication of the potential benefits of adopting best technology for cooling water intake structures, this section presents information from existing sources on impingement and entrainment losses associated with cooling water intake structures and the economic benefits associated with reducing these losses. Benefits of the regulation come from preventing situations such as those discussed below. Examples are drawn from existing sources because the information needed to quantify and value potential reductions in losses at new facilities is not available. The reason the information is unavailable is that the exact location of future facilities is unknown. Also unknown are details of cooling water intake structure characteristics, such as the exact configuration of intake, the species present near an intake, the life stages of the species at the time they are present, and the susceptibility of these species to impingement and entrainment. For some facilities listed in the new NEWGen database, there is some general information about facility locations, but details of intake characteristics and the ecology of the surrounding waterbody are unavailable. For facilities projected into the future, there is no locational information at all. Site-specific information is critical in predicting benefits, because studies at existing facilities demonstrate that benefits are highly variable across facilities and locations. Even similar facilities on the same waterbody can have very different benefits depending on the aquatic ecosystem in the vicinity of the facility and intake-specific characteristics such as location, design, construction, and capacity.

In general, the probability of impingement and entrainment at future cooling water intake structure locations depends on intake and species characteristics that influence the intensity, time, and spatial extent of interactions of aquatic organisms with a facility's cooling water intake structure and the physical, chemical, and biological characteristics of the source waterbody. Flows commensurate with closed-cycle cooling systems (which are one part of the basis for best technology available) withdraw water from a natural waterbody, circulate the water through the condensers, and then send it to a cooling tower or cooling pond before recirculating it back through the condensers. Because cooling water is recirculated, closed-cycle systems generally reduce the water flow from 72 percent to 98 percent, thereby using only 2 percent to 28 percent of the water used by once-through systems. It is generally assumed that this would result in a comparable reduction in impingement mortality and entrainment.

Fish species with free-floating, early life stages are highly susceptible to cooling water intake structure impacts. Such planktonic organisms lack the swimming ability to avoid being drawn into intake flows. Species that spawn in nearshore areas, have planktonic eggs and larvae, and are small as adults experience even greater impacts, because both new recruits and reproducing adults are affected (*e.g.*, bay anchovy in estuaries and oceans). In general, higher impingement and entrainment are observed in estuaries and near coastal waters because of the presence of spawning and nursery areas.

The final regulatory framework also recognizes that for any given species and cooling water intake structure location, the proportion of the sourcewater flow supplied to the cooling water intake structure is a major factor affecting the potential for impingement and entrainment. In general, if the quantity of water withdrawn is large relative to the flow of the source waterbody, water withdrawal would tend to concentrate organisms and increase numbers impinged and entrained. Thus, the final flow requirements seek to reduce impingement and entrainment by limiting the proportion of the waterbody flow that can be withdrawn.

The following five examples from studies at existing facilities offer some indication of the relative magnitude of monetary damages associated with cooling water intake structures. These examples exhibit the magnitude of impingement and entrainment, on a per facility basis, that could be significantly reduced in the future for similar steam electric facilities under this final rule. In the following discussion, the potential benefits of lowering intake flows to a level commensurate with those of a closed-cycle recirculating cooling water system (for the projected 90 percent of facilities not already planning to use such systems) is illustrated by comparisons of once-through and closed-cycle cooling systems (*e.g.*, the Brayton Point and Hudson River facilities). The potential benefits of additional requirements defined by regional permit directors are demonstrated by operational changes implemented to reduce impingement and entrainment (*e.g.*, the Pittsburg and Contra Costa facilities). The Ludington example demonstrates how impingement and entrainment losses of forage species can lead to reductions in economically valuable species. Finally, the potential benefits of implementing additional design and construction technologies to increase survival of organisms impinged or entrained is illustrated by the application of modified intake screens and fish return systems (*e.g.*, the Salem Nuclear Generating Station).

The first example of the potential benefits of minimizing intake flow and associated impingement and entrainment is provided by data for the Brayton Point facility, located on Mt. Hope Bay in Massachusetts. In July 1984, the operation of Unit 4 was changed from closed-cycle cooling and piggyback operation to once-through cooling. Although conversion to once-through cooling increased intake flow by about 41 percent, the facility requested the change because of electrical problems associated with salt contamination from Unit 4's closed-cycle cooling canal equipped with spray modules. The lower losses expected under closed-cycle operation can be estimated by comparing losses before and after this modification. Based on reports providing predicted [106] or actual [107] losses after the Unit 4 modification, EPA estimates that the average annual reduction in entrainment losses of adult equivalents of catchable fish resulting from closed-cycle operation of a single unit at Brayton Point (reducing the flow of that unit from 1,045 MGD to 703 MGD) would range from 207,254 Atlantic menhaden (Brevoortia tyrannus) [1] and 155,139 winter flounder (Pleuronectes americanus) [2] to 20,198 tautog (Tautoga onitis) [2] and 7,250 weakfish (Cynoscion regalis) [2] per year. Assuming a proportional change in harvest, the lower losses associated with a closed-cycle system would be expected to result in an increase of 330,000 to 2 million pounds per year in commercial landings and 42,000 to 128,000 pounds per year in recreational landings.

The second example of the potential benefits of low intake flow is provided by an analysis of impingement and entrainment losses at five Hudson River power plants. Estimated fishery losses under once-through compared with closed-cycle cooling indicate that an average reduction in intake flow of about 95 percent at the three facilities responsible for the greatest impacts would result in a 30 to 80 percent reduction in fish losses, depending on the species involved.[108] An economic analysis estimated monetary damages under once-through cooling based on the assumption that annual percentage reductions in year-classes of fish result in proportional reductions in fish stocks and harvest rates.[109] A low estimate of damages was based on losses at all five facilities, and a high estimate was based on losses at the three facilities that account for most of the impacts. Damage estimates under once-through cooling ranged from about $1.3 million to $6.1 million annually in 1999 dollars. Over the next 20 years, EPA projects that 9 out of 83 new power plants would be built without recirculating systems in the absence of this rule. Most of the costs projected for the final rule are associated with installing recirculating systems as a result of this final rule.

The third example demonstrates how impingement and entrainment losses of forage species can lead to reductions in economically valued species. A random utility model (RUM) was used to estimate fishery impacts of impingement and entrainment by the Ludington Pumped Storage plant on Lake Michigan.[110] [111] This method estimates changes in demand for beneficial use of the waterbody as a function of changes in catch rates. The Ludington facility is responsible for the loss of about 1 to 3 percent of the total Lake Michigan production of alewife, a forage species that supports valuable trout and salmon fisheries. It was estimated that losses of alewife result in a loss of nearly 6 percent of the angler catch of trout and salmon each year. On the basis of RUM analysis, the study estimated that if Ludington operations ceased, catch rates of trout and salmon species would increase by 3.3 to 13.7 percent annually, amounting to an estimated recreational angling benefit of $0.95 million per year (in 1999 dollars) for these species alone.

The fourth example indicates the potential benefits of technologies that have been required in past section 316(b). Two plants in the San Francisco Bay/Delta, Pittsburg, and Contra Costa in California have made changes to their intake operations to reduce impingement and entrainment of striped bass *Morone saxatilis*). These changes include flow reduction through variable speed pumps. These operational changes have also reduced incidental take of several threatened or endangered fish species, including the delta smelt (*Hypomesus transpacificus*) and several runs of chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*Oncorhynchus mykiss*). According to technical reports by the facilities, use of these technologies reduced striped bass losses by 78 to 94 percent, representing an increase in striped bass recreational landings averaging about 100,000 fish each year.[112] [113] [114] [115] [116] A local study estimated that the consumer surplus of an additional striped bass caught by a recreational angler is $8.87 to $13.77.[117] This implies a benefit to the recreational fishery, from reduced impingement and entrainment of striped bass alone, in the range of $887,000 to $1,377,000 annually. The monetary benefit of reduced impingement and entrainment of threatened or endangered species might be substantially greater.

The final example indicates the potential benefits of technologies that can be applied to reduce impingement. In its 1999 permit renewal application, the Salem Nuclear Generating Station in the Delaware Estuary evaluated the potential benefits of dual-flow, fine mesh traveling screens designed to achieve an approach velocity of 0.5 ft/s.[118] Based on the facility's projections of net increases in recreational fisheries that would occur with this technology, EPA estimates that angler consumer surplus would increase by $531,247, to $1,780,104 annually in 1999 dollars. Assuming that nonuse benefits are at least 50 percent of recreational use benefits, nonuse benefits associated with the screens might be expected to amount to up to $890,052 per year.

A more detailed discussion of cooling water intake structure impacts and potential benefits can be found Chapter 11 of the *Economic Analysis* document.

[106] Marine Research, Inc. and New England Power Company. 1981. Final Environmental Impact Report and Sections 316(a) and 316(b) Demonstrations Made in Connection with the Proposed conversion of Generating Unit No. 4 from Closed-Cycle to Once-through Cooling.

[107] New England Power Company and Marine Research Inc. 1995. Brayton Point Station Annual Biological and Hydrological Report, January-December 1994.

[108] Boreman, J. And C.P. Goodyear. 1988. Estimates of entrainment mortality for striped bass and other fish species inhabiting the Hudson River Estuary. *American Fisheries Society Monograph* 4:152–160.

[109] Rowe, R.D., C.M. Lang, L.G. Chestnut, D.A. Latimer, D.A. Rae, S.M. Bernow, and D.E. White. 1995. *The New York Electricity Externality Study, Volume 1.* Empire State Electric Energy Research Corporation.

[110] Jones, C.A., and Y.D. Sung. 1993. *Valuation of Environmental Quality at Michigan Recreational Fishing Sites: Methodological Issues and Policy Applications.* Prepared under EPA Contract No. CR–816247 for the U.S. EPA, Washington, DC.

[111] Pumped storage facilities do not use cooling water and are therefore not subject to this final rule. However, the concept of economic valuation of losses in forage species is transferable to other types of stressors, including cooling water intake structures.

[112] Pacific Gas & Electric Company. 1996. Best Technology Available: 1995 Technical Report for the Contra Costa and Pittsburg Power Plants. Prepared for Central Valley and San Francisco Bay Regional Water Quality Control Boards.

[113] Pacific Gas & Electric Company. 1997. Best Technology Available: 1996 Technical Report for the Contra Costa and Pittsburg Power Plants. Prepared for Central Valley and San Francisco Bay Regional Water Quality Control Boards.

[114] Pacific Gas & Electric Company. 1998. Best Technology Available: 1997 Technical Report for the Contra Costa and Pittsburg Power Plants. Prepared for Central Valley and San Francisco Bay Regional Water Quality Control Boards.

[115] Pacific Gas & Electric Company. 1999. Best Technology Available: 1998 Technical Report for the Contra Costa and Pittsburg Power Plants. Prepared for Central Valley and San Francisco Bay Regional Water Quality Control Boards.

[116] South Energy California. 2000. Best Technology Available: 1999 Technical Report for the Contra Costa and Pittsburg Power Plants. Prepared for Central Valley and San Francisco Bay Regional Water Quality Control Board.

[117] Huppert, D.H. 1989. Measuring the value of fish to anglers: application to central California anadromous species. *Marine Resource Economics* 6:89–107.

[118] Public Service Electric and Gas Company. 1999. Appendix F, 1999 Permit Renewal Application, NJPDES Permit No. NJ0005622.

X. Regulatory Requirements

A. Executive Order 12866: Regulatory Planning and Review

Under Executive Order 12866, (58 *FR* 51735, October 4, 1993) the Agency must determine whether the regulatory action is ''significant'' and therefore subject to the Office of Management and Budget (OMB) review and the requirements of the Executive Order. The Order defines a ''significant regulatory action'' as one that is likely to result in a rule that may:

- Have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or Tribal governments or communities;
- Create a serious inconsistency or otherwise interfere with an action taken or planned by another agency;
- Materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or
- Raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order.

Pursuant to the terms of Executive Order 12866, it has been determined that this final rule is a ''significant regulatory action.'' As such, this action was submitted to OMB for review. Changes made in response to OMB suggestions or recommendations will be documented in the public record.

B. Paperwork Reduction Act

The Office of Management and Budget (OMB) has approved the information collection requirements contained in this rule under the provisions of the Paperwork Reduction Act, 44 U.S.C. 3501 *et seq.* and has assigned OMB control number 2040–0241. The information collection requirements relate to new electric generation and manufacturing facilities collecting information for baseline biological characterization, monitoring of impingement and entrainment, preparing comprehensive demonstrations, verifying compliance, and preparing yearly reports.

Since the proposal, EPA used updated sources and revised the number of facilities that will be subject to this rule (See Section IV.A.1 of this preamble). These new data sources resulted in an increase in the number of facilities projected as subject to this rule from 98 in the proposed rule analysis to 121 in the final rule. As a result, the cost and burden estimates for today's final rule have increased somewhat.

In the final rule, EPA has revised the requirements of the source water baseline biological characterization to allow the use of existing information, which lowers the cost incurred by new facilities. However, today's rule includes a Comprehensive Demonstration requirement for those facilities choosing Track II. Cost and burden estimates for today's final rule were revised accordingly.

Burden is defined as the total time, effort, or financial resources expended by persons to generate, maintain, retain, or disclose or provide information to or for a Federal agency. This includes the time needed to review instructions; develop, acquire, install, and utilize technology and systems for the purposes of collecting, validating, and verifying information, processing and maintaining information, and disclosing and providing information; adjust the existing ways to comply with any previously applicable instructions and requirements; train personnel to be able to respond to a collection of information; search data sources; complete and review the collection of information; and transmit or otherwise disclose the information.

The total burden of the information collection requirements associated with today's rule is estimated at 121,127 hours. The corresponding estimates of cost other than labor (labor and non-labor costs are included in the total cost of the rule discussed in Section VIII of this preamble) is $5.3 million for 18 facilities and 44 States and one Territory for the first three years after promulgation of the rule. Non-labor costs include activities such as capital costs for remote monitoring devices, laboratory services, photocopying, and the purchase of supplies. The burden and costs are for the information collection, reporting, and recordkeeping requirements for the three-year period beginning with the effective date of today's rule. Additional information collection requirements will occur after this initial three-year period as new facilities continue to be permitted and such requirements will be counted in a subsequent information collection request. EPA does not consider the specific data that would be collected under this final rule to be confidential business information. However, if a respondent does consider this information to be confidential, the respondent may request that such information be treated as confidential. All confidential data will be handled in accordance with 40 CFR 122.7, 40 CFR part 2, and EPA's Security Manual Part III, Chapter 9, dated August 9, 1976.

Compliance with the applicable information collection requirements imposed under this final rule (*see* §§ 122.21(r), 125.86, 125.87, 125.88, and 125.89) is mandatory. Before new facilities can begin operation, they would be required first to perform several data-gathering activities as part of the permit application process. Today's rule would require several distinct types of information collection as part of the NPDES application. In general, the information would be used to identify which of the requirements in today's final rule applies to the new facility, how the new facility would meet those requirements, and whether the new facility's cooling water intake structure reflects the best technology available for minimizing environmental impact. Specific data requirements of today's rule follow:

- Intake structure data, consisting of intake structure design and a facility water balance diagram, to evaluate the potential for impingement and entrainment of aquatic organisms; and
- Information on design and construction technologies implemented to ensure compliance with the applicable requirements set forth in today's rule.

In addition to the information requirements of the permit application, NPDES permits normally specify monitoring and reporting requirements to be met by the permitted entity. New facilities that fall within the scope of this rule would be required to perform biological monitoring of impingement and entrainment, monitoring of the screen or through-screen technology velocity, and visual inspections of the cooling water intake structure and any additional technologies. Additional ambient water quality monitoring may also be required of facilities depending on the specifications of their permits. The facility would be expected to analyze the results from its monitoring efforts and provide these results in an annual status report to the permitting authority. Finally, facilities would be required to maintain records of all submitted documents, supporting materials, and monitoring results for at least three years. (Note that the director may require that records be kept for a longer period to coincide with the life of the NPDES permit.)

All impacted facilities would carry out the specific activities necessary to fulfill the general information collection requirements. The estimated burden includes developing a water balance diagram that can be used to identify the proportion of intake water used for cooling, make-up, and process water. Some of the facilities (those choosing Track II) would gather performance data to determine the effectiveness of alternative technologies that reduce impingement and entrainment to levels commensurate with reductions achieved through use of recirculating wet cooling towers and document the basis of their determination in a demonstration study. The burden estimates include sampling, assessing the source waterbody, estimating the magnitude of impingement and entrainment, and reporting results in a comprehensive demonstration for certain facilities. The burden also includes conducting a pilot study to show that alternative technologies to be installed are equivalent in performance to the fast track technologies, if data are not publicly available for assessing the performance of certain technologies. Some of the facilities would need to perform additional activities related to velocity and flow reduction requirements. The burden estimates also incorporate the cost of preparing a narrative description of the design, structure, equipment, and operational features required to meet velocity and flow reductions.

In addition to the activities mentioned above, some facilities would need to prepare and submit a plan describing design characteristics of additional technologies to be installed that will reduce impingement and entrainment and maximize survival of aquatic organisms. The estimates for some facilities also incorporate the cost of sampling, analyzing, and reporting the type and number of impinged and entrained organisms; velocity monitoring; and biweekly inspections of installed technologies.

Exhibit 5 presents a summary of the maximum burden estimates for a facility to prepare a permit application and monitor and report on cooling water intake structure operations as required by this rule.

EXHIBIT 5.—MAXIMUM BURDEN AND COSTS PER FACILITY FOR NPDES PERMIT APPLICATION AND MONITORING AND REPORTING ACTIVITIES

Activities	Burden (hr)	Labor cost	Other direct costs (lump sum) [a]
Start-up activities	43	$1,585	$50
Permit application activities	146	4,598	500
Source waterbody flow information	104	3,010	100
Source water baseline biological characterization data	265	8,975	750
CWIS flow reduction requirements (Track I)	108	3,261	400
CWIS velocity requirements (Track I)	138	4,428	1,000
Design and construction technology plan (Track I)	85	2,840	50
Comprehensive demonstration study plan (Track II) [b]	383	13,563	1,000
Source water baseline biological characterization study (Track II)	5,178	274,845	13,000
Evaluation of potential CWIS effects (Track II)	2,577	135,141	500
Subtotal	9,027	452,246	17,350
Maximum Burden and Costs per Facility for Annual Monitoring and Reporting Activities			
Biological monitoring (impingement)	388	20,240	650
Biological monitoring (entrainment)	776	41,035	4,000
Velocity monitoring	163	4,993	100
Visual inspection of installed technology and remote monitoring equipment [c]	253	8,159	100
Verification monitoring (Track II) [d]	122	5,146	500
Yearly Status report activities	348	13,071	750
Subtotal	2,050	92,644	6,100

[a] Cost of supplies, filing cabinets, photocopying, boat renting, etc.
[b] The Comprehensive Demonstration Study also has contracted service costs associated with it.
[c] Remote monitoring equipment also has capital and O&M costs associated with it
[d] The verification monitoring also has contracted services associated with it.

EPA believes that all 44 States and one territory with NPDES permitting authority will undergo start-up activities in preparation for administering the provisions of the new facility rule. As part of these start-up activities, States and Territories are expected to train junior technical staff to review materials submitted by facilities, and then use these materials to evaluate compliance with the specific conditions of each facility's NPDES permit.

Each State's/Territory's actual burden associated with reviewing submitted materials, writing permits, and tracking compliance depends on the number of new in-scope facilities that will be built in the State/Territory during the ICR approval period. EPA expects that State and Territory technical and clerical staff will spend time gathering, preparing, and submitting the various documents. EPA's burden estimates reflect the general staffing and level of expertise that is typical in States/Territories that administer the NPDES permitting program. EPA considered the time and qualifications necessary to complete various tasks such as reviewing submitted documents and supporting materials, verifying data sources, planning responses, determining specific permit requirements, writing the actual permit, and conferring with facilities and the interested public. Exhibit 6 provides a summary of the burden estimates for States/Territories performing various activities associated with the final rule.

EXHIBIT 6.—ESTIMATING STATE/TERRITORY BURDEN AND COSTS FOR ACTIVITIES

Activities	Burden (hrs)	Labor cost	Other direct cost
Start-up activities (per state/territory)	100	$3,514	$50
State/territory permit issuance activities (per facility)	723	29,128	350
Annual state/territory activities (per facility)	50	1,670	50

An Agency may not conduct or sponsor, and a person is not required to respond to a collection of information, unless it displays a currently valid OMB control number. The OMB control numbers for EPA's regulations are listed in 40 CFR part 9 and 48 CFR Chapter 15. EPA is amending the table in 40 CFR part 9 of currently approved ICR control numbers issued by OMB for various regulations to list the information requirements contained in this final rule.

C. Unfunded Mandates Reform Act

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA), Public Law 104–4, establishes requirements for Federal agencies to assess the effects of their regulatory actions on State, local, and Tribal governments and the private sector. Under section 202 of UMRA, EPA generally must prepare a written statement, including a cost-benefit analysis, for proposed and final rules with ''Federal mandates'' that might result in expenditures to State, local, and Tribal governments, in the aggregate, or to the private sector, of $100 million or more in any one year. Before promulgating an EPA rule for which a written statement is needed, section 205 of UMRA generally requires EPA to identify and consider a reasonable number of regulatory alternatives and adopt the least costly, most cost-effective, or least burdensome alternative that achieves the objectives of the rule. The provisions of section 205 do not apply when they are inconsistent with applicable law. Moreover, section 205 allows EPA to adopt an alternative other than the least costly, most cost-effective, or least burdensome alternative if the Administrator publishes with the final rule an explanation why that alternative was not adopted. Before EPA establishes any regulatory requirements that might significantly or uniquely affect small governments, including Tribal governments, it must have developed under section 203 of the UMRA a small government agency plan. The plan must provide for notifying potentially affected small governments, enabling officials of affected small governments to have meaningful and timely input in the development of EPA regulatory proposals with significant intergovernmental mandates, and informing, educating, and advising small governments on compliance with regulatory requirements.

EPA has determined that this rule does not contain a Federal mandate that might result in expenditures of $100 million or more for State, local, and Tribal governments, in the aggregate, or the private sector in any one year. Total annualized compliance and implementation costs are estimated to be $47.9 million. Of the total costs, the private sector accounts for $43.8 million and the government sector (includes direct compliance costs for facilities owned by government entities) accounts for $4.1 million. EPA calculated annualized costs by estimating initial and annual expenditures of facilities and regulatory authorities over the 30-year period (2001–2030), calculating the present value of that stream of expenditures using a 7 percent discount rate. EPA estimates that the highest undiscounted cost incurred by the private sector in any one year is approximately $71.2 million and the highest cost incurred by government sector in any one year is approximately $19.0 million. Thus, today's rule is not subject to the requirements of sections 202 and 205 of UMRA.

EPA has determined that this final rule contains no regulatory requirements that might significantly or uniquely affect small governments. Thus, today's final rule is not subject to the requirements of section 203 of UMRA. A municipality that owns or operates a new electric generation facility is the primary category of small government operations that might be affected by this rule. Existing data indicate that only four government owned facilities will be constructed in the next twenty years. All four are expected to be owned by large governments. Of these, two are expected to be State owned, one is projected to be owned by a municipality and one by a municipality market. In addition, to minimize cost, this final rule excludes facilities that take in less than two (2) million gallons per day. Details and methodologies used for these estimates are included in the *Economic Analysis* document, which is in the docket.

D. Regulatory Flexibility Act (RFA), as Amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), 5 U.S.C. 601 et seq.

The RFA generally requires an agency to prepare a regulatory flexibility analysis of any rule subject to notice and comment rulemaking requirements under the Administrative Procedure Act or any other statute unless the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. Small entities include small businesses, small organizations, and small governmental jurisdictions.

Today's rule is intended to minimize the adverse environmental impact from cooling water intake structures and regulates new facilities that use cooling water withdrawn directly from waters of the U.S. The primary impact would be on new steam electric generating facilities (SIC 4911); however, a number of new facilities in other industries likely will also be regulated, including, but not limited to, paper and allied products (primary SIC 26), chemical and allied products (primary SIC 28), petroleum and coal products (primary SIC 29), and primary metals (primary SIC 33).

For the purposes of assessing the impacts of today's rule on small entities, small entity is defined as: (1) A small business according to the Small Business Administration (SBA) size standards; (2) A small governmental jurisdiction that is a government of a city, county, town, school district or special district with a population of less than 50,000; and (3) a small organization that is a not-for-profit enterprise which is independently owned and operated and is not dominant in its field. After considering the economic impacts of today's rule on small entities, I certify that this action will not have a significant economic impact on a substantial number of small entities. This rule is expected to regulate only a small number of facilities owned by small entities, representing a very small percentage of all facilities owned by small entities in their respective industries. EPA has estimated that 11 new facilities owned by small entities would be regulated by this final rule. Of the 11 new facilities owned by small entities, 8 are steam electric generating facilities and 3 are manufacturing facilities. This rule will not regulate any small governments or small organizations.

1. Electric Generation Sector

EPA has described the process by which prospective new steam electricity generating facilities subject to today's rule were identified in Section IV.A of this preamble and in Chapter 5 of the *Economic Analysis* document. As described in Chapter 8 of that document, EPA then identified those facilities subject to the rule whose owner would be defined as a small business. The analysis used the definitions of small businesses established by the Small Business Administration (SBA). (The SBA defines small businesses based on Standard Industrial Classification (SIC) codes and size standards expressed by the number of employees, annual receipts, or electric output.) The SBA defines a small steam electric generator as a firm whose facilities generate 4 million megawatt-hours output or less. EPA has determined that 8 facilities owned by small businesses in the steam electric generating industry are likely to be regulated by today's rule.

The estimated annualized compliance costs that facilities owned by small entities would likely incur represent between 0.11 and 0.44 percent of estimated facility annual sales revenue. All but one electric generating facilities owned by a small firm incur costs less than 0.3 percent of revenues. The results of this screening analysis indicated very low impacts at the facility level. Consequently, the costs to the parent small entity would be even lower.

The absolute number of small entities potentially subject to this rule is low. This is not unexpected since the total number of facilities subject to this rule is also low, even though the electric power industry is currently experiencing a rapid expansion and transition due to deregulation and new Clean Air Act requirements for emissions controls, and a large number of generating plants are under construction or planned for the early years of the final rule. First, there is a trend toward construction of combined-cycle technologies using natural gas, which use substantially less cooling water than other technologies. Second, there has been a decline in the use of surface water as the source of cooling water. An analysis of new combined-cycle facilities, identified from the NEWGen database shows a trend toward less use of surface cooling water. The analysis showed that 66 percent of the analyzed facilities use alternative sources of cooling water (*e.g.,* grey water, ground water, municipal water, or dry cooling). EPA believes this reflects the increased competition for water, an heightened awareness of the need for water conservation, and increased local opposition to the use of surface water for power generation. Taken together, the trend toward combined-cycle generating technologies, which have small cooling water requirements per unit of output, and the movement away from the use of surface cooling water result in a low projected number of regulated facilities, despite the expected expansion in new generating capacity.

2. Manufacturing Sector

Chapter 5 of the *Economic Analysis* document shows that 38 new manufacturing facilities are expected to incur compliance costs under today's rule. Since EPA's estimate of new manufacturing facilities is based on industry growth forecasts and not on specific planned facilities, actual parent firm information was not available. EPA, therefore, developed profiles of representative new facilities based on the characteristics of existing facilities identified in EPA's Industry Survey of existing facilities.

Using SBA size standards for the firm's SIC Code, only 3 of the 38 new manufacturing facilities are projected to be owned by a small entity. One of the 3 facilities is in the chemicals sector and two are in the metals sector (in both sectors, a small entity is defined as a firm with fewer than 1,000 employees). EPA compared annualized costs to annual sales revenue to assess impacts for manufacturing firms. The test was applied at the facility rather than the firm level, which provides a conservative estimate of the impacts because the ratio of costs to revenues were relatively lower at the firm level than at the individual facility level. The impact analysis showed a negligible impact on small entities: very low effects on facility sales revenue (ranging from 0.04 to 0.08 percent).

EPA has conducted extensive outreach to industry associations and organizations representing small government jurisdictions to identify small-entity manufacturing facilities. Based on the outreach effort and a review of the relevant industry trade literature, EPA concludes that, although the exact number of facilities owned by small entities that would be subject to the rule is difficult to quantify, it is evident that for the foreseeable future few, if any, small entities would be affected. EPA estimates that only 2.9 percent of future facilities in the next twenty years owned by small entities will use cooling water at levels that would bring them within the scope of this regulation.

The small number of small entities subject to this rule in the manufacturing sector is not surprising because the facilities likely to be subject to the rule are large industrial facilities that are not generally owned by small entities. There are many reasons for the limited projected number of in-scope new facilities owned by small entities. Depending on which industry sector is considered, these include industry downsizing; expansion of capacity at existing facilities as a means of meeting increased demand; mergers and acquisitions that reduce the overall number of firms; and addition of a significant number of facilities in at least one industry sector as part of a recently completed expansion cycle so that additional new facilities are not expected for the foreseeable future. The segments of the industries that are the primary users of cooling water are mostly large, capital intensive enterprises with few, if any, small businesses within their ranks.

A final reason why this rule does not have a significant economic impact on a substantial number of small entities is that EPA has established a two (2) MGD flow as the level below which facilities would not be subject to the requirements of the rule. This minimum flow level exempts many facilities using small amounts of water, including facilities owned by small entities, while covering approximately 99 percent of the total cooling water withdrawn from the waters of the U.S. Therefore, EPA concludes that there will be a negligible increase in the number of small facilities in these manufacturing industries subject to today's final rule. Exhibit 7 summarizes the results of small entity analysis.

EXHIBIT 7.—SUMMARY OF RFA/SBREFA ANALYSIS

Type of facility	Number of facilities owned by small entities	Annual compliance costs/annual sales revenue
Steam electric generating facilities	8	0.11%–0.44%
Manufacturing facilities	3	0.04%–0.08%
Total	11	0.04% to 0.44%

Although this rule will not have a significant economic impact on a substantial number of entities, EPA nonetheless has tried to reduce the impact of this rule on small entities. In particular, EPA does not require that a facility with intake flows equal to or greater than 2 MGD and less than 10 MGD reduce its intake flow to a level commensurate with use of a closed-cycle recirculating cooling system. Instead, these facilities are required to use the less costly design and construction technologies for minimizing entrainment at all locations. See 125.84(c)(4). EPA believes that the requirements of § 125.84(c) are an economically practicable way for these facilities to reduce impingement mortality and entrainment. EPA consulted many times with the Small Business Administration on matters associated with this rule. Upon invitation, EPA met several times with a mix of small businesses interested in this rule.

E. Executive Order 13132: Federalism

Executive Order 13132 (64 *FR* 43255, August 10, 1999) requires EPA to develop an accountable process to ensure ''meaningful and timely input by State and local officials in the development of regulatory policies that have federalism implications.'' ''Policies that have federalism implications'' is defined in the Executive Order to include regulations that have ''substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government.''

This final rule does not have federalism implications. It will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government, as specified in Executive Order 13132. Rather, this final rule would result in minimal administrative costs on States that have an authorized NPDES program. The annualized state implementation cost over the 30-year analysis period (2001 to 2030) is approximately $240,000 total for all States per year. Also, based on meetings and subsequent discussions with local government representatives from municipal utilities, EPA believes that the final new facility rule may affect, at most, only two large municipalities that own steam electric generating facilities. The annual impacts on these facilities is not expected to exceed 1,304 burden hours and $36,106 (non-labor costs) per facility.

The national cooling water intake structure requirements would be implemented through permits issued under the NPDES program. Forty-four States and the Virgin Islands are currently authorized pursuant to section 402(b) of the CWA to implement the NPDES program. In States not authorized to implement the NPDES program, EPA issues NPDES permits. Under the CWA, States are not required to become authorized to administer the NPDES program. Rather, such authorization is available to States if they operate their programs in a manner consistent with section 402(b) and applicable regulations. Generally, these provisions require that State NPDES programs include requirements that are as stringent as Federal program requirements. States retain the ability to implement requirements that are broader in scope or more stringent than Federal requirements. (See section 510 of the CWA)

Today's final rule would not have substantial direct effects on States or on local governments because it would not change how EPA and the States and local governments interact or their respective authority or responsibilities for implementing the NPDES program. Today's final rule establishes national requirements for new facilities with cooling water intake structures. NPDES-authorized States that currently do not comply with the final regulations might need to amend their regulations or statutes to ensure that their NPDES programs are consistent with Federal section 316(b) requirements. See 40 CFR 123.62(e). For purposes of this final rule, the relationship and distribution of power and responsibilities between the Federal government and the States and local governments are established under the CWA (e.g., sections 402(b) and 510); nothing in this final rule would alter that. Thus, Executive Order 13132 does not apply to this rule.

Although section 6 of Executive Order 13132 does not apply to this rule, EPA did consult with State governments and representatives of local governments in developing the rule. During the development of the section 316(b) rule for new facilities, EPA conducted several outreach activities through which State and local officials were informed about the proposed rule and they provided information and comments to the Agency.

EPA also held two public meetings in the summer of 1998 to discuss issues related to the section 316(b) rulemaking effort. Representatives from New York and Maryland attended the meetings and provided input to the Agency. The Agency also contacted Pennsylvania and Virginia to exchange information on this issue. In addition, EPA Regions 1, 3, 4, and 9 served as conduits for transmittal of section 316(b) information between the Agency and several States. In the spirit of Executive Order 13132, and consistent with EPA policy to promote communications between EPA and State and local governments, EPA specifically solicited comment on the proposed rule from State and local officials. More recently, EPA met with industry, environmental, and State and Federal government representatives, during May, June, and July 2001 to discuss regulatory alternatives for the new facility rule. The States that EPA consulted with or received public comment from, in general, supported the technology-based rule which focused on reducing the impingement mortality and entrainment resulting from cooling water intake structures. In particular, many States endorsed the 2 MGD threshold, capacity reduction, and proportional flow restrictions. A few States wanted more flexibility, whereas others wanted more stringent technology-based performance standards. EPA believes that it has achieved a balance between these two opposite concerns in establishing the two-track approach.

F. Executive Order 12898: Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations

Executive Order 12898 requires that, to the greatest extent practicable and permitted by law, each Federal agency must make achieving environmental justice part of its mission. Executive Order 12898 provides that each Federal agency must conduct its programs, policies, and activities that substantially affect human health or the environment in a manner that ensures that such programs, policies, and activities do not have the effect of excluding persons (including populations) from participation in, denying persons (including populations) the benefits of, or subjecting persons (including populations) to discrimination under such programs, policies, and activities because of their race, color, or national origin.

Today's final rule would require that the location, design, construction, and capacity of cooling water intake structures at new facilities reflect the best technology available for minimizing adverse environmental impact. For several reasons, EPA does not expect that this final rule would have an exclusionary effect, deny persons the benefits of the NPDES program, or subject persons to discrimination because of their race, color, or national origin. The final rule applies only to new facilities with cooling water intake structures that withdraw waters of the U.S. As discussed previously, EPA anticipates that this final rule would not affect a large number of new facilities; therefore, any impacts of the final rule would be limited. The final rule does include location criteria that would affect siting decisions made by new facilities, these criteria are intended to prevent deterioration of our nation's aquatic resources. EPA expects that this final rule would preserve the health of aquatic ecosystems located in reasonable proximity to new cooling water intake structures and that all populations, including minority and low-income populations, would benefit from such improved environmental conditions. In addition, because the final rule would help prevent decreases in populations of fish and other aquatic species, it is likely to help maintain the welfare of subsistence and other low-income fishermen or minority low-income populations.

G. Executive Order 13045: Protection of Children From Environmental Health Risks and Safety Risks

Executive Order 13045 (62 *FR* 19885, April 23, 1997) applies to any rule that (1) is determined to be ''economically significant'' as defined under Executive Order 12866, and (2) concerns an environmental health or safety risk that EPA has reason to believe might have a disproportionate effect on children. If the regulatory action meets both criteria, the Agency must evaluate the environmental health and safety effects of the planned rule on children, and explain why the planned regulation is preferable to other potentially effective and reasonably feasible alternatives considered by the Agency. This final rule is not an economically significant rule as defined under Executive Order 12866 and does not concern an environmental health or safety risk that EPA has reason to believe may have a disproportionate effect on children. Therefore, it is not subject to Executive Order 13045.

H. Executive Order 13175: Consultation and Coordination With Indian Tribal Governments

Executive Order 13175, entitled ''Consultation and Coordination with Indian Tribal Governments'' (65 FR 67249, November 6, 2000), requires EPA to develop an accountable process to ensure ''meaningful and timely input by tribal officials in the development of regulatory policies that have tribal implications.'' ''Policies that have tribal implications'' is defined in the Executive Order to include regulations that have ''substantial direct effects on one or more Indian tribes, on the relationship between the Federal government and the Indian tribes, or on the distribution of power and responsibilities between the Federal government and Indian tribes.''

This final rule does not have tribal implications. It will not have substantial direct effects on tribal governments, on the relationship between the Federal government and Indian tribes, or on the distribution of power and responsibilities between the Federal government and Indian tribes, as specified in Executive Order 13175. Given the available data on new facilities and the applicability thresholds in the final rule, EPA estimates that no new facilities subject to this final rule will be owned by tribal governments. This rule does not affect tribes in any way in the foreseeable future. Accordingly, the requirements of Executive Order 13175 do not apply to this rule.

I. Executive Order 13158: Marine Protected Areas

Executive Order 13158 (65 FR 34909, May 31, 2000) requires EPA to ''expeditiously propose new science-based regulations, as necessary, to ensure appropriate levels of protection for the marine environment.'' EPA may take action to enhance or expand protection of existing marine protected areas and to establish or recommend, as appropriate, new marine protected areas. The purpose of the Executive Order is to protect the significant natural and cultural resources within the marine environment, which means ''those areas of coastal and ocean waters, the Great Lakes and their connecting waters, and submerged lands thereunder, over which the United States exercises jurisdiction, consistent with international law.''

Today's final rule implements section 316(b) of the Clean Water Act (CWA) for new facilities that use water withdrawn from rivers, streams, lakes, reservoirs, estuaries, oceans or other waters of the United States (U.S.) for cooling water purposes. The final rule establishes national technology-based performance requirements applicable to the location, design, construction, and capacity of cooling water intake structures at new facilities. The national requirements establish the best technology available for minimizing adverse environmental impact associated with the use of these structures. It also requires the permit applicant to select and implement design and construction technologies to minimize impingement mortality and entrainment.

EPA expects that this final regulation will reduce impingement and entrainment at new facilities. The rule will afford protection of aquatic organisms at individual, population, community, or ecosystem levels of ecological structures. Therefore, EPA expects today's rule will advance the objective of the Executive Order to protect marine areas.

J. Executive Order 13211 (Energy Effects)

This rule is not a ''significant energy action'' as defined in Executive Order 13211, ''Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use'' (66 FR 28355; May 22, 2001) because it is not likely to have a significant adverse effect on the supply, distribution, or use of energy.

Track I of the final section 316(b) new facility rule requires facilities with an intake flow equal to or greater than 10 MGD to install a recirculating system or other technologies that would reduce the design intake flow to a level commensurate with that of a recirculating system. For the purposes of this Statement of Energy Effects, EPA believes that facilities that do not already plan to install a recirculating system in the baseline will install a recirculating wet cooling tower to achieve compliance with the rule (9 power plants). Installation of a cooling tower imposes an ''energy penalty,'' consisting of two components: (1) A reduction in unit efficiency due to increased turbine back-pressure; and (2) an increase in auxiliary power requirements to operate the recirculating wet cooling tower. EPA estimates that the installation of 9 recirculating wet cooling towers as a result of this rule (that is, those installed at new power plants that would otherwise not utilize recirculating wet cooling in absence of the rule) would reduce available generating capacity by a maximum of 100 megawatts (MW) nationally. EPA also considered the energy requirements of other compliance technologies, such as rotating screens, but found them insignificant and thus excluded them from this analysis.

EPA estimates that 4 new coal-fired power plants and 5 new combined-cycle power plants will install a recirculating wet cooling tower to comply with the final section 316(b) new facility rule. The estimated generating capacity of the four new coal facilities ranges from 63 MW to 3,564 MW. Each of the five combined-cycle facilities has a generating capacity of 1,031 MW. The estimated mean annual energy penalty is 1.65 percent of the generating capacity for coal-fired facilities and 0.40 percent for combined-cycle facilities. As a result, the installation of recirculating wet cooling towers to comply with the final rule is likely to reduce available energy supply by an average of approximately 74 MW per year over the next 20 years (2001 to 2020). The reduction will reach a maximum of 100 MW in 2017, when all 9 facilities are projected to have begun operation (*see* Section IV.A.1 of this preamble for details on the projected number and cooling water characteristics of new electric generators). These reductions are actually an overestimate due to the fact that some facilities may choose to comply with Track II and implement technologies other than recirculating wet cooling towers.

EPA believes that the estimated reduction in available energy supply as a result of the final section 316(b) rule does not constitute a significant energy effect. During the period covered by EPA's new facility projection, 2001 to 2020, the Energy Information Administration (EIA) forecasts total new capacity additions of 370 gigawatts (GW) (1 GW = 1,000 MW) and an average available generating capability of 921 GW. Compared to the EIA forecasts, the estimated energy effect of the final rule is insignificant, comprising only 0.03 percent of total new capacity (100 MW/370 GW) and 0.008 percent of the average available generating capability (74 MW/921 GW) at new facilities. Chapter 9 of the *Economic Analysis* provides more detail about the estimated energy effect of the final section 316(b) new facility rule. Chapter 3 of the *Technical Development Document* further discusses energy penalty estimation.

K. National Technology Transfer and Advancement Act

As noted in the proposed rule, section 12(d) of the National Technology Transfer and Advancement Act (NTTAA) of 1995, Pub L. 104–113, section 12(d) (15 U.S.C. 272 note) directs EPA to use voluntary consensus standards in its regulatory activities unless to do so would be inconsistent with applicable law or otherwise impractical. Voluntary consensus standards are technical standards (e.g., materials specifications, test methods, sampling procedures, and business practices) that are developed or adopted by voluntary consensus standard bodies. The NTTAA directs EPA to provide Congress, through the Office of Management and Budget (OMB), explanations when the Agency decides not to use available and applicable voluntary consensus standards.

This final rule does not involve technical standards. Therefore, EPA did not consider the use of any voluntary consensus standards.

L. Plain Language Directive

Executive Order 12866 requires each agency to write all rules in plain language. EPA has written this final rule in plain language to make the rule easier to understand. EPA specifically solicited comment on how to make this rule easier to understand. EPA received no comments on the plain language of the proposal or NODA.

M. Congressional Review Act

The Congressional Review Act, 5 U.S.C. 801 *et seq.*, as added by the Small Business Regulatory Enforcement Fairness Act of 1996, generally provides that before a rule may take effect, the agency promulgating the rule must submit a rule report, which includes a copy of the rule, to each House of the Congress and to the Comptroller General of the United States. EPA will submit a report containing this rule and other required information to the U.S. Senate, the U.S. House of Representatives, and the Comptroller General of the United States prior to publication of the rule in the **Federal Register**. A major rule cannot take effect until 60 days after it is published in the **Federal Register**. This action is not considered a ''major rule'' as defined by 5 U.S.C. 804(2). This rule will be effective January 17, 2002.

List of Subjects

40 CFR Part 9

Environmental protection, Reporting and recordkeeping requirements.

40 CFR Part 122

Environmental protection, Administrative practice and procedure, Confidential business information, Hazardous substances, Reporting and recordkeeping requirements, Water pollution control.

40 CFR Part 123

Environmental protection, Administrative practice and procedure, Confidential business information, Hazardous substances, Indian-lands, Intergovernmental relations, Penalties, Reporting and recordkeeping requirements, Water pollution control.

40 CFR Part 124

Environmental protection, Administrative practice and procedure, Air pollution control, Hazardous waste, Indians-lands, Reporting and recordkeeping requirements, Water pollution control, Water supply.

40 CFR Part 125

Environmental protection, Reporting and recordkeeping requirements, Waste treatment and disposal, Water pollution control.

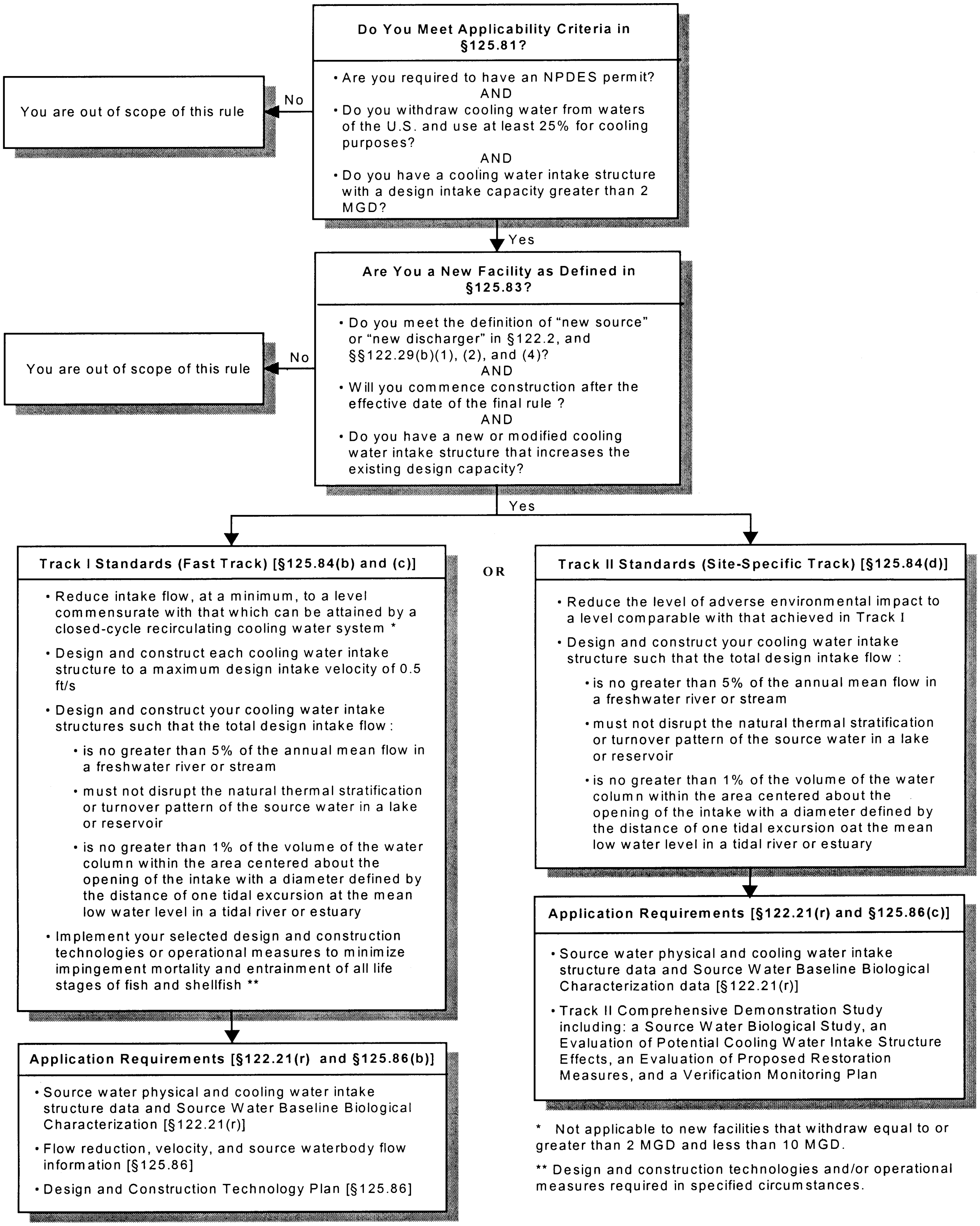
Dated: November 9, 2001.

Christine Todd Whitman,

Administrator.

BILLING CODE 6560–50–P

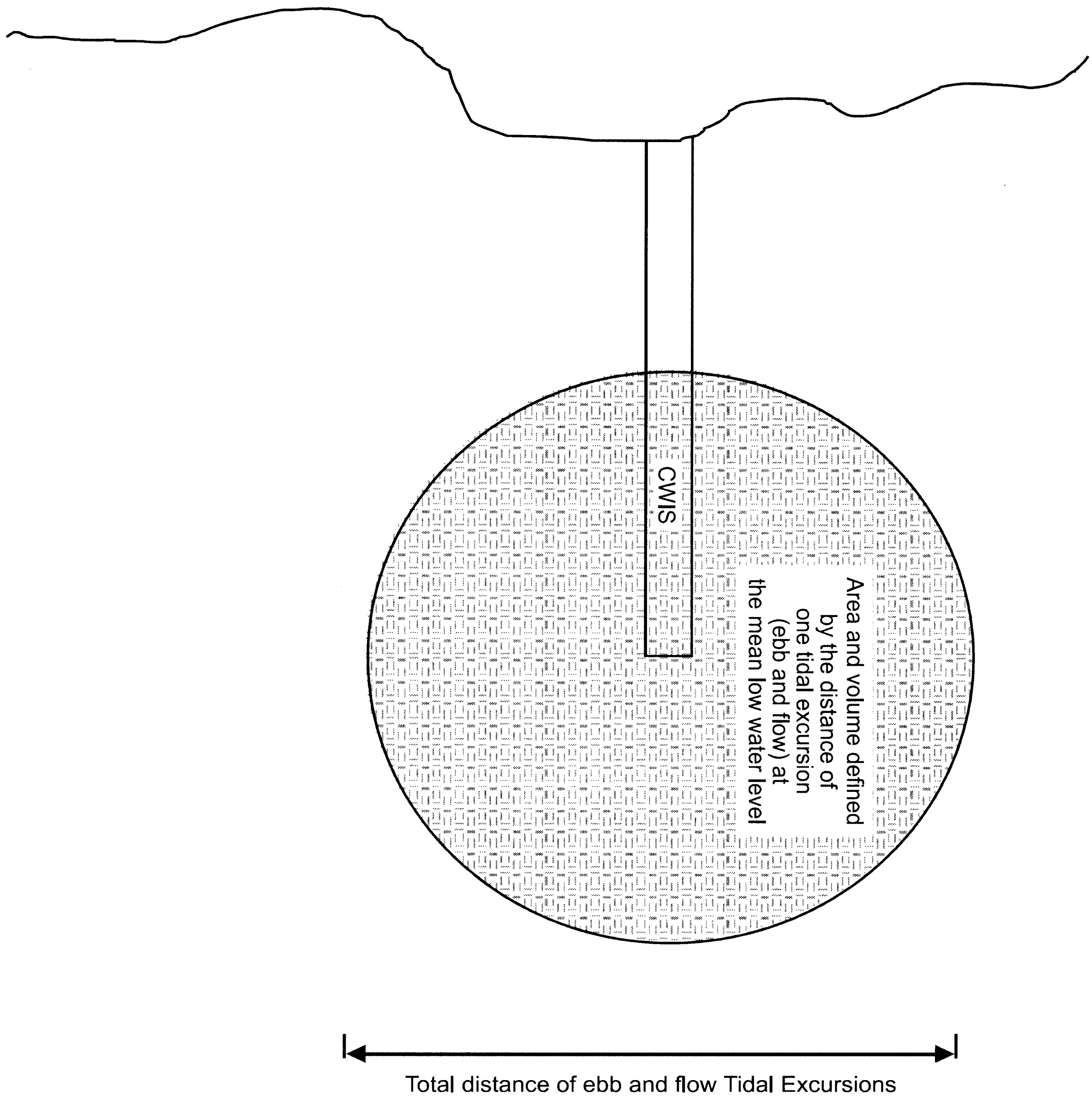
Appendix 1 to The Preamble—Section 316(b) New Facility Rule Framework



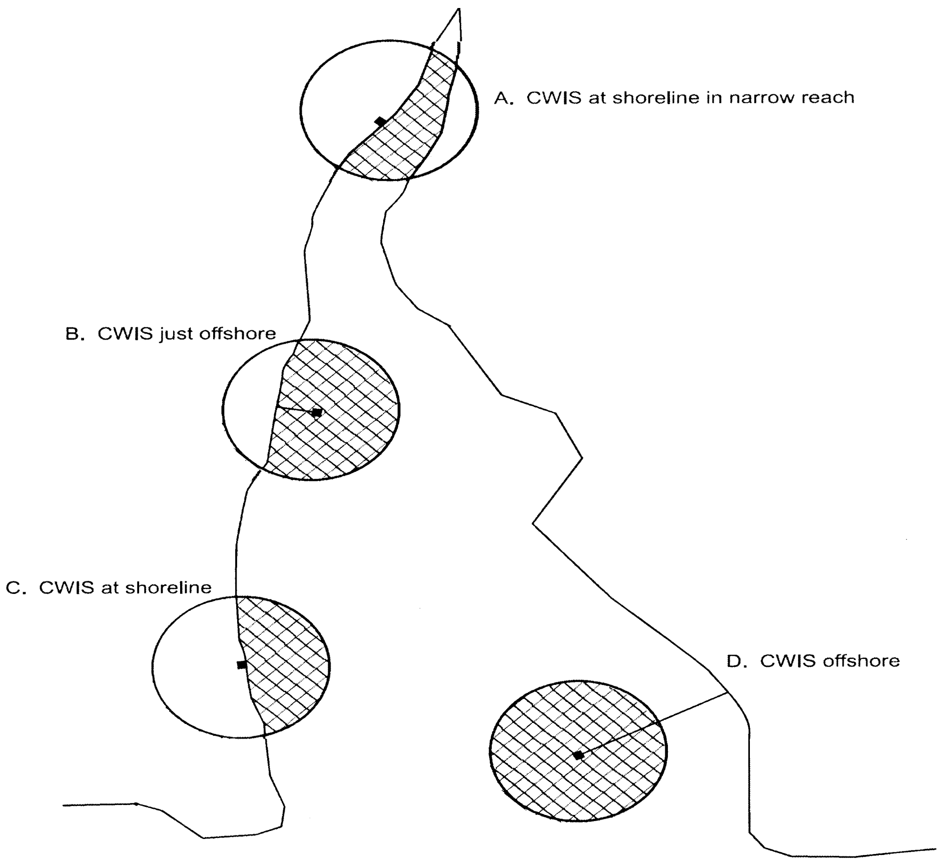
* Not applicable to new facilities that withdraw equal to or greater than 2 MGD and less than 10 MGD.

** Design and construction technologies and/or operational measures required in specified circumstances.

Appendix 2 to The Preamble—Illustration of Flow Requirement for Estuaries and Tidal Rivers



Appendix 3 to The Preamble—Examples of Areas and Volumes Defined in Estuaries or Tidal Rivers By The Tidal Excursion Distance



CWIS = Cooling Water Intake Structure

BILLING CODE 6560–50–C

For the reasons set forth in the preamble, chapter I of title 40 of the Code of Federal Regulations is amended as follows:

PART 9—OMB APPROVALS UNDER THE PAPERWORK REDUCTION ACT

1. The authority citation for part 9 continues to read as follows:

Authority: 7 U.S.C. 135 *et seq.*, 136–136y; 15 U.S.C. 2001, 2003, 2005, 2006, 2601–2671, 21 U.S.C. 331j, 346a, 348; 31 U.S.C. 9701; 33 U.S.C. 1251 *et seq.*, 1311, 1313d, 1314, 1318, 1321, 1326, 1330, 1342, 1344, 1345 (d) and (e), 1361; E.O. 11735, 38 FR 21243, 3 CFR, 1971–1975 Comp. p. 973; 42 U.S.C. 241, 242b, 243, 246, 300f, 300g, 300g–1, 300g–2, 300g–3, 300g–4, 300g–5, 300g–6, 300j–1, 300j–2, 300j–3, 300j–4, 300j–9, 1857 *et seq.*, 6901–6992k, 7401–7671q, 7542, 9601–9657, 11023, 11048.

2. In § 9.1 the table is amended by adding entries in numerical order under the indicated heading to read as follows:

§ 9.1 OMB approvals under the Paperwork Reduction Act.

* * * * *

40 CFR citation	OMB Control No.
* * * * *	
EPA Administered Permit Programs: The National Pollutant Discharge Elimination System	
* * * * *	
122.21(r)	2040–0241
* * * * *	
Criteria and Standards for the National Pollutant Discharge Elimination System	
* * * * *	
125.86	2040–0241
125.87	2040–0241
125.88	2040–0241
125.89	2040–0241
* * * * *	

PART 122—EPA ADMINISTERED PERMIT PROGRAMS: THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

1. The authority citation for part 122 continues to read as follows:

Authority: The Clean Water Act, 33 U.S.C. 1251 *et seq.*

2. Section 122.21 is amended by adding a new paragraph (r) to read as follows:

§ 122.21 Application for a permit (applicable to State programs, see § 123.25)

* * * * *

(r) *Applications for facilities with cooling water intake structures*—(1) *New facilities with new or modified cooling water intake structures.* New facilities with cooling water intake structures as defined in part 125, subpart I, of this chapter must report the information required under paragraphs (r)(2), (3), and (4) of this section and § 125.86 of this chapter. Requests for alternative requirements under § 125.85 of this chapter must be submitted with your permit application.

(2) *Source water physical data.* These include:

(i) A narrative description and scaled drawings showing the physical configuration of all source water bodies used by your facility, including areal dimensions, depths, salinity and temperature regimes, and other documentation that supports your determination of the water body type where each cooling water intake structure is located;

(ii) Identification and characterization of the source waterbody's hydrological and geomorphological features, as well as the methods you used to conduct any physical studies to determine your intake's area of influence within the waterbody and the results of such studies; and

(iii) Locational maps.

(3) *Cooling water intake structure data.* These include:

(i) A narrative description of the configuration of each of your cooling water intake structures and where it is located in the water body and in the water column;

(ii) Latitude and longitude in degrees, minutes, and seconds for each of your cooling water intake structures;

(iii) A narrative description of the operation of each of your cooling water intake structures, including design intake flows, daily hours of operation, number of days of the year in operation and seasonal changes, if applicable;

(iv) A flow distribution and water balance diagram that includes all sources of water to the facility, recirculating flows, and discharges; and

(v) Engineering drawings of the cooling water intake structure.

(4) *Source water baseline biological characterization data.* This information is required to characterize the biological community in the vicinity of the cooling water intake structure and to characterize the operation of the cooling water intake structures. The Director may also use this information in subsequent permit renewal proceedings to determine if your Design and Construction Technology Plan as required in § 125.86(b)(4) of this chapter should be revised. This supporting information must include existing data (if they are available). However, you may supplement the data using newly conducted field studies if you choose to do so. The information you submit must include:

(i) A list of the data in paragraphs (r)(4)(ii) through (vi) of this section that are not available and efforts made to identify sources of the data;

(ii) A list of species (or relevant taxa) for all life stages and their relative abundance in the vicinity of the cooling water intake structure;

(iii) Identification of the species and life stages that would be most susceptible to impingement and entrainment. Species evaluated should include the forage base as well as those most important in terms of significance to commercial and recreational fisheries;

(iv) Identification and evaluation of the primary period of reproduction, larval recruitment, and period of peak abundance for relevant taxa;

(v) Data representative of the seasonal and daily activities (e.g., feeding and water column migration) of biological organisms in the vicinity of the cooling water intake structure;

(vi) Identification of all threatened, endangered, and other protected species that might be susceptible to impingement and entrainment at your cooling water intake structures;

(vii) Documentation of any public participation or consultation with Federal or State agencies undertaken in development of the plan; and

(viii) If you supplement the information requested in paragraph (r)(4)(i) of this section with data collected using field studies, supporting documentation for the Source Water Baseline Biological Characterization must include a description of all methods and quality assurance procedures for sampling, and data analysis including a description of the study area; taxonomic identification of sampled and evaluated biological assemblages (including all life stages of fish and shellfish); and sampling and data analysis methods. The sampling and/or data analysis methods you use must be appropriate for a quantitative survey and based on consideration of methods used in other biological studies performed within the same source water body. The study area should include, at a minimum, the area of influence of the cooling water intake structure.

3. Section 122.44 is amended by adding paragraph (b)(3) to read as follows:

§ 122.44 Establishing limitations, standards, and other permit conditions (applicable to State NPDES programs, see § 123.25).

* * * * *

(b) * * *

(3) Requirements applicable to cooling water intake structures at new facilities under section 316(b) of the CWA, in accordance with part 125, subpart I, of this chapter.

* * * * *

PART 123—STATE PROGRAM REQUIREMENTS

1. The authority citation for part 123 continues to read as follows:

Authority: The Clean Water Act, 33 U.S.C. 1251 *et seq.*

2. Section 123.25 is amended by revising paragraph (a)(36) to read as follows:

§ 123.25 Requirements for permitting.

(a) * * *

(36) Subparts A, B, D, H, and I of part 125 of this chapter;

* * * * *

PART 124—PROCEDURES FOR DECISIONMAKING

1. The authority citation for part 124 continues to read as follows:

Authority: Resource Conservation and Recovery Act, 42 U.S.C. 6901 *et seq.;* Safe Drinking Water Act, 42 U.S.C. 300f *et seq.;* Clean Water Act, 33 U.S.C. 1251 *et seq.;* Clean Air Act, 42 U.S.C. 7401 *et seq.*

2. Section 124.10 is amended by redesignating paragraph (d)(1)(ix) as paragraph (d)(1)(x) and adding a new paragraph (d)(1)(ix) to read as follows:

§ 124.10 Public notice of permit actions and public comment period.

* * * * *

(d) * * *

(1) * * *

(ix) Requirements applicable to cooling water intake structures at new facilities under section 316(b) of the CWA, in accordance with part 125, subpart I, of this chapter.

* * * * *

PART 125—CRITERIA AND STANDARDS FOR THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

1. The authority citation for part 125 continues to read as follows:

Authority: The Clean Water Act, 33 U.S.C. 1251 *et seq.*, unless otherwise noted.

2. Remove the existing heading for subpart I and add new subpart I to part 125 to read as follows:

Subpart I—Requirements Applicable to Cooling Water Intake Structures for New Facilities Under Section 316(b) of the Act

Sec.

Subpart I—Requirements Applicable to Cooling Water Intake Structures for New Facilities Under Section 316(b) of the Act

§ 125.80 What are the purpose and scope of this subpart?

(a) This subpart establishes requirements that apply to the location, design, construction, and capacity of cooling water intake structures at new facilities. The purpose of these requirements is to establish the best technology available for minimizing adverse environmental impact associated with the use of cooling water intake structures. These requirements are implemented through National Pollutant Discharge Elimination System (NPDES) permits issued under section 402 of the Clean Water Act (CWA).

(b) This subpart implements section 316(b) of the CWA for new facilities. Section 316(b) of the CWA provides that any standard established pursuant to sections 301 or 306 of the CWA and applicable to a point source shall require that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact.

(c) New facilities that do not meet the threshold requirements regarding amount of water withdrawn or percentage of water withdrawn for cooling water purposes in § 125.81(a) must meet requirements determined on a case-by-case, best professional judgement (BPJ) basis.

(d) Nothing in this subpart shall be construed to preclude or deny the right of any State or political subdivision of a State or any interstate agency under section 510 of the CWA to adopt or enforce any requirement with respect to control or abatement of pollution that is more stringent than those required by Federal law.

§ 125.81 Who is subject to this subpart?

(a) This subpart applies to a new facility if it:

(1) Is a point source that uses or proposes to use a cooling water intake structure;

(2) Has at least one cooling water intake structure that uses at least 25 percent of the water it withdraws for cooling purposes as specified in paragraph (c) of this section; and

(3) Has a design intake flow greater than two (2) million gallons per day (MGD).

(b) Use of a cooling water intake structure includes obtaining cooling water by any sort of contract or arrangement with an independent supplier (or multiple suppliers) of cooling water if the supplier or suppliers withdraw(s) water from waters of the United States. Use of cooling water does not include obtaining cooling water from a public water system or the use of treated effluent that otherwise would be discharged to a water of the U.S. This provision is intended to prevent circumvention of these requirements by creating arrangements to receive cooling water from an entity that is not itself a point source.

(c) The threshold requirement that at least 25 percent of water withdrawn be used for cooling purposes must be measured on an average monthly basis. A new facility meets the 25 percent cooling water threshold if, based on the new facility's design, any monthly average over a year for the percentage of cooling water withdrawn is expected to equal or exceed 25 percent of the total water withdrawn.

(d) This subpart does not apply to facilities that employ cooling water intake structures in the offshore and coastal subcategories of the oil and gas extraction point source category as defined under 40 CFR 435.10 and 40 CFR 435.40.

§ 125.82 When must I comply with this subpart?

You must comply with this subpart when an NPDES permit containing requirements consistent with this subpart is issued to you.

§ 125.83 What special definitions apply to this subpart?

The following special definitions apply to this subpart:

Annual mean flow means the average of daily flows over a calendar year.

Historical data (up to 10 years) must be used where available.

Closed-cycle recirculating system means a system designed, using minimized makeup and blowdown flows, to withdraw water from a natural or other water source to support contact and/or noncontact cooling uses within a facility. The water is usually sent to a cooling canal or channel, lake, pond, or tower to allow waste heat to be dissipated to the atmosphere and then is returned to the system. (Some facilities divert the waste heat to other process operations.) New source water (make-up water) is added to the system to replenish losses that have occurred due to blowdown, drift, and evaporation.

Cooling water means water used for contact or noncontact cooling, including water used for equipment cooling, evaporative cooling tower makeup, and dilution of effluent heat content. The intended use of the cooling water is to absorb waste heat rejected from the process or processes used, or from auxiliary operations on the facility's premises. Cooling water that is used in a manufacturing process either before or after it is used for cooling is considered process water for the purposes of calculating the percentage of a new facility's intake flow that is used for cooling purposes in § 125.81(c).

Cooling water intake structure means the total physical structure and any associated constructed waterways used to withdraw cooling water from waters of the U.S. The cooling water intake structure extends from the point at which water is withdrawn from the surface water source up to, and including, the intake pumps.

Design intake flow means the value assigned (during the facility's design) to the total volume of water withdrawn from a source water body over a specific time period.

Design intake velocity means the value assigned (during the design of a cooling water intake structure) to the average speed at which intake water passes through the open area of the intake screen (or other device) against which organisms might be impinged or through which they might be entrained.

Entrainment means the incorporation of all life stages of fish and shellfish with intake water flow entering and passing through a cooling water intake structure and into a cooling water system.

Estuary means a semi-enclosed body of water that has a free connection with open seas and within which the seawater is measurably diluted with fresh water derived from land drainage. The salinity of an estuary exceeds 0.5 parts per thousand (by mass) but is typically less than 30 parts per thousand (by mass).

Existing facility means any facility that is not a new facility.

Freshwater river or stream means a lotic (free-flowing) system that does not receive significant inflows of water from oceans or bays due to tidal action. For the purposes of this rule, a flow-through reservoir with a retention time of 7 days or less will be considered a freshwater river or stream.

Hydraulic zone of influence means that portion of the source waterbody hydraulically affected by the cooling water intake structure withdrawal of water.

Impingement means the entrapment of all life stages of fish and shellfish on the outer part of an intake structure or against a screening device during periods of intake water withdrawal.

Lake or *reservoir* means any inland body of open water with some minimum surface area free of rooted vegetation and with an average hydraulic retention time of more than 7 days. Lakes or reservoirs might be natural water bodies or impounded streams, usually fresh, surrounded by land or by land and a man-made retainer (e.g., a dam). Lakes or reservoirs might be fed by rivers, streams, springs, and/or local precipitation. Flow-through reservoirs with an average hydraulic retention time of 7 days or less should be considered a freshwater river or stream.

Maximize means to increase to the greatest amount, extent, or degree reasonably possible.

Minimum ambient source water surface elevation means the elevation of the 7Q10 flow for freshwater streams or rivers; the conservation pool level for lakes or reservoirs; or the mean low tidal water level for estuaries or oceans. The 7Q10 flow is the lowest average 7 consecutive day low flow with an average frequency of one in 10 years determined hydrologically. The conservation pool is the minimum depth of water needed in a reservoir to ensure proper performance of the system relying upon the reservoir. The mean low tidal water level is the average height of the low water over at least 19 years.

Minimize means to reduce to the smallest amount, extent, or degree reasonably possible.

Natural thermal stratification means the naturally-occurring division of a waterbody into horizontal layers of differing densities as a result of variations in temperature at different depths.

New facility means any building, structure, facility, or installation that meets the definition of a ''new source'' or ''new discharger'' in 40 CFR 122.2 and 122.29(b)(1), (2), and (4) and is a greenfield or stand-alone facility; commences construction after January 17, 2002; and uses either a newly constructed cooling water intake structure, or an existing cooling water intake structure whose design capacity is increased to accommodate the intake of additional cooling water. New facilities include only ''greenfield'' and ''stand-alone'' facilities. A greenfield facility is a facility that is constructed at a site at which no other source is located, or that totally replaces the process or production equipment at an existing facility (*see* 40 CFR 122.29(b)(1)(i) and (ii)). A stand-alone facility is a new, separate facility that is constructed on property where an existing facility is located and whose processes are substantially independent of the existing facility at the same site (*see* 40 CFR 122.29(b)(1)(iii)). New facility does not include new units that are added to a facility for purposes of the same general industrial operation (for example, a new peaking unit at an electrical generating station).

(1) Examples of ''new facilities'' include, but are not limited to: the following scenarios:

(i) A new facility is constructed on a site that has never been used for industrial or commercial activity. It has a new cooling water intake structure for its own use.

(ii) A facility is demolished and another facility is constructed in its place. The newly-constructed facility uses the original facility's cooling water intake structure, but modifies it to increase the design capacity to accommodate the intake of additional cooling water.

(iii) A facility is constructed on the same property as an existing facility, but is a separate and independent industrial operation. The cooling water intake structure used by the original facility is modified by constructing a new intake bay for the use of the newly constructed facility or is otherwise modified to increase the intake capacity for the new facility.

(2) Examples of facilities that would not be considered a ''new facility'' include, but are not limited to, the following scenarios:

(i) A facility in commercial or industrial operation is modified and either continues to use its original cooling water intake structure or uses a new or modified cooling water intake structure.

(ii) A facility has an existing intake structure. Another facility (a separate and independent industrial operation), is constructed on the same property and connects to the facility's cooling water intake structure behind the intake pumps, and the design capacity of the cooling water intake structure has not been increased. This facility would not be considered a ''new facility'' even if routine maintenance or repairs that do not increase the design capacity were performed on the intake structure.

Ocean means marine open coastal waters with a salinity greater than or equal to 30 parts per thousand (by mass).

*Source wate*r means the water body (waters of the U.S.) from which the cooling water is withdrawn.

Thermocline means the middle layer of a thermally stratified lake or reservoir. In this layer, there is a rapid decrease in temperatures.

Tidal excursion means the horizontal distance along the estuary or tidal river that a particle moves during one tidal cycle of ebb and flow.

Tidal river means the most seaward reach of a river or stream where the salinity is typically less than or equal to 0.5 parts per thousand (by mass) at a time of annual low flow and whose surface elevation responds to the effects of coastal lunar tides.

§ 125.84 As an owner or operator of a new facility, what must I do to comply with this subpart?

(a)(1) The owner or operator of a new facility must comply with either:

(i) Track I in paragraph (b) or (c) of this section; or

(ii) Track II in paragraph (d) of this section.

(2) In addition to meeting the requirements in paragraph (b), (c), or (d) of this section, the owner or operator of a new facility may be required to comply with paragraph (e) of this section.

(b) *Track I requirements for new facilities that withdraw equal to or greater than 10 MGD.* You must comply with all of the following requirements:

(1) You must reduce your intake flow, at a minimum, to a level commensurate with that which can be attained by a closed-cycle recirculating cooling water system;

(2) You must design and construct each cooling water intake structure at your facility to a maximum through-screen design intake velocity of 0.5 ft/s;

(3) You must design and construct your cooling water intake structure such that the total design intake flow from all cooling water intake structures at your facility meets the following requirements:

(i) For cooling water intake structures located in a freshwater river or stream, the total design intake flow must be no greater than five (5) percent of the source water annual mean flow;

(ii) For cooling water intake structures located in a lake or reservoir, the total design intake flow must not disrupt the natural thermal stratification or turnover pattern (where present) of the source water except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies);

(iii) For cooling water intake structures located in an estuary or tidal river, the total design intake flow over one tidal cycle of ebb and flow must be no greater than one (1) percent of the volume of the water column within the area centered about the opening of the intake with a diameter defined by the distance of one tidal excursion at the mean low water level;

(4) You must select and implement design and construction technologies or operational measures for minimizing impingement mortality of fish and shellfish if:

(i) There are threatened or endangered or otherwise protected federal, state, or tribal species, or critical habitat for these species, within the hydraulic zone of influence of the cooling water intake structure; or

(ii) There are migratory and/or sport or commercial species of impingement concern to the Director or any fishery management agency(ies), which pass through the hydraulic zone of influence of the cooling water intake structure; or

(iii) It is determined by the Director or any fishery management agency(ies) that the proposed facility, after meeting the technology-based performance requirements in paragraphs (b)(1), (2), and (3) of this section, would still contribute unacceptable stress to the protected species, critical habitat of those species, or species of concern;

(5) You must select and implement design and construction technologies or operational measures for minimizing entrainment of entrainable life stages of fish and shellfish if:

(i) There are threatened or endangered or otherwise protected federal, state, or tribal species, or critical habitat for these species, within the hydraulic zone of influence of the cooling water intake structure; or

(ii) There are or would be undesirable cumulative stressors affecting entrainable life stages of species of concern to the Director or any fishery management agency(ies), and it is determined by the Director or any fishery management agency(ies) that the proposed facility, after meeting the technology-based performance requirements in paragraphs (b)(1), (2), and (3) of this section, would contribute unacceptable stress to these species of concern;

(6) You must submit the application information required in 40 CFR 122.21(r) and § 125.86(b);

(7) You must implement the monitoring requirements specified in § 125.87;

(8) You must implement the record-keeping requirements specified in § 125.88.

(c) *Track I requirements for new facilities that withdraw equal to or greater than 2 MGD and less than 10 MGD and that choose not to comply with paragraph (b) of this section.* You must comply with all the following requirements:

(1) You must design and construct each cooling water intake structure at your facility to a maximum through-screen design intake velocity of 0.5 ft/s;

(2) You must design and construct your cooling water intake structure such that the total design intake flow from all cooling water intake structures at your facility meets the following requirements:

(i) For cooling water intake structures located in a freshwater river or stream, the total design intake flow must be no greater than five (5) percent of the source water annual mean flow;

(ii) For cooling water intake structures located in a lake or reservoir, the total design intake flow must not disrupt the natural thermal stratification or turnover pattern (where present) of the source water except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies);

(iii) For cooling water intake structures located in an estuary or tidal river, the total design intake flow over one tidal cycle of ebb and flow must be no greater than one (1) percent of the volume of the water column within the area centered about the opening of the intake with a diameter defined by the distance of one tidal excursion at the mean low water level;

(3) You must select and implement design and construction technologies or operational measures for minimizing impingement mortality of fish and shellfish if:

(i) There are threatened or endangered or otherwise protected federal, state, or tribal species, or critical habitat for these species, within the hydraulic zone of influence of the cooling water intake structure; or

(ii) There are migratory and/or sport or commercial species of impingement concern to the Director or any fishery management agency(ies), which pass through the hydraulic zone of influence of the cooling water intake structure; or

(iii) It is determined by the Director or any fishery management agency(ies) that the proposed facility, after meeting the technology-based performance requirements in paragraphs (c)(1) and (2) of this section, would still contribute unacceptable stress to the protected species, critical habitat of those species, or species of concern;

(4) You must select and implement design and construction technologies or operational measures for minimizing entrainment of entrainable life stages of fish and shellfish;

(5) You must submit the application information required in 40 CFR 122.21(r) and § 125.86(b)(2), (3), and (4);

(6) You must implement the monitoring requirements specified in § 125.87;

(7) You must implement the recordkeeping requirements specified in § 125.88.

(d) *Track II.* The owner or operator of a new facility that chooses to comply under Track II must comply with the following requirements:

(1) You must demonstrate to the Director that the technologies employed will reduce the level of adverse environmental impact from your cooling water intake structures to a comparable level to that which you would achieve were you to implement the requirements of paragraphs (b)(1) and (2) of this section.

(i) Except as specified in paragraph (d)(1)(ii) of this section, this demonstration must include a showing that the impacts to fish and shellfish, including important forage and predator species, within the watershed will be comparable to those which would result if you were to implement the requirements of paragraphs (b)(1) and (2) of this section. This showing may include consideration of impacts other than impingement mortality and entrainment, including measures that will result in increases in fish and shellfish, but it must demonstrate comparable performance for species that the Director, in consultation with national, state or tribal fishery management agencies with responsibility for fisheries potentially affected by your cooling water intake structure, identifies as species of concern.

(ii) In cases where air emissions and/or energy impacts that would result from meeting the requirements of paragraphs (b)(1) and (2) of this section would result in significant adverse impacts on local air quality, significant adverse impact on local water resources not addressed under paragraph (d)(1)(i) of this section, or significant adverse impact on local energy markets, you may request alternative requirements under § 125.85.

(2) You must design and construct your cooling water intake structure such that the total design intake flow from all cooling water intake structures at your facility meet the following requirements:

(i) For cooling water intake structures located in a freshwater river or stream, the total design intake flow must be no greater than five (5) percent of the source water annual mean flow;

(ii) For cooling water intake structures located in a lake or reservoir, the total design intake flow must not disrupt the natural thermal stratification or turnover pattern (where present) of the source water except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies);

(iii) For cooling water intake structures located in an estuary or tidal river, the total design intake flow over one tidal cycle of ebb and flow must be no greater than one (1) percent of the volume of the water column within the area centered about the opening of the intake with a diameter defined by the distance of one tidal excursion at the mean low water level.

(3) You must submit the application information required in 40 CFR 122.21(r) and § 125.86(c).

(4) You must implement the monitoring requirements specified in § 125.87.

(5) You must implement the recordkeeping requirements specified in § 125.88.

(e) You must comply with any more stringent requirements relating to the location, design, construction, and capacity of a cooling water intake structure or monitoring requirements at a new facility that the Director deems are reasonably necessary to comply with any provision of state law, including compliance with applicable state water quality standards (including designated uses, criteria, and antidegradation requirements).

§ 125.85 May alternative requirements be authorized?

(a) Any interested person may request that alternative requirements less stringent than those specified in § 125.84(a) through (e) be imposed in the permit. The Director may establish alternative requirements less stringent than the requirements of § 125.84(a) through (e) only if:

(1) There is an applicable requirement under § 125.84(a) through (e);

(2) The Director determines that data specific to the facility indicate that compliance with the requirement at issue would result in compliance costs wholly out of proportion to those EPA considered in establishing the requirement at issue or would result in significant adverse impacts on local air quality, significant adverse impacts on local water resources not addressed under § 125.84(d)(1)(i), or significant adverse impacts on local energy markets;

(3) The alternative requirement requested is no less stringent than justified by the wholly out of proportion cost or the significant adverse impacts on local air quality, significant adverse impacts on local water resources not addressed under § 125.84(d)(1)(i), or significant adverse impacts on local energy markets; and

(4) The alternative requirement will ensure compliance with other applicable provisions of the Clean Water Act and any applicable requirement of state law.

(b) The burden is on the person requesting the alternative requirement to demonstrate that alternative requirements should be authorized.

§ 125.86 As an owner or operator of a new facility, what must I collect and submit when I apply for my new or reissued NPDES permit?

(a)(1) As an owner or operator of a new facility, you must submit to the Director a statement that you intend to comply with either:

(i) The Track I requirements for new facilities that withdraw equal to or greater than 10 MGD in § 125.84(b);

(ii) The Track I requirements for new facilities that withdraw equal to or greater than 2 MGD and less than 10 MGD in § 125.84(c);

(iii) The requirements for Track II in § 125.84 (d).

(2) You must also submit the application information required by 40 CFR 122.21(r) and the information required in either paragraph (b) of this section for Track I or paragraph (c) of this section for Track II when you apply for a new or reissued NPDES permit in accordance with 40 CFR 122.21.

(b) *Track I application requirements.* To demonstrate compliance with Track I requirements in § 125.84(b) or (c), you must collect and submit to the Director the information in paragraphs (b)(1) through (4) of this section.

(1) *Flow reduction information.* If you must comply with the flow reduction requirements in § 125.84(b)(1), you must submit the following information to the

Director to demonstrate that you have reduced your flow to a level commensurate with that which can be attained by a closed-cycle recirculating cooling water system:

(i) A narrative description of your system that has been designed to reduce your intake flow to a level commensurate with that which can be attained by a closed-cycle recirculating cooling water system and any engineering calculations, including documentation demonstrating that your make-up and blowdown flows have been minimized; and

(ii) If the flow reduction requirement is met entirely, or in part, by reusing or recycling water withdrawn for cooling purposes in subsequent industrial processes, you must provide documentation that the amount of cooling water that is not reused or recycled has been minimized.

(2) *Velocity information.* You must submit the following information to the Director to demonstrate that you are complying with the requirement to meet a maximum through-screen design intake velocity of no more than 0.5 ft/s at each cooling water intake structure as required in § 125.84(b)(2) and (c)(1):

(i) A narrative description of the design, structure, equipment, and operation used to meet the velocity requirement; and

(ii) Design calculations showing that the velocity requirement will be met at minimum ambient source water surface elevations (based on best professional judgement using available hydrological data) and maximum head loss across the screens or other device.

(3) *Source waterbody flow information.* You must submit to the Director the following information to demonstrate that your cooling water intake structure meets the flow requirements in § 125.84(b)(3) and (c)(2):

(i) If your cooling water intake structure is located in a freshwater river or stream, you must provide the annual mean flow and any supporting documentation and engineering calculations to show that your cooling water intake structure meets the flow requirements;

(ii) If your cooling water intake structure is located in an estuary or tidal river, you must provide the mean low water tidal excursion distance and any supporting documentation and engineering calculations to show that your cooling water intake structure facility meets the flow requirements; and

(iii) If your cooling water intake structure is located in a lake or reservoir, you must provide a narrative description of the water body thermal stratification, and any supporting documentation and engineering calculations to show that the natural thermal stratification and turnover pattern will not be disrupted by the total design intake flow. In cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish you must provide supporting documentation and include a written concurrence from any fisheries management agency(ies) with responsibility for fisheries potentially affected by your cooling water intake structure(s).

(4) *Design and Construction Technology Plan.* To comply with § 125.84(b)(4) and (5), or (c)(3) and (c)(4), you must submit to the Director the following information in a Design and Construction Technology Plan:

(i) Information to demonstrate whether or not you meet the criteria in § 125.84(b)(4) and (b)(5), or (c)(3) and (c)(4);

(ii) Delineation of the hydraulic zone of influence for your cooling water intake structure;

(iii) New facilities required to install design and construction technologies and/or operational measures must develop a plan explaining the technologies and measures you have selected based on information collected for the Source Water Biological Baseline Characterization required by 40 CFR 122.21(r)(3). (Examples of appropriate technologies include, but are not limited to, wedgewire screens, fine mesh screens, fish handling and return systems, barrier nets, aquatic filter barrier systems, etc. Examples of appropriate operational measures include, but are not limited to, seasonal shutdowns or reductions in flow, continuous operations of screens, etc.) The plan must contain the following information:

(A) A narrative description of the design and operation of the design and construction technologies, including fish-handling and return systems, that you will use to maximize the survival of those species expected to be most susceptible to impingement. Provide species-specific information that demonstrates the efficacy of the technology;

(B) A narrative description of the design and operation of the design and construction technologies that you will use to minimize entrainment of those species expected to be the most susceptible to entrainment. Provide species-specific information that demonstrates the efficacy of the technology; and

(C) Design calculations, drawings, and estimates to support the descriptions provided in paragraphs (b)(4)(iii)(A) and (B) of this section.

(c) *Application requirements for Track II.* If you have chosen to comply with the requirements of Track II in § 125.84(d) you must collect and submit the following information:

(1) *Source waterbody flow information.* You must submit to the Director the following information to demonstrate that your cooling water intake structure meets the source water body requirements in § 125.84(d)(2):

(i) If your cooling water intake structure is located in a freshwater river or stream, you must provide the annual mean flow and any supporting documentation and engineering calculations to show that your cooling water intake structure meets the flow requirements;

(ii) If your cooling water intake structure is located in an estuary or tidal river, you must provide the mean low water tidal excursion distance and any supporting documentation and engineering calculations to show that your cooling water intake structure facility meets the flow requirements; and

(iii) If your cooling water intake structure is located in a lake or reservoir, you must provide a narrative description of the water body thermal stratification, and any supporting documentation and engineering calculations to show that the natural thermal stratification and thermal or turnover pattern will not be disrupted by the total design intake flow. In cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish you must provide supporting documentation and include a written concurrence from any fisheries management agency(ies) with responsibility for fisheries potentially affected by your cooling water intake structure(s).

(2) *Track II Comprehensive Demonstration Study.* You must perform and submit the results of a Comprehensive Demonstration Study (Study). This information is required to characterize the source water baseline in the vicinity of the cooling water intake structure(s), characterize operation of the cooling water intake(s), and to confirm that the technology(ies) proposed and/or implemented at your cooling water intake structure reduce the impacts to fish and shellfish to levels comparable to those you would achieve were you to implement the requirements in § 125.84(b)(1)and (2) of Track I. To meet the ‘‘comparable level’’

requirement, you must demonstrate that:

(i) You have reduced both impingement mortality and entrainment of all life stages of fish and shellfish to 90 percent or greater of the reduction that would be achieved through § 125.84(b)(1) and (2); or

(ii) If your demonstration includes consideration of impacts other than impingement mortality and entrainment, that the measures taken will maintain the fish and shellfish in the waterbody at a substantially similar level to that which would be achieved through § 125.84(b)(1) and (2); and

(iii) You must develop and submit a plan to the Director containing a proposal for how information will be collected to support the study. The plan must include:

(A) A description of the proposed and/or implemented technology(ies) to be evaluated in the Study;

(B) A list and description of any historical studies characterizing the physical and biological conditions in the vicinity of the proposed or actual intakes and their relevancy to the proposed Study. If you propose to rely on existing source water body data, it must be no more than 5 years old, you must demonstrate that the existing data are sufficient to develop a scientifically valid estimate of potential impingement and entrainment impacts, and provide documentation showing that the data were collected using appropriate quality assurance/quality control procedures;

(C) Any public participation or consultation with Federal or State agencies undertaken in developing the plan; and

(D) A sampling plan for data that will be collected using actual field studies in the source water body. The sampling plan must document all methods and quality assurance procedures for sampling, and data analysis. The sampling and data analysis methods you propose must be appropriate for a quantitative survey and based on consideration of methods used in other studies performed in the source water body. The sampling plan must include a description of the study area (including the area of influence of the cooling water intake structure and at least 100 meters beyond); taxonomic identification of the sampled or evaluated biological assemblages (including all life stages of fish and shellfish); and sampling and data analysis methods; and

(iv) You must submit documentation of the results of the Study to the Director. Documentation of the results of the Study must include:

(A) *Source Water Biological Study.* The Source Water Biological Study must include:

(*1*) A taxonomic identification and characterization of aquatic biological resources including: a summary of historical and contemporary aquatic biological resources; determination and description of the target populations of concern (those species of fish and shellfish and all life stages that are most susceptible to impingement and entrainment); and a description of the abundance and temporal/spatial characterization of the target populations based on the collection of multiple years of data to capture the seasonal and daily activities (e.g., spawning, feeding and water column migration) of all life stages of fish and shellfish found in the vicinity of the cooling water intake structure;

(*2*) An identification of all threatened or endangered species that might be susceptible to impingement and entrainment by the proposed cooling water intake structure(s); and

(*3*) A description of additional chemical, water quality, and other anthropogenic stresses on the source waterbody.

(B) *Evaluation of potential cooling water intake structure effects.* This evaluation will include:

(*1*) Calculations of the reduction in impingement mortality and entrainment of all life stages of fish and shellfish that would need to be achieved by the technologies you have selected to implement to meet requirements under Track II. To do this, you must determine the reduction in impingement mortality and entrainment that would be achieved by implementing the requirements of § 125.84(b)(1) and (2) of Track I at your site.

(*2*) An engineering estimate of efficacy for the proposed and/or implemented technologies used to minimize impingement mortality and entrainment of all life stages of fish and shellfish and maximize survival of impinged life stages of fish and shellfish. You must demonstrate that the technologies reduce impingement mortality and entrainment of all life stages of fish and shellfish to a comparable level to that which you would achieve were you to implement the requirements in § 125.84(b)(1) and (2) of Track I. The efficacy projection must include a site-specific evaluation of technology(ies) suitability for reducing impingement mortality and entrainment based on the results of the Source Water Biological Study in paragraph (c)(2)(iv)(A) of this section. Efficacy estimates may be determined based on case studies that have been conducted in the vicinity of the cooling water intake structure and/ or site-specific technology prototype studies.

(C) *Evaluation of proposed restoration measures.* If you propose to use restoration measures to maintain the fish and shellfish as allowed in § 125.84(d)(1)(i), you must provide the following information to the Director:

(*1*) Information and data to show that you have coordinated with the appropriate fishery management agency(ies); and

(*2*) A plan that provides a list of the measures you plan to implement and how you will demonstrate and continue to ensure that your restoration measures will maintain the fish and shellfish in the waterbody to a substantially similar level to that which would be achieved through § 125.84(b)(1) and (2).

(D) *Verification monitoring plan.* You must include in the Study the following:

(*1*) A plan to conduct, at a minimum, two years of monitoring to verify the full-scale performance of the proposed or implemented technologies, operational measures. The verification study must begin at the start of operations of the cooling water intake structure and continue for a sufficient period of time to demonstrate that the facility is reducing the level of impingement and entrainment to the level documented in paragraph (c)(2)(iv)(B) of this section. The plan must describe the frequency of monitoring and the parameters to be monitored. The Director will use the verification monitoring to confirm that you are meeting the level of impingement mortality and entrainment reduction required in § 125.84(d), and that the operation of the technology has been optimized.

(*2*) A plan to conduct monitoring to verify that the restoration measures will maintain the fish and shellfish in the waterbody to a substantially similar level as that which would be achieved through § 125.84(b)(1) and (2).

§ 125.87 As an owner or operator of a new facility, must I perform monitoring?

As an owner or operator of a new facility, you will be required to perform monitoring to demonstrate your compliance with the requirements specified in § 125.84.

(a) *Biological monitoring.* You must monitor both impingement and entrainment of the commercial, recreational, and forage base fish and shellfish species identified in either the Source Water Baseline Biological Characterization data required by 40 CFR 122.21(r)(3) or the Comprehensive Demonstration Study required by § 125.86(c)(2), depending on whether you chose to comply with Track I or Track II. The monitoring methods used must be consistent with those used for the Source Water Baseline Biological Characterization data required in 40 CFR 122.21(r)(3) or the Comprehensive Demonstration Study required by § 125.86(c)(2). You must follow the monitoring frequencies identified below for at least two (2) years after the initial permit issuance. After that time, the Director may approve a request for less frequent sampling in the remaining years of the permit term and when the permit is reissued, if supporting data show that less frequent monitoring would still allow for the detection of any seasonal and daily variations in the species and numbers of individuals that are impinged or entrained.

(1) *Impingement sampling.* You must collect samples to monitor impingement rates (simple enumeration) for each species over a 24-hour period and no less than once per month when the cooling water intake structure is in operation.

(2) *Entrainment sampling.* You must collect samples to monitor entrainment rates (simple enumeration) for each species over a 24-hour period and no less than biweekly during the primary period of reproduction, larval recruitment, and peak abundance identified during the Source Water Baseline Biological Characterization required by 40 CFR 122.21(r)(3) or the Comprehensive Demonstration Study required in § 125.86(c)(2). You must collect samples only when the cooling water intake structure is in operation.

(b) *Velocity monitoring.* If your facility uses surface intake screen systems, you must monitor head loss across the screens and correlate the measured value with the design intake velocity. The head loss across the intake screen must be measured at the minimum ambient source water surface elevation (best professional judgment based on available hydrological data). The maximum head loss across the screen for each cooling water intake structure must be used to determine compliance with the velocity requirement in § 125.84(b)(2) or (c)(1). If your facility uses devices other than surface intake screens, you must monitor velocity at the point of entry through the device. You must monitor head loss or velocity during initial facility startup, and thereafter, at the frequency specified in your NPDES permit, but no less than once per quarter.

(c) *Visual or remote inspections.* You must either conduct visual inspections or employ remote monitoring devices during the period the cooling water intake structure is in operation. You must conduct visual inspections at least weekly to ensure that any design and construction technologies required in § 125.84(b)(4) and (5), or (c)(3) and (4) are maintained and operated to ensure that they will continue to function as designed. Alternatively, you must inspect via remote monitoring devices to ensure that the impingement and entrainment technologies are functioning as designed.

§ 125.88 As an owner or operator of a new facility, must I keep records and report?

As an owner or operator of a new facility you are required to keep records and report information and data to the Director as follows:

(a) You must keep records of all the data used to complete the permit application and show compliance with the requirements, any supplemental information developed under § 125.86, and any compliance monitoring data submitted under § 125.87, for a period of at least three (3) years from the date of permit issuance. The Director may require that these records be kept for a longer period.

(b) You must provide the following to the Director in a yearly status report:

(1) Biological monitoring records for each cooling water intake structure as required by § 125.87(a);

(2) Velocity and head loss monitoring records for each cooling water intake structure as required by § 125.87(b); and

(3) Records of visual or remote inspections as required in § 125.87(c).

§ 125.89 As the Director, what must I do to comply with the requirements of this subpart?

(a) *Permit application.* As the Director, you must review materials submitted by the applicant under 40 CFR 122.21(r)(3) and § 125.86 at the time of the initial permit application and before each permit renewal or reissuance.

(1) After receiving the initial permit application from the owner or operator of a new facility, the Director must determine applicable standards in § 125.84 to apply to the new facility. In addition, the Director must review materials to determine compliance with the applicable standards.

(2) For each subsequent permit renewal, the Director must review the application materials and monitoring data to determine whether requirements, or additional requirements, for design and construction technologies or operational measures should be included in the permit.

(3) For Track II facilities, the Director may review the information collection proposal plan required by § 125.86(c)(2)(iii). The facility may initiate sampling and data collection activities prior to receiving comment from the Director.

(b) *Permitting requirements.* Section 316(b) requirements are implemented for a facility through an NPDES permit. As the Director, you must determine, based on the information submitted by the new facility in its permit application, the appropriate requirements and conditions to include in the permit based on the track (Track I or Track II) the new facility has chosen to comply with. The following requirements must be included in each permit:

(1) *Cooling water intake structure requirements.* At a minimum, the permit conditions must include the performance standards that implement the requirements of § 125.84(b)(1), (2), (3), (4) and (5); § 125.84(c)(1), (2), (3) and (4); or § 125.84(d)(1) and (2). In determining compliance with proportional flow requirement in §§ 125.84(b)(3)(ii); (c)(2)(ii); and (d)(2)(ii), the director must consider anthropogenic factors (those not considered ''natural'') unrelated to the new facility's cooling water intake structure that can influence the occurrence and location of a thermocline. These include source water inflows, other water withdrawals, managed water uses, wastewater discharges, and flow/level management practices (e.g., some reservoirs release water from below the surface, close to the deepest areas).

(i) For a facility that chooses Track I, you must review the Design and Construction Technology Plan required in § 125.86(b)(4) to evaluate the suitability and feasibility of the technology proposed to minimize impingement mortality and entrainment of all life stages of fish and shellfish. In the first permit issued, you must put a condition requiring the facility to reduce impingement mortality and entrainment commensurate with the implementation of the technologies in the permit. Under subsequent permits, the Director must review the performance of the technologies implemented and require additional or different design and construction technologies, if needed to minimize impingement mortality and entrainment of all life stages of fish and shellfish. In addition, you must consider whether more stringent conditions are reasonably necessary in accordance with § 125.84(e).

(ii) For a facility that chooses Track II, you must review the information submitted with the Comprehensive

Demonstration Study information required in § 125.86(c)(2), evaluate the suitability of the proposed design and construction technologies and operational measures to determine whether they will reduce both impingement mortality and entrainment of all life stages of fish and shellfish to 90 percent or greater of the reduction that could be achieved through Track I. If you determine that restoration measures are appropriate at the new facility for consideration of impacts other than impingement mortality and entrainment, you must review the Evaluation of Proposed Restoration Measures and evaluate whether the proposed measures will maintain the fish and shellfish in the waterbody at a substantially similar level to that which would be achieved through § 125.84(b)(1) and (2). In addition, you must review the Verification Monitoring Plan in § 125.86(c)(2)(iv)(D) and require that the proposed monitoring begin at the start of operations of the cooling water intake structure and continue for a sufficient period of time to demonstrate that the technologies, operational measures and restoration measures meet the requirements in § 125.84(d)(1). Under subsequent permits, the Director must review the performance of the additional and /or different technologies or measures used and determine that they reduce the level of adverse environmental impact from the cooling water intake structures to a comparable level that the facility would achieve were it to implement the requirements of § 125.84(b)(1) and (2).

(2) *Monitoring conditions.* At a minimum, the permit must require the permittee to perform the monitoring required in § 125.87. You may modify the monitoring program when the permit is reissued and during the term of the permit based on changes in physical or biological conditions in the vicinity of the cooling water intake structure. The Director may require continued monitoring based on the results of the Verification Monitoring Plan in § 125.86(c)(2)(iv)(D).

(3) *Record keeping and reporting.* At a minimum, the permit must require the permittee to report and keep records as required by § 125.88.

[FR Doc. 01–28968 Filed 12–17–01; 8:45 am]

BILLING CODE 6560–50–P

B

LEXSTAT 40 CFR 125.84

*** THIS SECTION IS CURRENT THROUGH THE JANUARY 14, 2009 ISSUE OF ***
*** THE FEDERAL REGISTER ***

TITLE 40 -- PROTECTION OF ENVIRONMENT
CHAPTER I -- ENVIRONMENTAL PROTECTION AGENCY
SUBCHAPTER D -- WATER PROGRAMS
PART 125 -- CRITERIA AND STANDARDS FOR THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
SUBPART I -- REQUIREMENTS APPLICABLE TO COOLING WATER INTAKE STRUCTURES FOR NEW FACILITIES UNDER SECTION 316(B) OF THE ACT

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40 CFR 125.84

§ 125.84 As an owner or operator of a new facility, what must I do to comply with this subpart?

(a)(1) The owner or operator of a new facility must comply with either:

(i) Track I in paragraph (b) or (c) of this section; or

(ii) Track II in paragraph (d) of this section.

(2) In addition to meeting the requirements in paragraph (b), (c), or (d) of this section, the owner or operator of a new facility may be required to comply with paragraph (e) of this section.

(b) Track I requirements for new facilities that withdraw equal to or greater than 10 MGD. You must comply with all of the following requirements:

(1) You must reduce your intake flow, at a minimum, to a level commensurate with that which can be attained by a closed-cycle recirculating cooling water system;

(2) You must design and construct each cooling water intake structure at your facility to a maximum through-screen design intake velocity of 0.5 ft/s;

(3) You must design and construct your cooling water intake structure such that the total design intake flow from all cooling water intake structures at your facility meets the following requirements:

(i) For cooling water intake structures located in a freshwater river or stream, the total design intake flow must be no greater than five (5) percent of the source water annual mean flow;

(ii) For cooling water intake structures located in a lake or reservoir, the total design intake flow must not disrupt the natural thermal stratification or turnover pattern (where present) of the source water except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies);

(iii) For cooling water intake structures located in an estuary or tidal river, the total design intake flow over one tidal cycle of ebb and flow must be no greater than one (1) percent of the volume of the water column within the area centered about the opening of the intake with a diameter defined by the distance of one tidal excursion at the mean low water level;

(4) You must select and implement design and construction technologies or operational measures for minimizing impingement mortality of fish and shellfish if:

(i) There are threatened or endangered or otherwise protected federal, state, or tribal species, or critical habitat for these species, within the hydraulic zone of influence of the cooling water intake structure; or

(ii) Based on information submitted by any fishery management agency(ies) or other relevant information, there are migratory and/or sport or commercial species of impingement concern to the Director that pass through the hydraulic zone of influence of the cooling water intake structure; or

(iii) It is determined by the Director, based on information submitted by any fishery management agency(ies) or other relevant information, that the proposed facility, after meeting the technology-based performance requirements in paragraphs (b)(1), (2), and (3) of this section, would still contribute unacceptable stress to the protected species, critical habitat of those species, or species of concern;

(5) You must select and implement design and construction technologies or operational measures for minimizing entrainment of entrainable life stages of fish and shellfish if:

(i) There are threatened or endangered or otherwise protected federal, state, or tribal species, or critical habitat for these species, within the hydraulic zone of influence of the cooling water intake structure; or

(ii) Based on information submitted by any fishery management agency(ies) or other relevant information, there are or would be undesirable cumulative stressors affecting entrainable life stages of species of concern to the Director and the Director determines that the proposed facility, after meeting the technology-based performance requirements in paragraphs (b)(1), (2), and (3) of this section, would still contribute unacceptable stress to the protected species, critical habitat of those species, or these species of concern;

(6) You must submit the application information required in 40 CFR 122.21(r) and § 125.86(b);

(7) You must implement the monitoring requirements specified in § 125.87;

(8) You must implement the record-keeping requirements specified in § 125.88.

(c) Track I requirements for new facilities that withdraw equal to or greater than 2 MGD and less than 10 MGD and that choose not to comply with paragraph (b) of this section. You must comply with all the following requirements:

(1) You must design and construct each cooling water intake structure at your facility to a maximum through-screen design intake velocity of 0.5 ft/s;

(2) You must design and construct your cooling water intake structure such that the total design intake flow from all cooling water intake structures at your facility meets the following requirements:

(i) For cooling water intake structures located in a freshwater river or stream, the total design intake flow must be no greater than five (5) percent of the source water annual mean flow;

(ii) For cooling water intake structures located in a lake or reservoir, the total design intake flow must not disrupt the natural thermal stratification or turnover pattern (where present) of the source water except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies);

(iii) For cooling water intake structures located in an estuary or tidal river, the total design intake flow over one tidal cycle of ebb and flow must be no greater than one (1) percent of the volume of the water column within the area centered about the opening of the intake with a diameter defined by the distance of one tidal excursion at the mean low water level;

(3) You must select and implement design and construction technologies or operational measures for minimizing impingement mortality of fish and shellfish if:

(i) There are threatened or endangered or otherwise protected federal, state, or tribal species, or critical habitat for these species, within the hydraulic zone of influence of the cooling water intake structure; or

(ii) Based on information submitted by any fishery management agency(ies) or other relevant information, there are migratory and/or sport or commercial species of impingement concern to the Director that pass through the hydraulic zone of influence of the cooling water intake structure; or

(iii) It is determined by the Director, based on information submitted by any fishery management agency(ies) or other relevant information, that the proposed facility, after meeting the technology-based performance requirements in paragraphs (c)(1) and (2) of this section, would still contribute unacceptable stress to the protected species, critical habitat of those species, or species of concern;

(4) You must select and implement design and construction technologies or operational measures for minimizing entrainment of entrainable life stages of fish and shellfish;

(5) You must submit the application information required in 40 CFR 122.21(r) and § 125.86(b)(2), (3), and (4);

(6) You must implement the monitoring requirements specified in § 125.87;

(7) You must implement the recordkeeping requirements specified in § 125.88.

(d) Track II. The owner or operator of a new facility that chooses to comply under Track II must comply with the following requirements:

(1) You must demonstrate to the Director that the technologies employed will reduce the level of adverse environmental impact from your cooling water intake structures to a comparable level to that which you would achieve were you to implement the requirements of paragraphs (b)(1) and (2) of this section. This demonstration must include a showing that the impacts to fish and shellfish, including important forage and predator species, within the watershed will be comparable to those which would result if you were to implement the requirements of paragraphs (b)(1) and (2) of this section.

This showing may include consideration of impacts other than impingement mortality and entrainment, including measures that will result in increases in fish and shellfish, but it must demonstrate comparable performance for species that the Director identifies as species of concern. In identifying such species, the Director may consider information provided by any fishery management agency(ies) along with data and information from other sources.

(2) You must design and construct your cooling water intake structure such that the total design intake flow from all cooling water intake structures at your facility meet the following requirements:

(i) For cooling water intake structures located in a freshwater river or stream, the total design intake flow must be no greater than five (5) percent of the source water annual mean flow;

(ii) For cooling water intake structures located in a lake or reservoir, the total design intake flow must not disrupt the natural thermal stratification or turnover pattern (where present) of the source water except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies);

(iii) For cooling water intake structures located in an estuary or tidal river, the total design intake flow over one tidal cycle of ebb and flow must be no greater than one (1) percent of the volume of the water column within the area centered about the opening of the intake with a diameter defined by the distance of one tidal excursion at the mean low water level.

(3) You must submit the application information required in 40 CFR 122.21(r) and § 125.86(c).

(4) You must implement the monitoring requirements specified in § 125.87.

(5) You must implement the record-keeping requirements specified in § 125.88.

(e) You must comply with any more stringent requirements relating to the location, design, construction, and capacity of a cooling water intake structure or monitoring requirements at a new facility that the Director deems are reasonably necessary to comply with any provision of state law, including compliance with applicable state water quality standards (including designated uses, criteria, and antidegradation requirements).

HISTORY: [66 FR 65256, 65340, Dec. 18, 2001; 67 FR 78948, 78954, Dec. 26, 2002, withdrawn at 68 FR 14164, Mar. 24, 2003; 68 FR 36749, 36754, June 19, 2003]

AUTHORITY: AUTHORITY NOTE APPLICABLE TO ENTIRE PART:
The Clean Water Act, 33 U.S.C. 1251 et seq.

NOTES: [EFFECTIVE DATE NOTE: 68 FR 36749, 36754, June 19, 2003, amended this section, effective July 21, 2003.]

NOTES APPLICABLE TO ENTIRE CHAPTER:
[PUBLISHER'S NOTE: Nomenclature changes to Chapter I appear at 65 FR 47323, 47324, 47325, Aug. 2, 2000.]
[PUBLISHER'S NOTE: For Federal Register citations concerning Chapter 1 Notice of implementation policy, see: 71 FR 25504, May 1, 2006.]

NOTES TO DECISIONS: COURT AND ADMINISTRATIVE DECISIONS SIGNIFICANTLY DISCUSSING SECTION --
Riverkeeper, Inc. v United States EPA (2004, CA2) 358 F3d 174, 57 Envt Rep Cas 1961, 34 ELR 20017

1778 words

C

LEXSTAT 40 CFR 125.94

*** THIS SECTION IS CURRENT THROUGH THE JANUARY 14, 2009 ISSUE OF ***
*** THE FEDERAL REGISTER ***

TITLE 40 -- PROTECTION OF ENVIRONMENT
CHAPTER I -- ENVIRONMENTAL PROTECTION AGENCY
SUBCHAPTER D -- WATER PROGRAMS
PART 125 -- CRITERIA AND STANDARDS FOR THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
SUBPART J -- REQUIREMENTS APPLICABLE TO COOLING WATER INTAKE STRUCTURES FOR PHASE II EXISTING FACILITIES UNDER SECTION 316(B) OF THE ACT

Go to the CFR Archive Directory

40 CFR 125.94

§ 125.94 How will requirements reflecting best technology available for minimizing adverse environmental impact be established for my Phase II existing facility? [This section is suspended. See 72 FR 37107, 37109, July 9, 2007.]

[PUBLISHER'S NOTE: This section was suspended for an indefinite period of time at 72 FR 37107, 37109, July 9, 2007, effective July 9, 2007.]

(a) Compliance alternatives. You must select and implement one of the following five alternatives for establishing best technology available for minimizing adverse environmental impact at your facility:

(1)(i)You may demonstrate to the Director that you have reduced, or will reduce, your flow commensurate with a closed-cycle recirculating system. In this case, you are deemed to have met the applicable performance standards and will not be required to demonstrate further that your facility meets the impingement mortality and entrainment performance standards specified in paragraph (b) of this section. In addition, you are not subject to the requirements in §§ 125.95, 125.96, 125.97, or 125.98. However, you may still be subject to any more stringent requirements established under paragraph (e) of this section; or

(ii) You may demonstrate to the Director that you have reduced, or will reduce, your maximum through-screen design intake velocity to 0.5 ft/s or less. In this case, you are deemed to have met the impingement mortality performance standards and will not be required to demonstrate further that your facility meets the performance standards for impingement mortality specified in paragraph (b) of this section and you are not subject to the requirements in §§ 125.95, 125.96, 125.97, or 125.98 as they apply to impingement mortality. However, you are still subject to any applicable requirements for entrainment reduction and may still be subject to any more stringent requirements established under paragraph (e) of this section.

(2) You may demonstrate to the Director that your existing design and construction technologies, operational measures, and/or restoration measures meet the performance standards specified in paragraph (b) of this section and/or the restoration requirements in paragraph (c) of this section.

(3) You may demonstrate to the Director that you have selected, and will install and properly operate and maintain, design and construction technologies, operational measures, and/or restoration measures that will, in combination with any existing design and construction technologies, operational measures, and/or restoration measures, meet the performance standards specified in paragraph (b) of this section and/or the restoration requirements in paragraph (c) of this section;

(4) You may demonstrate to the Director that you have installed, or will install, and properly operate and maintain an approved design and construction technology in accordance with § 125.99(a) or (b); or

(5) You may demonstrate to the Director that you have selected, installed, and are properly operating and maintaining, or will install and properly operate and maintain design and construction technologies, operational measures, and/or restoration measures that the Director has determined to be the best technology available to minimize adverse environmental impact for your facility in accordance with paragraphs (a)(5)(i) or (ii) of this section.

(i) If the Director determines that data specific to your facility demonstrate that the costs of compliance under alternatives in paragraphs (a)(2) through (4) of this section would be significantly greater than the costs considered by the Administrator for a facility like yours in establishing the applicable performance standards in paragraph (b) of this section, the Director must make a site-specific determination of the best technology available for minimizing adverse environmental impact. This determination must be based on reliable, scientifically valid cost and performance data submitted by you and any other information that the Director deems appropriate. The Director must establish site-specific alternative requirements based on new and/or existing design and construction technologies, operational measures, and/or restoration measures that achieve an efficacy that is, in the judgment of the Director, as close as practicable to the applicable performance standards in paragraph (b) of this section, without resulting in costs that are significantly greater than the costs considered by the Administrator for a facility like yours in establishing the applicable performance standards. The Director's site-specific determination may conclude that design and construction technologies, operational measures, and/or restoration measures in addition to those already in place are not justified because of the significantly greater costs. To calculate the costs considered by the Administrator for a facility like yours in establishing the applicable performance standards you must:

(A) Determine which technology the Administrator modeled as the most appropriate compliance technology for your facility;

(B) Using the Administrator's costing equations, calculate the annualized capital and net operation and maintenance (O&M) costs for a facility with your design intake flow using this technology;

(C) Determine the annualized net revenue loss associated with net construction downtime that the Administrator modeled for your facility to install this technology;

(D) Determine the annualized pilot study costs that the Administrator modeled for your facility to test and optimize this technology;

(E) Sum the cost items in paragraphs (a)(5)(i)(B), (C), and (D) of this section; and

(F) Determine if the performance standards that form the basis of these estimates (i.e., impingement mortality reduction only or impingement mortality and entrainment reduction) are applicable to your facility, and if necessary, adjust the estimates to correspond to the applicable performance standards.

(ii) If the Director determines that data specific to your facility demonstrate that the costs of compliance under alternatives in paragraphs (a)(2) through (4) of this section would be significantly greater than the benefits of complying with the applicable performance standards at your facility, the Director must make a site-specific determination of best technology available for minimizing adverse environmental impact. This determination must be based on reliable, scientifically valid cost and performance data submitted by you and any other information the Director deems appropriate. The Director must establish site-specific alternative requirements based on new and/or existing design and construction technologies, operational measures, and/or restoration measures that achieve an efficacy that, in the judgment of the Director, is as close as practicable to the applicable performance standards in paragraph (b) of this section without resulting in costs that are significantly greater than the benefits at your facility. The Director's site-specific determination may conclude that design and construction technologies, operational measures, and/or restoration measures in addition to those already in place are not justified because the costs would be significantly greater than the benefits at your facility.

(b) National performance standards. -- (1) Impingement mortality performance standards. If you choose compliance alternatives in paragraphs (a)(2), (a)(3), or (a)(4) of this section, you must reduce impingement mortality for all life stages of fish and shellfish by 80 to 95 percent from the calculation baseline.

(2) Entrainment performance standards. If you choose compliance alternatives in paragraphs (a)(1)(ii), (a)(2), (a)(3), or (a)(4) of this section, you must also reduce entrainment of all life stages of fish and shellfish by 60 to 90 percent from the calculation baseline if:

(i) Your facility has a capacity utilization rate of 15 percent or greater, and

(ii)(A) Your facility uses cooling water withdrawn from a tidal river, estuary, ocean, or one of the Great Lakes; or

(B) Your facility uses cooling water withdrawn from a freshwater river or stream and the design intake flow of your cooling water intake structures is greater than five percent of the mean annual flow.

(3) Additional performance standards for facilities withdrawing from a lake (other than one of the Great Lakes) or a reservoir. If your facility withdraws cooling water from a lake (other than one of the Great Lakes) or a reservoir and you propose to increase the design intake flow of cooling water intake structures it uses, your increased design intake flow must not disrupt the natural thermal stratification or turnover pattern (where present) of the source water, except in cases where the disruption does not adversely affect the management of fisheries. In determining whether any such disruption does not adversely affect the management of fisheries, you must consult with Federal, State, or Tribal fish and wildlife management agencies).

(4) Use of performance standards for site-specific determinations of best technology available. The performance standards in paragraphs (b)(1) through (3) of this section must also be used for determining eligibility for site-specific determinations of best technology available for minimizing adverse environmental impact and establishing site specific requirements that achieve an efficacy as close as practicable to the applicable performance standards without resulting in costs that are significantly greater than those considered by the Administrator for a facility like yours in establishing the performance standards or costs that are significantly greater than the benefits at your facility, pursuant to § 125.94(a)(5).

(c) Requirements for restoration measures. With the approval of the Director, you may implement and adaptively manage restoration measures that produce and result in increases of fish and shellfish in your facility's watershed in place of or as a supplement to installing design and control technologies and/or adopting operational measures that reduce impingement mortality and entrainment. You must demonstrate to the Director that:

(1) You have evaluated the use of design and construction technologies and operational measures for your facility and determined that the use of restoration measures is appropriate because meeting the applicable performance standards or site-specific requirements through the use of design and construction technologies and/or operational measures alone is less feasible, less cost-effective, or less environmentally desirable than meeting the standards or requirements in whole or in part through the use of restoration measures; and

(2) The restoration measures you will implement, alone or in combination with design and construction technologies and/or operational measures, will produce ecological benefits (fish and shellfish), including maintenance

or protection of community structure and function in your facility's waterbody or watershed, at a level that is substantially similar to the level you would achieve by meeting the applicable performance standards under paragraph (b) of this section, or that satisfies alternative site-specific requirements established pursuant to paragraph (a)(5) of this section.

(d)(1) Compliance using a technology installation and operation plan or restoration plan. If you choose one of the compliance alternatives in paragraphs (a)(2), (3), (4), or (5) of this section, you may request that compliance with the requirements of § 125.94(b) during the first permit containing requirements consistent with this subpart be determined based on whether you have complied with the construction, operational, maintenance, monitoring, and adaptive management requirements of a Technology Installation and Operation Plan developed in accordance with § 125.95(b)(4)(ii) (for any design and construction technologies and/or operational measures) and/or a Restoration Plan developed in accordance with § 125.95(b)(5) (for any restoration measures). The Technology Installation and Operation Plan must be designed to meet applicable performance standards in paragraph (b) of this section or alternative site-specific requirements developed pursuant to paragraph (a)(5) of this section. The Restoration Plan must be designed to achieve compliance with the applicable requirements in paragraph (c) of this section.

(2) During subsequent permit terms, if you selected and installed design and construction technologies and/or operational measures and have been in compliance with the construction, operational, maintenance, monitoring, and adaptive management requirements of your Technology Installation and Operation Plan during the preceding permit term, you may request that compliance with the requirements of § 125.94 during the following permit term be determined based on whether you remain in compliance with your Technology Installation and Operation Plan, revised in accordance with your adaptive management plan in § 125.95(b)(4)(ii)(C) if applicable performance standards are not being met. Each request and approval of a Technology Installation and Operation Plan shall be limited to one permit term.

(3) During subsequent permit terms, if you selected and installed restoration measures and have been in compliance with the construction, operational, maintenance, monitoring, and adaptive management requirements in your Restoration Plan during the preceding permit term, you may request that compliance with the requirements of this section during the following permit term be determined based on whether you remain in compliance with your Restoration Plan, revised in accordance with your adaptive management plan in § 125.95(b)(5)(v) if applicable performance standards are not being met. Each request and approval of a Restoration Plan shall be limited to one permit term.

(e) More stringent standards. The Director may establish more stringent requirements as best technology available for minimizing adverse environmental impact if the Director determines that your compliance with the applicable requirements of this section would not meet the requirements of applicable State and Tribal law, or other Federal law.

(f) Nuclear facilities. If you demonstrate to the Director based on consultation with the Nuclear Regulatory Commission that compliance with this subpart would result in a conflict with a safety requirement established by the Commission, the Director must make a site-specific determination of best technology available for minimizing adverse environmental impact that would not result in a conflict with the Nuclear Regulatory Commission's safety requirement.

HISTORY: [69 FR 41576, 41685, July 9, 2004; suspended at 72 FR 37107, 37109, July 9, 2007]

AUTHORITY: AUTHORITY NOTE APPLICABLE TO ENTIRE PART:
The Clean Water Act, 33 U.S.C. 1251 et seq.

NOTES: [EFFECTIVE DATE NOTE: 69 FR 41576, 41685, July 9, 2004, added Subpart J, effective Sept. 7, 2004; 72 FR 37107, 37109, July 9, 2007, suspended this section for an indefinite period of time, effective July 9, 2007.]

NOTES APPLICABLE TO ENTIRE CHAPTER:
[PUBLISHER'S NOTE: Nomenclature changes to Chapter I appear at 65 FR 47323, 47324, 47325, Aug. 2, 2000.]
[PUBLISHER'S NOTE: For Federal Register citations concerning Chapter 1 Notice of implementation policy, see: 71 FR 25504, May 1, 2006.]

2438 words

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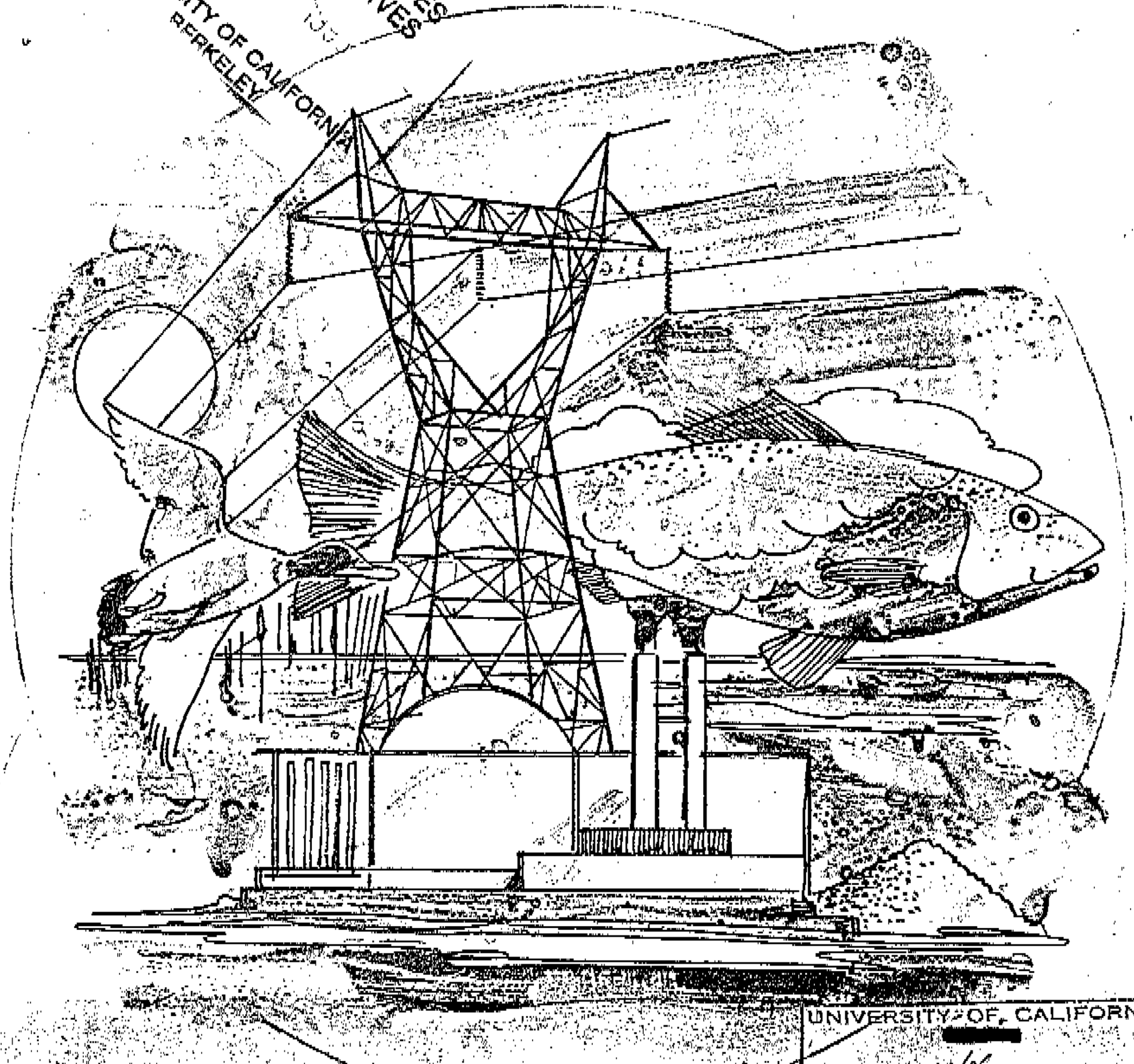
Biological Services Program

FWS/OBS-76/20.1
March 1977

Topical Briefs: Fish and Wildlife Resources and Electric Power Generation, no. 1

Impacts of Power Plant Intake Velocities on Fish



Fish and Wildlife Service

U.S. Department of the Interior

The Biological Services Program was established within the U.S. Fish and Wildlife Service to supply scientific information and methodologies on key environmental issues which impact fish and wildlife resources and their supporting ecosystems. The mission of the Program is as follows:

1. To strengthen the Fish and Wildlife Service in its role as a primary source of information on national fish and wildlife resources, particularly in respect to environmental impact assessment.

2. To gather, analyze, and present information that will aid decision makers in the identification and resolution of problems associated with major land and water use changes.

3. To provide better ecological information and evaluation for Department of the Interior development programs, such as those relating to energy development.

Information developed by the Biological Services Program is intended for use in the planning and decision making process to prevent or minimize the impact of development on fish and wildlife. Biological Services research activities and technical assistance services are based on an analysis of the issues, the decision makers involved and their information needs, and an evaluation of the state of the art to identify information gaps and determine priorities. This is a strategy to assure that the products produced and disseminated will be timely and useful.

Biological Services projects have been initiated in the following areas:

- Coal extraction and conversion
- Power plants
- Geothermal, mineral, and oil shale development
- Water resource analysis, including stream alterations and western water allocation
- Coastal ecosystems and Outer Continental Shelf development
- Systems and inventory, including National Wetlands Inventory, habitat classification and analysis, and information transfer.

The Program consists of the Office of Biological Services in Washington, D.C., which is responsible for overall planning and management; National Teams which provide the Program's central scientific and technical expertise and who arrange for contracting Biological Services studies with States, universities, consulting firms, and others; Regional staff who provide a link to problems at the operating level; and staff at certain Fish and Wildlife Service research facilities who conduct in-house research studies.

FWS/OBS-76/20.1
March 1977

Topical Briefs: Fish and Wildlife Resources and
Electric Power Generation, no. 1

IMPACTS OF POWER PLANT INTAKE VELOCITIES ON FISH

by

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Preface

The series Topical Briefs: Fish and Wildlife Resources and Electric Power Generation is published by the National Power Plant Team of the Power Plant Project to provide a set of concise summaries on topics related to electric power generation and transmission and their effects on fish and wildlife resources. The briefs are written for fish and wildlife biologists who review and make recommendations regarding electric power projects. Each brief contains background information on and a discussion of the particular topic, a selected bibliography of additional information sources, and, in some cases, a strategy to address the problem.

Any suggestions or questions regarding Topical Briefs should be directed to:

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IMPACTS OF POWER PLANT INTAKE VELOCITIES ON FISH

Abstract

This report outlines biological problems associated with power plant intake velocities. Information needed to assess impacts of intake velocities on fishery resources and a list of technical references containing more detailed analyses of the problems and mitigation alternatives are included.

INTRODUCTION

There is growing recognition that mortality of aquatic biota due to entrainment or impingement at power plant intakes produce substantial impacts on estuarine, riverine, lacustrine, and coastal ecosystems. In some power plants water withdrawal may produce greater losses to fishery resources than thermal pollution. For example, up to 165.5 million menhaden larvae were killed per day by entrainment at the Brayton Point Plant in Massachusetts during the summer of 1971 (U.S. Environmental Protection Agency 1972). The ecological implications of this mortality are not yet known.

POWER PLANT	ENTRAINMENT EVENT	DATE	COMMENT
Brayton Point, Mt. Hope Bay, Mass.	7.0 to 165.5 million menhaden (some river herring) killed per day	Summer, 1971	Estimated from EPA's sampling techniques. 164.5 million kill on July 2; fish mangled.
	50 million fish killed in 11 days	August 10-21, 1971	Estimated from net tons at discharge; menhaden and blueback herring; tests showed all fish died.
Millstone, Niantic Bay, Conn.	36 million fish killed in 16 days (probably menhaden blueback herring)	Nov. 2-18, 1971	Estimated by sampling of vertebrae of dead fish in discharge channel.
	2.5 million flounder entrained	Apr.-June 1972	Death rate not estimated
Connecticut Yankee, Conn. River, Conn	179 million fish larvae killed per year	1969&1970	Estimated by B. Marcy.
Indian Point, Hudson Estuary, N.Y.	Predicted 7.3 million striped bass killed per year, larvae and juveniles	Future	For Units 1&2; estimated from estuary sampling in 1966 and 1967.
Seabrook, Hampton-Seabrook Estuary, N.H.	Predicted kill of 74 million clam larvae per day	Future	Estimate for proposed plant; 74 million is initial kill at plant startup, lower rate after equilibrium reached.

Table 1. Reports and Predictions of Power Plant Entrainment (U.S. Environmental Protection Agency 1976*a*)

POWER PLANT	IMPINGEMENT EVENT	DATE	COMMENT
Millstone, Niantic Bay Conn.	Massive kill of small menhaden (more than 2.0 million), screens clogged.	1971	Occurring late summer, early fall; plant shut down on 8/21/71; persistent low kill of 10 other species.
P. H. Robinson, Galveston Bay, Tex.	7,191,785 fish impinged in one year.	1969-70	Projected from sampling of operating plant; principal species were menhaden, anchovy, croaker; highest in March.
Indian Point, No. 1	Yearly kill of 1.0 to 1.5 million fish.	1965-72	Primarily white perch with 4-10% striped bass.
Hudson River, N.Y.	Kill of 1.3 million in 9 1/2 weeks	1969-70	10% striped bass; plant closed Feb. 8.
Indian Point, No. 2	Massive kills; maximum per day 120,000	Jan. 71	Testing cooling system of new plant (no heat); white perch & other species
	175,000 fish killed in 5 days.	Feb. 72	Testing again (no heat) Con. Ed. fined $1.6 million by N.Y. for kills.
Indian Point, No. 1,2	Predicted total kill 6.5 million fish per year		With both plants in full operation
Port Jefferson Long Island, N.Y.	2 truckloads (at least) of fish killed on screens in 3 days.	Jan. 26-28 1966	Mostly small menhaden; also white perch.
Crystal River (near) Cedar Key, Fla.	Predicted annual kill of 400,000 fish and 100,000 shellfish.	1969	Based upon operation of 3 units (2 units now destroy 1.2 this amount).
Brayton Point Mt. Hope Bay, Mass.	350,000 fish impinged in one year; mostly menhaden	1971-72	Heaviest from Nov-March; flounder, silverside, & other also impinged.
Oyster Creek, Barnegat Bay, N.J.	10,000 fish, 5,000 crabs, destroyed per month in spring and summer.	1971	Estimated from 19 days of sampling; screen kill in cold season unknown.
Surry Power Station James River, Va.	6 million river herring destroyed in 2-3 months	Oct.-Dec. 1972	Estimated by AEC from screen samplings during partial power runs.

Table 2. Reports and Predictions of Power Plant Impingement (U.S. Environmental Protection Agency 1976*a*)

STATEMENT OF THE PROBLEM

Rates of entrainment and impingement of aquatic resources are directly related to intake velocities at and around the intake structures, and also to numerous other physical and biological phenomena. An understanding of these phenomena is necessary to make effective recommendations concerning intake velocities.

Hydrodynamic conditions in the water body are the principal physical phenomena controlling entrainment and impingement. Three types of hydrodynamic conditions may exist (with associated site-specific modifications): a stagnant pool system, such as a lake or pond with no prevailing currents; an uni-directional system, such as a stream, river, or coastal system with one prevailing current in the vicinity of the intake; and a multi-directional flow system, such as in an estuary.

Relative location and construction details of the intake structure are also important, because they control flow conditions in the immediate vicinity of the intake. The location of the structure in relation to the shoreline, bottom, and water surface influences the abundance, variety, and extent of withdrawal of aquatic organisms. Construction of skimmer walls, submerged weirs, velocity caps, etc., can limit the zone of power plant water withdrawal, and screens set at an angle to the direction of inflow may reduce the impingement of small fish considerably (Stone & Webster Engineering Corporation 1976).

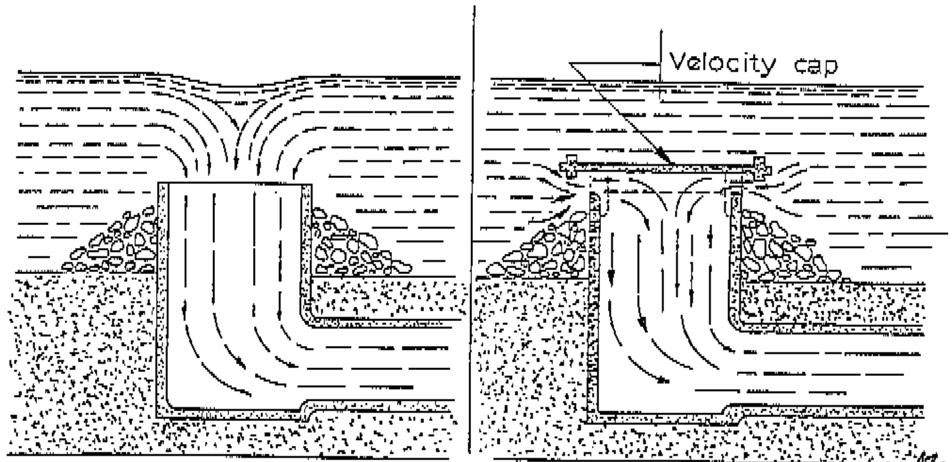

Figure 1. Operation of the Velocity Cap (U.S. Environmental Protection Agency 1976*a*)

Biological phenomena that influence the magnitude of entrainment and impingement of aquatic organisms include their: (1) motility; (2) physiological and behavioral responses to factors such as temperature, salinity, oxygen concentration, currents, etc.; (3) vertical and horizontal distribution in the vicinity of the power plant intake; and (4) growth rate which governs the period of vulnerability to entrainment or impingement during each life stage.

The biologist should be aware of the following problems inherent in discussions of entrainment and impingement impacts on critical fishery resources that appear in environmental reports, environmental impact statements, 316(b) demonstrations and other such reports. The biologist should also consider the design stage.

4 Intake Velocities

Prediction of the zone of water withdrawal. No universally accepted method has yet been established for predicting the zone of influence on aquatic organisms around power plant intake. Three-dimensional velocity profile models superimposed on movement patterns of aquatic species are one approach to this problem. However, these models are still in the formulative stage. Simplistic mathematical models neglect important hydrodynamic phenomena necessary for predicting flow conditions in the vicinities of power plant intakes. Field verifications by dye or drogue studies do not reflect the reaction of aquatic organisms to the higher velocities in the immediate vicinity of intakes and, therefore, are unreliable for predictive purposes.

Relating swimming speeds of fishes to intake vulnerability. Impingement and entrainment rates of fishes are dependent on much more than simply their ability to maintain position in a given velocity for a given period of time. For example, available data indicates that impingement rates of fishes are strongly influenced by temperature and salinity conditions in the vicinities of estuarine power plant intakes. Rheotaxis (response of an organism to current), phototaxis (response to light), and tactile responses also are important in determining the vulnerability of a species. Furthermore, fish may hold a position immediately in front of the intake structure and become susceptible to entrainment or impingement upon exhaustion.

Reports may also mention an organism's capacity to exert a burst of speed to support arguments for reduced vulnerability to intakes. However, such arguments are seldom supportable because initial orientation, distance and direction travelled, and the types of stimuli that elicit a sudden burst of speed all are variables that can not be sufficiently documented.

Measurements of intake velocities. The report should state exactly where measurements or estimates of intake velocities have been made with respect to the intake structure, water surface and bottom, tide, river stage, and other pertinent variables. Often an average intake velocity is reported with no indication of the range of velocities across the intake structure; some parts of the intake may have close to zero velocity, while others may have velocities much higher than the "average". Furthermore, low velocities are extremely difficult to measure, and the accuracy of these measurements may be questionable.

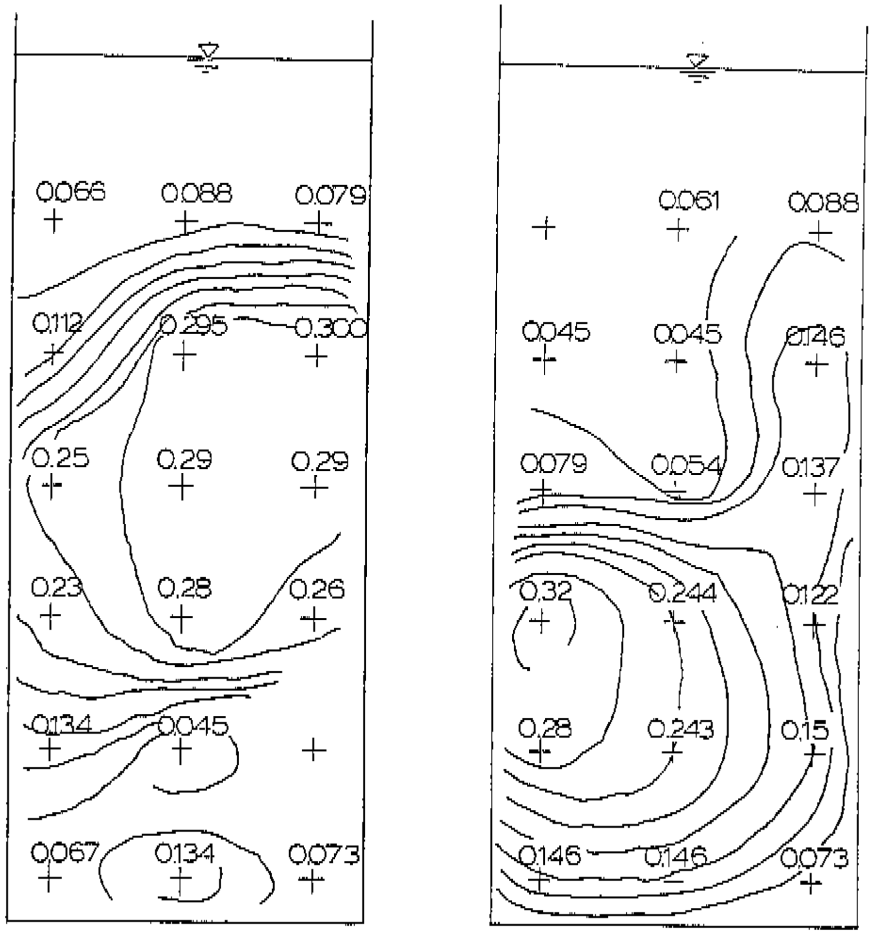

Figure 2. Undesirable Intake Well Velocity Profiles
(U.S. Environmental Protection Agency 1976*a*)

Stagnant pool areas around the intake. All intakes are designed to prevent the pumps from running dry. To keep them from running dry some companies construct a reservoir. In such cases, a stagnant water area usually occurs in the vicinity of intakes, which allows material such as sand and silt to settle out and concentrations of aquatic organisms to increase. Vulnerability of the aquatic organisms to the intakes is also increased. These areas can be created by breakwaters in combination with a dredged-out area, sheet pile walls, ponds dredged adjacent to the river, intake canals, etc.

Relation of intake location to plant discharge. Fish and shellfish often are attracted to the discharge, and more of them may be subjected to entrainment or impingement if the intake is located too near the discharge.

6 Intake Velocities

SUGGESTED STRATEGY

Entrainment: Eggs and early larval stages of aquatic organisms are particularly vulnerable to entrainment. Volume of intake flow is often more important than intake velocity in determining degree of impact. If important fishery resources are likely to be entrained at a power plant, the project report should include the following:

- Accurate delineation of vertical and horizontal distribution of eggs and larvae by species in the expected zone of withdrawal.

- Information on the period of vulnerability of the resource to entrainment, including data on duration of the egg and larval stages, length of spawning season, and relationship of developmental periods to environmental factors (e.g., temperature) that are likely to affect them.

- Description of the physical and biological phenomena that could increase vulnerability, such as tidal cycles, current patterns, location of intake, behavior, etc.

- Indication of the volume of water withdrawal in relation to the net flow of the water body.

- Estimates of the egg and larvae population sizes.

- Evaluation of significance of entrainment losses to recreational and commercial fisheries.

Reduction of entrainment losses can be accomplished by several methods, including use of skimmer walls, velocity caps, and submerged weirs to control the zone of withdrawal; relocation of the intake in areas of less critical habitat; or construction of a closed-cycle cooling system to reduce the volume of water withdrawal. Seasonal mode operation of once-through cooling during periods of low potential impact may also be recommended. It cannot be overemphasized that the best way to minimize the impact of a power plant on important aquatic resources is to site the plant in a location where such resources are very scarce.

Impingement. Juvenile (post-larval) stages of fish are much more vulnerable to impingement losses than any other life stage. In some instances, however, substantial impingement of adult fish can occur.

If critical fishery resources are likely to be impinged at power plant intakes, the project report should contain the following:

- Accurate delineation movement patterns of the critical fishery resource through the zone of withdrawal.
- Description of the physical and biological phenomena that may increase the vulnerability of a species to impingement, such as temperature, salinity, currents, behavior, etc.
- If fish by-pass systems are utilized, evidence that fish returned to the water body will survive, grow, and reproduce successfully.
- Estimation of the numbers and sizes of impinged species in relation to the quantity of water passing through the plant, intake current velocities, season, water temperatures, stage of tide, illumination, and other environmental conditions.
- Population estimates of the impingeable stocks of aquatic organisms.
- Evaluation of the degree to which impingement losses will reduce recreational and commercial fisheries.

Reduction of impingement can be accomplished by use of methods such as travelling screens, fish bypass systems, louvers, relocation of the intake, etc. Air bubbler screens and sound waves have not been shown to be effective measures.

More detailed analyses of alternate intakes that will reduce entrainment and impingement are found in the Atomic Industrial Forum source book on cooling water intakes (Battelle 1975) and the U.S. Environmental Protection Agency's cooling water intake development document (1976*a*). Guidelines for studies related to power plant intake velocity impacts on aquatic resources are presented in the U.S. Environmental Protection Agency's 316(b) technical guidance manual (1976*b*).

It is important to keep in mind that closed-cycle cooling is not the best available technology in all cases. Minor alterations in existing open-cycle systems to minimize impact should be recommended whenever possible. Each system must be judged on a case-by-case basis.

8 Intake Velocities

CURRENT POLICY

The U.S. Environmental Protection Agency (1973) recommends reducing intake velocities to below 0.5 ft/sec(fps) at the trash rack to enable fish to escape the screenwell. The U.S. Nuclear Regulatory Commission (1975) recommends that "...the site should have characteristics that allow placement of intake structures where the relative abundance of important species is small and where low approach velocities can be attained." Also "...approach velocity and screen face velocity are the principal design criteria for controlling the impingement of larger organisms, principally fish, on intake screens. Acceptable approach and screen face velocities are based on fish swim speeds which will thus vary with the species, site and season. Maximum acceptable approach velocities are on the order of 0.5 fps."

Fish and Wildlife Service concerns on intake velocities appeared in Dr. Willis King's Instructional Memorandum RB-44, dated February 5, 1973, and in the Navigable Waters Handbook (U.S. Fish and Wildlife Service 1974). The memorandum reads: "The maximum velocity protecting most small fish is 0.5 fps but even lower velocities will entrain larvae and plankton and even small fish where intake channels are not provided with an effective escape bypass."

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EPA-660/2-73-016
October 1973

REVIEWING ENVIRONMENTAL IMPACT STATEMENTS - POWER PLANT COOLING SYSTEMS, ENGINEERING ASPECTS

by
National Thermal Pollution Research Program
Pacific Northwest Environmental Research Laboratory
National Environmental Research Center
Corvallis, Oregon

Program Elements 1BA032 & 1BB392

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ABSTRACT

This report describes the approach and technical base that have been used by EPA's National Thermal Pollution Research Program for reviewing those portions of Environmental Impact Statements (EIS's) relative to the engineering aspects (including economics) of cooling water systems for thermal power plants. The report provides techniques and data to enable the EIS reviewer to make sound judgments concerning the adequacy of both the cooling water system selected for the power plant and the EIS comments on that system. Literature citations are provided to direct the reviewer to additional and more detailed information.

The report provides information and discussions on cooling system configurations, operation, environmental effects, and costs. Consideration is given to the intake as well as the discharge.

Various closed-cycle cooling systems employing cooling towers, cooling ponds, spray systems, and other devices are covered. Methods of assessing alternative selections and benefit-cost analyses are presented. Non-thermal aspects of cooling water systems are discussed.

The report lays the groundwork for a technically sound EIS review; however, the reviewer must supplement the material presented herein with references and perhaps technical consultation to prepare comprehensive and detailed review comments.

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ACKNOWLEDGEMENTS

The principal individuals contributing individually and collectively to the substance of this report are, in alphabetical order: Alden G. Christianson, Frank H. Rainwater, Mostafa A. Shirazi, and Bruce A. Tichenor.

SECTION I
SUMMARY

This report provides the Environmental Impact Statement (EIS) reviewer with background information to assist in the development of technically sound review comments. The techniques and data presented herein must be supplemented by the references cited to give the review process a substantial technical base. This report is limited to discussions of the engineering aspects of power plant cooling system, and does not deal with the biological portions of EIS's.

In most cases, the material presented will enable the reviewer to make an initial and reasoned judgment as to the adequacy of the EIS. For example, "Are the data presented on cooling tower water loss accurate?", "Is the cooling pond size reasonable?", or "Are the costs excessive?" It must be recognized, however, that a complete technical analysis of a specific problem, such as for an adversary proceeding, will require the use of techniques beyond the scope of this report. These techniques are presented in the references. In addition, some problems preclude an easy solution (e.g., thermal plume analysis). Here again, the reviewer will have to rely heavily on the reference material. Consultation with specialists may also be required.

While this report provides substantial information relative to the review of thermal power plant cooling systems, in the end the responsibility for the technical adequacy of the review rests with the reviewer. He must use all of the technical and intellectual resources available to him. Individual initiative coupled with common sense must be applied to the review process, and no report or reference can supply these requirements. Thus, the review process requires substantial effort; it is hoped that this report will provide a solid basis for that effort.

SECTION II
INTRODUCTION

PURPOSE

Section 102 of the National Environmental Policy Act of 1969 (NEPA) requires Federal Agencies to evaluate the environmental impact of their actions, including licensing. The Calvert Cliffs decision (U. S. Court of Appeals, District of Columbia, Nos. 24839 and 24871) highlights the applicability of NEPA to the licensing of nuclear power plants and leaves no doubt as to the need for technically sound and comprehensive environmental impact statements (EIS's) as a basis for licensing.

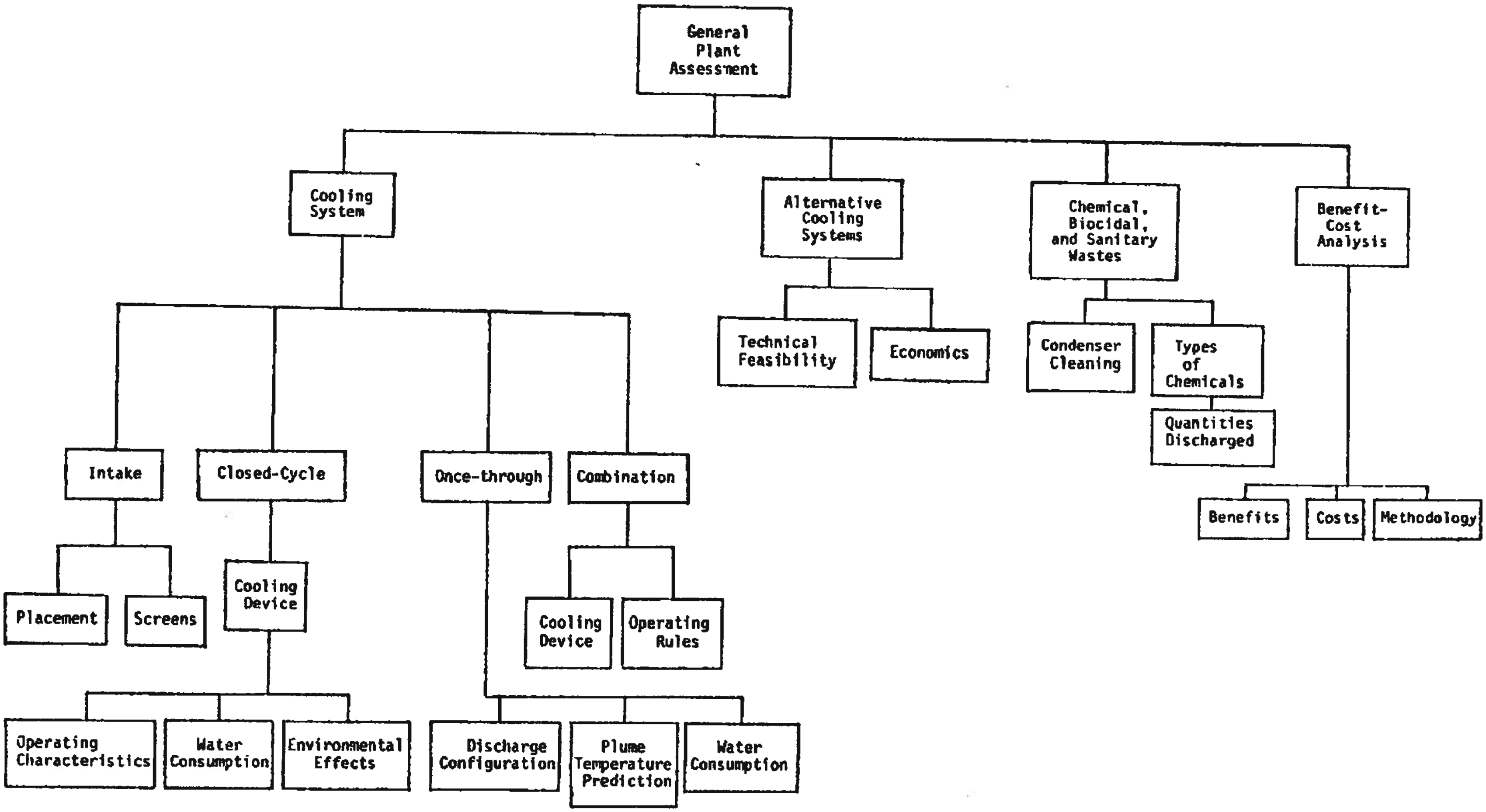
The Atomic Energy Commission[1] has issued guidelines for applicant's reports used in preparation of environmental impact statements, which have proliferated in response to current requirements. Through May 31, 1973, the National Thermal Pollution Research Program has provided technical input to EPA's review comments on about 80 draft environmental impact statements for nuclear power plants, covering a wide range of siting, engineering, and ecological combinations. Review of nuclear power plant EIS's will be a continuing function of regulatory agencies; fossil fueled plants will also require EIS's in some cases and detailed review in others. From the standpoint of technical analysis of cooling systems, fossil fired plants do not differ from nuclear plants, and most of the technical material in this report are applicable to both types of thermal power plants.

The purpose of this report is to (1) identify the environmentally critical facets of cooling water systems, (2) point out some of the problems that frequently surface in impact statement reviews, and

(3) summarize and reference the many research products applicable to the engineering-economic-environmental analysis required of EPA. Water quality criteria are not included.

Figure 1 provides a "flow chart" of the review process for thermal power plant cooling systems. More specifically, Figure 1 highlights particular points of concern which will require technical consideration by the reviewer.

Figure 1. Flow Chart for Evaluating Thermal Power Plant Cooling Systems



CRITICAL ENVIRONMENTAL ASPECTS OF COOLING WATER SYSTEMS

Cooling systems can impact the environment several ways. The word "system" is chosen advisedly. Most components are interrelated and hence can and should be considered together for environmental optimization. It is significant to note that of the many plants reviewed to date, only one is so poorly sited that design of an environmentally acceptable cooling systems is virtually impossible.

The EIS review should consider as a minimum the following:

1. Rate of cooling water withdrawal, with respect to:
    a. Local and regional water supply and uses and the effect of proposed withdrawals thereon.
    b. Entrainment and subsequent kill of planktonic organisms in passing through the condenser.
2. Intake design and hydraulics with respect to entrapment and damage to fish.
3. Temperature rise across the condenser.
4. Effluent mixing zone.
    a. A maximum temperature of discharge increase in temperature above natural.
    b. Size and geometry.
5. Land requirements for cooling systems, particularly ponds.
6. Water loss.
7. Local meteorological effects such as fog or ice.
8. Drift characteristics and terrestrial impact.
9. Chemical or physical cooling water treatment program.
10. Blowdown.
    a. Cycles (multiples) of concentration and flowrate
    b. Treatment and/or disposal
11. Overall minimization of waste discharges to water, air, and land.
12. Cost implications of environmentally desirable refinements or alternatives.

GENERIC DEFICIENCIES OF ENVIRONMENTAL IMPACT STATEMENTS

Although the technical quality of draft statements differs widely, the major, or more frequently occurring, deficiencies are in five areas:

1. The staff preparing the statement ignores or does not desc proximal and cumulative waste sources, and presents the plant as dis- charging into virgin waters. An "area of influence" approach to environmental assessment is required.

2. Inadequate data or description of methodology are presentec in the draft or supplemental Environmental Reports for EPA's indepenc review and evaluation. EPA cannot accept unsupported statements such as "applicable water quality standards will be met" or "the 3°F isoth will encompass only 35 acres."

3. Alternative cooling systems are treated in a cursory manner Such treatment is justified only if the proposed system is obviously the best choice to protect the environment. Otherwise a thorough and accurate analysis of secondary environmental impacts and costs is required.

4. Data or conclusions presented on cooling system performance and secondary environmental impacts are obsolete or grossly inaccurate

5. Economic (benefit-cost) analysis of alternative systems is inadequate or inapplicable to system selection.

SECTION III
GENERAL PLANT ASSESSMENT

No two sites or plants are identical. Seldom, if ever, is a power plant located or designed with environmental protection as the primary objective function. This is not to say that some progressive utilities do not do everything reasonable to negate or minimize adverse impacts. It follows that such differences between plants affect the feasibility of various cooling alternatives, the choice among alternatives for maximum environmental protection, and the monetary costs.

As a first step in the review process, it is advisable for the reviewer to become familiar with the plant as a whole as described in the EIS and in backup material such as the utility's environmental report. Information pertinent to the cooling system evaluation is often found scattered throughout various EIS sections. All applicable information should be located.

The initial perusal should also be used to catalog general information affecting the acceptability of the cooling system choice. This includes such factors as hydrologic and meteorologic conditions, general water and land availability and use, recreation, etc.

In the general assessment, the reviewer considers the size of the generating unit or units covered in the statement and any additional units existing or planned at the site. He must also consider the plant's thermal output, the cooling water requirements, and the temperature rise across the condenser. The interfaces of the plant characteristics with cooling systems are described in two EPA contract reports prepared by Dynatech R/D Company[2] and Hittman Associates, Inc.[3]

Location characteristics such as hydrology, meteorology, topography, land area, and rural versus urban setting should also be considered because they can influence the cooling system choice. A few generalizations (which may not hold for any particular site) exemplify such relations:

1. If intake water is scarce or water appropriation is an issue, the cooling system should be designed to minimize water intake and consumption. Normally, once-through cooling is out and cooling towers or spray systems would be preferable over cooling pond construction because of the differential in water loss.

2. Meteorology controls the efficiency and limits of all cooling systems and influences their potential adverse environmental effects.

3. There are several regional generalizations related to geography or topography. Along much of the West Coast and some of New England, deep, cold ocean receiving water can be reached by a discharge pipe in a short distance and at reasonable cost. In such cases, the rapid mixing attributes of submerged diffusers on a once-through system might be exploited. Conversely, most of the coastal waters of the Gulf of Mexico and the southeastern United States are too shallow for submerged diffusers to be either effective or economical. In the Applachian Highlands natural draft towers are usually selected over mechanical draft towers to get the exhaust plume up over the ridges and minimize contribution to characteristic valley fog. Conversely, in the hurricane or tornado prone Atlantic Seaboard or Midwestern Plains, the comparative structural stability of mechanical and natural draft towers can favor the former. In the Colorado River Basin and other parts of the arid west, the probability of fogging problems is remote, but water availability and salinity are prime water quality problems; in this case, cooling system selection and operation should be developed to minimize consumptive use of water and salinity contribution. In fact, dry or wet/dry towers on mine mouth plants are not beyond the pale of economic feasibility in the region.

4. The significance of land availability and urban versus rural setting are rather obvious. Usually the exclusion zone and other site limitations for nuclear power plants provide ample space for closed-cycle

cooling systems, but attention must be given to items such as tower height, proximity to airports, and the probability for fogging of major highways.

5. Added benefits may accrue to cooling ponds from recreational use. On the other hand, such large areas are required for nuclear power plants that close attention must be given to other land use penalities and to the efficiency of the pond design (see Section IV); the least -cost design--measured in terms of construction--can be wasteful both in terms of land and water resources. Ponds are somewhat unique among cooling systems in that electric utilities may in some locations acquire under condemnation proceedings land that will actually appreciate in value over the life of the plant.

In addition to plant and site characteristics, the stage of design or construction is an important factor. A plant ready to go on line or for which most components are installed cannot be sent back to the drawing board. The draft review must be directed to the question, "What is reasonable for this plant at this time?"

The reviewer will usually find that much more information is given relative to the cooling system selected by the utility than to alternative possibilities. This is more acceptable in some cases than others. For example, when commitments and funding for design, equipment, or construction have already been made, the cost-benefit ratio has been biased in favor of the chosen system; it is then very difficult to justify a complete system change unless environmental effects are totally unacceptable. In this case, it is most important to place primary review emphasis on the design and operation of the chosen system to ensure that the utmost environmental compatibility is achieved under the circumstances.

In cases where significant commitments and funding have not been made toward a specific design, a more unbiased situation exists and the reviewer should evaluate all possible alternatives in a thorough and like manner. This will require more back-up information on all systems so that a truly optimum system may be obtained.

After initial familiarization with all available information and general assessment of broad considerations described in this Section, the reviewer can proceed with the more detailed evaluation of the proposed cooling system and its alternatives.

SECTION IV
COOLING SYSTEMS

A. INTRODUCTION

Thermal power plant cooling systems contain three basic elements:

1. An intake for supplying cooling water to the power plant.
2. A condenser where the turbine exhaust steam is condensed at low temperature and pressure while transferring the waste heat to the cooling water.
3. A device or mechanism for transferring this waste heat to the atmosphere (and finally to the ultimate sink--outer space).

These three elements should be designed to "match" the steam turbine in an optimum manner to minimize the cost of producing electric power and, at the same time, prevent adverse environmental effects[4]. In evaluating the environmental effects of a power plant cooling system, most of the attention is focussed on the third element--the mechanism used to transfer the waste heat from the cooling water to the atmosphere.

In practice, there are three basic methods of dissipating the waste heat to the atmosphere:

1. Closed-cycle cooling--this method requires an off-stream cooling device (i.e., pond, tower, spray system) to transfer the waste heat to the atmosphere. The cooling water is recycled through the cooling device after each pass through the condenser, and only a small portion of the cooling water (blowdown) is discharged to an adjacent water body or to an additional treatment facility.

2. Once-through cooling--in this method the cooling water is pumped from an adjacent water body (i.e., river, lake, reservoir,

ocean, etc.) through the condenser and discharged back to the water body. The waste heat is transferred to the atmosphere from the heated receiving water.

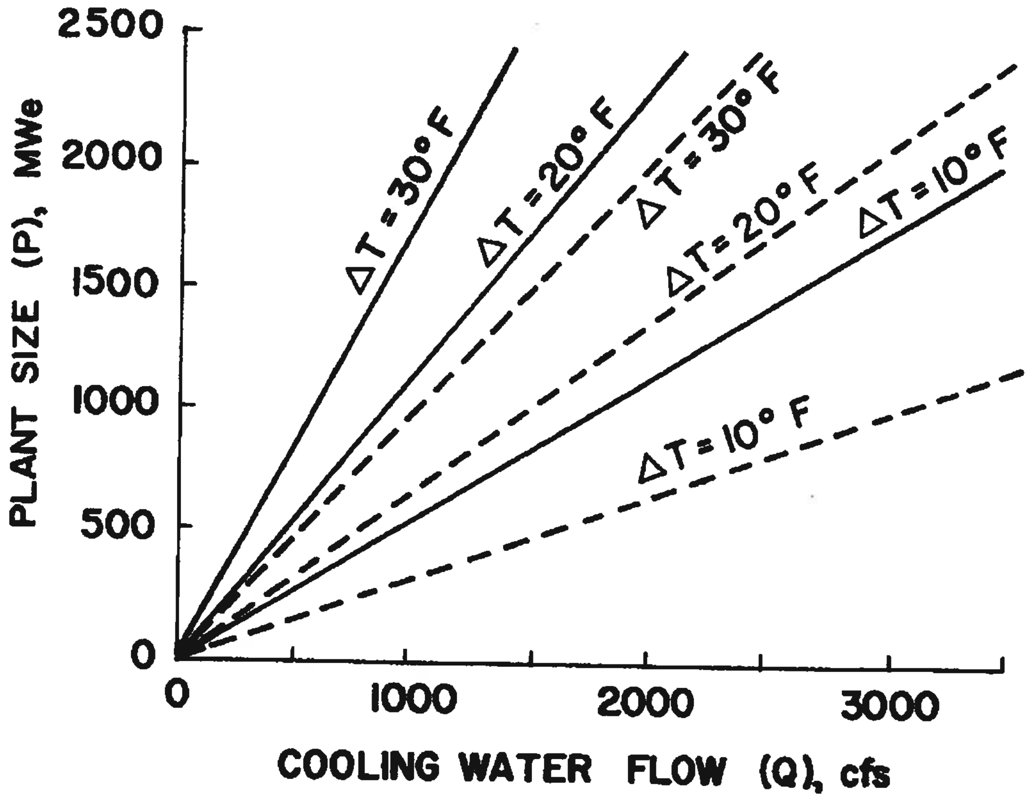
3. Combination cooling--this mode utilizes an off-stream cooling device to dissipate a portion of the waste heat load. The cooling water flow from this device may be sent directly to the receiving water or it may be recycled back to the condenser.

For any given power plant, the method of dissipating the waste heat dictates the amount of water flow through the intake. For once-through systems, a continuous flow of a thousand or more cfs is required for large nuclear power plants (see Figure 2)[5]. For closed-cycle systems, intake requirements are substantially less. Other water requirements (e.g. - service water, boiler make-up, etc.) are low in volume and can generally be disregarded in an evaluation of the waste heat disposal problem.

FIGURE 2
COOLING WATER REQUIREMENTS FOR FOSSIL AND NUCLEAR POWER PLANTS

--- NUCLEAR, η_t = 33 %, IN-PLANT LOSSES = 5 %

— FOSSIL, η_t = 40% IN-PLANT AND STACK LOSSES = 15 %



ΔT = CONDENSER TEMP. RISE
η_t = PLANT THERMAL EFFICIENCY

B. INTAKES

Cooling water intake structures for thermal power plants encompass a wide variety of designs. In general, however, intakes usually consist of:

1. A log boom to prevent large floating material from entering the intake area.

2. A trash rack to hold back medium size (approximately 4") debris.

3. A wire mesh screen to prevent the passage of small debris and fish through the condenser.

Variations of these standard components include the lack of log booms on submerged offshore intakes and the use of skimmer walls on canal type intakes.

The problems associated with the intake of large volumes of cooling water include:

1. The entrainment of organisms and subsequent passage through the power plant cooling system where, depending on design, time and temperature of exposure, and species of organisms, a variable fraction are killed.

2. The impingement of fish on intake screens.

3. The entrapment of fish in the intake structure (i.e., screenwell).

Intakes can and should be designed to reduce these effects.

The major environmental design problem is the prevention of fish kills at the intake. Naturally, the best technique is to minimize the number of fish which enter the intake area. This can be accomplished by locating the intake in an area of low fish population, reducing the velocity of the intake water, and eliminating areas where fish can be trapped (e.g., screenwells with no fish by-pass). If fish do go as far as the screens, provisions for fish by-pass or collection and harmless removal should be provided.

It should be noted that wire screens are used to "protect" the power plant, not the fish. Vertical travelling screens (the most common type) are usually moved only after a specified pressure drop across the screen face is reached. Thus, a fish may be impinged on the screen for several hours before removal, and thus suffer damage and possible death. In many cases, whether the fish is alive or not does not matter, since the material on the screen is often disposed of in a manner which causes mortality. Therefore, fish should be by-passed or collected prior to impingement on such screens. If continuously moving screens are employed, a suitable fish removal technique might be developed.

Several general criteria can be suggested for proper intake design and placement:

1. Place the intake to avoid recirculation of the discharged cooling water. Recirculation will cause increased thermal stress to entrained organisms as well as reduce the plant's thermal efficiency. If intake and discharge points must be separated by considerable distance to prevent recirculation, overall biological damage is reduced if the intake is the long leg and the discharge is the short leg of the cooling water system.

2. Avoid placing the intake in an area of high biological value (e.g., spawning, rearing, migration areas).

3. Reduce intake velocities to below 0.5 ft/sec at the trash rack to enable fish to escape the screenwell. Note that the use of fish avoidance techniques such as electrical fish "screens," air bubble "curtains," light, and sound have proven generally ineffective under field conditions (e.g., air bubbles and electric screens at Indian Point[6]). Thus, low velocity is the only effective method, at present, to prevent fish from entering the intake.

4. For off-shore, submerged intakes, velocity caps should be used to reduce fish entrainment. Note, however, that the effectiveness of such devices is not universally accepted[6].

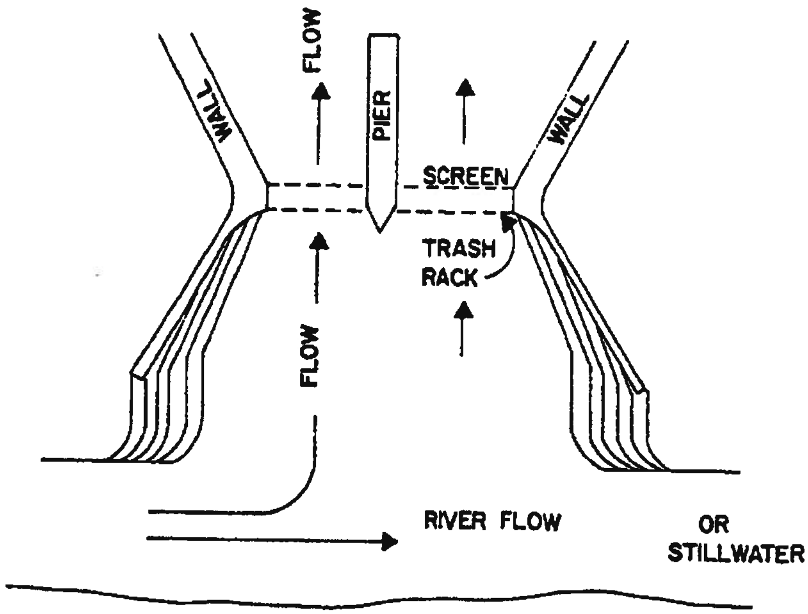
5. For shoreline intakes, avoid breaks in the natural shoreline and avoid the use of intake canals, since both may act as "fish traps."

6. Fish by-pass or collection and removal facilities should be provided in the screenwell. Stationary louvers have proved effective in guiding fish and could be employed as a fish by-pass system.

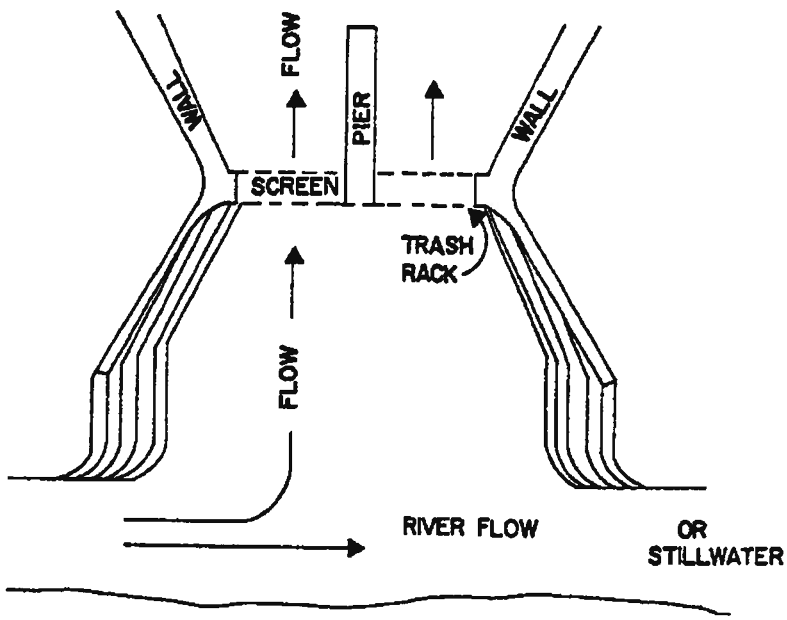
7. Travelling screens (mesh size of 3/8" or less) should be employed. Continuous movement with suitable fish removal procedures is preferred over intermittent movement. Note that horizontal traveling screens, now under experimental investigation, may prove effective as fish by-pass devices.

As an aid in assessing the adequacy of a given intake design, the reader is referred to Figures 3 through 5 taken from a report prepared by the State of Washington Water Research Center under an EPA grant[7]. These figures indicate both good and bad intake design configurations.

All other factors being equal, biological damage due to condenser passage is directly proportional to the volume of make-up water withdrawn. Thus, closed-cycle systems will cause less damage of this type than once-through systems. The following portion of this Section includes discussion of intake flow rates for closed-cycle cooling systems.



RECESSED SCREEN
NO BY-PASS
POOR DESIGN



SMOOTH FACED SCREEN
NO BY-PASS
SOMEWHAT BETTER DESIGN

FIGURE 3
INTAKE DESIGNS [7]

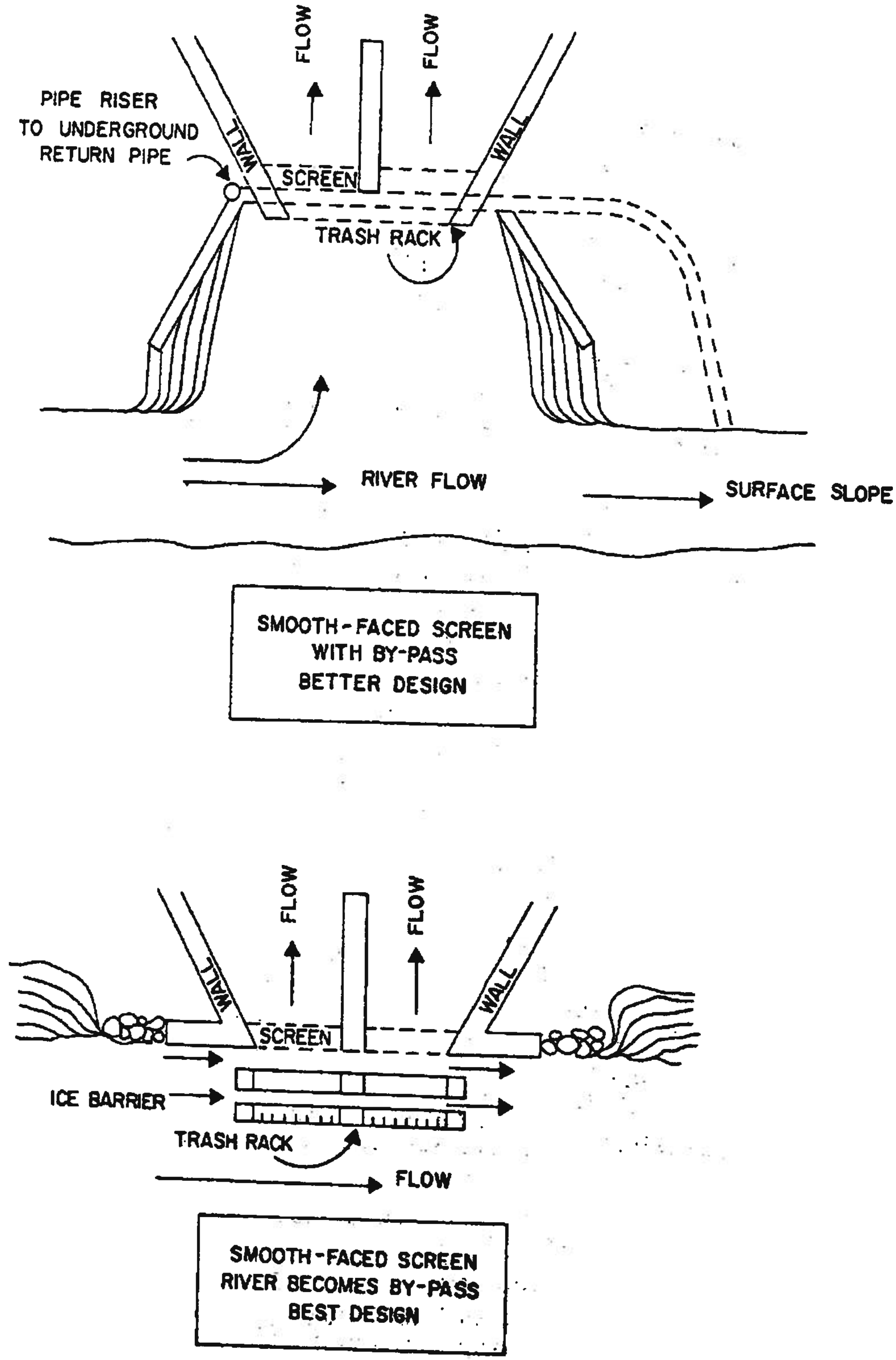
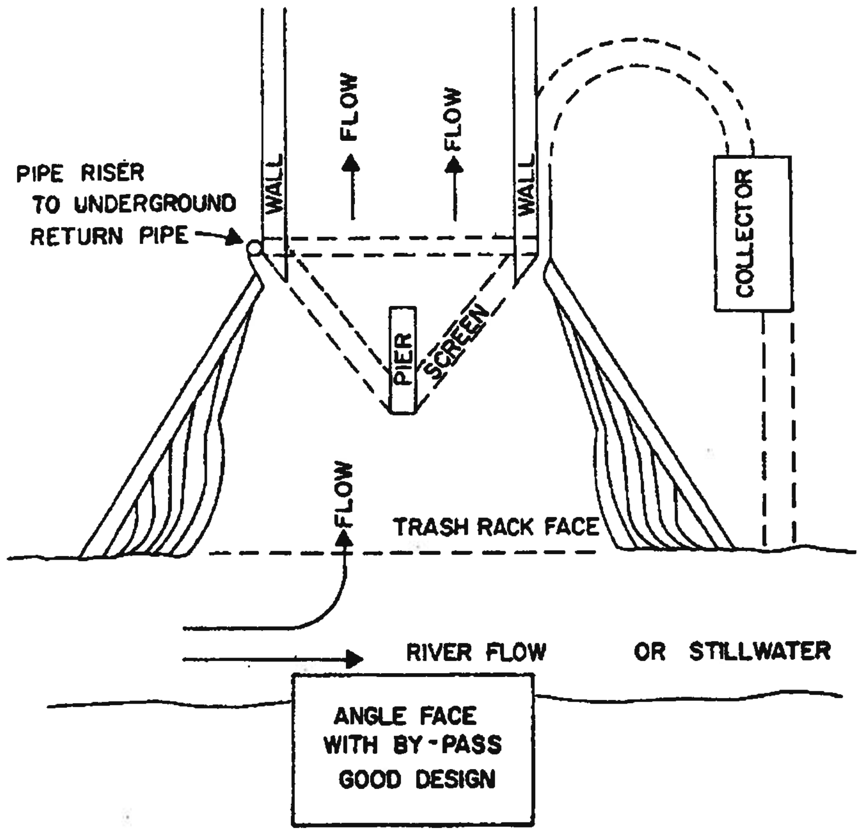


FIGURE 4
INTAKE DESIGNS [7]



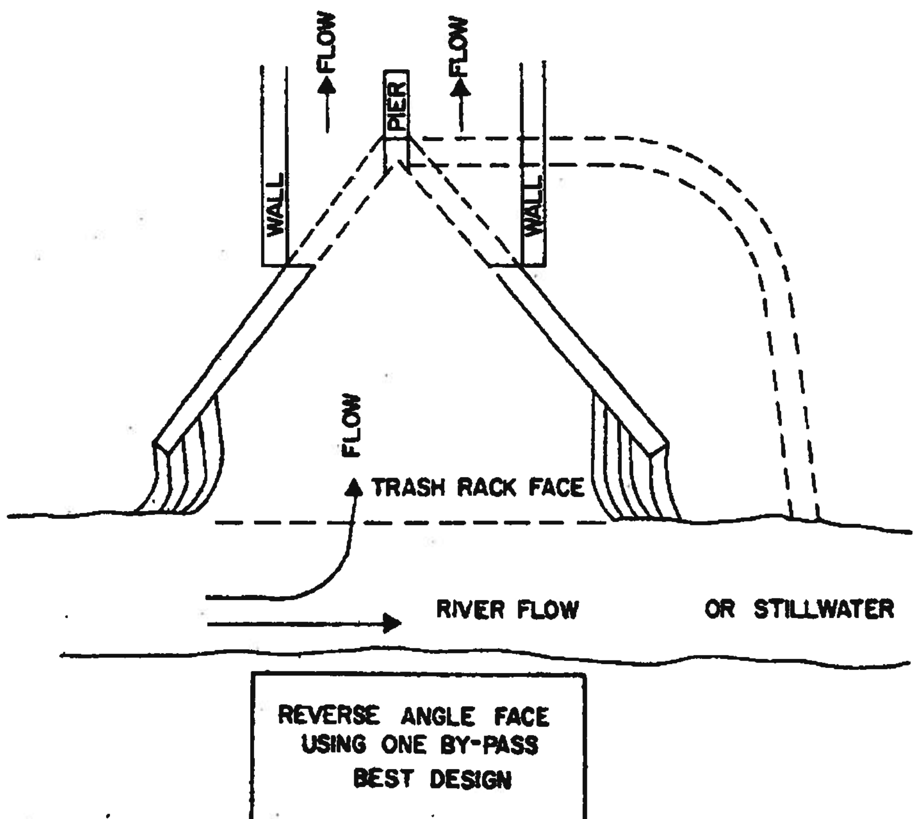


FIGURE 5
INTAKE DESIGNS [7]

Intake icing should also be considered. Severe icing could cause flow restrictions and/or structural damage, so de-icing procedures are sometimes employed. Such procedures generally include the discharge of warm condenser effluent in the vicinity of the intake (i.e., purposeful recirculation). If such warm discharges act as fish attractants, increased entrainment problems could occur. In addition, rapid "shut off" of this heated discharge at the conclusion of the de-icing program could cause cold shock to nearby organisms. Thus, the EIS reviewer should carefully evaluate proposed de-icing plans.

For further information on intake design considerations, the reviewer should consult the reports by Hanford Engineering Development Laboratory[6], State of Washington Water Research Center[7], and Johns Hopkins[8].

C. CLOSED-CYCLE COOLING

Several types of cooling devices are available for use in a closed-cycle cooling system, including:

1. Wet cooling towers (mechanical or natural draft).

2. Cooling ponds (flow-through or completely mixed).

3. Spray cooling systems (canal or pond type).

4. Dry cooling systems (direct or indirect; mechanical or natural draft).

5. Wet/dry cooling towers (mechanical or natural draft).

In reviewing an EIS for a plant using closed-cycle cooling, three basic factors should be considered:

1. Operating characteristics

2. Water consumption

3. Environmental effects.

Following is a discussion of these factors relating to the above cooling devices.

Wet Cooling Towers

Operating Characteristics -

Wet cooling towers, both mechanical and natural draft, dissipate the majority (approximately 75 percent) of the waste heat in the cooling water by latent heat transfer (evaporation) with the remainder lost by sensible heat transfer (conduction-convection). The wet-bulb temperature of the ambient air is the minimum temperature to which the water can be cooled. The tower is designed to cool the water to some specified temperature above the wet-bulb temperature.

The approach of the tower is defined as the difference between the cool outlet water and the wet-bulb temperature. Approaches of 15-20°F are generally used. The cooling range is the difference between the hot inlet water temperature and the cool outlet water temperature. In a closed-cycle system the range equals the condenser temperature rise and is generally between 25 and 40°F. Thus, given information on the approach, range, and wet-bulb temperature, one can determine the inlet (hot leg) and outlet (cold leg) tower temperatures.

In evaluating these temperatures, one must differentiate between design conditions and average conditions. Design wet-bulb temperature is often designated as not to be exceeded more than a fixed percentage (say 5%) of the time during the summer months. It represents a severe condition. Average conditions will be much more moderate. For example, a particular tower may be designed for a 15°F approach, a 30°F range, and 75°F wet-bulb temperature. This would provide a 120°F tower inlet temperature with a 90°F outlet temperature. Under more moderate off-design conditions, much cooler temperatures will be realized.

In reviewing an EIS, substantial operating and design data with respect to heat dissipation are not required. It is generally sufficient to assume that the particular tower design selected will be adequate to dissipate the waste heat load. However, information on the water balance of the tower is critical to the review process.

For more details on cooling tower operation and design, the reviewer is referred to Marley[9], McKelvey & Brooke[10], and Dynatech[11].

Water Consumption -

Since wet cooling towers operate primarily by latent heat transfer, significant quantities of water are consumed by evaporation. Two rough methods estimating the water loss by evaporation are available.

1. Assume that 75 percent of the waste heat is dissipated by latent heat transfer. Thus, using a value of 1,000 Btu/lb for the latent heat of vaporization for water, one can easily calculate the approximate evaporative loss on the basis of total waste heat to the cooling water. For example, a 1,000 MWe nuclear power plant with a thermal efficiency of 33 percent and 5 percent in-plant losses discharges 6.4×10^9 Btu/hr to the cooling water. Thus, one can compute the tower evaporation loss as:

$$(6.4 \times 10^9 \text{ Btu/hr})\ (75\%)/(1000 \text{ Btu/lb}) = 4.8 \times 10^6 \text{ lb/hr or } 21.4 \text{ cfs.}$$

(Conversion factor: $1 \text{ cfs} = 0.225 \times 10^6$ lb/hr)

2. One can also compute the evaporation loss given data on cooling water flow rate and condenser temperature rise. Using the same assumptions as above, the evaporation loss is equal to 0.75 percent of the flow rate per 10°F drop (or rise) in cooling water temperature. Thus, for the example shown above (temperature rise equals 30°F, flow rate equals 950 cfs, see Figure 2) the evaporation loss equals:

$$(0.75\%)\ (950 \text{ cfs})\ (30/10) = 21.4 \text{ cfs.}$$

Both of these calculations were conducted assuming the plant was operating under full load. To compute the average annual evaporation loss, one should multiply this value by the annual plant load factor. For example, given the same data as above with an annual load factor of 82 percent, the average annual evaporation loss would be:

$$(21.4 \text{ cfs})\ (82\%) = 17.5 \text{ cfs}$$

Finally, to compute the maximum (or design) evaporation rate under high dry-bulb temperature conditions which will minimize convective heat loss, one should assume that 95 percent of the waste heat in the cooling water is lost by evaporation. Thus, the maximum evaporation rate for the above example would be:

(21.4 cfs) (95/75) = 27.1 cfs

Note that the methodology presented above is only approximate, but it should enable the reviewer to evaluate the EIS data on evaporation in a reasonable manner. A more detailed technique is presented by Hittman Associates, Inc.[3]

Another mechanism by which water is lost from a wet cooling tower is drift. As the water falls down through the tower packing and below, it is possible for small droplets to become entrained in the air stream moving out through the tower top. These droplets have the same chemical characteristics as the cooling water in the system. The use of drift eliminators above the packing can reduce the drift loss substantially. State-of-the-art design can be used to obtain drift losses of 0.005% of the circulating flow rate for mechanical draft units and 0.002% for natural draft towers[12]. In no case should the drift loss exceed 0.01% for modern, well-designed towers. The only exception would be for a tower designed to maximize the drift loss in order to reduce the blowdown volume (see below).

The process of evaporation in a wet cooling tower causes an increase in the concentration of dissolved and suspended material in the circulating water. In order to prevent a build-up of undesirably high concentrations in the system, a small portion is continually or intermittently bled from the system. This stream is called blowdown. The blowdown (B) is a function of the available make-up (B+D+Ev) water quality and is related to evaporation (Ev) and drift (D) in the following manner:

$$C = (B + Ev + D)/(B + D) \qquad (1)$$

In this equation, C equals cycles of concentration, a dimensionless number which expresses the number of times the concentration of any constituent is multiplied from its original value in the make-up water. (It does not represent the number of passes through the system). B, Ev, and D are expressed in consistent units (e.g. percent of circulating water flow rate or actual flow rate).

For average make-up water quality, conventional practice sets the value of C between 4 and 6. For extremely high makeup quality water (or treated water) C values of 15 and above are possible. For salt or saline water, C values as low as 1.2 to 1.5 may be required. This is usually not a materials or operating limit, but rather a means of preventing biological damage from blowdown salinity.

The chemical characteristics of the recirculating water (treated or untreated) determine the maximum C value. Table 1 provides some "rules of thumb" to be used in establishing the maximum C value. Note that the $C_{subscript}$ designations used in the table represent individual constituent concentrations and should not be confused with C, cycles of concentration used above.

Table 1

RECIRCULATING WATER QUALITY LIMITATIONS

Characteristic	Limitation	Comment
pH and Hardness	Langelier Saturation Index = 1.0	Langelier Saturation Index = pH-pHs where
pH and Hardness with addition of proprietory chemicals for deposit control.	Langelier Saturation Index = 2.5	pH = measured pH pHs = pH at saturation with $CaCO_3$ See Sisson[13] for nomograph solution.
Sulfate and Calcium	$(C_{SO_4}) \times (C_{Ca}) = 500{,}000$	C_{SO_4} = concentration of SO_4 in mg/l C_{Ca} = concentration of Ca in mg/l as $CaCO_3$
Silica	$C_{SiO_2} = 150$	C_{SiO_2} = concentration of SiO_2 in mg/l
Magnesium and Silica	$(C_{Mg}) \times (C_{SiO_2}) = 35{,}000$	C_{Mg} = concentration of Mg in mg/l as $CaCO_3$

The "Limitation" column in Table 1 indicates the maximum value allowed in the recirculating water for each chemical characteristic given. The maximum C value would be established when any one of the "Limitations" is exceeded. Note that this table provides "rule of thumb" estimates, which may not be applicable to unique water quality problems.

The equation for C can be rewritten for blowdown (B):

$$B = \frac{Ev-D(C-1)}{C - 1} \qquad (2)$$

In order to minimize the total amount of make-up water by the cooling tower, one should operate at as high a C value as possible. The following data were computed using the above equation and illustrate the effect of C on the blowdown and make-up flow rates:

C (cycles of concentration)	Blowdown (cfs)	Make-up (cfs)
1.2	107	128
1.5	42.8	64.2
2.	21.4	42.8
5.	5.3	26.7
10.	2.3	23.7
20.	1.1	22.5

This table was developed assuming an evaporation rate (Ev) of 21.4 cfs and a drift rate (D) of 0.05 cfs (0.005% of 950 cfs).

There are several advantages to maintaining a high C value:

a. Minimizing the make-up water requirement, thus reducing the number of organisms entrained in the cooling water.

b. Minimizing the volume of blowdown water to be discharged.

c. Reducing the size and cost of make-up and blowdown handling facilities (i.e., pumps, pipes, screens, etc.).

Environmental Effects -

In addition to the consumption of water, wet cooling towers can cause potential adverse side effects due to the vapor plume, drift, and blowdown.

Cooling tower plumes have the potential for causing or increasing local fogging or icing conditions. The key word here is potential, since in most cases, no such problems will occur. Fog is defined here as a condition where vision is obstructed.

Cooling towers do produce visible plumes; however, plumes are normally not a problem unless they reach the ground. Under normal conditions, cooling tower plumes rise due to their initial velocity and buoyancy and rarely intersect the ground before they are mixed with the ambient air and dissipated. However, under adverse climatic conditions (i.e., high humidity and low temperature), the moisture could produce a fog condition if it were trapped in the lower levels of the atmosphere, such as during a period of high atmospheric stability (i.e., an inversion). In almost all cases, natural draft towers are less likely to cause fogging problems than mechanical draft towers. Mechanical draft towers may cause problems, but in most cases fogging and icing would be on-site (i.e., within 1000-2000 ft of the tower). Also the limited vertical mixing occurring during neutral stability conditions could limit plume dispersion.

Several analytical techniques have been used to evaluate the fog potential of cooling tower plumes:

1. One method is to estimate the concentration of liquid water added by the cooling tower plume to the ambient atmosphere in the vicinity of the cooling tower. EG&G[14] indicates that the amount of liquid water added by cooling towers is normally between 0.1 and 0.5 grams per cubic

meter, one or more kilometers downwind from cooling towers. Thus, any time the difference between the liquid water content of saturated air and the liquid water content of the ambient air is less than 0.1 to 0.5 grams per cubic meter, there is a potential for fog conditions within the specified distance from the cooling tower. Thus, a method which can be used to determine whether or not fog may occur for a particular tower is to evaluate the percent of time that the ambient air contains a liquid water concentration sufficiently close to the saturation liquid water content (i.e., within 0.1 to 0.5 grams per cubic meter). This method was used in analysis of potential fog from cooling towers in the vicinity of Lake Michigan and is described in detail in a 1970 FWQA report[4].

2. Another method involves approximating the dilution of a cooling tower plume by the ambient atmosphere using standard methods of evaluating smoke plumes from a point source. In this method one computes the total amount of liquid water added by the cooling tower and determines the downwind mixing with the ambient atmosphere by using the classical Gaussian dispersion models available in standard textbooks on air pollution[15]. This method was also used in evaluating potential fog from cooling towers in the vicinity of Lake Michigan[4].

3. Also available are mathematical models of cooling tower plumes which take into account the rise of the plume using information on cloud physics, such as liquid-vapor phase change reactions, liquid water content, and precipitation. To date, such models lack complete verification with field data and are thus subject to engineering judgment in their use. References on such models include EG&G[14], Hanna[16, 17] and Sierra Research[18].

4. Finally, empirical methods are also used in the prediction of potential fog from wet cooling towers. These methods utilize field observations from existing towers and correlation with meteor-olgical information. TVA has developed such models using data from their Paradise plant[19].

In reviewing that portion of the EIS describing the fogging potential of a cooling tower, one should assess the duration (e.g., hours per year or percent of time), frequency (number of occurances per year), and location (e.g., highway, airport, residential or industrial area) of the predicted episodes. A careful check of the methodology coupled with a critical evaluation of the meteorological data is required. In addition, the description of the methodology used for prediction should be sufficiently detailed to allow the reviewer to prepare independent calculations. In many cases, only a cursory analysis is provided, which may be sufficient if the site is not subjected to prolonged periods of high humidity and low temperature. A final point to consider is a possible interaction between the cooling tower plume and nearby point sources of air pollution from industrial plants. Potential problems such as acid mist may occur due to such interactions and would require further analysis.

As a rough check on the fog potential of power plant cooling towers, Figure 6 may be used. According to EG&G[14], this map provides a "qualitative classification for the potential for adverse cooling tower effects." The following criteria were used by EG&G[14] in developing this map.

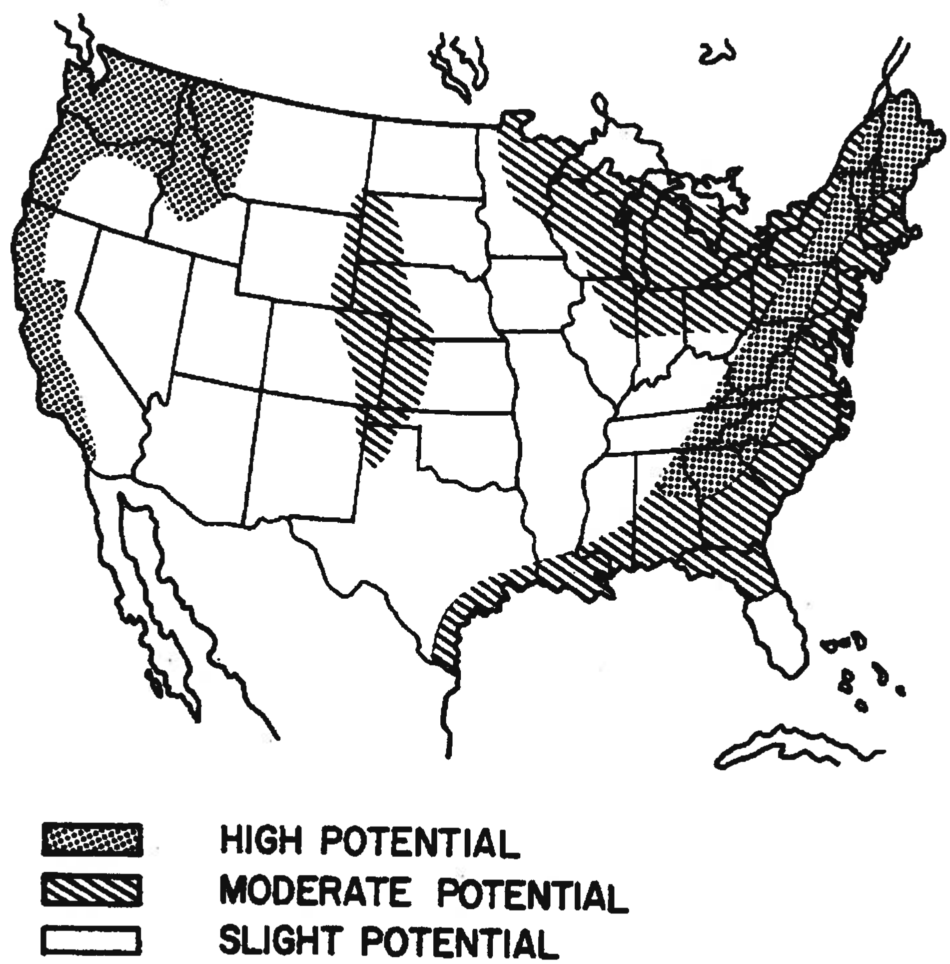
a. High Potential.

Regions where naturally occuring heavy fog is observed over 45 days per year, where October through March the maximum mixing depths are low (400-600 meters), and the frequency of low-level inversions is at least 20-30 percent.

b. Moderate Potential.

Regions where naturally occuring heavy fog is observed over 20 days per year, where October through March the maximum mixing depths are less than 600 meters, and the frequency of low-level inversions is at least 20-30 percent.

FIGURE 6
GEOGRAPHICAL DISTRIBUTION OF POTENTIAL ADVERSE EFFECTS FROM COOLING TOWERS



c. Low Potential.

Regions where naturally occuring heavy fog is observed less than 20 days per year, and where October through March the maximum mixing depths are moderate to high (generally greater than 600 meters).

It must be emphasized that the classifications of "high," "moderate," "low" potential are relative rather than absolute descriptors. Thus, a cooling tower located in an area of "high potential" would be more likely to cause a fogging problem than one located in an area of "moderate" or "low potential," but whether or not the tower ever produced a fog problem would depend upon specific site and climatic conditions.

During sub-freezing weather, fogging and drift conditions may result in icing. As with fog, experience with large power plant cooling towers has not resulted in major icing problems. Methods of predicting the accumulation of ice due to cooling tower plumes are not widely reported. In general, icing caused by plumes will be a low-density accumulation of granular ice tufts and is unlikely to cause damage due to its weight. A problem to be considered would be associated with the danger of icy roads. It should be noted that icing caused by the plume will be generally limited to vertical surfaces, and icing of horizontal roadways will be less severe. When such conditions may occur, the EIS should contain data on icing frequency, duration, and location. Also, suggestions for preventing safety problems should be made (i.e., plans for caution signs and/or lights).

As discussed above, drift is entrained water that is carried out of the top of a wet cooling tower in liquid droplets rather than as vapor. While some objection has been raised concerning the environmental effects from freshwater cooling towers, more vocal opposition has been expressed to large salt water towers because of the potential damage to the surrounding area from fallout of salt discharged to the atmosphere in drift particles.

In addition to data on the amount of drift given previously, some information is also available on the size of drift particles. Environmental Systems Corporation[12] conducted measurements on a mechanical draft tower (drift rate 0.005%) which showed that the size of particles contributing the majority of the total mass ranged from about 100 to more than 300 microns in diameter. Particles less than 100 microns in diameter contributed only about 5 percent of the total drift mass. On the other hand, measurements taken a few feet above the eliminators in a natural draft tower showed few particles greater than 100 microns.

In order to evaluate the environmental effect of drift, one must be able to predict the amount of deposition on the surrounding landscape. Unfortunately, the state-of-the-art is inadequate to precisely quantify the fallout characteristics of cooling tower drift; however, qualitative deductions are possible. Papers by Stewart[20] and Hosler, et. al.[21] can be used to provide such qualitative deductions. In general, these papers indicate that the majority of the drift particles will fall out within 2,000 feet of a cooling tower under normal conditions.

Two basic problems prevent one from making a firm judgment on the severity of environmental problems associated with cooling tower drift from salt water towers. First of all, only limited and qualitative information is available on the effect of various levels of salt concentration on various species of vegetation. Second, in order to effectively evaluate the cooling tower drift effect, information on the salt concentration in the ambient atmosphere and its deposition must be obtained. Such data are generally unavailable.

While limited experience has been gained in the operation of salt water cooling towers, no adverse environmental effects have been experienced at a tower which has been operating in Fleetwood, England, for several years. In addition, cooling towers associated with oil refineries in Texas and New Jersey have been operated on salt water for some time without objectionable effects. However, these examples should not be cited as proof, at the present time, that salt water towers can be used at *any* given site without drift damage to *any* type of surrounding. Finally, large natural draft cooling towers have been planned for operation on salt water at the Chalk Point power plant in Maryland and the Forked River nuclear power plant in New Jersey.

Two excellent references which discuss the problem of drift from salt water cooling towers are a report by Westinghouse[22] and the Forked River EIS[23].

The environmental effects of *blowdown* and its treatment and disposal are discussed later in Section V of this report.

Cooling Ponds

Operating Characteristics -

Cooling ponds are simply open bodies of water which use the natural heat exchange processes of evaporation, radiation, and conduction-convection to dissipate a power plant's waste heat load. The design of a cooling pond depends upon the plant size, the local meteorology, and the pond type--mixed or flow-through. *Mixed ponds* have uniform surface temperatures; *flow-through* (or slug flow) *ponds* are designed to exhibit a temperature decay from the warm inlet to the cool outlet. Flow-through ponds require smaller surface areas than mixed ponds.

The determination of cooling pond area requires an analysis of the pond's energy budget. An approximate analysis of the energy budget can be used by the EIS reviewer to calculate pond size. This method is referred to as the equilibrium temperature technique and involves a one-dimensional exponential temperature decay equation. Assuming a flow-through pond, the pond performance is described by:

$$T_{out} = (T_{in} - E)\ \exp\ (-0.505KA/\rho C_p Q) + E \qquad (3)$$

where T_{out} = pond outlet temperature, °F

T_{in} = pond inlet temperature, °F

E = equilibrium temperature, °F

K = energy exchange coefficient, Btu/day ft^2 °F

Q = cooling water flow, cfs

ρ = water density, lb/ft^3

C_p = specific heat, Btu/lb°F

A = pond surface area, acres

K and E values are basically functions of meteorological conditions. Methods of computing these parameters are found in Edinger and Geyer[24] and in the Industrial Waste Guide on Thermal Pollution[25]. Brady, et. al.[26] provide approximate techniques for computing K and E values. Also, values of K and E for average and extreme meteorological conditions are contained in a report by Vanderbilt[27] for various locations throughout the United States. K and E values should be averaged over the time of passage through the pond, which is usually at least a week.

The above equation can be simplified in order to provide direct computation of pond area. Given a water density (ρ) of 62.4 lb/ft^3 and specific heat (C_p) of 1 Btu/lb°F and solving for A gives:

$$A = (123Q/K)\ln\left[(T_{in}-E)/(T_{out}-E)\right] \qquad (4)$$

Defining:

T_{out} - E = cooling pond "approach" and

$T_{in} - T_{out}$ = condenser $\underline{\Delta T}$ for a closed cycle pond, equation 4 can be rewritten as:

$$A = \frac{123Q}{K} \ln \left(\frac{\Delta T + \text{Approach}}{\text{Approach}}\right) \qquad (5)$$

A graphical representation of this equation is presented in Figure 7 for a 1,000 MWe nuclear power plant (η_t = 33%, in-plant losses = 5%). Q and ΔT values were obtained from Figure 2. Three values of K and two "approach" levels are provided. Note that pond size decreases with increasing values of K, ΔT, and approach (with all other factors being constant). The effect of higher waste heat loads at a higher "approach" due to an increase in plant heat rate is not represented. Figure 8 and Table 2 provide information on the relationship between pond size and pond inlet water temperature for various regions of the U.S. under design summertime conditions for a 1,000 MWe nuclear power plant (η_t = 33%, In-plant losses = 5%). Note that as the inlet temperature increases, the required pond area decreases.

Table 2. K AND E VALUES[29]

Location	Location in U. S.	K (Btu/ft^2-day °F)	E (°F)
Portland, OR	Northwest (NW)	128	87
Dallas, TX	South Central (SC)	202	92
Bakersfield, CA	Southwest (SW)	166	88
Atlanta, GA	Southeast (SE)	132	98
Boston, MA	Northeast (NE)	184	87
Chicago, IL	Great Lakes (GL)	203	89

FIGURE 7
COOLING POND SIZE VS. ΔT

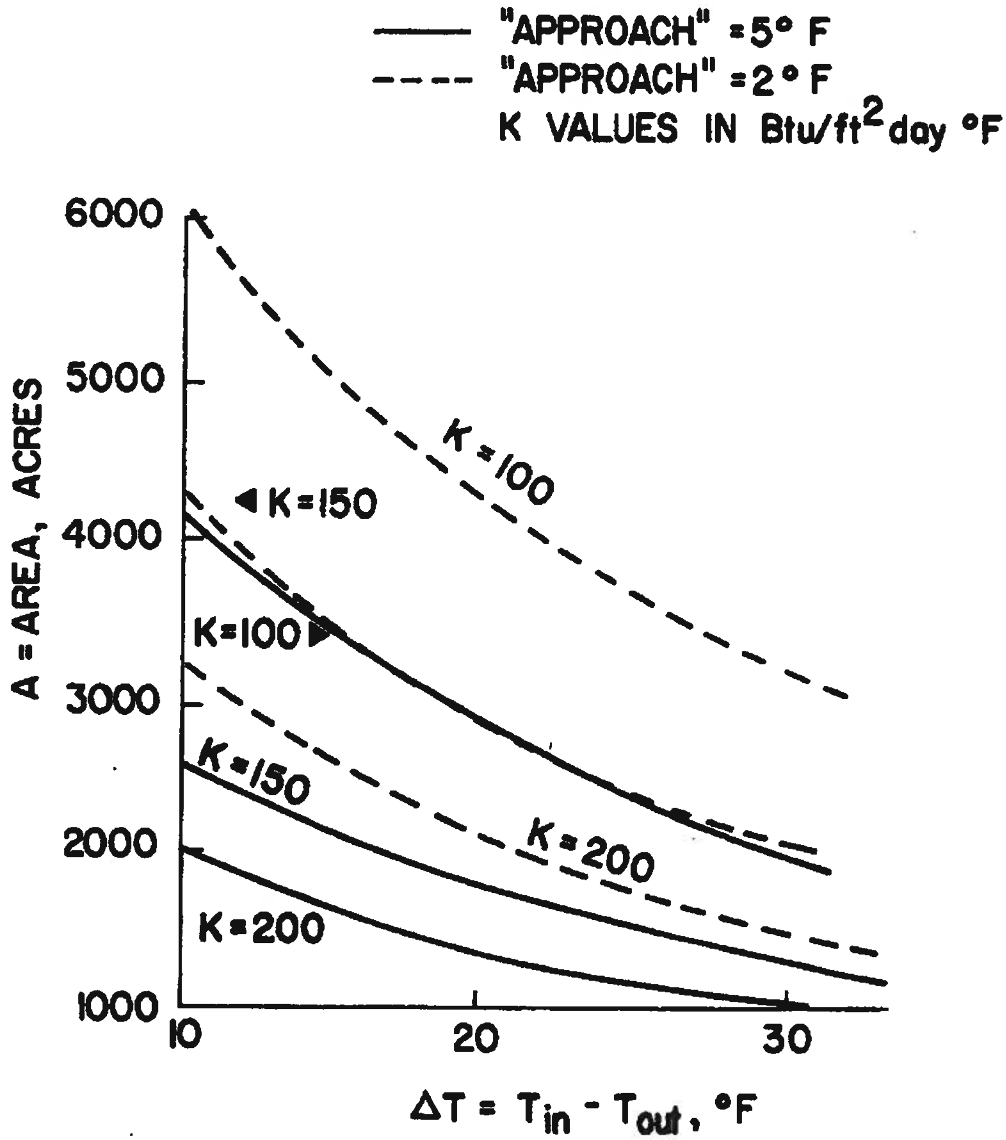
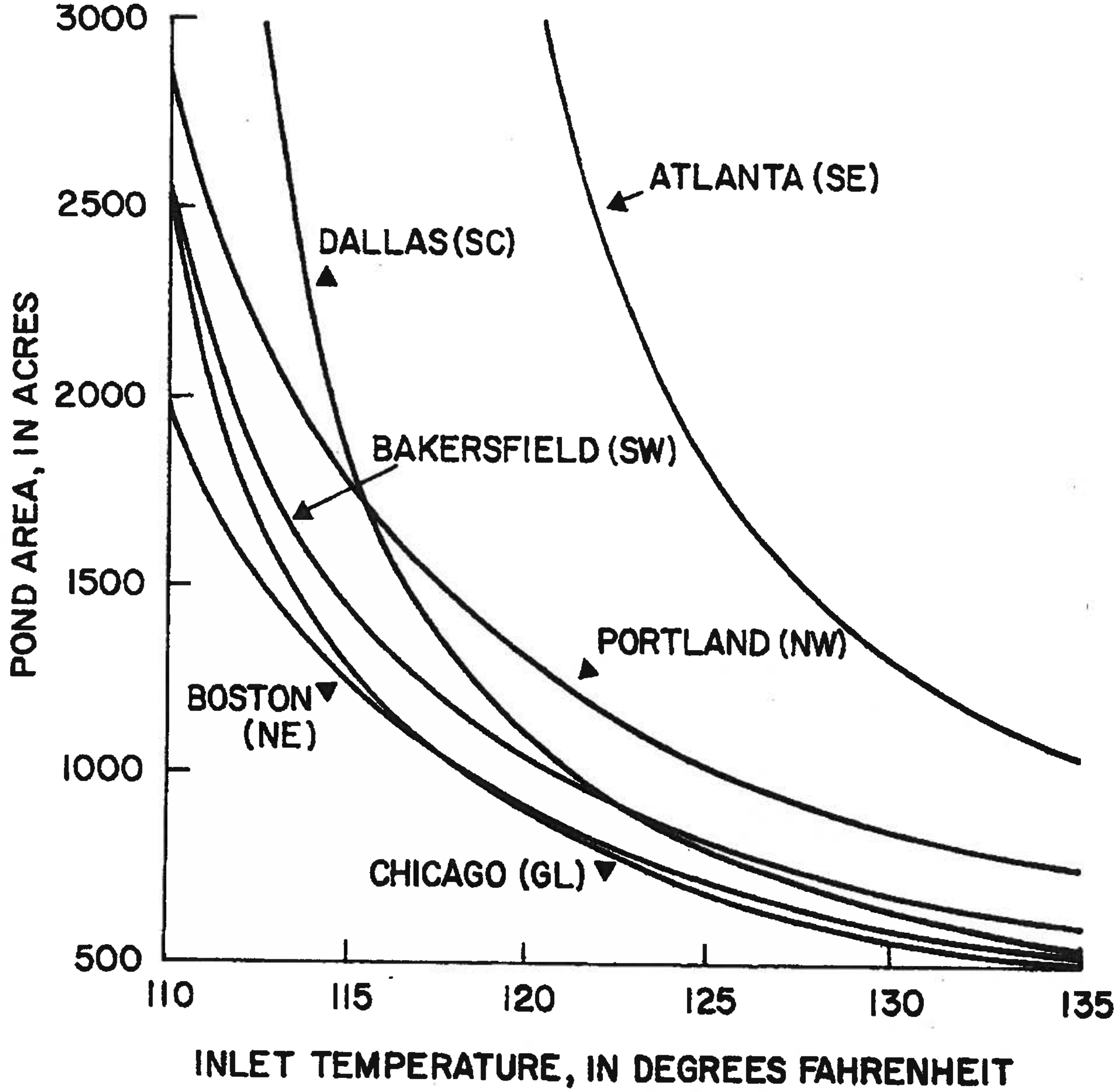


FIGURE 8
POND AREA VERSUS
INLET TEMPERATURE



The equilibrium temperature method is normally used to determine pond size under design meteorological conditions. It can also be used to evaluate pond performance under off-design conditions.

The equations presented above are for flow-through ponds. In order to obtain a truly flow-through configuration, the water must be directed through the pond by baffles or dikes, since the natural topography is often not adequate to provide the proper flow configuration. In many cases, a cooling pond will contain "dead spots" such as bays or inlets which do not participate in the heat exchange processes. In such cases, one should reduce the effective pond area to account for this reduced cooling capability. Also, ponds may be configured such that a portion is operating as a completely mixed pond rather than as a flow-through pond. In such cases, one should evaluate the lower effectiveness of the completely mixed portion.

Edinger and Geyer[24] present a table relating the temperature excess ratio, $(T_{out}-E)/(T_{in}-E)$ to the ratio of areas for the two pond types (mixed pond area/flow-through pond area). Figure 9 provides a plot of these data. This figure illustrates the fact that for a given value of E and condenser ΔT, the cooler the desired pond outlet temperature, the greater the area of a mixed pond with respect to that of a flow-through pond.

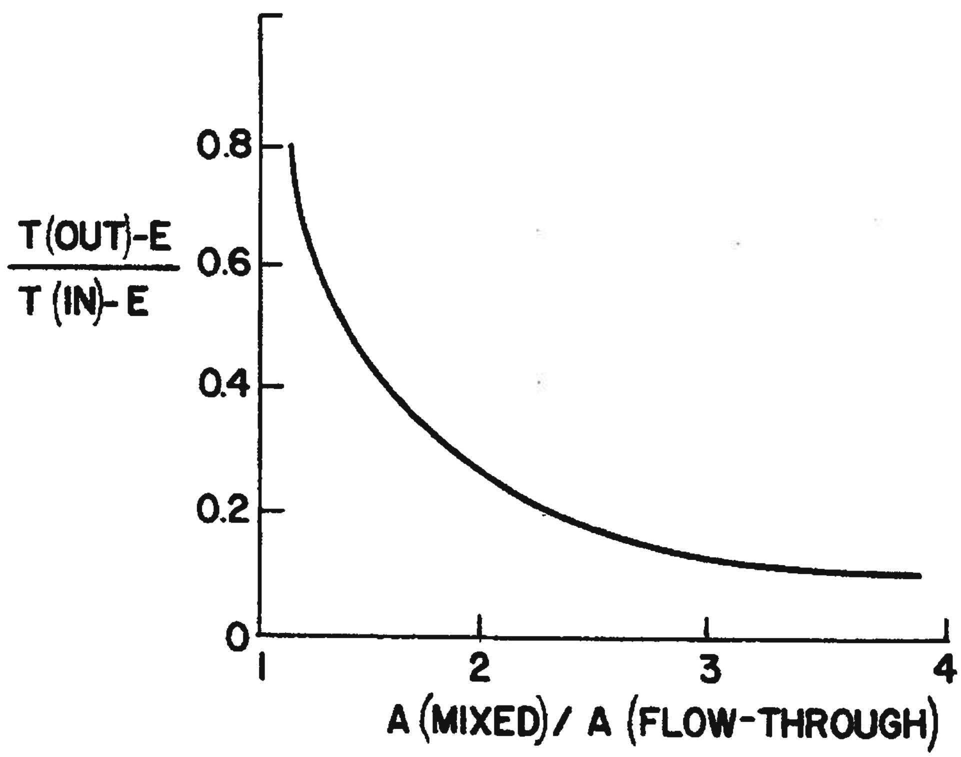
One can evaluate the temperature of the completely mixed portion of a cooling pond by using the following relationship:

$$T_m = \frac{(123\ QT_{in} + KAE)}{(123\ Q + KA)} \qquad (6)$$

where T_m = surface temperature of mixed pond, °F

In using the the relationship, note that T_{in} is the inlet temperature to the completely mixed portion of the pond, which may not equal the overall pond inlet temperature. Also, A is the area of the completely mixed portion.

FIGURE 9
MIXED VS FLOW-THROUGH PONDS



In evaluating pond designs presented in an EIS, the use of the above relationships is preferred over the application of "rules of thumb" for pond sizes. Meteorology plays such a dominant role in pond design that wide variations in pond sizes can be expected for similar power plants in different locations.

The material presented above merely highlights one method for calculating pond size. More complete information on cooling pond size and performance can be found in reports by FWPCA[25] Hittman[3], Littleton[28], Brady et. al.[26], Vanderbilt[27], Tichenor and Christianson[29], and Hanford Engineering Development Laboratory[30].

Water Consumption -

The computation of water consumption from cooling ponds cannot be accomplished with simplified "rules of thumb" as is possible for wet cooling towers. As discussed above, cooling pond operation is dictated by all components of the energy budget and thus a simple percentage estimate of latent heat transfer is not possible. Two methods are available for computing cooling pond evaporative water loss:

1. Energy budget - this method requires a complete evaluation of all components of the energy budget (e.g., long and short wave incident and reflected radiation, conduction-convection, and back radiation) to compute evaporative water loss, knowing the pond temperature. The reader is referred to Edinger and Geyer[24] for details of such computations. It must be noted that small variations in pond temperature can cause large changes in evaporation, thus one should use the energy budget method of evaporation prediction only when high confidence is placed in the pond temperature data.

2. Mass transfer equations - this method employs empirical equations of the form*:

$$Q_E = f(w)\,(e_s - e_a)A \qquad (7)$$

*This is the most common form used in such calculations, however, many other forms are available in the technical literature.

where Q_E = evaporative water loss, cfs

$f(w)$ = wind speed function, w(wind speed) in mph

e_s = vapor pressure of saturated air at the pond water temperature, inches Hg

e_a = vapor pressure in the ambient air, inches Hg

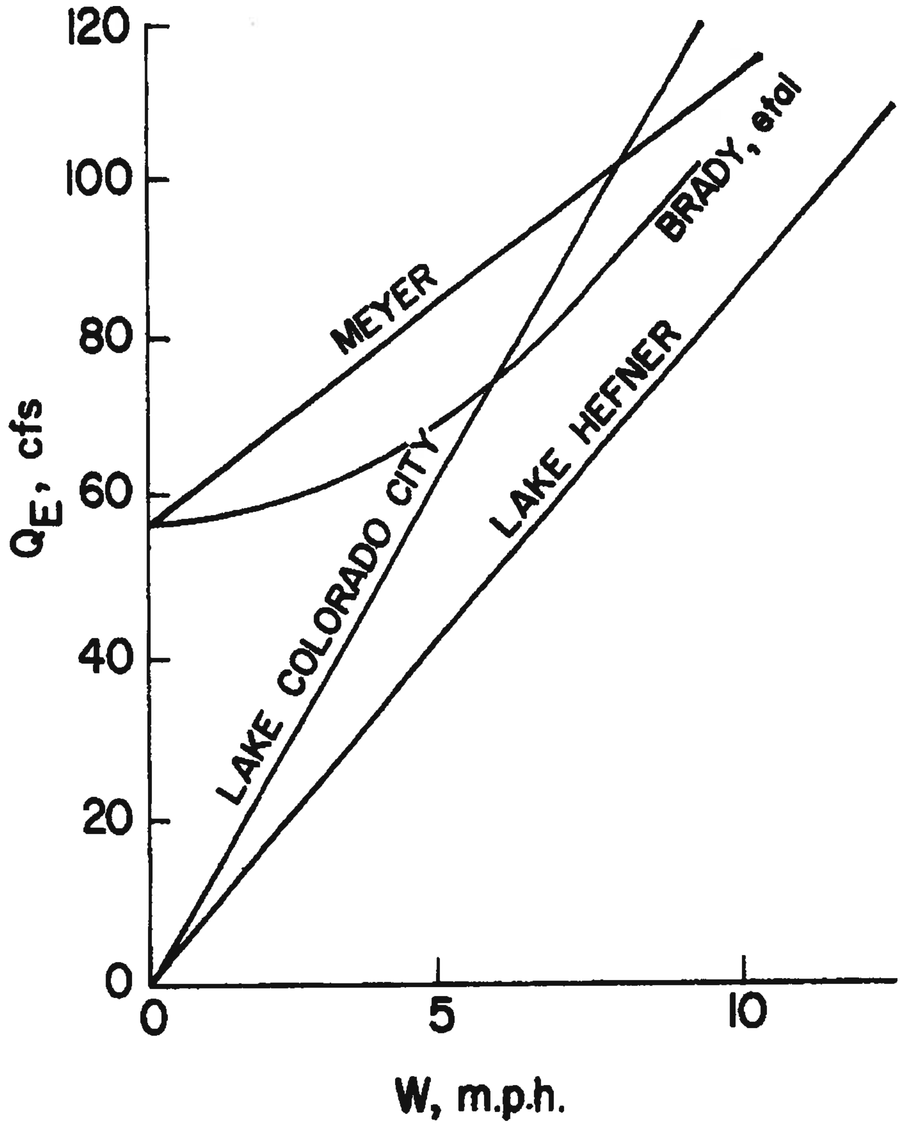
A = pond size, acres

The value selected for the f(w) coefficient is critical to the computation, and several values can be found in the literature[24, 26]. The following values of f(w) are presented in units consistent with this report:

Equation	f(w)
Lake Hefner[24]	$(2.25 \times 10^{-3})w$
Lake Colorado City[24]	$(3.31 \times 10^{-3})w$
Meyer[24]	$1.44 \times 10^{-2} + (1.44 \times 10^{-3})w$
Brady, et. al.[26]	$1.38 \times 10^{-2} + (1.38 \times 10^{-4})w^2$

Figure 10 shows the relationship between Q_E and w for $(e_s - e_a) = 2$ inches Hg for these four values of f(w), for a 2,000 acre pond. Unfortunately, no blanket statement can be made regarding the applicability of these or other estimates of f(w) to a particular situation. All formulations of f(w) given above are based on specific empirical data and none may be strictly applicable to a given cooling pond. Historically, the Lake Hefner function is the "most popular;" the Brady, et. al.[26], function was derived

FIGURE 10
POND EVAPORATION VS WIND SPEED
Q_E VS. W, $e_s - e_a = 2$ in Hg
A = 2000 acres



from cooling ponds located in the Southeast and South Central United States and is probably the "best" one to use in those locations.

When using Equation 7 to compute evaporative water loss for a flow-through cooling pond, one should not simply use the average pond temperature, (i.e., $(T_{in} - T_{out})/2$) to obtain e_s, because e_s is a nonlinear function of water temperature. A preferable method is to segment the pond into several areas of similar temperature and perform calculations on each segment.

Figure 11 illustrates the effect on evaporative water loss of varying the inlet temperature for a closed-cycle cooling pond serving a 1,000 MWe nuclear power plant. The curves in this figure were constructed using $f(w) = (2.96 \times 10^{-3})w$ for design summertime conditions at the indicated locations. The data on pond areas contained in Figure 8 were also used.

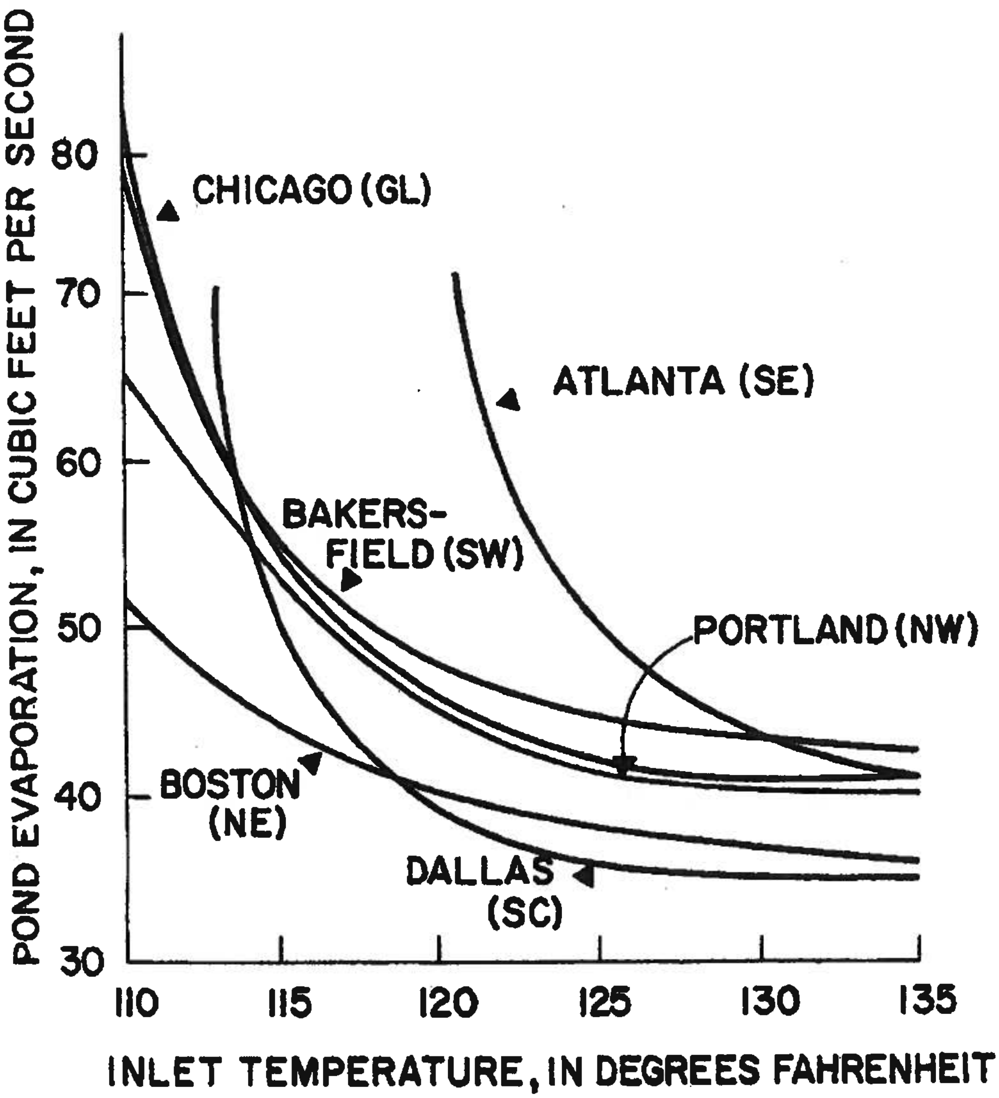
The above information can be used to estimate pond evaporation. In the case of cooling ponds, however, evaporation is not equivalent to consumptive water loss. The following considerations apply to the evaluation of consumptive water loss.

1. Cooling ponds will gain water by direct precipitation and runoff and possibly by infiltration. This water is subtracted from the evaporative loss in computing consumptive water loss.

2. If the pond existed prior to its use as a cooling facility, the natural evaporation from the pond must be subtracted in evaluating consumptive water loss.

3. For new ponds, the previous natural evapo-transpiration of the area covered by the pond should be subtracted in estimating consumptive water loss.

FIGURE 11
POND EVAPORATION VERSUS
INLET TEMPERATURE



4. Seepage from the pond should be added to the consumptive water loss.

As with cooling towers, the average annual consumptive water loss from cooling ponds is substantially lower than the loss under design meteorological and full load conditions. No simple "rules of thumb" can be provided to estimate this difference due to the complex nature of cooling pond consumptive loss mechanisms and regional differences in meteorological conditions. It would not be unusual, however, for average annual water losses to be less than half the losses under design conditions.

Cooling ponds may require a blowdown discharge. Since no drift will occur, Equation 2, can be rewritten as:

$$B = \frac{Ev}{(C-1)} \tag{8}$$

This equation assumes no precipitation, runoff, infiltration, or seepage. Precipitation, runoff, and infiltration would reduce the "effective evaporation" and lower the blowdown rate. Seepage would act as blowdown, and thus reduce the blowdown required.

If the pond requires blowdown, the make-up requirements would equal pond evaporation plus blowdown and seepage minus precipitation, runoff, and infiltration.

The methodology presented above provides the EIS reviewer with one technique for estimating cooling pond water consumption. Nomographs for computing pond evaporation are also available[3].

Environmental Effects -

Cooling ponds dissipate a large portion of the waste heat load by evaporation. Thus, large amounts of water vapor are discharged to the atmosphere. As with cooling towers, this phenomenon has the pote for increasing local fogging and icing. Unlike cooling towers, howe the water vapor is discharged over an extensive area and thus elevate plumes are unlikely.

There is limited information concerning the fogging potential of cooling ponds. Ponds do exhibit a "steam fog" directly over the sur during cold weather periods[30]. Experience with such ponds indicates however, that this fog will not extend over the land surrounding the pond for more than a few (i.e., 10-100) yards. However, under extre conditions, the fog may extend over land a mile or more. Also, stea fogs have been observed to cause icing on the vegetation near the po The icing is of a low-density, granular nature and is unlikely to ca weight damage.

The potential for cooling pond fogging and icing increases as the air temperature decreases, the humidity increases, and atmospheric stability increases. The downwind distribution of water vapor can be estimated using the dispersion calculations discussed previously with regard to cooling towers.

In reviewing an EIS, one should consider the factors given previousl for cooling tower fogging.

Spray Cooling Systems

Operating Characteristics -

Spray cooling systems, using fixed or floating spray nozzles or spir discs, are available from several manufacturers. They provide cooli by evaporative and convective heat exchange between the spray drople and the ambient air.

A great deal of flexibility is available in the design of a spray cooling system. They can be used in a canal (e.g., as designed for the Quad Cities plant) or a pond in a closed-cycle configuration. Also, they can be used in a canal in combination with a standard cooling pond (e.g., the Dresden Station). they may also be used in a combination cooling system in a discharge canal (e.g., the Chesterfield plant).

As with wet cooling towers, spray systems are designed for a specified range and approach. The EIS reviewer may generally assume that the system configuration provided by the manufacturer is adequate for the given design conditions.

Water Consumption -

Evaporation from spray systems is comparable to that from wet cooling towers except for ranges less than 10°F, and the estimates presented previously can be used. For closed-cycle spray systems, blowdown rates will also be comparable to wet cooling towers. Drift rates from spray systems have not been adequately studied, however, the contribution of drift to consumptive water loss is negligible. In summary, the make-up water requirements and consumptive water loss for closed-spray systems can be evaluated using the procedures given previously for wet cooling towers.

Environmental Effects -

As with wet cooling towers and cooling ponds, spray systems have the potential for fogging. Due to limited operating experience and minimal research on the problem, one can only provide a qualitative judgment on this potential. In general, under cold or humid weather conditions, the immediate area of the spray system will probably be foggy. Normally, this fog would not be extended over adjacent land. Extreme meteorological conditions could cause a greater area to be covered, and the EIS reviewer should use the techniques presented previously for cooling tower fogging to assess such a situation.

Icing due to spray systems is also a potential problem. Vegetation near the system can be expected to receive a coating of low density ice during cold weather periods; no structural damage to trees should occur. More widespread icing is not probable; however, the considerations presented for wet cooling towers would be applicable in evaluating extreme conditions.

Spray systems drift rates are not generally available. In terms of drift deposition on adjacent land and structures, two inherent characteristics of spray systems contribute to lessening the effect:

1. Low profile - the top of the spray pattern is only about 20 feet above the water surface.

2. No vertical air movement is involved, so the drift particles will not be carried aloft.

Also, spray systems that produce large droplets will cause fewer drift problems than those which operate with small droplet size.

Dry Cooling Systems

Operating Characteristics -

Dry cooling systems use only sensible heat transfer and are appropriate in areas of little or no water. There are two types of dry systems:

1. The direct air condenser where the turbine exhaust steam is condensed by the air and no cooling water is employed.

2. Indirect type dry systems where direct spray condensers (Heller type) are used and the cooling water and steam are mixed, with the resultant hot water going through an air heat exchanger. Thus,

there is no separate cooling water system. Recent studies indicate that a standard surface condenser could be used in place of a direct spray condenser.

Several dry cooling systems are operating and under construction in Europe; however, the only United States experience with dry cooling for power plants is at the Simpson station in Wyodak, Wyoming. This 20 MWe unit employs a direct air condenser. An additional unit several times this size is being planned for the Simpsom station using a dry cooling system.

The economic and technical feasibility of dry cooling systems has been widely reported[31, 4]. The major obstacle to their use on large power plants in the United States appears to be the lack of suitable high back pressure steam turbines. A wider use of dry towers in the United States awaits the successful demonstration of a large prototype. The most obvious use of dry systems is at fuel rich and water poor locations. Since nuclear power plants are not generally located with respect to fuel source, the major use of dry towers will probably be at mine-mouth fossil fueled plants. The exception would be the use of a dry system to alleviate environmental effects.

For information on technical and economic aspects of design and operation of dry cooling systems, the EIS reviewer should consult an EPA report by R. W. Beck and Associates "Research on Dry-Type Cooling Towers for Thermal Electric Generation"[31].

Water Consumption -

Dry cooling systems have essentially zero water loss. Heat exchanger leaks are possible, but would cause only minute water loss in comparison to wet cooling devices.

Environmental Effects -

By the nature of their operation, dry cooling systems will not cause fogging, icing, drift, or blowdown problems. There is some controversy over what the overall environmental effects of the warm air discharge from a dry cooling tower might be. A beneficial effect may be to increase ventilation in inversion prone areas. The potential modification of local meteorology, such as triggering the formation of cumulus clouds, requires further study. Also the overall meteorological consequences of large heat releases should be assessed; however this problem should be considered in the broad context of all large heat sources. In general, dry towers can be expected to be good environmental "neighbors," with the possible exception of noise problems.

A comprehensive analysis of the potential environmental effects of dry cooling towers is contained in a recent report by Boyack and Kearney[32] of Gulf General Atomic Company.

Wet/Dry Towers

Operating Characteristics -

Wet/dry cooling towers have received intensive study in recent years by several manufacturers. These systems, as the name implies, are constructed with both dry and evaporative heat exchangers. The normal design provides initial cooling water passage through a dry heat exchanger with the water then falling through conventional wet cooling tower packing. Other configurations are also possible, such as separate closed-loop cooling circuits for the wet and dry sections as proposed by Heller[33]. To date, only mechanical draft units have been tested on a full-scale. Single cells are operational, but no power plant operates completely on wet/dry towers.

The purposes of utilizing wet/dry towers are two-fold:

1. To reduce or eliminate the visible plume emission by a) decreasing the moisture content of the vapor discharge and b) heating the plume to allow it to hold more water vapor before becoming saturated.

2. To reduce water consumption. The tower designer can specify what proportion of the waste heat load must be rejected by the dry section and design the tower accordingly (i.e., 50% dry, 50% wet; 30% dry, 70% wet; etc.). In general, the dry section will have a larger heat rejection capacity than the wet section when water conservation is the goal.

The operation of the wet/dry tower will depend on meteorological, hydrological, and plant-load factors. For example, during meteorological conditions conducive to fog problems, maximal use of the dry section will reduce or eliminate the visible plume. During other weather conditions, the tower may operate primarily as an evaporative cooler. Low availability of make-up water will also require maximal use of the dry section, with due consideration to the effect of high turbine back pressure on the plant's capacity and efficiency (see Section VII).

As with both wet and dry towers, the EIS reviewer can assume that a design providing a wet/dry tower for a given closed-cycle cooling system is suitable to dissipate the waste heat. The reviewer can refer to the previous sections on wet and dry towers for operating and design information concerning the appropriate segment of the wet/dry tower. Reference should also be made to information contained in the technical literature[34, 35, 36, 33].

Water Consumption -

The water consumption from a wet/dry tower will vary considerably depending on the design (i.e., % dry vs. % wet), operation, and meteorology. Given this information, the EIS reviewer can use the procedures described previously for wet and dry towers to estimate water consumption.

Environmental Effects -

As discussed above, fogging (and thus icing) can be controlled by the design and operation of wet/dry towers. The EIS reviewer can use the information presented previously on fogging and icing for wet towers to assess a similar problem for wet/dry towers. Care must be taken, however, to include the effect of the dry heat exchange in evaluating the plume moisture.

Drift is caused by "mechanical" forces and is not affected by the heat exchange in a tower. Therefore, if all of the water is circulated through the wet section of a wet/dry tower, one would not expect the drift rate and subsequent deposition to be much different than for a conventional wet tower. Thus, the EIS reviewer can use the information presented on drift from wet towers to evaluate drift from wet/dry towers.

Conclusion

The material provided above on various closed-cycle cooling systems should provide the EIS reviewer with sufficient information to assess the great majority of power plant closed-cycle cooling systems. Unique systems, such as fan assisted natural draft towers[37], and oversized towers for fog control as proposed for the Sherburne County plant in Minnesota[38], were not discussed. However, enough general information is presented to enable the reviewer to address such unique systems in an informed manner.

D. ONCE-THROUGH COOLING

Introduction

The increasing scarcity of water supplies adequate to accomodate large multiple generating units, water temperature standards and mixing zone specifications, power plant effluent limitations, and the national goal of eliminating industrial waste discharges will tend to preclude once-through cooling for most new plants that use fresh water. In the remaining fresh and salt water cases, evaluation of the applicant's methods, findings and conclusions are required.

Data to support proposed once-through cooling may be in the form of physical model results, mathematical model results, transposition of data from an existing plant to an undeveloped site, or combinations of these. Although data transposition can complement model data, it will seldom stand alone in marginal cases because of physical, hydraulic, and plant dissimilarities between sites. So we turn here to physical and mathematical models.

The first question in evaluation is the suitability of the applicant's model to the case at hand.

Applicability of Models

Unfortunately, models are not always made to behave identically to their natural counterparts (that is, to their prototypes). The reasons are these: (a) Even if it were possible to formulate most general mathematical models so that they closely resemble nature, they would (1) become too difficult to solve mathematically, and (2) would depend on certain inputs that are not easily available; (b) Physical models can be made to closely reproduce the behavior of a prototype only if they are made as large and as complicated as the prototype itself.

For the reasons mentioned above, all practical models, whether mathematical or physical, are simplified so that (a) they become amenable to analysis, and (b) they are economically feasible to build and operate. Nevertheless, if simplification is made at the expense of those very processes in nature that the models are assumed to imitate, then the benefit derived from such models is limited proportionately to the sacrifice made to arrive at simplification. This should not imply that good models must be necessarily complicated, but it does mean that (a) a simple model can be developed to represent and predict reasonably well few (but not all) particular processes in nature, and (b) a complicated model may fail to predict a simple process if not properly applied.

In short, it is always important to examine all assumptions used in developing a model and to guard against applying the model to situations they are not intended to represent.

A report by Silberman and Stefan[38a] discusses the attributes and limitations of physical modeling. Where boundary conditions are complex or mathematical models are otherwise unreliable, an applicant seriously proposing once-through cooling should provide physical model data along with sufficient description of the model and studies for EPA evaluation.

In general, mathematical analytical techniques can be classified with respect to submergence of the discharge.

Deep submergence implies the absence of extraneous effects, such as proximity of the water surface and the ocean or river floor or any wall or barrier that might affect the plume trajectory. The jet must be submerged at least 40 or more diameters deep. Reference 39 provides a useful compilation of numerous practical analyses of this discharge category.

In a shallow discharge the effects of such disturbances as the bottom, water surface, and downstream flow conditions are accounted for either analytically or experimentally. Examples of vertical discharge in shallow water without current are given in Reference 39. Reference 40 is a comprehensive review of shallow discharges and provides analysis and experimental results of multiport diffusers. Reference 41 deals with single jet discharges. It contains limited but useful data.

State-of-the-art information on surface discharges is presented in Reference 42. Reference 43 is a User's Manual for surface discharges and Reference 44 is a compilation of recent data.

Generalizations on Plume Behavior

Thermal plume behavior depends on characteristics of both the receiving water and the discharge. Plume analysis is primary a matter of hydraulics (mixing); heat exchange between water surface and atmosphere usually, but not always, plays a relatively minor role in the location of isotherms less than about Δ2°F.

Inasmuch as receiving water charactersitics at a site are generally fixed whereas discharge characteristics are variable, the former imposes the first set of limitations on designing an acceptable once-through discharge.

The following is a listing of some possible receiving water characteristics that affect mixing:

a) The ambient water could be i) nearly motionless, such as in a lake, ii) flowing, such as in a river, or iii) intermittent, such as tidal waters.
b) The water body may be without temperature or salinity stratification or partially or totally stratified.

c) The water basin near the discharge may be deep and vast or there may be effects of boundaries, such as shoreline and bottom slope.
d) The ambient water may be influenced by the action of wind. This effect may be very strong or negligibly small at times.

Pertinent discharge characteristics include:

a) Submerged or surface discharge.
b) Discharges from single or multiple round ports or from a rectangular port.
c) Discharges from an open channel or a closed conduit.
d) Discharges in the general direction of the current, cross current, counter current, or other angles.
e) Discharges in a vertical, horizontal, or inclined direction.
f) Generally uniform and constant discharges or intermittent and time varying discharges.

Other factors being equal, the greatest degree of mixing can be accomplished with multiple port discharges in deep water. This is usually preferred from a biological standpoint because the smallest volumes of water are subjected to excess temperatures for the minimum length of time. Stratification with little or no mixing can result from a surface discharge from a channel. In rivers, such heated surface layers are usually not acceptable if they cover a major portion of the river width. A high velocity discharge into a cross current may in some cases cause too much penetration and blockage of the waterway, thus preventing the natural migration and other activities of fish. For this reason, discharges at an angle may be more desirable.

In the majority of situations, it is desirable to locate the discharges at some distance downstream of the intake; also when there is no predominant ambient current, to locate the discharges at a higher elevation than the intake, in order to avoid or eliminate the possibility of recirculation.

Once-through discharges using ocean water often require large diameter pipes extending hundreds or even several thousand feet into the ocean to reach deeper waters so that shallow coastal waters are protected from excess heated water. Such pipes are often made of concrete and they can be more than ten feet in diameter. Typical jet diameters for single port discharges may be on the order of ten feet and for a multiple port discharge, on the order of one foot. Typical dimensions of a surface jet channel may be up to one hundred feet wide and up to 30 feet deep. Typical discharge velocities from a submerged jet are 6 to 17 ft/sec and for surface discharges, 1 to 6 ft/sec. Excess temperature is on the order of 15 to 30°F depending on the waste heat load and the flow rate used.

The interaction of the plume with the ambient water results in the following:

a) dilution is enhanced by the turbulence in the ambient current, by wind, and by a high velocity discharge into a current,
b) plume rise from a submerged discharge is delayed by ambient current, and by jet inclination,
c) plume rise can be totally terminated in a stratified environment,
d) the discharge from the shore into a river can result in deep penetration if the jet velocity is much greater than the river current--otherwise the plume hugs the shoreline,
e) the plume width is generally greater in stagnant water than in moderate currents.

ater Consumption

he amount of water consumed by wet cooling devices (see information resented in Section IV-C) is often noted as an adverse effect. This ay or may not be true, depending upon the local availability of water. point often overlooked, however, is the fact that once-through ooling systems also cause water consumption (i.e. evaporation) to ccur. A significant portion of the waste heat in the discharge is ltimately transferred to the atmosphere by latent heat exchange at he water surface, which incidentally, may cause a "steam fog" to ccur. For example, a once-through cooling system for a 1000 MWe fossil plant on Lake Michigan could cause an annual average evaporation loss in excess of 8 cfs[4]. The EIS reviewer should make sure that a value for this evaporative loss is provided, to assist in both his assessment of the system and his comparison of alternatives.

Suggestions for Review

Although certain deviations may be necessary, the following checklist and approach have been useful.

1. The reviewer should familiarize himself with the general topography of the site, particularly with respect to the water body that is being used as the source of cooling water and as a recipient of the heated effluent. Important items to be reviewed are:

a) ambient flow conditions, such as the velocity, flow rate, tidal exchange and tidal prism, etc.,
b) water depth at the discharge and intake as well as the general depth contours,
c) seasonal variation in flow, particularly the extreme (such as the 7-day, once in 10-year occurrance) and average conditions as obtained from past records, and

d) the ambient weather conditions, particularly the presence of prevailing wind and severe or extreme climates.

2. The reviewer should then briefly check the applicant's calculation for the flow rate at a given ΔT against the quantity of heat that the plant is expected to release. The following equation can be used:

$$Q = 0.00445\ (WH)\ (P)/\Delta T \qquad (9)$$

where Q = Flow rate, cfs

WH = Waste heat to cooling water, Btu/KWH

P = Plant size, MWe

ΔT = Cooling water temperature rise, °F

Figure 2 is a graphical representation of this equation.

3. Some of the preliminary environmental considerations can be sized up at this point, as follows:

a) compare the relative flow rate of the ambient water against the discharge. If the river flow or tidal exchange is, say ten times the discharge rate or less, then the assessment of the physical impact, if not already obvious, should be reserved for further detailed examination,

b) check if the discharge is reasonably well extended into the deeper waters,

c) check if there is obvious scouring of the bottom or obvious plume hugging of the shoreline,

d) check for minimum length of piping ahead of the diffuser to see if the exposure time to heat could be minimized--note also the competing results from c) and d),

e) examine some of the results, such as centerline temperature, plume dimensions and plume areas enclosed by specified isotherms.

If in the above considerations, the following are observed, closer examination is needed:

a) if the plume area is relatively large compared with the gross water surface area near the discharge,
b) if the topography is very complex, such as shorelines, bends, etc.,
c) if there is tidal fluctuation, and
d) if there is the possibility of a sinking plume. The latter possibility could present itself if the discharge water is more saline than receiving water, or if there is temperature stratification under winter operating conditions, such that the discharge could be locally more dense than the receiving water anywhere along the trajectory of the plume.

4. There are situations where the reviewer may form a definite idea at this point as to whether or not the once-through system is an acceptable alternative. This happens only when there are clear indications of environmental acceptability of the plan or a clear indication of lack of such acceptability. In the other cases, however, a more detailed study may be required.

It should be pointed out that a complete analysis of once-through systems requires expertise in several disciplines including engineering, economics, and biology. Important factors in all these disciplines dictate the method of discharging heated water from a once-through system. Among the factors to be considered in selection of one method of discharge over another are:

a) environmental impact,
b) temperature criteria,
c) cost,
d) cooling performance, and
e) cooling water recirculation.

E. COMBINATION COOLING SYSTEMS

Operating Characteristics

Combination cooling systems have characteristics of both closed-cycle and once-through systems. Although terminology often differs, the "helper" category includes any of the cooling devices discussed previously in this section to recirculate any portion (0-100%) of the cooling water requirement. The operating mode is determined by the temporal characteristics of water supply availability, water temperature, meteorology, and by applicable water quality standards. Another combination system uses a "terminal difference" or auxiliary cooling device which removes a portion of the waste heat from a once-through system.

Cooling systems involving helpers should be reviewed carefully, inasmuch as the tempting by-pass option is always present. In terms of economics, any advantage of helper over closed-cycle for optimized new plants is marginal due to the interrelationship of the turbine condenser and cooling device[2, 3, 4]. For retrofitting an economic advantage may exist. In any event, the economic analysis must be approached on a case-by-case basis.

One problem with helpers is the inadequacy of the management (decision making) system in comparison to the versatility of the hardware. While theoretically a helper system can be tuned and operated so that the discharge quality will "just meet" water quality standards or effluent limitations, a rather sophisticated in-stream and in-plant sensing network coupled with a conditional probability program is required to turn the right valve at the right time. We have not seen such a system described in any environmental impact statements reviewed.

An EIS on a helper system should contain the following information:

1. The percent of time the cooling device will be operated.

2. The operation schedule throughout the annual cycle.

3. The amount of waste heat removed with respect to 1 and 2, above.

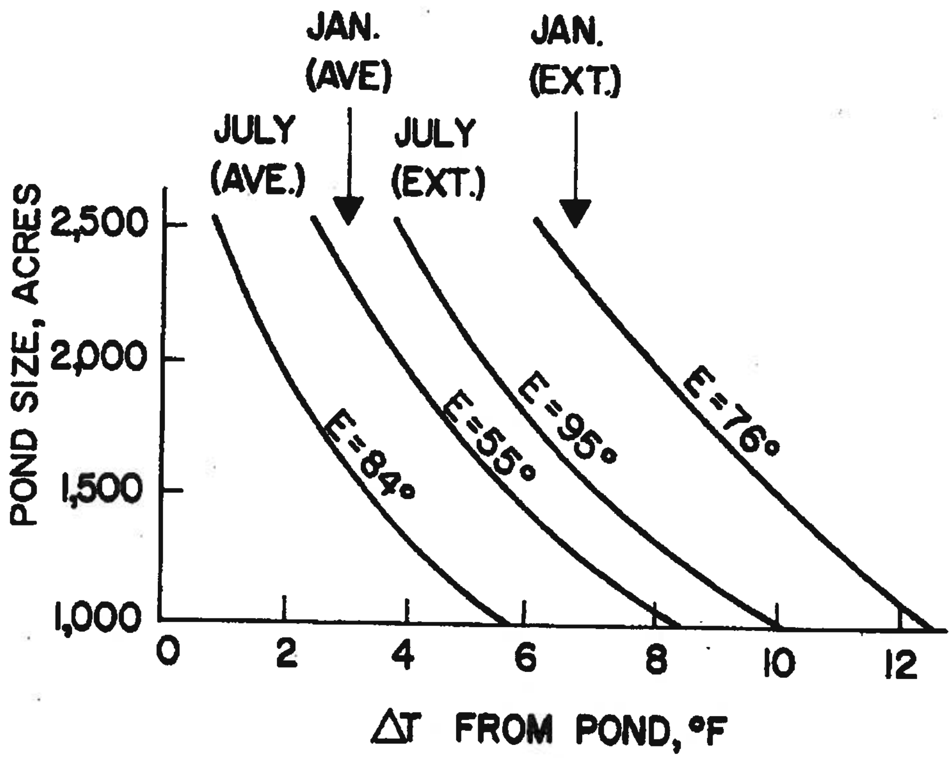
4. How the operation according to 1 and 2 above will affect the water consumption, fogging and icing potential, drift, and blowdown (if any).

The consent decree in the case of Houston Lighting and Power versus Ruckelshaus, et. al. allows an auxiliary system. In this instance, a cooling pond on a once-through cooling system dissipates a seasonally variable fraction of the waste heat from the condenser effluent for discharge into Trinity Bay.

Practical cooling limits of evaporative auxiliary systems, as related to equilibrium temperature and evaporation rate or wet bulb temperature, should be examined throughout the annual cycle. A system that can meet water quality standards in the summer, under design conditions, frequently will not in the winter if such standards limit the temperature rise above ambient temperature. Figure 12 exemplifies seasonal variations in cooling pond efficiency near Galveston Bay, Texas for an auxiliary pond on a 1,500 MWe fossil fueled station.

For cooling towers, an approach to wet bulb temperature of less than 10°F is rarely achieved under design conditions and certainly the approach is never less than 5°F. Therefore, to determine the effectiveness of auxiliary cooling towers on a once-through system, one can compare the practical cooling limit, (wet bulb plus approach) to the receiving water temperature. Table 3 provides such a comparison for the same geographical area. Note that through much of the year a tower effluent would be appreciably warmer than the receiving water.

FIGURE 12
SEASONAL PERFORMANCE OF AN AUXILARY COOLING POND FOR A 1500 MWe FOSSIL FUELED POWER PLANT



NOTES:

T IN = E + 20°F

T OUT = E + ΔT FROM POND

AVE. = AVERAGE METEOROLOGICAL CONDITIONS

EXT. = EXTREME METEOROLOGICAL CONDITIONS

Table 3. COMPARISON OF MECHANICAL DRAFT TOWER COOLING LIMITS TO RECEIVING WATER TEMPERATURE

Month	Cooling Limit (°F)		Receiving Water Temp (°F)	
	5°F Approach	10°F Approach	Average	Maximum
Jan	73	78	56	63
Feb	73	78	53	60
Mar	75	80	62	67
Apr	79	84	72	80
May	83	88	80	86
Jun	86	91	84	86
Jul	85	90	86	90
Aug	85	90	86	90
Sep	85	90	85	90
Oct	85	90	72	79
Nov	83	88	72	76
Dec	78	83	55	64

When air and water temperatures drop, prudence imposes another lower practical limit on tower effluent. Regardless of meteorologic limits on cooling capability, no plant superintendent is going to run a tower with a cold leg anywhere close to freezing temperatures because of the hazard of tower icing, which can be very costly.

Any wet cooling device can be used in a combination system for either an original design or a backfitted situation. For backfitted systems, the design and construction flexibility of spray systems is often overlooked in the EIS.

Water Consumption

The amount of water consumed by a combination cooling system will be governed by the same factors discussed previously for closed-cycle and once-through cooling systems. The EIS reviewer can compute the total water consumed on a design and annual basis using the procedures given previously coupled with information on the percent of waste heat dissipated and the seasonal operating schedule.

Environmental Effects

The environmental effects of combination systems can be assessed using the techniques described previously for closed-cycle systems. The operational characteristics of the combination system may ameliorate some environmental problems (e.g., reduced use of cooling towers in cold weather will lower probability of fogging and icing problems). On the other hand, an auxiliary cooling tower will increase the time-temperature exposure for entrained organisms and probably cause more damage to such organisms. Thus, the fact that an auxiliary cooling device will permit water quality standards to be met does not insure an improvement in the environmental acceptability of the cooling system.

In summary, any proposed combination cooling system should be viewed, initially at least, with judicious scepticism.

SECTION V
CHEMICAL, BIOCIDAL, AND SANITARY WASTES

Numerous chemical wastes and other effluents are generated during startup and normal operation of a nuclear power plant. Many of these effluents are totally independent of the type of cooling system utilized; however, it is common practice in most cases to combine these effluents with the cooling water or blowdown discharges at some point before final release. Therefore, although the quantity of many constituents is unrelated to the cooling system choice, the concentration of the constituent in the discharge stream may well be determined or influenced by cooling system choice and operating characteristics.

Although the combining of effluent streams before discharge is a common and acceptable practice, the dilution effect should not be pursued as a substitute for treatment of wastes prior to discharge. Since the quantity of blowdown is governed by the cycles of concentration in a closed-loop system (i.e. low C, greater blowdown volume), the reviewer is encouraged to assess carefully the reasons for running at the proposed number of cycles, especially if the C value appears excessively low. Cycles of concentration should be governed by water quality limitations as described in Section IV-C and should be as high as possible. Treatment of wastes may be required before dilution with other effluent streams.

Radioactive wastes and most toxic wastes are processed through the radwaste system. The following discussion is primarily oriented toward other wastes, from the plant or from cooling water treatment, which the reviewer should survey in connection with cooling system alternatives. Sanitary waste treatment is usually dictated by State requirements, to which conformance is normally verified quite easily.

Only a few of the most common chemical pollutants are cited herein because of the great variability of treatment requirements (and resulting effluent characteristics) occurring from site to site. The best approach for the reviewer is to carefully assess: (1) The quantity of each constituent added for plant operations, and (2) the before/after comparison of the concentrations of any constituent causing potential pollution concern. Resulting constituent levels in discharge effluents should then be compared with Water Quality Standards or applicable effluent requirements or pertinent information which may indicate the reasonableness or environmental acceptability of proposed discharges.

Liquid wastes with pollution potential emanate primarily from condenser cleaning, water treatment, and blowdown operations.

An important area to review is the method of control of biological growth in the condensers. Periodic addition of chlorine is an effective method of control which has been widely used in the power industry. However, the toxic effects of chlorine or chlorine derivatives to aquatic organisms require minimization and close control of these constituents in effluent discharges. When chlorination is proposed, the length of time and the concentration of residual chlorine (free and combined) in discharges should be reviewed for compliance with recommendations by Brungs[45], which follow in Table 4. It should be noted that these recommendations apply only to freshwater aquatic life and that the criteria vary according to time factors and type of organisms.

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Table 4

RESIDUAL CHLORINE RECOMMENDATIONS, from Brungs[45]

TYPE OF CHLORINE USE	CONCENTRATION OF TOTAL RESIDUAL CHLORINE	DEGREE OF PROTECTION
Continuous	A. Not to exceed 0.01 mg/l	This concentration would not protect trout and salmon and some important fish-food organisms, it could be partially lethal to sensitive life stages of sensitive fish species.
	B. Not to exceed 0.002 mg/l	This concentration should protect most aquatic organisms.
Intermittent	A. For a period of 2 hr a day, up to, but not to exceed, 0.2 mg/l	This concentration would not protect trout and salmon.
	B. For a period of 2 hr a day, up to, but not to exceed, 0.04 mg/l	This concentration should protect most species of fish.

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Intermittent	A. For a period of 2 hr a day, up to, but not to exceed, 0.2 mg/l	This concentration would not protect trout and salmon.
	B. For a period of 2 hr a day, up to, but not to exceed, 0.04 mg/l	This concentration should protect most species of fish.

If proposed chlorination practices are deemed unacceptable, various approaches may be applicable, depending on the situation, for further control, including:

(1) Practicing split stream chlorination, i.e. treating one condenser at a time.

(2) Reducing the chlorine feed period.

(3) Combining a discharge stream with another in-plant stream which has a high chlorine demand.

(4) Discontinuing blowdown during periods when residual chlorine is present in the cooling tower sump.

(5) Decreasing the rate of chlorine addition during feed, in proportion to the reduction of chlorine demand of recirculating water in closed-cycle systems. This method maintains a constant residual chlorine level at the condenser discharge.

(6) Adding sodium sulfite, sodium bisulfite, or sulfur dioxide to blowdown to reduce residual chlorine.

A recent report by Nelson[46] provides specific information on evaluating many of these control techniques.

A different type of control from those cited above is that of mechanical cleaning of condenser tubes which, from an environmental standpoint, is the preferred method because no chemicals are employed. Balls (Amertap System) or brushes (MAN System) are passed through the condenser tubes periodically to cleanse them of biological growth. Mechanical cleaning is being used in numerous instances, particularly in new plants where it can be incorporated into the initial design. Mechanical cleaning may promote better heat transfer efficiency; disadvantages include installation and maintenance problems and potentially higher costs than chemical cleaning. Also, the condenser alone is treated whereas chemical cleaning affects the entire cooling system.

Boiler water treatment wastes include demineralizer regenerant wastes, filter backwash and coagulant sludge blowdown. In this category total dissolved solids (mostly sodium sulfate) are most notably increased.

Steam generator blowdown may contain phosphate loads which could affect receiving water nuisance growth potential. Morpholine, a pH control agent, might also be present in this blowdown and has potential adverse aquatic effects.

Cooling tower blowdown will contain constituents in the makeup water and materials in the recirculating water which are scrubbed from the air and concentrated due to continual water evaporation by the cooling tower.

Other chemicals may be added infrequently or in small amounts for various purposes during plant operation. These can include deposit control agents (which may contain nitrogen or phosphorous), cleaning agents, or proprietary biocides, as required.

Corrosion control may be required in a very small number of cases, primarily those with high chloride concentrations in the circulating water. Generally, however, corrosion is not a significant factor because potential problems can be averted through proper choice of corrosion resistant materials or coatings. Where protection is required, chromate, zinc, or phosphate based inhibitors may be proposed. Their presence in blowdown waters requires careful assessment with regard to permissible concentration levels and potential reduction and/or removal.

The assessment of the above general or unpredictable plant wastes must be approached on an individual constituent basis, as mentioned previously. Waste characteristics and potential impact will vary from site to site, depending on source and receiving water quality, system type and operating procedures, required treatment, discharge procedures, etc. Common waste sources and constituents are covered here to orient the reviewer toward potentially significant areas, but individual parameters must be viewed in the context of applicable regulations and/or practical alternatives or treatment for the given situation.

SECTION VI
ALTERNATIVE COOLING SYSTEMS

The reviewer's objective in this area is basically three-fold: (1) to assure that all feasible cooling system alternatives are included in the EIS presentation, (2) to assure that alternatives are described accurately and thoroughly, and (3) to judge the validity of the applicant's proposed choice when compared to the alternatives described.

The AEC's Regulatory Guide 4.2, "Preparation of Environmental Reports for Nuclear Power Plants"[1] provides guidance to applicants for presenting information which forms the basis of the EIS. The following excerpts from this guide are cited below to indicate the intent and scope of the coverage of alternatives:

> "The applicant should ... show how the proposed plant design was arrived at through consideration of alternative designs of identifiable systems and through their comparative assessment."

> "The applicant should limit the discussion to those alternatives which the current state-of-the-art indicates are technically practicable."

> "The discussion should describe each alternative, present estimates of its environmental impact and compare the estimated impact with that of the proposed system."

> "Environmental effects of alternatives should be fully documented."

"The acquisition and operating costs of individual systems and their alternatives (as well as costs of the total plant and transmission facility and alternatives) are to be expressed as power generating costs."

If cooling system alternatives are described in full accordance with the context of the above instructions, the reviewer will have little problem in meeting his objectives. He should, however, follow a general stepwise procedure in his overall assessment.

The reviewer is referred to Section V - C for the description of devices, in addition to once-through, which are technically feasible under the current state-of-the-art. However, this does not imply that all of the systems described must be considered as viable alternatives for every situation.

Technical infeasibility may be established in instances where physical or operational design flexibility does not exist. For example, dry cooling towers are usually not applicable to backfitting situations, i.e. existing plants or those in design/construction stages where a turbine is on order. Space availability may also preclude consideration of certain control devices, most notably cooling ponds which require large land areas. Meteorological hazards may be a governing condition, e.g. natural draft towers may likely be excluded in areas of high hurricane potential. These examples indicate that there are a multitude of valid reasons why some devices are not feasible in some cases. The reviewer is encouraged to use the devices described in Section V - C as a check-list; if these devices are not presented as alternatives, he should look for valid reasons for their exclusion.

The description of each of the alternatives must be accurate and complete enough to permit an unbiased comparison of potentially applicable systems. Again, the reviewer is referred to the detailed technical and economic considerations for each system as presented in respective sections of this guide. Considerable judgment must be exercised in determining exactly what information must be included. Although the system characteristics discussed elsewhere should be used as a check-list, it is not possible to set absolute coverage requirements. There is a tendency in some EIS presentations to provide extensive coverage of the proposed system and lesser coverage of alternatives. It is the responsibility of the reviewer to see that each valid alternative is addressed in a manner which satisfies his evaluation needs. If he feels that inadequate information is provided, it should be expressed in review comments.

The ultimate purpose of reviewing cooling system alternatives is to support or challenge the applicant's choice. This decision must consider the overall relative implications of each system. Individual systems all have their own merits and disadvantages, so that a clear-cut choice is not always apparent. In the end, the reviewer's recommendations, comments, or conclusions should be based on a reasonable balance between technical/economic feasibility and environmental impact, as revealed through his review process.

SECTION VII
BENEFIT-COST ANALYSIS

The objective in this area of review is to assess, verify, and compare the economic implications of various cooling system alternatives. The emphasis is, therefore, placed upon <u>incremental</u> values associated directly with specific cooling systems rather than the absolute magnitude of basic factors which are not affected by the cooling system choice, such as the value of power to be sold or the cost of the basic plant excluding cooling system choice. In general, the EPA technical review is not concerned with other alternatives, such as alternative methods of providing power.

BENEFITS

The single direct benefit from a proposed power plant is represented by the total revenues to be obtained from sale of electrical energy, steam, or other products produced by the plant. In most cases the product will be electrical power and the amount to be generated will be specified, regardless of the choice of cooling system. Although the present value of this benefit can be checked rather easily, it is not necessary to do so for review purposes. It is important to recognize, however, that this is the single direct benefit from the proposed plant. Any other benefits that might be cited, e.g. taxes, employment, research, regional products, etc., are already covered by the single direct benefit. If these types of indirect or secondary benefits are attributed to the plant, they should be labeled as such.

COSTS

The review of the cost analysis related to cooling system alternatives is not a clear-cut approach, since judgment must be applied throughout. The basic reasons for this are as follows:

(1) Various environmental effects (costs) associated with different cooling systems cannot easily be monitized. Therefore, one can not adhere to a strict to ratio for comparisons and the review may approach more of a net cost ranking of alternatives than an absolute quantification.

(2) Equipment and operating costs attributable to specific cooling systems are not easily identified for comparative purposes.

(3) The degree of committment to a proposed plant design can alter the benefit-cost analysis. For example, if sizeable expenditures for design and construction have occurred, a cost analysis of alternatives is strongly biased toward the chosen system since others would incur the cost penalty of "scrapping" the system under construction.

The proposed plant and cooling system design serves as the reference design case in an EIS cost analysis. Monitary costs of alternative systems are presented in terms of incremental generating costs, on a total present worth or annualized basis, as compared to the reference design. Incremental generating costs reflect the combined effect of all fixed and variable cost differences from the reference design. An EIS will usually not provide the extensive background information which would be needed to individually reconstruct the two components of the incremental generating cost. However, in the majority of reviews it will not be necessary to attempt cost verification through such a complex procedure. The approach here will be to first provide the reviewer with general guidelines by which the reasonableness of incremental costs may be judged for the majority of cases. Secondly, a brief discussion of the scope of a detailed verification is presented along with numerous referenced sources of additional information pertinent to such a review.

Generalized Cost Verification Procedure

The information presented in this section will usually suffice for reviewing the following cases:

(1) When the base design and alternative cooling systems being considered are closed-cycle.

(2) When the proposed cooling system for a new plant is undoubtedly desirable in terms of minimized environmental effects. In this case, the outcome of the monitized cost comparison is of secondary importance.

(3) When plant construction has progressed to the point where "sunk" costs bias or control the benefit-cost ratio. In this case, it is obvious that monitary considerations alone will not indicate that a complete change in cooling system design is desirable. Environmental acceptability with minimum added cost must be sought.

In the EIS, the total capital cost of the reference plant may or may not be broken down into costs for the basic plant and costs for the cooling system. The basic plant cost, excluding the cooling system, varies greatly with site, design, and economic conditions and need not be challenged. Where capital costs of cooling systems alone are identifiable, one can compare the reasonableness of the costs with the typical values for new plants cited in Table 5.

Table 5. CAPITAL COSTS FOR NUCLEAR PLANT COOLING SYSTEMS[47]

Once-through system:	3	to	5	$/KW
Natural draft cooling towers:	9	to	13	$/KW
Mechanical draft cooling towers:	8	to	11	$/KW
Cooling pond:	6	to	9	$/KW
Spray system*:	7	to	10	$/KW

The values cited above do not reflect operating penalties of the systems and therefore, cannot be used as a primary judgment factor. However, the capital cost comparison should be used as a first-cut evaluation which may identify systems requiring more detailed scrutiny.

The once-through system costs cited herein, later used as the basic or reference case, reflect a more-or-less typical or uncomplicated once-through situation. Long outfalls with diffusers can be quite costly, depending on site-specific factors. Economic data on long outfalls and diffusers are limited, but the following design-cost studies on existing installations are mentioned here to provide a feeling for the magnitude of costs which might be quoted.

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* Independent estimates, not in reference.

In 1967, Parkhurst, Haug, and Whitt[48] of the Sanitation Districts of Los Angeles reported on five major outfalls on the Pacific Coast. Their tabulation includes trunk diameters up to 12 ft, overall lengths up to 22,000 ft, and depths of discharge in excess of 200 ft. Costs range from slightly over $100/ft to almost $500/ft. The cost data are probably low by today's scale.

A 10 ft diameter steel sewer outfall running 18,000 ft out into Lake Ontario from Rochester, New York, is described in the September 17, 1970, issue of Engineering News Record[49]. The cost reported is 18.7 million dollars, or about $1,000 per ft.

Kempf and Fletcher[50] report on the effects of site selection on the capital costs of nuclear electric plants. They cite design data typical of construction costs for discharges on the West Coast. Overall unit costs range from $233 to $872 per ft, depending partially on trunk diameters, which range from 7.5 to 14 ft.

A more sensitive approach for judging cost reasonableness is to look at the magnitudes of incremental generating costs presented for the alternatives. As noted earlier, incremental generating costs reflect all capital and operating cost increases attributable to a cooling system; the percent increase is, therefore, also comparable to calculated increases in busbar costs for a given plant output.

In the EPA analysis of cooling system alternatives for new nuclear power plants near Lake Michigan[4], the maximum busbar cost increases were determined, as cited in Table 6:

Table 6

BUSBAR COST INCREASES--COOLING SYSTEMS FOR POWER PLANTS NEAR LAKE MICHIGAN

Type of Cooling System	Percent Busbar Increase Over Reference
Once-through (Reference)	----
Cooling Pond	< 1%
Wet Mechanical Draft Tower	2%
Wet Natural Draft Tower	3%

Since incremental generating costs may be expressed in either total present worth or annualized figures, the reviewer should be careful to use consistent bases when calculating the percent increase over total generating cost. Regardless of the choice, the percentage increase in generation cost due to respective cooling systems should generally correspond to the percentages cited above for new plants of optimized design.

Another way of looking at the magnitude of costs attributed to cooling systems is to express the cost difference from the reference design in terms of mills/KWH of electricity produced and them compare these figures with recent study results reflecting busbar cost variations. One should use annualized incremental generating costs between each pair of cooling systems being compared, thus:

$$\Delta Mills/KWH = \frac{[\Delta \text{ Annualized Cost, \$}] \times [1000 \text{ Mills/\$}]}{[\text{Plant capacity, KWe}] \times [\text{Annual Plant Factor,\%/100}] \times [8760 \text{ hr/yr}]}$$

Table 7 contains referenced results of busbar cost increases for new plants, compared to once-through, which can be used in comparing the relative magnitudes of busbar cost differences in mills/KWH:

Table 7

RELATIVE BUSBAR COSTS (Mills/KWH)
FOR NUCLEAR POWER PLANT COOLING SYSTEMS

Sources	Once-through Fresh Water	Once-through Salt Water	Cooling Pond	Mechanical Draft Tower	Natural Draft Tower
Woodson[51]	--	--	+0.08	+0.11	+0.22
EPA[4]	--	--	+0.06	+0.14	+0.22
Hauser[52]	--	+0.3	+0.09	+0.21	+0.20

The variation in the values cited above is worth noting. It points out the fact that one cannot go too far in evaluating cooling system costs of a specific plant by comparing them to general norms. However, the above costs do establish a relative level for reasonable incremental cooling system costs. Deviations from these levels may well be justified, but the reviewer is encouraged to investigate the reasons behind gross deviations.

One reason for differences in values given above is that penalties for various cooling systems are based on varying assumptions. Two cost penalties often identified specifically in EIS cost analyses are:

1) Capability loss (or capacity loss), which occurs when higher condensing temperatures, determined by the type of cooling system and meteorological conditions, cause higher back pressure on a turbine at full-load and reduce its output. Capability loss occurs only when the turbine's rated capacity can not be attained due to high back pressure.

(2) Added fuel cost (or effeciency loss), which is also a result of high turbine back pressure because it increases the heat rate (Btu/KWH) of the turbine for any level of output, thus more fuel is required to generate a KWH of electricity.

Costs for capability loss and added fuel cited in an EIS Benefit-Cost Analysis can have a sizeable impact on the economic feasibility of the systems involved, and it is important to have a gauge of their reasonableness. The work of Hauser[52] also includes an incremental cost breakdown (in mills/KWH) for capability loss and for added fuel cost for new plants. Table 8 presents this information along with an additional column showing the magnitude of annual costs represented by these two penalties. The annual costs were calculated by using the formula for Δ mills/KWH given above and from Hauser's assumptions of a 1000 MWe nuclear plant operating with an 80% plant factor.

Table 8

COSTS OF CAPABILITY LOSS AND ADDED FUEL ATTRIBUTED TO VARIOUS COOLING SYSTEMS

Type of Cooling System	Capability Loss (Mills/KWH)	Fuel Cost (Mills/KWH)	Combined Annual Cost (1000 MWe Plant)
1. Fresh Water (Once-through)	Base	Base	Base
2. Cooling Ponds	0.0300	0.0240	380,000
3. Sea Coast (Once-through)	Base	Base	Base
4. Wet Cooling Towers Mechanical Draft	0.0300	0.0240	380,000
5. Wet Cooling Towers Natural Draft	0.0300	0.0300	380,000
6. Dry Cooling Towers	0.1590	0.1272	2,000,000

As with other cost values presented herein for comparisons, it is important to realize that these figures are given to indicate reasonable cost levels; values for specific plants can vary considerably from site to site. Also, these figures were calculated in 1970 for new plants; hence, normal cost escalation should be taken into account. These factors do not detract from the intended use of the figures for guideline purposes, however.

Scope and References for Detailed Cost Verification Procedure

In a relatively small number of cases the validity of costs projected for various cooling system alternatives becomes paramount. This situation is usually encountered when a proposed once-through cooling system is questioned or challenged on environmental grounds while the applicant is attempting to justify his proposed choice, partly on the basis of economics. If the reviewer is faced with such a situation the benefit-cost analysis requires a thorough verification not only of the final figures presented but also of the values, assumptions, and procedures used in determining the costs cited for considered systems.

It is beyond the scope of this presentation to cover the multitude of assumptions, inputs, and calculations required for verifying a cost analysis in detail. Table 9 provides sources of more detailed information on procedures and economic factors. The EIS reviewer is urged specifically to obtain reference 3, which provides nomograph solutions for many of the cost estimates required.

Table 9

REFERENCES FOR DETAILED ECONOMIC REVIEW

Subject	References
1. AEC recommended approach for benefit-cost analysis.	1
2. Plant and/or cooling system economic analysis procedures.	3, 4, 52, 53
3. Plant and/or cooling system costs.	3, 4, 53, 55, 60
4. Fuel Costs.	3, 4, 53, 55, 59, 60
5. Production Costs.	3, 4, 53, 55, 60
6. Backfitting Costs.	3, 4, 56, 57, 58

Backfitting Costs

The reviewer will need to familiarize himself completely with power plant economics to do an acceptable job of reviewing an EIS benefit-cost analysis in detail. Many site specific factors arise with respect to individual plants which necessitate such familiarity for valid judgments to be made. A good example is for backfitted situations.

Estimates on the cost of backfitted cooling facilities are available for a large number of specific plants. These data are, for the most part, contained in utility environmental reports and AEC draft environmental impact statements. The most striking aspect concerning these data is the lack of consistency in the methods of reporting. This results in widely different cost estimates. For example, total capital cost data for backfitting power plants on Lake Michigan reported by Argonne National Laboratory[57] ranged from $19.4/KW to $95.7/KW for wet towers. Assuming a fixed charge rate of 14 percent and a plant load factor of 82 percent, the increase in busbar cost would be 0.38 and 1.86 mills/KWH, respectively. Thus, these backfitting costs differ by a factor of five.

In computing the increased busbar cost due to backfitting, care must be taken to use realistic values for plant capacity factor and fixed charge rate, since a short amortization period will increase the fixed charge rate. Reducing the capacity factor and/or increasing the fixed charge rate will increase the busbar cost differential for the same total capital cost differential.

While no single value for backfitting costs can be given with assurance, in general increased cost for retrofitted cooling systems will be from two to three times the increase in costs for optimized cooling systems given previously for new plants. On the basis of literature information, Tichenor[56] estimates that:

"Increased cost due to backfitting with a conventional wet tower system is about 0.6 mills/KWH; however, site specific problems can cause wide variations, both up and down, from this general value."

Finally, it is recognized that this report can not provide the expertise required to evaluate crucial or particularly difficult cases, and in such cases it is advisable for the reviewer to solicit outside help from sources experienced in power plant economic evaluations.

SECTION VIII

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SELECTED WATER RESOURCES ABSTRACTS

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Reviewing Environmental Impact Statements - Power Plant Cooling Systems, Engineering Aspects

5. Report Date

6.

8. Performing Organization Report No.

Christianson, A.G., Rainwater, F.H., Shirazi, M.A. and Tichenor, B.A.

National Thermal Pollution Research Program
Pacific Northwest Environmental Research Laboratory
EPA, NERC-Corvallis, Oregon

Type of Report and Period Covered

12. Sponsoring Organization Environmental Protection Agency

Environmental Protection Agency report number
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This report describes the approach and technical base that have been used by EPA's National Thermal Pollution Research Program for reviewing those portions of Environmental Impact Statements (EIS's) relative to the engineering aspects (including economics) of cooling water systems for thermal power plants. The report provides techniques and data to enable the EIS reviewer to make sound judgements concerning the adequacy of both the cooling water system selected for the power plant and the EIS comments on that system. Literature citations are provided to direct the reviewer to additional and more detailed information.

The report provides information and discussions on cooling system configurations, operation, environmental effects, and costs. Consideration is given to the intake as well as the discharge.

Various closed-cycle cooling systems employing cooling towers, cooling ponds, spray systems, and other devices are covered. Methods of assessing alternative selections and benefit-cost analyses are presented. Non-thermal aspects of cooling water systems are discussed.

The report lays the groundwork for a technically sound EIS review; however, the reviewer must supplement the material presented herein with references and perhaps technical consultation to prepare comprehensive and detailed review comments.

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17b. Identifiers

Environmental Impact statements*, Cooling water systems*

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A REVIEW OF THERMAL POWER PLANT INTAKE STRUCTURE DESIGNS AND RELATED ENVIRONMENTAL CONSIDERATIONS

HANFORD ENGINEERING DEVELOPMENT LABORATORY **P.O. Box 1970 Richland, WA 99352**
Operated by Westinghouse Hanford Company
A Subsidiary of Westinghouse Electric Corporation

Prepared for the U.S. Atomic Energy Commission
Division of Reactor Development and Technology
under Contract No. AT(45-1)-2170

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A REVIEW OF THERMAL POWER PLANT INTAKE STRUCTURE DESIGNS AND RELATED ENVIRONMENTAL CONSIDERATIONS

May 1973

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ABSTRACT

The widespread national concern about the environmental impact of large steam-electric power plants is well known and has been the subject of considerable legislation and debate for several years. Although much of the publicized concern for the aquatic environment has focused on plant effluents and their thermal and chemical characteristics, the plant outfall represents only half of the interface with this environment. This report deals primarily with the other half of the interface--the intake structure where water is withdrawn from the water body for subsequent in-plant usage consisting largely of turbine condenser cooling. A review of present designs and the pertinent characteristics of various water bodies serving as coolant sources to the plants is followed by a discussion of biological considerations in intake design. An attempt is made to match biological and technological demands and some economic data are presented. A review of concepts presently under development is provided and conclusions and recommendations are offered. Finally, an appendix detailing eight representative designs is included.

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In addition, the following utilities responded to a letter survey conducted by the authors.

American Electric Power Service Corporation - New York, New York

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Carolina Power & Light Company - Raleigh, North Carolina

Cincinnati Gas and Electric Company - Cincinnati, Ohio

Cleveland Electric Illuminating Company - Cleveland, Ohio

Connecticut Yankee Atomic Power Company - East Hampton, Connecticut

Consolidated Edison Company of New York, Inc. - New York, New York

Consumers Power Company - Jackson, Michigan

Dallas Power & Light Company - Dallas, Texas

Duke Power Company - Charlotte, North Carolina

Florida Power and Light Company - Miami, Florida

Gulf States Utilities Company - St. Gabriel, Louisiana

Houston Lighting & Power Company - Houston, Texas

Kansas Gas & Electric Company - Wichita, Kansas

Long Island Lighting Company - Hicksville, New York

Pennsylvania Electric Company - Johnstown, Pennsylvania

Pennsylvania Power & Light Company - Allentown, Pennsylvania

Philadelphia Electric Company - Philadelphia, Pennsylvania

Public Service Indiana - Plainfield, Indiana

Texas Power and Light Company - Dallas, Texas

Union Electric Company - St. Louis, Missouri

Wisconsin Electric Power Company - Milwaukee, Wisconsin

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I. INTRODUCTION

Electrical power generation in the United States has doubled every ten years since 1945. At the present time, approximately 80% of the annual generation of electrical power, estimated at 1.5 trillion kilowatt hours, is produced by steam electric power stations which circulate vast quantities of cooling water through condensers to extract waste heat. The amount of water annually withdrawn for this purpose is estimated at approximately 40 trillion gallons/year, which equals roughly 10% of the total flow of water in the rivers and streams of the contiguous United States.

Much attention has been focused on the water quality effects resulting from discharge of this heated effluent and, in particular, on the subsequent effect of this discharge on the life forms inhabiting the water. However, it should be recognized that an intake structure also interfaces with the aquatic environment at the source (to the plant) of this cooling water. Although some attention has been directed towards the design and operation of water intake structures, they have received relatively little publicity, and normally have taken a back seat to the dissemination of other seemingly more important design information. As a result, the design engineer has been placed in a position where he may accept existing designs as precedent with little concern for review or for establishment of meaningful criteria to match specific plant designs to the local environmental conditions.

A properly designed intake structure is a marriage between the biological, hydrological and aesthetic demands of the particular site and the cooling needs and economic restrictions of power plant operation. The harmony of this marriage will depend on the development of standardized design criteria which are sufficiently flexible to accomodate the spectrum of site-related characteristics and to encourage the innovative designs required to minimize the environmental impact.

The Federal Water Pollution Control Act as amended in 1972 (Public Law 92-500) states under Thermal Discharges Section 316(b); . . . "shall require that the location, design, construction, and capacity of cooling water <u>intake structures</u>* reflect the best technology available for minimizing adverse

---

* Emphasis added by author.

environmental impact". . . The purpose of this report is to inform the industry, as well as to assist it in avoiding future design problems. Primary emphasis is placed on discussing ways the intake structure can be integrated into the source water environment so as to minimize the biological and ecological impact.

II. SUMMARY

Initial cooling water system concepts for a particular power plant must consider the quantity of water necessary for efficient plant operation. Next, the selection of cooling water system depends on the dominant physical and biological features of the water resource available. The results of a survey of power plants with a capacity greater than 500 MWe illustrate the current trend of intake structures used for particular combinations of cooling water systems and water source types. In general, present intake structures are engineered to economically fit water intake requirements to the particular site features.

The optimum economic solution for the cooling water intake structure design may not necessarily represent the optimum ecological solution. An assessment of the biological factors and characteristics which should be considered in the design stages is the first step in assuring an economic system which is also compatible with the aquatic environment. A biological survey to identify the abundance and temporal and spatial distribution of indigenous species will help point out critical species. Once these have been identified, parameters peculiar to their survival become important in the location and specification of the intake structure. For example, if the critical organism is a fish, then fish behavior and swimming performance in relationship to water temperature and fish size may be crucial. For smaller organisms, the intake structure may pose less of a problem than the stresses of being pumped through the condenser cooling system. Should these stresses be excessive, more stringent exclusion requirements are placed on the intake.

Once the environmental problems have been assessed, criteria must be developed to assure that intake structure design includes provisions to protect aquatic species. To properly protect these water-borne organisms, design features such as low approach velocities, proper screen mesh size, and general layout of the intake structure should meet the criteria established by environmental considerations. Operational features such as water treatment, condenser cleaning, and structural protection should also be selected to minimize environmental impact.

Thus, the design process for an intake structure can be considered as having four parts:

1. Perform environmental surveys (hydrology, ecology) to determine the aquatic inhabitants and hydrologic characteristics of the proposed site.
2. Develop proper screening (or filtering) techniques according to the organisms considered.
3. Provide a means of excluding resident and migratory species from harmful areas (or of leading them past such areas) by consideration of their native avoidance and guidance characteristics.
4. Provide (for the case of screening) in the cooling system proper, a tolerant environment for those organisms which are pumped through the system.

These factors are each discussed in detail in the text of this report. The need for standardization of criteria (and of supporting data) is shown.

Final selection of a cooling water intake will depend on the economic as well as the environmental aspects. One section of the report addresses that topic specifically, including information on both shoreline and offshore installations.

Finally, sections on recommendations and on future design considerations have been provided to unify the presentation and to provide a logical and practical summary of the findings.

III. COOLING WATER AND PRESENT INTAKE STRUCTURE DESIGN: AN OVERVIEW

A. COOLING WATER SOURCES

The amount of cooling water required by a power plant strongly influences the intake structure design. A superficial examination of intake structures might suggest that a low water flow rate is desirable, as it minimizes the size of the structure. Several design goals satisfied by minimizing the amount of cooling water are: 1) a low approach velocity at the screens; 2) disturbance of only a small fraction of the total water resource and the associated biota; and 3) a compact design for reduced capital costs. Unfortunately, however, for once-through systems, the total cooling water system requires large water flow rates to reject the waste heat without violating discharge water temperature standards.

The important physical and biological features of the water source will affect the location and type of intake structure. An understanding of these characteristics is necessary to the subsequent discussions of intake structure location and economic considerations. Some aspects of this problem are discussed below.

1. Rivers

An attractive feature of rivers is that there naturally exists sufficient resistance due to gravity flow to permit the siting of a shoreline intake and possibly a shoreline discharge structure. The major drawback associated with using river flow for once-through cooling is the relatively small number of rivers possessing sufficient flow to permit utilization of this cooling method.

In a recent AEC-sponsored cooling capacity study(1), it was noted that only some 60 streams had a critical low flow greater than 1000 cfs, where the critical low flow was defined as the minimum mean monthly flow between the years 1950 and 1960. Using a criterion of 2000 cfs, the selection was limited to less than 40 rivers. In reality, other constraints exist which further restrict this selection. The first of these constraints is the cost of transporting power and the need to locate thermal stations near load centers.

The second is that usage of water for cooling is in constant competition with other domestic and industrial demands placed upon this resource. In a study made on the Missouri River,[2] it was noted that projected consumption from all uses reduces the 1970 mean annual discharge by approximately 50 per cent during the next fifty years. Finally, a third factor results from the presence of institutional constraints such as the Wild and Scenic Rivers Act, which effectively remove certain rivers (or reaches of rivers) from consideration as sources of cooling water.

The primary considerations in the design of an intake structure along a river are: 1) to properly allow for variation in the local hydrography; 2) to provide for handling debris and siltation; 3) to prevent recirculation (possible formation of an upstream thermal wedge should be examined); 4) to protect the local aquatic ecology; and 5) to maintain channels for navigation.

2. Estuaries

One normally thinks of estuaries as "drowned river basins" which are connected to a salt water inlet or the open sea. As a result, portions of the estuary are under the influence of tidal activity. Variations in these tidal forces, accompanied by the variable hydrology of inflowing rivers, create a constantly changing environment.

Estuaries are commonly cited as the most productive aquatic areas in the world. Estuaries and the coastal shoreline are the ultimate receiving waters for the discharges and environmental modifications caused by both natural and man-made activities inland. As a result, these areas are normally rich in nutrients. Marked changes in salinity brought about by changes in the balance of the hydrodynamic forces and variations in surface runoff contribute to the dynamic state of the estuary. Estuaries serve as nurseries for many aquatic organisms of importance to commercial and sports fisheries. Estuaries possess complex ecosystems and, as such, probably provide the biggest challenge to the design engineer. The range of design possibilities might extend from designing around a photosynthetic zone to designs accomodating the migratory or spawning behavior of anadromous fishes.

The design considerations for placing an intake structure on an estuary are a combination of the aspects discussed for rivers and the effects of stratification to be discussed with respect to lake sites. The presence of current reversals can bring about signficant recirculation problems. Large variations in the response of the local hydrography and similar variations in water chemistry should be considered. In addition, deposition from sediment transport is normally very significant.

3. Lakes

As opposed to rivers, lakes do not possess large gravity flow gradients and wind stresses provide the primary mechanism for convection, although in the larger water bodies, the effect of Coriolis forces might be significant. The combined effect of seasonal prevailing wind patterns, Coriolis forces and stratification produces the dominant circulation patterns.

Distinct zonation and stratification are characteristic features of lakes. In some large water bodies, marked stratification can exist in both the vertical and laterial or horizontal plane. This is evidenced by sampling results which show large differences in water quality and biological communities between inshore and offshore water. Horizontal and vertical stratification result from the presence of sufficient resistance to minimize interference between the mixing mechanisms in the various planes. In the Great Lakes, the horizontal stratification resulting from complex circulation patterns is called a thermal bar.

The ecosystem begins with what we shall call the photosynthetic zone, or the photic zone, in which the process of photosynthesis takes place. The productivity of this zone is determined by the degree of penetration of visible light needed for the process of photosynthesis, and the presence of necessary nutrients. Penetration of solar energy is a function of the water's clarity, a property usually referred to as transmissibility. It follows that shallow water should be the most productive, biologically speaking, since in this region, light is present and nutrients are continuously recycled from the bottom due to the vertical mixing process.

The design considerations for placing an intake structure on or in a lake are somewhat different than those discussed for river siting. As little as possible of the influent water should pass through the photosynthetic zone. In addition, it should be noted that a significant addition of waste heat to the epilimnion, or a significant withdrawal of cooler water from the hypolimnion, or a combination of both, could result in shifting of the thermocline. Care should be taken to guard against the possibility of recirculation. Depending upon the size of the water body, care should also be taken to protect the structure from adverse wave conditions. A minimum variation in the water surface elevation is normally anticipated. The movement of bottom sediments should be examined and the proximity of nearby inflow identified. Clearly, on navigable waters, the structure must not impede the flow of traffic and if there is a potential hazard, it must be properly marked.

4. Oceans

The section of the ocean floor adjacent to the continental land mass and having a water depth of about 200 meters is called the continental shelf. It is characterized by a gradual slope which can extend hundreds of miles offshore. Worldwide, the slope of the shelf averages about 0.2 per cent, or 2 fathoms per mile, although it is by no means constant or uniform. Along the California coastline, the slope is approximately five times as great. Large storm centers far offshore give rise to waves which are refracted to the point that they ultimately align themselves parallel to the shoreline. Under this same principle, wave energy is concentrated by the presence of headlands. Depending upon the relative size of the wave, slope of the shelf, and the depth of the water, the wave will ultimately break, resulting in a surf zone. It is within this zone of great turbulence and immense forces that perhaps the most difficult construction problem are encountered.

On the other hand, shoreline currents pose several different problems: the essentially undirectional, rather constant force of the current must be dealt with, deposition or removal of sediments can substantially affect performance, and the zone where the currents exist supports a rather dense population of aquatic organisms. Shoreline currents result from three conditions: 1) large scale circulation resulting from the overall balance of forces and imposed boundaries; 2) the return flow to sea of water transported by wave breaking; and 3) flushing and filling of nearby inlets due to tidal activity. Depending upon local conditions, the combination of these effects, often referred to as littoral or shoreline currents, can be significant.

The littoral zone is, biologically speaking, a highly productive region of the ocean, although it does not normally compare in productivity with estuaries. Beyond the surf zone, thermal stratification does exist, but not to the extent that it exists in lakes, primarily because of the higher level of vertical turbulence. Therefore, a photosynthetic zone in the ocean is not as sharply marked as in a lake. The photosynthetic or euphotic zone can range from 0 to 80 meters in depth.

In designing cooling systems to be placed in offshore open sea environments, primary consideration has centered on construction of the pipelines through the surf zone partly because the cost associated with this type of construction is high (see Section VI). The principal biological consideration has normally been merely the exclusion of large fish. The direction of the current or drift must be kept in mind when locating the intake and discharge structures to eliminate problems of recirculation. Once again, problems of sediment transport and the possibility of impeding navigation must be considered. The consideration of all of these factors ultimately governs the lengths of intake and discharge lines.

B. PRESENT DESIGNS

A brief discussion of present intake design techniques with special emphasis on the hardware, trash removal and flow control aspects is presented in this section. Further comments with greater emphasis on the biological aspects are found in Section V.

To gather up-to-date information, letters of inquiry were sent to power stations with capacities greater than 500 MWe listed in the Electrical World Directory of Electric Utilities (78th Ed.) Replies which were received from 26 utilities covered roughly 25% of these plants. Nearly all of the stations surveyed used traveling screens with 3/8-inch square mesh screen. Several plant designs did not consider screening to any great extent, since their cooling water sources are deep wells or private holding ponds.

The simplest conceivable system is a once-through circulating water system with both intake and discharge structures on the shoreline. Conceptually, the overall system design requires sufficient resistance between the location of the intake and the outfall so that essentially no recirculation of coolant water between the two points can take place. In the natural state, few sites offer this condition without resort to structures, such as pipes or canals, to separate the two points. Optimally, the required pipe lengths can be minimized for sites located along a few of the larger flowing rivers, or at sites where cooling water can be received from one body of water and discharged into another.

In the following sections, a brief review of various intake designs is presented. The discussion begins with the more basic shoreline intakes, and progresses towards the more complex offshore intakes. A somewhat more detailed description of several structures is found in the Appendix.

1. Shoreline Intake Structures

There are two major engineering design requirements for an intake structure: 1) the structure must be of sufficient size to accommodate the design coolant flow rate; and 2) the structure must have provisions to remove, at this flow rate, debris that will not easily pass through the entire cooling system. The maximum debris size criterion is normally set at approximately 50% of the condenser tube diameter.

Based upon these two requirements, typical intake designs that have evolved contain the following features: a trash rack and sometimes a log boom, screen gates, and a set of screens. As shown in Figure 1, these features are arranged in order in front of the pump well. The coarse bar rack and log boom are necessary to exclude large debris and to protect the finer screens. The trash rack usually consists of 3-inch x 3/8-inch flat steel bars placed on approximately 4-inch centers oriented in a vertical plane. Gates or stoplogs follow the coarse rack and are used for unwatering and filling the screen well in the event of required maintenance. As mentioned, the screens are included to remove the finer debris. Normally, the screen is made of monel wire with a

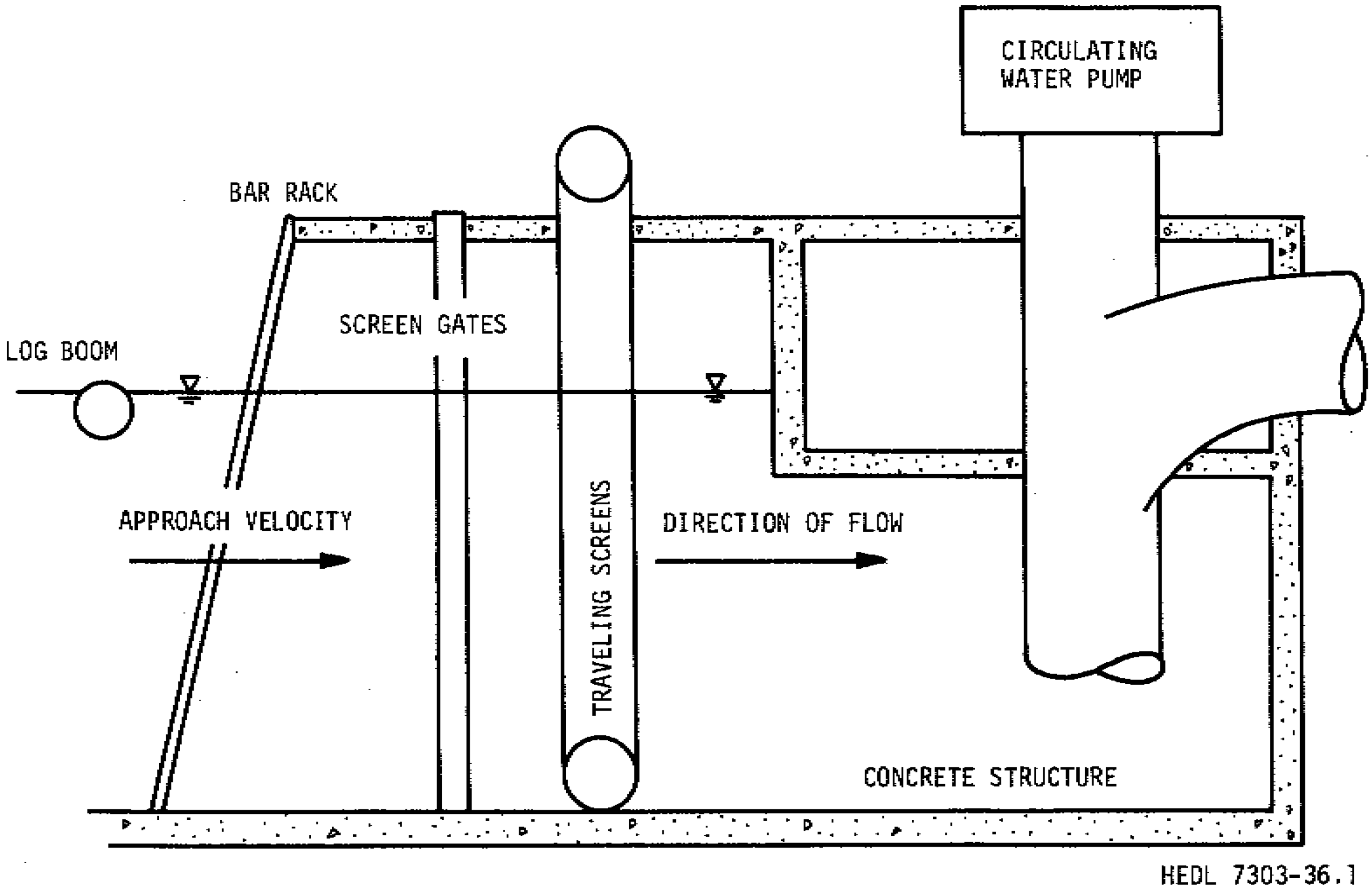


FIGURE 1. Features of a Typical Shoreline Intake Structure.

mesh size of 3/8 or 1/2 inch, and is arranged as a belt which travels in the vertical direction. Movement of the screen is usually automated, and is governed by the pressure drop, measured by manometers, across the wire mesh. A high pressure water spray is used for cleaning the screen.

In many cases, the design of the intake structure must include provisions for changes in the surface elevation of the source water body. Along some rivers, the stage variation resulting from natural seasonal variation of the discharge hydrograph can be quite substantial. Design considerations, which include stage variations of 10 to 30 feet, are not uncommon along some of the major rivers. In consideration of this fact, a design which has been used on a number of occasions for plants located along the Mississippi River employs the use of a siphon. The siphon extends from the pump well located on shore to an intake well located in the river. Figure 2 presents the intake design with the sipon used at the Willow Glen Station near St. Gabriel, Louisiana.[3] In other designs, this variable stage factor is accounted for by simply sizing the intake structure based on the low flow design condition. It should be noted that the design of the water cooling system must be based upon the most adverse flow condition. The location of the pump house with respect to the location of the plant and the intake structure will, of course, depend on the particular aspects of a chosen site. On a few occasions, TVA has found it economical to place the circulating water pumps at the screenwell outside of the equipment area surrounding the power station.

In tidal waters, the ease with which recirculation can occur normally requires that either the intake or discharge structures be connected to a canal or pipe. This problem can, of course, be circumvented if it is possible to take cooling water from one body of water and discharge it into another, thus separating the source and sink reservoirs. Examples of how this technique can be used effectively are shown in the design of a number of stations owned and

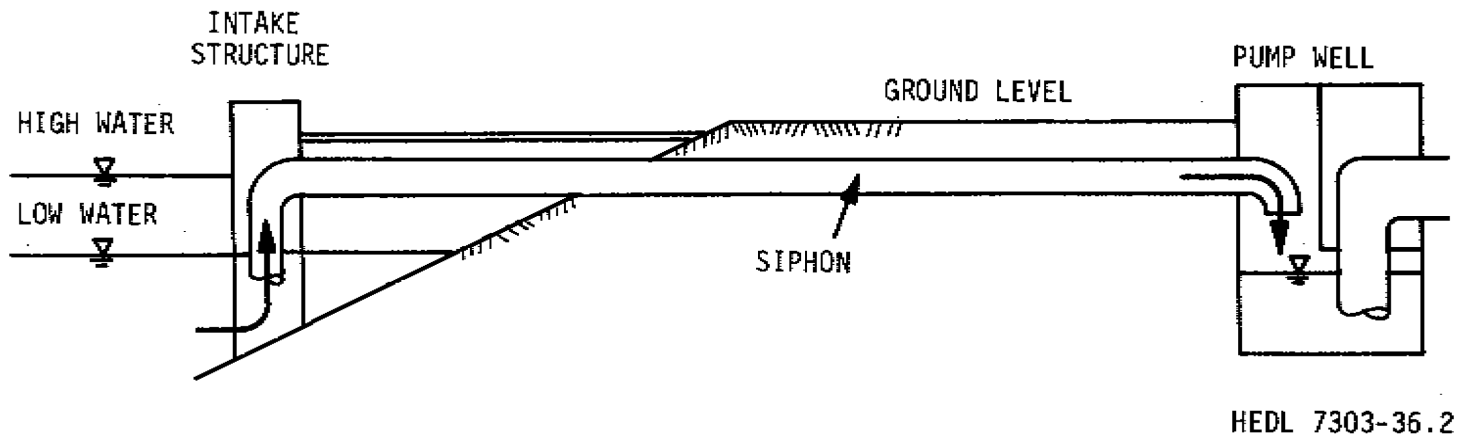


FIGURE 2. Schematic Representation of Siphon Used at Willow Glen Station, St. Gabriel, LA.

operated by Pacific Gas and Electric in Central and Northern California, e.g., the Moss Landing and Morro Bay power stations.

Figure 3 shows a schematic of the once-through circulating cooling system used at the Moss Landing Station placed in service in 1950 at Monterey Bay. The intake structure is located on Moss Landing Harbor, with a 350-foot intake conduit located between the intake and the screen well. Flow at the intake is restricted to the lower 11 feet of the intake structure to take advantage of cooler water. The effluent is discharged into Elkhorn Slough. Similarly, at Morro Bay, the coolant is removed from Morro Bay, and discharged into the Pacific Ocean next to Morro Bay.

2. Offshore Intake Structures

The engineering problems associated with constructing an intake line extending thousands of feet through difficult terrain such as a surf zone can be immense, possibly even economically insurmountable. This aspect, along with the problems associated with designing structures to be comaptible with resident biological communities, is providing a major challenge to the designer.

As in the design of shoreline intakes, care must be taken to properly locate the intake and discharge structures to provide sufficient resistance to eliminate any interaction or circulation of flow. In addition to the horizontal resistance factor, sufficient vertical resistance sometimes exists in the larger water bodies such as lakes and bays. Under these conditions, it is possible to locate the intake structure offshore and the discharge structure on the shoreline. The buoyant behavior of the effluent, coupled with the low level of vertical turbulence, allows the water body to stratify. Proper location and design of the intake structure thus allows for the selective removal of the cooler subsurface water. As a general rule, for lakes, approximately 20 feet is suggested to assure the proper vertical resistance. However, the required depth may be as great as 60 feet, as recently suggested in the design of the proposed Bell Station on Lake Cayuga.[5] Thus, each site must be examined on an individual basis.

An example of placing the intake structure offshore and the discharge structure on the shoreline is found in the Blount Street Power Station on Lake

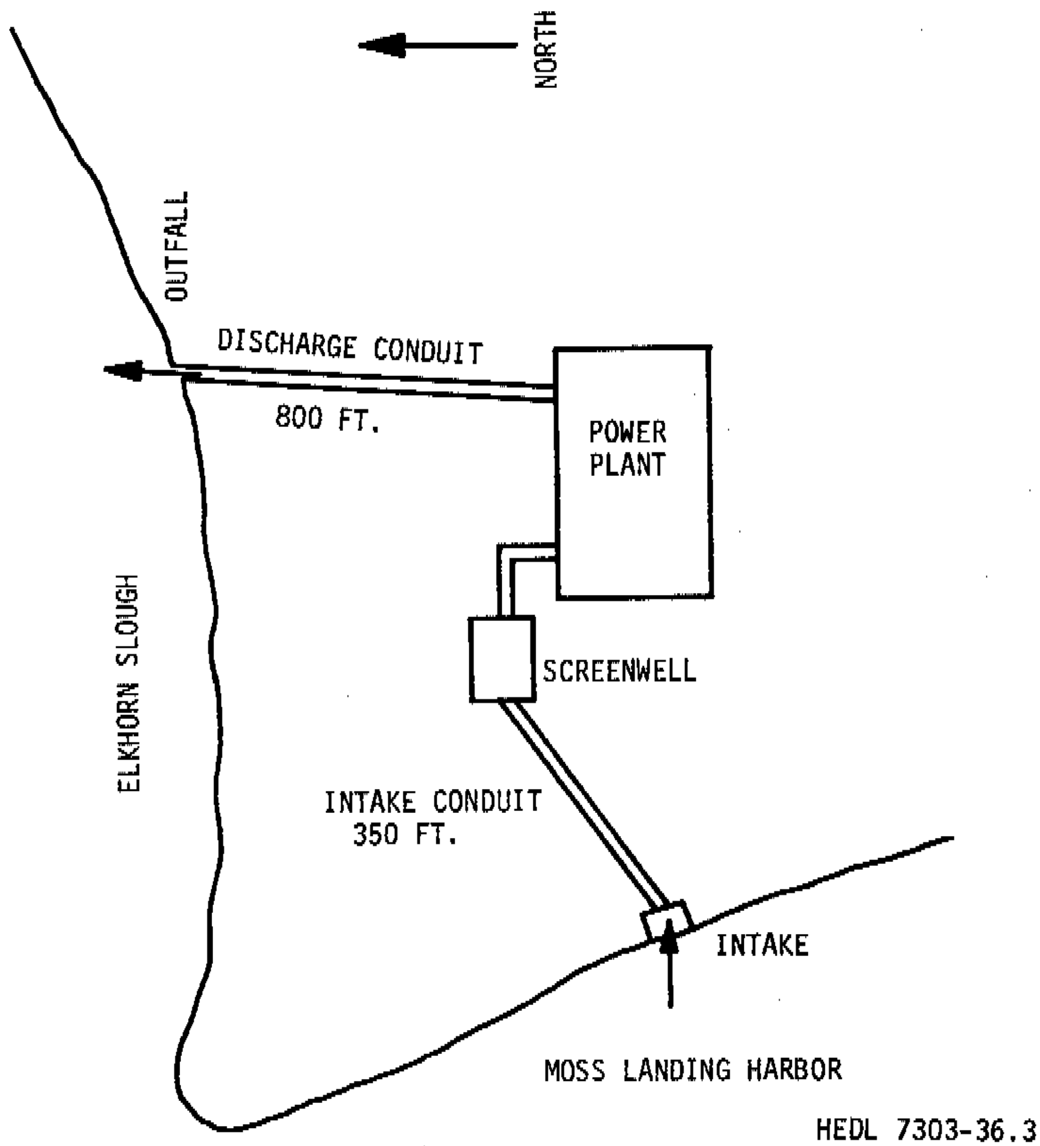


FIGURE 3. Moss Landing Electric Cooling Water System.

Monona (operated by Madison Gas and Electric Company). Figure 4 schematically shows the relative location of the two structures. The station is small, with a peak power production of approximately 120 MWe and a maximum coolant flow of 140 cfs. The intake structure is located 390 feet offshore in line with the outfall structure, at a normal depth of approximately 17 feet.[6,7] The operating experience indicates that there are few problems associated with recirculation.

When an offshore intake is employed, the pump station and screenwell are normally located onshore. In addition to the subject of recirculation, other engineering features included in the design of intake structure are: 1) the shoreline screenwell is placed at a grade which will permit gravity flow from the intake; 2) the actual intake structure is turned upright and is located above the bottom topography to minimize the problems of siltation and deposition; and 3) the intake structure is set at a grade which will not impede navigation.

The need to protect aquatic life adds another complication to the design. Requirements to minimize interference with aquatic biota as well as recreational activities, have on a number of occasions forced both the intake and discharge structures to be located offshore. Under this situation, the requirement to minimize recirculation still applies. This has normally been accomplished by separating the two structures by some distance from each other and from the shoreline, and by placing the intake structure in deeper water than the outfall structure. However, on occasion, the relative location of these two structures has been reversed.

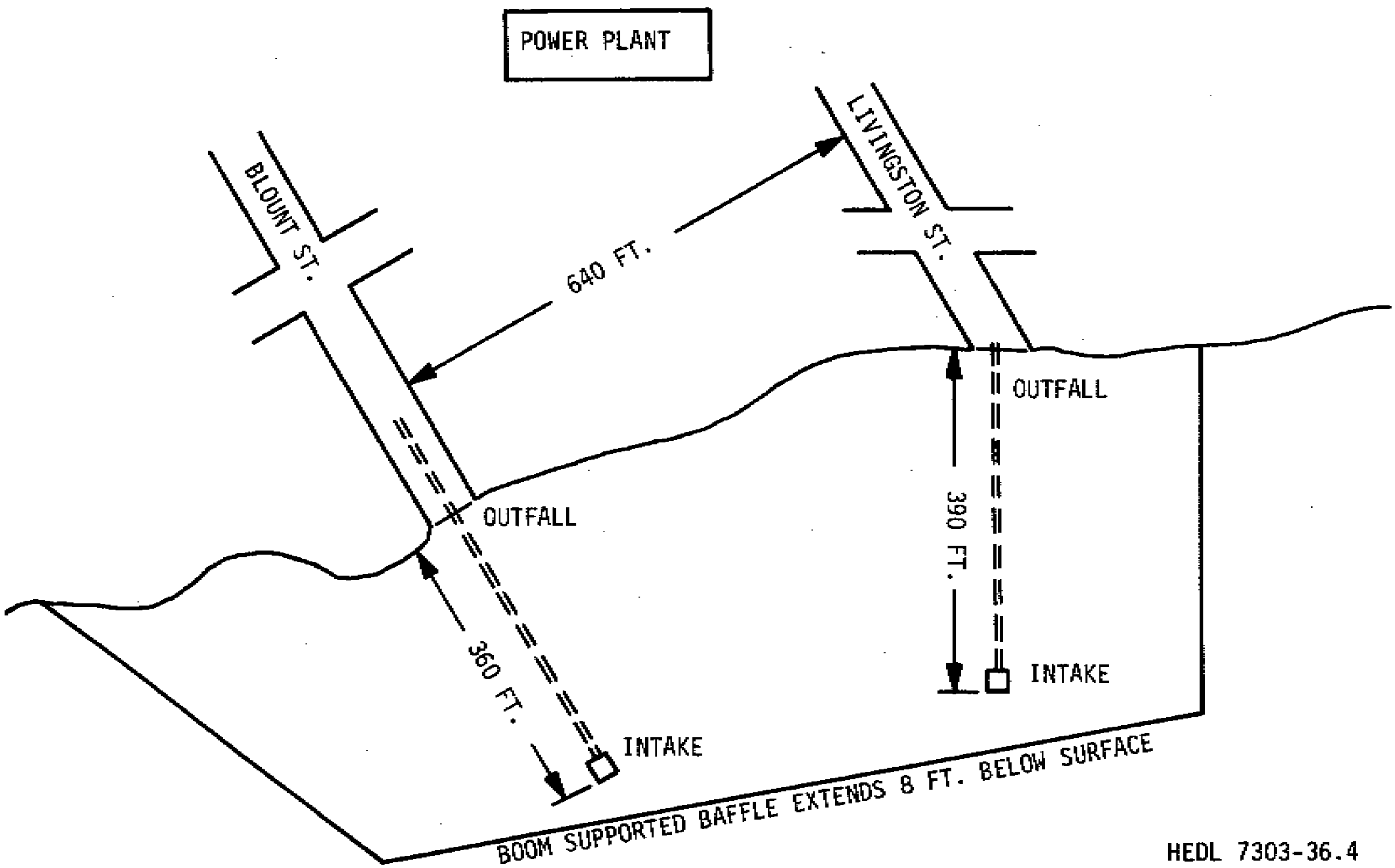


FIGURE 4. General Layout of Cooling Water System and Ponded Outfall Blount Street Power Station, Lake Monona, Wisc.

IV. BIOLOGICAL CONSIDERATIONS

To develop intake designs that are responsive to biological considerations requires an understanding of the more important characteristics of the overall ecosystem and, more specifically, the important characteristics of the various species within the biological community. The aquatic organisms can be defined by mode of living as follows:

1) Benthos - bottom dwellers; can be either sessile or motile.
2) Plankton - microscopic or small organisms characterized by no motility.
3) Nekton - free swimming pelagic organisms (fish).

An analysis of the relationships and interactions between intake structures and biota requires careful identification of the local resident organisms. Complete elimination of interaction between the biota and the intake structure is unlikely. Motile organisms such as fish can be screend, but provisions should also be made to avoid trapping them in the structure. Fish guidance and avoidance characteristics should be considered when planning screenwell mechanisms and layouts. Fish swimming performance becomes a significant characteristic during selection of structural features which determine the approach velocity of the water at the screen face. Organisms with limited or no motility, and which are too small to screen from the cooling water, will be pumped through the system. The stresses imposed on the pumped organisms as they pass through the cooling water system should be identified so that the effects can be considered in the planning stages.

A. ABUNDANCE AND DISTRIBUTION OF INDIGENOUS SPECIES

Before a proper assessment of the potential effects of power plant siting on the aquatic environment can be made, it is necessary to have an accurate survey of the occurrences and abundance of resident and transient species at, or in the vicinity of, the proposed site. To achieve this goal, it becomes necessary to answer the specific questions of what, when, where, and how many aquatic species occupy the region.

What species are present is the first question that must be answered. This question commonly centers on the presence of a target species possessing some sport or commercial value. However, it should be pointed out that important differences do exist among biologists over what needs to be protected and the particular level of protection desired. It is not the intent of this study to examine this question to any extent. Rather, a general discussion is presented to assist in establishing guidelines to match specific environmental protection needs.

The range of target or desired species is considerable, extending from the more resident benthic shellfish such as oysters, clams, shrimp, lobster, etc., at one end of the spectrum, to the anadromous fish such as shad, salmon, etc., at the other end of the spectrum. In a complex ecosystem, such as an estuary, the list of important target species usually includes numerous organisms.

As part of this primary classification, the species should be sized, and a population estimate should be made. Care should be taken to include such aspects as proximity to spawning grounds and the spawning characteristics of the particular species. For example, when considering the spawning behavior of fish, it is important to note that, while some species deposit their eggs in a suspended fashion, others place their eggs in the bottom sediments and vegetation. Suspended eggs are planktonic, as defined previously. When considering the presence of benthic organisms, it is important to note that, during the larval stages, the organisms are usually suspended in the water column and, consequently, are also planktonic.

In addition to identifying major target species and their protection, consideration should be directed towards maintaining the integrity of the entire existing ecostructure. It must be noted that the flow of energy through an ecosystem can be limited by both water quality parameters (such as temperature and dissolved oxygen, etc.) and/or the direct interaction of one organism with another organism. Whenever it is possible to identify existing weak links or points of stress in the ecosystem, steps should be taken to design around these critical areas.

The question of when particular species occupy a specific locale is important as it relates to the ambient water quality parameters. At various stages of development, organisms require different optimal environments. It follows that the temporal and spatial variations of the important water quality parameters should be established. Design and operation of the cooling system must be referenced to these parameters.

The third question which must be answered as a part of the biological inventory concerns the location of the species. One aspect of this subject was touched upon in discussions concerning the identification of spawning grounds. In considering the plankton forms, care should be taken to identify any biological stratification that might exist. In addition to vertical stratification, it is conceivable that, in some water bodies, horizontal stratification of organisms may also be present. Furthermore, the location of these productive areas might vary spatially with time.

Resident species include both fish and bottom-dwelling invertebrates (crabs, clams, etc.) Studies should be conducted to identify the distribution in space of these resident populations during the various seasons

Anadromous fish may enter the area to spawn or they may simply migrate through. Local spawning grounds should be identified. The migratory pathways of fish passing the site must also be identified. The spatial and temporal distribution of these anadromous species must be charted for both adults and juveniles. In performing such a task, it is advisable to identify major physical factors such as rivers, inlets, etc., and relate their presence to the creatures' observed behavior.

B. GUIDANCE AND AVOIDANCE OF FISH

The incidents of fish becoming trapped in power plant facilities are numerous. On occasion, the impingement of fish on the intake screen has forced plants to lower load and even to shut down. Therefore, it is important to study guidance and avoidance in order to deal with fish that become trapped, as well as to develop methods to preclude fish entrapment. A number of studies have been conducted in hopes of better understanding fish behavior. In the laboratory, fish have been exposed to various stimuli and their responses measured.

Techniques used for guiding and controlling the behavior of fish have centered on the use of stimuli such as light, velocity and acceleration, pressure, electrical shock, chemicals, and temperature. The Corps of Engineers has sponsored intensive research programs related to effective passage of salmon around hydroelectric dams on the Columbia River. During 1960-1965, the cost of the program exceeded $4,000,000[8]. While the program has focused on safe passage around dams, the basic problem is to guide fish. The practical results of this program are reflected in more efficient fish facilities and in substantial savings in fishway costs. Of special interest to intake structure problems are the different stimuli that were studied to determine efficiency in guiding salmon. It is recognized that variations due to species of fish, age, physiological state, etc., do not permit simple extrapolation of response and behavior of salmon to all fish. Nevertheless, because of the extensive work, especially on juvenile salmon, it seems pertinent to briefly review the guidance of young salmon with various stimuli.

1. Light

Much work has been done by Fields[9] on the use of artificial light to guide young salmon to safe areas. Some of the early work indicated an apparent contradictory result because, under certain conditions, young salmon were attracted to light, but in other conditions they were repelled by light. Fields summarizes the two light-guiding principles as follows:

a) "Under some conditions, artificial light can repel migrants and divert them from certain areas. In such situations, the problem is one of balancing various environmental stimuli so that light intensity overrides velocity, turbidity, depth and temperature."

b) "Under other conditions, artificial light can attract migrants and concentrate them in particular areas. Some degree of light adaptation is necessary before attraction will occur."

Dark-adapted young salmon can be guided by light repulsion when they are in relatively clear water flowing at more than 1 ft/sec. Any light perceptibly brighter than the adaptation light will elicit the avoidance response under controlled conditions. In an area with a velocity of 4 ft/sec or more, unshaded lights, for example, placed along the stream banks will move the downstream migrants away from the bank. A constant light for young salmon is more effective than an interrupted or flashing light, because the fish float into or through the light barrier during the dark phase of the cycle.

Fields[9] found guidance by light attraction inevitably involved a certain degree of light adaptation. For example, a light barrier thrown across a stream at a 90-deg angle may block all migrants for a short time, but if the water current is swift, the fish will eventually be carried into areas of higher illumination. They will then swim toward a downstream light if the other lights are turned off. The brighter the initial adapting light and the longer the adaptation period, the better the movements of young migrants can be controlled. Overall light is not an effective guiding stimulus until it is combined with other stimuli, particularly with velocity.

2. Velocity

Cruising and lower sustained swimming speeds are generally attractive (see Section B for definition of terms). Fish are very sensitive to velocity changes. Consequently, all accelerations and decelerations should be gradual. Guidance by light is not effective in still water, but velocity combined with lights provides some effective guidance through alternate channels. Further comments on the use of velocity are to be found under Visual Stimuli.

3. Pressure

Pressure, in combination with light, showed an encouraging potential as a guiding stimulus. Smolts of three species of salmon and young steelhead trout uniformly respond by swimming toward a faint light source if they are quickly subjected to increased pressure. The increase in pressure encountered by fish at a dam site as they descend from the upper 20 feet of water to 65 to 70 feet was sufficient to evoke a response of swimming toward a light source of a 100 W, 200 W and 500 W surface lamp.

4. Electrical Shock

Electrical fields have been investigated as fish barriers and guiding devices for fish passage research. The results have been of very limited success in field applications[10]. Although electro-fishing devices using d.c. current in fresh water are effective in attracting and stunning fish for capture, there are a number of problems in using an array of electrodes with direct current or interrupted direct current to guide fish. One of the major problems is the phenomenon of "fatigue" in fish. When fish are guided down an electrode array, they are subjected to alternately strong and weak electric fields. This variable field induces a muscular fatigue reaction, but at a much faster rate than if the fish were expending muscular energy voluntarily. This phenomenon of fatigue is an important factor that may cause electroguiding to fail, especially if the lateral distance over which the fish must be moved is large. On the other hand, such an electro-array may be effective in a screenwell to lead trapped fish into a fish bypass.

It is well known that alternating currents cause no electrotaxis in fish, but will bring about tetany, loss of equilibrium and death under extended exposure. Hence, alternating currents are effective as barriers for fish swimming against the current because if the fish becomes "stunned," it will be carried out of the electrical field by the water current. If there is a need to keep fish out of the discharge canal, a barrier at the mouth of the canal may be very effective. Finally, electric fields may be useful in fresh water systems, but sea water poses unique problems because of the high salt content.

5. Chemicals

Fish react differently to the presence of various chemicals. If possible, they apparently avoid sublethal levels of copper and zinc. Although they may avoid slugs of chlorine, they can become locked into an environment where the chlorine concentration level is lethal. Fish do not avoid all pesticides or herbicides, although salmon and trout have refused to enter areas where 2-4-D is present in extremely low concentrations.

6. Temperature

Fish are very sensitive to temperature gradients and they may avoid high temperatures, since they are capable of sensing low temperature differentials. However, it has been observed that fish will remain at temperatures near their upper tolerance for long periods before moving into cooler waters. Fish have been attracted to heated effluents, particularly in cold weather.

7. Sound

Sound has been used as a device to repel fish. A study performed by Van Der Walker[11] indicates that fish respond to selected frequencies. The fish tested did not become less sensitive after repeated exposure. However, use of sound to repel fish at the Indian Point Power Plant proved unsuccessful.

8. Visual

The other behavioral characteristic that should be discussed at this time deals with fish response to geometrical barriers. Two popular concepts which have been explored extensively during recent years in hopes of guiding fish involve the use of louvers and screens. Air curtains are another form of visual stimuli.

Screens are the most effective means of preventing fish from entering an area. Vertical traveling screens have become a standard feature in the design of thermal power stations. Depending on the mesh size and the size of the species present, fish can be totally screened. (This subject will be discussed in detail in Chapter V of this report.) When arranged properly, screens can also provide an effective means of guiding fish. It has been observed that as fish approach physical barriers, they will orient themselves perpendicular to, and with head away from, the physical barrier. A vectorial representation of this phenomenon is shown in Figure 5. Therefore, by placing screens or barriers at an angle to the direction of flow, fish can be guided in specific directions. In a study conducted in California, a coarse bar rack aligned at an angle of 20 to 30 degrees to the incoming flow proved effective in deflecting fish[12].

Louver screens which employ both visual and velocity stimuli have been used successfully as a means of guiding fish. Louvers take advantage of most

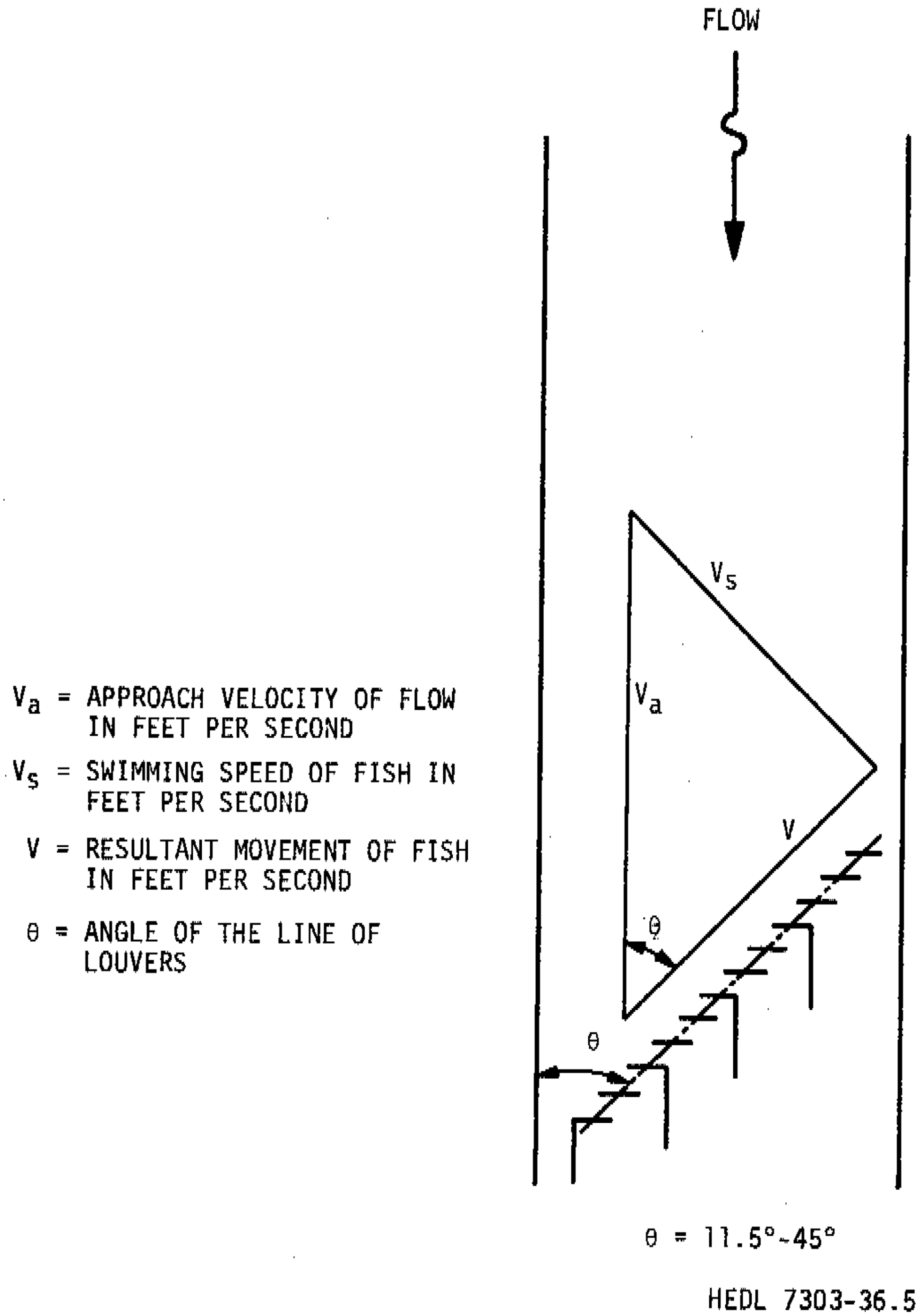


FIGURE 5. Diagrams Showing Range of Angles in Lines of Louvers Tested and Vectors of Force in Flow and Fish Movement.

fishs' natural tendency to avoid entering a zone of high velocity when they can remain in a zone of lower velocity. This behavior, combined with the natural orientation which fish assume when confronted with a physical barrier, adds to the potential success of the design. Although, to date, most of their success has been confined to small-scale and laboratory studies, large-scale facilities using louvers are currently being designed into the California diversion projects[12]. Large-scale floating debris, which has defeated field efforts in the past[13], is restrained through the use of floating booms and trashracks located upstream. The California Delta Fish Protective Facility is shown in Figure 6.

Generally, the use of air screens or curtains have proved ineffective in restraining fish passage. This is particularly true at night when they cannot see the barrier. Air curtains combined with screens, temperature and other stimuli, show signs of usefulness; however, to date the results are rather inconclusive. Air can be used to minimize the formation of surface or fragile ice[12].

C. SWIMMING PERFORMANCE OF FISH

In addition to the size of the fish, environmental factors, such as water quality, play a significant role in determining the motility of fish. The two major factors, which normally define the desirability of an environment to a particular species, are water temperature and the level of dissolved oxygen. Therefore, parametrically, fish performance should be referenced from these two water quality characteristics. This entails considerable work and, consequently, not all studies have produced comparable results, although it can normally be assumed that the dissolved oxygen level was near saturation.

The motility of fish can be discussed with respect to three ranges of swimming speed. These speeds, defined in order of endurance as suggested by Bell[6], are:

1) Cruising speed - that speed which may be maintained for long periods of time (hours). (V_c)
2) Sustained speed - that speed which can be maintained for minutes. (V_s)
3) Darting speed - that speed which can be obtained by a single effort. (V_d)

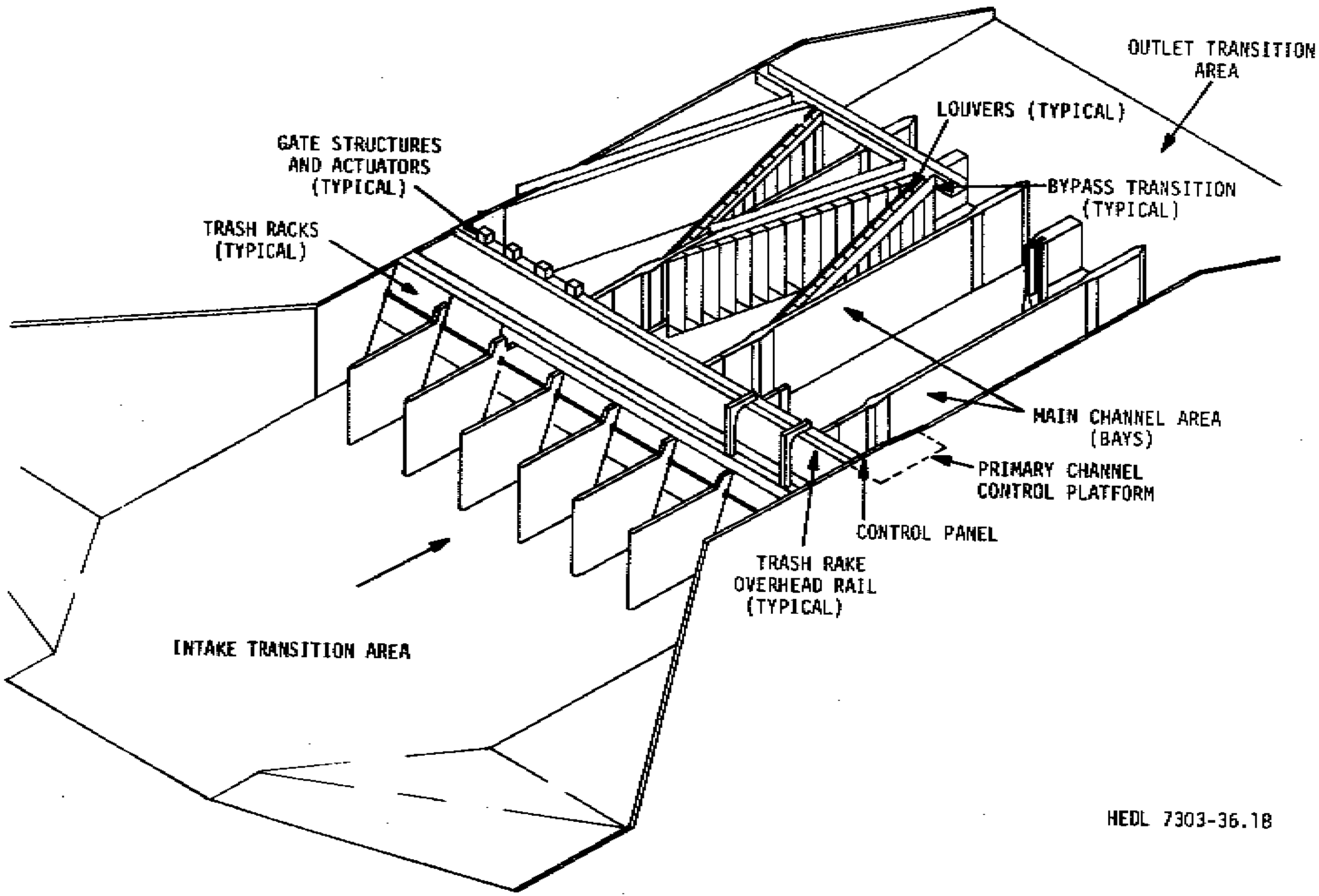


FIGURE 6. Delta Fish Facility Primary Channel System. (From California Dept. of Water Resources Manual OM-201.)

Fish employ a cruising speed for normal movement, such as migration. Sustained speeds are associated with avoiding minor perils. The darting speed is employed to avoid grave perils, or for purposes of predation. Each of these efforts requires a different amount of muscular energy.

A number of studies have been conducted to determine the relative range of these efforts for various species. As a general rule, a criterion that has been used to relate these various capabilities is that the sustained speed is greater than the cruising speed by a factor of 2 ($V_s = 2\ V_c$) and the darting speed is greater by a factor of 6 ($V_d = 6\ V_c$).[14]

Figure 7 graphically depicts the relative speeds for a number of fish using the above definitions. It should be noted that the variance associated with the use of the mean coefficients discussed above can be considerable.

The size of the fish directly affects its ultimate swimming speed. A number of empirical models have been presented that quantitatively summarize this aspect of performance. Theory developed by Lighthill[15] suggests that the swimming speed of a slender fish is directly proportional to the product of its length and the frequency of its tail motion. The theory was developed by assuming that fish propel themselves by passing a wave down their body. To the investigator in the laboratory, this motion becomes observable in terms of the frequency or beats of the tail. In a study performed by Bainbridge[16] using a trout, a dace, and a goldfish, the empirical model developed was:

$$V = 1/4\ L(3f-4)$$

where:

V = velocity in cm/sec,

f = frequency of tail motion in terms of beats/sec,

L = body length in cm.

The generality of the model is unknown. However, it should be noted that the empirical findings are consistent with the theory.

As mentioned previously, other factors directly affecting fish motility are the temperature and dissolved oxygen concentration of the ambient water. The absolute water temperature, as well as the thermal history of the organism, has a significant effect upon the performance of the fish as measured by its

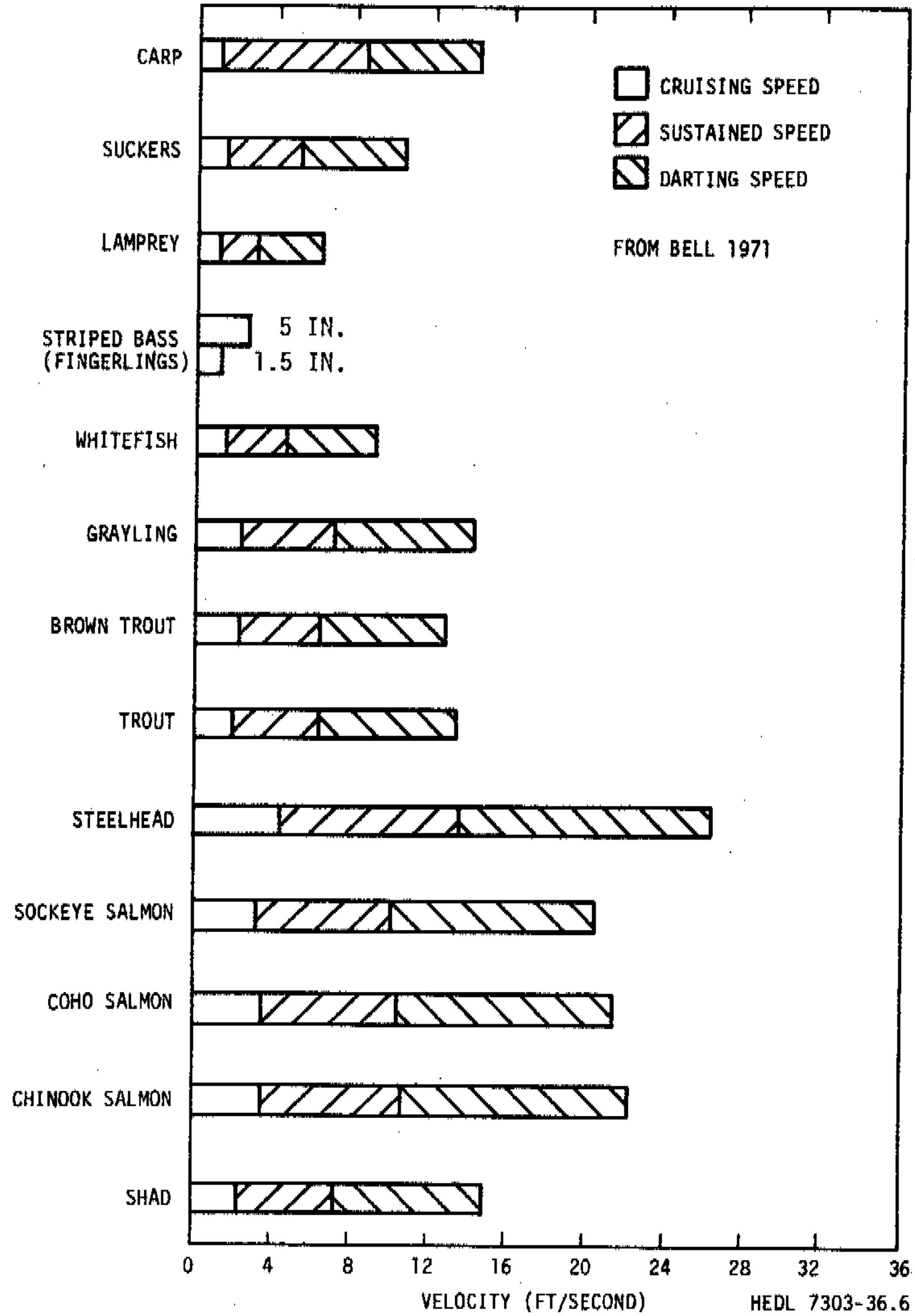


FIGURE 7. Relative Swimming Speeds of Averaged Size Adult Fish.

swimming speed. This statement has been confirmed in a number of studies. Temperature on either side of an optimal environment will affect the swimming performance. A graphical representation of this phenomenon is shown in Figure 8 from Brett[17]. This illustration indicates a 50 percent reduction of swimming effort over the entire tolerant temperature range shown.

The swimming performance is also affected by the available oxygen. Dissolved oxygen should be maintained near the saturation level. Studies have indicated that, as the oxygen content becomes reduced, the swimming performance falls off drastically. Reducing the oxygen level to one-third saturation reduces fish swimming performance by a factor of 2[14].

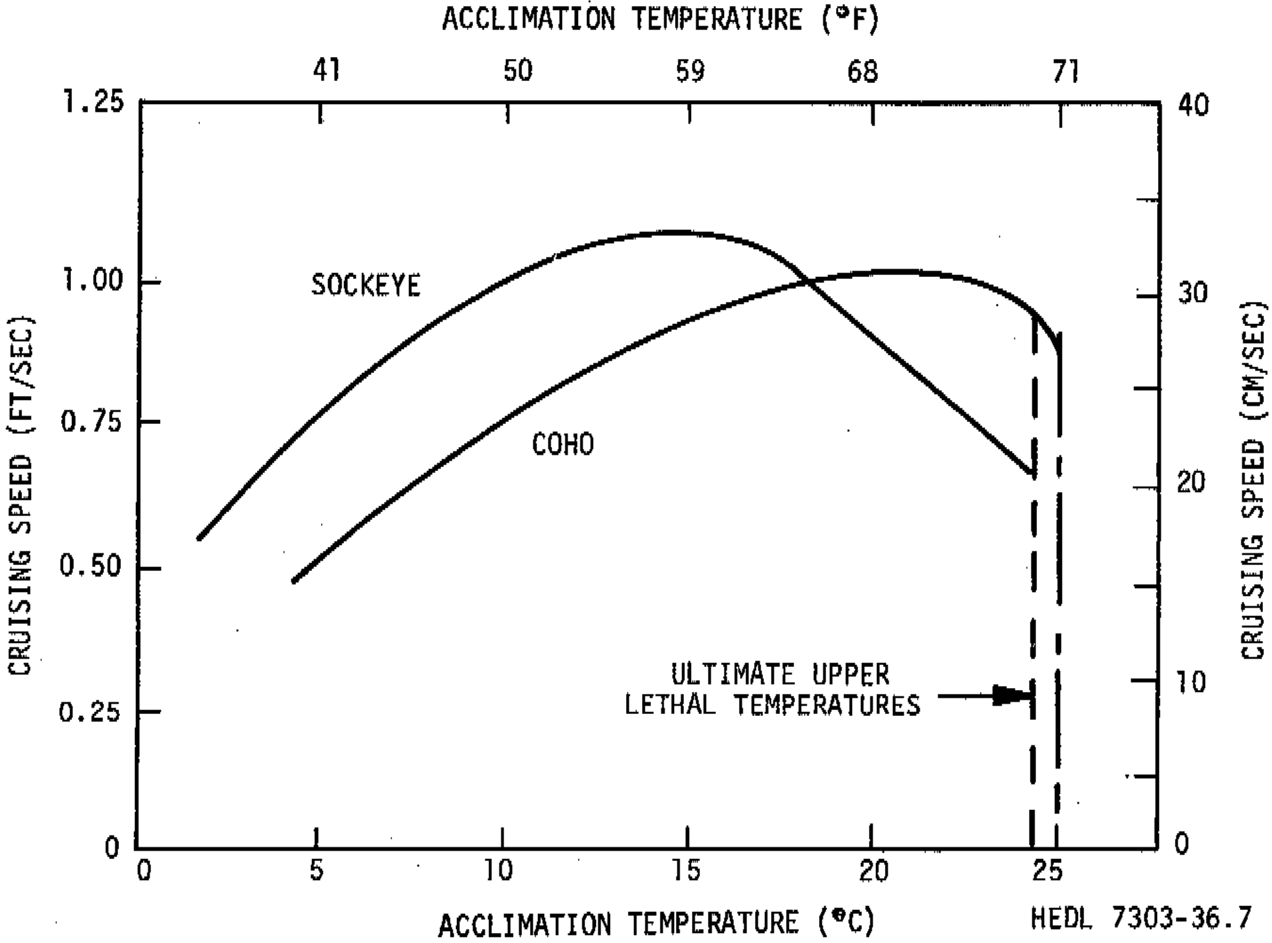


FIGURE 8. Maximum Sustained Cruising Speed of Sockeye and Coho Underyearlings in Relation to Temperature.

D. ENTRAINED OR PUMPED ORGANISMS

As discussed, using conventional designs, it is impossible to screen all organisms. Plankton and small fish are therefore ultimately sucked into the intake structure and subsequently pumped through the remainder of the cooling system. Plankton may include organisms from small microscopic zooplankton and phytoplankton to larger larval and juvenile fish. It is therefore important to examine the stresses imposed on these organisms in passing through the cooling water system if the potential biological damage is to be properly assessed.

1. Identification of Stresses

Organisms are exposed to various kinds of stresses as they pass through the cooling water system. These stresses result from the presence of mechanical devices, pressure changes, temperature changes, and chemical additions within the system.

Mechanical stress is defined as a stress brought about by the impingement of an organism on a rigid surface. This stress most notably would occur in passage through pumps, around bends in pipes, and through constricted areas. Two important variables in determining the measure of an organism's susceptibility to damage relate to the organism's size and density. A number of studies have been conducted by the Corps of Engineers in attempts to develop suitable models for predicting fish mortality resulting from their passage through turbines. The models developed indicate that the probability of contact is proportional to the rotational velocity of the impeller, length of the fish, overall cross sectional area of the passage, and the cosine of the inlet angle. To the authors' knowledge, relatively little effort has been expended on developing similar models describing the potential threat to plankton in secondary cooling systems.

Seemingly significant pressure changes and pressure gradients are experienced by organisms passing through cooling systems. Defining these potential stresses is difficult, since the pressure history that the organisms are exposed to varies from station to station, as well as from organism to organism passing through the same system. If it can be assumed that the organisms are hydrodynamically similar to water particles, we might consider the history of these organisms analogous to water particles.

As indicated in Figure 9, the first major pressure change in the cooling water system is developed in the cooling water pumps. The total pressure change at this point varies from station to station as dictated by the overall pressure losses throughout the system. Typical pressure changes range from 20 to 40 feet or 10 to 20 psi. In traveling from Point A to Point B, only a minor pressure gradient exists, the change in pressure resulting from losses experienced along the supply conduit. The system head loss and gradient across the condenser is larger than that of the supply conduit. In addition, it should be noted that for some designs, portions of the discharge side of the condenser can be above the system hydraulic gradeline, indicating the presence of a negative pressure. Finally, from the discharge side of the condenser, the cooling water is returned to a receiving body or sink.

In summary, it can be stated that, in addition to the presence of abrupt positive gradients, negative gradients are characteristic of the system.

The temperature change in the coolant water occurs across the condenser. This average temperature change has been included in Figure 9. The temperature change, of course, varies slightly from condenser tube to condenser tube and, once again, from power station to power station. The temperature gradient is dependent upon the time of travel through the condenser, normally a few seconds.

Chemicals are added for fouling and corrosion control. Chlorine is often added intermittently at the intake headworks just in front of the circulating water pumps. The chlorine residual on the exhaust side of the condenser is commonly 0.2 ppm or less. More complete discussion of this aspect can be found in Chapter V.

2. Studies on Induced Stresses

Although it is not the intent of this review to list in detail the studies performed to date dealing with biological damage to organisms passing through cooling systems, a few points should be mentioned.

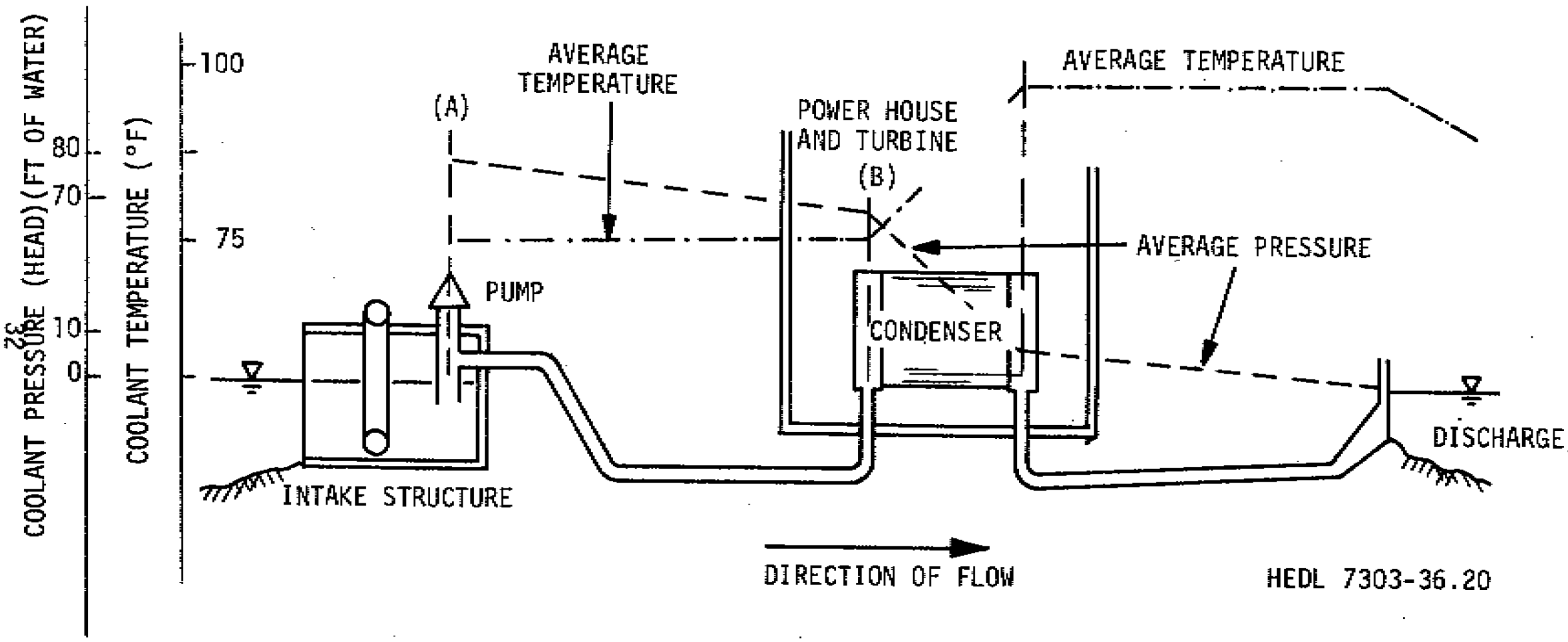


FIGURE 9. Hydraulic and Temperature Gradients Through a Secondary Cooling System.

Most of the effort that has been performed on the effect of induced stress to aquatic organisms has centered on the subject of thermal tolerance. Instantaneously changing an organism's environment can be thought of in terms of a dose. This dose is characterized by the acclimated temperature of the organism, the incremental rise of temperature, and the length of time or duration of exposure. In Figure 9, the thermal history of a water particle was shown. As indicated, the temperature increases as the water particle moves through the condenser. This increase, which usually occurs over a few seconds, might be termed a thermal shock. The organisms are then subsequently held at this temperature until the effluent is discharged into the receiving waters, where the temperature of the effluent is reduced primarily through dilution. The duration of time required to travel through the discharge conduit to the point of release is normally a few minutes. A number of field and laboratory studies have been conducted to measure the thermal tolerance of various species. The reader is referred to reviews presented by C. C. Coutant[18,19] and others.

One of the first studies conducted in the field to measure the effect of thermal shock was performed at the Contra Costa Power Station in 1952[20]. In this experiment, a condenser tube was isolated by extending it out on each end of the water box walls and connecting it to hoses. The hoses were in turn connected to dispersing and receiving tanks. Juvenile Chinook salmon and juvenile striped bass were then passed through the condenser tube. High survival was experienced by both species, indicating little, if any, effect.

A number of studies have recently been performed, and several are underway, to detect the effect on organisms passed through cooling systems under load by collecting measurements in both the intake and discharge structures. It is difficult to generalize the results of these studies unless sufficient care is taken to define the specific system stresses previously defined. The effect of gradients discussed previously, if not properly identified, could significantly reduce the usefulness of the study results. In addition, the interactive effects should be examined.

In support of this statement, let us consider the case discussed previously on passing fish through the Contra Costa cooling system. By connecting the condenser tubes to a separate dispersing and receiving tank, the system continuum was broken. Consequently, although the thermal history of the two systems is similar, the mechanical and pressure stresses may be different. Thus, the effect of pressure gradients and the mechanical stress factor were essentially removed from the experiment.

V. MATCHING BIOLOGICAL AND TECHNOLOGICAL DEMANDS

In Chapter IV, the various biological characteristics important to intake design were discussed. In this Chapter, an attempt is made to interface the requirements for the particular waterbody and its contained biological community with the requirements of the power plant to arrive at a best design. Meaningful guidelines or criteria should be established which relate the technological demands of the power plant to the level of protection thought desirable.

A. ESTABLISHING CRITERIA

As a point of discussion, consider the following criteria that were used in the design of the Calvert Cliffs Nuclear Power Plant cooling system. To quote from Reference 20:

1) Condensers should be designed so that the temperature rise in the cooling water which passes through them is as low as practicable. This will avoid subjecting pumped organisms to temperatures above their thermal damage threshold and will minimize thermal shock.

2) The cooling water intake to the plant should draw water from below the photosynthetic zone to minimize the entrainment of plankton and other microscopic organisms.

3) The intake velocity of the cooling water to the plant should be low enough to avoid disturbance of the schooling and swimming patterns of fish and to permit ease of egress for those fish that swim into the intake basin.

4) The cooling water system design should utilize mechanical equipment to clean condenser tubes to minimize the use of biocides for fouling control.

5) The point of discharge of the cooling water should be located far enough out from the shore so as not to disturb the current patterns and temperature regimes of the shallow water areas and should provide ample opportunity for mixing of the warmed cooling water with the receiving waters.

6) The cooling water discharge should be designed to create a high velocity jet to induce rapid mixing with the receiving waters to minimize changes in natural temperatures and oxygen content.

7) The cooling water discharge should be designed to minimize the time at which the maximum temperature elevation exists. Short exposure times as well as a minimum temperature rise are important in protecting the aquatic life."

Criteria 1 through 4 relate to intake design and the stresses found in the secondary cooling system. Criteria 5 through 7 relate to outfall design, and have been included to show added examples of environmental protection criteria.

As indicated in the previous chapter, the spectrum of aquatic life which might be considered in designing an intake structure extends in size from microscopic plankton to larger fish forms. It was suggested that screens provide a very effective means for both guiding and stopping fish. In concept, the sizing of the screen mesh is based on the size of locally important fish species. However, there are limitations to the minimum size of screen mesh that can be employed. Operationally, for a given flow rate, reducing the mesh size increases the head loss across the screened area, and increases the potential for fouling or clogging, since the open area of the barrier is reduced. The use of fine mesh also invites a potential frazil ice problem. In addition to the operational problem, reducing the screen mesh opening increases the probability for the smaller organisms to become impinged on the wire. Since these smaller organisms are extremely delicate, mechanical stresses of this type should be avoided. In practice, the normal mesh size ranged from 3/8 to 1/2 inch.

1. Plankton

Large water bodies can become both horizontally and vertically stratified. The governing factor, as indicated in Chapter III, depends on the relative resistance and scale. The location of the more highly productive areas of desired species that need protection should be identified by the biological survey discussed in Chapter IV. The existence of a clearly defined photosynthetic zone will vary from one water body to another, depending on a number of factors, including level of turbulence, convective motion in the vertical water column, and transmissibility of the water.

A study should be performed to relate cause and effect and to identify the reasons why some areas are more productive than others. Key factors to be identified include circulation, salinity, temperature, light, etc. Next, the operation of the power station should be superimposed upon this overall hydrologic/biologic structure. The effect of dispersing significant quantities of waste heat into the epilimnion, and removing large quantities of cooler water from the hypolimnion on the location of the thermocline should be examined. An example of such a study has been presented by Sundaram, et al.[5], in examining the effect of siting the Bell Power Station on Lake Cayuga.

Another approach to providing the proper level of protection suggests the relative volume of cooling water which can be withdrawn from the water source. Clearly, in rivers, the potential for damage is greater for a station where a substantial portion of the river flow is diverted or affected by the operation of a thermal power plant. In this context, it is worthwhile noting that, in the report of the Committee on Water Quality Criteria[22], a safe passageway (unaffected zone) was specified as consisting of 75 percent of the cross-sectional area and/or volume of flow in a river or estuary.

2. Fish

Once the species and size distribution of the resident population have been identified, the design criteria for the intake structure can be established. In establishing the design criteria for fish, such items as screen mesh sizing, the scaling of approach velocities, and the variation of fish endurance as it relates to the water quality parameters should be factored into the decision making process.

Depending on the species, size of species, and time of year, fish behavior and motility vary considerably. The speed at which fish can swim is related to their overall length. Their physical condition, measured by endurance, varies seasonally, depending upon the water quality. Both of these aspects should be considered for the species of interest. Specific questions that might be asked are:

1) At what velocities are fish safe against impingement?
2) What size screen mesh should be used to stop fish from penetrating the barrier?

Answers to these questions should account for the characteristics of local water quality; specifically, temperature and dissolved oxygen.

Typical endurance curves for salmon and striped bass are shown in Figures 10 and 11. The results were obtained in a study performed by the California Department of Fish and Game and the Bechtel Corporation for Pacific Gas and Electric Company[20] for the design of the Contra Costa Steam Plant. The experimental endurance curves were obtained by placing the test population of fish in a screened flume and subjecting them to the velocity shown in the abscissa for the duration of time indicated. At the conclusion of the test, the velocity was reduced to zero, and a typical head count was performed. Such experiments should be repeated for the range of environmental conditions that most probably will exist and for the various species of interest. A realistic approach velocity can be decided upon once this information is obtained.

The screen mesh sizing should be considered. The physical shape of fish varies with species and also varies individually within the species. Fish of the same age group may be long and slender or short and fat. If fish become exhausted, they normally become impinged broadside on the screens. Thus, it has been found that fish will be stopped by a screen, although they are physically small enough to pass through it. If, by chance, fish should align themselves perpendicularly to the mesh opening, the fish can be stopped physically by the bony part of their head, as indicated by Bell[14]. For this condition, Bell has proposed the following model for computing mesh size as a function of fish measurements.

$$M = 0.04\,(L - 1.35)F; \quad 5 \le F \le 6.5 \tag{5.1}$$

$$M = 0.03\,(L - 0.85)F; \quad 6.5 \le F \le 8.0 \tag{5.2}$$

where:

M = maximum screen mesh opening in inches
L = length of the fish in inches
D = body depth in inches
F = L/D = fineness ratio

However, as pointed out by Bell, the number of fish used to determine the model was small and, consequently, the formulation should be used primarily as a guide. The envelope or range of relationships using Equations 5.1 and 5.2 is shown in Figure 12. By way of comparison, the data presented by Kerr[20] are also shown in Figure 12.

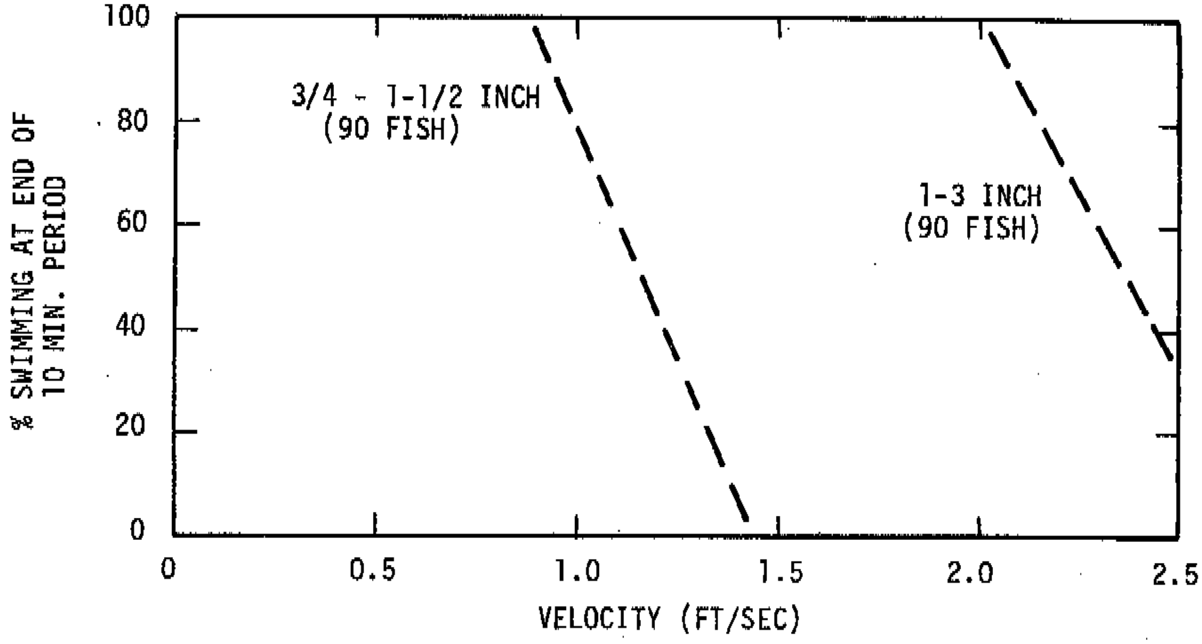


FIGURE 10. Ten-Minute Velocity Endurance Curve for Striped Bass.

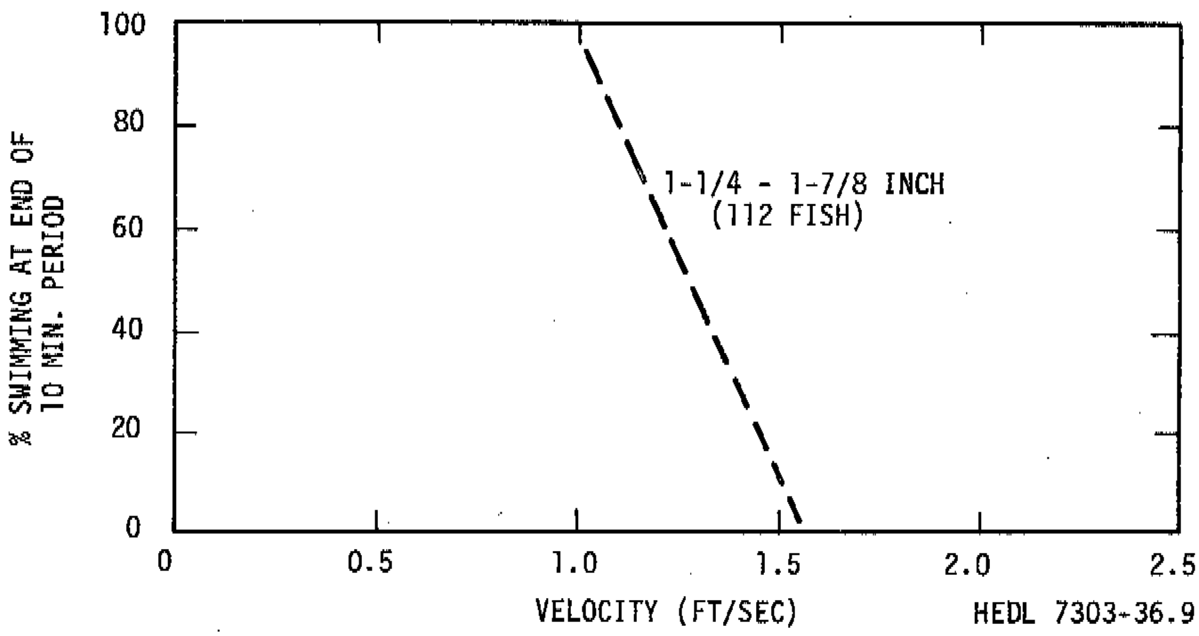


FIGURE 11. Ten-Minute Velocity Endurance Curve for Chinook Salmon.

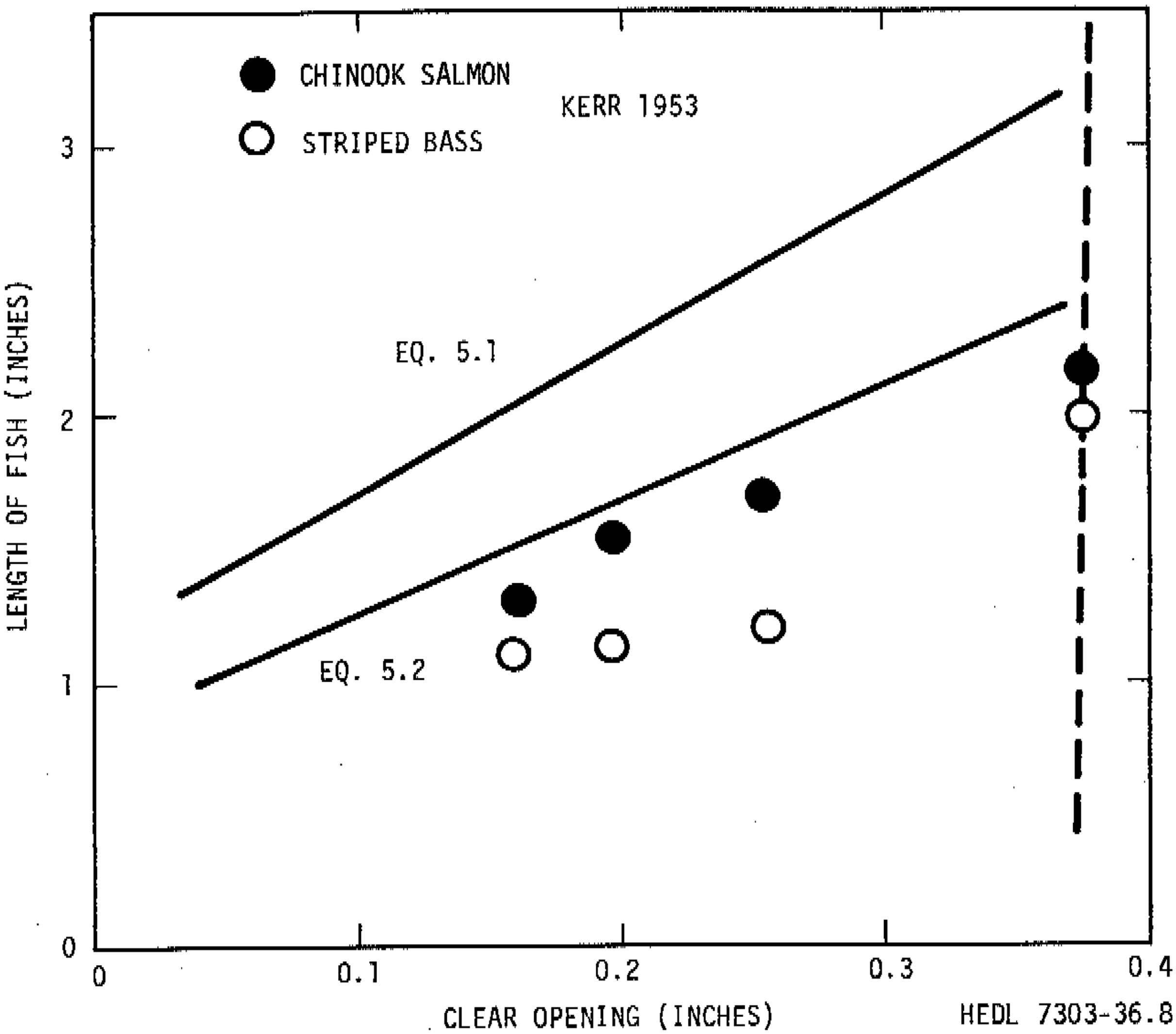


FIGURE 12. Effectiveness of Screening: Clear Opening vs Length of Fish.

The swimming ability of fish decreases as their size decreases. Thus, the designer must eventually reach a point where it is no longer feasible to design a structure based on approach velocities because reducing mesh size is no longer practicable. A value judgment must be made regarding the extent to which screen sizes can be reduced before significantly increasing the potential for impingement.

B. CANALS AND SKIMMER WALLS

On occasion, approach canals and skimmer walls have been used. If not designed properly, the use of these features can sometimes result in fish traps.

1. Canals

Intake canals have been built for purposes of: 1) providing a protected area for the intake structure; 2) a means of locating the intake structure and pump station near the power station, reducing pumping head losses, etc.; and 3) separating the location of the intake and outfall structure. The problem associated with the construction of an intake canal is that fish frequently swim into these recessed areas and become trapped. If an intake canal is used, some means of safely returning the fish must be included in the design.

Discharge canals are constructed for basically two reasons. First, they are a means of providing enough resistance between the intake and the discharge so that no recirculation occurs. Secondly, they provide a means whereby the temperature of the effluent can be reduced by dilution before it is discharged into the receiving water.

Warm water in discharge canals can either attract or repel fish, depending on the preferred temperature for the specific fish and on the time of year. Generally, during the cold season, fish congregate near the effluent discharge. This is particularly true of warm water species. However, during the warm summer months, the discharge canal may present a potential hazard. As indicated in

Figure 9, the temperature increase induced by the condensers remains until the cooling water temperature is reduced through dilution. If a discharge canal is included in the design, the reduction of this temperature is restricted and the thermal profile might instead look like the profile shown in Figure 13[19]. This situation should be avoided, as criterion 7 of the Calvert Cliffs plant indicates. The condition can, of course, be lessened by introducing auxiliary cooling units to temper the water. This particular concept is employed in the operation of the Fort Marlin station on the Monogahela River[23] and Oyster Creek station on Barnegat Bay[24]. Auxiliary pumps have been installed to reduce the effluent discharge temperature through dilution.

2. Skimmer Walls

Skimmer walls are used under conditions where vertical stratification exists and to collect floating debris. The walls, once again, are designed to provide the necessary resistance between the intake and discharge location. The presence of a skimmer wall can create problems similar to those encountered with the intake and discharge canal. Fish can find their way into the partitioned areas around intakes, and once there, remain. Skimmer walls used around discharge points to pond the heated effluent do not present as serious a problem as discharge canals, since fish can always sound in order to avoid the warm water, provided there is sufficient depth.

C. DESIGN

Comments on intake design based upon biological considerations are presented in this section.

1. Shoreline Intakes

The arrangement of the various features associated with conventional shoreline intake designs was shown in Figure 1 and a set of representative criteria suggested for their design (from Calvert Cliffs) was given at the beginning of this chapter. As suggested, the ecological survey should include the identification of biologically productive zones. In addition to vertical stratification (criterion 2) the presence of horizontal stratification should be examined. The intake velocity of the cooling water should be low enough

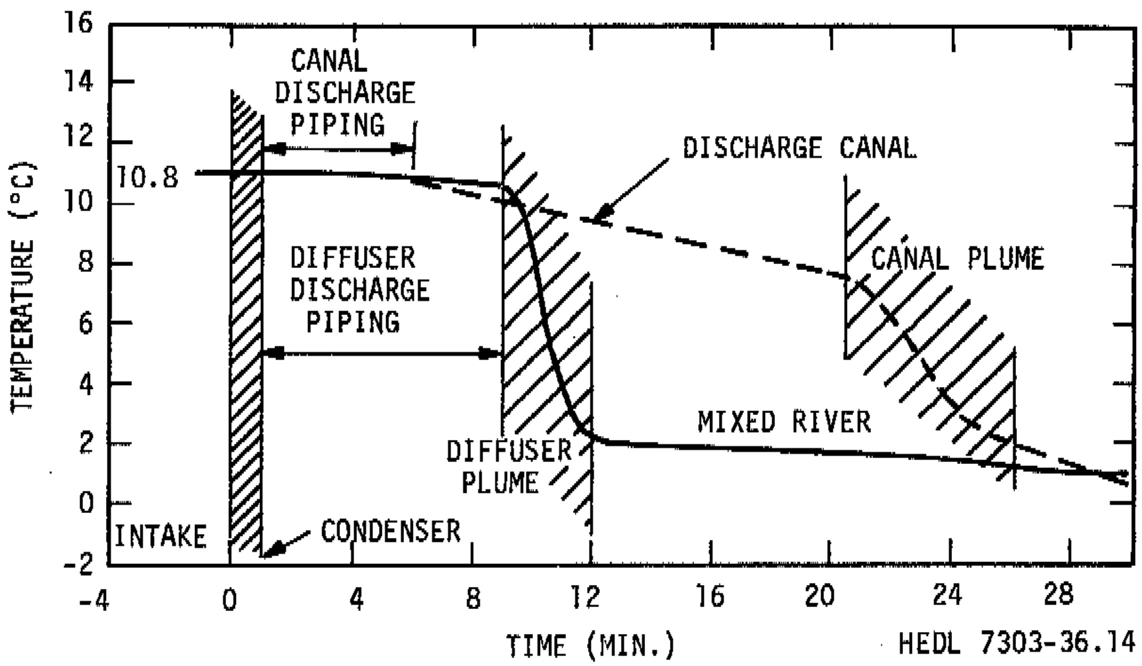


FIGURE 13. Comparison of Temperature Profiles in a Large River: Discharge Canal vs. Direct Discharge.

to avoid disturbing the fish's schooling and swimming patterns (criterion 3). In the case where anadromous species occupy the source water body, the location and operation of the intake structure should not impede their migration. The orientation of the structure is very important. The intake structure should be placed such that the integrity of the preconstruction shoreline is maintained. Extensive indentations such as canals should be avoided whenever possible.

The Pittsburg (California) power station employs the "Pacific Gas and Electric Intake Design." The design includes the basic features discussed previously. The intake and screenwell structure are placed together at the shoreline. The overall sizing of the structure has been considered in reducing the approach velocity to one that can be tolerated by the resident fish. The actual arrangement of the features of the PGE design is shown in Figure 14. The cooling water screens are placed flush with the face of the intake at the shoreline. The trash racks form a cage located out in the source water body, keeping debris from the screens, but allowing free passage of fish[25,26].

At the Pittsburg Station, the effluent is discharged upstream of the intake into Suisun Bay. Recirculation at the Pittsburg Station has been prevented by the construction of a retaining wall that extends from the shoreline approximately 800 feet outwards into the bay (Figure 14).

Based on the research performed using the resident anadromous species of the San Joaquin and Sacramento Rivers, striped bass and chinook salmon, the design approach velocities for the Contra Costa and Pittsburg steam plants were set at 1 ft/sec. The approach velocity is the velocity of flow through the exterior bar rack structure in front of the traveling screens. The fine mesh opening for both plants was set at 3/8 inch square.

The 3/8-inch mesh corresponds to stopping both 2 to 3 inch striped bass and 2 to 3 inch chinook salmon fingerling (see Figure 12). Both the 2-inch striped bass and the chinook salmon fingerling possess the capability of swimming at a sustained speed greater than 1 foot per second. Therefore, the fish intended to be excluded from being pumped through the system possess the swimming capability to tolerate the design approach velocities. It is presently believed that the design approach velocity should be as low as practical to minimize impingement.

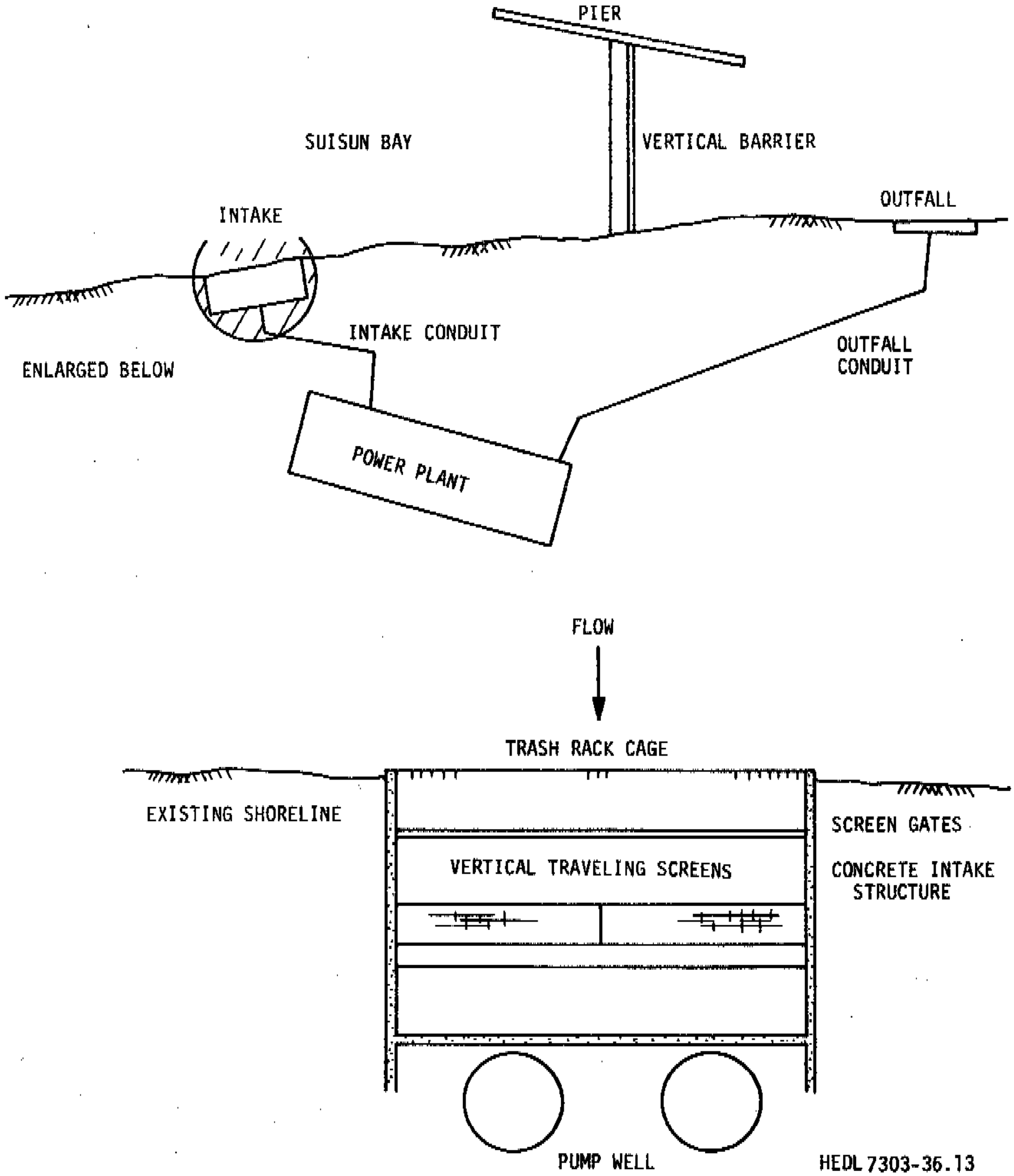


FIGURE 14. Secondary Circulating Cooling System used at Pacific Gas and Electric Pittsburg Steam Electric Plant.

In the design of the Peach Bottom Nuclear Station located on the Susquehanna River in Southeastern Pennsylvania, the recommended approach velocity was set at 3/4 foot per second[27]. This velocity was based on studies performed on the swimming speed of the native white crappie and channel catfish. At the Salem Nuclear Station to be located on the Delaware River Estuary[28], and the Millstone Station[29], a 1 foot per second approach velocity has been recommended.

2. Offshore Intakes

In the 1950's, the operation of the Redondo and El Segundo Power Stations by Southern California Edison resulted in occasional fish kills. Large schools of fish would enter the intake pipe and become concentrated in front of the fish screens[30]. Two basic approaches to alleviate the problem were considered. In the first approach, fish were prevented from entering the pipeline. In the second approach, fish were removed from the screenwell and returned to the open water.

A solution from the first approach of preventing fish from entering the intake pipe resulted from the observation that fish sense and subsequently react to vertical flow fields much more slowly than to horizontal flow fields. As a result, fish near a vertically oriented intake can be drawn into the structure quite easily. Steps were taken to reorient the flow pattern from the vertical plane into a horizontal flow field. This was accomplished by inserting a velocity cap on top of the previous design, as shown in Figure 15.

As mentioned in Reference 31, "...Test results were startling. Without a velocity cap, the small fish were swallowed up and rapidly disappeared into the pipe. However, it was almost impossible to draw any fish into the pipe when a velocity cap was being used..."

The entrance velocity is controlled by the opening of flow gap, which is adjusted by setting the lid at the desired grade. The flow gap at the El Segundo intake is set at two feet, giving a maximum normal entrance velocity of approximately 3.5 feet per second. The flow gap at the Huntington Beach Station is set at 4.5 feet, resulting in an entrance velocity of approximately two feet per second. The design entrance velocity should, of course, depend upon the local species of fish and should be such that the fish are capable of tolerating the

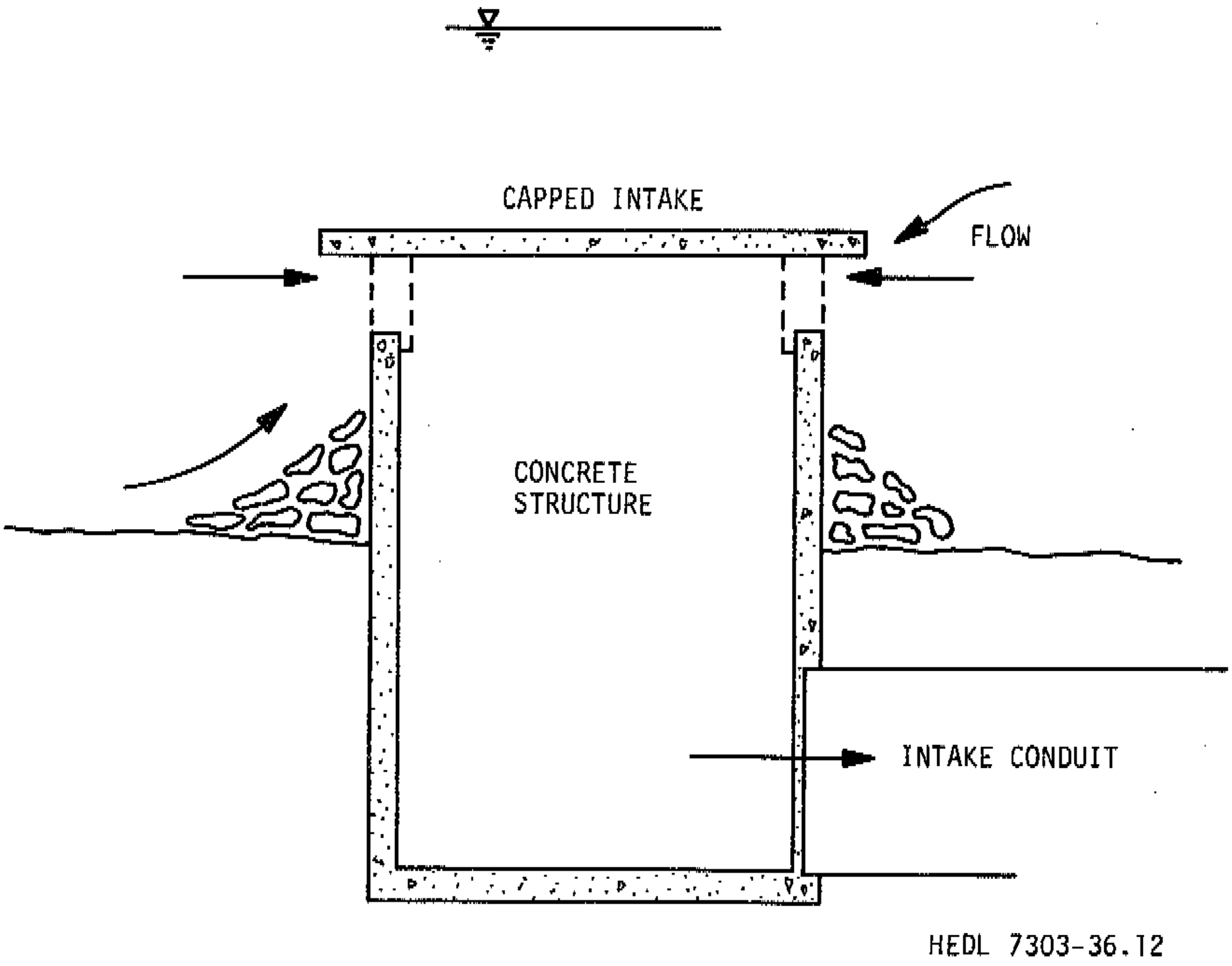


FIGURE 15. Velocity Capped Intake Structure.

field. Again, it would seem the design velocities should be set in the species' cruising speed range. A rule of thumb for approximating the cruising speed of salmon species can be obtained by multiplying the length of the fish by a factor (2/sec)[14].

The first prototype velocity cap was inserted on the El Segundo intake in June 1957. The velocity cap provided at El Segundo consists of a concrete slab 12 inches thick, 24 feet long, 23 feet wide, having four hairpin legs for seating upon the lip of the intake tower, and weighing 43 tons. The apparent effectiveness of the velocity cap, as shown in Reference 9, reduces the tonnage of fish entering the screenwell by approximately 95%[31]. Presently, there is some controversy over this assessment of the structure's effectiveness.

A design similar to the velocity cap concept has been proposed for the intake structure of the Zion plant along the shores of Lake Michigan[32]. Figure 16 shows the proposed structure. The major difference between the design of the proposed Zion structure and the design of the California structure is that the Zion structure includes provisions for melting ice.

The design of the intake structure for the Point Beach nuclear plant, also located along the shores of Lake Michigan, is shown in Figure 17[33]. The structure has been designed around what might be termed an inflow gallery concept. The plan calls for the gallery, to be constructed with steep piling and limestone blocks, to form a hollow cylinder which will extend from the lake bottom to a height 8 feet above the water surface. The cooling water enters the gallery by flowing through a number of 30-inch diameter pipes located in the wall of the cylinder with 1" x 1" x 13/16" bar grating over the faces of the portals.

Water enters the Zion intake at approximately 2.5 ft/sec and the Point Beach intake at two ft/sec. These velocities, which are higher than those typically recommended for shoreline intakes, have been considered suitable for offshore structures provided they were not located in "nursery grounds" containing large numbers of juvenile fish. Since the typical offshore location does not contain enough vegetation or other cover for protection of small fish from predation, the higher velocity seems generally appropriate on the basis of behavior of a single fish. It is possible that schooling characteristics could modify this approach, and where schooling is active, a lower velocity may be indicated.

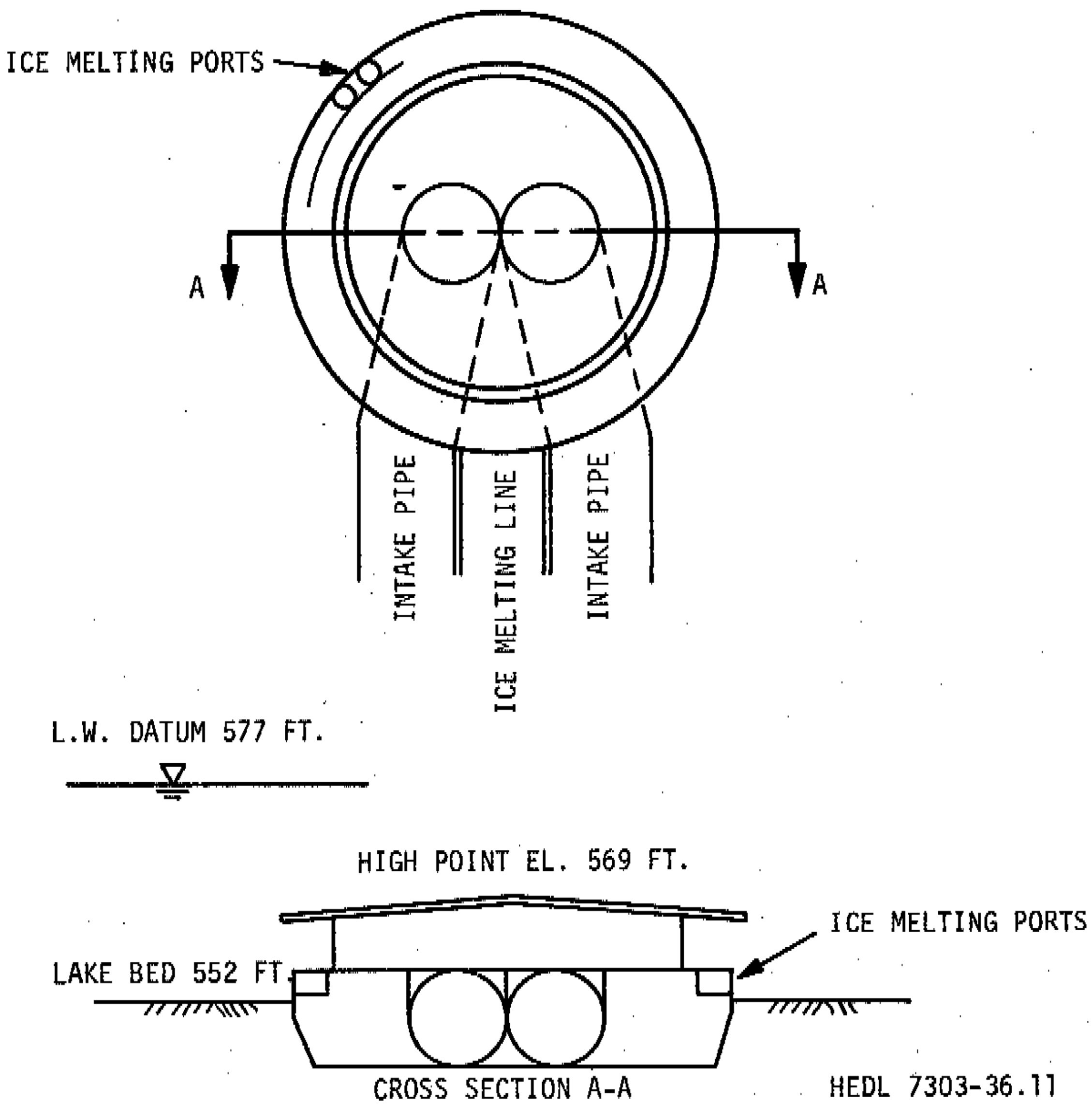


FIGURE 16. Proposed Intake Structure for the Zion Nuclear Plant on Lake Michigan.

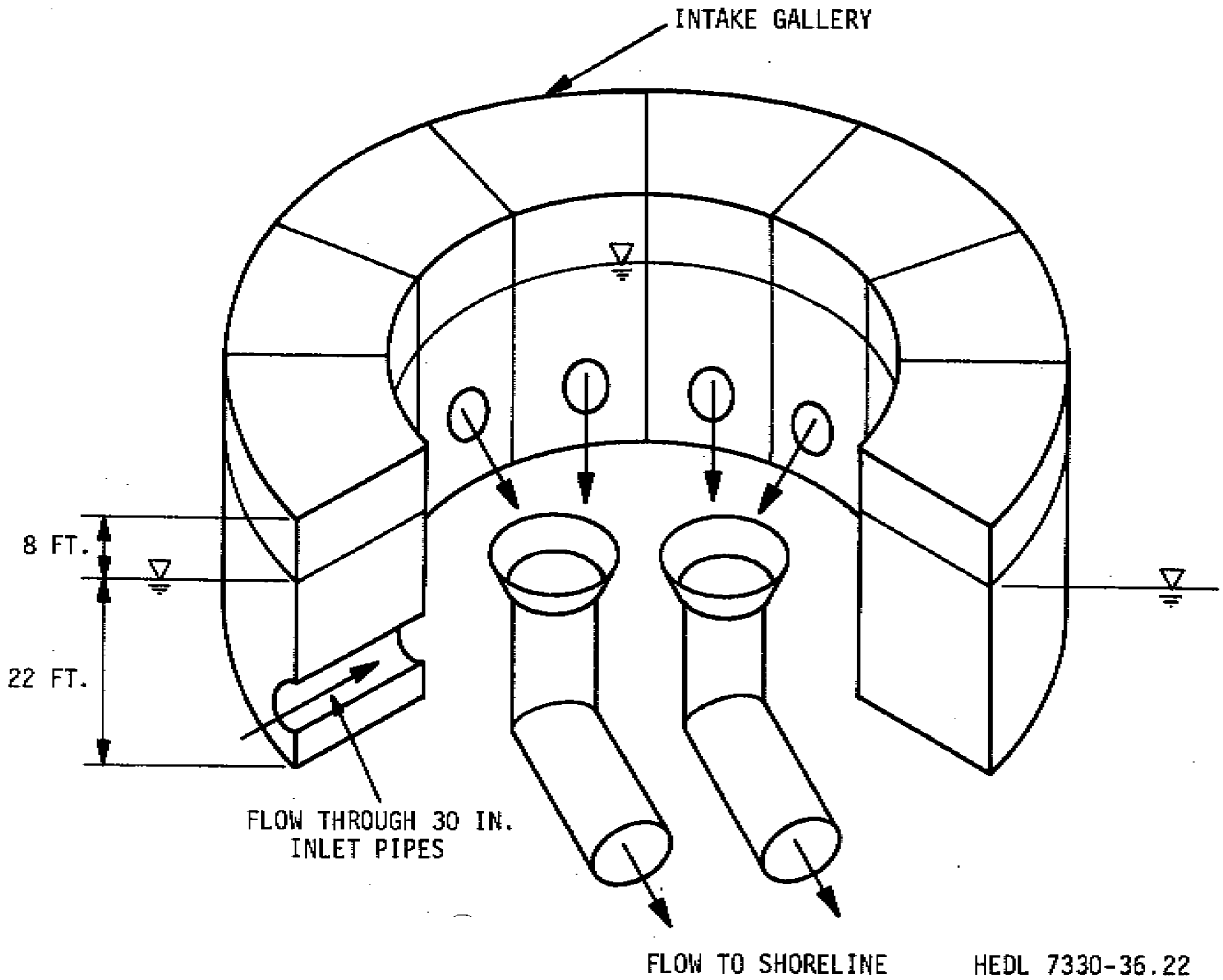


FIGURE 17. Intake Structure of Point Beach Nuclear Plant.

3. Screenwells

The screenwell is located between the intake and the pumpwell. Depending on the overall system design, the distance separating the location of the various features might be considerable. Fish that become sucked into the intake structure flow into the screenwell structure. Therefore, the design of the screenwell structure should include provisions for removing fish.

In the design of the Huntington Beach Power Station, extensive model studies were performed on the screenwell structure. The purpose of the studies was twofold: 1) to assure that the proper hydraulic conditions existed in the screenwell; and 2) to include proper provisions for the handling of fish.[31]

A review of the Huntington Beach screenwell design indicates that the water flows into the screenwell structure through a 14-foot diameter pipe with a design velocity of approximately 6 feet per second. Since this velocity was too high for proper screening, the cooling flow had to be decelerated. To spread the coolant flow uniformly over the four screens used in the design, a series of turning vanes was included. This feature is shown in Figure 18. As a solution to the possible fish problem, the decision was made to provide quiet areas within the screenwell where fish might congregate so that they could be collected and safely returned to sea. The location of these quiet rest areas is also shown in Figure 18. The degree of success has varied considerably, as recently reported by the utility. However, it should be noted that fish will congregate in the low velocity area only if they first become sufficiently fatigued from swimming against the currents in the screenwell so that they attempt to seek out these quieter zones and, secondly, if they can find these quieter zones once they do become fatigued.

A design concept that has recently been suggested by Bell[14] is shown in Figure 19. The design overcomes the problems mentioned above by providing directional guidance to a built-in fish bypass system. In addition, the system has no irregularly projecting surfaces that could pocket or inhibit fish movement. The concept could be used with both fixed or moving screen installations. Model studies performed on the concept will assure the proper hydraulic characteristics.

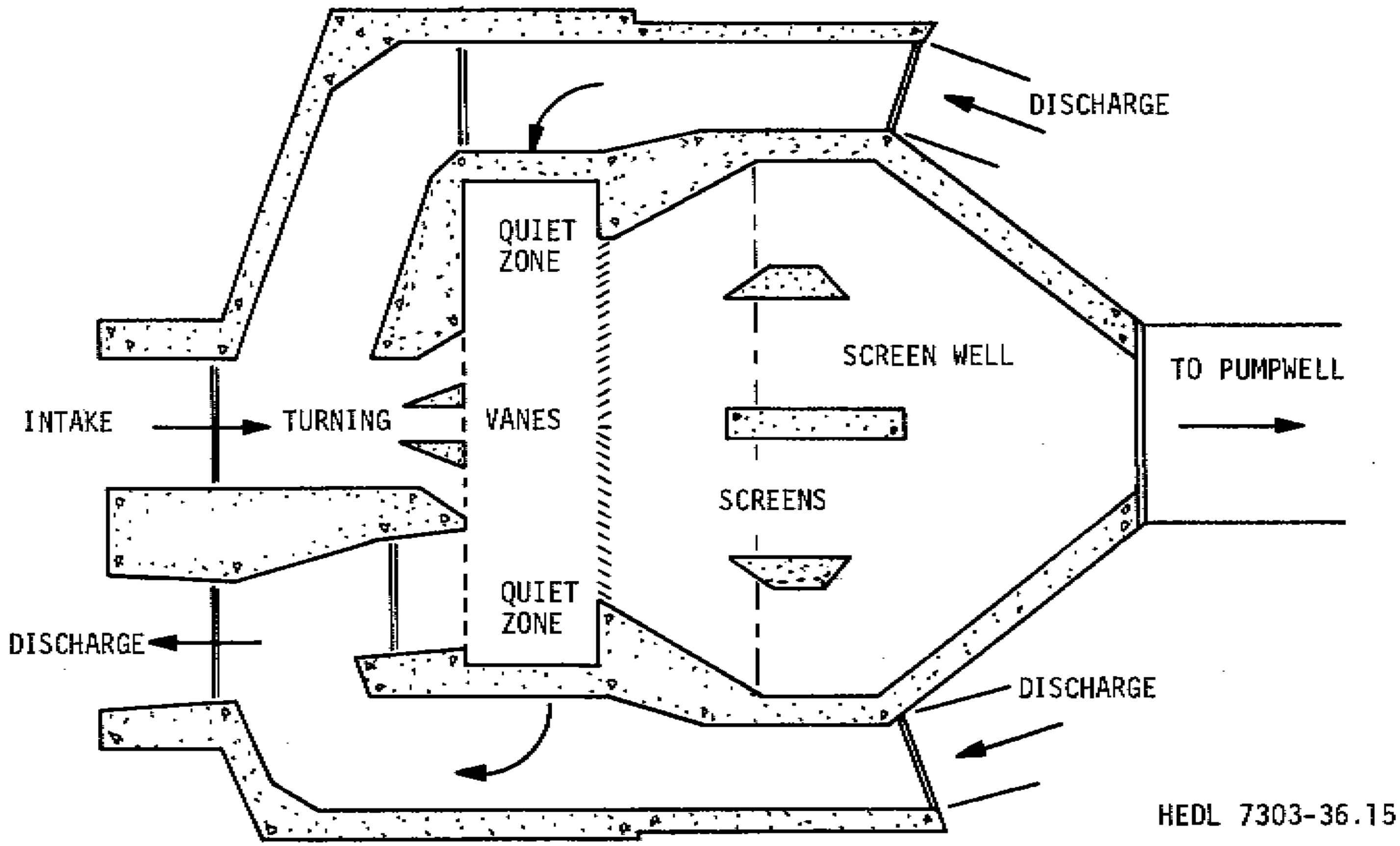


FIGURE 18. Plan View of Screenwell Used at Huntington Beach Steam Electric Plant.

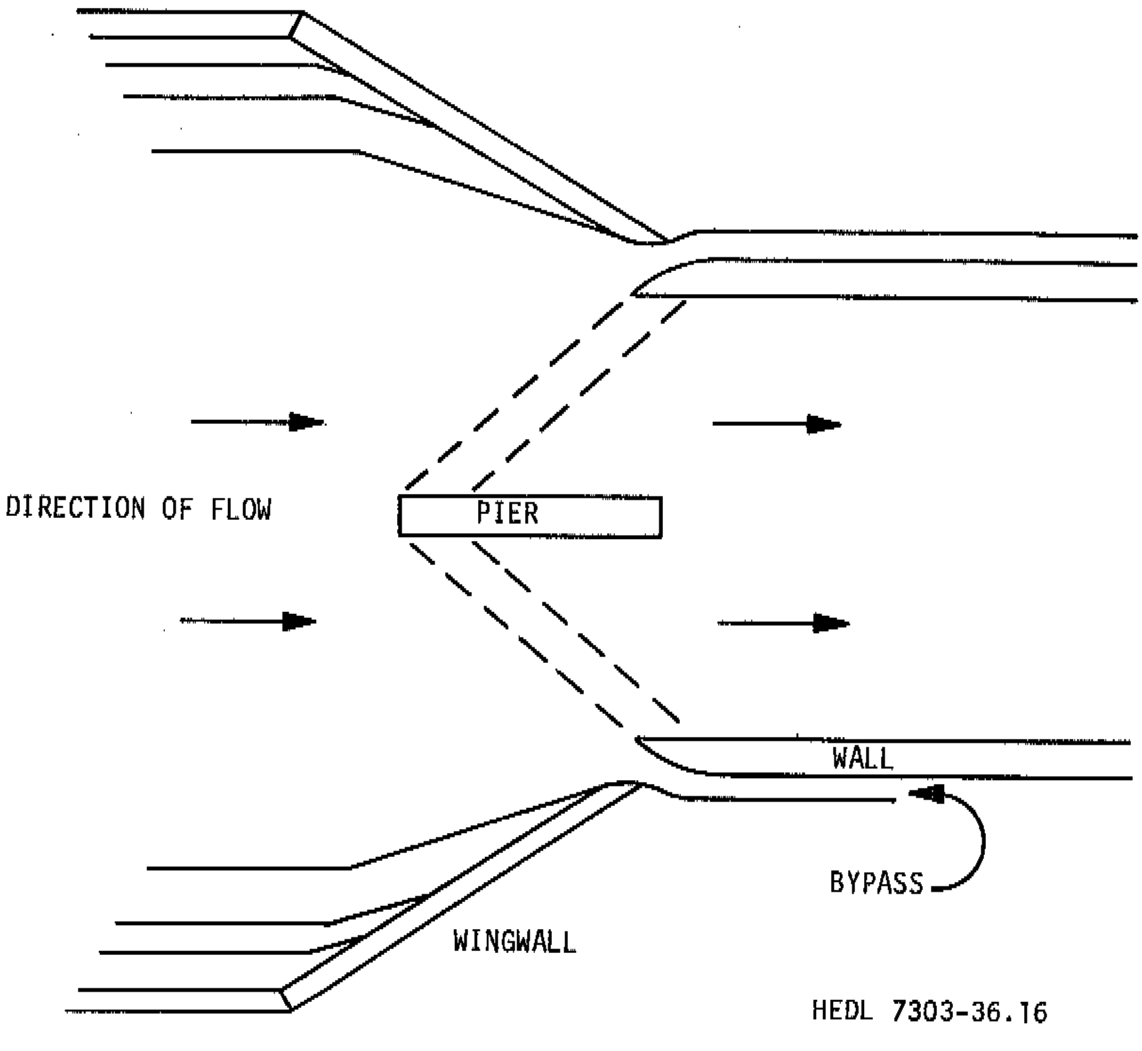


FIGURE 19. Proposed Concept to Provide Directional Assistance for Fish to Bypass Structures.

D. FISH REMOVAL TECHNIQUES

Fish must be removed from screenwells if significant numbers become trapped. However, in order for fish removal techniques to be efficient, the fish must first be concentrated into a relatively small area. Once the fish are concentrated, several techniques can be used for removing them. The more popular techniques include the use of fish pumps, locks and elevators, and nets.

1. Fish Pumps

Fish pumps have become a potential technique for handling fish. The pumps employed normally possess a special impeller and the casing has been contoured to remove sharp edges. On several occasions, centrifugal pumps designed to move produce have been used. Tests conducted in California fish hatcheries using produce pumps have been quite successful. Using a 5-inch pump, fish ranging in size from 2 to 12 inches were pumped without harm.[34] Optimum performance for fish of all sizes was achieved by operating a pump speed of 700 revolutions per minute.[14,34] During one test, a total of 2000 pounds of trout were pumped during a 6-minute interval.[35]

As mentioned in Chapter IV, a number of techniques have been used in attempts to guide fish. Velocity of flow in conjunction with an a-c electric field was used at the Wheeler Dam hydroelectric station (TVA) to concentrate and remove gizzard shad from the tail race.[35] It was observed that the shad would concentrate along one of the power house wing walls as the flow rate through certain generating units was increased. A string of electrodes was placed along the wing wall. As the shad drifted into the area, they were stunned by the electric field and, subsequently, carried by the water current into a funnel arrangement which was connected to a 6-inch fish pump. It has been reported that 1100 pounds of shad have been removed during a one-hour period by this method.

Lights have been used on several occasions to guide or attract fish. A light arrangement has been used in conjunction with a fish pump by Southern California Edison at the Huntington Beach Power Station. The light attracts the fish into an area where they are removed by the suction of a 6-inch fish pump.[36]

2. Fish Elevators

Fish elevators can also be used to remove fish. However, to be effective, the use of this device requires that the fish be concentrated to an even greater extent. The concept behind a fish elevator is to first concentrate the fish, next, close off their escape route, and then lift the fish into a discharge canal. The fish can be raised by placing a screened bottom on the chamber (lock) and moving it through the water column.

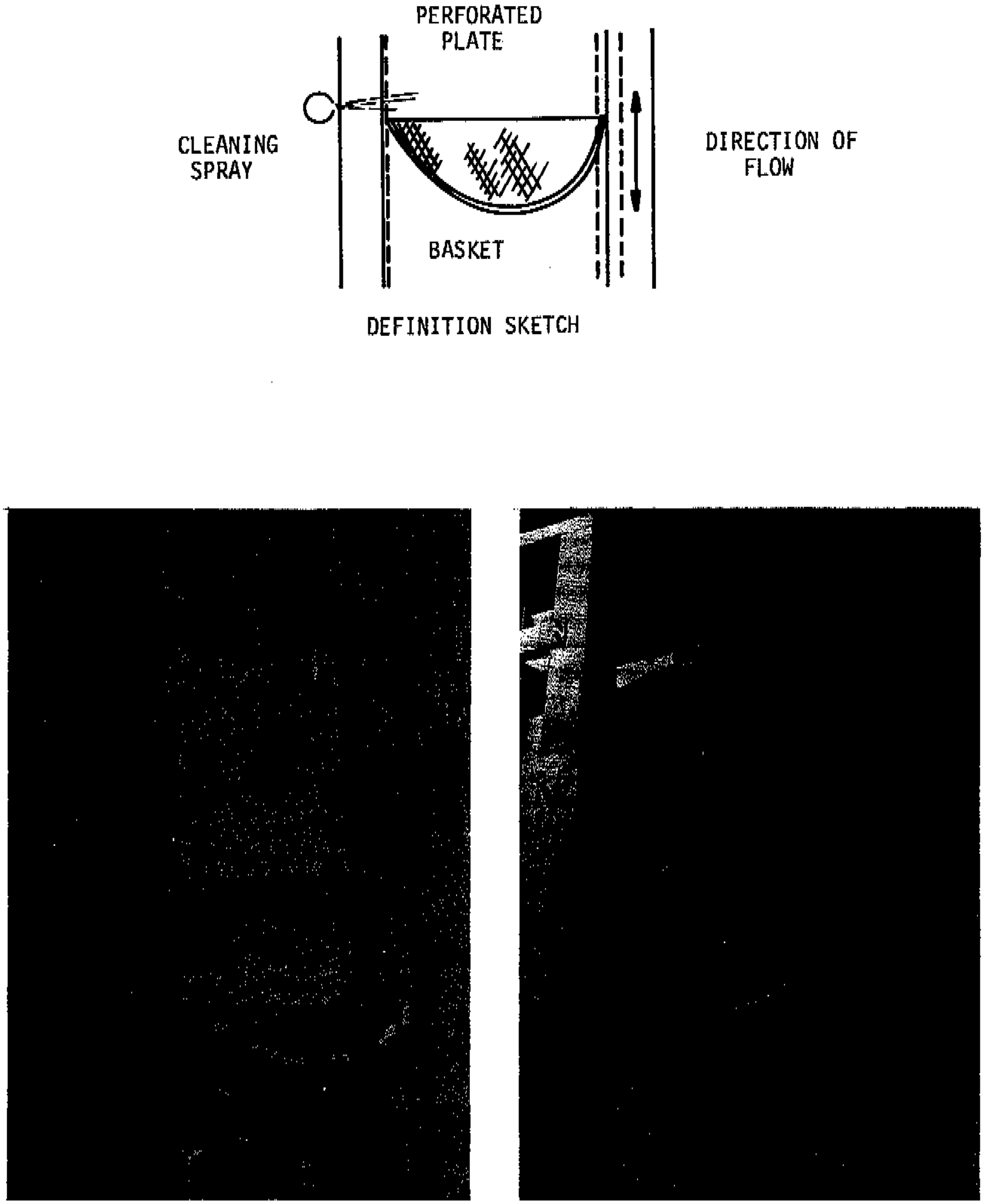
3. Nets

Recently, a concept which has received considerable support involves using a moving basket screen. The basket moves vertically along the face of the vertical traveling screen. The concept, called a "Fish Collector Basket" is shown in Figure 20.

This concept has not been tested under prototypic conditions. However, the design has undergone considerable model testing. The concept tentatively includes replacing the vertical traveling screen with a perforated plate. The perforated plate can be mounted directly on the front of the support piers, thus eliminating irregular surfaces which can act as fish pockets. The basket collector moves along the front of this perforated plate as shown in Figure 20. Manual operation of fish nets simply involves dipping the fish from the screenwell and transporting them to a discharge point.

E. MATERIALS OF CONSTRUCTION AND OPERATIONAL CONSIDERATIONS

Fouling and corrosion in the power plant cooling system reduces efficiency and can ultimately cause plant shutdowns for cleaning or repairs. Prevention, or at least control, of a particular power plant's fouling and corrosion problems must be considered during the design stage as well as the operational stage. The techniques intended for ultimate use in the plant should be selected with consideration of their effects on the entrained plankton and the organisms associated with the intake structure. Protection of the ecosystem is an important standard to meet when considering antifouling methods, but it is certainly not the only consideration. Improper techniques for intake structure protection could result in detaching organisms from the structure and allowing



MOVING ALONG PLATE

AT TOP

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FIGURE 20. Proposed Fish Collector Basket.

them to enter the cooling system. So it is important to characterize the organisms associated with a plant site and their response to fouling and corrosion control techniques.

Fouling, the growth of organisms on the surfaces of water system components, can range from scaling by biological slimes to system blocks by large organisms such as mussels. Slime-forming microorganisms include bacteria, algae, fungi and diatoms. Besides forming scale, some of these organisms release acids and gases along the surface they attach to, leading to anodic corrosion.[37] Common seawater fouling organisms listed by Anderson and Richards[38] are:

Plants	(Algae and Slimes)
Sea Mosses	(Hydroids)
Sea Anemones	(Metridium)
Barnacles	(Balanus)
Mussels	(Mytilus)

Methods of controlling fouling depend either on preventing the attachment of embryos on cooling system surfaces or by removing or killing the adult organisms. A number of techniques for the control of fouling have been proposed. They include:[38]

1) An increase in temperature
2) Removal of dissolved oxygen
3) High water velocities
4) Protective toxic coatings
5) Protective toxic materials
6) Filtering the water
7) Acid treatment
8) Poison treatment
9) Increase or decrease in salinity (seawater systems)
10) Mechanical removal

Common techniques used currently are heat treatment and chlorination. Adequate water velocities to prevent setting of organisms and toxic cooling system materials (90-10 copper-nickel) show promise for some applications. The other methods listed should be given consideration for specific problems, and all the techniques should be carefully analyzed to determine their disadvantages. For example, filtering water to remove microscopic organisms is not likely to be economical. Acid or poison treatment should be regulated to avoid cooling system corrosion or harmful effects to organisms.

The possibility of using several of the methods in combination might be advantageous. For example, the exposure time to kill mussels with chlorine is dramatically reduced by combination with heat treatment, as shown in Figure 21.

Details of various fouling control methods for seawater intake structures can be found in a recent Office of Saline Water Handbook.[38]

Corrosion in cooling water systems can be extremely expensive in terms of equipment repairs and revenue lost during shutdowns, so the economic incentive to prevent corrosion is high. The basic methods of controlling corrosion are:

1) Protective coatings
2) Sacrificial anode protection
3) Use of materials suited for conditions
4) Control of corrosive environment

Protective coatings, such as dips, paints and plastic or concrete sheaths have been used to protect structural members from corrosion in water environments. The recent application of PVC for traveling screens has dramatically reduced screen corrosion. Sacrificial anodes which have found application in marine equipment might have success in some instances. The methods discussed so far prevent corrosion in ways which are unlikely to be harmful to organisms associated with the intake structure. However, corrosion prevention by control of the water composition normally requires physical and/or chemical treatment which might be harmful to biota. The various methods used for water treatment in the power industry are listed in Table 1.[22]

The treatment used to adjust the water quality to standards necessary for use in the power plant are selected on the basis of available technology and economics. The chemical composition of effluent streams or intake streams which may affect the plant environment must meet certain standards. Some criteria for the protection of fresh and seawater organisms can be found in "Report of the Committee on Water Quality Criteria."[22]

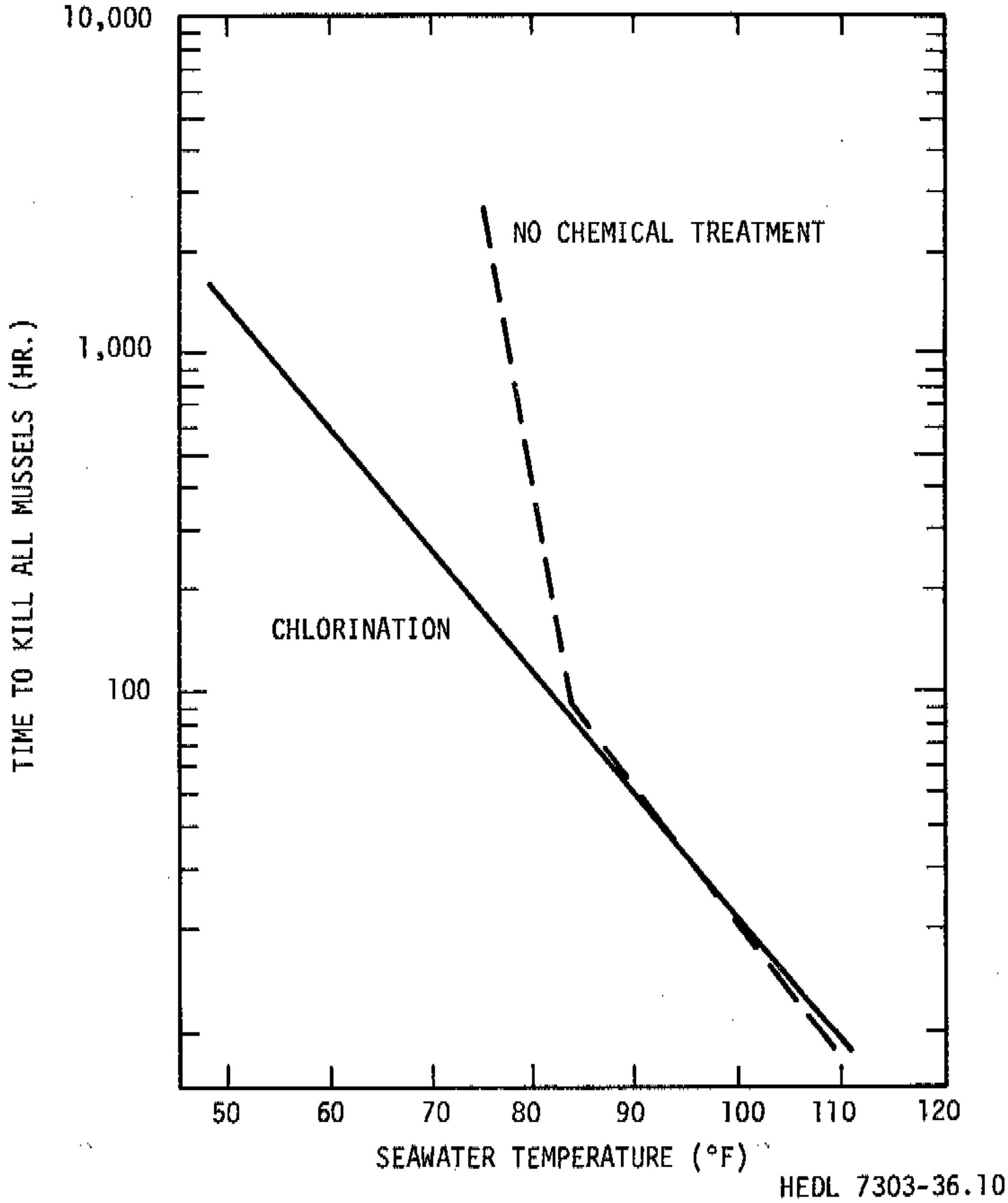

FIGURE 21. Comparative Time for Killing Shelled Mussels Chlorination and Temperature.

Additional standards or regulations might apply to specific stations. The standards, of course, are not all-inclusive and special attention to limiting conditions for specific site environments must be considered. Analyses to determine the effects of fouling and corrosion controls on the organisms in the water source should include the possibility of changes in organism types and relative quantities due to site modifications. Physical and chemical alterations which might cause organism population changes include water temperature, disturbance of the water bottom, chemical composition of the water, and additional strata for attaching organisms, such as intake pipelines. Early treatment of structures such as pipelines and canals prior to plant start-up can prevent initial growth of foulants and ease the burden on control systems during operation.

Several special applications of fouling and corrosion control deserve mention. The use of backwashing to remove organisms from the intake structure has found moderate success. Increased water velocities detach some organisms and the flow reversal removes them from the structure vicinity. Backwashing in combination with heat treatment can be applied by stations with the ability to discharge heated effluents through a portion of their intake strucutres, or to introduce heat by some other means. Another physical means of control used in condensers is the Amertap system. This technique provides physical scrubbing of the condenser tubes by passing small sponge rubber balls through the condenser. Two types of balls are available--one plain, and one with a narrow band of abrasive material on its surface.

In summary, the sources and controls for fouling and corrosion are numerous and complex. Protection of the cooling system and the aquatic environment demands an analysis of the total interacting system during the station design stage. The selection and application of corrosion and fouling control techniques should be exercised with care to prevent damage to the ecosystem. Minimum standards are available from federal and state regulations, but detailed examination and thoughtful solution to specific site problems is the best assurance of cooling system protection without detrimental effects to the station environment.

TABLE 1

WATER CONTROL CRITERIA

	Cooling	
	Once-through	Recir-culated
Suspended Solids and Colloids Removal:		
Straining	X	X
Sedimentation	X	X
Coagulation	-	X
Filtration	-	X
Aeration	-	X
Dissolved Solids Modification Softening:		
Cold lime	-	X
Hot lime soda	-	-
Hot lime zeolite	-	-
Cation exchange sodium	-	X
Alkalinity Reduction:		
Cation exchange hydrogen	-	X
Cation exchange hydrogen & sodium	-	X
Anion exchange	-	-
Dissolved Solids Removal:		
Evaporation	-	-
Demineralization	-	X
Dissolved Gases Removal:		
Degasification-mechanical	-	X
Degasification-vacuum	X	-
Degasification-heat	-	-
Internal Conditioning:		
pH adjustment	X	X
Hardness sequestering	X	X
Hardness precipitation	-	-
Corrosion inhibition general	-	X
Corrosion embrittlement	-	-
Corrosion oxygen reduction	-	-
Sludge dispersal	X	X
Biological control	X	X

Notes: "-" not used. "X" may be used.

VI. ECONOMICS

The cost associated with constructing a power plant intake structure is strongly site-dependent. Variation in capital costs result from differences in: construction rates; land acquisition costs; taxes; shipping charges; and of course the type of water body utilized. With due respect to this limitation, a discussion of costs associated with the construction of various intake structures is presented in this section. Since economy is generally considered inherent in design, the intent is to provide the reader with some insight as to the cost of protecting the environment by means of providing unit costs for various design features.

A. COSTS ASSOCIATED WITH OFFSHORE CONSTRUCTION

Offshore construction costs depend primarily upon the behavior of the water body and the condition and/or composition of the bottom material. Constructing a pipe line through a difficult environment such as a surf zone can be significantly more expensive than laying a pipe line on the bottom of a quiescent body of water such as a lake. The usual construction method calls for laying a line through a surf zone using a traveling crane. First, a trestle is built which extends through the zone on which the crane can travel. Excavating the trench and laying the line is then performed with the crane. Normally, after the pipe is installed and buried, the filled trench is protected with heavy rip rap.

The cost of construction through various surf zones can vary significantly from site to site. The overall cost of the El Segundo system, two 10-foot precast conduits extending 2600 and 2100 feet offshore, excluding the intake structures, was $2,6000,000*.[4] The cooling water system was installed during 1955 and 1956. Construction costs associated with the Redondo Beach Power Station cooling system were $4,400,000.[4] Water flows to this power station through 10-foot diameter concrete conduits located 1700 feet offshore. Construction took place during 1957. The cost associated with the 14-foot diameter intake and discharge conduits at Huntington Beach was $4,100,000[4] in 1958.

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* Figures shown in the text are actual cash costs and do not reflect interest and/or inflation.

This converts to an overall unit cost ranging from 550 to 900 dollars per foot, or a present cost range of approximately 1300 to 2000 dollars per foot. However, as will be noted later, the unit costs can be much higher.

All of the structures mentioned above terminate in 30 to 40 feet of water just beyond the surf zone. Less costly construction methods can be used beyond this zone. Excavation and pipe handling might be performed from a barge or from a mobile floating tower and the costs should be comparable to placing large conduits in lakes or bays. Under these conditions, the cost of construction is primarily dependent on the depth at which the construction is taking place and the diameter of the pipe being placed. Cost estimates based upon a 1966 study[39] for an 8 to 10-foot diameter pipe are shown in Table 2.

TABLE 2

UNIT COSTS OF OFFSHORE CONSTRUCTION

Depth	Unit Costs ($/ft)
Up to 100 ft	380/ft
100 to 200 ft	480/ft
200 to 300 ft	950/ft

The estimates include trenching and backfilling with a rock cover.

B. SHORELINE INTAKES AND SCREENWELLS COSTS

In Sections 4 and 5, establishment of appropriate approach velocities was discussed. Knowing the system design flow rate and the approach velocity, the required cross-sectional area of the intake can be readily determined. It would be convenient to have a unit cost factor to evaluate this design feature. As in the case of defining the cost associated with offshore constructions, the cost of constructing screenwells varies significantly, depending upon the local conditions and the design employed. The figures presented herein should be used as a guide to relative costing, rather than the detailed costing of proposed construction. This caution will become evident as the discussion develops.

A series of reports has been published by the Tennessee Valley Authority[41,41,42,43,44] which itemize in detail the cost of constructing thermal power stations. Under Account 141, the cost of constructing the circulating water system is presented. Only the cost data presented for the Paradise and Bull Run steam plants will be used here.

The cost of excavating, backfilling, and constructing the screenwell for the Paradise Steam Plant (built in 1965) was given as approximately $400,000. Design flow rate for the first two units was approximately 1100 cfs. At design minimum water level, the velocity through the traveling screens is 2.1 feet per second. This suggests a unit cost of approximately $760 per square foot. Performing a similar analysis for the Bull Run Steam Plant results in a unit cost of approximately $660 per square foot.

The cost of installing the vertical traveling screens, backwashing facilities, sluiceway, etc. for the Paradise Steam Plant was approximately $130,000. This converts to a unit cost of $250 per square foot. The cost of installing similar equipment at the Bull Run steam plant was approximately $150,000, which converts to approximately $300 per square foot.

The total cost of these two items at both the Paradise and Bull Run steam plants was therefore approximately $1000 per square foot. It is interesting to note that, for the Calvert Cliffs Nuclear Station, a comparative cost figure can be established using the overall construction cost estimates. A total of $10,000,000[45] has been estimated for the construction of the cooling system, neglecting the cost of the condenser. The design flow rate is approximately 5000 cfs, with an approach velocity of approximately 0.5 foot per second. This converts to a unit cost of approximately $1000 per square foot. For the cases discussed, the cost of inflation has tended to offset the economy of scale.

All of the designs mentioned above use 3/8-inch mesh screens. It should be mentioned that, in reducing the mesh size, the proportion of open area decreases. For example, decreasing the mesh size from 3/8 to 1/4 inch decreases the open area of the screen by approximately 15%[46]. Unit cost figures should be modified to reflect this condition if smaller mesh sizing is desired.

VII. FUTURE DESIGN CONSIDERATIONS

In this section, a few designs which might be considered for future use are discussed.

Traveling Screens

The horizontal traveling screen has been under development by the National Marine Fisheries Service since 1965. The structure consists of an endless belt of wire cloth strung in a horizontal, rather than a vertical plane. In concept, the screen is placed across the flow field at an angle. The rotational motion of the screen is compatible with the direction of flow. The orientation and motion of the screen act to reduce the seriousness of impingement by the organisms on the screens. Figure 22 shows the use of the screen as proposed for the Leaburg Power Plant intake canal at Eugene, Ore.[47].

The use of the horizontal traveling screen could be included in the design of intake structures. The concept could be included in both the design of basic shoreline intake structures, or the design of screenwell structures. The horizontal screens could be included in the design proposed by Bell shown in Figure 19. Due to the manner in which the screens continually move, they are somewhat self-cleaning. The current feeling appears to be that its biological and hydraulic performance, its practical features, such as bottom and side seals, and inspection and maintenance methods for it requires systematic investigation before any major prototype can be considered.[14]

Revolving Drum Screen

The revolving drum screen is a large, perforated drum, usually installed with its axis of rotation horizontal and across the stream flow. The drum revolves slowly, with the exposed upper surface moving in a downstream direction, preventing passage of fish but lifting impinged debris clear of the water. The debris is washed off into the downstream side of the channel by the flow through the screen, unless a jetting system to wash debris into a collecting trough is incorporated. Drum screens could be used with various orientations. It is conceivable that the drums could even be mounted in a vertical plane replacing the vertical traveling screen, provided a uniform velocity across the face of the screen and provisions for escapement are included.

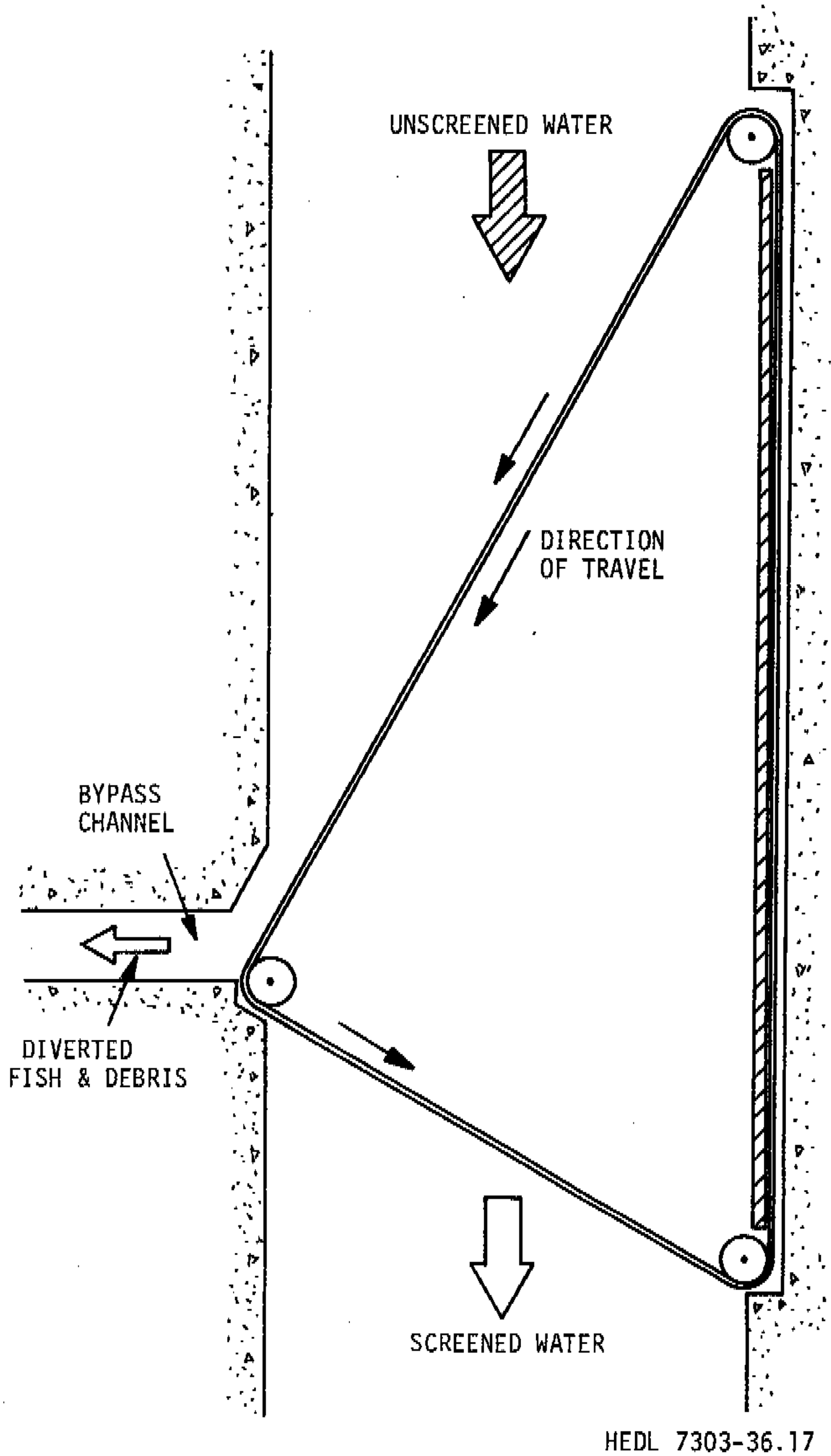
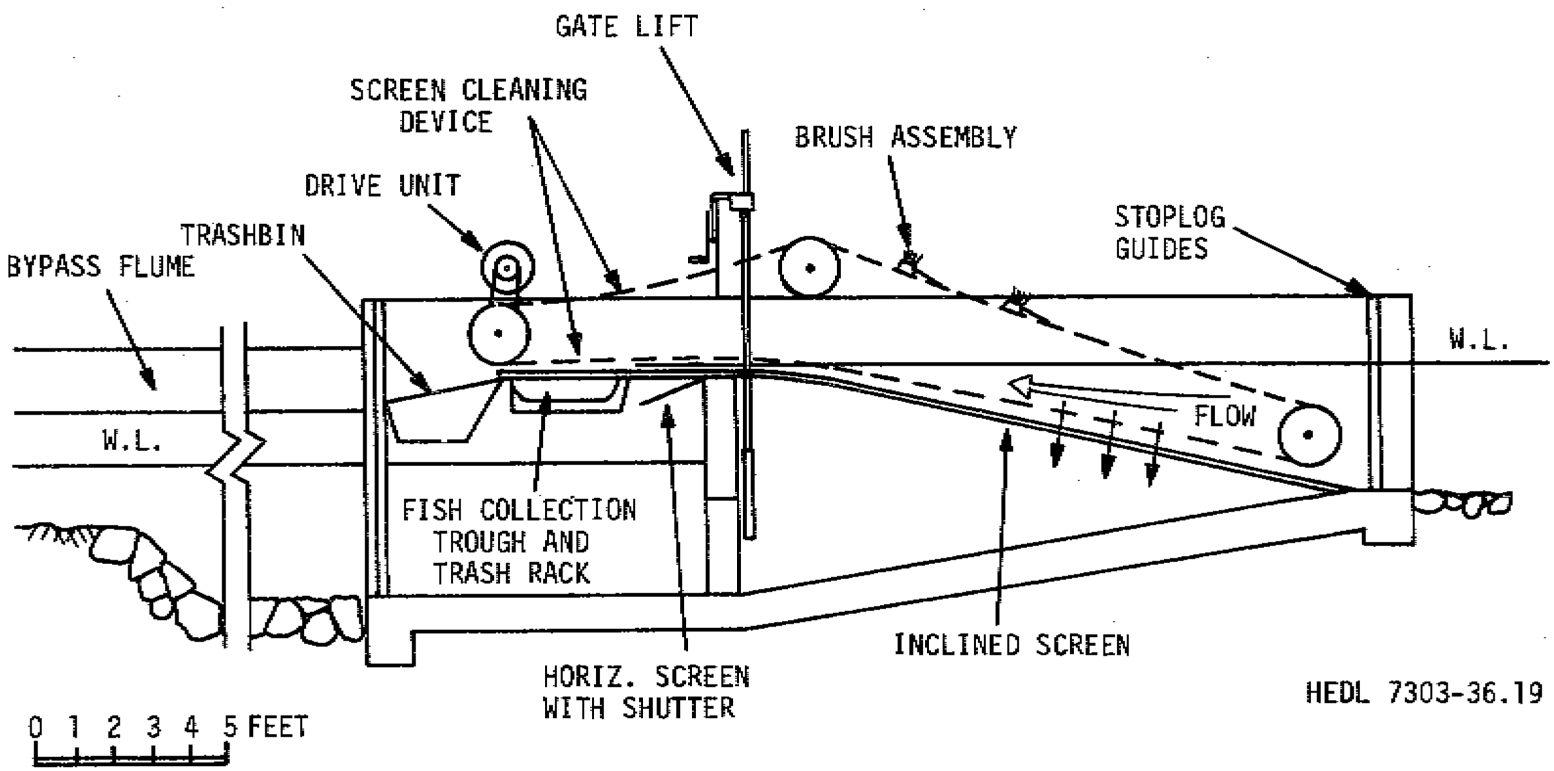


FIGURE 22. Horizontal Traveling Screen-Schematic Layout.



From Canadian Fish Culturist, No. 37, Sept. 1966.

FIGURE 23. Inclined Plane Screen.

Inclined Plane Screen

The inclined plane screen consists of a simple fixed screen inclined downstream as shown in Figure 23. Cleaning is accomplished by bars or brushes which slide up the screen surface, scraping debris into a trough at the crest. Where the screen is being used to divert fish, a shallow incline is used. The bars can then be used to nudge fish through shallows over the crest into a bypass trough. Such an installation is used in Canada to direct downstream migrating fish.[48] For the screen to be used in conjunction with the other standard shoreline intake features would require additional space and careful consideration of stage variations. Intuitively, inclusion of an inclined screen into the design of a thermal power plant intake structure seems quite feasible.

Beloit - Passavant Screen

This screen is a variant of the common vertical traveling screen. Although it has been used in Europe for some time, its introduction into the United States is fairly recent. The unique feature of this screen concept, shown in Figure 24, is that the water enters the central part of the screen and flows outward through both faces. This can be particularly attractive because it permits low flow velocities to be attained more economically. As with other designs, provisions must be included to allow easy escape, such as keeping both ends of the assembly open. The design warrants further biological testing.

Filter Beds

Studies have been conducted to determine the feasibility of siting a nuclear power station on Kiket Island in Puget Sound, some fifty miles north of Seattle, Washington. The site is near the Skagit River, which is one of the most productive salmon spawning streams in the state. As a result of the relative abundance of juvenile salmon passing the proposed site, the Fisheries Research Institute at the University of Washington has just recently completed a series of studies to examine the impact of plant construction and operation on the local ecology.[49] During the field studies performed to inventory the aquatic species in the vicinity of the proposed site, pink salmon were found along the shores of Kiket Island with their yolk sac partially intact. Based upon this size and

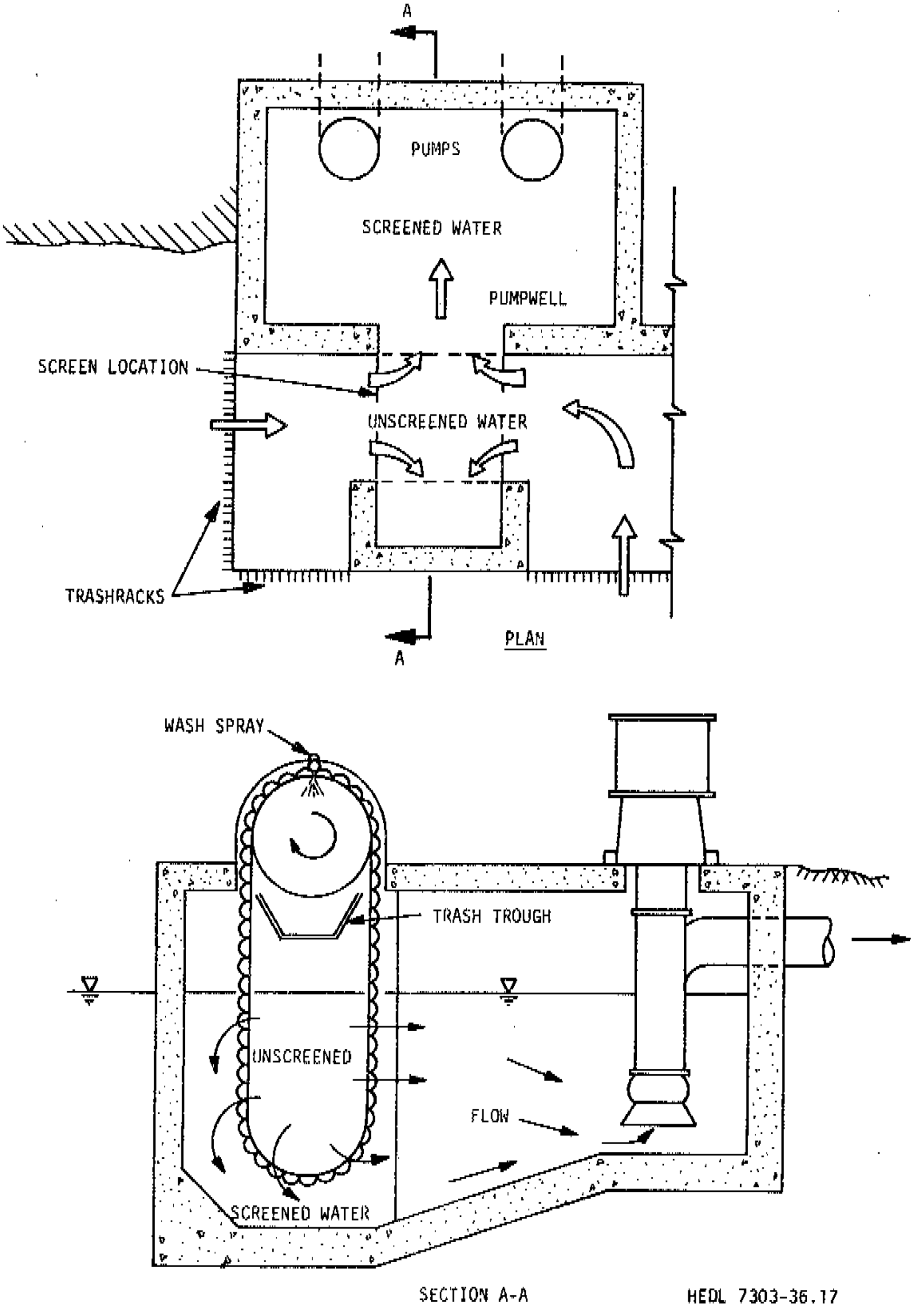


FIGURE 24. Beloit-Passavant Screen Installation.

stage of development, design approach velocities of 0.2 feet per second, and screen mesh sizing of 1/8 inch have been conjectured. As a result the use of a submarine filter system has been proposed as an alternative.

The overall size of a submarine filter suitable for providing the design coolant flow rate for a once-through 1000 MW thermal power plant is on the order of 2 to 4 acres. In addition to size, operational problems associated with flushing or unclogging the potential growth of marine organisms in the bed could reduce the feasibility. Capital cost estimates for a preliminary filter design, consisting of a graded gravel bed with an anthracite cover, and supporting structure, were approximately $8.5 million for a two acre bed. Operational expenses, which include daily backflushing and heat and chlorine treatment, were estimated at $800,000 annually[50].

Basket Collectors

A concept which has recently received considerable attention includes the use of "fish collector baskets". The concept, as shown in Figure 20, involves the use of a basket screen which moves in a vertical direction along the face of the fine filtering medium. In this design, the finer mesh screens have been replaced with perforated plates to eliminate projecting surfaces which could cause pockets creating fish traps.

Testing of the concept is planned for the near future. If the concept proves acceptable, it is a design which can easily be backfitted into existing screenwell designs to facilitate the removal of fish. The cost of backfitting the design to replace the presentvertical traveling screens is estimated at less than $5,000 per panel[45].

VIII. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

I. The initial steps which should be undertaken when considering the design of a thermal power plant intake structure are as follows:

- Conduct both a hydrological and biological survey. The hydrologic survey should include a study of local currents, sedimentation, stage variation, and water quality. The biological survey should identify resident aquatic organisms. Size,abundance, temporal, and spatial distribution of the resident and migratory species should be identified.
- Assemble an interdisciplinary team of biologists, ecologists, hydrologists, and engineers to establish design criteria for the entire cooling system, including the outfall structure.

II. The design of an intake structure should be based upon meaningful criteria which will undoubtedly vary somewhat from site to site, reflecting specific demands. To date, intake design criteria have been based primarily upon the following considerations:

1. Select design approach velocity and an appropriate screen mesh size conducive to screening the design organism. In the case of fish, the technique should be based upon the cruising speed and body size. Care should be taken to provide a uniform velocity across the face of the screen.
2. Where possible, the intake structure should be located in an area of low productivity. The location should not coincide with heavy concentrations of fish or benthic shellfish. Structures such as wharfs, bulkheads, piling arrays, etc., should be avoided. The biological survey should delineate these more productive zones.
3. Recirculation of cooling water through the cooling system should be prevented for both engineering and biological reasons. Care should be taken to provide sufficient hydraulic resistance between the intake and outfall to eliminiate this possibility.

4. The selection and application of control techniques for fouling and corrosion should be exercised with care to prevent damage to the ecosystem. The effect of using various chemicals should be fully understood.
5. The use of attraction and avoidance stimuli might be warranted. Combinations of various stimuli can be used for guidance. Note that the use of warm water for purposes of deicing can attract fish.

III. Specifically, the following guidelines are presently being used in intake structure design.

SHORELINE INTAKES

Type of Water	Design Provision
Rivers Estuaries Bays Harbors	1. Establish a uniform velocity across the face of the screen. 2. Avoid the use of fixed skimmer walls and inverted weirs. 3. Place circulating water pumps behind screens. 4. Do not locate screenwell or intake in highly productive or high population density areas. 5. Prohibit recirculation of cooling water--suggest the use of physical model in design process. A. Screenwell flush with shoreline 6. Base total screen area requirements upon; design approach velocity, minimum stage, and maximum coolant flow rate. 7. Include provisions for the lateral escapement of fish. B. Screenwell located away from shoreline. 8. Include provisions within the screenwell for safely returning fish to the mainstream.

9. Avoid excessive negative pressures within the intake conduits.
10. Do not use intake canals.

OFFSHORE INTAKES

Types of Water	Design Provision
Ocean Shorelines Lakes	1. Do not locate in "nursery areas." 2. Provide for gravity flow from the intake to the screenwell. 3. Include provisions for safely removing fish from the screenwell. 4. Locate circulating water pumps behind screens. 5. Design approach velocities should be based upon resident and migratory fish. 6. The intake structure should not impede navigation. 7. Prohibit recirculation of cooling water--use a physical or analytical model. 8. Use velocity caps, or accept lower intake velocities.

IV. The backfitting of fish protection devices to existing intake structures has normally met with limited success. Although, occasionally avoidance and guidance of fish has been accomplished using a combination of stimuli, this approach is normally not sufficiently reliable to completely offset design inadequacies.

B. RECOMMENDATIONS

Within reasonable limitations, procedures for collecting and analyzing field data, both hydrological and biological, have been established. However, standardization of procedures which allows the extrapolation of field data into usable design information does not presently exist. Such standardization would include: 1) the development of a procedure to determine design approach velocities, and 2) the development of a methodology to assess the significance of loss through the modeling of population dynamics.

Apparently the results from numerous studies of fish swimming performance and behavior have not been published. For the cases where the results have been documented, there is seemingly little consistency in the reporting technique. The standardization of reporting techniques and the establishment of a repository and an information retrieval system for such information would be of great assistance. Such a facility could be used as a centralized means of collecting information on the operational experience from various power plants.

Due to the length of time required to construct large thermal power plants, the benefits of design changes will not be realized for some time. If present designs do not prove to be satisfactory, future improvements might include the following:

For Shoreline Intakes:

- Use of traveling screens, revolving drum screens, inclined screens, and the Beloit-Passovant screen to promote better screening. Each of these screens provides the designer with specific advantages. For example, the traveling and Beloit-Passovant screens appear to be better adapted to situations including substantial variations in stage. Whereas, under conditions of uniform channalized flow, revolving drum and inclined screens appear to be the better choice since they probably require less design and construction and hence may be less expensive.
- Use of louvers between the bar rack and screens (or perhaps even to replace the screens) to promote better fish guidance.
- Use of air rather than heat to inhibit the formation of ice.

For Offshore Intakes:

- Use of submarine filter beds.
- Modification of screenwell design to include better directional stimuli for bypassing fish.

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APPENDIX

SELECTED INTAKE STRUCTURE DESIGNS

APPENDIX

SELECTED INTAKE STRUCTURE DESIGNS

Brief descriptions of intake structures at eight facilities are presented in this appendix. The principle intent is to illustrate the material presented in a general way in the text by presenting additional details of the concepts discussed. The facilities were selected to provide diversity in situation and in approach so that a few "typical" instances would give added insight. Four nuclear plants, two fossil plants, a proposed plant, and a water diversion facility are included. These facilities, taken from various geographic regions of the country encompass essentially all major types of water source. Concepts discussed include some of the newer ones proposed as well as some that are commonly used.

Some discussion of related environmental studies has also been included. The rather limited sampling presented here does not adequately reflect the substantial amount of research and monitoring presently underway, but does indicate the type of feedback information being developed.

DELTA FISH DIVERSION

The Delta fish diversion is located immediately downstream of the Old River diversion to the California Aqueduct east of San Francisco. The water diverted from the Old River flows into a 2300 acre forebay from which it then flows through a breach in the dike into the fish diversion facilities. The purpose of the facility, of course, is to remove the fish from the water before entering the aqueduct. The ultimate design capacity of the facility is 10,000 cfs.

The facility, consisting of three and one-half 40-foot bays, is shown in Figure A-1. Trash racks are located at the head end of each bay. Located behind each trash rack are louvers to divert fish into a bypass. The louvers are constructed outward from the walls of the bay at an angle of 15° to the direction of flow forming a vee pointing downstream. The fish are collected in a bypass located at the apex of the vee. From the primary facility, the bypass channel flows underground into a secondary facility containing another set of louvers to further concentrate the fish. In passing through the two sets of louvers the volumetric flow rate of the water containing the fish is reduced by more than 95%. The fish are ultimately discharged into a series of holding tanks.

The fish diversion facility has been designed to accommodate various kinds of fish. However, of primary interest have been the anadromous species consisting primarily of American shad, striped bass, chinook salmon and steelhead, trout. For purposes of design, a rather large range in fish size must be considered. For striped bass, for example, the size ranges from 1/2" to 5", for chinook salmon from 1-1/2" to 5", and for shad from 3" to 5". In studies conducted by the California Department of Fish and Game, it was concluded that for fish more than 1" long, screening efficiency is inversely proportional to flow velocity[A1]. The overall efficiency for removing fish 1/2" long or smaller was estimated at 40-60%. Present plans call for additional studies to be performed on diverting and screening small fish.

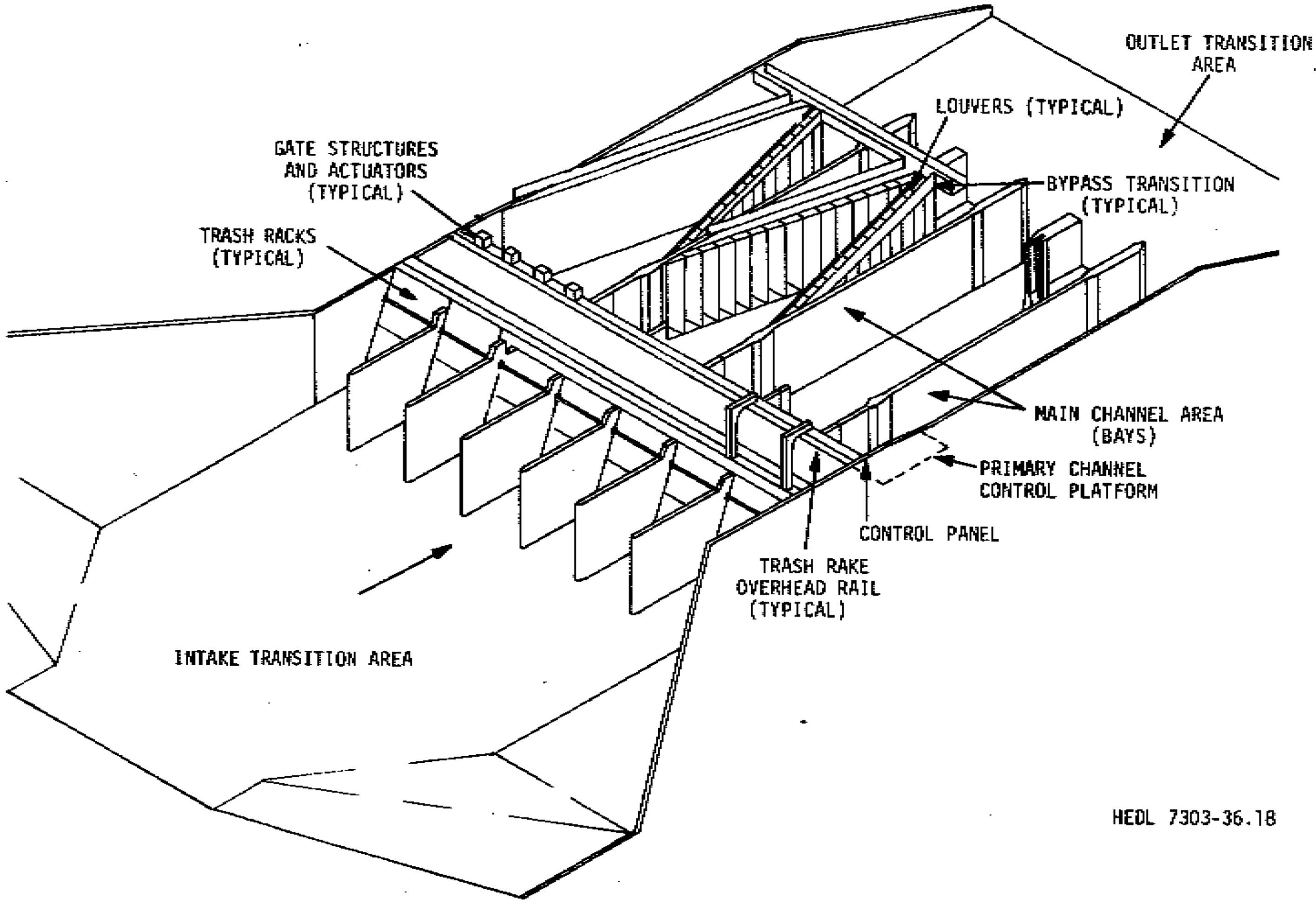

FIGURE A-1. Delta Fish Facility Primary Channel System. (From California Dept. of Water Resources Manual OM-201.)

SAN ONOFRE

The San Onofre nuclear power plant operated by Southern California Edison Company is located on the Pacific Coast near San Clemente, California. Unit 1 began operation in 1968. The intake system design is very similar to that of the Huntington Beach steam power station which utilizes the velocity capped intake structure shown in Figure A-2 and the screenwell shown in Figure A-3. San Onofre 2 and 3, scheduled to come on line in 1978-79, will also use a similar design(A2). Each unit will be supplied by a separate intake structure located in 30 feet of water approximately 3500 feet off shore. The velocity capped structure will draw water from the bottom 10 feet of the water column at an inflow velocity of 2.5 feet/second. Water will flow into the screenwell through a conduit 18 feet in diameter buried in the ocean floor.

The annual number of fish entrapped in the San Onofre screenwell is less than has been experienced at the Huntington Beach facilities. The difference has been attributed primarily to the fact that fewer fish inhabit the vicinity of this intake structure. Although fish entrapment has not been of major concern at San Onofre Unit 1, provisions are being included in the design of the screenwells for Units 2 and 3 to safely remove entrained fish. Southern California Edison has recently completed a series of studies to determine the guidance/avoidance characteristics of indigenous species, principally anchovies, queenfish, and surf perch. Based upon studies conducted at the Redondo Beach Power Plant, it was concluded that louvers could be used in the design of the screenwell to guide fish into areas where they could be safety removed(A3). Design details of the screenwell have not yet been disclosed by the utility.

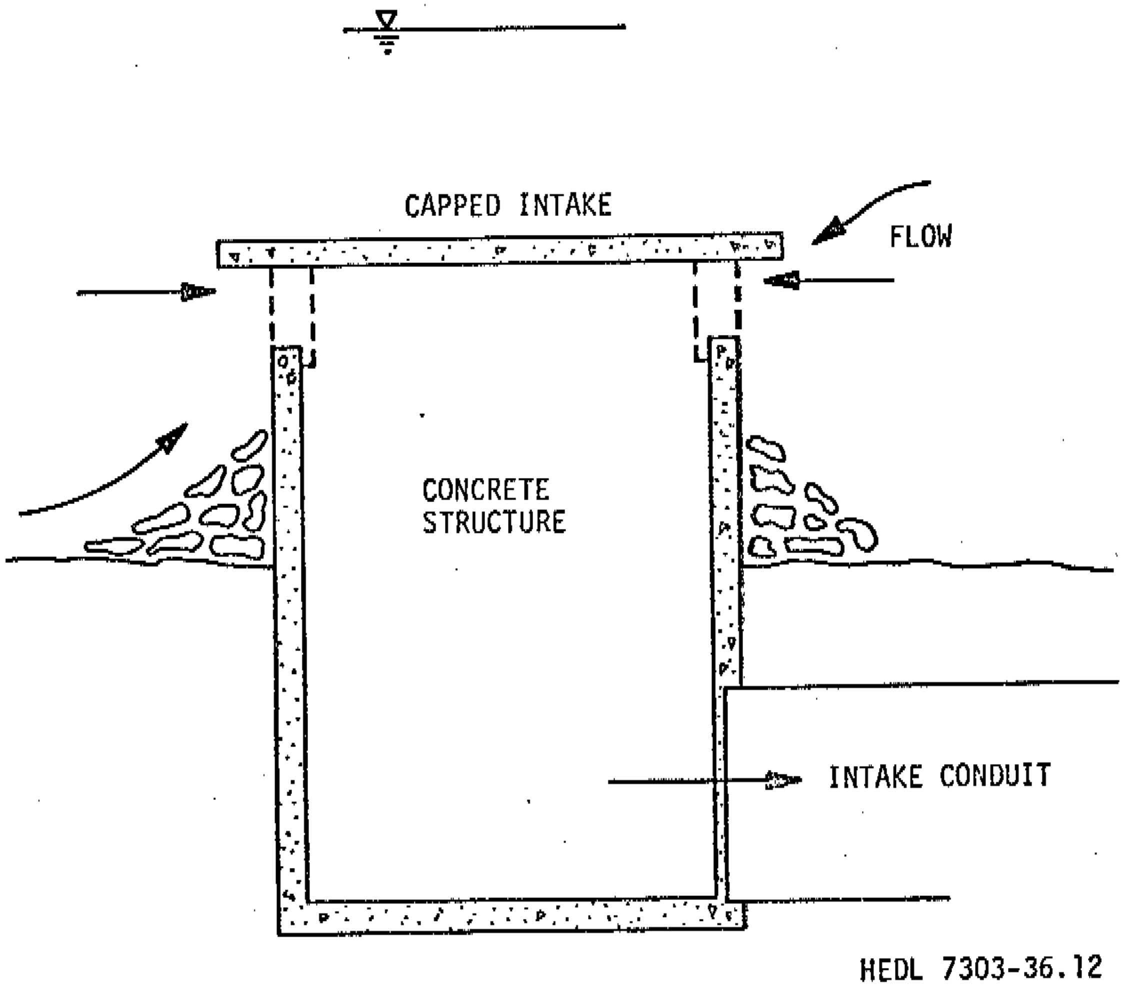

FIGURE A-2. Velocity Capped Intake Structure Typical of San Onofre Nuclear Plant.

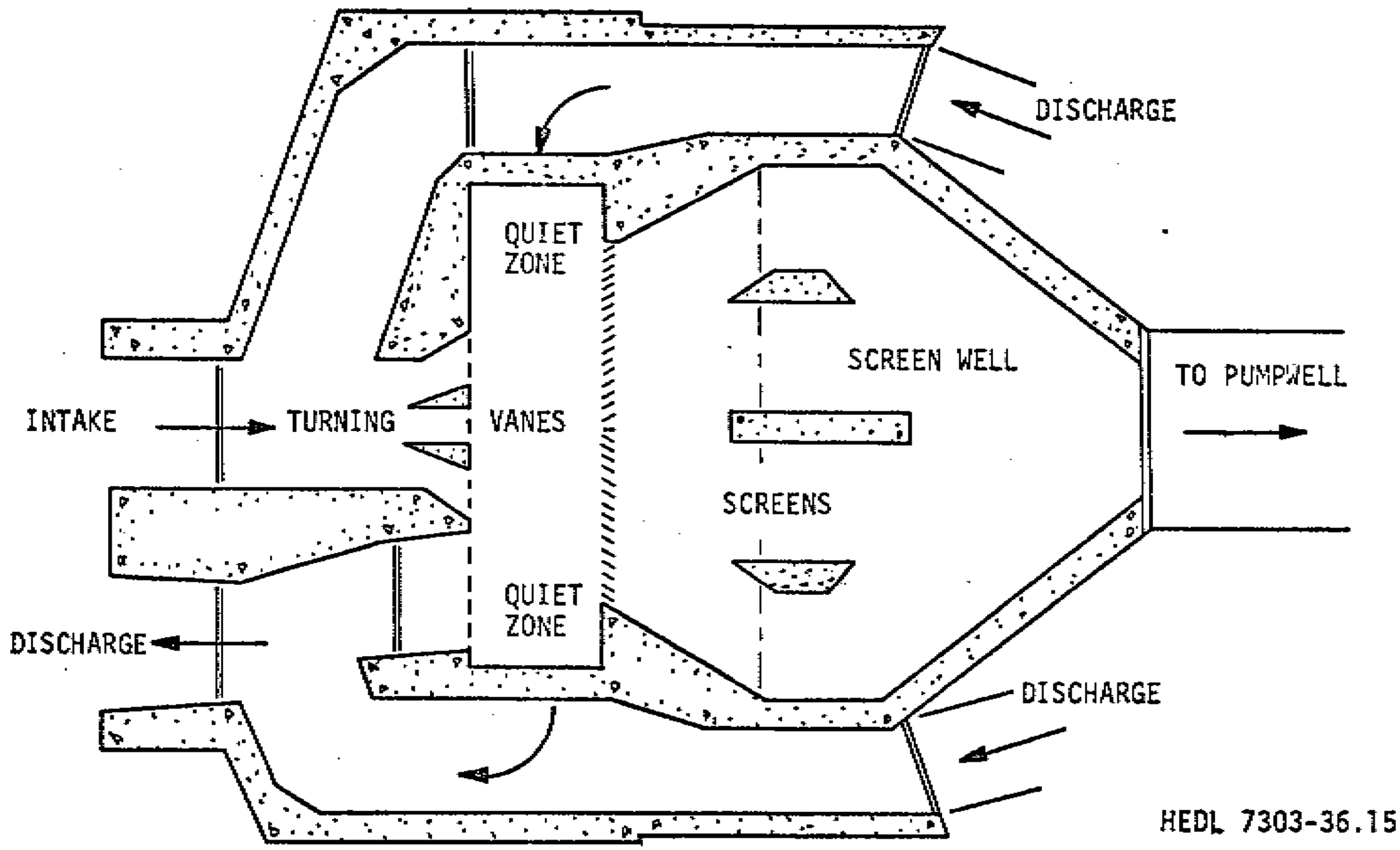

FIGURE A-3. Plan View of Screenwell Used at Huntington Beach Steam Electric Plant.

KIKET ISLAND

As mentioned, studies have been conducted on the feasibility of using rapid sand filters in connection with siting a nuclear power plant on Kiket Island in Puget Sound. The studies are being performed for Snohomish County P.U.D. and Seattle City Light.

A model rapid sand filter was mounted aboard a barge anchored off the shore of Kiket Island where the filter tests were conducted. Four different filter compositions involving various combinations of anthracite coal, sand, and gravel were tested[A4]. Water was drawn from the bay through the filter by a pump throttled to give three different filtering rates. The three flow rates investigated averaged 4.15, 6.49, and 9.54 gpm/ft^2 over the series of tests conducted. Head loss as a function of time was recorded for each of the three flow rates and four different filter compositions. When the head loss across the filter reached 70 inches the case was terminated and the filter backwashed at a rate of 15 gpm/ft^2.

The results from the tests can be summarized as follows[A5]: Filter flow velocities of 0.01 to 0.02 ft/sec were achieved. These velocities will not result in sink flow rates which affect the mobility of juvenile fish and larger invertebrates. The exclusion of plankton was not considered practical. Turbidity or silt loading seemed to have the greatest effect on reducing filter performance. The most effective technique for controlling fouling consisted of backwashing daily with heated chlorinated sea water, or inducing anoxia.

POINT BEACH

The Point Beach Nuclear Power Plant operated by the Wisconsin Michigan Power Company is located along the western shore of Lake Michigan approximately 30 miles southwest of Green Bay, Wisconsin. The first of the two 500 MWe units presently planned for the site began operation in December 1970. Cooling water for the plant is withdrawn from Lake Michigan using the intake structure shown in Figure A-4. Briefly, the intake structure consists of an array of steel piling filled with limestone blocks forming an upright hollow cylinder standing on the bottom.

Water enters the central chamber of the cylinder through void spaces around the limestone blocks and through several 30-inch diameter pipes which penetrate the cylinder wall at an elevation 5 feet above the lake bottom. The portals for these pipes are covered by 1-3/16" x 2 inch bar grating to prevent large fish and debris from entering the intake. The structure, located 1750 feet offshore in approximately 20 feet of water, is sufficiently large to provide cooling water for both units. To prevent icing during the winter months, heated water can be recycled through one of the intake conduits. The screenwell, located at the shoreline, contains a bar rack and vertical traveling screens. Although provisions for removing fish trapped in the screenwell are included in the design, the fish and debris are not returned to the lake[A6].

To establish baseline indicators benthic surveys were started during 1964-65. Since that time, a number of investigations have been undertaken. During the first year of operation entrainment studies were performed on Unit 1. The studies concluded that no significant mortality was incurred by phytoplankton in passing through the cooling system. For zooplankton, the physical damage caused by impingement was more significant than damage resulting from thermal exposure. Entrainment losses were estimated at less than 20%[A6]. Few eggs or larval fish forms were found in the intake water supporting the theory that the intake was not situated in a "nursery area". During 1971, a few fish were trapped in the screenwell when a portion of the intake structure failed. The opening was repaired promptly.

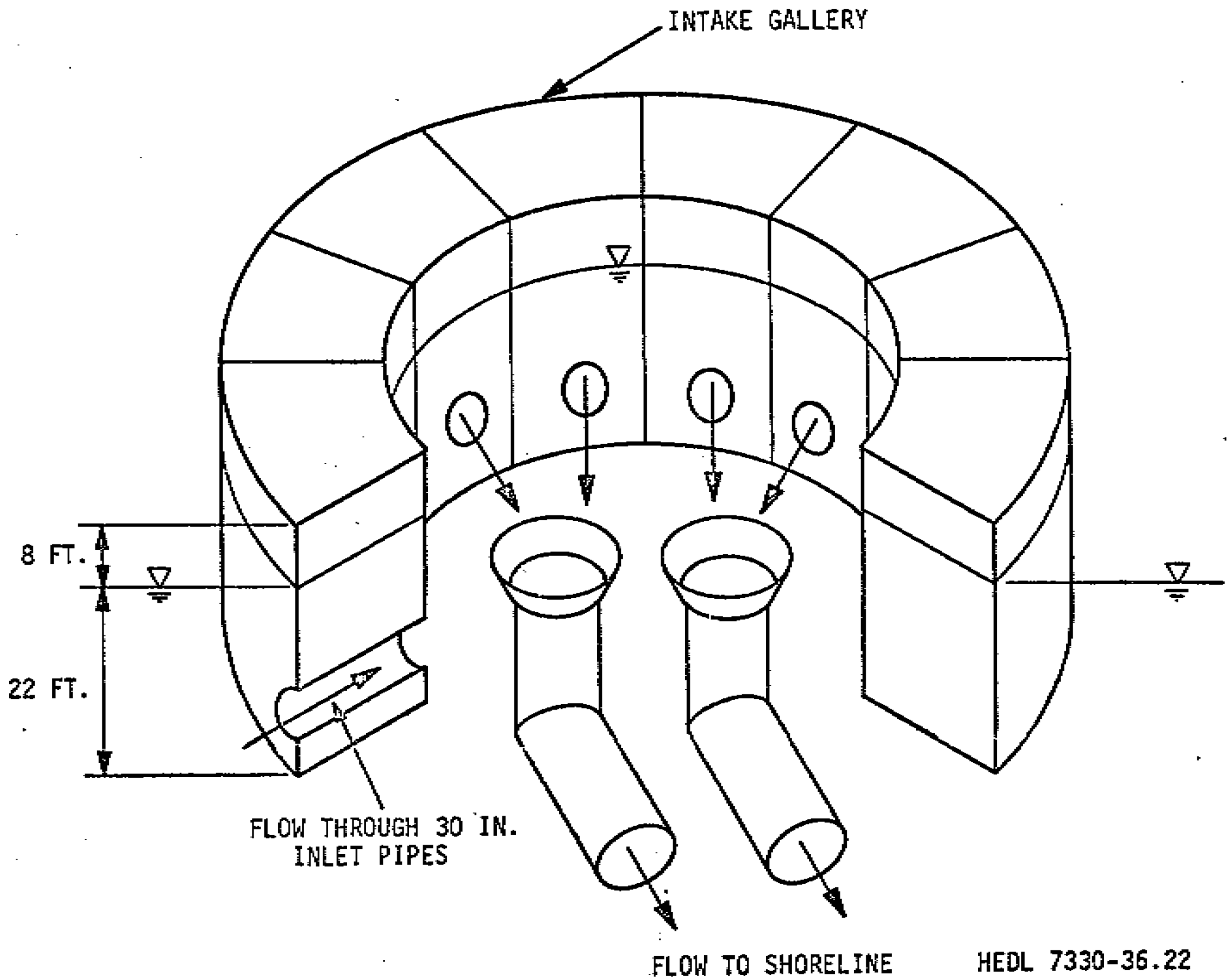

FIGURE A-4. Intake Structure of Point Beach Nuclear Plant.

MARSHAL

The Marshal Power Station, operated by Duke Power, is located in North Carolina on Lake Norman--a 33,000 acre lake formed in 1963 by the construction of Cowan's Ford Dam on the Catawba River[A7]. The 1971 generating capacity of the Marshal Steam Station was 2136 MW. It operates with an overall efficiency of 40%, discharging approximately 2500 MW of heat into the lake.

Cooling water is withdrawn from Lake Norman into an intake cave under a skimmer wall designed to restrain the upper 60 feet of water and withdraw coolant only from the hypolimnion. The intake structure, which is located at the end of the mile long intake cave, consists of six bays each of which contains a bar rack, a fixed galvanized wire screen (3/8" x 3/8"), and the circulating water pump. The overall width of the intake structure is approximately 100 feet.

Since 1965, a continuous program of data collection has been underway. Initially, the program consisted of collecting hydrological and meteorological data. In 1968, the program was expanded to include the collection of biological data pertaining to the effects of thermal discharges from the plant. Presently, studies include primary production, zooplankton entrainment, and population characteristics of plankton, benthic invertebrates, and fish[A8].

OYSTER CREEK

The Oyster Creek Nuclear Power Plant, rated at 640 MWe and operated by Jersey Central Power and Light, is located on Barnegat Bay along the New Jersey coast line. Cooling water is taken from the Bay and the South Branch of the Forked River through a dredged intake canal on the north side of the power plant. The heated effluent is discharged to a canal dredged into Oyster Creek and then flows into Barnegat Bay.

The intake structure contains the features typically employed. In addition to the trash rack, traveling screens, stop logs, and recirculating water pumps, provisions for deicing by circulation of heated water have been included in the design. Trash and fish collected on the intake screens are diverted to the discharge canal. The temperature of the effluent in the discharge canal is reduced through dilution, using three dilution pumps, each with a capacity of 260,000 gal/min, which together have the potential to reduce the temperature of the effluent by more than 50%.

To establish pre-operational baseline conditions, field surveys and studies were commenced in the spring of 1966. A number of monitoring stations have been established in the Bay and the canals. Since the inception, studies on fish, benthos, and plankton have been conducted by various agencies and consulting firms on a continuous basis. At the present time, the effect of operating the power plant on the aquatic inhabitants of Barnegat Bay is inconclusive although there have been fish kills, notably a winter, 1972, kill of Atlantic Menhaden in the discharge canal subsequent to a reactor shutdown[A9].

INDIAN POINT

The Indian Point Power Station, operated by Consolidated Edison, is located on the Hudson River several miles north of New York. Since the startup of Unit 1 in late 1962, there has been a history of intermittent fish kills. Although there has been controversy over the magnitude, the problem is generally recognized, and estimates place the loss at over one million fish (mostly white perch and some small striped bass) in some years[A10]. As a result, a number of modifications to the intake structure have been made in an attempt to alleviate the situation.

The intake structure, as originally designed, consisted of four eleven-foot wide open intakes located at the shoreline under a loading wharf. Water, normally 26 feet deep at this location, was drawn into a forebay under a 13-foot deep skimmer wall. Traveling screens were located in the forebay, roughly 30 feet from the shoreline.

Observations in 1963, and on many occasions since then, showed that fish were being attracted to the screenwells of the condenser circulating water system, indicating an inadequacy in the design of the intake structure. Air bubble screens were installed in front of the openings to the screenwells in the first attempt to repel the fish. Results proved that technique to be ineffective. Investigations using electrical fish screens proved ineffective due to the changing salinity level of the ambient waters[A11]. In the summer of 1963, an attempt was made to fence off the wharf area; however, the need for constant maintenance limited the usefulness of this approach. In February of 1964, Alden Laboratory constructed a physical model of the Indian Point Site. The results of the Alden Laboratory study coupled with the recommendation of a local consultant led to the removal of the hanging section of sheet piling at the North and South ends of the wharf. To reduce the possibility of recirculating,the discharge channel was extended 200 feet downstream. The openings in the concrete wall at the river's edge of the screenwell were enlarged to reduce the approach velocity to less than 1 ft/sec. Stainless steel screens with 3/8" mesh openings were installed in front of the screenwell openings and were situated so that there were no recesses where fish could become trapped. The modification proved effective in reducing fish kills by a factor of 10.

Since installation of the screens, two major problems have arisen: (1) during the winter, frazil ice forms on the fine screens blocking flow through the screens, and (2) during the other seasons there is excessive fouling of the screens with debris. In 1969 a special task force was organized to examine the problem. The task force recommended construction of a new intake structure.

Present plans call for a new structure to be built upstream from the present installation. The structure, containing bar racks and traveling screens, will be placed 75-100 feet out from the shoreline into the main channel. The design approach velocity will be less than 0.5/sec. Sheet piling will extend from the intake to the location of the outfall thereby blocking off the old intakes. The cost of this installation is estimated at $12,000,000 with a scheduled completion data during the summer of 1973.

P. H. ROBINSON

The P. H. Robinson plant, operated by Houston Lighting and Power Company, is located on the west side of Galveston Bay near Houston, Texas. The present capacity of the plant is 1550 MW, but a fourth unit of 750 MW is under construction and scheduled for start-up during 1974(A12). The power plant is cooled by water from the Dickinson Bay section of Galveston Bay. Cooling water from the bay flows approximately two miles northeast through an intake canal to the plant. Heated effluent is returned through a canal to Galveston Bay. The intake structure is equipped with typical log stops, vertical traveling screens, and circulating water pumps. As an extra precaution, a fixed screen panel has been inserted between the traveling screens and the pumps. Fish and trash collected on the traveling screens are sluiced through a tunnel into the discharge canal.

A number of studies have been conducted to assess the effect of power plant operation on the local aquatic organisms. Since Dickinson Bay provides a "nursery grounds" for a large number of fish, they are continuously being drawn into the intake canal. The greatest number of fish pass through the cooling system during the spring(A12). During the warm period of the year, the impact on the fish recruited into the discharge canal is lessened by diluting the effluent with water diverted from the intake canal through a bypass to the discharge canal. The effectiveness of reducing the temperature of the discharge canal is presently being assessed.

Rotation of the traveling screens is based upon the pressure drop across the face of the screen, as is common practice. Tests on operating the vertical traveling screens on a continuous basis indicate that loss through impingement could be reduced by 50%(A13). Sampling of fish impinged at the screens of Units 1 and 2 as presently operated, indicate a total loss of fish in excess of 50 tons annually. Although this seems impressively large, it is alleged to be less than the impact of shrimping operations in the bay from a single boat(A13).

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THE BEHAVIOURAL BASIS OF FISH EXCLUSION FROM COASTAL POWER STATION COOLING WATER INTAKES

by

A.W.H. Turnpenny

SUMMARY

Much has been written on the subject of fish protection at water intakes and engineers responsible for intake design are confronted with a diversity of approaches to the problem. Some of the information in the literature is site specific. Some of the approaches recommended may work well in a laboratory environment, but fail to make the transition to a full-scale system operating in the natural environment. In others, the cost of the facility simply outweighs the benefit to fisheries.

This Report goes back to first principles of fish behaviour in flow fields, to consider why fish enter water intakes and how they can best be excluded. It is shown that there are three vital elements to fish exclusion:

(1) the fish must be able to detect its approach to an intake before it can attempt to escape; (2) the direction of water flow must be horizontal, since fish are ill-equipped to react to vertical flow components; (3) the water velocity must be within the fish's swimming performance range. All three requirements must be met simultaneously; it is futile, for example, to reduce intake current velocities where waters are perpetually turbid, since fish would be unlikely to detect their approach to the intake.

There has been confusion in the literature over the particular characteristics of fish swimming performance that are important for fish to escape from water intakes. In this Report it is shown that velocity criteria based on maximum 'burst' swimming speeds are inappropriate, since the steady hydraulic conditions at water intakes do not stimulate 'burst' swimming. Instead, criteria based on maximum sustainable swimming must be adopted. A synopsis of swimming speed data applicable to the common groups of fish present in coastal waters in Britain is presented, and it is shown how these can be used to determine appropriate intake velocities for fish exclusion. Reference is made also to the problem of asymmetrical velocity distributions around offshore intakes located in tidal crossflows, and the correct application of velocity criteria in these situations.

Possible solutions are discussed where fish exclusion is a priority but the ability of fish to detect intakes is likely to be poor due to high turbidity. These involve the use of sound, light or hydraulic stimuli. However, results are likely to be site-specific and field trials would be required.

The fish-attractant properties of offshore intake structures are considered. Designers of many existing intake structures have unwittingly incorporated features which are now recognized as fish attractants, in particular, open steelwork superstructures and boulder rip-rap. Such features can be expected to add to the problem of fish ingress.

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1. INTRODUCTION

Large, direct-cooled power stations inevitably draw in quantities of fish and other aquatic organisms with the cooling water (CW) supply, which from any point of view is undesirable. Environmentally, the presence of dead and dying fish in screenwash 'trash' creates a bad public impression, even though it has been demonstrated repeatedly that the numbers of fish involved are unlikely to harm stocks as a whole (Turnpenny, Utting, Millner and Riley, 1983; Henderson, Turnpenny and Bamber, 1984; Henderson and Holmes, 1985). From a power-plant operational aspect, fish ingress adds to the daily problem of screenwash 'trash' disposal. At worst it can lead to screen blockage and reductions in generating load or even a complete shutdown, often with the possibility of physical damage to screening plant. In Britain, screen blockage by fish has occurred on several occasions at power stations operating on the south and east coasts (Dungeness, Isle of Grain, Sizewell, Kincardine) involving costs estimated at millions of pounds sterling in lost generation and repairs (Mawer and Harris, 1975; Langford, 1983).

There is no shortage of scientific literature on the subject of excluding fish from CW intakes. Techniques range from the bizarre (underwater rock music: Schuler and Larson, 1975) to costly systems involving ultra-fine screens or filters or fish return systems (Langford, 1983). Some ideas work well under laboratory conditions but fail to make a satisfactory transition to an engineering design; others seem good as engineering solutions but fail to work for biological reasons. A common fault throughout the literature is the failure to recognize the fundamental biological principles which lead to fish capture, and a subsequent failure to recognize the limitations imposed by a hostile aquatic environment and by engineering constraints.

This Report describes the biological reasons underlying fish entry into CW intakes, and attempts to establish basic principles of intake design for fish protection. This is based upon review of published literature, and the results both of 10 years of study of fish impingement at the CEGB's major coastal power stations, and of fish behavioural studies carried out at the CERL Marine Biology Unit, Fawley. It is hoped that the information presented will help to make engineers aware of how and why fish become drawn into water intakes, and how this problem may be alleviated.

Reference is made also to research into the design of fishing gear since the behavioural basis of fish capture is similar for both water intakes and towed fishing gears, although the aims regarding fish are diametrically opposed. It is quite valid in many instances simply to reverse the sense in which the principles are applied.

2. FISH BEHAVIOUR IN FLOW FIELDS

Water currents are a natural feature of the aquatic environment and fish react to them in a number of ways. This subject has been reviewed comprehensively by Arnold (1974). The response to currents varies between species, and within species according to the time of day, tidal currents and stage of the life cycle. Three main categories of response can be distinguished:

(i) random movement or passive drift (i.e. no response);

(ii) positive or negative rheotropism (i.e. swimming with or against currents);

(iii) selective tidal stream transport/modulated drift.

At low current speeds (<1-3 cm s^{-1}), the current has no effect on the direction in which the fish swims. At higher current speeds, a common response is for the fish to head into the current (positive rheotropism) and to maintain station relative to the background (i.e. sea bed, fixed structures, etc.). Most often this response is mediated visually by the optomotor reflex. The optomotor reflex is a behavioural response whereby the fish attempts to stabilize its visual field by maintaining station with reference to the most prominent components of the visual field. The optomotor reflex is also important in maintaining school structure in pelagic species (Blaxter, 1975).

The optomotor reflex breaks down in low visibility. This can be caused by turbidity, or by the light intensity falling below a threshold level. This light threshold is surprisingly low, e.g. down to 10^{-7} lux (Arnold, 1974). It has been shown recently on the west coast of Scotland that even on the darkest night in midsummer there is sufficient light for mackerel to school (Glass, Wardle and Mosjiewicz, 1986).

In the absence of light, either passive drift occurs (predominantly in pelagic species such as herring and sprat) or else fish must rely upon cues derived from tactile contact with the sea bed (demersal fish only). It is possible also that fish can detect currents by means of velocity gradients or rotational currents, but the extent to which these mechanisms are used is not clear (Arnold, 1974).

Exceptions to positive rheotropism do occur. Fish inhabiting intertidal areas must follow the ebb and flow of the tide, though this may be due to a combination of negative rheotropism and response to depth change (i.e. hydrostatic pressure). More obvious exceptions are migrating diadromous fish (e.g. eels, shad, salmonids), moving from river to sea or vice versa. Salmonid smolts are negatively rheotropic when leaving the rivers and positively rheotropic when returning.

The final category is not directly relevant to flow fields around CW intakes but will be described for the sake of completeness. Within the sea, many species use selective tidal-stream transport to reduce energy costs of migration (Harden Jones, 1968). The mechanism involves moving with the tide in the direction of the destination, but remaining stationary on or near the sea bed during the reverse tidal phase. An analogous mechanism, known as 'modulated drift', is used by some freshwater species (notably salmonids) to effect downstream dispersal (as fry, parr, smolts). Their movement is modulated by light intensity, the fish remaining stationary in the light and drifting in the dark (Arnold, 1974).

Within this framework of natural behaviour, it is possible to predict how fish will respond to man-made currents at CW intakes. It is evident that fish which are attempting to follow currents will be particularly susceptible to impingement, which may be why salmonid smolts, for example, tend to be attracted towards cooling water intakes sited in the path of their seawards migration. Fish leaving inter-tidal feeding areas on a falling tide are similarly vulnerable. For all fish, the natural response to a strong current in daylight conditions will be to turn into the current and to maintain station relative to the background, (e.g. the sea bed, sea wall or components of the intake structure) or else to swim away, but this will depend on the ability of the fish to detect the relative movement of the water. Escape at this stage will be possible only if the fish can swim fast enough.

Many older designs of offshore CW intake are open-topped and create a vertical drawdown of water which fish are ill-equiped to detect or escape from. Weight (1958) introduced the concept of a capped intake structure so that water is drawn in horizontally rather than vertically, offering fish a flow field more akin to the natural situation. The cap is known as a 'velocity cap' and can reduce fish ingress by as much as 90% (Downs and Meddock, 1974).

There are therefore three fundamental requirements for fish exclusion at water intakes. These can be summarized in the three key words, <u>detection</u>, <u>velocity</u>, and <u>direction</u>:

1. <u>Detection</u>: in order to escape, the fish must first be able to detect its approach to the intake, either visually or through mechanical cues (touch, noise, pressure changes, etc.). Poor visibility through low light or high turbidity may inhibit this, in which case alternative signals must be provided.

2. <u>Velocity</u>: the velocity along the line of escape must be within the fish's range of swimming performance.

3. <u>Direction</u>: the direction of water flow must be maintained in a horizontal plane for fish to resist being drawn in.

The following sections review aspects of fish reactions to water intakes and discuss how these requirements can be met by proper intake design.

3. SWIMMING PERFORMANCE OF FISH

3.1 'Burst' and Sustained Swimming

Fish locomotion has fascinated biologists and physicists for many years and there exists a vast literature dealing with the mechanics, physiology and biochemistry, as well as the speeds which fish can attain (see reviews by Blaxter, 1969; Wardle, 1976; Blake, 1983). Much of the work on swimming speeds has been carried out to determine optimum towing speed of trawling gears to maximize fish capture. The same data can, of course, be applied to intake design so that velocities at water intakes can be kept within the swimming speed capabilities of the fish. However, not all the data in the literature are relevant to this consideration and the findings require careful interpretation.

The swimming activity of fish is described by terms such as 'cruising speed', 'maximum sustainable speed', 'burst speed', 'critical swimming speed', 'voluntary swimming speed', and so on (Blaxter, 1969; Brett, 1967; Sonnichsen, Bentley, Bailey and Nakatani, 1973). From a physiological standpoint, only two categories are justified, these usually being termed 'maximum sustainable swimming speed' and 'burst speed'. Blake (1983) refers to this as a 'two-geared' system. The basis for this distinction is the fact that most fish possess two types of propulsive musculature, known as 'red' and 'white' muscle, respectively. The smaller component is the red muscle, normally comprising 10-20% of the total muscle volume. The red coloration is due to a high content of the oxygen-storing pigment myoglobin. Also, the muscle is heavily infiltrated with blood capillaries to maintain a good oxygen supply which the red muscle fibres require for contraction. For this reason, red muscle is also commonly referred to as 'aerobic' muscle. In most fish, the red muscle is identifiable as a narrow band along the flanks of the fish, though deep red fibres are found in some species (Fig. 1). Despite the relatively smaller volume of the red muscle, it is responsible for most of the fish's activity, providing the 'low gear' for normal cruising and sustained swimming.

White muscle, on the other hand, represents up to 90% of muscle volume, and is used almost exclusively for rapid acceleration to achieve burst speeds, the so-called 'high gear'. White muscle fibres contract faster than red fibres and, because they function anaerobically, are not limited by the rate of arterial oxygen supply.

Typically, burst swimming is used by predatory fish when feeding, or by the prey fish when escaping. At normal cruising speeds the additional mass of unused white muscle is no great burden to the fish since it is approximately neutrally buoyant. However anaerobic muscle fatigues within a few minutes and studies have shown that repayment of the oxygen debt may take up to 24 hours (Batty and Wardle, 1979). During this recovery period the fish is unable to attain maximal performance and hence is at increased risk of predation.

The relevance of these facts to intake design centres on the question of which mode of swimming is likely to be employed by fish attempting to escape from an intake. Clearly, if they engage anaerobic swimming muscle they will achieve higher swimming speeds, typically 2-5 times higher (Wardle, 1976). Evidence does not point this way, and most investigators agree that fish which come into contact with intake currents adopt a steady sustained swimming postue and not the 'burst-drift' posture associated with anaerobic swimming (e.g. Schuler and Larson, 1975; Turnpenny, 1983). The pattern of behaviour observed for juvenile clupeid schools (sprat and herring) by Turnpenny (1983) at the intakes of Fawley Power Station, Hampshire, is almost exactly analogous to that described by Wardle (1976) on the basis of underwater filming of fish behaviour in front of towed fishing gears. From these observations, three stages can be distinguished: (1) the fish perceive the approach of the net or intake and turn to swim away from it; (2) the fish adopt a steady sustained swimming posture, maintaining a constant distance from the approaching structure for as long as possible; (3) finally, the fish either fatigue and drop back with current into the net or intake and are captured, or else they swim out ahead of the current and escape.

This pattern of behaviour leads one to question why many of the fish which are caught apparently do not bring into action the higher performance white muscle, thereby increasing their chance of escape. The answer may lie in the high penalty to be paid by fish which make a wrong decision about the mode of swimming to adopt, by way of the risk at which they place themselves during the recovery period after anaerobic swimming. Fish may have evolved an escape response in answer to quite specific stimuli, criteria of which may not be met in front of a steadily moving trawl or in the steady current approaching a water intake. This explanation is supported by observations of fish behaviour in front of towed fishing gears. Wardle (1976) reports that "divers have shown that if they reach out and grab at a haddock swimming between the wings (of the net), this fish can easily burst away at great speed and swim out of the gear". With steady movements, however, they choose not to. Similarly, in front of the water intakes at Fawley Power Station (Turnpenny, 1983), clupeid schools are seen to be quite capable of escape when startled by a sudden movement or noise such as an object being dropped into the water nearby.

3.2 Measures of Sustained Swimming Performance

Sustained swimming performance has been measured in a number of ways. There are reports in the literature on swimming speeds of fish measured in the natural environment by sonar (e.g. Harden Jones, 1962), acoustic tagging (Greer Walker, Harden Jones and Arnold, 1978) and other such observational methods. Whilst these methods are unlikely to suffer from the disadvantage of stress induced by handling and confinement which may affect laboratory findings, there is no way of knowing whether the fish are swimming at the limits of their performance. It is these limits which are of interest in the context of intake design.

Experimental methods of measuring maximum sustainable swimming performance usually entail use of a flume. That used by CERL at Fawley has a 7 m (L) × 0.6-1.5 m (W) × 0.2-0.5 m (D) test section in which water velocities from 5-120 cm s^{-1} can be achieved by means of a paddle wheel driving a water circuit (Turnpenny, 1982). Velocity across the test section is maintained to within ±1 cm s^{-1} across the width of the flume, thus ensuring that all the fish are exposed to the same velocity.

There are two approaches to the measurement of sustained swimming performance (Turnpenny and Bamber, 1983). In one method, batches of fish are introduced into the flume at a range of velocities and the times to exhaustion are noted. From these, swimming speed/endurance plots, such as shown in Fig. 2, can be constructed. Maximum sustainable swimming speed is that speed at which endurance time drops from hours to minutes, e.g. at about five body lengths per second (L s^{-1}) for sand smelt (Fig. 2). The disadvantage of this method is that it requires a separate batch of fish for each velocity tested. Each group represents a single experiment, which makes the exercise time-consuming and costly in fish.

The second method devised by Brett (1967) uses a single batch of fish which are exposed to a stepwise increase in velocity each hour until they fall back and become impinged on a downstream grid. Brett then defines the Critical Swimming Speed (U_{crit}) as:-

$$U_{crit} = \begin{matrix}\text{Velocity at time step}\\ \text{prior to impingement}\end{matrix} + \left(\frac{\text{Minutes at impingement velocity}}{\text{Time step (minutes)}}\right) \times \text{Velocity increment}$$

As can be seen from Fig. 2 the mean U_{crit} line for a group of fish corresponds closely with the estimate of maximum sustainable speed based on the more laborious incremental method. In both cases, the swimming speeds indicated represent the point at which white muscle is used to support swimming activity (i.e. the point of anaerobic swimming) and for practical purposes the critical swimming speed can therefore be regarded as the maximum sustainable swimming speed.

The U_{crit} method has been adopted for all routine measurements of fish swimming performance at CERL.

3.3 Factors Affecting Sustained Swimming Performance

3.3.1 Inter-specific differences

Sustained swimming performance varies widely between species as a result of variations in body form, proportion and disposition of red muscle and the mechanics of movement through the water. These differences reflect the various lifestyles to which different species have become adapted (Blake, 1983). In general, sustained swimming performance must be considered for individual species, though, as will be shown, within certain groups of fish performance characteristics may be similar.

As a rough guide, pelagic species such as the scombrids (tuna, mackerel) and clupeids (e.g. sprat, herring) are recognized as the fastest swimmers, followed by demersal species such as gadoids (cod, haddock, saithe, etc.) and flatfishes. Inshore benthic species (e.g. blennies, gobies, sea scorpions, dragonets, bullheads, pipefishes) on the other hand, have no recognizable sustained performance capability, since their mode of life involves either browsing or darting for food or cover if threatened.

The anadromous salmonids also have quite fast sustained performance, as befits their requirement for protracted migrations (Blaxter, 1969).

3.3.2 Intra-specific differences

Swimming performance within individual species is known to be affected by a number of factors including physiological condition, size, and water quality (Blaxter, 1969). The relationship between fish size and sustained swimming performance has been investigated by many authors (see reviews by Bainbridge, 1961, Blaxter, 1969, Wardle, 1977, Blake, 1983). It is frequently assumed that swimming speed is directly proportional to the length of the fish, and hence many accounts refer to swimming speeds in terms of body lengths swum per second ($L\ s^{-1}$). It is now well known that this relationship does not hold over a wide range of fish sizes, and that smaller fish can swim a larger number of $L\ s^{-1}$ than can bigger fish,

$$\text{i.e. } U \propto L^d \ (d < 1) \qquad \ldots (1)$$

Where U is the distance swum in unit time, L is fish length. This finding is especially important in considering intake design, since most published swimming performance data refer to mature commercial sized fish, whereas fish impinged at power station intakes are predominantly small species or juveniles of commercial species, and these may swim faster than published data would suggest. It is therefore necessary to obtain performance data directly for smaller sized fish, or else to re-scale values based on larger specimens by determining an appropriate value for the exponent.

Bainbridge (1961) examined reasons for the relative decrease in performance in larger fish by examining the relationship between power available from swimming muscles and the drag forces on the fish's body, based on the hydrodynamic theory of flow over a flat plate. His analysis, developed further by Turnpenny (1984), leads to the conclusion that increased drag limits the performance of larger fish such that for laminar and turbulent flow conditions respectively:

$$U_{lam} \propto L^{(b-1.5)0.40} \qquad \ldots (2)$$

and

$$U_{turb} \propto L^{(b-1.8)0.36} \qquad \ldots (3),$$

where b is the coefficient in the regression of fish weight (W) on length:

$$W = a L^{b} \qquad \ldots (4).$$

Assuming isometric growth, which is approximately true for many species, then b = 3.0 and expressions (2) and (3) simplify to:

$$U_{lam} \propto L^{0.60} \qquad \ldots (5)$$

$$U_{turb} \propto L^{0.43} \qquad \ldots (6)$$

Wardle (1977) has shown that during sustained swimming activity, fish tend to remain below critical Reynolds numbers (1×10^{6}) at which laminar flow becomes turbulent, and hence expression (5) can be adopted.

Turnpenny (1984) fitted this model to performance data for the gadoid species pout, in the length range 6.1-20.5 cm and showed that the resulting curves adequately accommodated data for other members of the gadoid family up to 40 cm in length. Both the oxygen content and the temperature of the surrounding water have been shown to influence sustained swimming performance. A clear demonstration of these effects was given by Brett (1964) who studied performance of Pacific Salmon in a tunnel respirometer. Brett showed a logarithmic increase in oxygen demand with increased temperature over the range 5-15°C. At temperatures above 15°C swimming speed was reduced due to oxygen limitations which result from the combination of increased oxygen demand and decreased oxygen solubility at higher temperatures. These effects of temperature on sustained swimming performance have also been shown for some marine fish species (Turnpenny and Bamber, 1983; Turnpenny, 1984).

The influence of water temperature on fish catch at water intakes is widely reported (Langford, 1983). Catches tend to increase at low winter water temperatures, due to the decreased swimming performance and hence escape potential. Under these conditions oxygen is unlikely to become a limiting factor except where the oxygen level is greatly reduced by pollution. In general, therefore, consideration of metabolic effects can be confined to temperature effects.

3.4 Swimming Performance Data for Representative British Species

Although several hundred species of fish have been recorded in British coastal waters (Wheeler, 1968), and typically 50-80 species occur in intake screen catches from any one power station, a sub-set of a dozen or so species (Table 1) has been found to account for 80-90% of the catch at coastal sites in Britain (P.A. Henderson, pers. comm.). It is therefore sensible to narrow the discussion to these species in order to establish criteria for fish exclusion. From time to time there will be additional species which deserve attention for ecological or socio-political reasons. A typical example is the Atlantic salmon and so the salmonid family is also included in the synopsis of swimming speed data contained in this section. Even for this subset of species, data are sparse, and only provisional estimates of performance can be made for some species, pending further experimental work.

Within the literature on swimming speed, a variety of different formulae has been used to express maximum sustainable swimming speeds. To facilitate comparison and further utilization, the data summarized here have been re-examined and fitted to a standard model of form:

$$U_{crit} = (a + k_t.T)L^{0.6} \qquad \ldots (7)$$

In this formula, U_{crit} is the maximum sustainable swimming speed measured in units of distance swum per second and T is the water temperature, a and k_t being species-specific regression coefficients. Table 2 lists values of these coefficients for several different species.

As seen from Fig. 3 the slopes of the lines and hence the values of the temperature coefficient, k_t, are similar, especially for those species of fish where larger numbers of specimens have been tested. The mean value of the temperature coefficient, weighted for the number of specimens in each case tested, is 0.58. This value has therefore been assumed in cases where adequate data covering a range of temperatures were not available.

Further assumptions are also made:

1. Performance of species within any one family is comparable. For practical purposes, this assumption appears to hold within the Gadidae (Turnpenny, 1984) and within the Clupeidae (Turnpenny, 1983) and, in view of the similar morphology should hold within the flatfish too (Pleuronectidae, Soleidae).

2. No data was available for the flatfish, species listed. Wardle (1976) locates plaice on a similar performance curve to cod. Also, Beamish (1966) gives data for the North American winter flounder, which indicate similar performance to gadoid species. Values of a and b derived from gadoid data have therefore been applied to flatfishes.

3. Finally, at high water temperatures oxygen will become limiting, and thus performance will decline. For Pacific Salmon (Brett, 1967) and pout (Turnpenny, 1984) this occurs at temperatures of 15-20°C, though in sand-smelt performance is linear up to 20°C (Turnpenny and Bamber, 1983). In polluted waters having a lower oxygen content, oxygen will become limiting at correspondingly lower temperatures. For the present purpose, a linear relationship up to 17.5°C has been assumed for all species.

4. SWIMMING SPEED DATA IN INTAKE DESIGN

4.1 Specification of Approach Velocities

The water velocity ahead of the primary (coarse) screening systems of a water intake structure is termed the 'approach velocity'. A more precise definition for the present purpose is the maximum velocity in an intake system against which fish must swim to escape. To ensure that fish can escape, the approach velocity must therefore be kept below the maximum sustainable swimming speeds of the fish.

The swimming speed required for escape depends on the orientation of the fish. If the screen is not aligned normal to the flow and the velocity is close to the maximum sustainable swimming speed, fish are often observed to swim ahead of the screen, in a direction perpendicular to the screen face (Sonnichsen et al., 1973; Arnold, 1974). This indicates that the fish are orientating to the face of the screen rather than the hydraulic streamlines. A similar behaviour has been observed in fishing gear research amongst flatfish herded by the sweeps and bridles of a trawl (Main and Sangster, 1981). It is generally agreed, therefore, that the design velocity for fish escape should be computed as the velocity vector normal to the bars of an intake and not along the streamline, unless these happen to be perpendicular to the trash-rack face.

Design values for approach velocities have been adopted by various agencies with a view to fish exclusion. Schuler and Larson (1975) cite a design velocity of 76 cm s^{-1} for the Southern California Edison Company's (SCEC) offshore) intake structures, but from their own experimental trials recommended a modified design value of 46 cm s^{-1} for SCEC's San Onofre Nuclear Generating Station. Other utilities in the USA have adopted design values as low as 15-30 cm s^{-1} (Sonnichsen et al., 1973). In Britain, the CEGB has no rigid policy on this matter, though for example for the proposed Sizewell 'B' Power Station design, Mawer (1982) specifies a peripheral velocity at the capped offshore structure 'in the order of 50 cm s^{-1} to enable fish to escape.

It must be borne in mind that other factors influence the choice of approach velocity, for example the necessity to prevent sedimentation in waters with a high silt burden, and the higher cost of the larger structure required to maintain low approach velocities. The final design velocity must therefore reflect an optimization of all the salient factors, of which fish exclusion is only one; its importance will depend upon the significance of the locality to fisheries.

Fish Escape Model

To ascertain approach velocities from which fish can escape, it is necessary to consider first the species present in the locality and then the size distributions present. From this information, swimming performance data can be used to predict the proportion of fish vulnerable at any given water temperature. Where significant seasonal variations occur due to age-selective migrations or growth, separate length distribution and temperature values can be applied for each season.

For fish to escape an approach velocity V_a the condition is

$$V_{crit} > V_a \qquad \ldots (8)$$

The critical length L_{crit}, i.e. the smallest size of fish which can escape, is derived from expressions (7) and (8) as:

$$L_{crit} = [V_a/(a + k_t.T)]^{1/0.6} \qquad \ldots (9)$$

The proportion of fish vulnerable is then the sum of fish smaller than L_{crit} divided by the total population size, or if the length - frequency distribution is described by n classes of width w, such that $\sum_{i=1}^{n} L(i) = 1$ then the proportion vulnerable, p, is given by

$$P = \sum_{i=1}^{L_{crit}/W} L(i) \qquad \ldots (10)$$

Examples of this model applied to a range of species are shown in Fig. 4 (a - n). Here, values of p have been calculated for approach velocities in the range 0-150 cm s^{-1} at 5 cm s^{-1} increments. Along with these are shown the length distributions on which the curves are based.

Swimming speed coefficients are those listed in Table 2. The length distributions are for illustrative purposes and will vary from one coastal location to another, but are taken from recorded observations at UK coastal sites and are fairly typical of the inshore waters around power stations. The main site to site differences are likely to be in the proportional representation of different age classes. For example sprats at estuarine sites tend to be dominated by the 0+ age group, whereas at open coastal sites, particularly on the east coast of Britain, older classes predominate in winter months. To simplify presentation in these plots, the bulk annual length distributions have been used, summated for each of the 12 months, and curves have been computed based on swimming performance at four temperature values covering a typical annual range of 2.5-17.5°C.

For all species, the probability of escape is lowest when waters are coldest and thus to design for the worst case the 2.5°C temperature curve is most appropriate. However, in cases where the inshore presence of the species is seasonal, a temperature value relevant to that season should be selected. For example, for salmon smolts having a spring migration past the intakes, a water temperature of around 12.5°C might be appropriate.

Table 3 lists the maximum approach velocities for total exclusion of each species corresponding to the four temperatures shown in Figs 4a-n. Two sets of figures are shown. The left hand columns represent maximum approach velocities to enable fish of all age groups to escape. The right hand columns represent values for fish of age one year and older which can be applied to locations where 0-group fish are not strongly represented and where values in the left hand columns would therefore be excessively stringent. The values for one group and older fish are calculated from equation (7) using the minimum length values for age one fish shown in Table 3.

To provide an example, consider the problem of sprat influxes at power stations on the south-east and east coast of Britain. Their exclusion requires that approach velocities should be kept low enough for the fish to escape (given the necessary stimulus to do so). As the fish involved are predominantly of age one and older, and as the problems occur only during the winter months (Turnpenny and Utting, 1980) when water temperatures are low, a design approach velocity of 50 cm s^{-1} would be chosen for sprat exclusion.

To achieve successful exclusion, other criteria would have to be met, and these are discussed in the next sections.

4.2 Velocity Characteristics of Water Intakes

4.2.1 Onshore and shoreline intakes

An 'onshore' intake is defined as one where the water is abstracted without the need for an offshore pipeline and intake structure. Where the marginal water is shallow, water is normally taken via a deep canal, or directly through a sea wall where the marginal water is deep. The second type is known as a 'shoreline' intake.

A typical onshore intake layout is shown in Fig. 5. Water enters via an orifice in a vertical wall. The opening is normally protected by a coarse screen or 'trash rack' of vertical steel bars fixed at ~15 cm centres. Beyond this is a travelling band or drum screen of ~8 mm square mesh opening which removes entrained fish and debris. While it has been shown (R.H.A. Holmes, pers. comm. and Turnpenny and Utting, 1981) that live fish released behind the coarse screens into the screenwell area can escape from the system, the hazards of turbulence in the screenwells and of toxicity due to chlorine injected to prevent bio-fouling render this opportunity unlikely as a general rule. The design expectation should therefore be that fish are enabled to escape before passing through the coarse screens.

The vertical openings of onshore intake designs lend themselves to fish escape since the water currents are predominantly horizontal at the coarse screens. The main consideration for fish escape is therefore that the approach velocity at that point, under all operating conditions, is kept within the swimming speed ranges of the fish as indicated in Section 4.1. It is preferable that a uniform velocity profile be achieved across the face of the screens but, if not, that the conditions for fish escape are met at the maximum velocity value.

A difficulty of some canalized onshore intake designs is that the point of maximum approach velocity in the canal is at some distance ahead of the coarse screens and not at the screen face. An example is at Fawley Power Station, where velocity values at the canal entrance may reach 150 cm s^{-1} at full load on a low spring tide, whereas the approach velocity at the screens is around 80 cm s^{-1} (Turnpenny and Utting, 1981). As a consequence, by the time fish come into contact with the coarse screens and attempt to escape, poorer swimmers become trapped within the system. The obvious answer to this problem is to avoid designing narrow constrictions in the canal ahead of the coarse screens but this is not always practical due to increased likelihood of siltation. As a protective measure, some form of behavioural barrier or warning system might prove effective in reducing fish ingress (see Section 5).

4.2.2 <u>Offshore intakes</u>

Offshore intakes vary widely in design, but generally comprise an offshore structure connected by a sub-sea tunnel to the shoreline. Older designs, such as Sizewell 'A' are open-topped and have strong vertical draw-down currents, whereas more recent designs such as Dungeness 'B'; Wylfa (both operational) and Sizewell 'B' (not yet built) have capped intakes with a more horizontal flow pattern (Fig. 6).

It is difficult to make comparisons of performance for capped and uncapped structures currently operating in Britain. Some evidence is provided by Spencer and Fleming (CEGB internal communication), who conducted a comparative survey of fish catch at Dungeness 'A' and 'B' power stations. The 'A' station intake is not a capped design, but is partially enclosed by a concrete in-fill on top of the intake grill which complicates the flow pattern. The 'B' station, on the other hand, is a capped design. Over a twelve month period, 'A' station catches per unit CW flow were invariably higher than 'B' station catches, the ratio of numbers caught for

'A':'B' ranging from 1.2:1 to 65:1. The differences may, however, have been partly due to differences in approach velocity, though no velocity measurements have been made to substantiate this. Nevertheless, this example perhaps emphasises the importance of the design of capped intakes and the fact that blocking the top of an intake without due regard to the flow pattern is not sufficient to guarantee fish protection.

Development of intake designs with horizontal flow is a specialized subject which cannot be treated in depth here. As a simple criterion for a fish protecting intake, Schuler and Larson (1975) proposed that "to create the desired uniformity in entrance velocity and to increase the time for reaction (of fish) to the flow, the cap and lip of the riser must extend horizontally from the riser body 1.5 times the height of the opening" (Fig. 6c). There are, however, reasons unrelated to fish protection for adopting capped intake designs. Goldring (1984) showed that capped intakes have superior characteristics for selective withdrawal of cooler water in thermally stratified environments - another example of how intake design must reflect a variety of requirements. An optimal solution should not be difficult to achieve with available mathematical models of fluid flow, capable of simulating the three-dimensional flow around an intake structure.

The horizontal flow pattern around an offshore structure is equally important. In still water, inflow is uniform around the structure and streamlines are normal to the trash-rack bars. In a tidal cross-flow, the distribution becomes biassed, with most of the water entering close to the upstream radial axis where the approach velocity is consequently higher (Fig. 7). It would be expected from this that catch rate at an offshore structure sited in a tidal stream would tend to be maximal around mid-flood and mid-ebb, and minimal around the slack water period. This has indeed been shown to be the case at Sizewell 'A' Power Station where the CW intake structure is located within a longshore tidal flow and where it has been possible to make hourly measurements of fish catch and tidal velocity (Fig. 8).

Normal-to-bar velocities are in general lower in this situation (Fig. 7) but the velocity along the tidal axis remains the same. It is therefore important that the peak value, and not the average velocity figure is selected to enable fish to escape. In hydraulic model tests carried out at CERL (B.T. Goldring, pers. comm.) using a capped, circular intake with a nominal approach velocity (flow/screen area) of 25 cm s^{-1}, the measured peak velocity in a simulated 50 cm s^{-1} tidal crossflow was 70 cm s^{-1}. Using mathematical models of fluid flow, it is possible to simulate velocity profiles in crossflow conditions for any given intake configuration, and this should greatly assist in specifying the design of structure necessary to achieve acceptable approach velocities.

As a principle, it is not possible to achieve maximum approach velocities of less than the tidal cross-flow velocity using a circular intake structure. Where the maximum tidal velocity at the depth of the intake opening is higher than the recommended approach velocity for fish protection, an alternative intake design is required. A hydraulic model of a side-entry intake, with openings orthogonal to the tidal flows, has been tested successfully at CERL (B.T. Goldring, pers. comm.), but such a design would undoubtedly be more costly to construct than a circular intake and would only be worth considering where fish exclusion was of paramount importance.

Alternative possibilities, such as locating the intake in a lower velocity tidal stream or abstracting from close to the sea-bed boundary layer where velocity will be lower, also merit consideration, but the possibility of higher fish densities in these areas, and increased silt and weed ingress, must also be taken into account.

5. DETECTION OF INTAKES BY FISH

Several sources of information may contribute to detection of intakes and orientation to currents, including visual and tactile cues, sound and hydraulic stimuli resulting from flow fields around intakes.

This section considers the sensory cues which may be available to fish in the vicinity of an intake and how these cues may be reinforced by improved intake design or by addition of supplementary stimuli.

5.1 Hydraulic Flow Patterns and Physical Contact

Flow fields around water intakes possess a number of hydraulic characteristics which fish may be able to detect. Large-scale (relative to body size) turbulence is recognized as a whole-body displacement, detected by labyrinthine receptors, while small-scale turbulence on the body surface is detected by the lateral line organ (Arnold, 1974).

The main turbulence around intakes will be in proximity to the structure itself, for example around screen bars, and in the downstream turbulent wake of an offshore intake structure located in a tidal cross-flow (Goldring, 1984). Since in the latter case, most of the water (and fish) entering the intake will arrive from the up-stream direction, the downstream wake is unlikely to be of use to them as a means of detecting the intake. Small-scale turbulence around structural components is therefore likely to be the main turbulent feature which fish detect.

It has been shown that fish can respond to shearing surfaces in the water (Bainbridge, 1975). The normal response is for the fish to turn into a higher velocity flow when passing through a shearing surface. It is not expected that discrete shearing surfaces would be a deliberate design feature of the water intakes, though velocity gradients perpendicular to the streamlines do occur and will be evident for example across the intake screen surface at an offshore intake (Fig. 7). In theory, at least, this should elicit a rheotropic response causing the fish to swim head upstream, aligned parallel to the streamlines. This behaviour would ensure that they were facing an appropriate direction for escape when they reached the structure. In the absence of any other stimuli, a fish so aligned may attempt to escape as its tail touches the screen bars or some other part of the structure, or it encounters small-scale turbulence associated with these components. The proportion of fish making contact in this way will depend on bar width and will be higher for larger bar widths and smaller spacings.

Louvre Screens

The sensitivity of fish to shearing surfaces is utilized in a mechnical screen known as the 'louvre screen'. The louvre screen consists of a horizontal array of vertical slats and flow straighteners set at an angle to the water flow like a venetian blind on edge (Fig. 9). As the flow strikes the louvres, eddy-currents are set up between the louvre elements. This enables the fish to orientate to the screen and pass along the screen face to the by-pass. Louvre screens were first devised in North America (Bates and Visonhaler, 1956), and have since been tested widely in experimental systems (Arnold, 1974; Environmental Protection Agency, 1976). Under optimal conditions, guiding efficiency is commonly >90%, whether in daylight or darkness, so that there is no requirement for illumination. The main parameters that vary are: louvre angle to flow, screen angle to flow, louvre spacing, number of flow straighteners, approach velocity, by-pass velocity and by-pass width. Too many variations of these parameters have been tested to list all here, but some details of experiments carried out in relation to Scottish hydro-electric developments in the 1960's (W.R. Munro, unpublished reports) will provide an illustration. These experiments used hatchery-reared salmonids and an experimental louvre array fitted into an aquaduct flume with the following parameter values:

Screen angle to flow:	12°
Louvre angle to flow:	90°
Louvre spacing:	5, 10 or 15 cm
Maximum approach velocity:	120 cm s^{-1}
By-pass velocity:	1.4 × approach velocity
By-pass width:	45 cm

Under these conditions, over 90% guiding efficiency was attained.

An important point to note is that the fish orientates itself perpendicular to the screen array and attempts to maintain a constant distance between itself and the barrier as it swims. The velocity at which it must swim to do this is therefore much lower than the approach velocity. In Fig. 9 this is shown by the vector diagram, where V_s is the approach velocity and V_f the fish's swimming velocity. V_f is given by ($V_s \tan \phi$), where ϕ is the screen angle. For example, for a maximum approach velocity of 120 cm s^{-1}, and a screen angle of 12°, the fish need only swim at a velocity of 26 cm s^{-1} in order to escape.

Despite demonstrations that louvre screens are effective for guiding fish without the need for supplementary lighting, very few louvre screens have been constructed for other than experimental purposes. A potential problem is the likelihood of weed and debris accummulation on the louvres which would impede the flow and impair fish guidance. The problem can be overcome by using horizontal or vertical travelling louvre screens (Ray et al., 1976) but these are costly and not amenable to all applications. The concept of louvre screening is adaptable to a variety of intake configurations including offshore marine intakes (Mussalli, Taft and Larsen, 1980) and aquaducts (Sonnichsen et al., 1973).

5.2 Light

The Importance of Light for Fish Exclusion.

Visual cues are pre-eminent in allowing fish to orientate to currents because of the wide variety of visual information usually available. The minimum threshold velocity for detection of water currents by fish using visual cues is about an order of magnitude lower than that for tactile cues (i.e. 'brushing' the sea bed or attached weed: Arnold, 1974).

The importance of light in enabling fish to escape from fishing gears is well known, and night fishing is frequently found to be more effective since visual escape cues are obscured (Roessler, 1965). For similar reasons fishing in turbid waters can be more successful than in clear waters (Murphy, 1959).

The role of visual cues in avoidance of water intakes by fish is indicated by the diurnal patterns of screen catch. Fig. 10 shows the averaged hourly index of catch measured on 41 dates at Sizewell Power Station, Suffolk and indicates that peak catches occurred at night. Van den Broek (1979) reports fish catch rates 1.5 times higher at night than in daylight at Kingsnorth Power Station, Kent. Similar observations are recorded by Grimes (1975) in the USA and Hadderingh (1982) in the Netherlands. Hadderingh states that fish lost orientation at light intensities < 300 lux (surface measurement) and that fish impingement increased below this.

At Dungeness 'A' Power Station in Kent, Turnpenny and Utting (1980) showed that the catch of sprats increased severalfold after dark with an increase in the mean size of fish. This was interpreted to be the result of larger fish being able to see and avoid the intake by day but not by night. Smaller fish, on the other hand, although they could see the intake by day could not swim fast enough to escape.

It is noteworthy that no nocturnal increase in fish catch has been found at Fawley Power Station, Hampshire (Langford, Utting and Holmes, 1977). This site has an onshore canalized intake with overhead safety lights, which presumably enable fish to orientate to the intake at night.

For similar reasons, turbidity appears to affect catches, although there is no quantitative documentary evidence of this. At a number of UK power stations investigated by CERL, catches have been found to increase following stormy weather, most probably as a result of fish becoming disorientated by the increased turbidity. Continuously high turbidity levels in the Severn Estuary around Hinkley Point Power Station (range 152-1432 mg l^{-1} solids: R.J. Aston and A.G.P. Milner, pers. comm.) probably account for the lack of any discernible diurnal pattern in the fish catch (P.A. Henderson and R.H.A. Holmes, pers. comm.), since the intake is obscured by suspended particles throughout the 24 hour period. In such situations it is unlikely that lowering the approach velocity, would be of any benefit to fish unless additional warning signals were provided.

Artificial Light

Langford (1983) reviewed experience of using artificial light to control fish ingress. Reactions of fish are mixed (attraction or repulsion) depending on species and lighting conditions. Hadderingh (1982) for example successfully used arrays of surface and underwater lights at Bergum power station to reduce fish entry and by a combination of negative phototaxis (repulsion) and increased visual orientation. Some species were attracted, a finding which is not unexpected since artificial light is widely used in commercial fishing to draw fish towards nets (Ben-Yami, 1976). Other researchers have attempted to use the phototactic response to guide fish towards fish rescue systems (Haymes, Patrick and Onisto, 1984) or away from intakes. A CEGB scheme to exclude sprats from Dungeness 'A' Power Station relied on this principle, but was unsuccessful (N. Robinson, T. Wickett, pers. comm.), and the approach in general is unpredictable because of the ambivalent reactions of fish to light.

A method which appears more promising is use of artificial light to make the intake visible to fish. At power stations where there is a marked nocturnal increase in fish catch, this should act to reduce catches to daylight levels. The light level employed is critical. It should be adequate to make the intake visible under all turbidity conditions at a distance of a few metres from the intake bars, while at the same time not attracting additional fish into the danger zone. This can be achieved most effectively by lighting the intake structure from within so that the bar elements are silhouetted. Under these conditions, dark adapted fish of a number of species have been shown to elicit an optomotor response at light levels above 10^{-3} lux (Pavlov, 1970). However higher light levels may be necessary to compete with background illuminance, and the levels required would have to be determined experimentally according to local circumstances.

An elaboration of this approach has been investigated by Patrick (1980, 1981, 1983) who used a combination of physical diversion barriers (ropes, chains, nets) and artificial lighting to exclude fish in a simulated intake system. He found that white strobe light, with a flash frequency >200 flashes/minutes, was more effective for fish exclusion than continuous illumination. Apparently the flashing light disturbed fish and caused them to stay away from its source, as well as illuminating the physical barrier. The rapid discharge characteristics of strobe light (flash duration ~60 μs) make it more effective as a fish deterrent than flashing incandescent or metal halide lamps. It was not intended that the barrier should act as a direct physical restraint to fish, but that exclusion should be a visual response. With no light, the barrier was ineffective, and a light level of approximately 10 lux at the barrier was required to ensure that it would be visible under turbid conditions with the light source placed behind the barrier. The visual characteristics of the barrier were also shown to be important, the most effective design comprising vertical elements (chains) and horizontal elements (nylon ropes) at 15 cm spacings, with the diameter of the elements >3 cm. A pre-requisite for such a system to be effective is that the approach velocity should be within the fish's sustainable swimming speed range, in Patrick's experiments, values <32 cm s^{-1} being used.

Micheletti (1987) has recently reported on tests using strobe lights (200 flashes/min) at CW intakes in the USA. Success varied with species, but up to 56% reduction in fish ingress was recorded.

To summarize, artificial light can be used to supplement natural light, allowing fish to determine visually their approach towards an intake. Best results are obtained if the light source is placed behind a bar structure, the latter preferably with vertical and horizontal components at ∿15 cm spacings. The problem of fish attraction towards the light source can be eliminated by using a white strobe light with a flash rate of >200 flashes/minute. Patrick (1983) also found no evidence of fish becoming habituated to strobe light.

There will be practical difficulties in maintaining an artificial lighting system at a marine intake structure. Perhaps the best solution would be to use powerful overhead lighting and to rely on particle scattering to produce even illumination. Such a system could possibly be mounted within non-submerged offshore intake structure. Alternatively, an overhead light source feeding a light guide dipped into the water might be feasible, provided that suitable provision was made for antifouling and cleaning.

5.3 Sound

Orientation to Sounds

Sound may also cause a fish to react to a water intake. Although sound generally does not appear to be an important source of information for orientation to currents (Arnold, 1974), fish do have a directional hearing capability (Blaxter, Gray and Denton, 1981) and thus should be able to detect their movement relative to a looming point source of sound.

Hearing in fish utilizes two separate sensory channels. Low frequency sounds (5-25 Hz) are detected by the lateral line and higher frequencies (up to 13000 Hz) by the auditory labyrinth. For most species, maximum sensitivity is in the range from a few hundred to one or two thousand Hz (Hawkins, 1973). It is not possible at present to assess the importance of sound as either a sensory cue or a deterrent at cooling water intakes. Undoubtably machinery noise, particularly from pumps and moving parts in direct contact with the cooling water system will be transmitted via the inlet culvert to an offshore intake structure, but the frequencies and sound levels involved have not been measured. Furthermore, it is not possible to infer from catch statistics any effects due to these sounds since changes in sound levels are most likely to stem from variations in the pumping rate which, irrespective of noise level will markedly affect catch. Loeffelman (1987) reported that fish were repelled from the intake of a bulb-type hydro-electric turbine by the noise it produced. In a bulb turbine the generating unit is located underwater in the turbine draft tube, which acts like a megaphone. The main frequencies were in the range 80-800 Hz, i.e. at the optimum sensitivity of most fish, and the sound levels were as high as 197 dB (3697×10^{-7} watts cm^{-2}) close to the intake. This was clearly a phonotactic and not a rheotactic response.

Using Sound to Repel Fish

Several workers have investigated the use of artificial underwater sound to keep fish away from intakes. Records of killer whales and rock music played through underwater loudspeakers failed to elicit a startle response in fish. However, sounds with an associated shock wave were effective, for example, a wooden mallet struck on a submerged plank of wood or metal, or pneumatic 'poppers' of the type used in underwater seismic exploration. Poppers were used in short term tests at Redondo Beach Power Station (southern California), operated at a frequency of 6-12 cycles min^{-1}. Fish were repelled immediately and remained at a distance from the intake throughout a 3 h test period (Schuler and Larson, 1975). More protracted tests at two power stations over a two year period gave a 73-78% reduction of alewife, though there was less success with other species (Micheletti, 1987).

Loeffelman (1987) has proposed playing back recorded sounds from bulb turbines through underwater loudspeakers to deter fish from intakes. A powerful sound system would be required to reproduce sound levels found at actual turbine inlets.

As with lights, there will be practical difficulties, due to fouling, corrosion and wave action, with maintenance of any such system at a marine intake, particularly one located offshore. Some sort of pneumatic or electromagnetic device mounted within the intake structure with only a conduit in contact with the water might be more feasible than a system employing underwater transducers. This could be particularly effective against sprat and herring which belong to the same family as alewife (Clupeidae) and which have been shown to be capable of a directional startle response (Blaxter, Gray and Denton, 1981).

6. FISH ATTRACTANT PROPERTIES OF INTAKE STRUCTURES

Any sizeable structure projecting from the sea bed will serve to attract certain types of fish. The reasons for this are complex and the accumulation of fish around such structures may be related to a need to shelter from predators or tidal currents, or to take advantage of food resources around or attached to the structures. Some offshore intakes possess features akin to purpose-built artificial reefs. Just as cooling water intakes should be designed as the antithesis of a fishing gear, so the intake structure should be designed as the antithesis of an artificial reef.

A number of concepts can be found in artificial reef design. One is simply to simulate a natural rock reef by dumping rock, broken concrete or similar (Fig. 11b) which provides a substrate for settlement and crevices for invertebrates and fish. Reefs of this type tend to develop naturalistic communities and increase of fish productivity (Wilson, Togstad, Lewis and McKee, 1987). Another type of reef uses large open cage structures of wood, plastic, steel or concrete with a minimum of material occupying a maximum volume (Fig. 11a). Reefs of this kind are perhaps more important for shelter than for food (Ogawa, 1978). Redundant oil platforms are being used for this purpose.

It will be clear from this that offshore intake structures often embody characteristics of both of these kinds of reef. Schuler and Larson (1975) comment that the boulder rip-rap around the Redondo Beach Power Station intake and the structure itself, act as an artificial reef. This too will apply to many of the offshore intakes in the UK, where the practice has been to use boulder rip-rap around the base of the structure, and a latticed-girder super-structure to support navigation lights, cranes and maintenance equipment. An example is shown in Fig. 11c, where the similarities with purpose built fish reefs can be seen.

The fish attractant effects of an offshore intake structure can probably never entirely be overcome. In general, the engineer should attempt to minimize superstructure as far as possible, to simplify the number of structural elements, to keep surface area for colonisation to a minimum and eliminate as far as possible holes and crevices. Wake-eddies have been shown to be important for fish shelter, and therefore, streamlining elements of the structure may help to minimize available shelter. The vertical relief from the sea bed has also been shown to be significant; high structures accumulate more fish.

7. CONCLUSIONS

(1) At most sites, fish entry into water intakes is not a serious hazard to plant operation nor a threat to the fish stocks themselves. Therefore, the cost and effort devoted to fish protection in intake design and siting should be commensurate with the magnitude of the problem. By providing an understanding of the causes of fish ingress and the principles of fish exclusion, it is hoped that (a) design pitfalls may be avoided without necessarily incurring higher costs and, (b) where improved fish protection is essential the means of providing this will be more apparent. Any such measures should not be allowed to conflict with requirements to exclude weed and prevent siltation.

(2) The main requirements for fish exclusion from water intakes are summarized by three key words: detection, velocity, and direction.

Fish must be able to detect its approach to an intake if it is going to be able to react to escape.

The velocity of the water entering the intake must be low enough at the point of reaction for the fish to be able to escape.

The direction of water flow must be horizontal as fish are not good at escaping from a vertical draw-down.

All three of these requirements must be met simultaneously if fish are to escape.

(3) Detection of Intakes Intakes normally are detected visually. If the light level is low or the turbidity high, fish catch increases. Artificial light has been used successfully to improve detection of intakes by fish, but it can attract some species if strong illumination is used. Experimental evidence suggests that strobe lights can be used to illuminate intakes, whilst at the same time repelling fish. These are most effective if placed on the downstream side of an intake screen so as to silhouette

the bar elements. Low frequency pulsed sound, such as emitted by an acoustic 'popper', or a rumble such as produced by bulb turbine machinery, also shows some promise. Further work on the engineering practicability of operating either of these systems in a hostile marine environment is required. Louvre screens, which depend on hydraulic stimuli, can be used to deflect fish, and are effective in light or dark conditions.

(4) Approach Velocities The swimming capabilities of fish vary with species, size and water temperature. Because the fish at risk differ from site to site and also seasonally, it would be counter-productive to specify a standard intake approach velocity. Instead, the design velocity should be tailored to the species identified locally as being the greatest threat (to plant operations) or most at risk. Although swimming performance data presented in this Report are not exhaustive, they should be adequate for most needs. In calculating approach velocities, velocity components normal to the screen or trash-rack should be used.

(5) Flow Patterns around Intakes A capped intake converts a vertical drawdown into a horizontal water flow. Physical and mathematical models have been used successfully to model three-dimensional flow patterns around intakes. These will be useful in future to ensure that (a) flow is maintained in a horizontal direction and (b) that maximum velocities are kept below target requirements all around the intake structure in tidal crossflows. Where the velocity of the tidal crossflow precludes use of a 360° intake opening, side-entry intakes may have to be used.

(6) Fish Attraction Consideration must be given to the fish-attractant properties of the intake structure. All offshore structures will intrinsically tend to attract fish, but this can be minimised by simplifying the super-structure and keeping the area of rip-rap to the minimum required to prevent erosion.

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Tables 1-3, Drg. No. RL8.2.318-341 attached.

Table 1: Species of Fish Commonly Captured on Intake Screens at British Coastal Power Stations

Family	Species	Common Name
Clupeidae	Sprattus sprattus Clupea harengus	Sprat Herring
Gadidae	Gadus morhua Merlangius merlangus Trisopterus luscus Trisopterus minutus	Cod Whiting Pout Poor Cod
Pleuronectidae	Pleuronectes platessa Platichthys flesus Limanda limanda	Plaice Flounder Dab
Soleidae	Solea vulgaris	Sole
Serranidae	Dicentrarchus labrax	Bass
Mugiladae	Liza auratus Crenimugil labrosus	Grey Mullets
Atherinidae	Atherina boyeri	Sand Smelt

Table 2: Swimming Speed Coefficients for Selected Fish Species

U_{crit} is calculated from Equation (7).
References indicate data sources used to compute the coefficients.

Species	Coefficients a	b	n	Source Reference
Sprat, Herring	9.3	0.58	285	Turnpenny, 1983; Blaxter and Hunter, 1982
Cod, Whiting, Pout, Poor Cod	3.8	0.56	170	Turnpenny, 1984
Plaice, Flounder, Dab, Sole	3.8	0.56 *		Wardle, 1976, Beamish, 1966
Bass	6.2	0.82	56	Turnpenny, 1980 + unpublished
Grey Mullets	6.2	0.82	67	Turnpenny, 1980 + unpublished
Sand Smelt	5.0	0.55	166	Turnpenny and Bamber, 1983
Salmon	8.0	0.32	35	Brett, 1967

n = number of experimental observations.

* = gadoid values assumed

Table 3: Maximum Approach Velocities Which Will Enable Fish to Escape at Different Water Temperature

	Age Group 0 and Older				Min. Length	Age Group 1 and Older			
Temp °C	2.5	7.5	12.5	17.5	Age 1	2.5	7.5	12.5	17.5
Species	$cm\ s^{-1}$				cm	$cm\ s^{-1}$			
Sprat	30	40	50	60	8	50	64	78	92
Herring	30	40	50	60	12	50	65	80	94
Cod	15	30	40	55	15	30	52	74	95
Whiting	10	25	40	50	15	35	55	79	102
Pout	8	15	20	29	20	34	60	83	105
Poor Cod	10	25	35	50	10	26	40	59	73
Plaice	8	15	20	30	8	28	48	67	92
Flounder	10	20	30	40	12	28	46	66	86
Dab	2	10	20	26	10	12	23	34	46
Sole	5	15	20	30	11	22	40	57	72
Bass	20	35	50	66	9	37	59	83	109
Grey Mullets	20	35	50	60	10	30	50	69	89
Sand Smelt	10	20	30	40	7	24	40	53	70
	Age Group 1 and older					Age Group 2 and older			
Salmon Smolts	45	60	70	80	15	55	68	79	91

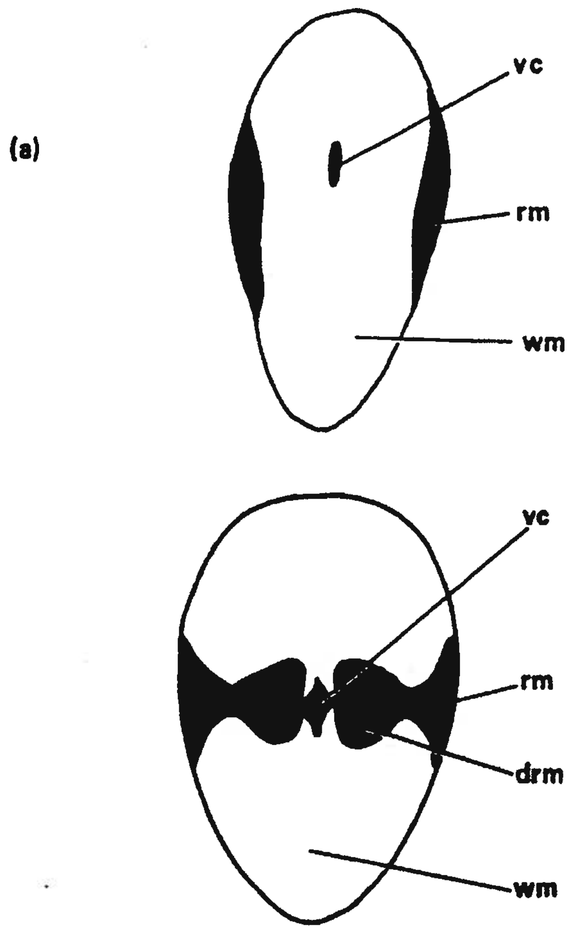


FIG. 1 FISH CROSS SECTIONS SHOWING THE DISTRIBUTION OF RED AND WHITE MUSCLE FIBRES:

(a) A CLUPEID – THE ANCHOVY, *ENGRAULIS MORDAX* (AFTER GREER WALKER, HORWOOD & EMERSON, 1980);

(b) A SCOMBRID – THE SKIPJACK TUNA, *KATSUWONUS PELANRIS* (AFTER REYNER & KEENAN, 1967)

vc = VERTEBRAL COLUMN, wm = WHITE MUSCLE
rm = RED MUSCLE, drm = DEEP RED MUSCLE

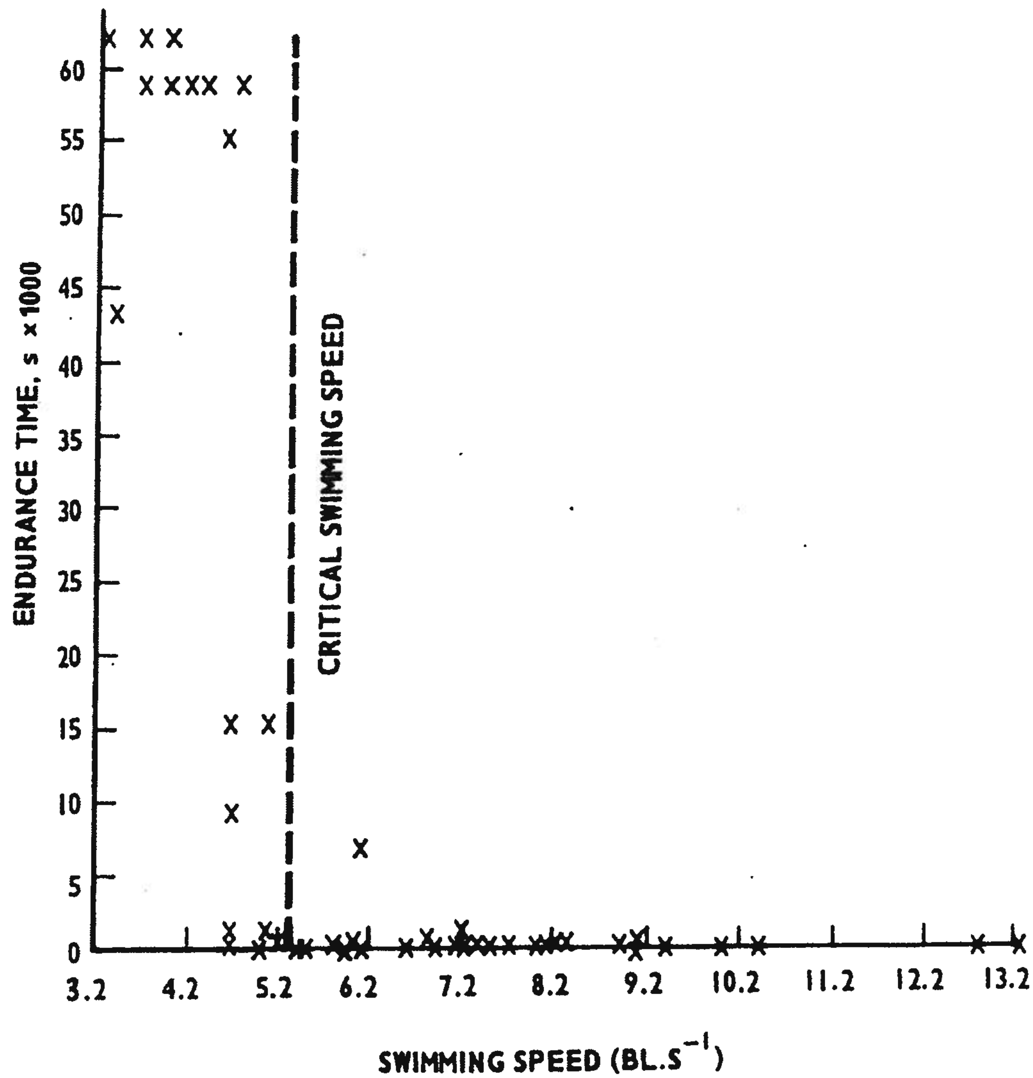


FIG. 2 COMPARISON OF FIXED VELOCITY AND INCREMENTAL SWIMMING SPEED TESTS FOR DETERMINING MAXIMUM SUSTAINABLE SPEED

VERTICAL BROKEN LINE INDICATES MEDIAN CRITICAL SWIMMING SPEED DETERMINED BY THE INCREMENTAL METHOD: POINTS INDICATE ENDURANCE TIMES OF INDIVIDUAL FISH AT DIFFERENT FIXED VELOCITIES. DATA FOR O-GROUP SAND-SMELT AT 11.4°C.

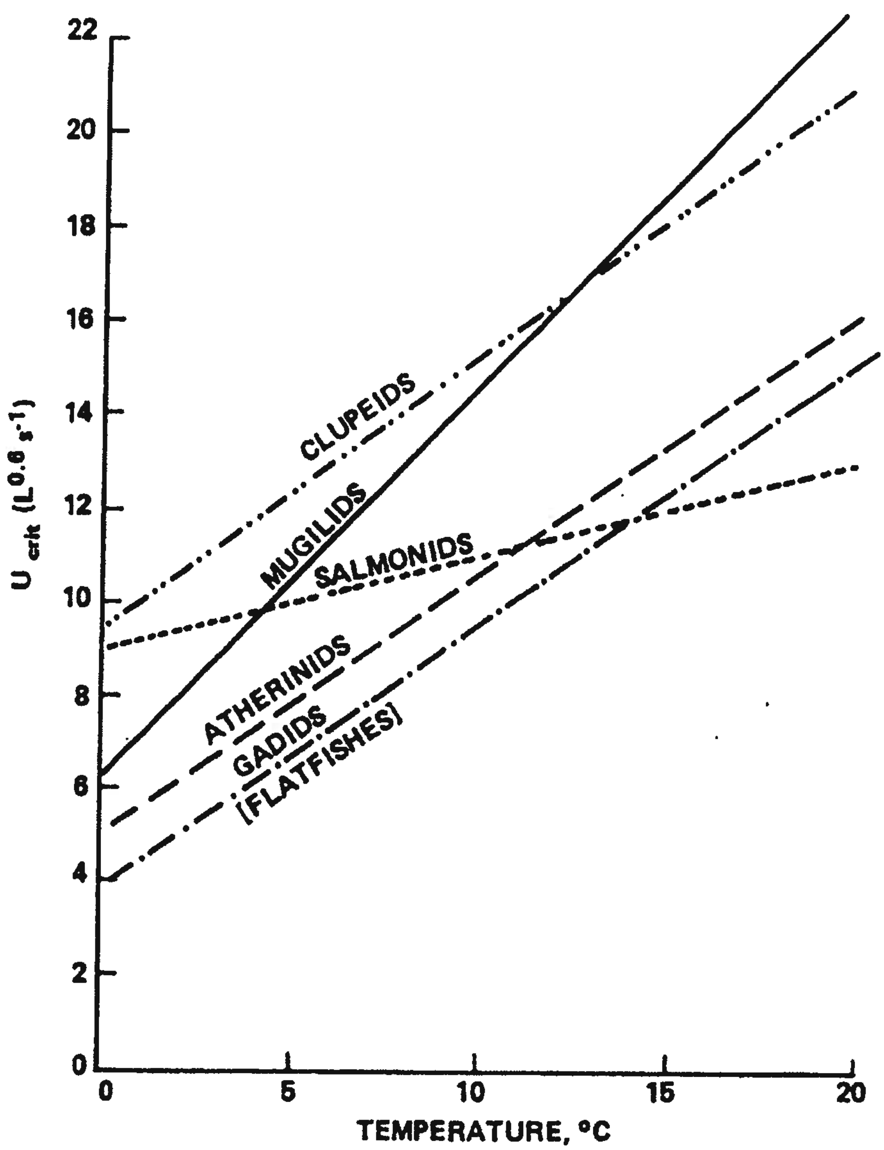
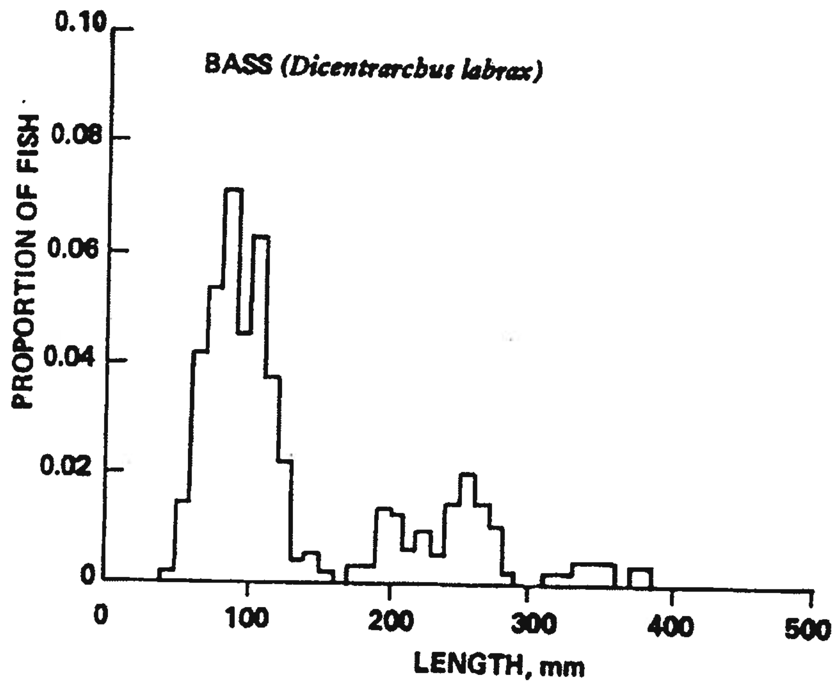


FIG. 3 SWIMMING SPEEDS IN RELATION TO BODY LENGTH AND WATER TEMPERATURE FOR VARIOUS GROUPS OF FISH (SEE TABLE 2 FOR SOURCES OF DATA)



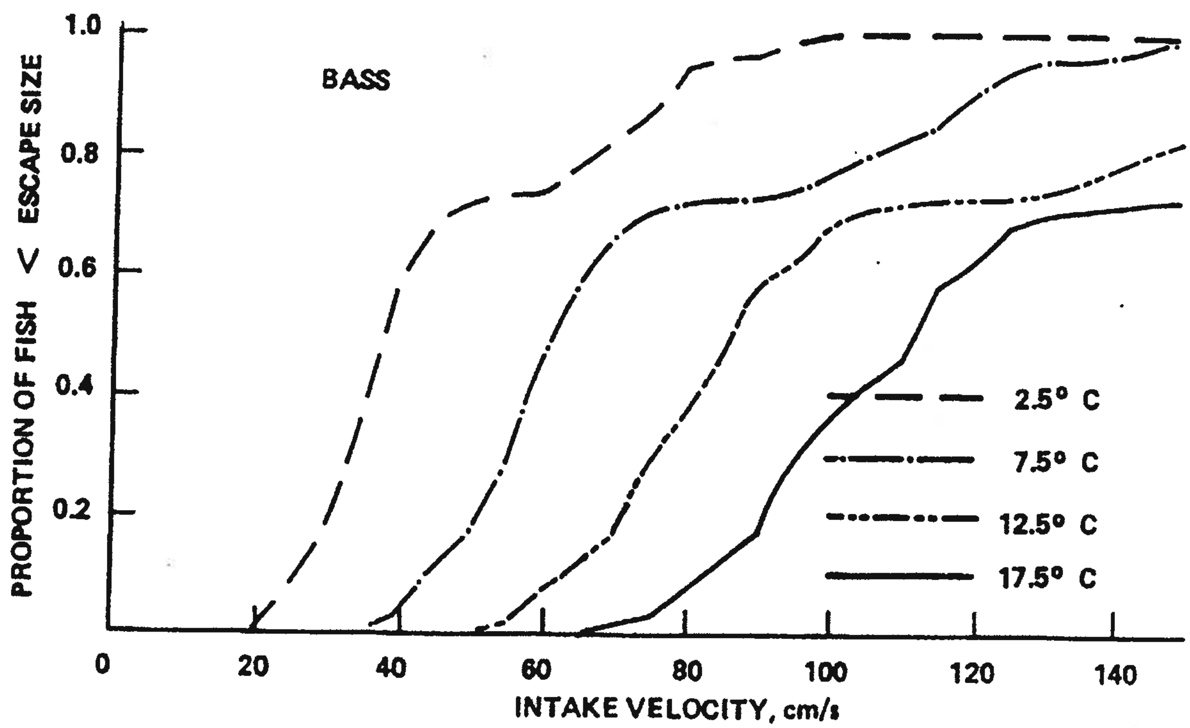
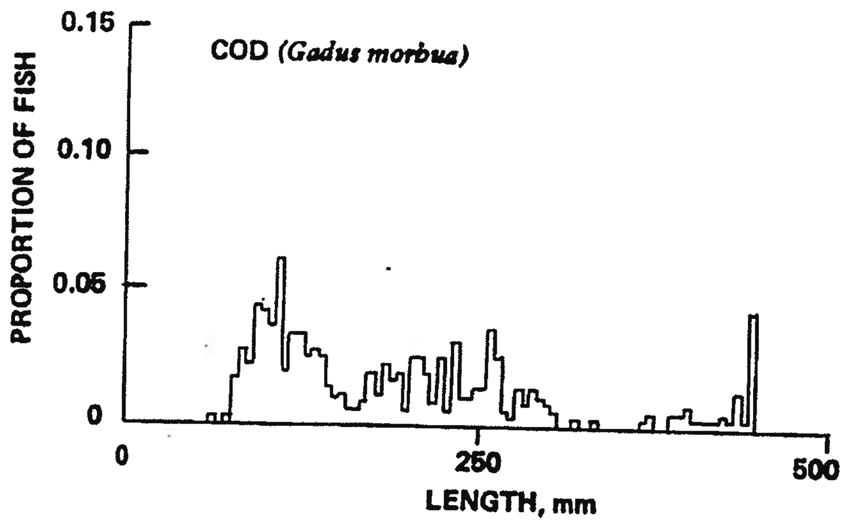


FIG. 4(a) CURVES DEPICTING THE PROPORTION OF FISH TOO SMALL TO ESCAPE FROM WATER INTAKES, IN RELATION TO WATER VELOCITY AT DIFFERENT WATER TEMPERATURES. The upper histogram shows the fish length distribution on which the curves have been calculated



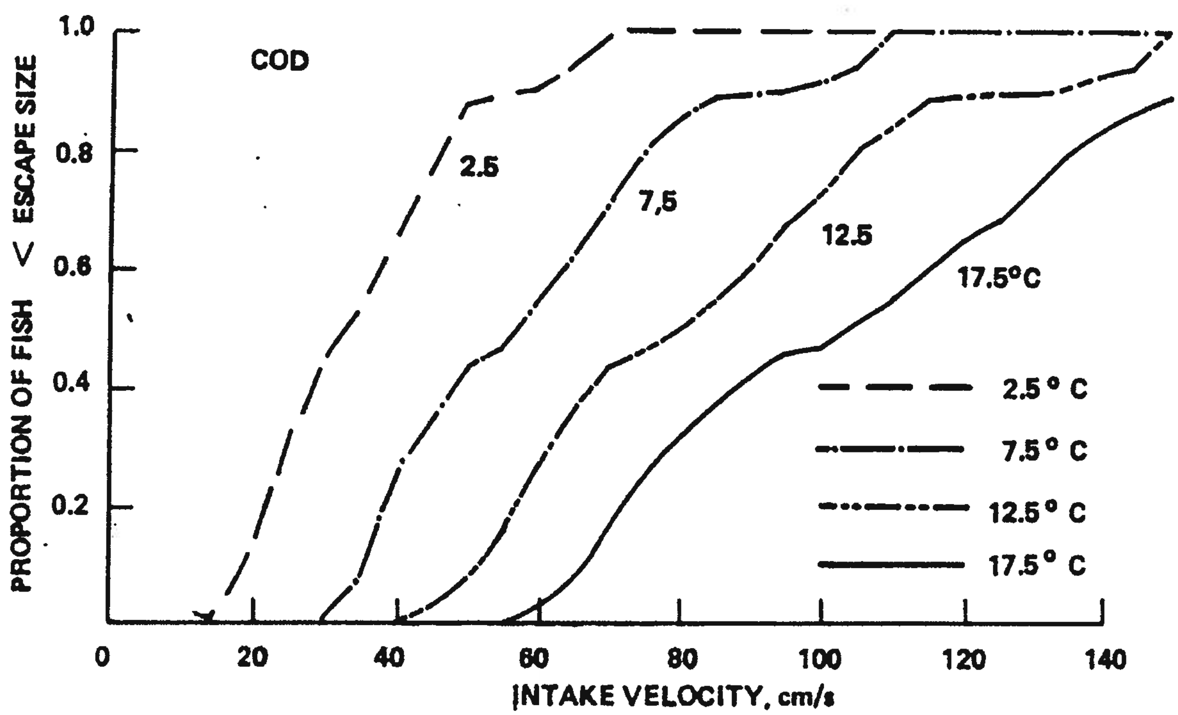


FIG.4(b) CURVES DEPICTING THE PROPORTION OF FISH TOO SMALL TO ESCAPE FROM WATER INTAKES, IN RELATION TO WATER VELOCITY AT DIFFERENT WATER TEMPERATURES. The upper histogram shows the fish length distribution on which the curves have been calculated

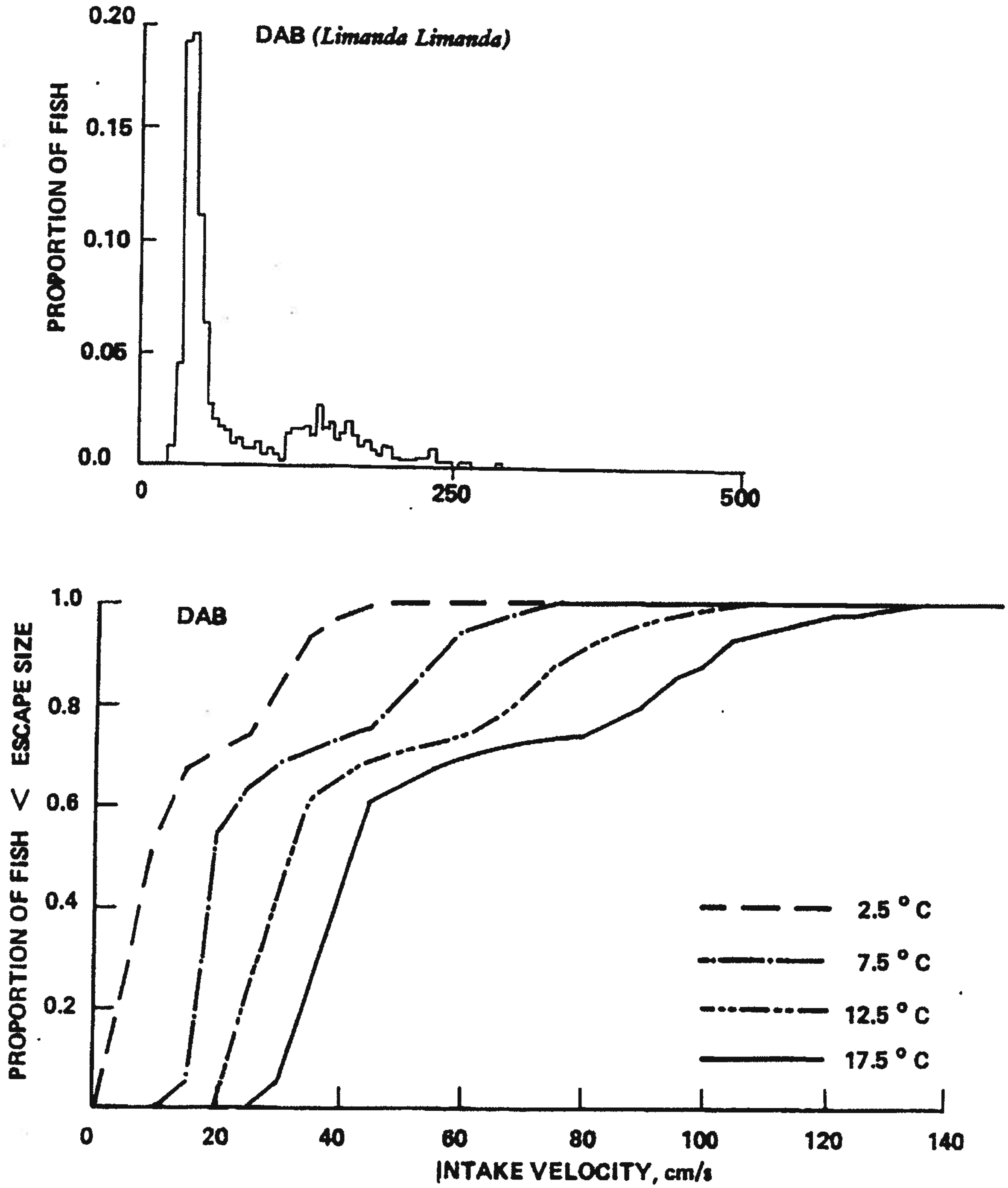
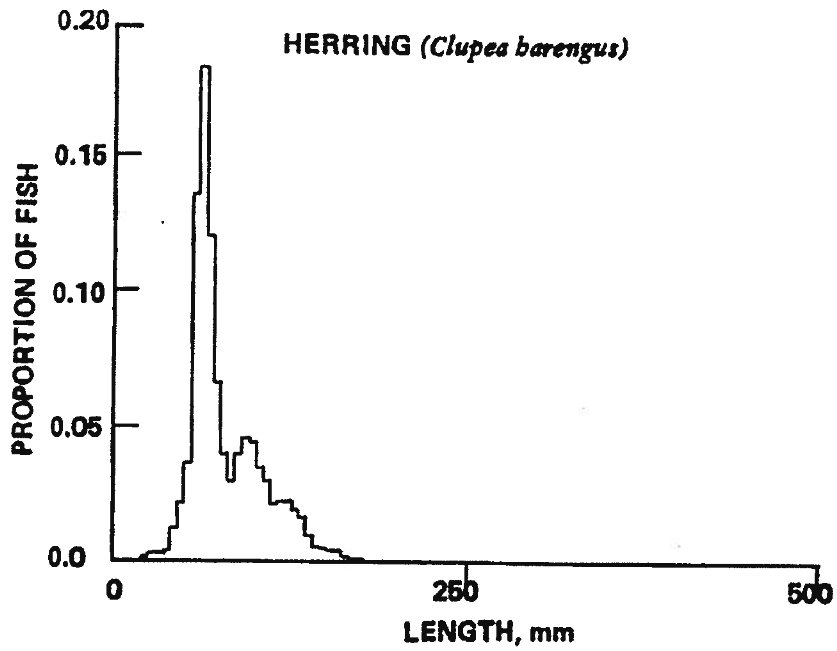


FIG. 4(c) CURVES DEPICTING THE PROPORTION OF FISH TOO SMALL TO ESCAPE FROM WATER INTAKES, IN RELATION TO WATER VELOCITY AT DIFFERENT WATER TEMPERATURES. The upper histogram shows the fish length distribution on which the curves have been calculated



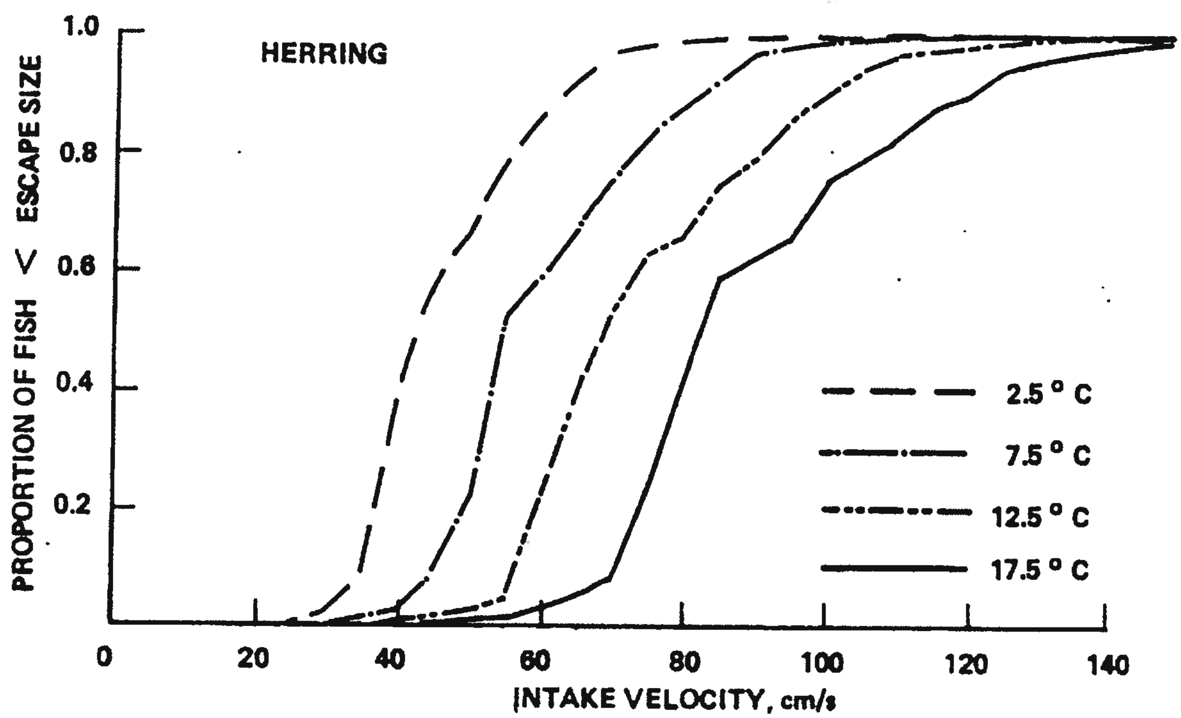


FIG. 4(d) CURVES DEPICTING THE PROPORTION OF FISH TOO SMALL TO ESCAPE FROM WATER INTAKES, IN RELATION TO WATER VELOCITY AT DIFFERENT WATER TEMPERATURES. The upper histogram shows the fish length distribution on which the curves have been calculated

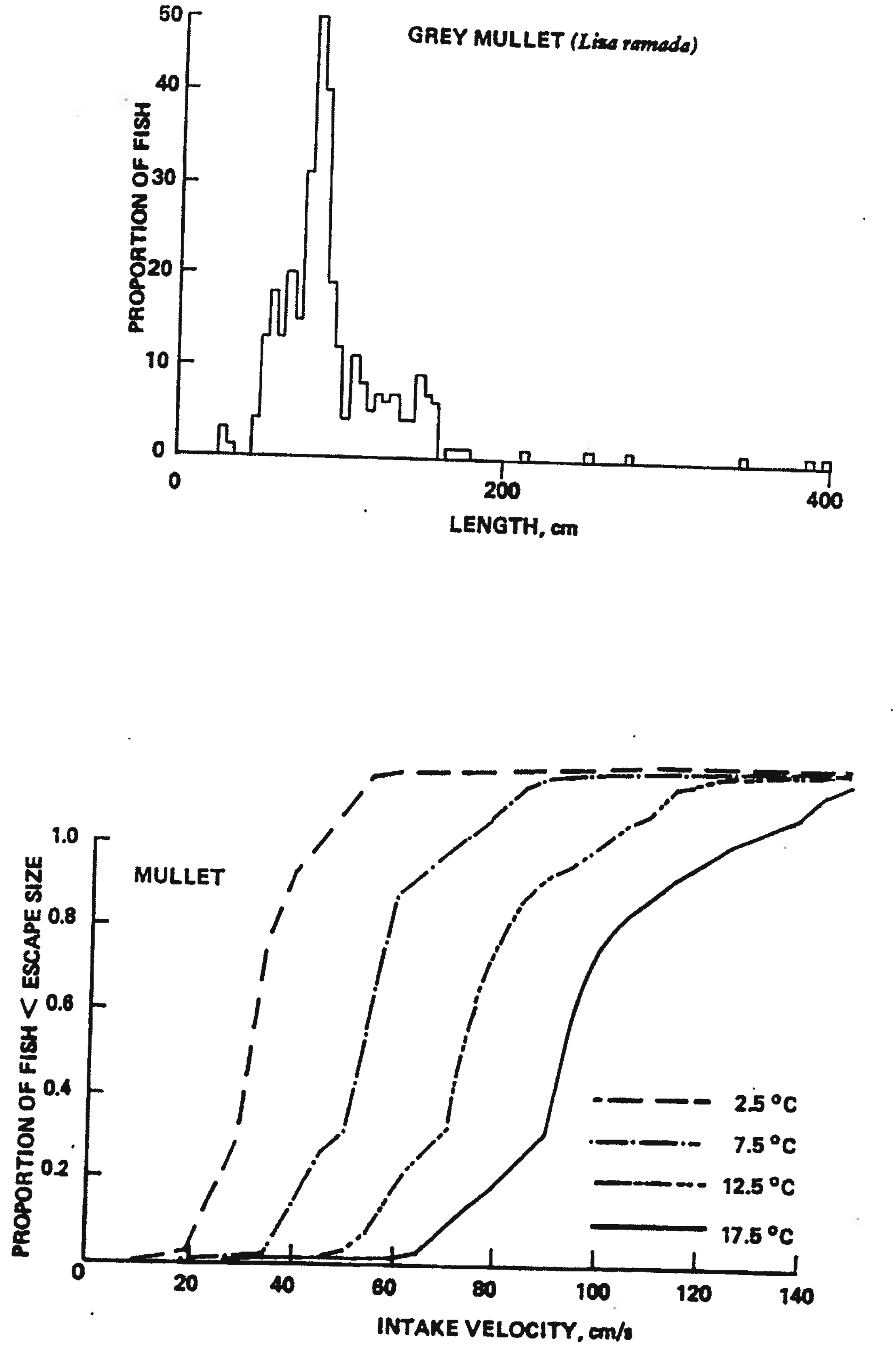
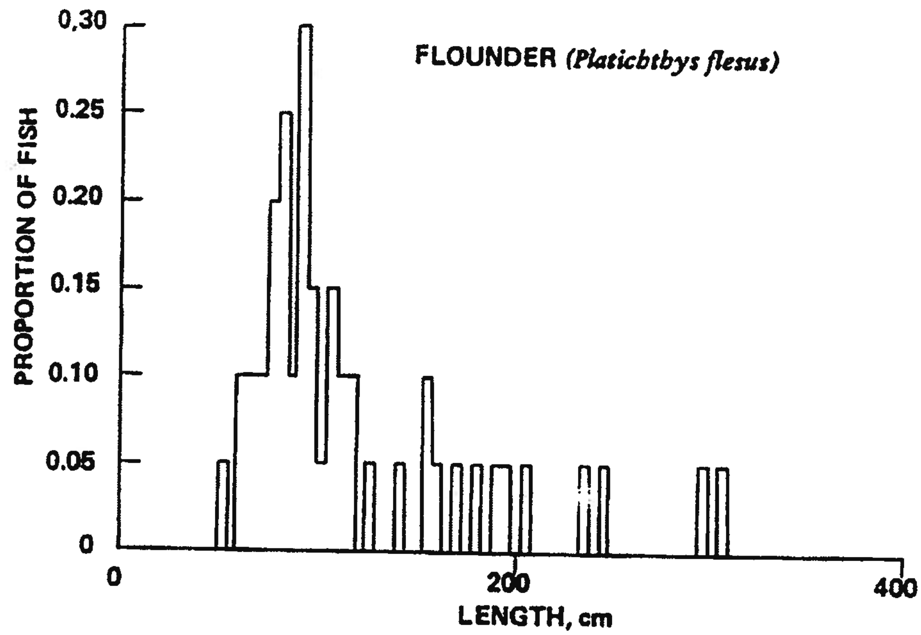


FIG. 4(e) CURVES DEPICTING THE PROPORTION OF FISH TOO SMALL TO ESCAPE FROM WATER INTAKES, IN RELATION TO WATER VELOCITY AT DIFFERENT WATER TEMPERATURES. The upper histogram shows the fish length distribution on which the curves have been calculated.



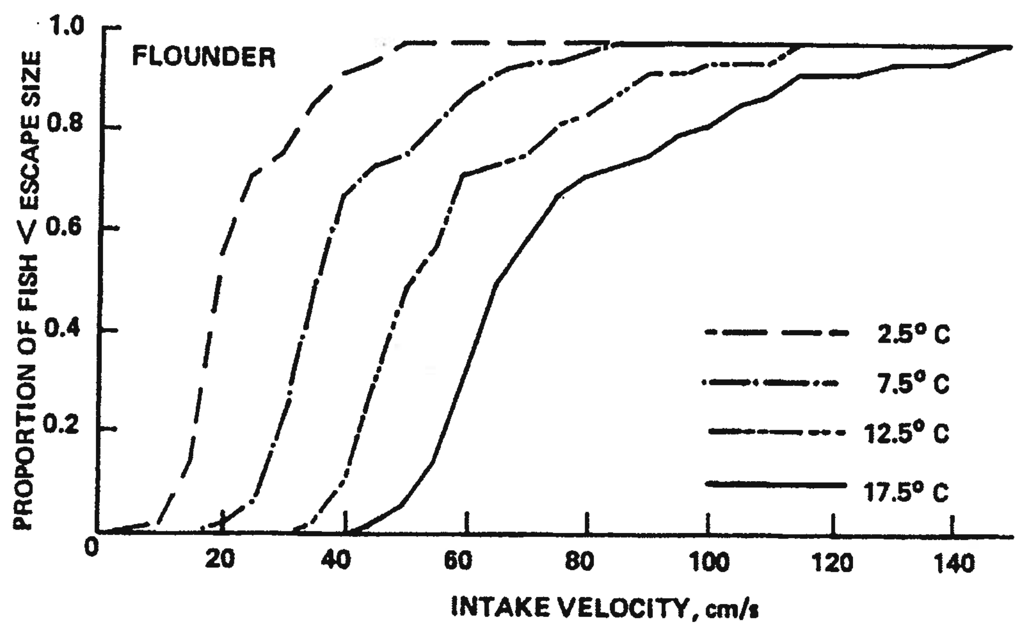
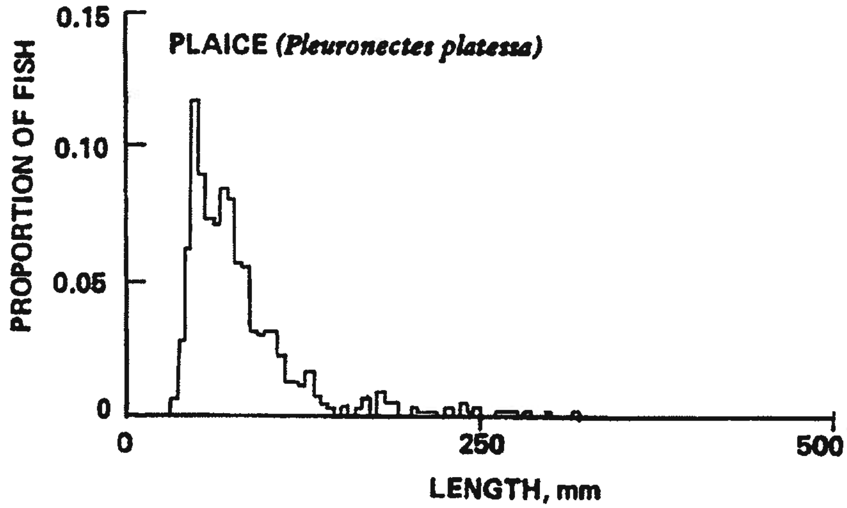


FIG. 4(f) CURVES DEPICTING THE PROPORTION OF FISH TOO SMALL TO ESCAPE FROM WATER INTAKES, IN RELATION TO WATER VELOCITY AT DIFFERENT WATER TEMPERATURES. The upper histogram shows the fish length distribution on which the curves have been calculated.



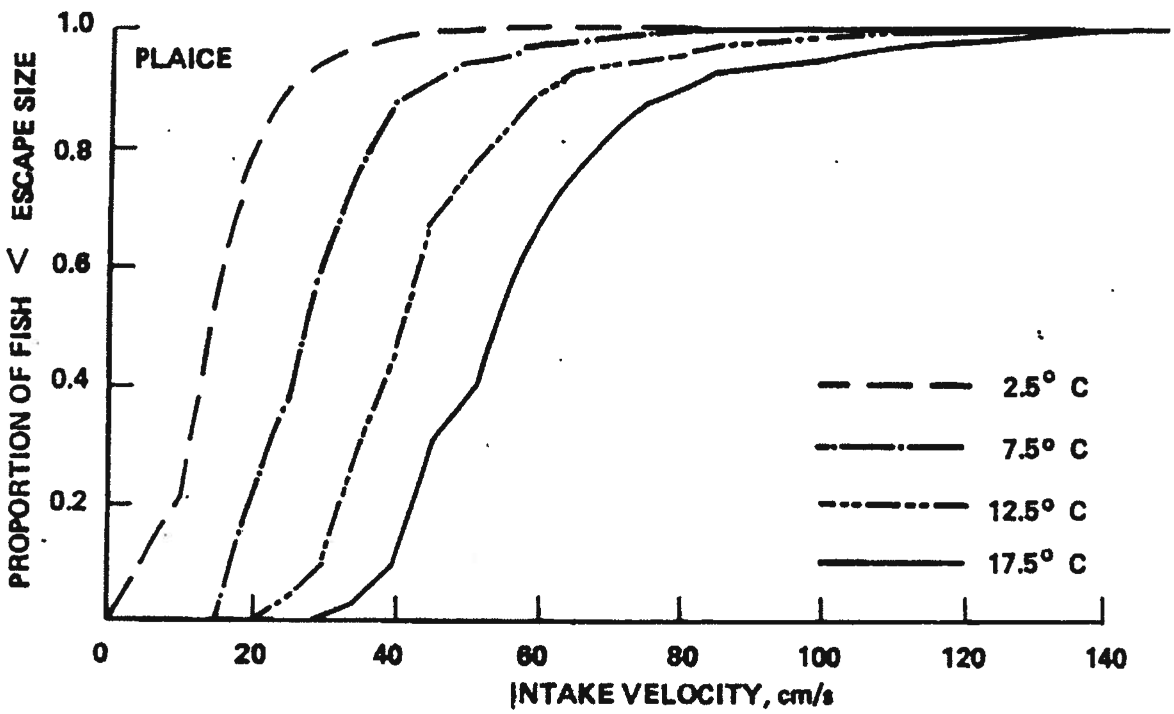
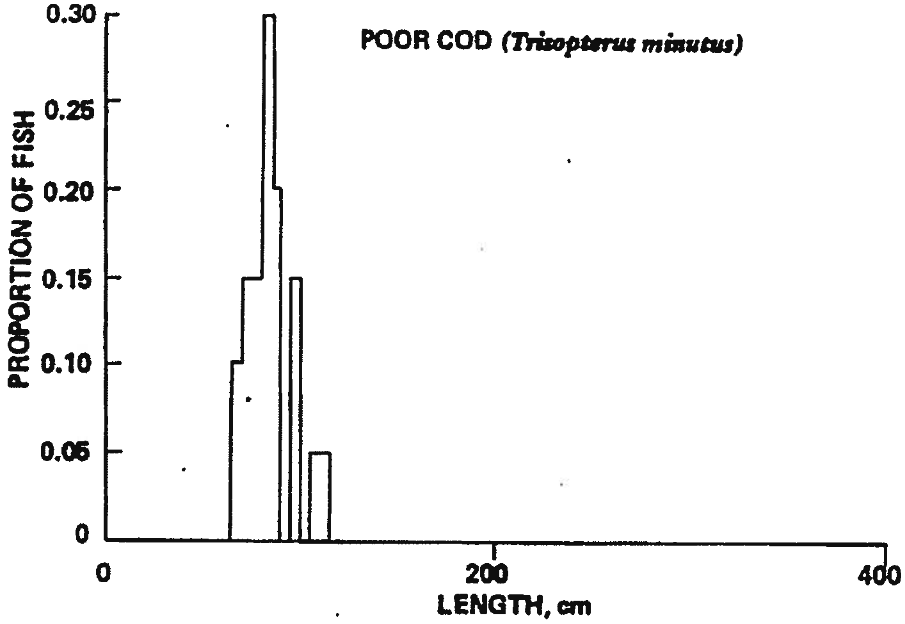


FIG. 4(g) CURVES DEPICTING THE PROPORTION OF FISH TOO SMALL TO ESCAPE FROM WATER INTAKES, IN RELATION TO WATER VELOCITY AT DIFFERENT WATER TEMPERATURES. The upper histogram shows the fish length distribution on which the curves have been calculated



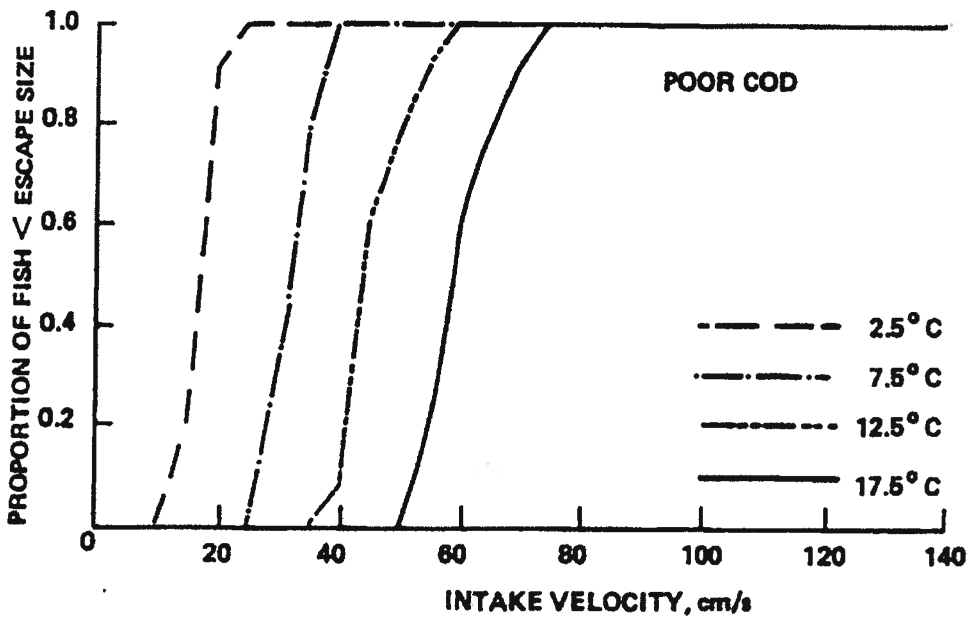
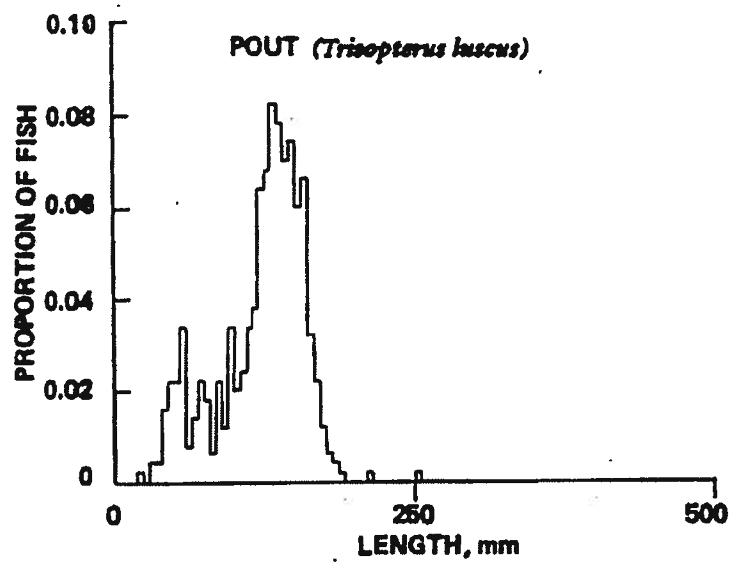


FIG. 4(h) CURVES DEPICTING THE PROPORTION OF FISH TOO SMALL TO ESCAPE FROM WATER INTAKES, IN RELATION TO WATER VELOCITY AT DIFFERENT WATER TEMPERATURES. The upper histogram shows the fish length distribution on which the curves have been calculated.



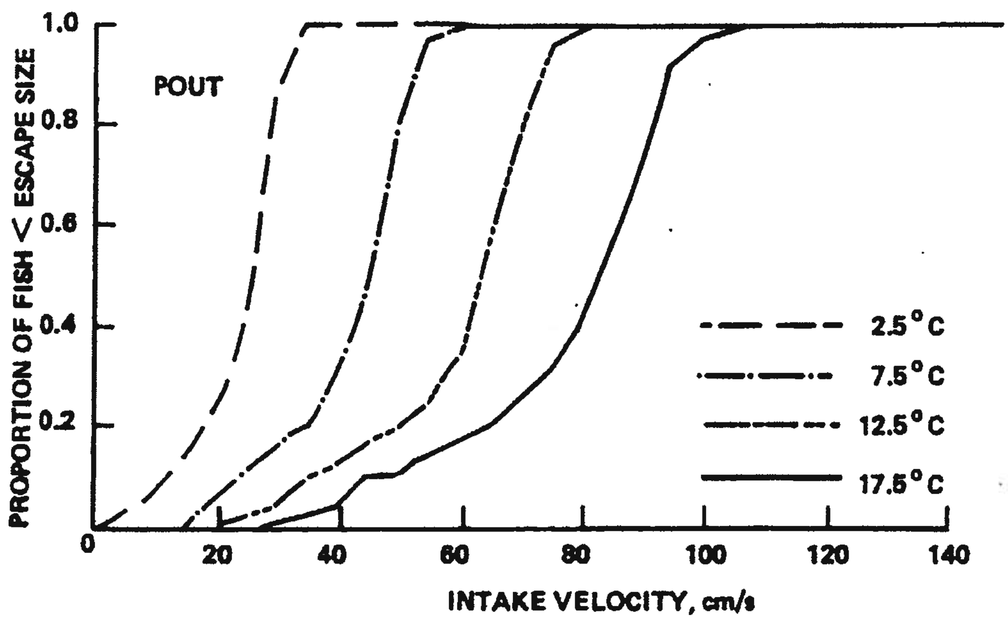


FIG. 4(i) CURVES DEPICTING THE PROPORTION OF FISH TOO SMALL TO ESCAPE FROM WATER INTAKES, IN RELATION TO WATER VELOCITY AT DIFFERENT WATER TEMPERATURES. The upper histogram shows the fish length distribution on which the curves have been calculated.

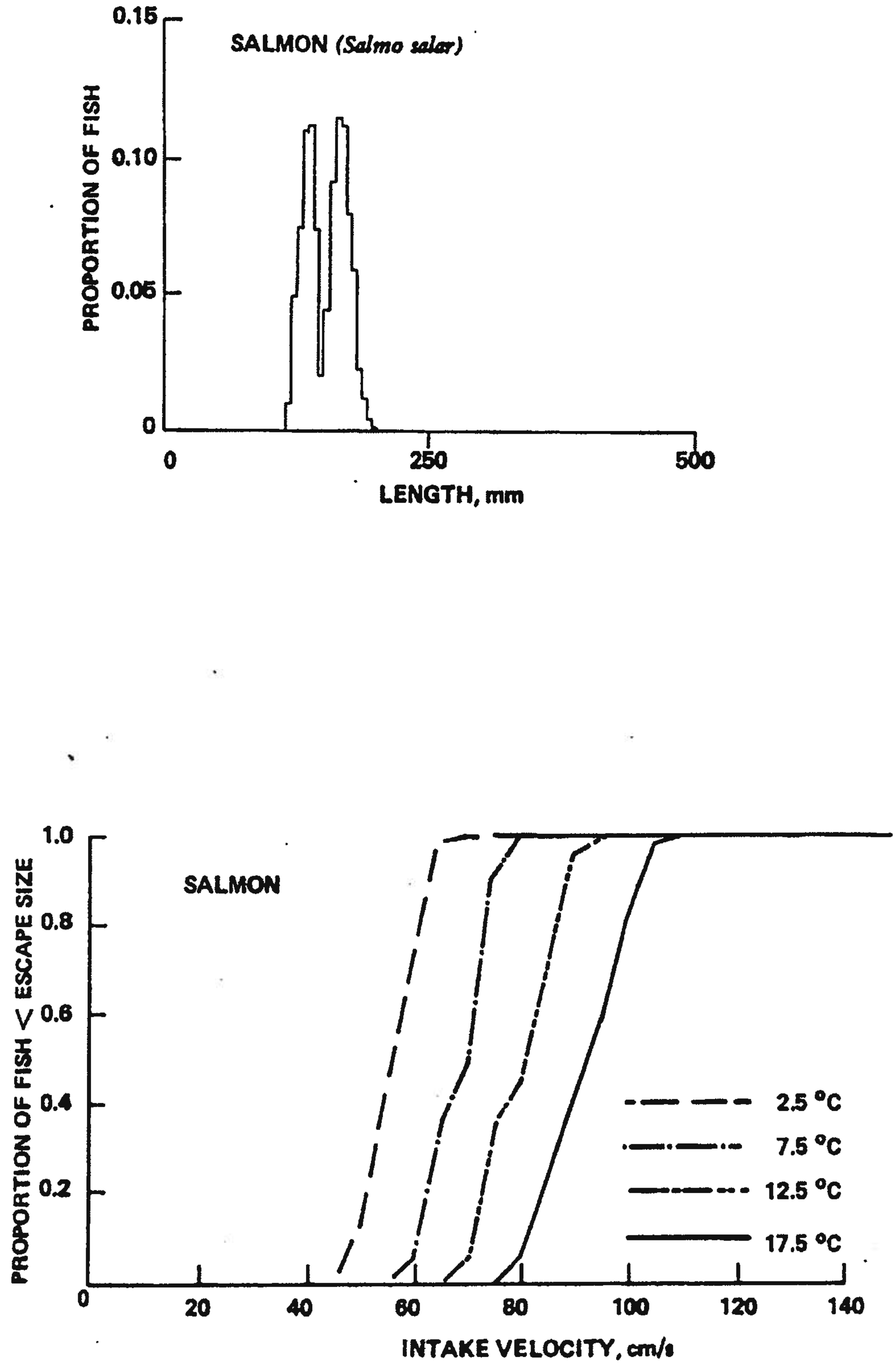
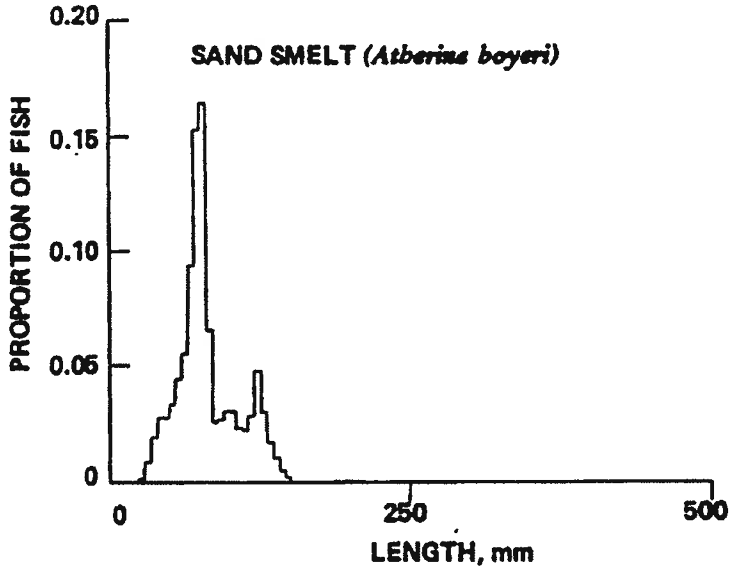
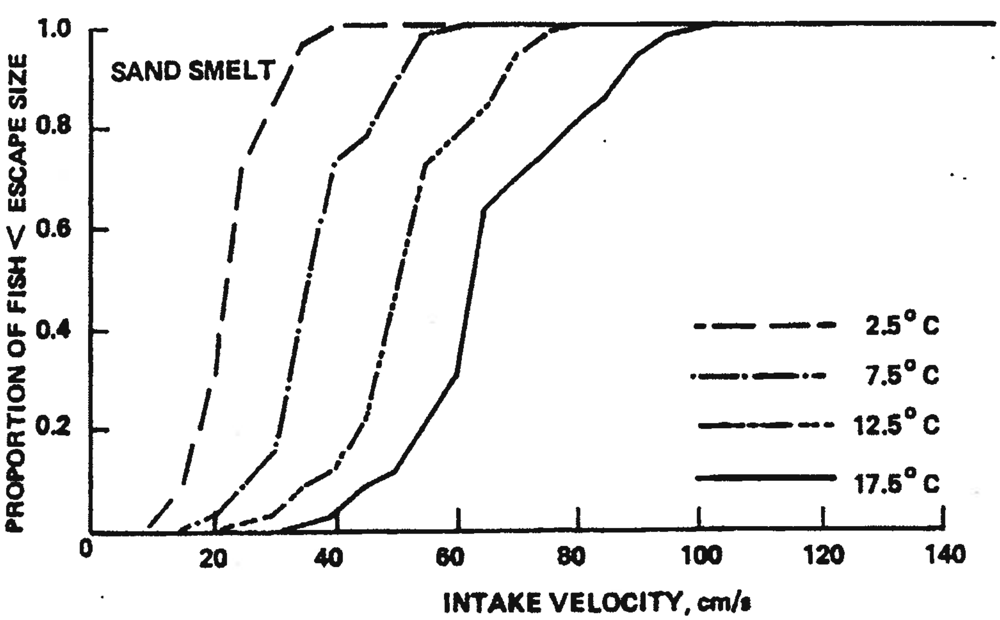


FIG. 4(j) CURVES DEPICTING THE PROPORTION OF FISH TOO SMALL TO ESCAPE FROM WATER INTAKES, IN RELATION TO WATER VELOCITY AT DIFFERENT WATER TEMPERATURES. The upper histogram shows the fish length distribution on which the curves have been calculated.





(FIG. 4(k) CURVES DEPICTING THE PROPORTION OF FISH TOO SMALL TO ESCAPE FROM WATER INTAKES, IN RELATION TO WATER VELOCITY AT DIFFERENT WATER TEMPERATURES. The upper histogram shows the fish length distribution on which the curves have been calculated.

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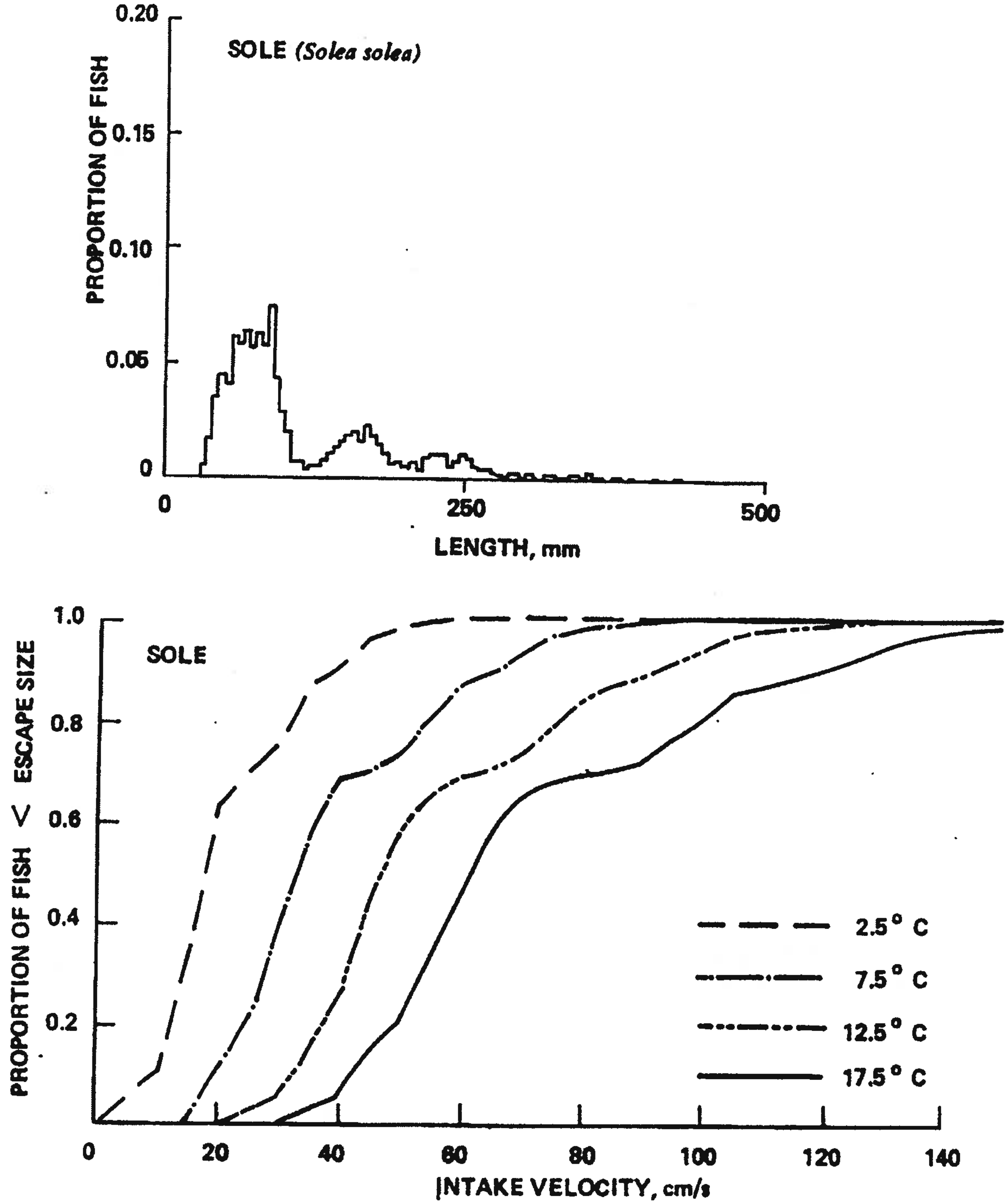
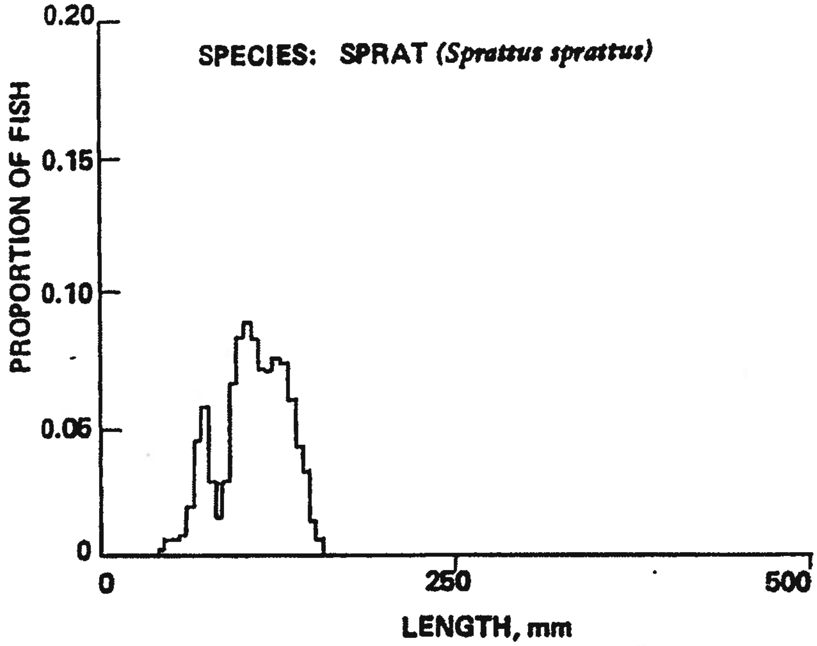


FIG. 4(I) CURVES DEPICTING THE PROPORTION OF FISH TOO SMALL TO ESCAPE FROM WATER INTAKES, IN RELATION TO WATER VELOCITY AT DIFFERENT WATER TEMPERATURES. The upper histogram shows the fish length distribution on which the curves have been calculated



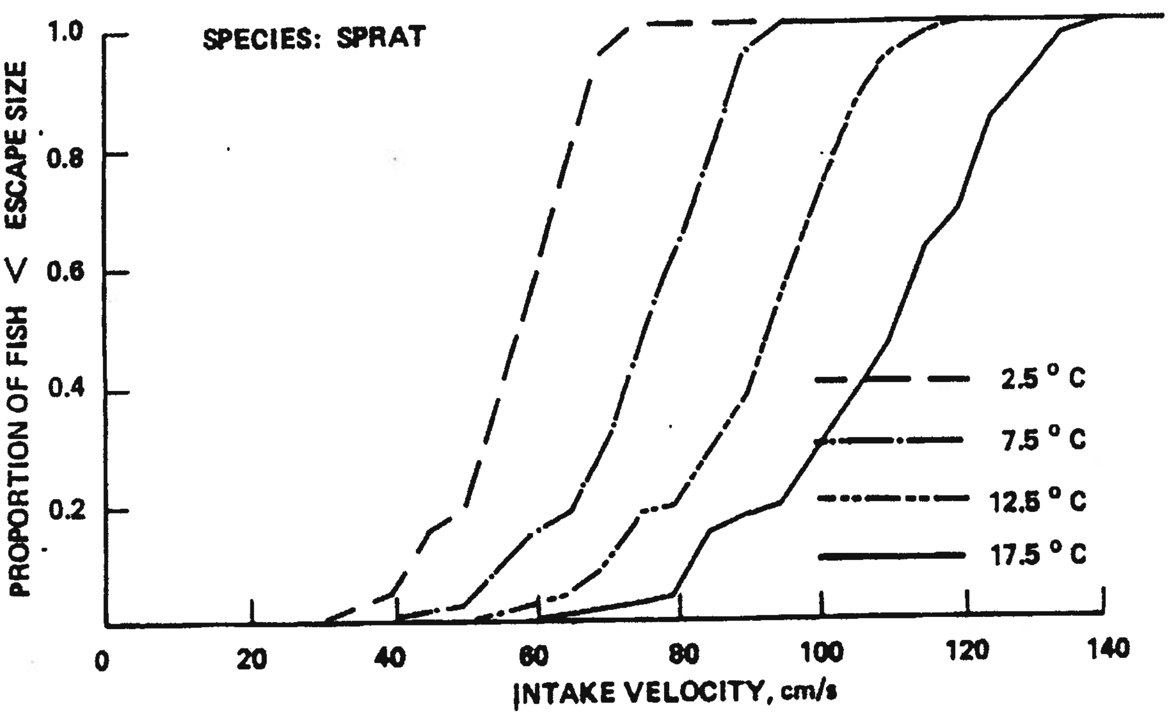
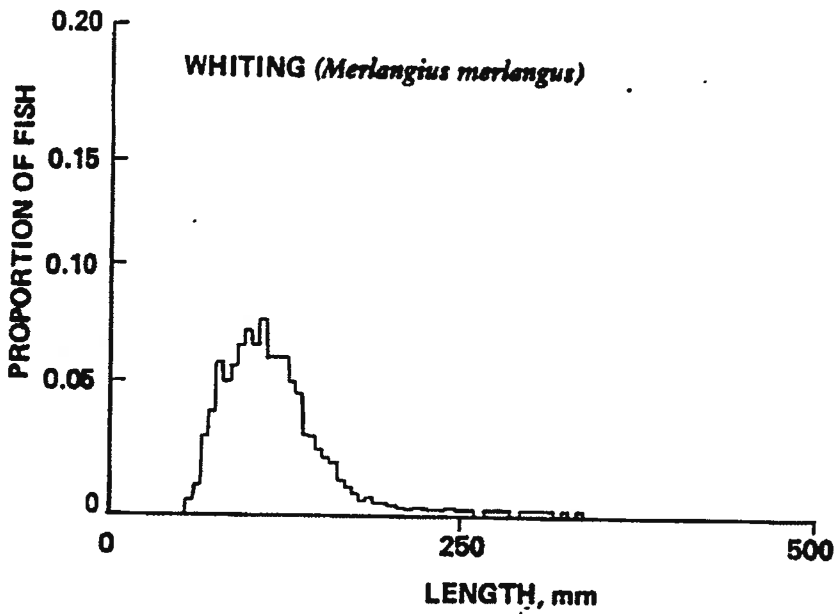


FIG. 4(m) CURVES DEPICTING THE PROPORTION OF FISH TOO SMALL TO ESCAPE FROM WATER INTAKES, IN RELATION TO WATER VELOCITY AT DIFFERENT WATER TEMPERATURES. The upper histogram shows the fish length distribution on which the curves have been calculated



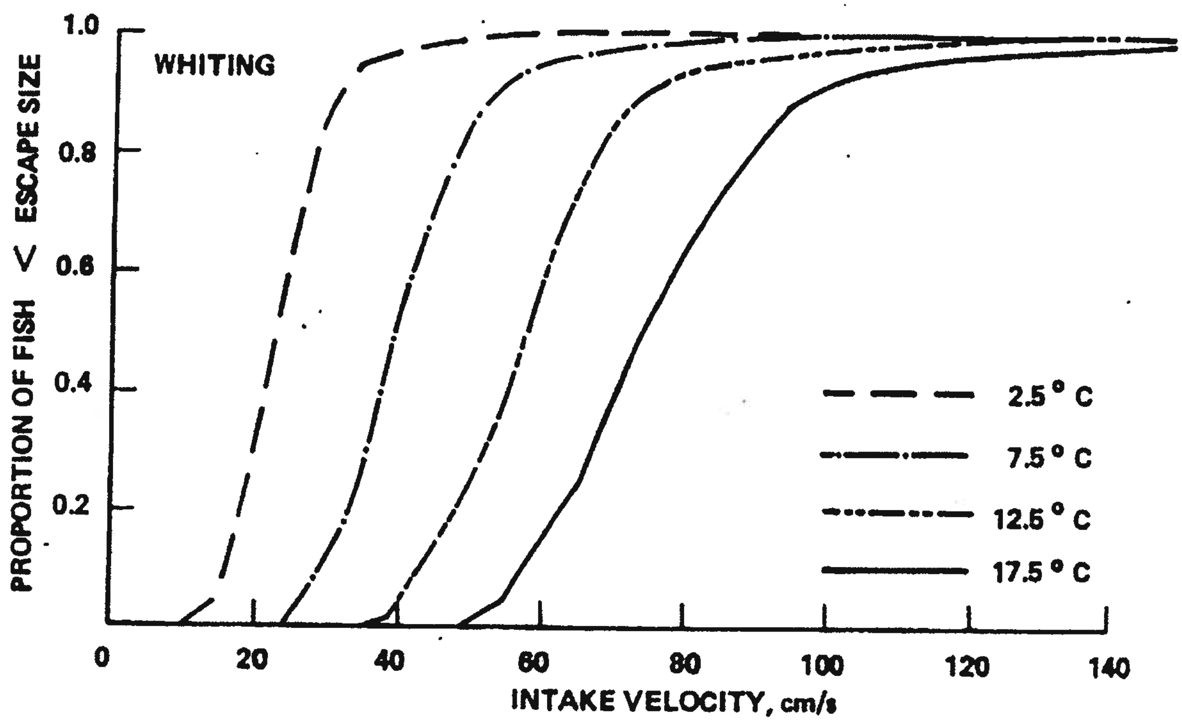


FIG. 4(n) CURVES DEPICTING THE PROPORTION OF FISH TOO SMALL TO ESCAPE FROM WATER INTAKES, IN RELATION TO WATER VELOCITY AT DIFFERENT WATER TEMPERATURES. The upper histogram shows the fish length distribution on which the curves have been calculated

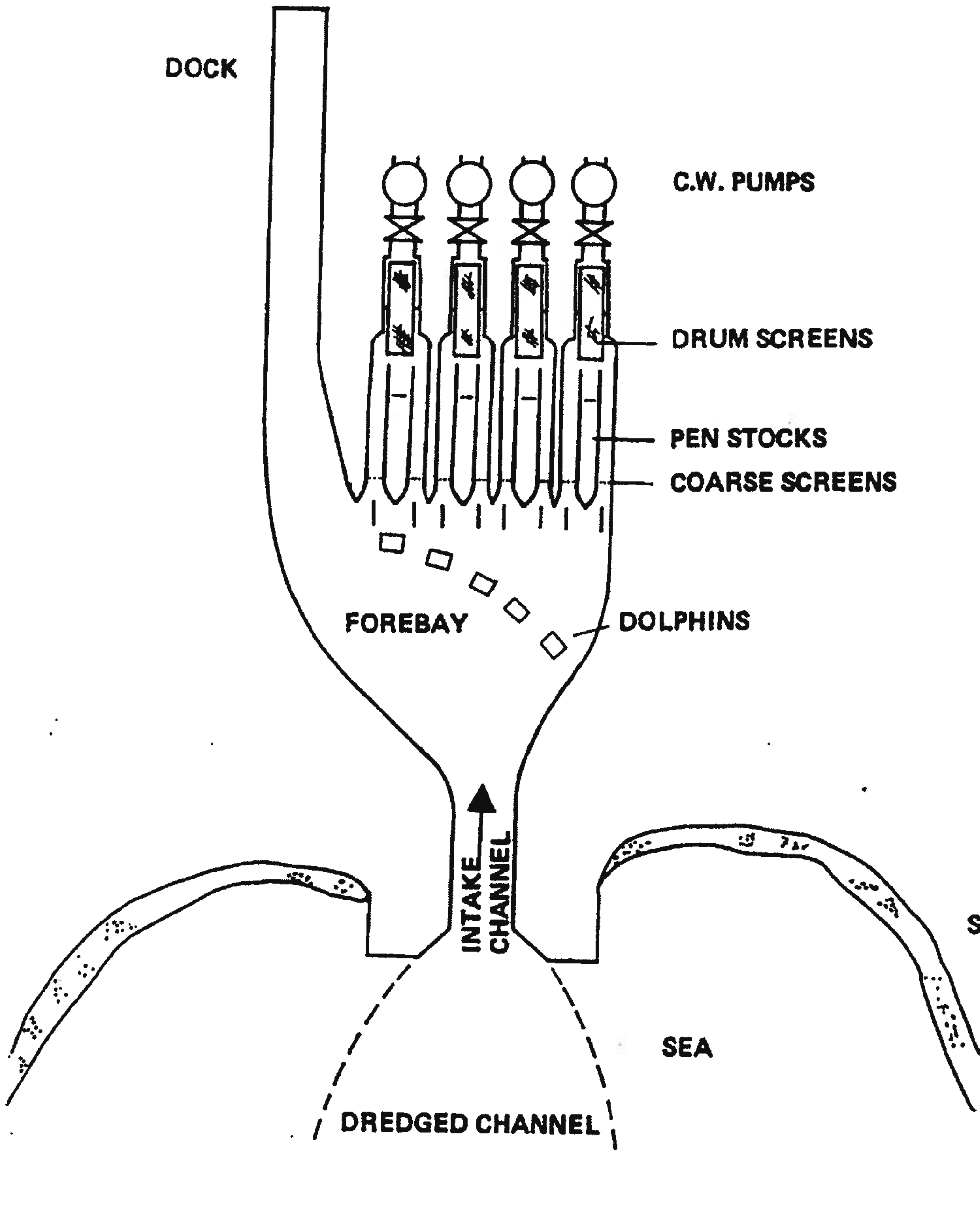


FIG. 5 LAYOUT OF THE ONSHORE INTAKE SYSTEM AT FAWLEY POWER STATION, HAMPSHIRE

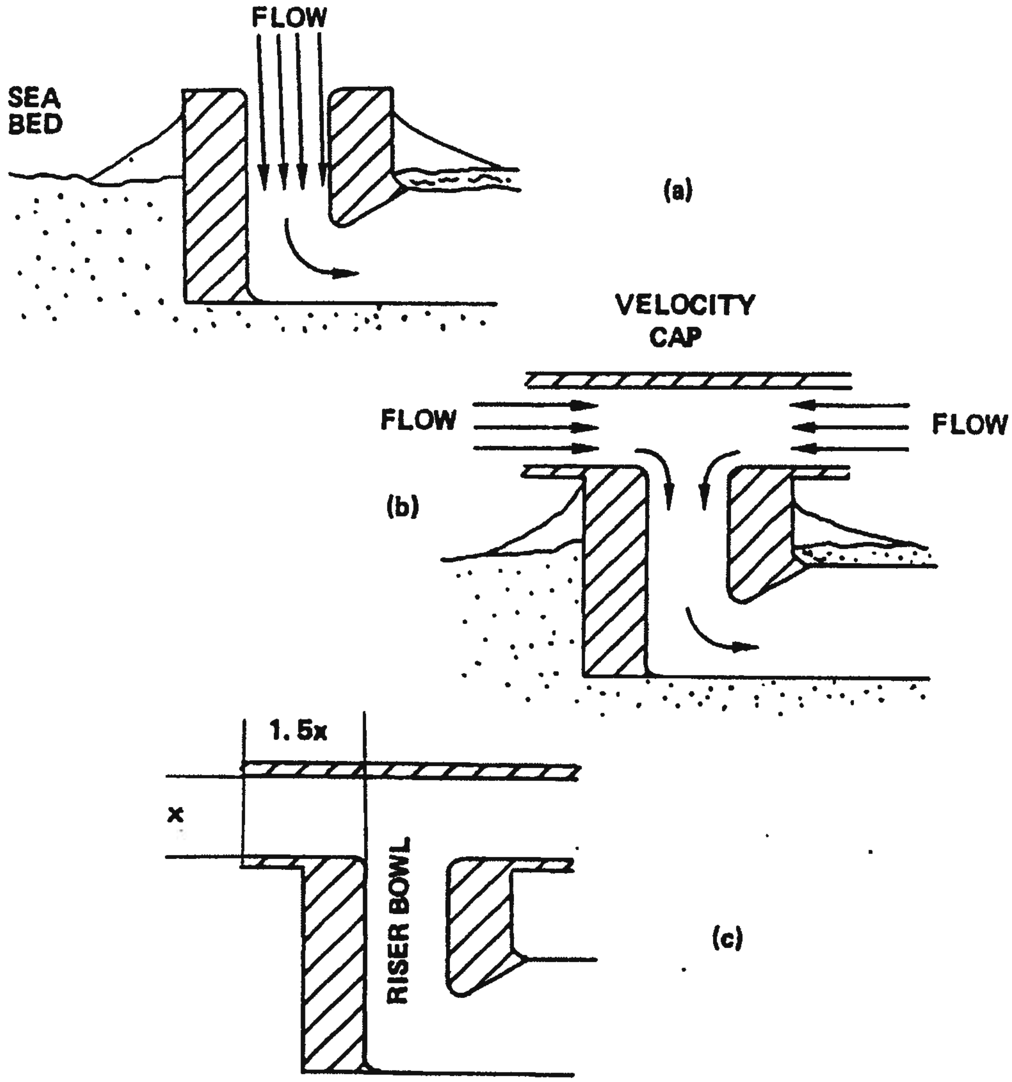


FIG. 6 THE VELOCITY CAP. (a) Section of uncapped intake showing vertical draw-down pattern, (b) section of velocity capped intake showing horizontal flow pattern, (c) as (b) but showing critical relationship between vertical opening (x) and length of horizontal entrance (1.5x) for fish reactions. Intake grills omitted. (After Schuler and Larson, 1975)

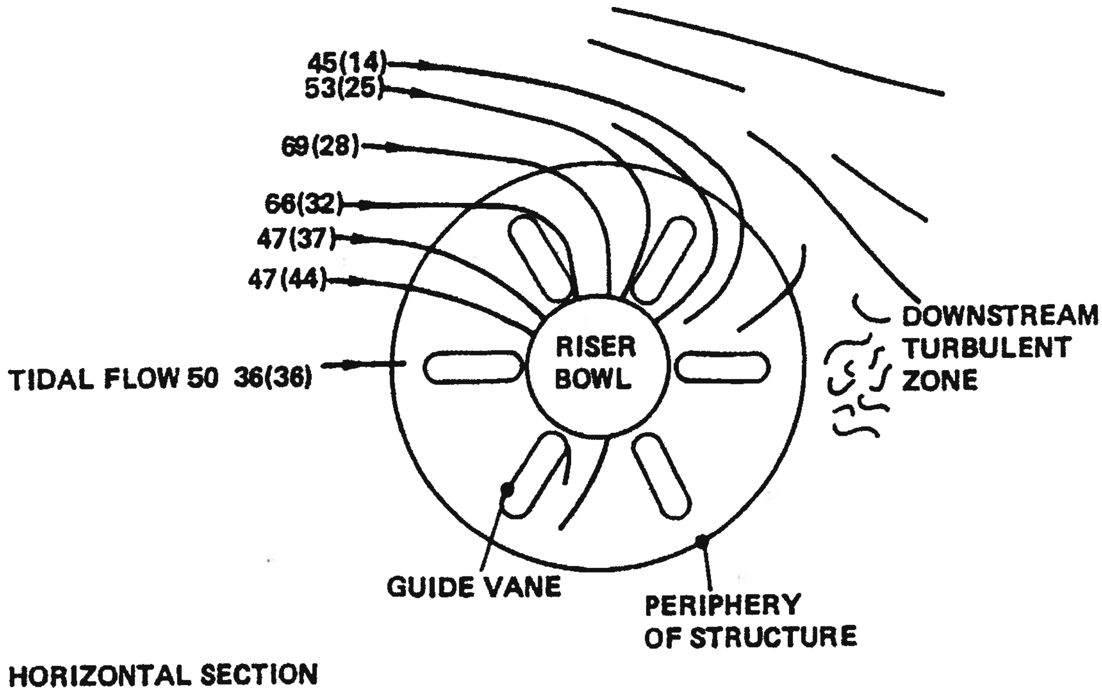


FIG. 7 HORIZONTAL DISTRIBUTION OF STREAMLINES AND WATER VELOCITY AROUND A CIRCULAR CAPPED INTAKE STRUCTURE IN A TIDAL CROSSFLOW.

Intake flow = 13.7 $m^3 s^{-1}$, tidal velocity = 50 cm s^{-1}, velocity values shown are as measured at mid-intake level along the direction of streamlines at the periphery of the intake structure. Values in parentheses are vectors normal to the periphery. All values are in units of cm s^{-1}. [Based on trials with a 1/50 scale model at Central Electricity Research Laboratories, B.T. Goldring, pers. comm.]

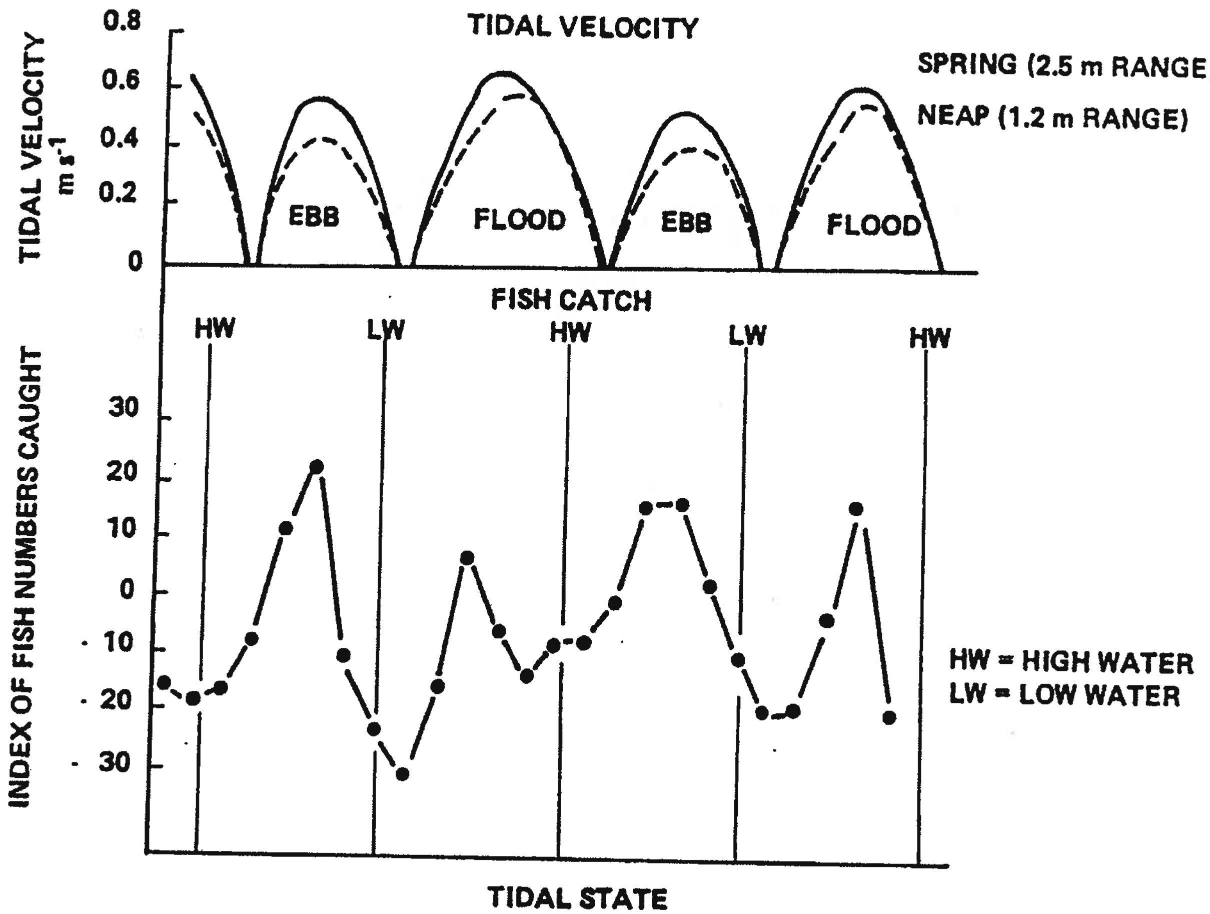


FIG. 8 RELATIONSHIP BETWEEN FISH CATCH, TIDAL STATE AND TIDAL VELOCITY AT SIZEWELL 'A' POWER STATION (Based on hourly samples collected on 41 days, April 1981-May 1982. Figures standardised as Index = $(x - \bar{x})/s$, where $\bar{x}$ is mean hourly fish catch for each 24 h period, x is the hourly fish catch for any one hour and s is the 24 h standard deviation. Tidal velocities measured by moored current meter 100 m south of intake

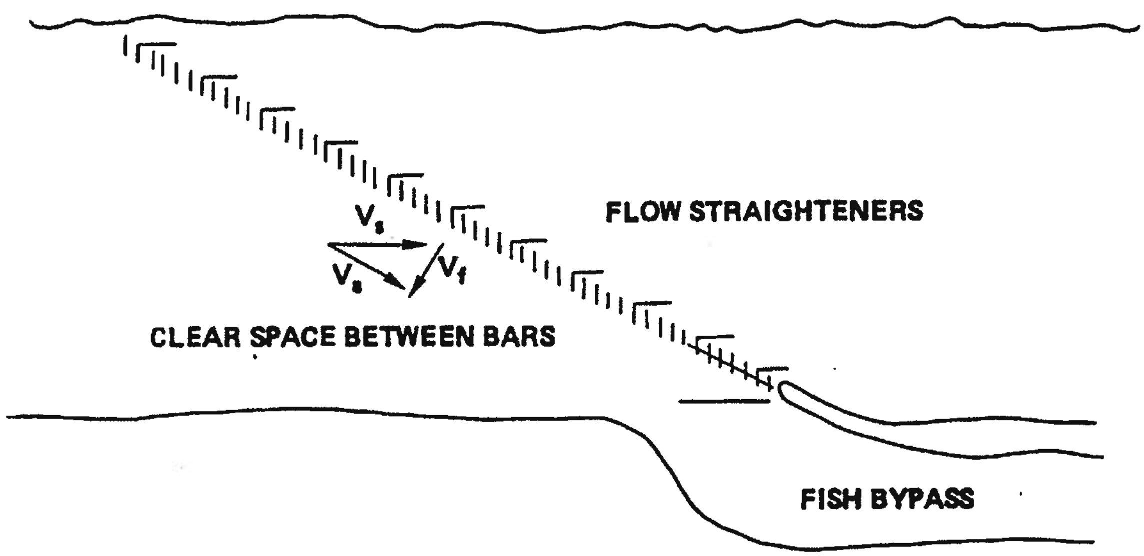


FIG. 9 SCHEMATIC DIAGRAM OF A LOUVRE SCREEN (PLAN VIEW) WITH VECTOR DIAGRAM OF THE RELATIONSHIP BETWEEN APPROACH VELOCITY (V_a) AND THE FISH'S SWIMMING VELOCITY (V_f) REQUIRED FOR ESCAPE.
(V_s is the velocity at which the fish moves laterally along the screen (from Environmental Protection Agency, 1976)

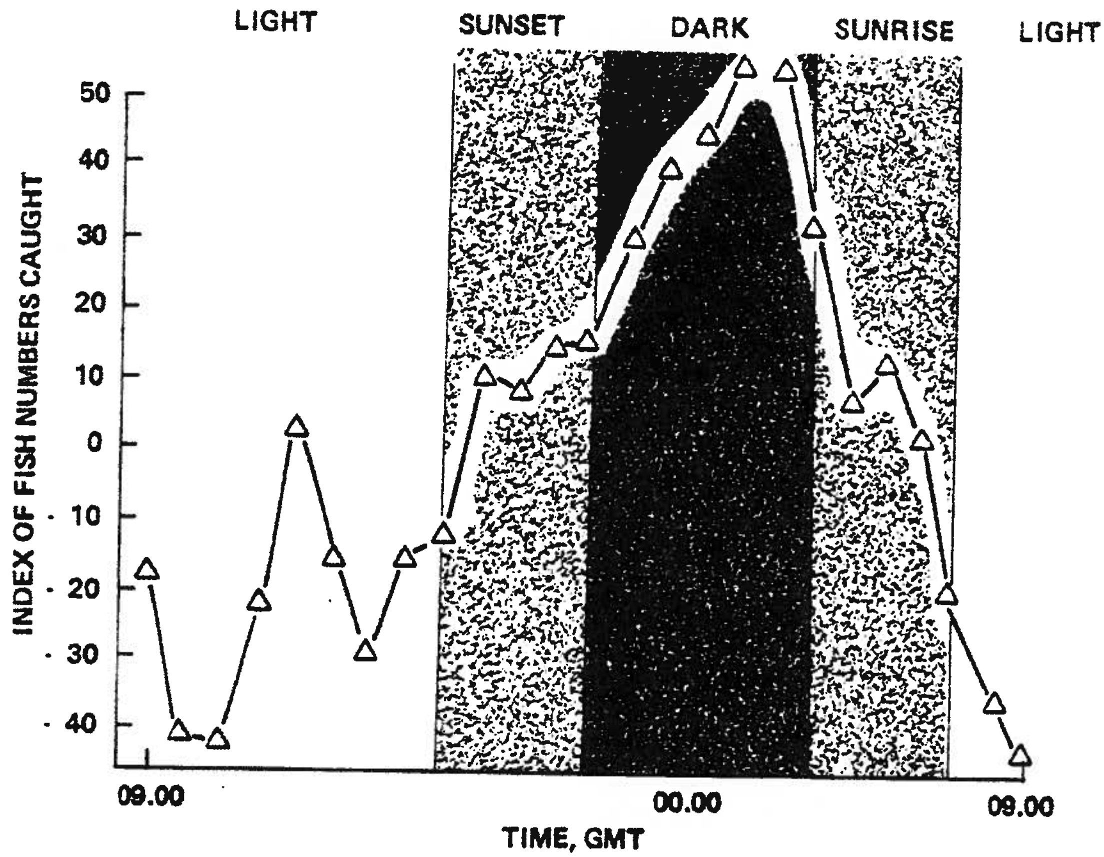
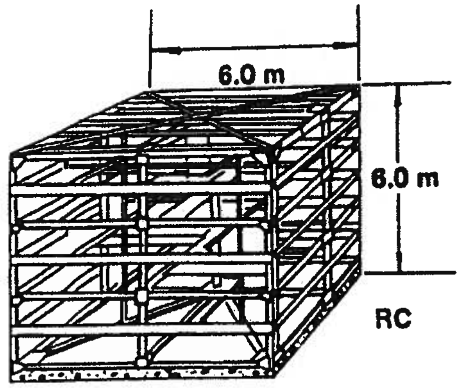
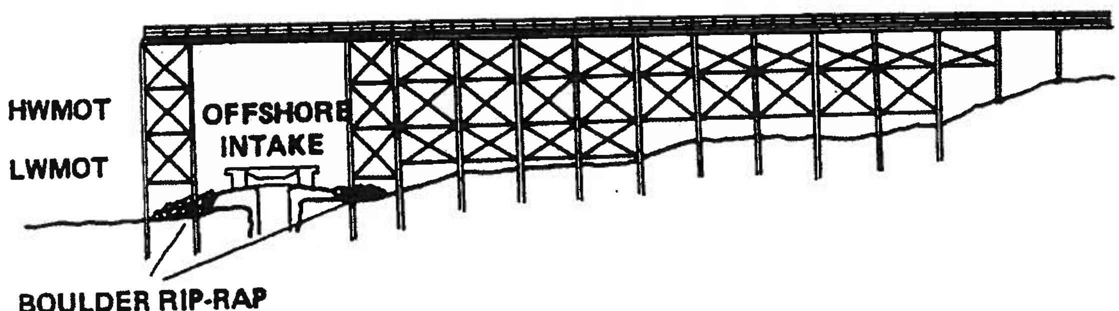


FIG. 10 DIURNAL PATTERN OF FISH CATCH AT SIZEWELL 'A' POWER STATION, AVERAGED OVER 41 SAMPLING DAYS. (see caption to Fig. 8 Lightly stippled areas show range of times of dusk and dawn from mid-winter to mid-summer. Dark stippling shows hours of darkness common to all dates



(a) JAPANESE CUBIC STEEL FISH AGGREGATING REEF (KOSAI CLUB, TOKYO, JAPAN)

(b) BOULDER REEF (FROM WILSON et al., 1987)



(c) TYPICAL OFFSHORE INTAKE WITH JETTY SUPERSTRUCTURE AND BOULDER RIP-RAP

FIG. 11 INTAKE STRUCTURES AS ARTIFICIAL REEFS. (a) & (b) show two concepts in artificial reefs for fish aggregation, (c) shows how both of these concepts are unwittingly incorporated into offshore intake structures

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ADDRESS ONLY THE DIRECTOR, BUREAU OF SPORT FISHERIES AND WILDLIFE

United States Department of the Interior
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
WASHINGTON, D.C. 20240

February 5, 1973

Instructional Memorandum RB-44

Memorandum

To: Regional Directors, Alaska Area Director and Division of River Basin Studies Personnel

From: Assistant Director, Bureau of Sport Fisheries and Wildlife

Subject: Review of NPDES (National Pollutant Discharge Elimination System) Permit Applications processed by the EPA (Environmental Protection Agency) or by the State with EPA oversight

This replaces Dr. King's Instructional Memorandum RB-41, included as Part E-10 of the draft of the DRBS Navigable Waters Handbook. It is intended to serve until its subject matter is included in the handbook's detailed policy and procedural guidelines and while experience is gained with this new permit program.

The NPDES permit system was authorized by the Federal Water Pollution Control Act Amendments of 1972, P.L. 92-500 (enacted October 18, 1972) which Act completely revised the FWPCA (Federal Water Pollution Control Act). (See Navigable Waters Handbook Appendix Part D-2s.)

The NPDES permit program was established by Section 402 of the revised Act and specifically incorporates the prior program for the control of pollutant discharges established under joint authority of earlier revisions of the Act and Section 13 of the Act of March 3, 1899 (33 U.S.C. 407). Such aspects of the control of "refuse" discharges under Section 13 as relate to navigation are reserved to the Secretary of the Army acting through the Chief of Engineers (in consultation with the Coast Guard's Secretary) by Sections 402(b)(6) and 404 of the Act.

The new Act provides that a State may be granted authority to administer a permit system within its borders, subject to oversight of EPA and under defined conditions. A number of States already have been granted interim authority, and guidelines have been promulgated by EPA defining standards each State must meet before permanent (revokable for cause by EPA) authority can be granted by EPA to such State. (Navigable Waters Handbook Appendix Part D-4b(1))

The Regional Director, if he has not already done so as recommended by Dr. King's January 4 memorandum of similar subject, should promptly request that notice and related fact sheet for each application for NPDES permit be provided him upon publication. Since both EPA and some if not all of the States will be processing the permits, requests for notices and fact sheets must be directed to EPA Regional Offices and to each State known to be administering the program. Dr. King's cited memorandum listed 10 States granted interim authority and you should request EPA Regional Offices to keep you apprised of changes in authority granted to the States in your region.

The following procedural guidelines are recommended for reviewing applications for NPDES permits:

1. Each permit application received must be logged, screened, scheduled, reviewed, coordinated and reported upon, as appropriate, or otherwise classified and processed as outlined in Sections 3, 4, 6, and 7 of the Navigable Waters Handbook. As with other types of permit applications, a field investigation of reconnaissance grade will be made and a field appraisal report completed in pertinent parts by the assigned field biologist for each application involving significant Service interest.

2. In considering the acceptability of an NPDES application, the objectives and policies of Section 2 and the general and detailed guidelines of Section 5 of the Navigable Waters Handbook should be followed insofar as applicable.

3. As an aid to assessing the impact of an ongoing or proposed pollutant discharge, at least the following items should be considered:

   -- the detailed characteristics (volumes; rates; degree or intensity; and diurnal, weekly, and seasonal patterns) and composition (by averages, ranges, variations, and patterns) of the applied for pollutant discharge including:

      -- total volume rate of discharge in MGD or other rate, and in relation to the rate of flow or exchange of the receiving water.

      -- BOD (biological oxygen demand) and COD (chemical oxygen demand) each in parts per million over a defined time span.

      -- velocity of discharge and its direction and tendency to cause scouring of shoreline or bottom materials.

      -- temperature and in relation to ambient temperature of the receiving water.

      -- concentration or occurrence of indicator (coliform), harmful, pathogenic, or parasitic bacteria and other organisms; weed or exotic species, their seeds, eggs, or larvae.

-- density of discharge and in relation to ambient densities of the receiving water, giving special attention to sinking plumes and other density related effects.

-- TDS (total dissolved solids).

-- chlorides, sulfates, carbonates, bicarbonates, and other salts.

-- DO (dissolved oxygen).

-- pH (acidity - alkalinity).

-- toxic and hazardous substances (heavy metals, pesticides, PCB's, chlorine, hydrogen sulfide, phenols, cresols, etc.).

-- oils, greases, fatty substances, etc.

-- nutrients (nitrogen, phorphorus, carbon).

-- settleable solids, fibers, abrasive substances, etc.

-- colloidal solids (clays, organics, etc.).

-- sugar and other highly oxidizable organics.

-- turbidity.

-- color.

-- the historical or pristine natural quality of the receiving water and the fish and wildlife species and populations native thereto.

-- the existing quality of the receiving water contrasted with that forecast with the proposed discharge (considering ranges and variations, as well as averages, patterns of occurrence and distribution--horizontally and vertically throughout the receiving water body and other factors noted below). In particular, does the receiving water meet water quality standards without the applied-for discharge? Would or does the applied-for discharge degrade the receiving water? Would or does the discharge meet other established water quality requirements, including effluent limitations, standards of performance, etc., if any? Would or does the discharge require or involve a waiver of any water quality requirement? Is the discharge to be treated; if so, will the treatment be adequate; or if inadequate or untreated, what treatment is required? Such questions should be answered by the regulatory agency, but the investigator may have to pose them to it.

-- the particular species of fish and wildlife, including their supporting habitat and food species, known or likely to be of concern together with their tolerance and sensitivity to the water quality parameters being or to be altered. Guidance as to tolerance should be sought in Water Quality Criteria, a report to the Secretary of the Interior by the National Technical Advisory Committee, April 1, 1968, until an updated version is issued by the EPA.

-- appropriate comparisons and extensions of the foregoing items, including:

-- patterns of dispersion downstream and within the receiving water body;

-- persistence of involved pollutants; adsorption, precipitation, flocculation, and other physical means of accumulation of such pollutants on surfaces and in sediments;

-- biological magnification and biochemical intensification of toxicity (e.g., methylation of mercury);

-- synergistic intensification of toxicity (e.g., copper and zinc);

-- effects of scheduled and emergency shutdowns of the proposed discharge (especially in regard to any thermal loads); etc.

In such comparisons and extensions due regard must be given to:

-- density current and stratification phenomena due to variations and prospective changes in temperature, sediment, and salinity;

-- additions and cumulative effects of pollutants from proximal and other related discharges, non-point sources, and natural deposits;

-- tidal, littoral, riverine, and other currents and exchanges;

-- modifications of current patterns by the coriolis force, winds, air pressure, etc;

-- natural changes due to runoff accretions, upstream storage and regulation, evapotranspiration, and groundwater exchanges; and

-- variations in sensitivity of concerned organisms among individuals and during different life stages.

In summary, the assigned biologist must make his best judgment of the total impact of an applied-for pollutant discharge for each species of concern, including the effects on human uses thereof due to odors, tastes, etc., by review of the available data in light of the factors known or suspected to intensify or lessen the apparent impact. Generally this will form an adequate basis for questioning conclusions of others and making cautionary recommendations. The information and expertise available will likely never be sufficient to support unequivocal conclusions or recommendations. This should not deter the responsible field biologist nor his supervisors from strongly defending their judgment, for it is probable that the "experts" also lack unequivocal answers to most of the questions posed by all but the simplest pollutant discharges.

In reporting the Service assessment of existing or potential impact of a pollutant discharge, any questions of the ability of the applicant to meet the standards, effluent limitations or other requirements of the FWPCA should be left to the EPA or the State with EPA oversight. However, the established requirements, per se, may be questioned if they are determined or otherwise known to be inadequate for the known or suspected needs of a fish or wildlife species, life stage of a species, or group of species dependent on the waterway concerned. Yet the Service report on a particular application is not an entirely adequate vehicle for such questioning; such a question also should be separately addressed to the EPA with a copy to the concerned State agencies.

The Service assessment and comment will be directed to the anticipated impacts of specific pollutants on specific species or specific habitat areas. Emphasis will be placed on any critical situations found or anticipated to develop as a result of the place, time, or rate of discharge, the quantity or velocity of the discharge, or the siting of related facilities, per se, e.g. siting of lagoons or treatment works on productive marsh, etc. Particular attention should be given to sensitive species, life stages, and habitats. Also the facilities for diverting water as well as for discharging water should be closely examined for potential mechanical hazards requiring saving devices such as screens and bypasses at intake and diffusion facilities on the discharge lines. Entrainment of larvae, plankton organisms, and other weak swimmers can occur at both the intake and outlet when velocities are excessive. The maximum velocity protecting most small fish is 0.5 f.p.s. (foot per second) but even lower velocities will entrain larvae and plankton and even small fish where intake channels are not provided with an effective escape bypass.

Recommendations for conditioning a pollutant discharge permit or denying issuance of the permit, in accordance with the severity of the expected impacts, will be made as suggested in Appendix Part C of the Navigable Waters Handbook if any or a combination of the following findings have been made:

-- Service investigations and assessment of the applied-for discharge, including the siting of related lagoons and other facilities, indicate that damage or degradation of fish and wildlife, their habitat (aquatic, submersible or upland), or the human satisfaction and uses thereof are or would be significant.

-- The discharge includes or would include toxic, hazardous, harmful, and/or unevaluated potentially harmful substances in concentrations significant or questionably significant to fish and wildlife, their habitats, or the human satisfactions and uses thereof.

-- Facilities needed to protect fish and wildlife or their habitats (e.g. screens, bypasses, diffusion structures, etc.) are either lacking, improperly designed or operated, or unacceptably planned.

Reports will be made directly to the permitting agency (the EPA or the State). If reporting is to the State a copy should be sent to the EPA since it has oversight responsibility for any State permitting actions under the program. Notices of applications found not to involve a significant Service interest may be responded to weekly or biweekly by form letter as arranged with the permitting agency or otherwise (see Sections 3 and 7 of the Navigable Waters Handbook).

Willis King