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Environmental Protection
Agency

Technical Development Document for the Final Section 316(b) Existing Facilities Rule

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Contents

Chapter 6: Technologies and Control Measures 6-1

Chapter 7: Regulatory Options 7-1

Chapter 8: Costing Methodology 8-1

Exhibits

Chapter 1: Background

1.0 Introduction

This chapter provides background information on the development of 316(b) regulations including the final existing facilities rule. This chapter describes the goal of the final existing facilities rule and provides an overview of the legislative background, prior 316(b) rulemakings, and associated litigation history leading up to the rulemaking. This document builds on and updates record support compiled for the Phase I rule, the remanded 2004 Phase II rule, the Phase III rule, and the proposed existing facilities rule, including the Technical Development Documents (TDD) for each.

1.1 Purpose of Technical Development Document and Final Regulation

The purpose of this TDD is to provide record support for the final existing facilities rule and to describe the methods used by EPA to analyze various options. The goal of the regulation is to establish national requirements for cooling water intake structures at existing facilities that implement section 316(b) of the CWA. 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.

EPA first promulgated regulations to implement section 316(b) in 1976. The U.S. Court of Appeals for the Fourth Circuit remanded these regulations to EPA which withdrew them, leaving in place a provision not remanded that directed permitting authorities to determine BTA for each facility on a case-by-case basis. In 1995, EPA entered into a consent decree establishing a schedule for taking final action on regulations to implement section 316(b). Pursuant to a schedule in the amended decree providing for final action on regulations in three phases, in 2001, EPA published a Phase I rule governing new facilities. The U.S. Court of Appeals for the Second Circuit, while generally upholding the rule, rejected the provisions allowing restoration to be used to meet the requirements of the rule. *Riverkeeper, Inc. v. U.S. EPA,* 358 F. 3d 174, 181 (2d Cir.2004) ("*Riverkeepe*r I").

In 2004, EPA published the Phase II rule applicable to existing power plants. Following challenge, the Second Circuit remanded numerous aspects of the rule to the Agency, including the Agency's decision to reject closed-cycle cooling as BTA. The Agency made this determination, in part, based on a consideration of incremental costs and benefits. The Second Circuit concluded that a comparison of the costs and benefits of closed-cycle cooling was not a proper factor to consider in determining BTA. *Riverkeeper, Inc. v. U.S.EPA,* 475 F. 3d 83 (2d Cir. 2007) ("*Riverkeeper* II"). In 2008, the U.S, Supreme Court agreed to review the *Riverkeeper* II decision limited to a single issue: whether section 316(b) authorizes EPA to balance costs and benefits in 316(b) rulemaking. In April 2009, in *Entergy Corp. v. Riverkeeper Inc.*, 129 S. Ct. 1498, 68 ERC

1001 (2009) (40 ER 770, 4/3/09), the Supreme Court ruled that it is permissible under section 316(b) to consider costs and benefits in determining the best technology available to minimize adverse environmental impacts. The court left it to EPA's discretion to decide whether and how to consider costs and benefits in 316(b) actions, including rulemaking and BPJ determinations. The Supreme Court remanded the rule to the Second Circuit. Subsequently, EPA asked the Second Circuit to return the rule to the Agency for further review.

In 2006, EPA published the Phase III rule. The Phase III rule establishes 316(b) requirements for certain new offshore oil and gas extraction facilities. In addition, EPA determined that, in the case of electric generators with a design intake flow of less than 50 mgd and existing manufacturing facilities, 316(b) requirements should be established by NPDES permit Directors on a case-by-case basis using their best professional judgment. In July 2010, the U. S. Court of Appeals for the Fifth Circuit issued a decision upholding EPA's rule for new offshore oil and gas extraction facilities. Further, the court granted the request of EPA and environmental petitioners in the case to remand the existing facility portion of the rule back to the Agency for further rulemaking.

On April 20, 2011, EPA published the proposed rule for existing facilities, which was in response to the remand of the Phase II rule and the remand of the existing facilities portion of the Phase III rule. In addition, EPA also responded to the decision in *Riverkeeper* I by proposing to remove from the Phase I new facility rule the restoration-based compliance alternative and the associated monitoring and demonstration requirements. On June 11th and 12th, EPA also published two Notices of Data Availability (NODA). Today's final rule incorporates all of EPA's experience, with a focus on the existing facilities rule as the most current and most comprehensive. See Section 1.2 below for a more detailed discussion of the history of EPA's actions to address standards for cooling water intake structures.

The final rule's requirements reflect the best technology available for minimizing adverse environmental impact, applicable to the location, design, construction, and capacity of cooling water intake structures for existing facilities. EPA is addressing existing power generating facilities and existing manufacturing and industrial facilities in one proceeding. This final rule applies to all existing power generating facilities and existing manufacturing and industrial facilities that have the design capacity to withdraw more than two million gallons per day of cooling water from waters of the United States and use at least twenty-five (25) percent of the water they withdraw exclusively for cooling purposes.

1.2 Background

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). Among the goals of the Act is

> "wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water…" 33 U.S.C. § 1251(a)(2).

In furtherance of these objectives, 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 United States, except in compliance with the statute; (2) authority for EPA or authorized States or Tribes to issue National Pollutant Discharge Elimination System (NPDES) permits that authorize and regulate the discharge of pollutants; and (3) requirements for effluent limitations and other conditions in NPDES permits to implement applicable technology-based effluent limitations guidelines and standards and applicable State water quality standards.

Section 402 of the CWA authorizes 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 United States. Forty-six 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 by requiring dischargers to meet technology-based effluent limitations guidelines (ELGs) or new source performance standards (NSPS) established pursuant to section 301 or section 306. Where such nationally applicable ELGs or NSPS exist, permit authorities must incorporate them into permit requirements. Where they do not exist, permit authorities establish effluent limitations and conditions, reflecting the appropriate level of control (depending on the type of pollutant) based on the best professional judgment of the permit writer. Limitations based on these guidelines, standards, or on best professional judgment are known as technology-based effluent limits. Where technology-based effluent limits are inadequate to meet applicable State water quality standards, section 301(b)(1)(C) of the Clean Water Act requires permits to include more stringent limits to meet applicable water quality standards. NPDES permits also routinely include standard conditions applicable to all permits, special conditions, and monitoring and reporting requirements. In addition to these requirements, NPDES permits must contain conditions to implement the requirements of section 316(b).

Section 510 of the Clean Water Act provides, that except as provided in the Clean Water Act, nothing shall preclude or deny the right of any State (or political subdivision thereof) to adopt or enforce any requirement respecting control or abatement of pollution; except that if a limitation, prohibition or standard of performance is in effect under the Clean Water Act, such State may not adopt any other limitation, prohibition, or standard of performance which is less stringent than the limitation, prohibition, or standard of performance under the Act. EPA interprets this to reserve for the States authority to implement requirements that are more stringent than the Federal requirements under state law. *PUD No. 1 of Jefferson County v. Washington Dep't of Ecology,* 511 U.S. 700, 705 (1994).

Sections 301, 304, and 306 of the CWA require that EPA develop technology-based effluent limitations guidelines and new source performance standards that are used as the basis for discharge requirements in wastewater discharge permits. EPA develops these effluent limitations 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 limitations guidelines and standards under sections 301, 304, and 306 of the CWA for more than 56 industries. See 40 CFR parts 405 through 471. EPA has established effluent limitations guidelines and standards that apply to most of the industry categories that use cooling water intake structures (e.g., steam electric power generation, paper and allied products, petroleum refining, iron and steel manufacturing, and chemicals and allied products).

Section 316(b) states, in full:

> Any standard established pursuant to Section 301 or Section 306 of [the Clean Water] Act 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.

Section 316(b) addresses the adverse environmental impact caused specifically by the intake of cooling water, rather than discharges into water. Despite this special focus, the requirements of section 316(b) remain 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. Thus, while effluent limitations apply to the discharge of pollutants by NPDES-permitted point sources to waters of the United States, section 316(b) applies to facilities subject to NPDES requirements that also withdraw water from a water of the United States for cooling and that use a cooling water intake structure to do so.

The CWA does not describe the factors to be considered in establishing section 316(b) substantive performance requirements that reflect the “best technology available for minimizing adverse environmental impact.” The most recent guidance in interpreting 316(b) comes from the U.S. Supreme Court’s decision in *Entergy Corp. v. Riverkeeper, Inc*. As noted, the decision was limited to the single question of whether section 316(b) of the Clean Water Act authorizes EPA to compare costs and benefits of various technologies when setting national performance standards for cooling water intake structures under section 316(b) of the Clean Water Act. In *Riverkeeper* II, the Second Circuit rejected EPA’s determination that closed-cycle cooling was not BTA because it could not determine whether EPA had improperly considered costs and benefits in its 316(b) rulemaking. The Supreme Court reversed and remanded the Second Circuit ruling in a 6-3 opinion authored by Justice Scalia. The Court held that it is reasonable for EPA to conduct a cost-benefit analysis in setting national performance standards for cooling water intake structures under section 316(b). The Court held that EPA has the discretion to consider costs and benefits under section 316(b) but is not required to consider costs and benefits. The Court’s discussion of the language of section 316(b) – section 316(b) is “unencumbered by specified statutory factors” -- and its critique of the Second Circuit’s decision affirms EPA’s broader discretion to consider a number of factors in standard setting under section 316(b). While the Supreme Court’s decision is limited to whether or not EPA may consider one factor (cost/benefit analysis) under section 316(b), the language also suggests that EPA has wide discretion in considering factors relevant to

316(b) standard setting. ("It is eminently reasonable to conclude that § *1326b*'s silence is meant to convey nothing more than a refusal to tie the agency's hands as to whether cost-benefit analysis should be used, and if so to what decree." (*emphasis supplied)*, 129 S.Ct. 1498, 1508 (2009).

Regarding the other factors EPA may consider, section 316(b) cross references sections 301 and 306 of the CWA by requiring that any standards established pursuant to those sections also must require that the location, design, construction and capacity of intake structures reflect BTA. Thus, among the factors EPA may use to determine BTA, EPA may look to similar phrases used elsewhere in the CWA. See *Riverkeeper* v. *EPA*, (2nd Cir. Feb. 3, 2004). Section 306 directs EPA to establish performance standards for *new* sources based on the "best available demonstrated control technology" (BADT). 33 U.S.C. 1316(a)(1). In establishing BADT, EPA "shall take into consideration the cost of achieving such effluent reduction, and any non-water quality environmental impact and energy requirements." 33 U.S.C. 1316(b)(2)(B). The specific cross-reference in CWA section 316(b) to CWA section 306 "is an invitation to look to section 306 for guidance in discerning what factors Congress intended the EPA to consider in determining the 'best technology available'" for new sources.

Similarly, section 301 of the CWA requires EPA to establish standards known as "effluent limitations" for *existing* point source discharges in two phases. In the first phase, applicable to all pollutants, EPA must establish effluent limitations based on the "best practicable control technology currently available" (BPT). 33 U.S.C. 1311(b)(1)(A). In establishing BPT, the CWA directs EPA to consider the total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application, and shall also take into account the age of the equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques, process changes, non-water quality environmental impact (including energy requirements), and such other factors as [EPA] deems appropriate. 33 U.S.C. 1314(b)(1)(b).

In the second phase, EPA must establish effluent limitations for conventional pollutants based on the "best conventional pollution control technology" (BCT), and for toxic pollutants based on the "best available technology economically achievable" (BAT). 33 U.S.C. 1311(b)(2)(A), (E).

In determining BCT, EPA must consider, among other factors,

> "the relationship between the costs of attaining a reduction in effluents and the effluent reduction benefits derived, and the comparison of the cost and level of reduction of such pollutants from the discharge from publicly owned treatment works to the cost and level of reduction of such pollutants from a class or category of industry source…. and the age of equipment and facilities involved, the process employed, the engineering aspects …. of various types of control techniques, process changes, the cost of achieving such effluent reduction, non-water quality environmental impacts (including energy requirements), and such other factors as [EPA] deems appropriate." 33 U.S.C. 1314(b)(4)(B).

In determining BAT, the CWA directs EPA to consider "the age of equipment and facilities involved, the process employed, the engineering aspects …. of various types of control techniques, process changes, the cost of achieving such effluent reduction, non-water quality environmental impacts (including energy requirements), and such other factors as [EPA] deems appropriate." 33 U.S.C. 1314(b)(2)(B).

Section 316(b) expressly refers to section 301, and the phrase "best technology available" is very similar to the phrases "best available technology economically achievable " and "best practicable control technology currently available" in that section. Thus, Section 316(b), section 301(b)(1)(A) -- the BPT provision-- and section 301(b)(1)(B) -- the BAT provision -- all include the terms "best," "technology," and "available," but neither BPT nor BAT goes on to consider minimizing adverse environmental impacts, as BTA does. See 33 U.S.C. 1311(b)(1)(A) and (2)(A). These facts, coupled with the brevity of section 316(b) itself, prompts EPA to look to section 301 and, ultimately, section 304 for further guidance in determining the "best technology available to minimize adverse environmental impact" of cooling water intake structures for existing facilities.

By the same token, however, there are significant differences between section 316(b) and sections 301 and 304. See *Riverkeeper, Inc.* v. *United States Environmental Protection Agency* (2nd Cir. Feb. 3, 2004) ("not every statutory directive contained [in Sections 301 and 306] is applicable" to a section 316(b) rulemaking). Moreover, as the Supreme Court recognized, while the provisions governing the discharge of toxic pollutants must require the elimination of discharges if technically and economically achievable, section 316(b) has the less ambitious goal of "minimizing adverse environmental impact." 129 S.Ct. 1498, 1506. In contrast to the effluent limitations provisions, the object of the "best technology available" is explicitly articulated by reference to the receiving water: to minimize adverse environmental impact in the waters from which cooling water is withdrawn. This difference is reflected in EPA's past practices in implementing sections 301, 304, and 316(b). EPA has established BPT and BAT effluent limitations guidelines and NSPS based on the efficacy of one or more technologies to reduce pollutants in wastewater in relation to their costs without necessarily considering the impact on the receiving waters. This contrasts to 316(b) requirements, where EPA has previously considered the costs of technologies in relation to the benefits of minimizing adverse environmental impact in establishing 316(b) limits, which historically has been done on a case-by case basis. In *Re Public Service Co. of New Hampshire*, 10 ERC 1257 (June 17, 1977); *In Re Public Service Co. of New Hampshire*, 1 EAD 455 (Aug. 4, 1978); *Seacoast Anti-Pollution League* v. *Costle*, 597 F. 2d 306 (1st Cir. 1979) EPA concluded that, because both section 301 and 306 are expressly cross-referenced in section 316(b), EPA reasonably interpreted section 316(b) as authorizing consideration of the same factors, including costs, as in those sections. EPA interpreted "best technology available" to mean the best technology available at an "economically practicable" cost. This approach squared with the limited legislative history of section 316(b) which suggested the BTA was to be based on technology whose costs were "economically practicable." In debate on section 316(b), one legislator explained that "[t]he reference here to 'best technology available' is intended to be interpreted to mean the best technology available commercially *at an economically practicable cost*." 118 Cong. Rec. 33,762 (1972) (statement of Rep. Clausen) (emphasis added).

For EPA’s initial Phase II rulemaking, as it had during 30 years of BPJ section 316(b) permitting, EPA therefore interpreted CWA section 316(b) as authorizing EPA to consider not only the costs of technologies but also their effects on the water from which the cooling water is withdrawn.

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Chapter 2: Summary of Data Collection Activities

2.0 Introduction

In developing the final rule, EPA used previously collected data from the Phase I, 2004 Phase II, and Phase III rulemakings in combination with newly collected data and information. This chapter first provides information on major data collection activities from the previous rulemakings and then provides summaries of information obtained through more recent data collection activities.

2.1 Primary Data Sourced from Previous 316(b) Rulemakings

This section summarizes the major data collection activities conducted during development of the Phase I, 2004 Phase II, and Phase III rulemakings that EPA also considered in developing this final rule. For additional, more detailed information on these previous activities, see the Phase I proposed rule (65 FR 49070), Phase I NODA (66 FR 28853), Phase II proposal (67 FR 17131), Phase II NODA (68 FR 13524), Phase III proposal (69 FR 68457), Phase III NODA (70 FR 71057), Phase III final (71 FR 35018), and Phase III final TDD (Chapter 3). Also see the proposed rule for existing facilities (76 FR 22174), the two NODAs (77 FR 34315 and 77 FR 34927), and the existing facility rule proposed TDD.

2.1.1 Survey Questionnaires

Industry characterization data, including facility-specific technical and financial information, for the existing facility rule and EPA's Phase I, 2004 Phase II, and Phase III rulemakings was collected through an industry-wide survey conducted in 2000.[1] This information was fundamental to EPA's development of its previous rulemakings and is similarly fundamental to the existing facilities rule. EPA has relied on the previously collected technical (e.g., cooling water system data and cooling water intake configuration specifications and intake flow rates) and financial information.[2, 3]

Two types of surveys were issued: detailed questionnaires (DQ) and short technical questionnaires (STQ). Detailed questionnaires were longer and requested more specific information about technologies, plant operations, and other characteristics. Short technical questionnaires were developed as a way to statistically sample a larger number of facilities while maintaining a manageable burden on the industry respondents; these surveys contained far less detailed information.

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[1] For the Phase III rule, EPA also issued industry questionnaires to offshore industries (see 69 FR 68458).

[2] Specific details about the questions are found in EPA's Information Collection Request (DCN 3– 3084-R2 in Docket W–00–03) and in the questionnaires (see DCN 3–0030 and 3– 0031 in Docket W–00–03 and the Docket for the proposed existing facilities rule); these documents are also available on EPA's web site (http://water.epa.gov/lawsregs/lawsguidance/cwa/316b/index.cfm)

[3] EPA did update some of the financial information. For a discussion of financial data used, see the EA.

2.1.2 Technology Efficacy Data

For the Phase II rule, EPA compiled a database of cooling water intake structure technology performance information otherwise known as the Technology Efficacy Database (TED) (DCN 6-5000 and FDMS Document ID EPA-HQ-OW-2002-0049-1595). The Technology Efficacy Database was the result of an extensive literature search supplemented by information obtained through discussions with State and EPA regional staff, and meetings with nongovernmental organizations that had conducted national or regional data collection efforts (e.g., Electric Power Research Institute (EPRI) and Tennessee Valley Authority). EPA's goal in developing this database was to collect information and data to evaluate the performance of various impingement and entrainment control technologies. The resulting database contains over 150 records from over 90 documents that include narrative descriptions of biological sampling information and efficacies for a range of impingement and entrainment minimization technologies. See Chapter 4 of the TDD for the 2004 Phase II Final rule for a complete description of this database. As described in Section 2.2.3 below, EPA updated and supplemented this database with new information and new analyses for today's final rule.

2.1.3 Existing Data Sources

In developing 316(b) regulations, EPA used existing data sources, where available and applicable. This includes information collected by other Federal agencies as well as data compiled by private companies. Additional details are found in the 2002 proposed Phase II rule at 67 FR17131, but the sources contacted include:

- Federal Energy Regulatory Commission (FERC);
- Energy Information Administration (EIA);
- Rural Utility Service (RUS);
- U.S. Nuclear Regulatory Commission (NRC);
- Utility Data Institute;
- NEWGen database;
- Electric Power Research Institute (EPRI); and
- Edison Electric Institute (EEI).

2.1.4 Public Participation Activities

Historically, EPA has worked extensively with stakeholders from industry, public interest groups, State agencies, and other Federal agencies in the development of previous 316(b) rulemakings, including numerous meetings with individual stakeholder groups. These public participation activities focused on various section 316(b) issues including biology, technology, and implementation issues. For example, EPA has conducted public meetings focused on technology, cost and mitigation issues, a technical symposium sponsored by EPRI and a symposium on cooling water intake structure technologies. See the 2002 proposed Phase II rule (68 FR 17127) for a discussion of these and other public participation activities.

EPA has also issued twelve Federal Register notices regarding the 316(b) regulation development process.[4] As a result, EPA has received over 1750 public comments from environmental groups, industry associations, facility owners, State and Federal agencies, and private citizens.

See below and the preamble to the final rule for more information on data provided by stakeholders and EPA's outreach efforts.

2.2 New Data Collected

For the existing facilities rule, EPA supplemented its previous data collection activities. EPA collected updated information on various aspects of the rulemaking. However, in an effort to better inform its BTA determination, EPA's main focus was on the performance of impingement and entrainment technologies.

2.2.1 Site Visits

As documented in the 2004 Phase II rule, EPA conducted site visits to 22 power plants in developing the 2004 rule. See 67 FR 17134. Since 2007, EPA has conducted over 50 site visits to power plants and manufacturing sites. The purpose of these visits was to: gather information on the intake technologies and cooling water systems in place at a wide variety existing facilities; better understand how the site-specific characteristics of each facility affect the selection and performance of these systems; gather data on the performance of technologies and affected biological resources; and to solicit perspectives from industry representatives.

While visiting certain sites, EPA also collected information on 7 additional facilities that staff did not physically visit; usually, these were other facilities that were owned by the parent company of a site visited by EPA. EPA further met with representatives of other companies or owners of specific power plant or manufacturing sites at EPA Headquarters in Washington DC.

In general, EPA visited a wide variety of sites representative of the industries and facilities subject to the existing facility rule. Copies of the site visit reports (which provide an overall facility description as well as detailed information on electricity generation, the facility's cooling water intake structure and associated fish protection and/or flow reduction technologies, impingement and/or entrainment sampling and associated data, and a discussion of the possible application of cooling towers) for each site were provided in the docket for the proposed existing facility rule (one was also provided in the June 12, 2012 NODA record). Where possible, EPA also made these reports publicly available well before publication of the proposed rule. A list of the facilities visited by EPA is provided in Exhibit 2-1 below; Exhibits 2-2 and 2-3 show the other facilities for which EPA was provided site-specific data and a geographic

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[4] See 65 FR 49060, 66 FR 28853, 66 FR 65256, 67 FR 17122, 68 FR 13522, 69 FR 41576, 69 FR 68444, 70 FR 71057, 71 FR 35006, 76 FR 22174, 77 FR 34315, and 77 FR 34927. Also see the EA and BA for a discussion of the Federal Register notices for economics-related issues.

representation of facilities visited by EPA as well as facilities for which EPA collected site-specific technical and engineering information.

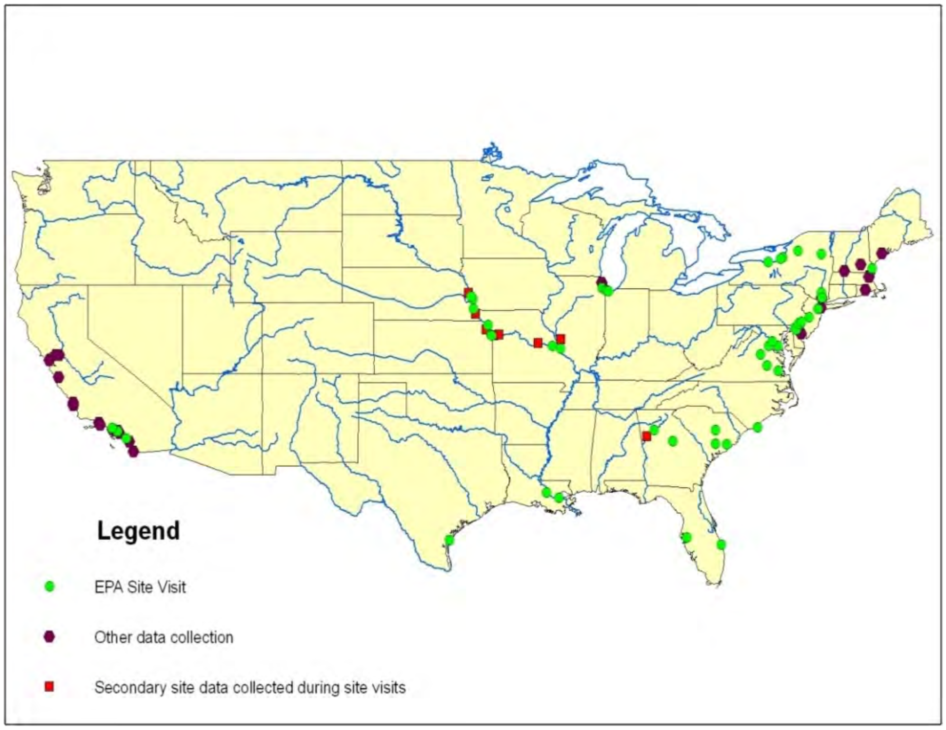
Exhibit 2-1. Facilities visited by EPA

Facility Name	State	Industry	Date Of Visit
El Segundo	CA	Generator	9/1/2009
Haynes	CA	Generator	9/2/2009
San Onofre	CA	Generator	9/2/2009
Scattergood	CA	Generator	8/31/2009
Valero (Delaware City)	DE	Manufacturer	7/15/2009
Big Bend	FL	Generator	3/27/2008
St. Lucie	FL	Generator	3/26/2008
Harlee Branch	GA	Generator	2/11/2009
McDonough	GA	Generator	2/11/2009
Council Bluffs	IA	Generator	3/2/2009
Crawford	IL	Generator	8/4/2009
Arcelor Mittal (Indiana Harbor)	IN	Manufacturer	8/3/2009
Cargill (Hammond)	IN	Manufacturer	8/3/2009
US Steel (Gary)	IN	Manufacturer	8/4/2009
Nearman Creek	KS	Generator	3/3/2009
Quindaro	KS	Generator	3/3/2009
Dow (Louisiana Operations/Plaquemine)	LA	Manufacturer	1/12/2010
Dow (St Charles)	LA	Manufacturer	1/13/2010
Chalk Point	MD	Generator	12/3/2007
Labadie	MO	Generator	3/4/2009
Lake Road	MO	Generator	3/3/2009
Meramec	MO	Generator	3/4/2009
Brunswick	NC	Generator	1/28/2008
Nebraska City	NE	Generator	3/2/2009
North Omaha	NE	Generator	3/2/2009
Seabrook	NH	Generator	4/17/2008
Linden	NJ	Generator	5/26/2010
Logan	NJ	Generator	1/22/2008
Mercer	NJ	Generator	5/26/2010
Salem	NJ	Generator	1/22/2008
Beaver Falls	NY	Generator	4/1/2008
Danskammer	NY	Generator	4/16/2008
East River	NY	Generator	4/15/2008
Ginna	NY	Generator	4/3/2008
Nine Mile Point	NY	Generator	4/2/2008
Oswego	NY	Generator	4/2/2008
Wheelabrator Westchester	NY	Generator	4/16/2008
Eddystone	PA	Generator	1/23/2008
Sunoco (Marcus Hook)	PA	Manufacturer	7/14/2009
Sunoco (Philadelphia)	PA	Manufacturer	7/14/2009
Canadys	SC	Generator	2/10/2009
Wateree	SC	Generator	2/10/2009
Williams	SC	Generator	2/9/2009
Barney Davis	TX	Generator	3/3/2008
Birchwood	VA	Generator	7/28/2011
Chesterfield	VA	Generator	3/10/2009
North Anna	VA	Generator	4/28/2009
Possum Point	VA	Generator	3/10/2009
Potomac	VA	Generator	12/3/2007
Surry	VA	Generator	1/28/2008

Exhibit 2-2. Facilities that provided data to EPA

Facility Name	State	Industry
Alamitos	CA	Generator
Contra Costa	CA	Generator
Diablo Canyon	CA	Generator
Diablo Canyon	CA	Generator
Encina	CA	Generator
Harbor	CA	Generator
Huntington Beach	CA	Generator
Mandalay	CA	Generator
Morro Bay	CA	Generator
Moss Landing	CA	Generator
Ormond Beach	CA	Generator
Pittsburg	CA	Generator
Potrero	CA	Generator
Redondo Beach	CA	Generator
South Bay	CA	Generator
Yates	GA	Generator
Fisk	IL	Generator
Winnetka	IL	Generator
Brayton Point	MA	Generator
General Electric (Lynn)	MA	Manufacturer
Callaway	MO	Generator
Hawthorn	MO	Generator
Iatan	MO	Generator
Sibley	MO	Generator
Sioux	MO	Generator
Georgia Pacific	multiple	Manufacturer
Cooper	NE	Generator
Fort Calhoun	NE	Generator
Hope Creek	NJ	Generator
Oyster Creek	NJ	Generator
Brooklyn Navy Yard	NY	Generator
Indian Point	NY	Generator
Elm Road	WI	Generator
Oak Creek	WI	Generator

Exhibit 2-3. Site visit locations and locations of other site-specific data collected



EPA used a wide variety of criteria in selecting the sites to visit, including the following factors:

- **Industry sector:** In 2007, EPA met with several trade associations to discuss data and information sources that would be useful to EPA as it updated analyses. EPA solicited industry recommendations for criteria for selecting sites, as well as suggestions for specific sites. Among generators, EPA visited facilities owned by utilities, non-utilities, and municipalities. For manufacturers, EPA visited steel mills, petroleum refineries, chemical manufacturers, and a food processing facility.[5]
- **Facility location:** EPA visited facilities in 8 EPA Regions and 20 States. Facilities were located on all types of waterbodies (ocean, estuary/tidal river, lake/reservoir, Great Lake and freshwater river). EPA also visited facilities on major waterbodies, such as the Missouri/Mississippi Rivers, the Gulf of Mexico, the Chesapeake Bay, and both the Pacific and Atlantic Oceans.
- **Intake technology:** Selected sites employed a wide range of intake technologies, including coarse and fine mesh traveling screens, Ristroph traveling screens, coarse and fine mesh wedgewire screens, offshore velocity caps, and barrier nets.

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[5] EPA was unable to schedule a visit to a pulp and paper facility, but based on the Agency's experience with other regulatory activities (including the Pulp and Paper Effluent Limitations Guideline) has found that this industry sector is not remarkably different from other manufacturers in terms of cooling water intake structures. EPA also met with Georgia Pacific and the American Pulp and Paper Association to better understand the use of cooling water and cooling water intake structures for this industry sector.

Sites also employed a variety of intake configurations, including shoreline, offshore, and intake canals.

- **Cooling system technology:** Most facilities visited employ once-through cooling, but EPA also visited multiple sites with closed-cycle cooling systems. Some facilities were designed and constructed as closed-cycle systems, while other sites retrofitted to closed-cycle cooling; some sites used combination cooling systems. EPA also visited sites with helper cooling towers.
- **Logistics:** Proximity to EPA Headquarters was a cost-effective way for multiple EPA staff to attend site visits. For non-local travel, proximity of sites to one another enabled clustered site visits, reducing travel costs and maximizing staff time onsite.
- **Biological data:** Most facilities were selected because they had conducted some form of performance study (impingement or entrainment) in recent years.
- **Fuel or generation type:** Selected sites used a variety of fuel types (coal, natural gas, nuclear, municipal waste). Most generated power through steam generation, but EPA also visited several combined cycle facilities.
- **Facility size:** EPA visited sites of all sizes, with a wide range of generating capacity (MW), intake flow (mgd), and land area. Additionally, EPA visited sites in rural areas, industrial areas, and in highly urbanized environments.

In summary, EPA learned the following from the site visits:

- A majority of facilities use coarse mesh screens. However, the screens are principally used to protect the facility from debris; as such facilities do not always optimize operation of the screens to protect fish;
- Costs are paramount to facility owners, as any costs could potentially impact planning and business decisions;
- While site-specific characteristics may set some facilities apart, most facilities (including manufacturers) were found to be very similar in how they use cooling water, how the intake technologies were selected and constructed, and challenges facilities faced in operating CWIS technologies;
- Long-term planning is important to facilities to maintain reliable energy supplies (issues such as repowering, air rules, increased energy demand, control of greenhouse gas (GHG) emissions, and local transmission issues have long-term implications);
- Closed-cycle cooling, while potentially expensive for some sites, is technically feasible at most sites;
- Some manufacturing facilities may use cooling water for contact cooling (such as quench water). Contact cooling is rarely observed at power plants.
- Manufacturers have different opportunities to reduce and reuse cooling water. In some cases, manufacturers have conducted water and energy audits that reduced total water withdrawals by more than half.

During the site visits, EPA collected current facility information including power generation, capacity, and fuel source; permit status; cooling water usage; and cooling water intake structure and IM&E technologies and controls (including design, operation, and installation and operational cost information, where available). Through the site visits, EPA gained a more thorough understanding of the operation of the various IM&E technologies and controls including challenges, or lack thereof, and efficacy. EPA also gained more detailed information on any IM&E performance studies at each site, and, ultimately, the performance data. EPA additionally obtained information on the application of the suspended Phase II rulemaking. For example, EPA requested information on how each facility planned to comply with the suspended 2004 rule, and what challenges might have resulted from implementation of the suspended rule at each facility. Finally, EPA also gained a better understanding of the possible application of closed-cycle cooling at each facility. As a result of these site visits, EPA gained valuable information covering a wide range of topics. Several facilities provided National Pollutant Discharge Elimination System (NPDES) permit application data originally intended for submission under the 2004 Phase II rule. These studies typically included Proposals for Information Collection as well as portions of Comprehensive Demonstration Studies. Several facilities also provided technology efficacy data or impingement and entrainment data. Some provided IM&E feasibility studies as well.

Following each visit, EPA prepared a site visit report. These reports document the information EPA collected through each site visit and its discussions with facility representatives. Each facility was given the opportunity to review and comment on these reports. Where the information is not claimed to be confidential, these reports are available in the record.

EPA also visited Alden Laboratories in Holden, Massachusetts.

2.2.2 Data Provided to EPA by Industrial, Trade, Consulting, Scientific or Environmental Organizations or by the General Public

EPA has continued to work with various stakeholders in developing the existing facilities rule. Through these interactions, EPA has received additional data and information including, but not limited to, the following: technology efficacy data, operating information, cost information, feasibility, and non-water quality related impact information.

2.2.2.1 EPRI and Industry

EPA met with representatives from EPRI and industry on topics ranging from the feasibility and cost of installing cooling towers at certain facilities, current studies of impingement on the Ohio River, and the latest advancements in fish protection technologies for traveling screens. Alden Laboratories also participated in some of these meetings and provided a status report on the latest advancements in fish protection at cooling water intake structures. EPA reviewed over 40 EPRI or EPRI-funded studies dated between 1985-2008, and multiple studies since the publication of the 2004 Phase II rule, including:

- Fish Protection at Cooling Water Intakes: A Technical Reference Manual (2007) (DCN 10-6813)
- Net Environmental and Social Effects of Retrofitting Power Plants with Once-Through Cooling to Closed-Cycle Cooling (2008) (DCN 10-6927)
- Beaudrey Water Intake Protection (WIP) Screen Pilot-Scale Impingement Survival Study (2009) (DCN 10-6810)
- Comparison of Alternate Cooling Technologies for U.S. Power Plants: Economic, Environmental, and Other Tradeoffs (2004) (DCN 10-6961)
- Laboratory Evaluation of an Aquatic Filter Barrier for Protecting Early Life Stages of Fish (2004) (DCN 10-6815)
- Field evaluation of wedgewire screens for protecting early life stages at cooling water intake structures: Chesapeake Bay studies (2006) (DCN 10-6806)
- Laboratory evaluation of modified Ristroph traveling screens for protecting fish at cooling water intakes (2006) (DCN 10-6801)
- Design considerations and specifications for fish barrier net deployment at cooling water intake structures (2006) (DCN 10-6804)
- Laboratory evaluation of fine-mesh traveling water screens for protecting early life stages of fish at cooling water intakes (2008) (DCN 10-6802)
- Latent impingement mortality assessment of the Geiger Multi-Disc screening system at Potomac River Generating Station (2007) (DCN 10-6814)
- The role of temperature and nutritional status in impingement of clupeid fish species (2008) (DCN 10-6970)
- Cooling Water Intake Structure Area-of-Influence Evaluations for Ohio River Ecological Research Program Facilities (2007) (DCN 10-6971)
- Closed-Cycle Cooling System Retrofit Study: Capital and Performance Cost Estimates (2011) (DCN 12-6807)
- Seasonal Patterns of Fish Entrainment for Regional U.S. Electric Generating Facilities (2011) (DCN 12-6892)
- Fish Life History Parameter Values for Equivalent Adult and Production Foregone Models: Comprehensive Update (2012) (DCN 12-6981)
- Effects of Fouling and Debris on Larval Fish within a Fish Return System (2012) (DCN 12-6801)
- Field Evaluation of Debris Handling and Sediment Clogging of 2.0 mm Fine-mesh Traveling Water Screen at the Hawthorn Power Plant, Missouri River, Kansas City, MO (2012) (DCN 12-6825)
- Full-Time/Seasonal Closed-cycle Cooling: Cost and Performance Comparisons (2012) (12-6945)

Materials from some of these meetings (e.g., PowerPoint presentations and demonstration movies) are available at DCNs 10-6816 to 10-6828.

2.2.2.2 Vendors

EPA also contacted cooling water intake structure technology vendors to investigate the use of several new technologies for potential application at existing facilities. EPA contacted or received detailed data from the following technology vendors:

- Beaudrey screens (DCN 10-6606)
- Hydrolox screens (DCN 10-6807)
- Passavant (Geiger) screens (DCNs 10-6601A and B)
- Hendricks screens (DCNs 10-6601C and D)
- EIMCO screens
- Agreco (modular cooling towers) (DCNs 10-6647 and 6677)
- Blue Stream Services (modular cooling towers) (DCN 10-6677)
- EEA (substratum intakes) (DCN 10-6609)
- Gunderboom
- Sontek (acoustic velocimeters)

Vendors provided information on design, operation, and efficacy of these technologies as well as capital and O&M costs. See the record for the existing facilities rule for this information.

2.2.3 Updated Technology Information

As discussed in Section 2.1.2 and in the 2002 proposed Phase II rule (68 FR 13538-13539), EPA previously developed a Technology Efficacy Database in an effort to document and assess the performance of various technologies and operational measures (other than closed-cycle cooling[6]) designed to minimize the impacts of cooling water withdrawals (see DCN 6-5000 in the docket for the 2004 Phase II rule). EPA has since created an updated performance database for modified traveling screens. In creating the updated database, EPA's objective was to review the methods used to generate data in these studies and to combine relevant data across studies in order to produce statistical estimates of the overall performance of the technology. See DCN 12-5400 in the final rule record for this database.

In developing the updated database, EPA considered data from over 473 documents. This includes documents previously contained in EPA's 316(b) rulemaking records as well as new documents obtained during development of the existing facilities rule. Some of the documents are compilations of multiple studies, such as, EPRI's 2007 Fish Protection at Cooling Water Intakes: A Technical Reference Manual (DCN 10-6813), which includes results of over 100 studies. Others are facility-specific studies, or describe the results of research laboratory experiments conducted in a controlled setting. These documents contain information on the operation or performance of various forms and applications of

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[6] EPA developed this database to evaluate possible BTA limitations for intake-based technologies. EPA did not include closed-cycle cooling in this database because that technology operates through a reduction in flow, creating a different set of evaluation criteria.

these technologies, typically at a specific facility or controlled setting. The studies presented in these documents were performed by owners of facilities with cooling water intake structures, organizations that represent utilities and the electric power industry, and other research organizations.

To address EPA's objectives of bringing information from these documents together to better assess technology performance across different technology categories, EPA obtained and reviewed these documents for the presence of relevant data. Not all documents fulfilled this objective. While a document might present data that were acceptable for use in meeting the document's original objectives, this does not necessarily imply that these data will meet EPA's current objective to combine data across multiple sources to better assess performance of the different technology categories. Thus, it was necessary to establish some general criteria for accepting data from the documents:

- The data must be associated with technologies for minimizing impingement mortality or entrainment that are currently viable (as recognized by EPA) for use by industries with cooling water intake structures that are (or will be) subject to section 316(b) regulation.
- The data must represent a quantitative measure (e.g., counts, densities, or percentages) that is related to the impingement mortality or entrainment of some life form of aquatic organisms within cooling water intake structures under the given technology.

For studies meeting the above criteria, EPA populated an Excel database. Within this database, each document was distinguished by a unique document ID. The performance study database consisted of two primary data tables:

- A table containing specific information on a particular study, such as the document and study IDs, facility name, date of study, data classification - (e.g., impingement mortality, entrainment), technology category, technology description, survival holding times, and other test conditions when specified (e.g., mesh size, intake velocity, conditions when the technology is in place).
- A table containing the reported performance data for a given study. Each entry in this table contains one or more performance measures for a particular species along with other factors when they were specified (e.g., dates or seasons of data collection, elapsed time to mortality, number impinged, number or percent dead).

EPA used this database to develop performance estimates for certain intake technologies, and to compare the national performance levels for various impingement mortality and entrainment technologies. The screening criteria, methodology, and subsequent statistical analyses conducted to develop national performance standards are discussed in detail in Chapter 11 of this TDD.

2.2.4 Other Resources

EPA also collected information on cooling water system and cooling water intake structure-related topics from a variety of other sources.

2.2.4.1 State Cooling Water Policies

In recent years, several states have developed policies or regulations regarding cooling water use. EPA did not participate directly in the development of any of these state activities, but did closely monitor their progress. These State programs are summarized below.

California

California's Ocean Protection Council (OPC) adopted the April 20, 2006 resolution called *Regarding the Use of Once-Through Cooling Technologies in Coastal Waters* (2006 Resolution, DCN 10-6963) which urged State agencies to "implement the most protective controls to achieve a 90–95 percent reduction in [impingement and entrainment] impacts" and analyze the costs and constraints involved with the conversion of once-through cooling systems to an alternative technology. In February 2008, OPC completed a study entitled, *California's Coastal Power Plants: Alternative Cooling System Analysis*, (DCN 10-6964) which evaluates the feasibility of retrofitting coastal facilities to closed-cycle cooling towers to mitigate impingement and entrainment impacts at these sites. EPA reviewed this study to identify site-specific considerations involved in cooling tower retrofits.

California adopted its final Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling on May 4, 2010. (See http://www.waterboards.ca.gov/water_issues/programs/ocean/cwa316/ for more information). Per the State website, the Policy "establishes technology-based standards to implement Federal Clean Water Act section 316(b) and reduce the harmful effects associated with cooling water intake structures on marine and estuarine life. The Policy will apply to the 19 existing power plants (including two nuclear plants) that currently have the ability to withdraw over 15 billion gallons per day from the State's coastal and estuarine waters using a single-pass system, also known as once-through cooling." The Policy requires that existing facilities reduce their intake flow to a level commensurate with a wet closed-cycle system; California established a 93 percent reduction in design flow as the minimum flow reduction, in addition to limiting intake velocities to 0.5 feet per second (fps).[7]

California also proposed an amendment to the final Policy to extend the implementation schedule for certain facilities that are planning to undergo repowering projects. The State solicited comments, held public meetings, and adopted the amended policy on July 19, 2011. The State is also considering additional minor amendments to the policy, as described at their June 18, 2013 meeting.

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[7] The Policy also contains a Track 2 that permits facilities to demonstrate that compliance with Track 1 (described above) is not feasible; these facilities must reduce impingement mortality and entrainment to at least 90 percent of the level achievable by compliance with Track 1.

Delaware

In March 2009, Delaware's House of Representatives introduced House Concurrent Resolution No. 7 (HCR 7)[8]; the resolution urges the Delaware Department of Natural Resources and Environmental Control (DNREC) to "declare that "Closed-cycle" cooling systems constitute the best technology available for water cooling intake structures" and "to require that all facilities that operate in Delaware waters and that use cooling water intake structures to adopt "Closed-cycle" cooling systems as quickly as possible." The resolution also notes the biological impacts associated with once-through cooling. The resolution was adopted (as amended) by the State Senate and the State House in June 2009. At the time of publication of the final rule, Delaware had not yet enacted a State regulation, but several facilities had made strides in reducing cooling water flows. A DNREC permit fact sheet[9] noted that the State's largest power plant (Indian River, located in Millsboro) is closing all three generating units that employ once-through cooling,[10] leaving Indian River with only a closed-cycle cooling system for Unit 4. During EPA's site visit to the Valero refinery in Delaware City, facility representatives noted that their upcoming NPDES permit would require a substantial flow reduction.[11]

New York

In July 10, 2011 New York issued a policy that would require a reduction in impingement and entrainment mortality to a level equivalent to closed-cycle cooling at all existing facilities.[12] The policy does not specifically require a reduction in cooling water flow, however, noting that flow is but one of several alternatives. New York also requires all new power plants to employ dry cooling systems, which reduce water withdrawals even further than wet cooling towers.

2.2.4.2 Individual NPDES Permit Renewals

In addition to state-wide cooling water policies, some recent individual NPDES permits have incorporated requirements for significant reductions in cooling water flow. The best-known example is Brayton Point in Somerset, Massachusetts. EPA Region I (which develops NPDES permits for several non-delegated New England states) issued a final NPDES permit in October 2003 that required a reduction in cooling water intake flow

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[8] See http://legis.delaware.gov/LIS/LIS145.NSF/93487d394bc01014882569a4007a4cb7/674b902d7832ddd785257583005af947?OpenDocument.

[9] See http://www.wr.dnrec.delaware.gov/SiteCollectionDocuments/IRGS%20FactSheet_20100908.pdf.

[10] In December 2004, EPA Region III developed a Total Maximum Daily Load (TMDL) for temperature in the Indian River. The Indian River power plant is the only significant discharger to the receiving stream. See http://www.epa.gov/waters/tmdldocs/IndianRiveEstablish.pdf and http://www.epa.gov/waters/tmdldocs/DE/IndianRiverEstablish_Report.pdf.

[11] See DCN 10-6553. The facility closed soon after the site visit, but was purchased by another firm and has since reopened. As an NPDES condition for the renewed operations at the facility, DNREC has included a requirement to reduce its intake flow by 33 percent by the end of 2013. See http://www.dnrec.delaware.gov/News/Pages/DNREC-issues-air-permit-to-restart-cooling-tower-at-Delaware-City-Refinery-.aspx.

[12] NYDEC Policy CP-#52 / Best Technology Available (BTA) for Cooling Water Intake Structures. See: http://www.dec.ny.gov/docs/fish_marine_pdf/btapolicyfinal.pdf.

and thermal discharges of approximately 95 percent.[13] Following several years of appeals and litigation, the facility agreed in December 2007 to implement the requirements of the permit and is currently constructing two natural draft cooling towers at the facility.

EPA also visited a number of sites that had retrofitted to closed-cycle cooling for reasons other than solely section 316(b) requirements:

- McDonough (GA), Yates (GA), Canadys (SC) and Wateree (SC) converted all generating units to closed-cycle cooling primarily to reduce thermal discharges. (See DCNs 10-6536, 10-6538, 10-6535, and 10-6534, respectively.)
- Nearman Creek (KS) converted its generating units to reduce the need for cooling water at times of the year when the source water level is low. (See DCN 10-6524.)
- Linden (NJ) constructed several new combined cycle units to replace retiring fossil units and uses grey water from a nearby treatment plant for its makeup water. (See DCN 10-6557.)

While the reasoning for some retrofits may not explicitly include consideration of 316(b), flow reduction is clearly an issue in the forefront of permitting and operational decisions at many facilities. Even in cases where 316(b) was not a consideration, the benefits to aquatic communities are realized nonetheless.

2.2.4.3 International Cooling Water Policy

EPA sought information on how other nations address the impacts from cooling water withdrawals. (See, e.g., DCNs 10-6620 and 6621.) In general, EPA found that many countries lack an overarching regulatory structure analogous to section 316(b), so efforts to address impacts from cooling water intake structures tend to be somewhat inconsistent. Some countries address the issue on a facility-by-facility basis, while others may make broader conclusions based on facility location. EPA's research did indicate a distribution of once-through and closed-cycle cooling systems similar to that found in the U.S. Lastly, EPA collected a European Union policy on cooling systems (see DCN 10-6846), which generally advocated that plant efficiency should be the primary decision criterion in determining the proper cooling system.

2.2.4.4 EPA's 1974 Steam Electric Effluent Limitation Guideline

EPA also reviewed its 1974 ELG for steam electric generators, as this was the Agency's first attempt at regulating cooling water withdrawals. In the 1974 final ELG (see 39 FR 36186), any existing electric generator built after 1970 with a capacity greater than 500 MW or any generating unit built after 1974 would have been required to retrofit to closed-cycle cooling; all new units were to be subject to the same standard. EPA's rationale at the time was that these facilities were relatively new, operated as baseload facilities, and would be in service for an extended period, thereby justifying the costs to retrofit. EPA considered many of the same factors in the ELG that it did in developing

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[13] See http://www.epa.gov/ne/braytonpoint/index.html.

the existing facilities rule. The rule was remanded on administrative grounds and the subsequent revised ELG (see 47 FR 52290) was silent on cooling water withdrawals and cooling system types.

2.2.5 Implementation Experience

Following promulgation of the 2004 Phase II rule, States and EPA Regions began to implement the rule. During that time, EPA worked to assist States in understanding the rule, develop guidance materials, and support the review of the documentation of the new requirements. As a result, EPA became aware of certain elements of the 2004 rule that had become particularly troublesome to implement; as a result, EPA has considered these challenges and crafted a regulatory framework that the Agency concludes is simpler for all stakeholders to understand and implement.

2.2.5.1 Calculation Baseline

The 2004 Phase II rule required that facilities reduce impingement mortality and entrainment from the calculation baseline. The calculation baseline was intended to represent a “typical” Phase II facility and outlined a configuration for a typical CWIS (see 69 FR 41590). EPA defined the calculation baseline as follows:

> “an estimate of impingement mortality and entrainment that would occur at your site assuming that: the cooling water system has been designed as a once-through system; the opening of the cooling water intake structure is located at, and the face of the standard 3/8 inch mesh traveling screen is oriented parallel to, the shoreline near the surface of the source waterbody; and the baseline practices, procedures, and structural configuration are those that [a] facility would maintain in the absence of any structural or operational controls, including flow or velocity reductions, implemented in whole or in part for the purposes or reducing impingement mortality and entrainment.”

In doing so, a facility that had undertaken efforts to reduce impingement and entrainment impacts (e.g., by installing a fine mesh screen or reducing intake flow) would be able to “take credit” for its past efforts and only be required to incrementally reduce impingement mortality or entrainment to meet the performance standards.

In practice, both permittees and regulatory agencies encountered difficulty with the calculation baseline, specifically how a facility should determine what the baseline represented and how a particular facility’s site-specific configuration or operations compared to the calculation baseline. For facilities whose site configuration conforms to the calculation baseline, it was relatively easy to determine impingement mortality and entrainment at the conditions representing calculation baseline. However, for facilities that have a different configuration, estimating a hypothetical calculation baseline could be difficult. For example, facilities with intake configuration that differed significantly from the calculation baseline (e.g., a submerged offshore intake) were unsure as to how to translate their biological and technological data to represent a shoreline CWIS. Oftentimes facilities encountered difficulty in determining the appropriate location for monitoring to take place. Other facilities were unsure as to how to take credit for retired generating units and other flow reductions practices. In site visits, EPA learned that facilities with little or no historical biological data encountered a particularly difficult and time-intensive task of collecting appropriate data and developing the calculation baseline. As a result, EPA has developed a new approach to the technology-based requirements that does not require a calculation baseline.

2.2.5.2 Entrainment Exclusion Versus Entrainment Survival

As EPA worked towards revising the existing facility rules, EPA discovered a nuance to the performance based requirements of the 2004 Phase II rule: entrainment exclusion versus entrainment survival. As discussed in Section III.C in the proposed rule preamble, EPA re-reviewed the data on the performance of intake technologies and conducted statistical analysis of the data. From this analysis, it became apparent that the 2004 Phase II rule did not fully consider the true performance of intake technologies in affecting “entrainable” organisms.

By definition, entrainment is the incorporation of aquatic organisms into the intake flow, which passes through the facility and is then discharged. In order to pass through the technologies located at the CWIS (e.g., intake screens, nets, etc.), the organisms must be smaller than the smallest mesh size.[14] For coarse mesh screens (3/8” mesh size), most “entrainables” simply pass through the mesh (and through the facility) with only some contact with the screen.[15] In this situation the mortality of organisms passing through the facility was assumed to be 100 percent, although some facilities have since collected data showing survival of certain hardier species and lifestages of aquatic organisms. However, as mesh sizes are reduced,[16] more and more entrainables will actually become impinged on the screens (i.e., “converted” from entrainable to impingeable) and would then be subjected to spray washes and return along with larger impinged organisms as well as debris from the screens. Under the 2004 Phase II rule, these “converts” would be classified as a reduction in entrainment, since the entrainment performance standard simply required a reduction in the number (or mass) of entrained organisms entering the cooling system. However, for some facilities, the low survival rate of converts would have resulted in the facility have difficulty complying with the impingement mortality performance standards. By comparison, the performance standard for impingement was measured as impingement mortality. Organisms that were impinged (i.e., excluded) from the CWIS were typically washed into a return system and sent back to the source water. In this case, impingement mortality is an appropriate measure of the biological performance of the technology.

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[14] In the case of many soft-bodied organisms such as eggs and larvae, the force of the intake flow can be sufficient to bend organisms that are actually larger than the screen mesh and pull them into the cooling system.

[15] Eggs are generally smaller than 2 millimeters in diameter, while larvae head capsids are much more variable in size, increasing as they mature to the juvenile stage.

[16] Fine mesh screens were considered to be one technology that could be used to meet the entrainment performance standards under the 2004 Phase II rule. EPA also reviewed performance data for screens with mesh sizes as small as 0.5 mm, as described in section III.C.

Through EPA's review of control technologies, the Agency found that the survival of "converts" on fine mesh screens was very poor, and in some extreme cases comparable to the extremely low survival of entrained organisms that are allowed to pass entirely through the facility.[17] More specifically, EPA found that most eggs were entrained unless the mesh slot size was 2.0 mm or less, and mortality of eggs "converted" to impingement approached 20 to 30 percent. More telling, the mortality of larvae off a fine mesh screen was rarely less than 80 percent. As a result, a facility with entrainment exclusion technologies such as fine mesh screens could approach 90 percent performance, but the subsequent survival of these organisms overall ranged from 0 to 52 percent, and the facility's impingement mortality rates increased. In other words, a facility that simply excluded entrainable organisms (with no attention being paid to whether they survive or not) could be deemed to have met its entrainment requirements under the 2004 Phase II rule, when in fact it may be causing the same level of mortality as a facility with no entrainment controls at all.

2.2.5.3 Cost-Cost Test

In the 2004 Phase II rule, EPA developed facility-specific cost estimates, and published those costs in Appendix A (69 FR 41669). The 2004 Phase II rule also included a cost-cost test (see 69 FR 41644) where a facility could demonstrate that its costs to comply with the 2004 rule were significantly greater than those that EPA had considered. Since initial implementation of the July 9, 2004 316(b) Phase II rule, EPA has identified several concerns with the facility-specific cost as well as the use of that cost in Appendix A. First, EPA has identified numerous inconsistencies between facility permit applications, responses in the facility's 316(b) survey, and overall plant capacity as reported in the most recent EIA database. These inconsistencies resulted in Appendix A costs that were not comparable to many facility's own compliance cost estimates.

In addition, as described more fully in Chapter 8, EPA does not have available technical data for all existing facilities. EPA obtained the technical data for facilities through industry questionnaires. In order to decrease burden associated with these questionnaires, EPA requested detailed information from a sample, rather than a census, of facilities. EPA has concluded that the costs provided in Appendix A are not appropriate for use in a facility-level cost-cost test. As a result, EPA is not providing a framework similar to Appendix A in the existing facilities rule. (See the final rule preamble and Chapter 8 of the TDD for more information about how EPA developed compliance costs.) The impingement mortality requirements of the existing facilities rule are economically achievable,[18] and the low variability in the costs of IM controls at a facility makes such a provision ineffectual. Furthermore, the existing facilities rule requirements for entrainment mortality requires facilities to submit facility-specific compliance cost estimates. The determination of whether the cost of specific entrainment mortality

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[17] Through-plant entrainment survival has been studied extensively, with EPRI's Review of Entrainment Survival Studies being amongst the most comprehensive. See DCN 2-017A-R7 from the Phase I docket.

[18] The Phase II rule found impingement mortality (plus entrainment on certain waterbodies) was economically achievable; EPA has not identified any reason this revising this conclusion. See Response to Comment 316bEFR.330.009 in the Phase II Response to Comment Document (DCN 6-5049).

technologies is too high is made by the Director on a site-specific basis; accordingly a cost-cost provision is unnecessary.

2.2.6 New or Revised Analyses

In addition to collecting new information, EPA has re-evaluated some existing data and analyses.

2.2.6.1 Review of Study Data/New Performance Database

The standards of the 2004 Phase II regulation required impingement mortality reduction for all life stages of fish and shellfish of 80 to 95 percent from the calculation baseline (for all Phase II facilities) and entrainment reduction requirements of 60 to 90 percent (for certain Phase II facilities). EPA based these performance requirements on a suite of technologies and compliance alternatives.

For the existing facilities rule, EPA reanalyzed BTA. This includes, but is not limited to, a re-analysis of candidate BTA technologies, their effectiveness, their costs, and their application. This section highlights some of the major changes resulting from this re-analysis. See the preamble for today's final rule for a thorough discussion of EPA's updated BTA analysis and determination.

New Performance Database

As described above, in its section 316(b) rule development efforts to date, EPA has gathered industry documents and research publications with information from studies which evaluated the performance of a range of technologies for minimizing impingement or entrainment.

EPA subsequently used this database to develop impingement mortality and entrainment performance standards. However, as described in the preamble, the performance data for screens and other intake technologies did not indicate that those technologies were nearly as effective at minimizing impingement and entrainment as closed-cycle cooling.

Impingement Mortality and Entrainment Technology Performance Estimates

To evaluate the effectiveness of different control technologies and the extent to which the various regulatory options considered for the existing facilities rule minimize adverse environmental impacts associated with cooling water intake structures, EPA used the data collected in the new analysis to develop impingement mortality and entrainment reduction estimates. For some technologies, the existing facilities rule reflects updated information or a different methodology for estimating effectiveness.

2.2.6.2 Cooling Towers

In the 2004 Phase II rule, EPA estimated facilities employing freshwater cooling towers and saltwater cooling towers would achieve flow reductions, and therefore associated entrainment and impingement mortality reductions, of 98 percent and 70-96 percent, respectively.[19] At that time, EPA's record demonstrated that saltwater cooling towers typically operated at 1.1-2.0 cycles of concentration. However, more recent information demonstrates that, as a result of advances in design and operation, saltwater cooling towers typically operate at 1.5 cycles of concentration (COC) or more. This equates to a 94.9 percent reduction in flow over a once-through cooling system. To better reflect the advances in cooling tower design, EPA now estimates that freshwater cooling towers and saltwater cooling towers reduce impingement mortality and entrainment by 97.5 percent (based on a COC of 3.0) and 94.9 percent, respectively.[20]

2.2.6.3 Exclusion Technologies

As discussed in Chapter 6, screens and other technologies operate using a principle of excluding organisms from entering the cooling system. For technologies other than cooling towers, EPA generally calculated their efficacy as the mean percent efficacy of the available data. Because EPA has sufficient data to evaluate impingement *mortality*, its impingement mortality technology efficacy calculations account for mortality. However, because EPA has data on entrainment exclusion but lack sufficient entrainment *mortality* data to calculate exclusion technology entrainment mortality efficacy, EPA's calculated mean entrainment percent efficacy does not account for mortality. In reality, whether or not an organism is excluded from the cooling water intake does not minimize entrainment-related environmental impacts unless the excluded organisms survive and ultimately are returned back to the waterbody. Available data on the technology basis demonstrate that entrainment reductions associated with fine mesh technologies vary depending on life stage and mesh size.

In the 2004 Phase II rule, EPA made the assumption that any organism entrained died (i.e., 100 percent mortality for organisms passing through the facility) and any organism not entrained survived. In other words, if a technology reduced entrainment by 60 percent, then EPA estimated 40 percent of the organisms present in the intake water would die in comparison to 100 percent in the absence of any entrainment reduction. As explained in this section EPA has received new data on this issue, and found that some sites could demonstrate entrainment survival of select hardier species under certain conditions. However, the overall entrainment survival is still extremely low. As such, EPA has not altered its conclusion that, for purposes of national level estimates, entrainment leads to 100 percent mortality of entrainable organisms.

EPA analyzed the limited data on the survivability of organisms that are "converted" from entrained to impinged on fine mesh screens. These data show that under most operational conditions, many, if not all, larvae may die as a result of the impact on fine mesh screens. In the case of eggs, the data indicate that some species may die, while others may survive. The data also demonstrate that if the organisms can withstand the

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[19] As discussed in the preamble, impingement mortality and entrainment reductions are proportional to flow reductions.

[20] Note that, in the final rule, EPA is not including explicit requirements for cooling towers to achieve a specific percent reduction or COC. EPA provided these COC values as indicative of cooling towers that are being properly operated to minimize makeup and blowdown flows.

initial impingement on the fine mesh screen, the majority of organisms survive after passing through a fish return and returning to the source water.

2.2.6.4 Compliance Cost Methodology

To assess the economic impact of various regulatory control options, EPA estimates the costs associated with regulatory compliance. These costs of compliance may include initial fixed and capital costs, annual operating and maintenance costs, downtime costs, recordkeeping, monitoring, studies, and reporting costs. The costs estimates reflect the incremental costs attributed only to the existing facilities rule.

For the purposes of estimating incremental compliance costs attributable to regulatory requirements, EPA traditionally develops either facility-specific or model facility costs. Facility-specific compliance costs require detailed process information, including production, capacity, water use, overall management, monitoring data, geographic location, financial conditions, and other industry-specific data for each facility. When facility-specific data are not available, EPA develops model facilities to provide a reasonable representation of the industry.

As discussed in the preamble and the TDD, model facility costs were developed for facilities that completed a detailed industry questionnaire (and therefore the facilities for which EPA had the best and most detailed information) and national costs were estimated by multiplying model facility costs by a weighting factor.

EPA has also adopted a new methodology for estimating costs for retrofitting to closed-cycle cooling. EPRI developed a cost model that incorporates facility-specific data and reflects state-of-the-art cooling tower design. This model was based on a number of site-specific engineering design studies at facilities across the U.S. and incorporates a wide variety of site conditions and facility characteristics. The model is also capable of incorporating design features such as plume abatement.

EPA also made other changes to its costing assumptions and approaches. For a summary discussion of these revisions, see the preamble and Chapter 8 of the TDD.

2.2.6.5 Case Studies (Environmental Impacts, Thermal Impacts)

EPA conducted a brief review of NPDES 316(a) and (b) conditions in NPDES permits.

Addressing Section 316(a) Permit Provisions

The various methods used to address relevant CWA section 316(a) provisions in permit limitations for thermal discharges are compared in Exhibit 2-4.[21] Of the 103 permits reviewed, approximately half (53 percent) had some form of effluent temperature limitations. These were divided between facility permits with some form of an EPA-approved 316(a) variance (33 percent) and those with temperature limits based on either State temperature standards or a State-approved model or mixing zone study (20 percent).

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[21] For a description of the entire analysis, see DCN 10-6623.

Exhibit 2-4. Methods used to address Section 316(a) requirements by EPA Region

EPA Region[1]	Permits	None Given (Towers in place)		Not Specified		No Temp. Limits/ No Monitoring		Temp. Guidance/ Monitoring Only		Application of State Temp. Limits/ Mixing Zone (No 316(a) Req.)		316(a) Variance Study	
2	8							2	(25%)	3	(38%)	3	(38%)
3	15	1	(7%)			1	(7%)	3	(20%)	2	(13%)	8	(53%)
4	23					3	(13%)	6	(26%)	4	(17%)	10	(43%)
5	20							10	(50%)	3	(15%)	7	(35%)
6	19	3	(16%)	2	(11%)	5	(26%)	3	(16%)	6	(32%)		
7	5							3	(60%)	1	(20%)	1	(20%)
9	5	1	(20%)									4	(80%)
10	8			3	(38%)	1	(13%)	1	(13%)	2	(25%)	1	(13%)
Total	103	5	(5%)	5	(5%)	10	(10%)	28	(27%)	21	(20%)	34	(33%)

[1] No permits from Regions 1 or 8 were included in the permit review

For the 47 percent of the facilities with no temperature limits in their permit; approximately 27 percent had temperature monitoring and reporting requirements. The remaining 20 percent of the facilities had no permit-based temperature limitations (this included 5 percent with existing cooling towers).

Of the 34 permits with approved 316(a) variances, 17 were approved with historic evaluation studies that were typically 15-25 years old or of indeterminate vintage (i.e., insufficient evidence to date effort), with two of these scheduled for a re-evaluation during the next permit cycle. For 10 of the 13 permits with historic variance studies, the regional permit quality review (PQR) material indicated that documentation of the study was not available as part of the permit package. Seventeen facilities had updated 316(a) studies that had been completed within the last five years.

A comparison was made of the section 316(a) permit provisions between electrical power generating plants and manufacturers nationwide. The large majority (77 percent) of the twenty-two manufacturing facilities had either no effluent temperature limitations or monitoring and reporting requirements. None of manufacturers had an approved 316(a) variance study whereas 42 percent of the power plants did.

Addressing Section 316(b) Permit Provisions

The various methods used to address relevant section 316(b) provisions in permit limitations are compared in Exhibit 2-5. A breakdown of the compliance categories indicates that 51 percent of the facilities' permit conditions contained little or no references to 316(b) regulations. Further analysis of the 316(b) provision status nationwide indicates that none of the manufacturing facilities had 316(b) requirements specified in their permits, while 36 percent of the generators had none.

Exhibit 2-5. Methods used to address Section 316(b) requirements by EPA Region

EPA Region	Permits	Not Specified		None		CDS[a], not initiated		CDS, ongoing		Approved permit conditions				New Facility (subject to Phase I)		None Given (Tower in place)	
										Historic Evaluations		Current Re-evaluation					
2	8	4	(50%)			1	(13%)					3	(38%)				
3	15	3	(20%)			4	(27%)	3	(20%)	1	(7%)			2	(13%)	2	(13%)
4	23	15	(65%)			2	(9%)			3	(13%)	2	(9%)			1	(4%)
5	20	5	(25%)			3	(15%)	4	(20%)	4	(20%)	4	(20%)				
6	19	13	(68%)	2	(11%)			2	(11%)			2	(11%)				
7	5	2	(40%)			3	(60%)										
9	5					4	(80%)									1	(20%)
10	8	8	(100%)														
Total	**103**	**50**	**(49%)**	**2**	**(2%)**	**17**	**(17%)**	**9**	**(9%)**	**8**	**(8%)**	**11**	**(11%)**	**2**	**(2%)**	**4**	**(4%)**

[a] “CDS” refers to Comprehensive Demonstration Study

Approximately 19 percent of the facilities had an approved 316(b) demonstration; which included 11 percent that were scheduled for a re-evaluation during the next permit cycle. Nine percent of the facilities reportedly had initiated a CDS investigation while 17 percent were required to conduct the CDS within the current 5-year permit cycle but had not started at the time of permit issuance. The current status of these CDS activities is uncertain due to the remand of the Phase II facility 316(b) regulations in midst of the current permit cycle. Specifically, on July 9, 2007 (72 FR 37107), EPA suspended the bulk of the Phase II 316(b) regulation and announced that, pending further rulemaking (currently ongoing), permit requirements for cooling water intake structures at Phase II facilities should be established on a site-specific, best professional judgment (BPJ) basis.

Of the 103 facilities reviewed, eleven facilities had cooling towers already installed with an additional six facilities in the process of installing cooling towers.

Overview of New or Revised Analyses

A review of 103 NPDES permits, together with corresponding factsheets and relevant EPA PQR documents, identified permit effluent limitations and/or operating conditions pertaining to how generation and manufacturing facilities dealt with potential sections 316(a) and 316(b) permit provisions. Based on this review:

- Of the permits reviewed, 53 percent had effluent temperature limitations either based on EPA-approved 316(a) variance (33 percent of all facilities) or State-approved models or mixing zone studies (20 percent). The remaining facilities either had no temperature limits (20 percent) or monitoring only (27 percent);
- For facilities with approved 316(a) variances, about half were based on historic studies or required re-evaluation the following permit cycle, while half were based on updated 316(a) studies conducted within the last five years;
- Permit temperature limitations for maximum temperature varied widely between states and environmental settings. Permit limits for allowable deviation from

ambient conditions generally adhered to States water quality temperature standards;

- Over half (51 percent) of the NPDES permits reviewed did not contain any reference to section 316(b) requirements. However, inclusion of 316(b) compliance requirements varied widely between permits for manufacturing facilities (0 percent included 316(b) requirements) and generators (64 percent); and
- Cooling towers were installed in 11 and were scheduled to be installed at six of the 103, or 16 percent of all, facilities considered.

2.2.6.6 Closed-cycle Cooling

EPA considered a wide variety of technical aspects associated with retrofitting cooling towers, including (but not limited to) the availability of land, noise and plume effects, evaporative losses, and nuclear safety concerns.

As discussed in Chapter 10 of the TDD, EPA had previously conducted analyses for these effects; Chapter 10 provides the updated analyses.

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Chapter 3: Scope/Applicability of Final Rule

3.0 Introduction

The final rule includes all existing facilities with a DIF of more than 2 mgd. EPA estimates that a total of 1,065 facilities will be subject to the final rule, including 544 Electric Generators, 509 Manufacturers in six Primary Manufacturing Industries, and 12 Manufacturers in Other Industries. The rule also clarifies the definition and requirements for new units at existing facilities. The applicable requirements are summarized in Exhibits 3-1 and 3-2.

Exhibit 3-1. Applicability by phase of the 316(b) rules

Facility characteristic	Applicable rule
New power-generating or manufacturing facility	Phase I rule
New offshore oil and gas facility	Phase III rule
New unit at an existing power-generating or manufacturing facility	This rule
Existing power-generating or manufacturing facility	This rule
Existing offshore oil and gas facility and seafood processing facilities	This rule (site-specific, BPJ)

Exhibit 3-2. Applicable requirements of today's rule for existing facilities

Facility characteristic	Applicable requirements
Existing facility with a DIF greater than 2 mgd and an AIF (actual intake flow) greater than 125 mgd	Impingement mortality requirements at 40 CFR125.94(c) (categorical rule) and Director determination of BTA for entrainment based on characterization and study requirements at 40 CFR125.94(d)
Existing facility with a DIF greater than 2 mgd but AIF not greater than 125 mgd	Impingement mortality standards at 40 CFR 125.94(c) and Director determination of BTA for entrainment requirements under 40 CFR125.94(d)
New unit at an existing facility where the facility has a DIF greater than 2 mgd	New unit entrainment standards at 40 CFR125.94(e) (categorical rule)
Other existing facility with a DIF of 2 mgd or smaller or that has an intake structure that withdraws less than 25 percent of the water for cooling purposes on an actual intake flow basis	Site-specific, BPJ

At an early stage in the development of section 316(b) requirements, EPA divided its rulemaking effort into three phases. The first addressed new facilities, the second, large existing electricity utility facilities and the third, the remaining electric generating facilities not addressed in the earlier phases as well as existing manufacturing operations. As EPA's analysis progressed, however, it became clear that it could address in one rulemaking cooling water intake structures at both steam electric and manufacturing facilities. From a biological perspective, the effect of intake structures on impingement and entrainment[22] does not differ depending on whether an intake structure is associated with a power plant or a manufacturer. EPA has here consolidated the universe of potentially regulated facilities from the remanded 2004 Phase II rule with the existing facilities in the remanded 2006 Phase III rule for establishing requirements in a single proceeding.

3.1 General Applicability

This rule applies to owners and operators of existing facilities[23] that meet all following criteria:

- The facility is a point source that uses or, in the case of a new unit at an existing facility, proposes to use cooling water from one or more cooling water intake structures, including a cooling water intake structure operated by an independent supplier not otherwise subject to 316(b) requirements that withdraws water from waters of the United States and provides cooling water to the facility by any sort of contract or other arrangement;
- The facility-wide DIF for all cooling water intake structures at the facility is greater than 2 mgd;
- The cooling water intake structure withdraws cooling water from waters of the United States; and
- At least 25 percent of the water actually withdrawn -- actual intake flow (AIF) -- is used exclusively for cooling purposes.

A facility may choose to demonstrate compliance with the final rule for the entire facility, or for each individual cooling water intake structure.

EPA is adopting provisions that promote the reuse of certain water for cooling and that ensure that the rule does not discourage the reuse of cooling water for other uses such as process water. The final rule at 40 CFR 125.91(c) specifies that obtaining cooling water from a public water system, using reclaimed water from wastewater treatment facilities or desalination plants, or recycling treated process wastewater effluent (such as wastewater treatment plant “gray” water) does not constitute use of a cooling water intake structure for purposes of this rule. In addition, the definition of cooling water at 40 CFR 125.92 provides that cooling water obtained from a public water system, reclaimed water from wastewater treatment facilities or desalination plants, treated effluent from a manufacturing facility, or cooling water 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 facility’s intake flow that is used for cooling purposes. Therefore, water used for both cooling and non-cooling purposes does not count toward the 25 percent

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[22] Throughout the preamble and support documents, the terms “entrainment” and “entrainment mortality” may be used interchangeably. The record shows that, in most instances, entrainment mortality is 100 percent, leaving little distinction between the two terms.

[23] Throughout the preamble and supporting documents, the terms “owner or operator of a facility” and “facility” may be used interchangeably. In cases where the document may state that a facility is required to do a given activity, it should be interpreted as the owner or operator of the facility is required to do the activity.

threshold. Examples of water withdrawn for non-cooling purposes includes water withdrawn for warming by LNG (liquefied natural gas) facilities and water withdrawn for public water systems by desalinization facilities.

Today's rule focuses on those facilities that are significant users of cooling water. The rule provides that only those facilities that use more than 25 percent of the water withdrawn exclusively for cooling purposes (on an actual intake flow basis) are subject to the rule. Because power-generating facilities typically use far more than 25 percent of the water they withdraw exclusively for cooling purposes, the 25 percent threshold will ensure that intake structures accounting for nearly all cooling water used by the power sector are addressed by today's rule requirements. While manufacturing facilities often withdraw water for more purposes than cooling, the majority of the water is withdrawn from a single intake structure. Once water passes through the intake, water can be apportioned to any desired use, including uses that are not related to cooling. However, as long as at least 25 percent of the water is used exclusively for cooling purposes, the intake is subject to the requirements of today's rule. EPA estimates that approximately 68 percent of manufacturers and 93 percent of power-generating facilities that meet the first three criteria for applicability also use more than 25 percent of intake water for cooling and thus are subject to today's rule. (See 66 FR 65288, December 18, 2001.)

For facilities that are below any of the applicability thresholds in today's rule, for example a facility that withdraws less than 25 percent of the intake flow for cooling purposes, the Director must set appropriate requirements on a site-specific basis, using best professional judgment (BPJ) , based on 40 CFR 125.90(b). Today's rule is not intended to constrain permit writers at the Federal, State, or Tribal level, from addressing such cooling water intake structures. Also, EPA decided to adopt for the final rule the proposed provision that requires the owners and operators for certain categories of facilities (existing offshore oil and gas facilities, existing offshore seafood processing facilities and offshore LNG terminals) to meet site-specific BTA impingement and entrainment requirements, established by the Director. Such facilities are subject to permit conditions implementing CWA section 316(b) if the facility is a point source that uses a cooling water intake structure and has, or is required to have, an NPDES permit.

3.1.1 What is an "Existing Facility" for Purposes of the Final Rule?

In today's rule, EPA is defining the term "existing facility" to include any facility that is not a "new facility" as defined in 40 CFR 125.83.

A point source discharger would be subject to Phase I or today's rule even if the cooling water intake structure it uses is not located at the facility[24]. In addition, modifications or additions to the cooling water intake structure (or even the total replacement of an existing cooling water intake structure with a new one) does not convert an otherwise unchanged existing facility into a new facility, regardless of the purpose of such changes (e.g., to comply with today's rule or to increase capacity). Rather, the determination as to

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[24] For example, a facility might purchase its cooling water from a nearby facility that owns and operates a cooling water intake structure.

whether a facility is new or existing focuses on whether it is a greenfield or stand-alone facility and whether there are changes to the cooling water intake to accommodate it.

3.1.2 What is "Cooling Water" and What is a "Cooling Water Intake Structure?"

EPA has not revised the definition of cooling water intake structure from proposal for today's rule. A cooling water intake structure is defined as the total physical structure and any associated constructed waterways used to withdraw cooling water from waters of the United States. Under the definition in today's rule, 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. The final rule at 40 CFR 125.91(c) also specifies that obtaining cooling water from a public water system, using reclaimed water from wastewater treatment facilities or desalination plants, or recycling treated effluent (such as wastewater treatment plant "gray" water) does not constitute use of a cooling water intake structure for purposes of this rule.

Today's rule adopts the new facility rule's definition of cooling water as water used for contact or non-contact cooling, including water used for equipment cooling, evaporative cooling tower makeup, and dilution of effluent heat content. The definition specifies that the intended use of cooling water is to absorb waste heat not being efficiently used or recaptured for production and thus rejected from the processes used or auxiliary operations on the facility's premises. The definition also indicates that cooling water obtained from a public water system, reclaimed water from wastewater treatment facilities or desalination plants, treated effluent from a manufacturing facility that is used in a manufacturing process either before or after it is used for cooling, or is process water would not be considered cooling water for purposes of determining whether 25 percent or more of the actual intake flow is cooling water. This clarification is necessary because cooling water intake structures typically bring water into a facility for numerous purposes, including industrial processes; use as circulating water, service water, or evaporative cooling tower makeup water; dilution of effluent heat content; equipment cooling; and air conditioning. Note, however, that all intake water (including cooling and non-cooling process) is included in the determination as to whether the 2-mgd DIF threshold for covered intake structures is met.

3.1.3 Would My Facility Be Covered Only if it is a Point Source Discharger?

Today's rule applies only to facilities that have an NPDES permit or are required to obtain one. This is the same requirement EPA included in the Phase I new facility rule at 40 CFR 125.81(a)(1). Requirements for complying with CWA section 316(b) will continue to be applied through NPDES permits.

On the basis of the Agency's review of potential existing facilities that employ cooling water intake structures, the Agency anticipates that most facilities will control the intake structure that supplies them with cooling water, and discharge some combination of their cooling water, wastewater, or stormwater to a water of the United States through a point source regulated by an NPDES permit. In such cases, the facility's NPDES permit must include the requirements for the cooling water intake structure. If an existing facility's only NPDES permit is a general permit for stormwater discharges, the Agency anticipates that the Director would write an individual NPDES permit containing requirements for the facility's cooling water intake structure. Alternatively, requirements applicable to cooling water intake structures could be incorporated into general permits. If requirements are placed into a general permit, they must meet the requirements set out at 40 CFR 122.28.

As EPA stated in the preamble to the final Phase I rule (66 FR 65256, December 18, 2001), the Agency encourages the Director to closely examine scenarios in which a facility withdraws significant amounts of cooling water from waters of the United States but is not required to obtain an NPDES permit. As appropriate, the Director must apply other legal requirements, where applicable, such as CWA sections 401 or 404, the Coastal Zone Management Act, the National Environmental Policy Act, the Endangered Species Act, or similar State or Tribal authorities to address adverse environmental impact caused by cooling water intake structures at those facilities.

3.1.4 Would My Facility Be Covered if it Withdraws Water From Waters of the United States? What if My Facility Obtains Cooling Water from an Independent Supplier?

The requirements in today's rule apply to cooling water intake structures that have the design capacity to withdraw more than 2 mgd from waters of the United States. Waters of the United States include the broad range of surface waters that meet the regulatory definition at 40 CFR 122.2, which includes lakes, ponds, reservoirs, nontidal rivers or streams, tidal rivers, estuaries, fjords, oceans, bays, and coves. These potential sources of cooling water can be adversely affected by impingement and entrainment.

Some facilities use an impoundment such as a man-made pond or reservoir as part of their cooling system. Cooling water is withdrawn from the pond or reservoir at one point and heated water is discharged to a different point, using mixing and evaporative processes. These impoundments can be closed-cycle recirculating systems if the pond or reservoir was not constructed by impounding a water of the U.S., and therefore might already comply with some of or all the technology-based requirements in today's rule. In other cases, the impoundment was lawfully created from a water of the U.S. as part of a cooling system. Facilities that withdraw cooling water from impoundments that are waters of the United States and that meet the other criteria for coverage (including the requirement that the facility has or will be required to obtain an NPDES permit) are subject to today's rule. In many cases, EPA expects that such makeup water withdrawals are commensurate with the flows of a closed-cycle cooling tower, and again the facility might already comply with requirements to reduce its intake flow under the rule. In those cases where the withdrawals of makeup water come from a water of the United States, and the facility otherwise meets today's criteria for coverage (including a DIF of greater than 2 mgd), the facility would be subject to today's rule requirements. Some of these impoundments may qualify for the waste treatment exclusion found in the definition of a waste treatment system at 40 CFR 122.2, and this rule does not affect the applicability of that exclusion.

EPA does not intend for this rule to change the regulatory status of impoundments. Impoundments are neither categorically included nor categorically excluded from the definition of waters of the United States at 40 CFR 122.2. The determination whether an impoundment is a water of the United States is to be made by the Director on a site-specific basis. The EPA and the U.S. Army Corps of Engineers have jointly issued jurisdictional guidance concerning the term waters of the United States in light of the Supreme Court's decision in *Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Engineers*, 531 U.S. 159 (2001) (SWANCC). A copy of that guidance was published as an Appendix to an Advanced Notice of Proposed Rulemaking on the definition of the phrase waters of the United States, see 68 FR 1991, January 15, 2003, which is at http://www.epa.gov/owow/wetlands/pdf/ANPRM-FR.pdf. The agencies additionally published guidance in 2008 regarding the term waters of the United States in light of both the *SWANCC* and subsequent *Rapanos* case (*Rapanos v. United States*, 547 U.S. 715 (2006)).

EPA recognizes that some impoundments may be man-made waterbodies that support artificially managed and stocked fish populations. As a result, EPA has included a provision in today's final rule to allow the Director to waive certain permit application requirements for such facilities. Note, however, that these facilities are still subject to the final rule.

EPA acknowledges that the point of compliance for facilities located on impoundments may also vary depending on whether the facility withdraws from a water of the United States. As such, the Director may impose requirements at the facility's main cooling water intake structure or at its makeup water withdrawal intake.

The Agency recognizes that some facilities that have or are required to have an NPDES permit might not own and operate the intake structure that supplies their facility with cooling water. In addressing facilities that have or are required to have an NPDES permit that do not directly control the intake structure that supplies their facility with cooling water, revised 40 CFR 125.91 provides (similar to the new facility rule) that facilities that obtain cooling water from a public water system, use reclaimed water from a wastewater treatment facility or desalinization plant, or use treated effluent are not deemed to be using a cooling water intake structure for purposes of this rule. However, obtaining water from another entity that is withdrawing water from a water of the United States would be counted as using a cooling water intake structure for purposes of determining whether an entity meets the threshold requirements of the rule. For example, facilities operated by separate entities might be located on the same, adjacent, or nearby property. One of these facilities might take in cooling water and then transfer it to other facilities that discharge to a water of the United States. Section 125.91(b) specifies that use of a cooling water intake structure includes obtaining cooling water by any sort of contract or arrangement with one or more independent suppliers of cooling water if the supplier or suppliers withdraw water from waters of the United States but that is not itself a new or existing facility subject to CWA section 316(b), except if it is a public water system, a wastewater treatment facility or desalination plant providing reclaimed water, or a facility providing treated effluent for reuse as cooling water pursuant to 125.91(c).

As a practical matter, existing facilities are the largest users of cooling water and typically require enough cooling water to warrant owning the cooling water intake structures. In some cases, such as at nuclear power plants or critical baseload facilities, the need for cooling water includes safety and reliability reasons that would likely preclude any independent supplier arrangements. Therefore, EPA expects this provision will have only limited applicability. EPA is nevertheless retaining the provision to prevent facilities from circumventing the requirements of today's rule by creating arrangements to receive cooling water from an entity that is not itself subject to today's rule and that is not explicitly exempt from today's rule (such as drinking water or treatment plant discharges reused as cooling water).

3.1.5 What Intake Flow Thresholds Result in an Existing Facility Being Subject to the Final Rule?

EPA determines the cooling water flow at a facility in two ways. The first way is based on the DIF, which reflects the maximum intake flow the facility is capable of withdrawing. While this normally is limited by the capacity of the cooling water intake pumps, other parts of the cooling water intake system could impose physical limitations on the maximum intake flow the facility is capable of withdrawing. The second way is based on the AIF, which reflects the actual volume of water withdrawn by the facility. EPA has defined AIF to be the average water withdrawn each year over the preceding three calendar years[25]. Both of these definitions are used in today's rule.

In this rule, EPA considered requirements based on the intake flow at the existing facility. Today's final rule applies to facilities that have a total design intake capacity of greater than 2 mgd (see §40 CFR 125.91).[26] Above 2 mgd, 99.7 percent of the total water withdrawals by utilities and other industrial sources could be covered (if the other criteria for coverage are met), including 70 percent of the manufacturing facilities and 87 percent of electric generating facilities. EPA also chose the greater than 2-mgd threshold to be consistent with the applicability criteria in the Phase I rule.[27] EPA has concluded that this threshold ensures that the users of cooling water causing the most adverse environmental impact will be subject to the rule.

EPA is continuing to base applicability on DIF as opposed to AIF for several reasons. In contrast to AIF, DIF is a fixed value based on the design of the facility's operating system and the capacity of the circulating and other water intake pumps. This provides clarity because the DIF does not vary with facility operations, except in limited circumstances, such as when a facility undergoes major modifications. On the other hand,

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[25] For permit terms subsequent to the first permit issued under today's rule, the rule defines AIF as the average flows over the 5 years in the previous permit term

[26] The 2004 Phase II rule would have applied to existing power-generating facilities with a design intake flow of 50 mgd or greater. Facilities potentially in scope of the Phase III rule had a DIF of greater than 2 mgd.

[27] For more information, see 66 FR 65288, December 18, 2001.

actual flows can vary significantly over sometimes short periods. For example, a peaking power plant might have an AIF close to the DIF during times of full energy production, but an AIF of zero during lengthy periods of standby. Use of DIF provides clarity as to regulatory status, is indicative of the potential magnitude of environmental impact, and avoids the need for monitoring to confirm a facility's status. For more information about these thresholds, see 69 FR 41611, July 9, 2004.

Under this rule, all facilities with a DIF of greater than 2 mgd must submit basic information describing the facility, source water physical data, source water biological characterization data, and cooling water intake system data. In addition, these facilities must submit additional facility-specific information including the selected impingement compliance option and operational status of each of the facility's units.[28] Certain facilities withdrawing the largest volumes of water for cooling purposes have additional information and study requirements such as relevant biological survival studies and the Entrainment Characterization Study as described below.

The final rule uses AIF rather than DIF for purposes of determining which facilities must provide the information required in 40 CFR 122.21(r)(9)-(13), including an Entrainment Characterization Study. Thus, the rule provides that any facility subject to the rule with actual flows in excess of 125 mgd must provide an Entrainment Characterization Study with its permit application. Adverse environmental impacts from entrainment result from actual water withdrawals, and not the maximum designed level of withdrawal. Further, using actual flow might encourage some facilities to adopt operational practices to reduce their flows to avoid collecting supplemental data and submitting the additional entrainment characterization study. Furthermore, any facility that has DIF greater than 2 mgd is required to submit basic information that will allow the Director to verify its determination of whether it meets the 125-mgd AIF threshold.

EPA has selected a threshold of 125-mgd AIF for submission of the Entrainment Characterization Study (as well as studies described at 40 CFR 122.21(r)((7) and (10)-(13)) because this threshold will capture 90 percent of the actual flows but will apply only to 30 percent of existing facilities. EPA concluded that this threshold struck the appropriate balance between the goal of capturing the greatest portion of intake flow while minimizing the study requirements for smaller facilities. Exhibit 3-3 presents a plot of cumulative AIF for facilities with AIF sorted from low to high with a marker illustrating the location of the largest facility that would fall below a threshold of 125 mgd. While there is no obvious break point or change in slope at this particular data point, it is a reasonable approximation of where the curve begins to flatten out. The selected threshold would significantly limit facility burden at more than two-thirds of the potentially in-scope facilities while focusing the Director on major cooling water withdrawals. Contrary to a number of public comments, however, EPA is not implying or concluding that the 125-mgd threshold is an indicator that facilities withdrawing less than 125-mgd are (1) not causing any adverse impacts or (2) automatically qualify as employing BTA. In other words, the threshold, while justified on a technical basis, does not result in exemptions from the rule. Instead, EPA is making a policy decision on

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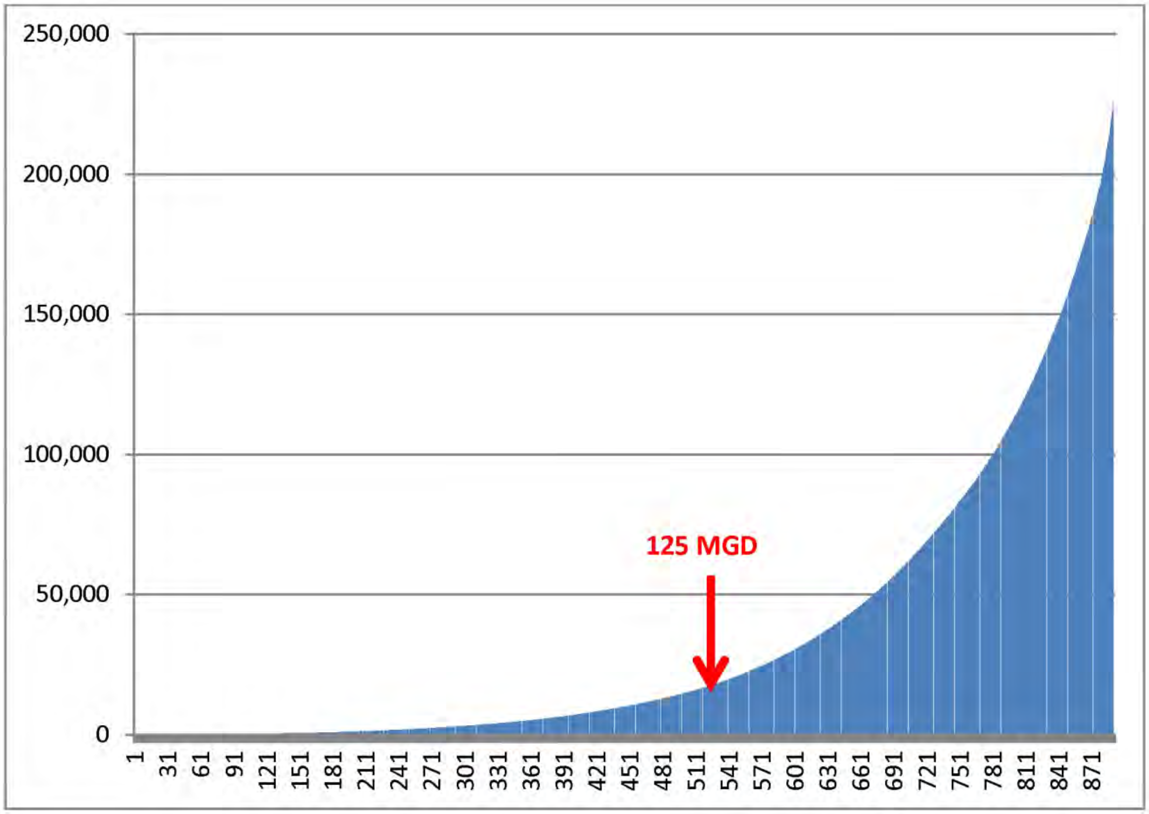
[28] The final rule contains streamlined information submission requirements for facilities that already employ closed-cycle cooling.

which facilities must provide a certain level and type of information. The Director, of course, will retain the discretion to require reasonable information to make informed decisions at the smaller facilities. The 125-mgd threshold is simply an administrative cutoff that focuses on the facilities with the highest intake flows and the highest likelihood of causing adverse impacts; it is not an indicator that facilities under that threshold are no longer of concern in the final rule.

Exhibit 3-3. Plot of Cumulative AIF in MGD



In today's rule, EPA seeks to clarify that for some facilities, the DIF is not necessarily the maximum flow associated with the intake pumps. For example, a power plant might have redundant circulating pumps, or might have pumps with a name plate rating that exceeds the maximum water throughput of the associated piping. EPA intends for the DIF to reflect the maximum rate at which a facility can physically withdraw water from a source waterbody (usually normalized to a daily rate in mgd). This also means that a facility that has permanently taken a pump out of service should be able to consider such constraints when reporting its DIF, as the facility's capacity to withdraw water has fundamentally changed. Additionally, if a facility's flow is limited by constrictions in the piping or other physical limitations (e.g., a given portion of its cooling system that can only safely handle a given amount of flow) and that flow is lower than the DIF for the pumps, the facility should be able to consider such constraints when reporting its DIF, because it is not capable of withdrawing its full DIF without compromising the cooling system.

3.1.6 Existing Offshore Oil and Gas Facilities, Seafood Processing Vessels or LNG Import Terminals BTA Requirements Under the Final Rule

Under today's rule, existing offshore oil and gas facilities, seafood processing facilities and LNG import terminals would be subject to 316(b) requirements on a BPJ basis. In the Phase III rule, EPA studied offshore oil and gas facilities and seafood processing facilities[29] and could not identify any technologies (beyond the protective screens already in use) that are technically feasible for reducing impingement or entrainment in such existing facilities.[30] As discussed in the Phase III rule, known technologies that could further reduce impingement or entrainment would result in unacceptable changes in the envelope of existing platforms, drilling rigs, mobile offshore drilling units, offshore seafood processing vessels, and similar facilities as the technologies would project out from the hull, potentially decrease the seaworthiness, and potentially interfere with structural components of the hull. It is also EPA's view that for many of these facilities, the cooling water withdrawals are most substantial when the facilities are operating far out at sea and, therefore, not withdrawing from a water of the United States. EPA is aware that LNG facilities may withdraw hundreds of million gallons per day of seawater for warming (re-gasification). However, some existing LNG facilities might still withdraw water where 25 percent or more of the water is used for cooling purposes. EPA has not identified a uniformly applicable and available technology for minimizing impingement mortality and entrainment at these facilities. However, technologies might be available for some existing LNG facilities. LNG facilities that withdraw any volume of water for cooling purposes would be subject to site-specific, BPJ BTA determinations.

EPA has not identified any new data or approaches that would result in a different determination. Therefore, EPA has adopted the approach of the proposed rule and is requiring that NPDES permit Directors, on a site-specific basis using BPJ, determine BTA for existing offshore oil and gas extraction facilities and offshore seafood processing facilities..

3.1.7 What is a "New Unit" and How Are New Units Addressed Under the Final Rule?

Today's rule establishes requirements for new units at an existing facility that are different than the requirements that otherwise apply to existing units at an existing facility. The requirements for new units at existing facilities are modeled after the requirements for a new facility in the Phase I rule. Under today's rule, a new unit means the *addition* of a newly built, stand-alone unit. EPA is also clarifying that while Phase I definition of new facility does not include newly constructed units for the same general

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[29] EPA studied naval vessels and cruise ships as part of its developing a general NPDES permit for discharges from oceangoing vessels. (For more information, see http://cfpub.epa.gov/npdes/home.cfm?program_id=350.) EPA studied offshore seafood processing vessels and oil and gas exploration facilities in the 316(b) Phase III rule.

[30] As discussed in today's preamble, requirements for new offshore facilities set forth in the Phase III rule remain in effect.

industrial activity, such units are new units at an existing facility and are subject to today's final rule.

On the basis of the public comments received on how to define new units, EPA has sought to provide a clear definition for this term in the final rule. In EPA's view, these definitions for a new unit at an existing facility establish a clear regulatory framework for both affected facilities and Directors. It captures facilities that are undergoing major construction projects, while not discouraging upgrades or the construction of replacement units. For example, a nuclear facility conducting a measurement uncertainty capture or a stretch power uprate (a Type I or Type II uprate) or a fossil-fuel plant repowering the existing generating units would not be considered a new unit. As another example, under this definition placing an offshore facility into a dry dock for maintenance or repair does not result in either the offshore facility or the dry dock as being defined as a new unit.

Electric Generators

The final rule defines a new unit at an existing facility as a newly built, stand-alone unit that is constructed at an existing facility and that does not meet the definition of a new facility. An existing unit that is repowered or undergoes significant modifications (such as where the turbine and condenser are replaced) is not considered a new unit. Exhibit I-3 below provides several examples and whether these hypothetical units will be defined as new or existing units.

Exhibit 3-4. Examples of new and existing units at electric generators

Examples of new units at an existing facility	Examples of existing units
A unit that is constructed at a stand-alone location at an existing facility (either adjacent to existing units or on newly acquired or developed property)	An existing unit is retired and demolished, with a new unit constructed in the former unit's location as a replacement (regardless of the change in generating capacity, the change in cooling water intake flow, or the use of an existing intake structure)
	A unit where a new boiler or fuel type is employed (e.g., a new heat recovery steam generator and combustion turbine is connected to an existing steam turbine and condenser)

Manufacturers

At the numerous manufacturing facilities that generate electricity onsite, the previous discussion of electric generators applies. Some manufacturers employ different industrial processes than an electric generator and therefore have different industrial equipment (including cooling systems). In particular, manufacturers may not use a steam condenser or steam turbine for their industrial processes, making the definition for "repowering" above inappropriate for manufacturing facilities. However, manufacturers do have opportunities to reuse cooling water that power plants may not, and in site visits, EPA found many manufacturers have conducted energy and water audits resulting in significant reductions in water withdrawals. The final rule provides for manufacturers to receive credit for such reductions in fresh water withdrawals.

A similar conceptual approach for defining manufacturing units with a new or replaced cooling system is not as easily defined since waste heat can be generated from a variety of sources including exothermic processes, product heating and cooling, and the processing, handling, treating, or disposal of feed streams, waste streams, by-products, and recycled components. Sources may include direct cooling transferred across an inert material (e.g., heat exchanger, steam condenser), indirect cooling using a working fluid (e.g., chillers, refrigeration), or contact cooling where cooling water comes into direct contact with a product or process stream.[31] Unlike electric generators where the majority of cooling water comes from a single process source (the steam condenser), manufacturing units may include many separate non-contact or contact cooling water sources dispersed throughout the production processes and the facility. Thus, a definition for manufacturing units with a new or replaced cooling system must take into consideration a broader category of cooling water sources.

Thus for power generators, the term “generating unit” is quite clear since there is only one product (electricity), the non-contact cooling water predominantly comes from one source, and the application of the term is well-understood in the industry. But for some manufacturing facilities, it may be unclear what constitutes a “unit” since manufacturing processes can involve numerous vertically integrated processes or production steps that may involve intermediate products. For example, a unit could encompass an entire series of production steps (start to finish) or simply the individual steps. Also, there may be ancillary support equipment that serves various functions and it is not clear whether this will be considered a unit or part of a unit. For example, a petroleum refiner will typically include various processes such as distillation, cracking, hydrotreating, coking, reforming, and different types of various products. Various intermediate products from these processes may be directly transported (piped) from one process to another or stored and some may be sold. And because various intermediate and final process products may be blended into different products, differentiating units on a product or intermediate product basis may not provide clear distinctions.

For these reasons EPA has defined new unit to simply mean a new stand-alone unit or process. A new unit may include distinct production lines that are added to increase product output and operate parallel and independently of existing production equipment. A new unit does not include the replacement or rebuilding of production lines or distinct processes where the majority of the waste heat producing equipment that serve as sources of non-contact cooling water and the majority of the heat exchanging equipment that contributes heat to the non-contact cooling water are replaced. Such modifications do not lead to considering the unit as a new unit, thereby continuing to treat the unit as an existing unit. In such cases, the existing unit is regulated under the existing unit provisions of this rule, and the unit is not subject to new unit requirements.

This definition therefore does not impose any disincentives for the replacement/upgrade of individual components or ancillary equipment alone.

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[31] Note that EPA did not include contact cooling category as part of its analysis of possible closed-cycle cooling system requirements but contact cooling water does nonetheless fall within the definition of cooling water at 40 CFR 125.92.

Exhibit I-4 below provides several examples and whether these hypothetical units are defined as new or existing units. As noted above, the Director has broad discretion to assess the scope of any modifications at the manufacturing facility and to determine whether the new construction comprises a stand-alone unit. For the purposes of today's final rule, the Director does not need to address whether the stand-alone unit is for the same general industrial purposes, or whether the new unit is a replacement unit. The key factors in assessing whether a unit will be defined as new lies with whether the construction results in a stand-alone unit.

Exhibit 3-5. Examples of new and existing units at manufacturers

Examples of new units at an existing facility	Examples of existing units
A unit that is constructed at a stand-alone location at an existing facility (either adjacent to existing units or on newly acquired or developed property)	A unit where only the waste heat generating process equipment or the cooling system equipment is replaced, but not both
A unit that is constructed adjacent to an existing unit for the same industrial activity (such as expanding the production output by building a second unit as a stand-alone unit next to the existing unit)	A unit where modifications are made to the waste heat generating process equipment or the cooling system (e.g., optimization, repairs, upgrades to operational elements up to, but not including full replacement)
	An existing unit is retired before or after a new unit is constructed as a replacement (regardless of the change in production capacity, the change in cooling water intake flow, or the use of an existing intake structure)
	An existing unit is retired and demolished, with a new unit constructed in the former unit's location as a replacement (regardless of the change in production capacity, the change in cooling water intake flow, or the use of an existing intake structure)
	Replacement or upgrade of ancillary equipment (e.g., pumps, motors, HVAC, etc.)

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Chapter 4: Industry Description

4.0 Introduction

This chapter presents a profile of the facilities potentially regulated under the existing facilities rule. The rule would apply national requirements to existing facilities that use cooling water intake structures to withdraw water for cooling from waters of the U.S. Specifically, the final rule would apply to owners and operators of existing facilities that meet all of the following criteria:

- The facility is a point source that uses or proposes to use one or more cooling water intake structures, including a cooling water intake structure operated by an independent supplier that withdraws water from waters of the United States and provides cooling water to the facility by any sort of contract or other arrangement;
- The total design intake flow of the cooling water intake structure(s) is more than 2 mgd; and
- The cooling water intake structure(s) withdraw(s) cooling water from waters of the United States and at least twenty-five (25) percent of the water withdrawn is used exclusively for cooling purposes measured on an average annual basis for each calendar year.

The existing facilities rule would apply to all existing power plants and all existing manufacturing facilities that meet the above criteria. This chapter presents information characterizing the categories of facilities subject to the rule.

Much of the information presented in this chapter is based on data from the U.S. Department of Energy's (DOE) "Annual Electric Generator Report" (Form EIA-860) and "Annual Electric Power Industry Report" (Form EIA-861), and EPA's Section 316(b) 2000 Industry Surveys (the Industry Short Technical Questionnaire [STQ] and the Detailed Industry Questionnaire [DQ] for Phase II Cooling Water Intake Structures). For more information on aspects of the industry that may influence the nature and magnitude of economic impacts of the existing facilities rule, see the Economic Analysis for the Final Section 316(b) Existing Facilities Rule (EA).

The electric power industry and the other industries subject to the existing facilities rule are studied extensively by many organizations and government agencies. DOE's Energy Information Administration (EIA), among others, publishes a multitude of reports, documents, and studies on an annual basis. This chapter profile is not intended to duplicate those efforts. Rather, this profile compiles, summarizes, and presents those industry data that are important in the context of the technical analysis for the existing facilities rule. For more information on general concepts, trends, and developments in the electric power industry and other industries affected by the proposal, see the "References," section of this chapter.

EPA first described the electricity industry in its April 2002 Phase II Proposed Rule (see 67 FR 17135-17136). A profile of other industries and existing manufacturers was developed to support the proposed Phase III Rule (see Phase III Proposed Rule TDD; EPA-821-R-04-015, DCN 7-0004 in the Phase III docket, available at EPA-HQ-OW-2004-0002-0025 to -0029). While these general descriptions still apply, EPA has updated some of its earlier estimates to reflect a more current and comprehensive industry profile for facilities subject to the existing facilities rule.

The glossary located at the end of this chapter provides definitions for all terms that are ***bolded and italicized*** throughout this chapter.

4.1 Industry Overview

This section provides a brief overview of the industry, including descriptions of major industry sectors and types of generating facilities.

4.1.1 Major Industry Sectors

In 1997, EPA estimated that over 400,000 facilities could potentially be subject to a cooling water intake regulation. Given the large number of facilities potentially subject to regulation, EPA decided to focus its data collection efforts on six industrial categories that, as a whole, are estimated to account for over 99 percent of all cooling water withdrawals. These six sectors are: ***Utility*** Steam Electric, ***Nonutility*** Steam Electric, Chemicals & Allied Products, Primary Metals Industries, Petroleum & Coal Products, and Paper & Allied Products. EPA's data collection efforts (via the 1998 industry questionnaire) focused on the electric generators (both ***utility*** and ***nonutility*** steam electric) and the four manufacturing industry groups that were identified as significant users of cooling water. These industries are presented below, as described by the Standard Industrial Classification (SIC) system, and are intended to represent all electric generators and manufacturers with a DIF greater than 2 mgd.

Electric Services

This industry sector is classified under SIC Major Group 49. This major group includes establishments engaged in the ***generation***, ***transmission***, and/or ***distribution*** of electricity or gas or steam. A detailed discussion of the electricity industry is provided in Section 4.2 of this chapter.

Chemical and Allied Products

This industry sector is classified under SIC Major Group 28. This major group includes establishments producing basic chemicals and establishments manufacturing products by predominantly chemical processes. Establishments classified in this major group manufacture three general classes of products: (1) basic chemicals, such as acids, alkalies, salts, and organic chemicals; (2) chemical products to be used in further manufacture, such as synthetic fibers, plastics materials, dry colors, and pigments; and (3) finished chemical products to be used for ultimate consumption, such as drugs, cosmetics, and soaps; or to be used as materials or supplies in other industries, such as paints, fertilizers, and explosives.

Primary Metals Industries

This industry sector is classified under SIC Major Group 33. This major group includes establishments engaged in smelting and refining ferrous and nonferrous metals from ore, pig, or scrap; in rolling, drawing, and alloying metals; in manufacturing castings and other basic metal products; and in manufacturing nails, spikes, and insulated wire and cable.

Paper and Allied Products

This industry sector is classified under SIC Major Group 26. This major group includes establishments primarily engaged in the manufacture of pulps from wood and other cellulose fibers, the manufacture of paper and paperboard, and the manufacture of paper and paperboard into converted products.

Petroleum and Coal Products

This industry sector is classified under SIC Major Group 29. This major group includes establishments primarily engaged in petroleum refining, manufacturing paving and roofing materials, and compounding lubricating oils and greases from purchased materials.

Other Industries

EPA sent industry questionnaires to individual facilities from a number of other industries outside of the four listed above and incorporated that data into the analysis for the existing facilities rule. In 2004, EPA also collected information on land-based liquefied natural gas (LNG) facilities.

The following sections describe the electricity industry and the other manufacturing sectors and describe how cooling water is withdrawn and used at these facilities. In many cases, the facility data has been aggregated into two major groups; Electric Generators (Electric Services) and Manufacturing Facilities. The Manufacturing Facilities group includes all industrial facilities described above that are not classified as Electric Generators (i.e., Chemical and Allied Products, Primary Metals Industries, Paper and Allied Products, Petroleum and Coal Products, and Other Industries).

4.1.2 Number of Facilities and Design Intake Flow Characteristics

Based on the technical survey, EPA estimates that approximately 1,263 facilities in the major industrial categories would be subject to regulation under the existing facilities rule. These facilities combine to account for a design intake flow of over 409 billion gallons per day of cooling water from approximately 1,836 cooling water intake structures. See Exhibit 4-1 below.

Exhibit 4-1. Cooling water use in surveyed industries

	Estimated number of facilities	Percent of total number of facilities	Estimated total Design Intake Flow (mgd)	Percent of total Design Intake Flow
Facilities potentially regulated under existing facilities rule (all existing facilities that withdraw more than 2 mgd)	1,263	100	409,600	100
Existing electric generators	671	53	370,126	90
Existing manufacturers	592	47	39,473	10

Source: Survey Data from Detailed and Short Technical Industry Questionnaires: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).

Note: All values are weighted and include facilities identified as baseline closures. Design intake flow for Short Technical Survey Facilities was imputed from average intake flow.

Exhibit 4-2 shows the geographic distribution of the estimated facilities subject to 316(b). For illustrative purposes, manufacturers and electric generators are distinctly shown.

Exhibit 4-2. Map of facilities subject to 316(b)

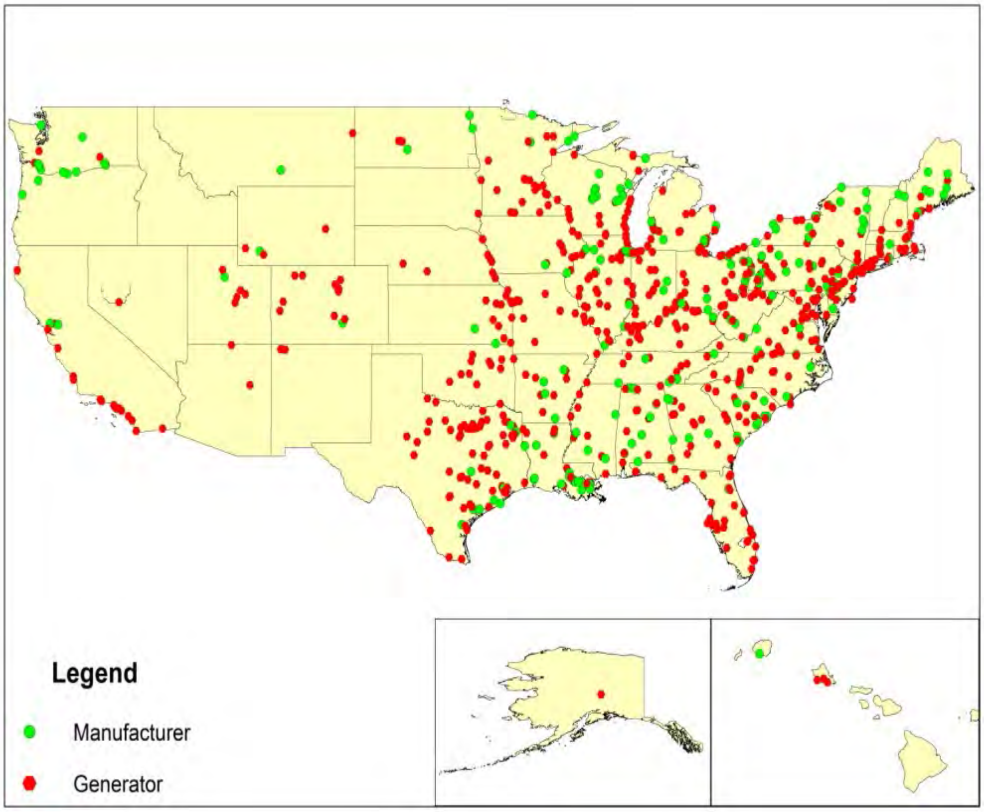

Exhibit 4-3 illustrates the range and distribution of the number of facilities by design intake flows (DIF).

Exhibit 4-3. Distribution of facilities by Design Intake Flow

Design Intake Flow (mgd)	Electric generators		Manufacturers	
	Estimated number of facilities	Percent of number of facilities	Estimated number of facilities	Percent of number of facilities
2 - 10	37	5	139	24
10 - 20	29	4	95	16
20 - 50	51	8	196	33
50 - 100	56	8	84	14
100 - 200	90	13	44	7
200 - 500	152	23	23	4
500 – 1,000	145	22	7	1
> 1,000	112	17	3	0.5
Total	671	100	592	100

Source: Survey Data from Detailed and Short Technical Industry Questionnaires: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).

Note: All values are weighted and include those facilities identified as baseline closures. Design intake flow for Short Technical Survey Facilities was imputed from average intake flow.

Exhibit 4-3 shows that the majority of electric generator facilities have a DIF >100 mgd while the majority of manufacturers have a DIF in the 2 to 50 mgd range.

Exhibit 4-4 shows the estimated total DIF and average intake flow (AIF) for each flow range shown in Exhibit 4-2. The percent AIF/DIF shows the relative volume of AIF to DIF for each flow range.

Exhibit 4-4. Relative volumes of Design Intake Flow and Average Intake Flow

Design Intake Flow (mgd)	Electric generators			Manufacturers		
	Total weighted DIF (mgd)	Total weighted AIF (mgd)	Percent AIF/DIF	Total weighted DIF (mgd)	Total weighted AIF (mgd)	Percent AIF/DIF
2 - 10	178	71	40%	719	321	45%
10 - 20	449	175	39%	1,322	667	50%
20 - 50	1,745	830	48%	6,217	3,158	51%
50 - 100	4,087	2,010	49%	5,887	3,341	57%
100 - 200	12,464	6,042	48%	6,355	3,043	48%
200 - 500	49,946	26,501	53%	7,883	4,247	54%
500 - 1,000	103,672	61,995	60%	4,606	2,767	60%
> 1,000	197,586	118,970	60%	6,484	3,696	57%
Total	370,126	216,593	59%	39,473	21,239	54%

Source: Survey Data from Detailed and Short Technical Industry Questionnaires: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).

Exhibit 4-4 shows that facilities with larger design flows tend to withdraw a higher proportion of their design flow on a daily basis and the trend is more pronounced for electric generators.

Exhibit 4-5 shows design intake flow values by industry type.

Exhibit 4-5. Design Intake Flow by industry type

Industry Type	Estimated number of facilities	Total Design Intake Flow (mgd)	Percent of total Design Intake Flow of all facilities	Average Design Intake Flow (mgd)[a]
Chemical and allied products	185	12,400	3	126
Primary metals	95	9,444	2	131
Paper and allied products	227	11,944	3	69
Petroleum and coal products	39	3,259	1	96
Food products	38	2,073	0.5	52
Other manufacturing	7	353	0.1	81
Total manufacturers	592	39,473	10	95
Electric generators	671	370,126	90	555
Total	1,262	409,600	100	434

[a] Average based on surveyed facilities. May not be reflective of actual industry-wide average design intake flows.

Source: Survey Data from Detailed and Short Technical Industry Questionnaires: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).

Note: All values are weighted and include facilities identified as baseline closures. Design intake flow for Short Technical Survey Facilities was imputed from average intake flow.

4.1.3 Source Waterbodies

Facilities potentially regulated under the existing facilities rule can be found on all waterbody types, but are predominantly located on freshwater rivers and streams. Exhibit 4-6 below illustrates the distribution of facilities by waterbody type.

Exhibit 4-6. Distribution of source waterbodies for existing facilities

Source of surface water	Electric generators		Manufacturers	
	Estimated number of facilities	Percent of facilities	Estimated number of facilities	Percent of facilities
Freshwater river or stream	349	52	454	77
Lake or reservoir	134	20	42	7
Great Lakes	48	7	46	8
Estuary or tidal river	117	17	39	7
Ocean	22	3	11	2
Total	671	100	592	100

Source: Survey Data from Detailed and Short Technical Industry Questionnaires: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).

Note: All values are weighted and include those facilities identified as baseline closures.

Exhibit 4-7 focuses on facilities located on freshwater rivers and streams. In the 2004 Phase II rule, any freshwater facility whose DIF exceeded 5 percent of its source river's mean annual flow (MAF) would have been subject to both impingement mortality and entrainment requirements.[32] The exhibit shows the withdrawal volumes for all facilities that completed a detailed technical questionnaire.

Exhibit 4-7. Facility intake flows as a percentage of mean annual flow

		DIF				AIF			
Electric generators	**Intake flow as a % of MAF**	**No. of facilities**	**% of no. of fac. with data**	**No. of wgtd. fac.**	**% of no. of wgtd. fac. with data**	**No. of facilities**	**% of no. of fac. with data**	**No. of wgtd. fac.**	**% of no. of wgtd. fac. with data**
	No data	8	-	16	-	8	-	16	-
	1-5%	81	51.6%	190	51.3%	112	71.3%	263	71.0%
	5-10%	24	15.3%	58	15.7%	23	14.6%	58	15.7%
	10-20%	27	17.2%	67	18.1%	7	4.5%	17	4.6%
	20-40%	10	6.4%	24	6.6%	4	2.5%	10	2.7%
	40-60%	3	1.9%	7	1.9%	3	1.9%	6	1.6%
	60-80%	0	0.0%	0	0.0%	4	2.5%	8	2.2%
	80-100%	4	2.5%	8	2.1%	0	0.0%	0	0.0%
	> 100%	8	5.1%	16	4.4%	4	2.5%	8	2.2%
	Total > 5%	76	48.4%	181	48.7%	45	28.7%	108	29.0%
	Total with Data	157	100%	371	100%	157	100%	371	100%
		DIF				**AIF**			
Manufacturers	**Intake flow as a % of MAF**	**No. of facilities**	**% of no. of fac. with data**	**No. of wgtd. fac.**	**% of no. of wgtd. fac. with data**	**No. of facilities**	**% of no. of fac. with data**	**No. of wgtd. fac.**	**% of no. of wgtd. fac. with data**
	No data	4	-	10	-	4	-	10	-
	1-5%	141	89.8%	368	99.1%	153	97.5%	400	107.7%
	5-10%	9	5.7%	25	6.6%	7	4.5%	17	4.6%
	10-20%	9	5.7%	23	6.2%	7	4.5%	15	4.2%
	20-40%	7	4.5%	14	3.7%	2	1.3%	4	1.2%
	40-60%	1	0.6%	1	0.3%	3	1.9%	5	1.3%
	60-80%	2	1.3%	3	0.9%	0	0.0%	0	0.0%
	80-100%	2	1.3%	3	0.9%	2	1.3%	3	0.8%
	> 100%	3	1.9%	7	2.0%	0	0.0%	0	0.0%
	Total > 5%	33	21.0%	76	20.6%	21	13.4%	45	12.0%
	Total with Data	174	111%	444	120%	174	111%	444	120%

Source: Survey Data from Detailed and Short Technical Industry Questionnaires: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).

Note: "Wgtd. Fac." and "Wgtd" refers to facility counts or distribution based on estimates using weighting factors

Note: All values are weighted and include those facilities identified as baseline closures.

Note: Extremely large withdrawal percentages may reflect flawed data or may represent facilities that withdraw as much as 100 percent of the waterbody's flow (see, for example, the discussion on Monroe Power Plant in the Case Study Analysis [DCN 4-0003] in the Phase II docket).

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[32] Today's final rule does not include such a requirement, but this analysis shows the relative scale of withdrawals.

4.1.4 Cooling Water System Configurations

Facilities potentially regulated under the existing facilities rule employ a variety of cooling water system (CWS) types. Exhibit 4-8 shows the distribution of cooling water system configurations.

Exhibit 4-8. Distribution of cooling water system configurations

CWS configuration	All facilities		Electric generators		Manufacturers	
	Estimated number of CWS[a]	Percent of total CWS	Estimated number of CWS	Percent of total CWS	Estimated number of CWS	Percent of total CWS
Once-through	1049	62	599	66	450	57
Once-through with non-recirculating impoundment	127	8	67	7	60	8
Once-through with non-recirculating tower	44	3	30	3	14	2
Recirculating with tower	406	24	182	20	224	28
Recirculating with impoundment	119	7	64	7	55	7
Combination	167	10	70	8	97	12
Other	156	9	35	4	121	15
Total	1,704	100	912	100	793	100

[a] Some facilities have more than one cooling water system. Some cooling systems have more than one type of CWS configuration.

Source: Survey Data from Detailed and Short Technical Industry Questionnaires: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).

Note: All values are weighted and include facilities identified as baseline closures.

Exhibit 4-9 shows the distribution of cooling water systems and the waterbody type from which they withdraw.

Exhibit 4-9. Distribution of facilities by cooling water system and waterbody type

Waterbody type	Recirculating		Once-through		Combination		Total	
	Number	% of total	Number	% of total	Number	% of total	Number	% of total
Freshwater stream or river	226.7	80%	461.8	58%	114	65%	**803**	**64%**
Lake or reservoir	47	17%	109.3	14%	19.6	11%	**176**	**14%**
Estuary or tidal river	6.1	2%	124.3	16%	26.3	15%	**156**	**12%**
Ocean	0	0%	33.1	4%	0	0%	**33**	**3%**
Great Lake	4	1%	74.4	9%	15.9	9%	**94**	**7%**
Total	**284**	**100%**	**802**	**100%**	**176**	**100%**	**1262**	**100%**

Source: Survey Data from Detailed and Short Technical Industry Questionnaires: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).

Exhibit 4-10 shows the distribution of cooling water system types at nuclear facilities.

Exhibit 4-10. Distribution of cooling water system configurations at nuclear facilities by waterbody type

CWS type	Waterbody type	Number of facilities
Combination	Ocean	0
	Estuary or tidal river	0
	Great Lake	1
	Freshwater river	3
	Lake or reservoir	4
Closed-cycle	Ocean	0
	Estuary or tidal river	2
	Great Lake	3
	Freshwater river	14
	Lake or reservoir	4
Once-through	Ocean	5
	Estuary or tidal river	8
	Great Lake	6
	Freshwater river	5
	Lake or reservoir	7

Exhibit 4-10 shows that nuclear facilities (which are virtually always baseload generators) with closed-cycle or combination cooling systems are most frequently located on freshwater rivers and lakes. Also, there are no nuclear facilities with closed-cycle cooling that withdraw from an ocean.

Exhibit 4-11 illustrates the intake structure arrangements for facilities potentially regulated under the rule.

Exhibit 4-11. Distribution of cooling water intake structure arrangements

	Electric generators		Manufacturers	
Intake arrangement	Estimated number of facilities	Percent of arrangements	Estimated number of facilities	Percent of arrangements
Canal or channel intake	185	28	112	19
Bay or cove intake	59	9	43	7
Submerged shoreline intake	216	32	179	30
Surface shoreline intake	212	32	128	22
Submerged offshore intake	105	16	186	32
Total	671	100	592	100

Source: Survey Data from Detailed and Short Technical Industry Questionnaires: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).

Note: The sum of facilities for each arrangement exceeds the total since some facilities employ multiple intake arrangements.

Note: All values are weighted and include facilities identified as baseline closures.

Exhibit 4-12 illustrates the distribution of cooling water system configurations as a function of facility age.

Exhibit 4-12. Estimated distribution of cooling water system configurations as a function of age

CWS age (Years)	CWS Configuration	Electric generators		Manufacturers	
		Estimated number of CWSs	Percent of CWSs	Estimated number of CWSs	Percent of CWSs
< 10	Once-through	4	0.5%	18	2%
	Recirculating	9	1%	10	1%
	Combination	4	1%	16	2%
	Other	0	0%	0	0%
	Total	17	2%	44	6%
10 to 20	Once-through	21	3%	27	4%
	Recirculating	24	3%	41	5%
	Combination	1	0.1%	31	4%
	Other	0	0%	3	0.4%
	Total	47	6%	102	13%
20 to 40	Once-through	224	29%	82	11%
	Recirculating	63	8%	36	5%
	Combination	29	4%	53	7%
	Other	3	0.4%	12	2%
	Total	319	41%	183	24%
> 40	Once-through	332	43%	221	29%
	Recirculating	21	3%	60	8%
	Combination	37	5%	101	13%
	Other	5	0.7%	49	6%
	Total	396	51%	431	57%
All	Once-through	581	75%	348	46%
	Recirculating	117	15%	147	19%
	Combination	71	9%	201	26%
	Other	9	1%	64	8%
	Total	779	100%	760	100%

Source: Survey Data from Detailed and Short Technical Industry Questionnaire: (DCN 4-0016F-CBI).

Note: Based on detailed technical survey data. Numbers are estimated using weighting factors. Estimated total CWSs do not match those in Exhibit 1-6 which are based on weighted detailed and short technical survey responses.

Exhibit 4-13 presents the distribution of in-scope facilities by the number of separate cooling water systems at each facility.

Exhibit 4-13. Estimated distribution of in-scope facilities by the number of cooling water systems

Number of cooling water systems	Electric Generators		Manufacturers	
	Estimated number of facilities	Percent of facilities	Estimated number of facilities	Percent of facilities
1	506	75%	463	78%
2	115	17%	103	17%
3	33	5%	4	1%
4	12	2%	9	1%
5 or more*	5	1%	12	2%
Total	**671**	100%	**592**	100%

* The largest number of cooling water systems was 7.

Source: Survey Data from Detailed and Short Technical Industry Questionnaire: (DCN 4-0016F-CBI).

Exhibit 4-13 shows that both electric generators and manufacturers have a similar distribution of number of cooling water systems and that the majority use a single CWS.

4.1.5 Design and Operation of Cooling Water Intake Structures

Each CWS may be serviced by more than one cooling water intake structure (CWIS). Exhibit 4-14 provides an estimate of the number and percent of facilities that have multiple CWISs.

Exhibit 4-14. Estimated distribution of in-scope facilities by the number of cooling water intake structures

Number of cooling water intake structures	Electric generators		Manufacturers	
	Estimated number of facilities	Percent of facilities	Estimated number of facilities	Percent of facilities
1	450	67%	452	76%
2	146	22%	101	17%
3	45	7%	18	3%
4	16	2%	9	2%
5 or more*	14	2%	12	2%
Total	**671**	100%	592	100%

* The largest number of cooling water intake structures was 8.

Source: Survey Data from Detailed and Short Technical Industry Questionnaire: (DCN 4-0016F-CBI).

Exhibit 4-14 shows that both electric generators and manufacturers have a similar distribution of number of CWISs and that the majority of both use a single CWIS.

For those power generators with multiple intake structures, Exhibit 4-15 illustrates the number of facilities that utilize closed-cycle cooling for at least some portion of the facility’s cooling system (i.e., a “combination” CWS).

Exhibit 4-15. Electric generators with multiple CWISs

CWS type	Flow range	Number of facilities
Once-through only	< 50 mgd	7
Once-through only	50-250 mgd	35
Once-through only	> 250 mgd	150
Closed-cycle + once-through	< 50 mgd	0
Closed-cycle + once-through	50-250 mgd	2
Closed-cycle + once-through	> 250 mgd	5

Source: Survey Data from Detailed and Short Technical Industry Questionnaire: (DCN 4-0016F-CBI).

Both mesh size and intake velocity affect impingement and entrainment reductions. In particular, screen mesh size is an important factor affecting impingement and entrainment rates. Exhibit 4-16 provides a national estimate of the number and percentage of facilities utilizing different mesh size screens.

Exhibit 4-16. Estimated distribution of screen mesh size

	Electric generators		Manufacturers	
Mesh size (mm)	Estimated number of CWISs	Percent of CWISs	Estimated number of CWISs	Percent of CWISs
≤ 5 mm (1/5 in)	21	2%	115	18%
> 9.5–19 mm (3/8 – 3/4 in)	885	88%	347	55%
Other/missing data	97	10%	171	27%
Total	1002	100%	633	100%

Source: Survey Data from Detailed and Short Technical Industry Questionnaire: (DCN 4-0016F-CBI).

Note: Includes data for multiple CWISs and multiple screens at many facilities.

Note: Assumes "other" and "missing" is > 9.

These data show that at the time the technical survey was conducted, only a small percentage of electric generators utilized fine mesh screens. EPA is aware that since then, additional facilities have installed fine mesh screens.

Exhibit 4-17 below illustrates the wide range of design intake velocities at facilities potentially regulated under this rule.

Exhibit 4-17. Distribution of cooling water intake structure design through-screen velocities

Velocity (feet per second)	Electric generators		Manufacturers	
	Estimated number of CWIS	Percent of CWIS	Estimated number of CWIS	Percent of CWIS
0 - 0.5	148	17	165	38
0.5 - 1	200	22	85	20
1 - 2	316	35	84	19
2 - 3	162	18	57	13
3 - 5	35	4	27	6
5-7	10	1	6	1
> 7	23	3	13	3
Total	893	100	436	100
Average (fps, unweighted)	1.9		1.6	
Median (fps, unweighted)	1.4		1.0	

Source: Survey Data from Detailed and Short Technical Industry Questionnaire: (DCN 4-0016F-CBI).

Note: Based on survey responses that provided data.

Note: The average design through-screen velocity for all surveyed cooling water intake structures (unweighted) is 1.8 feet per second. The median design through-screen velocity for all surveyed facilities is 1.3 feet per second.

Note: All values are weighted and include those facilities identified as baseline closures.

Exhibit 4-18 provides a national estimate of the number and percentage of cooling water intake structures by average number of days operating for all intakes for which data was reported. Data provided is based on a “typical” year for short technical survey facilities and the year 1998 for the detailed technical survey facilities.

Exhibit 4-18. Estimated distribution of intakes by average of CWIS operating days

Average intake operating days	Electric generators		Manufacturers	
	Estimated number of facilities	Percent of facilities	Estimated number of facilities	Percent of facilities
< 60 days	81	8.0%	37	4.6%
60 – 180 days	113	11.1%	23	2.9%
180 – 270 days	81	8.0%	26	3.2%
> 270 days	684	67.2%	676	82.6%
Unknown	58	5.7%	56	6.8%
Total	1,017	100.0%	819	100.0%

Source: Survey Data from Detailed and Short Technical Industry Questionnaires.

Exhibit 4-18 shows that the intakes for manufacturers tend to operate more days per year than electric generators. Nearly 75 percent of both types of facilities operate more than 270 days per year. For electric generators, the number of operating days is a component of the ***capacity utilization rate*** (CUR); the other component is the proportion of the total generating capacity actually generated during the operating period. The number of operating days also gives an indication of the general amount of operational downtime that may be available to help defray costs of compliance technology construction downtime.

4.1.6 Existing Intake Technologies

Most facilities potentially regulated under the existing facilities rule have intake technologies already in place. Exhibit 4-19 illustrates the number of existing facilities utilizing different types of intake technologies. EPA notes that not all intake technologies may be sufficient to meet the performance standards or the requirements of the rule. While not using an intake technology per se, facilities with cooling towers have also been included in this table to demonstrate the usage of flow reduction as a method to reduce impingement mortality and entrainment.

Exhibit 4-19. Distribution of intake technologies

	Electric generators		Manufacturers	
Intake technology type	**Estimated number of technologies**	**Percent of facilities**	**Estimated number of technologies**	**Percent of facilities**
Bar rack or trash rack	281	42	403	68
Screening technologies	623	93	431	73
Passive intake technologies	130	19	205	35
Fish diversion or avoidance system	44	7	36	6
Fish handling or return system	145	22	23	4
No Intake technologies	6	1	14	2
Cooling tower	191	28	209	35
Total	671	100	592	100

Source: Survey Data from Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (DCN 4-0016F-CBI).

Note: The total number of technologies exceeds the total number of facilities, since many facilities employ multiple intake technologies.

Note: All values are weighted and include those facilities identified as baseline closures.

4.1.7 Age of Facilities

Exhibit 4-20 shows the age of existing generating units. As discussed in Chapter 5, this data may not be entirely representative of the actual age of equipment used, as power plants and manufacturers tend to be long-lived facilities that commonly add new units or replace existing units.[33]

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[33] As a result, the age of the facility as a whole may not be representative of the age of its units; original units may have been retired or replaced.

Exhibit 4-20. Age of electric generating units by fuel type

Unit age (years)	Coal		Natural gas		Nuclear		Oil		Other	
	Units	%	Units	%	Units	%	Units	%	Units	%
> 60	22	2	11	1	0	0	8	2	0	0
51-60	275	29	119	14	0	0	27	6	6	26
41-50	271	28	137	16	0	0	123	27	1	4
31-40	218	23	276	33	49	50	241	53	0	0
11-30	167	17	121	14	49	50	41	9	13	57
< 10	9	1	180	21	0	0	16	4	3	13
Total	**962**		**844**		**98**		**456**		**23**	

Source: EIA Form 860 Database, year 2008 data.

Note: Data was not available for approximately 34 facilities.

As shown in Exhibit 4-20, over eighty percent of the coal-fired units are at least 30 years of age and more than 31 percent of coal units are at least 50 years of age. Natural gas facilities tend to be much newer and most nuclear powered units continue to operate under a recently renewed 20 year operating license or are in the process of seeking such renewals.[34]

4.1.8 Water Reduction Measures at Manufacturers

During EPA's site visits to manufacturing facilities, EPA noted many flow reduction and/or water reuse practices being employed. Flow reductions were demonstrated through process innovations, internal audits and leak checks, reengineering to capture lost resources (e.g., water, heat), water reuse or conservation initiatives, process changes as a result of effluent limitations guideline (ELG) requirements, and other similar activities. EPA also reviewed specific ELG requirements and other incentive programs to identify water reduction requirements and approaches. A summary of the findings is presented below.

Site Visits

An overview of flow reduction information from the manufacturing site visits is provided in Exhibit 4-21 below.[35]

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[34] As discussed in DCN 10-6876, there are indications that some nuclear units may operate well beyond the initial projections for useful life.

[35] For a complete discussion of EPA's site visits, see Chapter 2 of this TDD.

Exhibit 4-21. Flow reduction at sites visited by EPA

Manufacturing site	Notes on intake flow reductions
ArcelorMittal—Indiana Harbor	East side recirculates an estimated 569 mgd via underground tunnel system and also has extensive cooling tower usage. West side uses a mix of once-through and CCRS, with power plant using most of once-through flow.
Cargill—Hammond	Reuses 10-15 percent of cooling water as process water. Other Cargill sites reuse higher percentages. Cargill formed a corporate water reduction team and has a company-wide goal of reducing water use by 5% by 2012.
Dow Chemical—Louisiana Operations (Plaquemine)	60 percent of the heat load is processed through cooling towers, leading to a commensurate reduction in flow.
Dow Chemical—St. Charles Operations (SCO)	4 percent of the heat load is processed through cooling towers.
Sunoco—Marcus Hook	Historical intake capacity (DIF) is 134 mgd, permitted limit (from DRBC) is 43 mgd, and AIF is 17 mgd. Significant use of cooling towers.
Sunoco—Philadelphia	Converted several process lines to CCRS in the 1980s and has significant water reuse and use of cooling towers. Actual flow reductions not available, but AIF is very low.
US Steel—Gary	A cooling tower recirculates approximately 148 mgd. Blast furnaces and steel shop also converted to CCRS.
Valero—Delaware City	Added dry and wet cooling systems to new process lines. Withdrawals are limited by DRBC; added towers in 1990s to expand production without increasing heat load.

Effluent Limitations Guidelines (ELGs)

In addition to conducting site visits to observe water reduction practices, EPA also researched ELGs to identify incentives and requirements for water reduction. ELGs are technology-based regulations and are intended to represent the greatest pollutant reductions that are economically achievable for a particular industrial category. As part of the regulatory development process that EPA uses in developing technology-based ELGs for industrial categories, EPA first gathers extensive information and data on the industry's processes, discharge characteristics, technologies and practices used to treat, minimize, or prevent wastewater discharges, as well as economic information.

Pollution prevention, management, and minimization practices have become a greater focus in the ELG development process, especially since EPA has been establishing ELGs for industrial categories and facilities that are not typical production facilities (i.e., airport deicing, construction and development, and concentrated aquatic animal production (aquaculture) facilities among others). EPA is also required by the CWA to reexamine existing ELGs to ensure they are still representative of the industrial category and meet the current levels of treatment technology (BAT, BCT, BPT, NSPS, PSES, and PSNS). For those industrial categories whose ELGs are being revised, new pollution prevention practices are thoroughly examined in addition to the traditional end-of-pipe treatment technologies.

As part of developing ELGs for various industry sectors, EPA typically assesses water use, technologies in place, and industry trends. The documents developed by EPA as part of this process provide the most accurate description of historic changes in water withdrawals on an industry or process/subcategory level.

For example, the factors used in developing the subcategories for the revised iron and steel ELG included:

- Age of equipment and facilities;
- Location;
- Size of the site;
- Manufacturing processes employed;
- Wastewater characteristics; and
- Non-water quality environmental impacts

Of the areas mentioned above, EPA determined that manufacturing processes and the resultant wastewater characteristics were the most significant factors for possible subcategorization of the industry. Detailed discussions of water use, pollutants generated, and production-normalized flow rates are found throughout the TDD for the iron and steel ELG. As part of the iron and steel regulatory development effort, EPA examined the following:

- In-process technologies and process modifications;
- Process water recycle technologies;
- Process water discharge flow rates;
- End-of-pipe wastewater treatment technologies; and
- Treated process wastewater effluent quality

Section 8 of the iron and steel TDD provides examples of wastewater minimization technologies.[36] For example, high-rate recycling can recycle approximately 95 percent or more from a process for reuse. As with other metal processes, countercurrent cascade rinsing can reduce water use by up to 90 percent while other discussions demonstrate process modifications that can result in the reduction of process water volumes by either extending the amount of time water can be utilized within a process or reducing the volume of process water required.

In the metal products and machinery ELG, a section of the TDD discusses pollution prevention practices and wastewater reduction technologies.[37] EPA estimated in the TDD, Section 8, that the use of flow reduction technologies can reduce water use by as much as 50 to 90 percent at applicable facilities.

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[36] Iron and Steel Manufacturing Point Source Category Final Rule: Development Document. EPA 821-R-02-004. Available at http://water.epa.gov/scitech/wastetech/guide/ironsteel/index.cfm.

[37] Effluent Guidelines, Metal Products and Machinery: Final Rule Development Document. EPA-821-B-03-001. Available at http://water.epa.gov/scitech/wastetech/guide/mpm/tdd_index.cfm.

In the organic chemicals, plastics, and synthetic fibers TDD, water conservation and reuse technologies are described although no estimates in reducing flow volumes are presented.[38]

Economic considerations play a large role in the efficient utilization of water within many industrial sectors. Recovering chemicals from waste streams can lower chemical costs but can also greatly reduce treatment expenses for wastewater discharges. In addition, efficient use of water within processes, cooling water for example, can improve process efficiencies throughout the rest of the facility (heated water can then be utilized by other processes in the facility). Leaks and spills at industrial facilities not only present productivity issues, but can possibly lead to health and safety issues.

Incentive Programs

EPA has also developed voluntary incentive programs for facilities that wish to go beyond the minimum regulatory requirements established in the applicable ELG. An example is the Voluntary Advanced Technology Incentives Program (VATIP) established as part of the revised National Emissions Standards for Hazardous Air Pollutants for Source Category: Pulp and Paper Production; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards: Pulp, Paper, and Paperboards (also known as the Pulp and Paper Cluster Rule). EPA established the VATIP to encourage facilities subject to the Bleached Papergrade Kraft and Soda Subcategory to achieve greater pollutant reductions by implementing pollution prevention controls. Pulp and paper mills that enroll in the VATIP receive additional time to comply with the regulation and have reduced monitoring requirements, among other incentives.

The VATIP comprises three tiers that represent increasingly more effective levels of environmental protection. Mills enrolled in the program have extended compliance dates in which to meet the requirements for each tier. Facilities that enter in to VATIP are required to prepare a milestone plan that reflects how the mill will achieve the limitations for their selected tier. This milestone plan can assist permitting authorities in developing interim limitations and requirements in NPDES permits. EPA established three phases to measure a facility’s progress in complying with permit requirements and to ensure compliance with the tier limitations. The three phases include:

- Initial limitations;
- Intermediate milestones; and
- Ultimate limitations

The initial limitations must reflect either the existing effluent quality or the current technology-based limits in the mill’s current permit, whichever is more stringent. This is for those pollutants (or flows) that are part of the VATIP. Under the Clean Water Act (CWA), facilities must comply with best available technology economically achievable (BAT) effluent limitations promulgated after March 31, 1989 immediately (CWA 40

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[38] Development Document for 1987 Effluent Limitations Guidelines and Standards for OCPSF. EPA 440-1-87-009. Available at http://water.epa.gov/scitech/wastetech/guide/ocpsf/index.cfm.

CFR 301(b)(2)). Under the VATIP, the limitations for the various tiers eventually become the BAT limits for those facilities. The pulp and paper ELG requires immediate compliance with ELG limits, but only if they have become enforceable BAT limits.

The intermediate milestones include the establishment of intermediate BAT limitations and the possible inclusion of interim milestones reflective of the facility moving forward to achieve the required limitations for the respective tier.

The ultimate limitations require the facility to meet the final effluent limitations for the applicable tier no later than the date specified in the regulation.

In addition to the time to allow participating facilities to meet the more stringent effluent limits, facilities participating in the VATIP is the reduction in monitoring requirements. Based on the tier chosen, monitoring frequencies are reduced once the facility has demonstrated it has reached the intermediate milestones (stage 2).

4.1.9 Land-based Liquefied Natural Gas Facilities

EPA's research also indicates that there are five existing land-based liquefied natural gas (LNG) facilities in the United States, all on the East coast. LNG facilities may withdraw hundreds of mgd of seawater for warming (re-gasification). Some existing LNG facilities may withdraw water and use 25 percent or more for cooling purposes. As discussed in the preamble, EPA has not identified a uniformly applicable and available technology for minimizing impingement and entrainment mortality at these facilities. However, technologies may be available for some existing LNG facilities. LNG facilities that withdraw any volume of water for cooling purposes would be subject to site-specific, best professional judgment BTA determinations under the proposed rule.

4.2 Electricity Industry

The electricity industry is made up of three major functional service components or sectors: ***generation***, ***transmission***, and ***distribution***. Each of these terms is defined as follows (Beamon, 1998; Joskow, 1997):

- The ***generation*** sector includes power plants that produce, or "generate," electricity.[39] Electric energy is produced using a specific generating technology, for example, internal combustion engines and turbines. Turbines can be driven by wind, moving water (hydroelectric), or steam from fossil fuel-fired boilers or nuclear reactions. Other methods of power ***generation*** include geothermal or photovoltaic (solar) technologies.
- The ***transmission*** sector can be thought of as the interstate highway system of the business – the large, high-voltage power lines that deliver electricity from power plants to ***distribution*** centers using a complex system. ***Transmission*** requires: interconnecting and integrating a number of generating facilities into a stable, synchronized, alternating current (AC) network; scheduling and dispatching all connected plants to balance the demand and supply of electricity in real time; and

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[39] The terms "plant" and "facility" are used interchangeably throughout this profile and document.

managing the system for equipment failures, network constraints, and interaction with other ***transmission*** networks.

- The ***distribution*** sector can be thought of as the local delivery system – the relatively low-voltage power lines that take power from a ***distribution*** center and bring it to homes and businesses. Electricity ***distribution*** relies on a system of wires and transformers along streets and underground to provide electricity to the ultimate end user: residential, commercial, and industrial consumers. The ***distribution*** system involves both the provision of the hardware (for example, lines, poles, transformers) and a set of retailing functions, such as metering, billing, and various demand management services.

Of the three industry sectors, only electricity ***generation*** uses cooling water and is, therefore, subject to section 316(b) regulations.

4.2.1 Domestic Production

This section presents an overview of U.S. generating capacity and electricity ***generation*** for the year 2007.[40] The rating of a generating unit is a measure of its ability to produce electricity.[41] Generator ratings are expressed in megawatts (MW). ***Nameplate capacity*** and net ***capability*** are the two common measurements (U.S. DOE, 2000a) and are defined as follows:

Nameplate capacity is the full-load continuous output rating of the generating unit under specified conditions, as designated by the manufacturer.

Net capability is the steady hourly output that the generating unit is expected to supply to the system load, as demonstrated by test procedures. The ***capability*** of the generating unit in the summer is generally less than in the winter due to higher ambient-air and cooling-water temperatures, which cause generating units to operate less efficiently. The ***nameplate capacity*** of a generating unit is generally greater than its net capability.

Exhibit 4-22 shows the net US generating capacity from 2000 to 2011 by fuel type.

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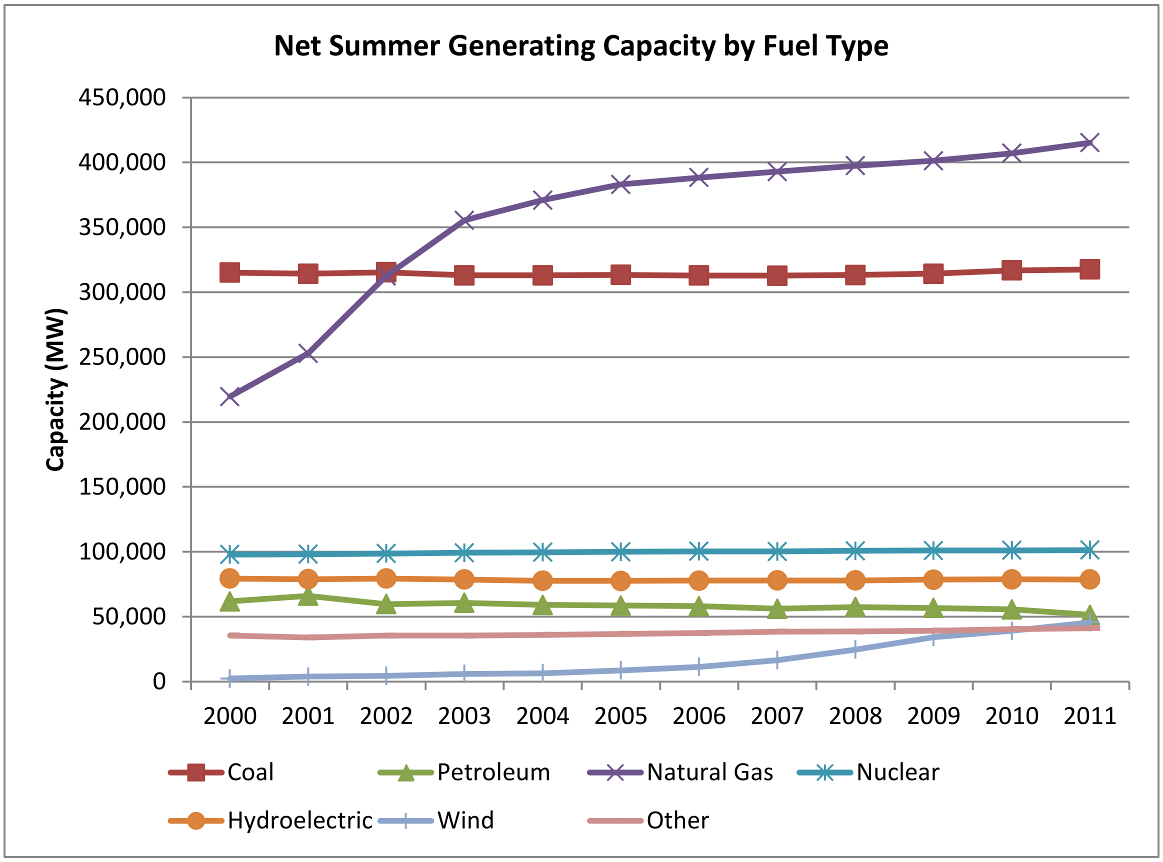
[40] The most recent analysis was for data from 2007. EPA has updated this information since the 2002 proposed Phase II rule, which used data from 1999.

[41] The numbers presented in this section are *capability* for utility facilities and *capacity* for nonutilities. For convenience purposes, this section will refer to both measures as “capacity.”

Exhibit 4-22. Existing generating capacity by energy source (2000 to 2009)



Source: DOE 2013. Table 1.2.

Note 1: Data reflects summer month capacity, during peak consumption.

Note 2: “Other” is a combination of the following: other gases (e.g., blast furnace gas, propane gas); solar; wood; and other renewables.

Exhibit 4-22 shows that the majority of capacity increases over the past 10 years have been fueled by natural gas, with a minor increase in wind power in recent years.

4.2.2 Prime Movers

Electric power plants use a variety of ***prime movers*** to generate electricity. The type of prime mover used at a given facility is determined based on the type of load the facility is designed to serve, the availability of fuels, and energy requirements. Most ***prime movers*** use fossil fuels (coal, petroleum, and natural gas) as an energy source and employ some type of turbine to produce electricity. The six most common ***prime movers*** are (U.S. DOE, 2000a):

- ***Steam Turbine:*** Steam turbine or “steam electric” units require a fuel source to boil water and produce steam that drives the turbine. Either the burning of fossil fuels or a nuclear reaction can be used to produce the heat and steam necessary to generate electricity. These units are often ***baseload*** units that are run continuously to serve the constant load required by the system. Steam electric units generate the majority of electricity produced at power plants in the U.S.[42]

- ***Gas Combustion Turbine:*** Gas turbine units burn a combination of natural gas and distillate oil in a high pressure chamber to produce hot gases that are passed directly through the turbine. Units with this prime mover are generally less than 100 megawatts in size, less efficient than steam turbines, and used for ***peakload*** operation serving the highest daily, weekly, or seasonal loads. Gas turbine units have quick startup times and can be installed at a variety of site locations, making them ideal for peak, emergency, and reserve-power requirements. These units do not use a steam loop and do not use cooling water; waste heat is discharged to the atmosphere.
- ***Combined Cycle Turbine:*** Combined cycle units utilize both steam and gas turbine prime mover technologies to increase the efficiency of the gas turbine system. After combusting natural gas in gas turbine units, the hot gases from the turbines are transported to a waste-heat recovery steam boiler where water is heated to produce steam for a second steam turbine.[3] The steam may be produced solely by recovery of gas turbine exhaust or with additional fuel input to the steam boiler. The combination of a gas turbine and steam turbine process results in a generating system that is much more efficient than either alone. Combined cycle generating units have generally been used for ***intermediate loads*** but may be used as ***baseload*** units when natural gas prices are favorable**.** These units use a steam loop in the steam turbine portion of the process and use cooling water to convert the steam back to water and use much less cooling water per MW generated that steam turbine units.
- ***Internal Combustion Engines:*** Internal combustion engines contain one or more cylinders in which fuel is combusted to drive a generator. These units are generally about 5 megawatts in size, can be installed on short notice, and can begin producing electricity almost instantaneously. Like gas turbines, internal combustion units are generally used only for peak loads. These units do not use a steam loop and do not use cooling water; waste heat is discharged to the atmosphere.
- ***Water Turbine:*** Units with water turbines, or "hydroelectric units," use either falling water or the force of a natural river current to spin turbines and produce electricity. These units are used for all types of loads. These units do not use a steam loop and do not use cooling water, as they typically do not generate excess waste heat.
- ***Other Prime Movers:*** Other types of ***prime movers*** include binary cycle turbine (geothermal), photovoltaic (solar), wind turbine, and fuel cell ***prime movers.*** The contribution of these ***prime movers*** is small relative to total power production in the U.S., but the role of these ***prime movers*** may expand in the future because recent legislation includes incentives for their use. Generally, with the exception

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[42] The steam is contained in a steam loop that is separate from the cooling water system and is, therefore, not the focus of this rule. Cooling water is used to convert steam back to water.

of binary cycle turbines, these movers do not generate excess waste heat. Binary cycle turbines generally use cooling towers to dissipate waste heat.

Exhibit 4-23, which is based on DOE's Form EIA-860, provides data on existing power generating plants by prime mover. This exhibit includes all facilities in the electric power industry (i.e., not just facilities subject to 316(b)) that have at least one non-retired unit and that submitted Form EIA-860 (Annual Electric Generator Report) in 2007.[43] For this analysis, EPA classified facilities as "steam turbine" or "***combined cycle***" if they had at least one generating unit of that type; facilities with both steam turbine- and combined cycle-based capacity were classified by the largest capacity generating unit. Facilities that had no steam electric units were classified under the prime mover of the largest capacity generating unit.

Section 316(b) is only relevant for electric generators that use cooling water. However, not all ***prime movers*** require cooling water. Only ***prime movers*** with a steam-electric generating cycle use large enough amounts of cooling water to fall under the scope of the proposed rule. EPA identified the two types of ***prime movers*** (steam turbine and ***combined cycle*** steam turbine) that constitute the steam electric ***prime movers*** of interest.[44]

Using this list of steam electric ***prime movers*** and DOE's Annual Electric Generator Report (which collects data to create an annual inventory of utilities and operating status of units), EPA identified the facilities that have at least one generating unit with a steam electric prime mover. The rest of this profile will focus on the generating plants with a steam electric prime mover (i.e., steam turbine or ***combined cycle***).

Exhibit 4-23. Number of existing utility and nonutility facilities by prime mover, 2007

Prime mover	Number of facilities
Steam turbine	1,349
Combined cycle	453
Gas turbine	834
Internal combustion	1,005
Hydroelectric	1,368
Other	365
Total	**5,374**

[a] Facilities are listed as steam electric if they have at least one steam electric generating unit.

[b] Facility counts are weighted estimates generated using the original 316(b) survey weights.

Sources: U.S. EPA, 2000; U.S. DOE, 2007.

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[43] Note that EPA's technology assessments and compliance cost estimates are based upon data that EPA collected through industry questionnaires. This technology data represents the year 2000. Since EPA has not collected any new information on intake technologies, intake flows, etc. for the existing facilities proposed rule, EPA is continuing to use the 2000 questionnaire data for some analyses as it reflects the best information available. However, because more recent information was available through existing sources, EPA conducted the analysis using 2007 data to more accurately account for possible impacts. As a result, some of the information presented in this chapter reflects the year 2000 while other reflects the year 2007.

[44] EIA identifies 11 other categories of prime mover, but these categories are not subject to 316(b).

4.2.3 Steam Electric Generators

Exhibit 4-24 provides summary data concerning the number of utilities/operators, number of plants, generating units, and total ***nameplate capacity.*** The table provides information for the industry as a whole, for the steam electric part of the industry, and for the part of the industry potentially subject to the existing facilities rule.

Exhibit 4-24. Summary of 316(b) electric power facility data

		Steam electric[f]		316(b)[b,c]	
	Total[f]	Number	% of Total	Number	% of Total
Utilities or operators[d]	2,537	1,158	46%	233	9%
Plants[d]	5,374	1,805	34%	559	10%
Units[e]	17,250	4,828	28%	2,132	12%
Nameplate capacity (MW)	1,072,497	790,690	74%	480,388	45%

[a] Data are for regulated and non-regulated entities.

[b] Number of units and capacity include steam and non-steam units and capacity, respectively, at 316(b) electric power facilities.

[c] Number of plants, number of units, and capacity are weighted estimates and are generated using the original 316(b) survey weights.

[d] Utilities/operators and plants are listed as steam electric if they have at least one non-retired steam electric unit.

[e] Total number of units includes non-steam generating units at facilities previously considered for the 316(b) regulation that have retired all of their steam generating units. Because these facilities no longer have steam operations they are excluded from the currently analyzed 316(b) universe.

[f] Estimates exclude facilities that have retired all of their operations - steam and non-steam - according to the 2010 base-case IPM run.

From the universe of facilities with a steam electric prime mover and based on data collected from EPA’s industry technical questionnaires and the compliance requirements for the final rule, EPA has identified 544 facilities to which the proposed rule is expected to apply.[45] All of these facilities are in the set of 554 facilities that were expected to comply with the suspended 2004 Phase II Final Rule and 117 electric generators with design intake flow between 2 and 50 mgd excluded from the 2006 Phase III Final Rule; however, based on 2007 ***EIA*** data and IPM data, a total of 93 of the 671 Phase II and Phase III facilities will have retired by 2012.[46] In addition, 19 coastal facilities are subject to the California “Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling” And 36 facilities located in the State of New York where requirements are at least as stringent the final rule[47] Exhibit 4-25 provides a summary of the estimated

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[45] EPA developed the estimates of the number and characteristics of facilities expected to be within the scope of the rule using the facility sample weights that were developed for the suspended 2004 Phase II rule and the 2006 Phase III Rule. These weights provide comprehensive estimates of the total number of in-scope facilities based on the full set of facilities sampled in EPA’s industry questionnaires. This estimate includes baseline closures. See the preamble and the EA for further discussion of the sample weights used in this analysis.

[46] Individual values do not sum to reported totals due to rounding as the result of the application of statistical weights.

[47] As described in the EA, these 19 California and 36 New York facilities were not included in the economic analysis for the rule, as they are subject to requirements under each state’s cooling water policy, which contains similar or more stringent requirements to the final rule.

number of facilities considered in the economic analysis under previous and current 316(b) regulation development.

Exhibit 4-25. Number of 316(b) regulated facilities

	Unweighted			Weighted[a]		
	Phase II	**Phase III**	**Total**	**Phase II**	**Phase III**	**Total**
Phase II/III	543	113	656	554	117	671
EIA-Retired[b,c]	41	11	52	43	11	54
IPM-Retired[b]	31	8	39	31	8	39
Coastal CA	17	0	17	19	0	19
New York	29	4	33	31	4	36
Currently Analyzed	454	94	548	461	98	559

[a] Facility counts generated using the original 316(b) survey weights.

[b] A facility is considered retired if it no longer has any steam operations even though it may still operate non-steam units.

[c] Includes facilities that have already retired and those that will do so before 2012 (i.e., the rule promulgation).

Sources: U.S. EPA, 2000; U.S. DOE, 2007 (GenY07); U.S. EPA Analysis, 2010.

Exhibit 4-26 presents the estimated number of 316(b) facilities by fuel type and prime mover category.

Facilities have multiple generating units and each unit uses only one type of prime mover. However, many facilities operate units with different types of ***prime movers.*** EPA estimates that 12 of the 525 steam turbine facilities also operate ***combined cycle*** generating units and that 10 of the 33 ***combined cycle*** facilities also operate steam turbine generating units. The data shown in Exhibit 4-24 are based on total capacity by prime mover type and do not necessarily indicate which prime mover type predominates with regard to annual power ***generation.***

Exhibit 4-26. 316(b) electric power facilities by plant type and prime mover

Plant type[a]	Prime mover	Number of 316(b) electric generators[b,c]
Coal steam	Steam turbine	342
Gas	Steam turbine	73
Nuclear	Steam turbine	56
Oil	Steam turbine	29
Other steam	Steam turbine	25
Total steam	Steam turbine	525
Combined cycle	Combined cycle	33
Total		559

[a] Facilities are listed as steam electric if they have at least one steam electric generating unit.

[b] Facility counts are weighted estimates generated using the original 316(b) survey weights.

[c] Individual values do not sum to reported total due to rounding as the result the application of statistical weights.

Sources: U.S. EPA, 2000; U.S. DOE, 2007 (GenY07); U.S. EPA Analysis, 2010

4.3 Manufacturers

4.3.1 Electric Generation at Manufacturers

Some manufacturing facilities also produce electricity (cogeneration). According to data from the 316(b) questionnaire, 164 manufacturing facilities responded that they had produced electricity in 1996, 1997, or 1998.[48] One hundred eleven (111) facilities responded that they did not generate electricity during the survey period. Twelve (12) facilities did not respond to the question.

Exhibit 4-27 shows the proportion of the 38 manufacturers that use coal as their primary fuel source.

Exhibit 4-27. Manufacturers with coal-fired generation

Total facility coal-fired generation capacity (MW)	Number of facilities
0-25	15
25-50	8
50-100	9
100-200	4
> 200	2
Total	**38**

The six largest manufacturers (i.e., those with a generating capacity above 100MW) came from 5 industry sectors: steel works (SIC 3312), iron ore (1011), electric services/non-ferrous metals (4911/3339), chemical (2800), and sanitary paper (2676).

4.4 Glossary

Baseload: The minimum amount of electric power delivered or required over a given period of time at a steady rate.

Baseload Generating Unit: A baseload generating unit is normally used to satisfy all or part of the minimum or base load of the system and, as a consequence, produces electricity at an essentially constant rate and runs continuously. Baseload units are generally the newest, largest, and most efficient of the three types of units. (http://www.eia.doe.gov/cneaf/electricity/page/prim2/chapter2.html)

Capacity Utilization Rate: The ratio between the average annual net ***generation*** of power by the facility (in MWh) and the total net ***capability*** of the facility to generate power (in MW) multiplied by the number of hours during a year.

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[48] Answered yes to Question 15(a) of the 31(6)b detailed industry questionnaire for manufacturers, which requested information on whether the facility generated electricity during the time period covered by the survey.

Combined cycle: An electric generating technology in which electricity is produced from otherwise lost waste heat exiting from one or more gas (combustion) turbines. The exiting heat is routed to a conventional boiler or to heat recovery steam generator for utilization by a steam turbine in the production of electricity. This process increases the efficiency of the electric generating unit.

Combined cycle Unit: An electric generating unit that consists of one or more combustion turbines and one or more boilers with all or a portion of the required energy input to the boiler(s) provided by the exhaust gas of the combustion turbine(s).

Distribution: The delivery of energy to retail customers (including homes, businesses, etc.).

Distribution System: The portion of an electric system that is dedicated to delivering electric energy to an end user.

EIA: The Energy Information Administration (EIA), created by Congress in 1977, is a statistical agency of the U.S. Department of Energy.

Electricity Available to Consumers: Power available for sale to customers. Approximately 8 to 9 percent of net ***generation*** is lost during the ***transmission*** and distribution process.

Gas Turbine Plant: A plant in which the prime mover is a gas turbine. A gas turbine typically consisting of an axial-flow air compressor and one or more combustion chambers, where liquid or gaseous fuel is burned and the hot gases are passed to the turbine and where hot gases expand to drive the generator and are then used to run the compressor.

Generation: The process of producing electric energy or the amount of electric energy produced by transforming other forms of energy, commonly expressed in ***kilowatt***-hours (kWh) or megawatt-hours (MWh).

Gross Generation: The total amount of electric energy produced by the generating units at a generating station or stations, measured at the generator terminals.

Internal Combustion Plant: A plant in which the prime mover is an internal combustion engine. An internal combustion engine has one or more cylinders in which the process of combustion takes place, converting energy released from the rapid burning of a fuel-air mixture into mechanical energy. Diesel or gas-fired engines are the principal fuel types used in these generators. The plant is usually operated during periods of high demand for electricity.

Kilowatt (kW): One thousand watts (W).

Kilowatt-hour (kWh): One thousand watt-hours (Wh).

Megawatt (MW): One thousand kilowatts (kW).

Megawatt-hour (MWh): One thousand kilowatt-hours (kWh)

Nameplate Capacity: The amount of electric power delivered or required for which a generator, turbine, transformer, ***transmission*** circuit, station, or system is rated by the manufacturer.

Net Capacity (Capability): The amount of electric power delivered or required for which a generator, turbine, transformer, ***transmission*** circuit, station, or system is rated by the manufacturer, exclusive of station use, and unspecified conditions for given time interval.

Net Generation: Gross generation minus plant use from all electric ***utility*** owned plants. The energy required for pumping at a pump storage plant is regarded as plant use and must be deducted from the gross equation.

Nonutility Power Producer: A corporation, person, agency, authority, or other legal entity or instrumentality that owns electric generating capacity and is not an electric utility. Nonutility power producers include qualifying cogenerators, qualifying small power producers, and other nonutility generators (including independent power producers) without a designated franchised service area that do not file forms listed in the Code of Federal Regulations, Title 18, Part 141. (http://www.eia.doe.gov/emeu/iea/glossary.html)

Peakload: The maximum load during a specified time period.

Peakload Generating Unit: A peakload generating unit, normally the least efficient of the three unit types, is used to meet requirements during the periods of greatest, or peak, load on the system. (http://www.eia.doe.gov/cneaf/electricity/page/prim2/chapter2.html)

Prime Movers: The engine, turbine, water wheel or similar machine that drives an electric generator; or, for reporting purposes, a device that directly converts energy to electricity directly (e.g., photovoltaic solar, and fuel cell(s)).

Regulated Entity: For the purpose of ***EIA***'s data collection efforts, entities that either provide electricity within a designated franchised service area and/or file forms listed in the Code of Federal Regulations, Title 18, Part 141 are considered regulated entities. This includes investor-owned electric utilities that are subject to rate regulation, municipal utilities, Federal and State power authorities, and rural electric cooperatives. Facilities that qualify as cogenerators or small power producers under the Public Utility Regulatory Power Act (PURPA) are not considered regulated entities.

Reliability: Electric system reliability has two components: adequacy and security. Adequacy is the ability of the electric system to supply customers at all times, taking into account scheduled and unscheduled outages of system facilities. Security is the ability of the electric system to withstand sudden disturbances, such as electric short circuits or unanticipated loss of system facilities. The degree of reliability maybe measured by the frequency, duration, and magnitude of adverse effects on consumer services. (http://www.eia.gov/cneaf/electricity/page/glossary.html)

Steam Electric Power Plant: A plant in which the prime mover is a steam turbine. The steam used to drive the turbine is produced in a boiler where fossil fuels are burned.

Transmission: The movement or transfer of electric energy over an interconnected group of lines and associated equipment between points of supply and points at which it is transformed for delivery to consumers, or is delivered to other electric systems. Transmission is considered to end when the energy is transformed for distribution to the consumer

Utility: A corporation, person, agency, authority, or other legal entity or instrumentality that owns and/or operates facilities within the United States, its territories, or Puerto Rico for the generation, transmission, ***distribution***, or sale of electric energy primarily for use by the public, with a dedicated service area, and files forms listed in the Code of Federal Regulations, Title 18, Part 141. Facilities that qualify as cogenerators or small power producers under the Public Utility Regulatory Policies Act (PURPA) are not considered electric utilities. (http://www.eia.doe.gov/emeu/iea/glossary.html)

Water Turbine: A unit in which the turbine generator is driven by falling water.

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Chapter 5: Subcategorization

5.0 Introduction

This section describes EPA's consideration of subcategories for the final rule. Section 5.1 discusses the methodology and factors considered when evaluating potential subcategories for the rule. The remainder of the chapter discusses EPA's analysis of each factor.

5.1 Methodology and Factors Considered for Basis of Subcategorization

In the development of other technology-based CWA regulations such as effluent limitations guidelines, EPA considers a number of different factors. Among others, these include the age of the equipment and facilities in the category, manufacturing processes employed, types of treatment technology to reduce effluent discharges, and the cost of effluent reductions (section 304(b)(2)(b) of the CWA, 33 U.S.C. 1314(b)(2)(B)). The statute also authorizes EPA to take into account other factors that the Administrator deems appropriate.

While the 316(b) language does not specifically require EPA to consider subcategories, EPA concludes it is reasonable to do so because section 316(b) cross references sections 301 and 306.

EPA considered a number of factors as a basis of subcategorization in determining best technology available. The major factors EPA considered are:

- the age of facility or unit;
- electricity generation or manufacturing process;
- existing intake type;
- application of various impingement and entrainment reduction technologies;
- geographical location;
- facility size;
- non-water quality environmental impacts (including energy requirements)
- the potential for adverse environmental impact; and
- the cost of achieving impingement and entrainment reductions.

The following sections discuss EPA's consideration of these factors with the exception of the cost of achieving impingement and entrainment reductions. See the EA for those analyses.

5.2 Age of the Equipment and Facilities

As discussed in Chapter 4, many power plants and manufacturers have been in operation for many years. Existing units may operate for decades before being replaced by new or more efficient units or retired altogether. EPA considered the age of equipment as a subcategorization basis. EPA concluded this is not an appropriate basis because power plants and manufacturing facilities tend to be long-lived facilities and have regular maintenance, equipment upgrades, plant expansions, and other activities. Equipment such as intake technologies is generally included in the scheduled maintenance. Factors such as the waterbody type, debris loading, and other site-specific factors will dictate how frequently a facility needs to replace this equipment. EPA did not find that the age of facilities or equipment changed the need of such facilities for cooling water (since gains in efficiency have typically been used to maintain or increase power production or productivity), or the impacts associated with cooling water use. Nor did EPA identify significantly different CWIS technologies based on facility age. For example, nuclear power facilities receive 30 or 40 year licensing, with license renewals of 10 or 20 years. In site visits, EPA found this period of licensing did not correlate with individual facility uprates, equipment replacement, or upgrades.

Using information collected through the industry questionnaire, site visits, and conversations with industry representatives, EPA also evaluated age of the existing facility as a possible basis for subcategorization. EPA determined that the age of a facility is not an appropriate measure for subcategorization. Electric generators often add new generating units and may then retire older, less-efficient units. As such, the date at which the facility began operations may not be reflective of a facility’s current operations.

However, EPA does recognize that many existing power plants and manufacturing facilities operate older units; as noted in Chapter 4, over 31 percent of coal-fired generating units are more than 50 years old. As a result, it may be undesirable to retrofit some older facilities to closed-cycle cooling, as these facilities may be approaching the end of their useful life.

5.3 Processes Employed

5.3.1 Electric Generators

The major difference between power plants in terms of “process” is the fuel source. As illustrated in Chapter 4 of the TDD, power plants use a variety of fuels to generate electricity.

Exhibit 5-1 shows the typical generating efficiencies for each fuel type.

Exhibit 5-1. Generating efficiency by fuel type

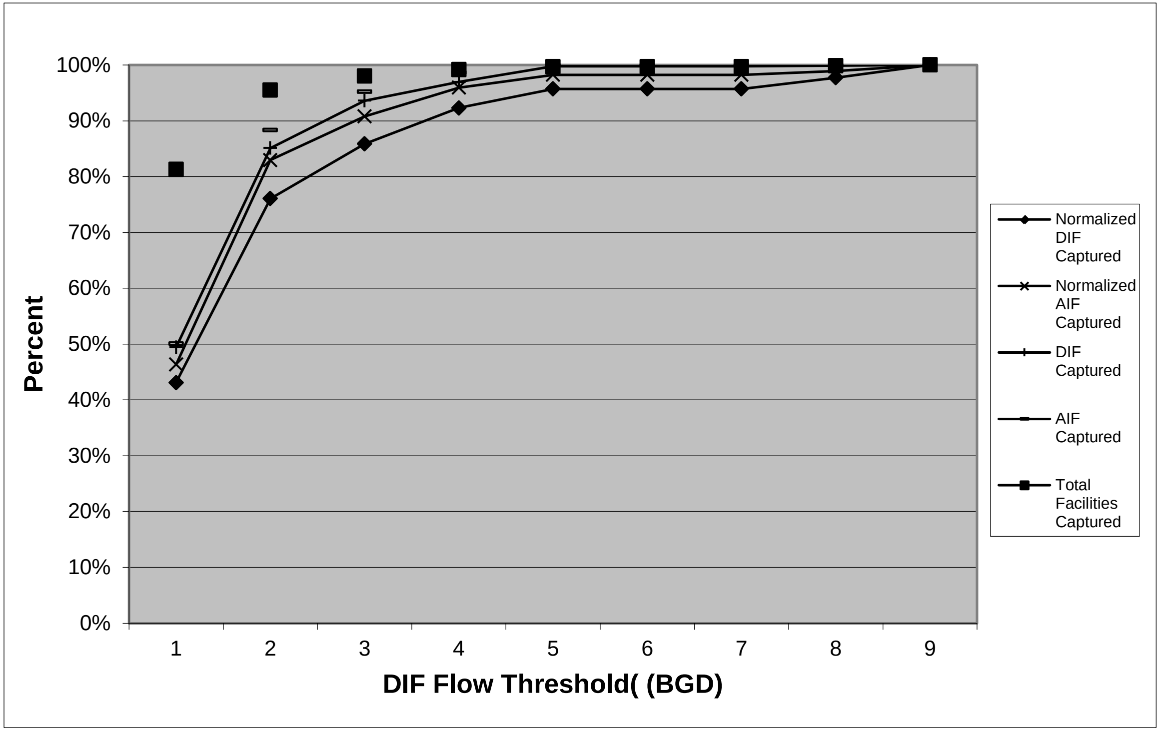
Fuel type	Typical plant efficiency (%)
Coal	32 - 42
Natural gas	32 - 38
Natural gas (combined cycle)	50 - 60
Nuclear	33

In general, the type of fuel used at a facility does not affect the design or operation of the facility's CWIS. The type of fuel may affect the volume of water needed, additional design considerations (e.g., emergency backup withdrawal capabilities), or other elements of the facility's operation, but these elements generally do not impact the selection or operation of intake technologies.[49]

EPA also explored the thermal (fuel) efficiency of different fuel types as a basis. While many reviews identify nuclear as far less efficient than coal, these comparisons do not factor in the significant heat losses from the stack of coal-fired units. When this source of heat is accounted for, there is no significant difference in thermal efficiency by fuel type for generating units using steam only as it relates to waste heat passing through the cooling system.

Based on discussions with industry during site visits, one of the main differences related to fuel type is intake flow for nuclear facilities. In order to more fully explore the assertion that nuclear facilities exhibit different trends in the utilization of cooling water, EPA plotted the cumulative intake flow for nuclear and non-nuclear facilities. Exhibits 5-2 and 5-3 below illustrate the flow data by non-nuclear facilities and nuclear facilities, respectively.

Exhibit 5-2. Distribution of intake flows for all non-nuclear electric generators



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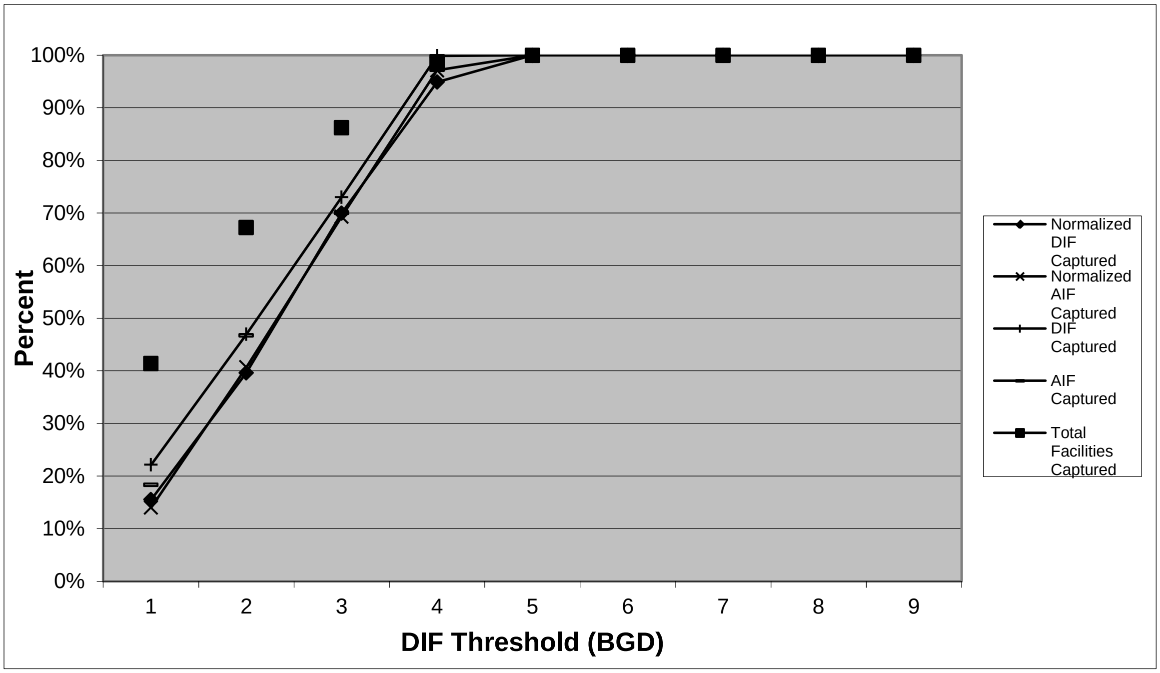
[49] Note that, where necessary, EPA has incorporated fuel type-based costs in determining the compliance costs for facilities. For example, downtime estimates for nuclear facilities are substantially longer than those for fossil fuel facilities.

Exhibit 5-3. Distribution of intake flows for all nuclear electric generators



These exhibits show that nuclear electric generator facilities on average have a larger flow than non-nuclear electric generators, which affects the size of the cooling system. However, EPA did not identify significant differences in CWIS technologies between nuclear and non-nuclear facilities and, therefore, this was not determined to be an appropriate basis for subcategorization.

EPA data also indicate that the distribution of nuclear facilities versus non-nuclear facilities does not differ significantly by waterbody type (see Exhibit 5-4).

Exhibit 5-4. Distribution of nuclear and non-nuclear facilities by waterbody type

Waterbody type	Percent of nuclear facilities	Percent of non-nuclear facilities
Freshwater river or stream	39.7	48.7
Tidal river or estuary	15.5	20.2
Lake or reservoir	22.4	20.9
Great Lake	13.8	6.8
Ocean	8.6	3.3

EPA data do indicate that a somewhat larger percentage of nuclear facilities use closed-cycle cooling than non-nuclear facilities (see Exhibit 5-5). However, because the percentage of nuclear facilities using closed-cycle cooling remains limited and the majority of applications of closed-cycle cooling are newly built units (i.e., Palisades is the only nuclear facility that has retrofitted to closed-cycle—see DCN 10-6888), this was not determined to be an appropriate basis for subcategorization.

Exhibit 5-5. Distribution of nuclear and non-nuclear facilities by cooling system type

Cooling water system type	Percent of nuclear facilities	Percent of non-nuclear facilities
Once-through	50.0	78.3
Closed-cycle	37.9	12.0
Combination or other	12.1	9.7

5.3.2 Manufacturers

In general, manufacturers use cooling water in much the same way as electric generators. While the end product may vary (e.g., paper products versus electricity), the cooling water is often used for similar industrial processes. As noted in Chapter 4, 164 (60 percent) of the 275 manufacturers surveyed indicated that they generated electricity onsite as part of their operation and some even sold electricity and steam. An analysis of water use survey data for cooling water intakes indicated that 47 percent of manufacturing facility cooling water intakes used at least a portion of the cooling water for electricity generation and that 9 percent of manufacturing facility intakes used greater than 90 percent of cooling water for power generation.[50] Where manufacturers differ is in their use of contact cooling water and process water, which are typically also withdrawn from the same intake structure as non-contact cooling water.[51] Contact cooling water comes into direct contact with the product, such as quench water for a steel mill and may acquire certain contaminants. Process water is used within the process to create the end product itself, such as water used in producing beverages. These two categories of water withdrawals are distinct from non-contact withdrawals in that they are much more difficult to reduce or eliminate without having a material effect on the end product. In other words, flow reduction (such as the use of closed-cycle cooling) is less likely to be a viable alternative for contact cooling or process flows, as the concentration of pollutants through evaporation would adversely affect the facility’s production. As a result, Options 2 and 3 (see Chapter 7 or the preamble for the proposed rule) excluded contact and process flows from flow reduction requirements. As discussed in Chapter 8, EPA adjusted its cost methodology for manufacturers to account for this difference; intake flow rates (the basis for cooling tower costs) at manufacturing facilities were adjusted by as much as 47 percent. As discussed in Chapter 3, intakes where less than 25 percent of intake volume is used exclusively for contact or non-contact cooling purposes are not subject to this rule.

Additionally, as shown in Chapter 4, manufacturers use essentially the same intake technologies and cooling system types as electric generators. There is no indication that cooling water withdrawal by manufacturers is any different than at generators and, as

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[50] The portion of manufacturing facility intakes (47 percent) that reported using cooling water for power generation is smaller than the portion of facilities that generate electricity (60 percent). This may be due to the fact that some manufacturers may generate electricity without using cooling water (e.g., cogeneration) and that many manufacturers have multiple intakes but may only use one for power generation (see DCN 12-6630).

[51] Electric generators use non-contact cooling water almost exclusively. As a result, no analysis of contact or process water is required for power plants.

noted above, a significant number of manufacturers use cooling water for similar purpose as generators.[52] EPA's observations during the site visits confirmed that most facilities (including both manufacturers and generators) were found to be very similar in how they use cooling water, how the intake technologies were selected and constructed, and the types of challenges facilities faced in operating CWIS technologies. As a result, there is no data suggesting that manufacturers should be addressed separately on the basis of intake or cooling system technologies.

5.4 Existing Intake Type

As illustrated in Chapter 4, existing facilities use a variety of intake locations, designs, and technologies for withdrawing cooling water. While a facility's site-specific characteristics will have a significant impact on the facility's choice for its intake location (e.g., shoreline, offshore, etc.) and the selection, design, and operation of the facility's intake technology, generally any of the possible intake locations will be able to supply sufficient cooling water to a facility. In addition, the various types of intake configurations (e.g., canal, surface, sub-surface, infiltration, sequenced intakes such as an intake emptying into a forebay) were not, by themselves, found to affect BTA. As such, EPA determined that it could not establish any appropriate subcategories based on the existing intake type. EPA did research the performance of existing far offshore intakes and associated velocity caps (see DCN 12-6601). Based on available performance data EPA concluded that the performance of neither the far offshore submerged intake location nor the velocity cap technology alone could be relied upon to meet the BTA impingement technology standard. However, the data indicated when used in combination and provided they met certain criteria that the performance was equivalent to the BTA impingement technology. Based on this analysis, EPA has deemed that existing far offshore intakes with velocity caps that met certain criteria are compliant with the BTA impingement requirement. See Chapter 6 for a more detailed discussion of velocity caps and offshore intakes.

In general, the intake type does not affect a facility's ability to retrofit closed-cycle cooling; the existing intake structure will have more than enough capacity to sustain the reduced level of water withdrawals. Therefore, EPA did not consider intake type as a factor in studying entrainment mortality requirements. Intake type may, however, affect impingement mortality requirements. Where appropriate, EPA's compliance costs reflect the existing intake location and the presence of existing intake technologies. As discussed in Chapter 8, facilities with technologies deemed to be compliant with the impingement mortality requirements of the rule are not assigned any compliance costs. Technologies are, in part, assigned based on intake location, in order to facilitate the most cost-effective compliance solution. Other facilities will be required to upgrade, as reflected in the assigned technology costs.

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[52] With regards to IM&E, there is no indication that fish and shellfish differentiate for what purpose the intake structure supplies cooling water.

5.5 Application of Impingement and Entrainment Reduction Technologies

The final rule and record identifies several impingement and entrainment reduction technologies in various categories, including flow reduction, closed-cycle cooling, screens, diversions, barriers, fish returns, behavioral systems, velocity reduction, physical configurations, and location. However, except for flow reduction, EPA has not identified data that indicate that a specific impingement and entrainment reduction technology is most effective for a particular segment of facilities. Rather, the data indicate that effective technologies can be applied in a variety of settings and that facilities typically use these technologies based on an appropriate configuration for the relevant facility. Thus, the available data does not support subcategorization based on particular impingement and entrainment reduction technologies already in place or the technology availability.

EPA evaluated the possibility of subcategorization based on flow reduction through closed-cycle cooling. Since closed-cycle cooling is deemed a compliant technology, facility intakes with existing closed-cycle cooling are considered compliant and require no additional technology or further designation. For those not currently employing closed-cycle cooling, EPA evaluated several facility attributes that could be considered as potential criteria for subcategorizing facilities based on the relative availability of closed-cycle cooling. These included factors such as land availability, energy reliability, air emissions, and remaining plant useful life.

As discussed in section 5.9.6 below, land requirements and land availability vary from site to site and EPA could not identify a specific metric such as a specific Gigawatt/acre threshold that could reliably assess land availability. EPA looked at local population densities as a proxy for land availability and the potential for additional requirements to provide for plume abatement and to control emissions associated with drift for tower exhaust air. While EPA concluded that roughly 25 percent of facilities may face such requirements, EPA could find no specific attribute that could reliably be used to identify and subcategorize them. EPA's evaluation of air emissions is discussed in TDD Chapter 10. A GIS analysis of increased power plant emissions due to closed-cycle cooling indicated that a significant number of facilities are located in nonattainment areas for PM2.5 and ozone. EPA concluded that the regional air pollutant non-attainment designation is not a suitable criterion for subcategorization as a proxy for availability of closed-cycle cooling due to air permitting issues since the permitting considerations will be subject to many site-specific factors.

As discussed in section 5.6 below, EPA conducted an analysis to evaluate energy reliability issues due to construction downtime and increased power requirements for closed-cycle auxiliary power and turbine efficiency reduction. Based on this analysis, EPA concluded that while there may be some reliability concerns in certain locations, the effects of closed-cycle cooling on national energy reliability would be minimal and that energy reliability is not a suitable criterion for subcategorization. EPA did find several examples of local situations in the Washington, DC, Los Angeles, and Chicago areas where limited grid connectivity might impact closed-cycle cooling availability as a result of energy reliability concerns (e.g., loss of voltage support) but concluded these instances are limited and are best addressed on a site-specific basis. See discussion and example in section 5.6 and site visit reports for Potomac (DCN 10-6512), Scattergood (DCN 10-6545), Haynes (DCN 10-6547), Fisk (DCN 10-6543), and Crawford (DCN 10-6544).

EPA found that remaining useful life of a plant as it relates to closed-cycle cooling is difficult to quantify since useful life may vary for different plant components and infrastructure including cooling systems. An aging generating unit with an apparent short useful life may be completely or partially repowered and may continue to use existing infrastructure such as cooling towers. Remaining useful life is subject to many economic considerations that make it difficult to quantify and thus unsuitable for consideration as a criterion for subcategorization.

As discussed in section 5.6 below, EPA also examined waterbody type as it related to the availability of closed-cycle cooling since water characteristics such as total dissolved solids (TDS) content can affect closed-cycle cooling system design and operating conditions. For example, EPA recognizes that closed-cycle systems that use makeup water with high TDS (such as from ocean and estuarine waterbodies) may need to operate at different cycles of concentration which may affect the degree of flow reduction and materials of construction, but concluded that while these considerations may affect costs and performance to some degree, they do not affect the availability of the technology (see section 6.1).

EPA also considered water consumption in the context of the availability of cooling water or makeup water in regions where water resources may be limited. EPA found that in such regions, the availability of evaporative closed-cycle cooling systems may be limited but that these limitations also extend to other cooling system types such as once-through cooling. Further, EPA found that, in many of these situations, existing facilities use alternative cooling systems such as dry cooling rather than once-through or evaporative closed-cycle cooling. EPA examined other factors in addition to those discussed above and could not identify any that could potentially serve as a criterion for subcategorization based on availability of closed-cycle cooling.

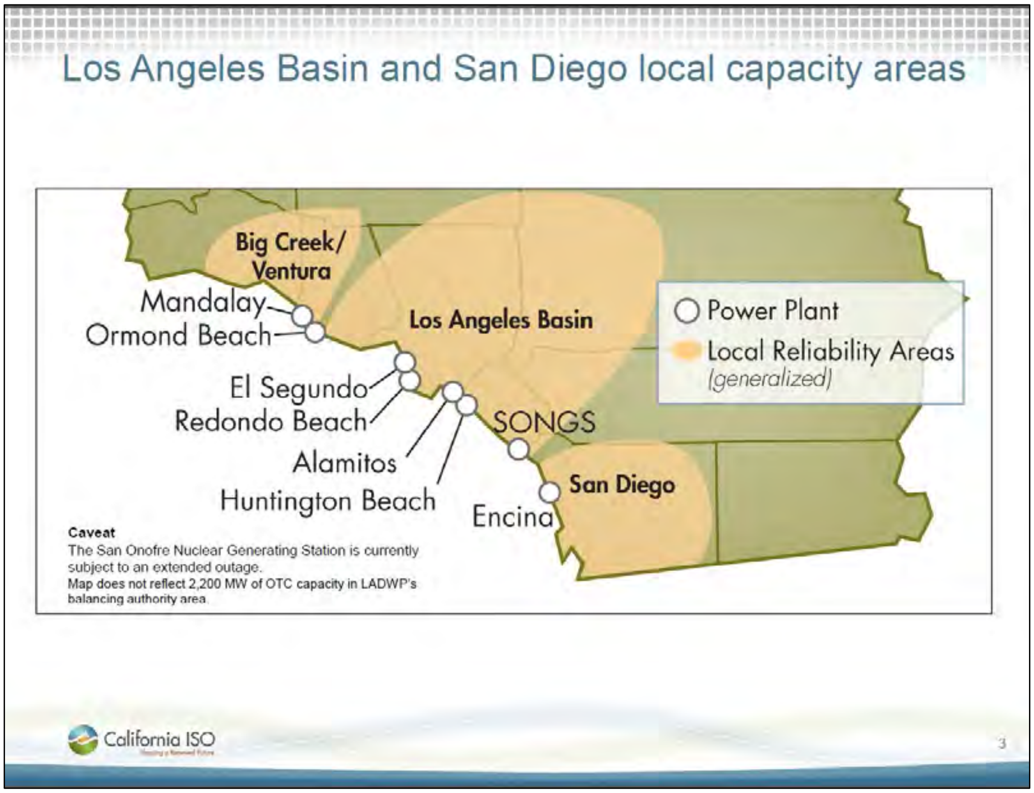
5.6 Geographic Location (including waterbody category)

Existing facilities are located throughout the United States (see Exhibit 4-2 in Chapter 4), operate in a variety of climatic, geologic, and hydrologic regimes, and are located in a range of populated areas from urban to rural. While the local conditions may affect how often a facility operates, its operational requirements, and the maintenance procedures necessary to operate efficiently, facilities are well-accustomed to these site-specific conditions and have incorporated these factors into their daily operations.

Geographic location can affect the physical and biological setting of a CWIS, but EPA has not identified general trends that would allow the agency to use geographic location as a basis for subcategorization. EPA specifically identified reservoirs and manmade impoundments with artificially managed fish populations as a possible candidate for different requirements, but did not identify locational factors that affect the efficacy or availability of the primary technologies that may comprise BTA. Rather, the data indicate that effective technologies can be applied in a variety of settings and that facilities typically use these technologies based on an appropriate configuration for the relevant facility. EPA notes that it has included "regional cost factors" that adjusts model facility costs based on the model facility's location to account for local conditions.[53]

As discussed in the preamble and EA, EPA has also analyzed the impacts of the final rule on the reliability of regional power production. As an example of localized reliability concerns, see Exhibit 5-6 below (taken from DCN 12-6840). This graphic illustrates the concept of localized reliability zones, which may limit a facility's ability to import power during downtime.

Exhibit 5-6. Example of local reliability concerns



Los Angeles Basin and San Diego local capacity areas

Caveat

The San Onofre Nuclear Generating Station is currently subject to an extended outage.

Map does not reflect 2,200 MW of OTC capacity in LADWP's balancing authority area.

EPA also considered waterbody category as a possible basis for subcategorization. As illustrated in Chapter 4 of the TDD, facilities are located on a variety of waterbody types. In the Phase I rule, certain waterbody types were required to meet design and operational criteria.[54] In the 2004 Phase II rule, EPA established different performance requirements based in part on a facility's location on different waterbody categories.[55] That approach was based on the general characteristics of the waterbody categories and of groups of aquatic organisms. However, in the final rule, EPA is not differentiating between

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[53] For example, facilities located near the Great Lakes are allotted an increased cost for managing zebra mussels.

[54] For example, facilities are not permitted to withdraw more than 1 percent of the tidal excursion. See 40 CRR 125.84(b)(3)(iii).

[55] Facilities located on estuaries, tidal rivers, Great Lakes, and oceans were subject to more stringent requirements. See 69 FR 41590 (July 9, 2004).

waterbody types; all facilities are required to meet the same impingement mortality and entrainment mortality requirements. This approach is based on the study data being used to establish BTA and the fact that these data do not reflect as clear a distinction between waterbody categories as was used in 2004. Specifically, the characterization data show the range of organism densities between waterbody types overlap. (See DCN 10-6701 for more information.)

Further, the density of organisms may not be a key factor in assessing adverse environmental impact. For example, some organisms are broadcast spawners and others are nest-builders.[56] A single egg in a freshwater system may be more important to that ecosystem than a single egg in a marine system.

In the absence of actual data that clearly establishes distinctions among waterbody categories, EPA has determined that it could not establish any appropriate subcategories based on waterbody type and that it is prudent to provide a consistent level of protection to aquatic organisms affected by CWISs.

5.7 Facility Size

EPA evaluated multiple metrics in analyzing facility size for existing facilities: electricity output, intake flow distribution, and the relationship of flow to compliance costs, small business designation, and environmental impacts.

5.7.1 Intake Flow

EPA examined the universe of electric generators and manufacturers for trends in intake flows. EPA recognizes that intake flow volume is an important element in determining impingement and entrainment and it is, therefore, logical to examine intake flow as a means for subcategorization.

Industry uses multiple metrics for intake flow: design intake flow (DIF), actual intake flow (AIF), and nameplate capacity. Design intake flow reflects the value assigned during the cooling water intake structure design to the maximum volume of water the cooling water intake system is capable of withdrawing from a source waterbody over a specific period of time. Actual intake flow is the average flow actually used over a specific period of time. Nameplate capacity is the amount of electric power delivered or required for which a generator, turbine, transformer, transmission circuit, station of system is rated by a manufacturer (this capacity is then correlated with required flow). EPA compiled DIF information from the industry questionnaires for all electric generators in ascending order and calculated the percent of flow captured by various flow thresholds (see Exhibits 5-7 through 5-11). To allow for the inclusion of closed-cycle facilities in this analysis, EPA first needed to normalize the design intake flow (DIF) for each facility with closed-cycle cooling to a comparable DIF that would be utilized by the facility if it employed a once-through cooling system. For facilities that utilize a combination cooling system (i.e., part

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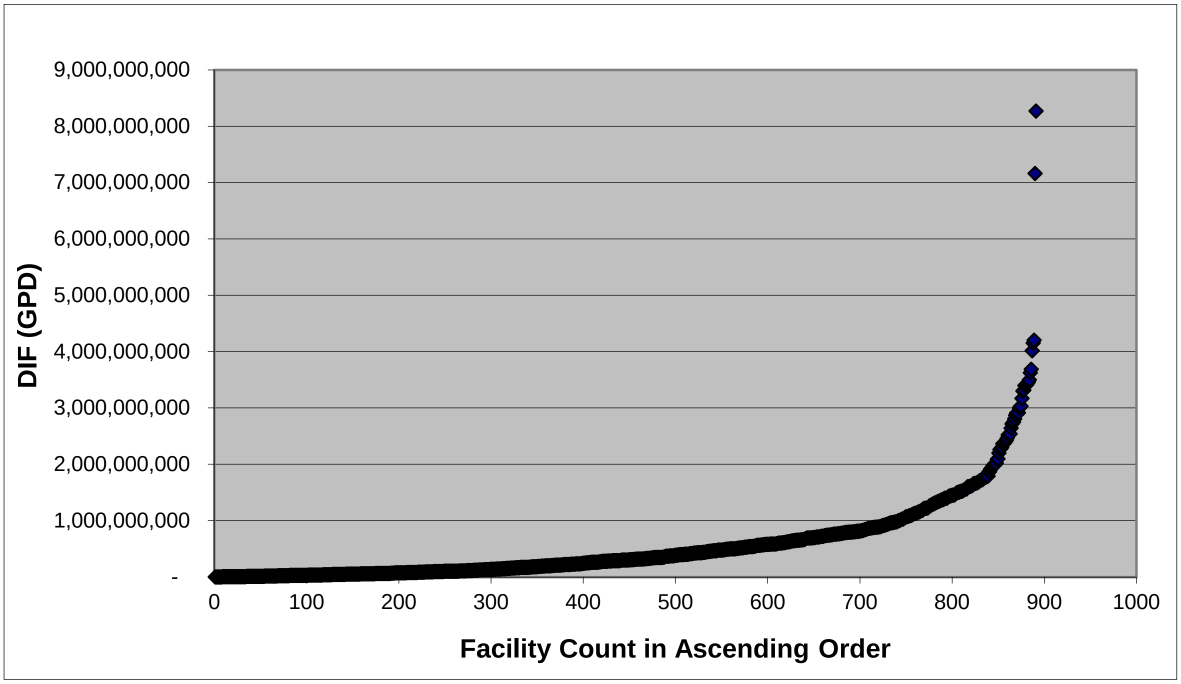
[56] Often, marine organisms are broadcast spawners while freshwater organisms are nest-builders or deposit eggs in specific locations.

once-through and part closed-cycle), EPA reviewed the industry surveys to determine the proportion of the DIF that would be converted.[57]

Exhibit 5-7 shows all electric generators plotted in ascending order by normalized DIF.

Exhibit 5-7. Normalized DIF at Phase II and III electric generating facilities



As shown by this plot, over 80 percent of these facilities have DIFs less than 1 BGD and approximately 95 percent of facilities have DIFs less than 2BGD.

Exhibits 5-8 through 5-12 present the distribution of DIF and AIF (normalized and non-normalized) flows across several criteria, as well as the distribution of nameplate generating capacity across normalized DIF. The percent captured values shown are the percent below each threshold.

- Exhibit 5-8 presents the percent of normalized DIF, normalized AIF, non-normalized DIF, non-normalized AIF and total facilities captured relative to DIF in billion gallons per day;
- Exhibits 5-9 through 5-12 present the percent of normalized and non-normalized DIF and AIF across waterbody categories (FWR – freshwater rivers and streams; TR&E – tidal rivers and estuaries; Oceans; GL – Great Lakes; and all facilities) relative to DIF in billion gallons per day.

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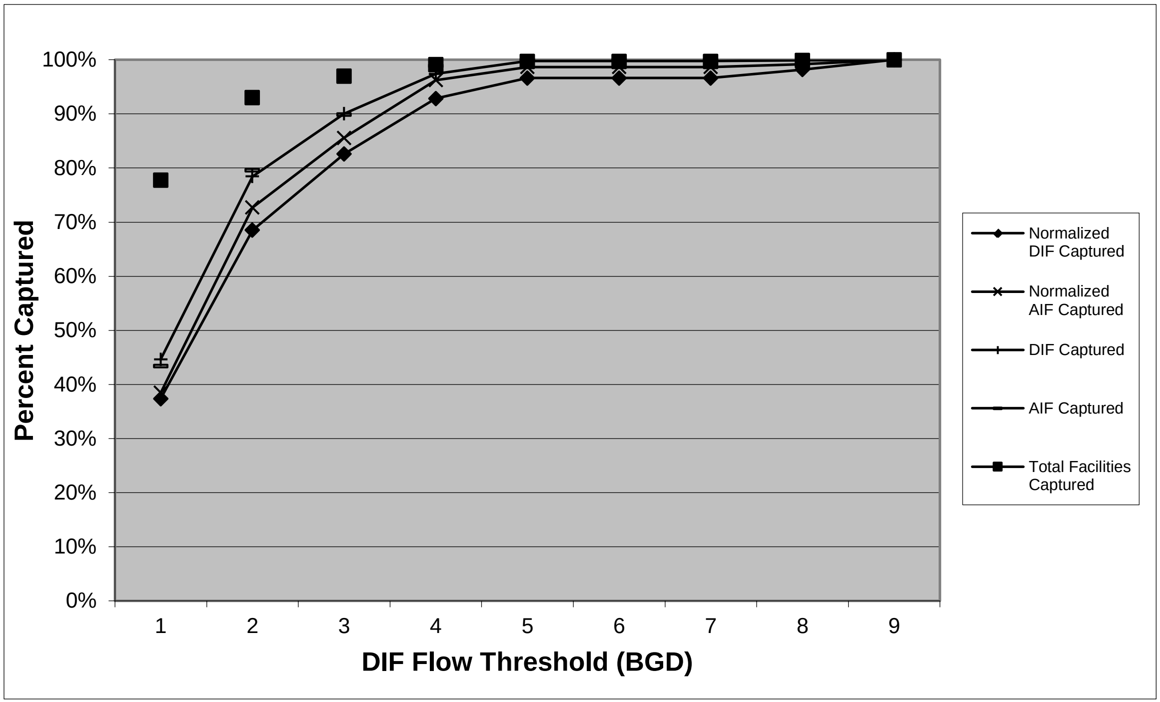
[57] In some cases, facilities use helper cooling towers, cooling lakes, or other configurations that are, for the purposes of this analysis, essentially once-through cooling. EPA did not adjust these flows.

Exhibit 5-8. Distribution of intake flows for all electric generators



The exhibit above shows that at thresholds below 3-4 BGD the distribution of flow is such that a higher percentage of facilities are captured relative to overall flow (normalized or non-normalized).

Exhibit 5-9. Distribution of normalized DIF for all electric generators

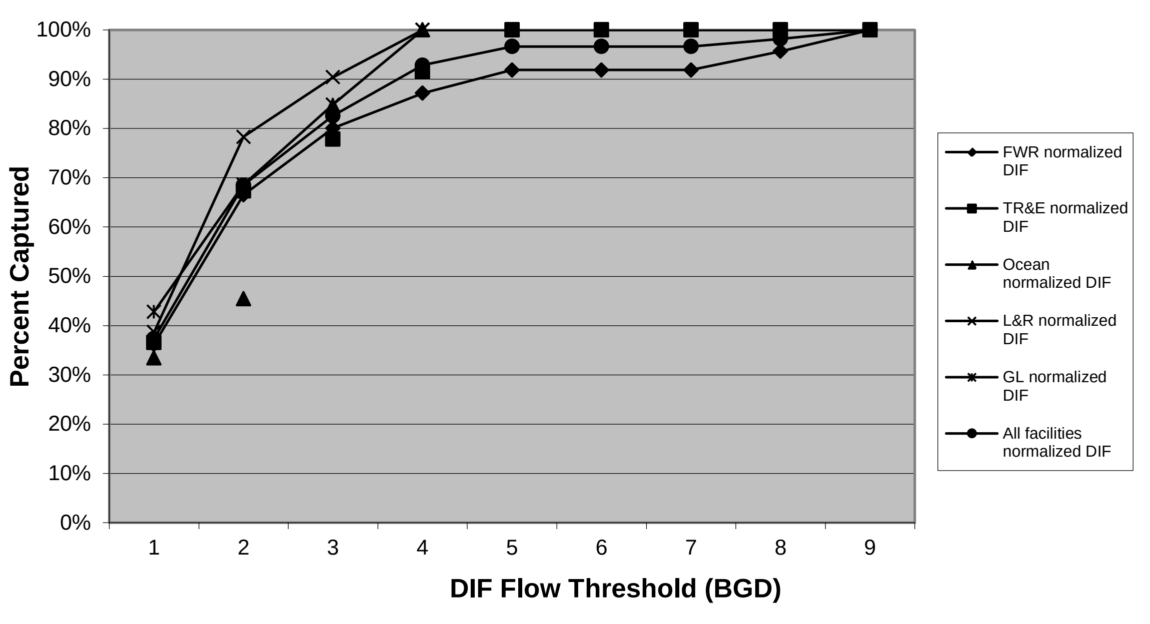
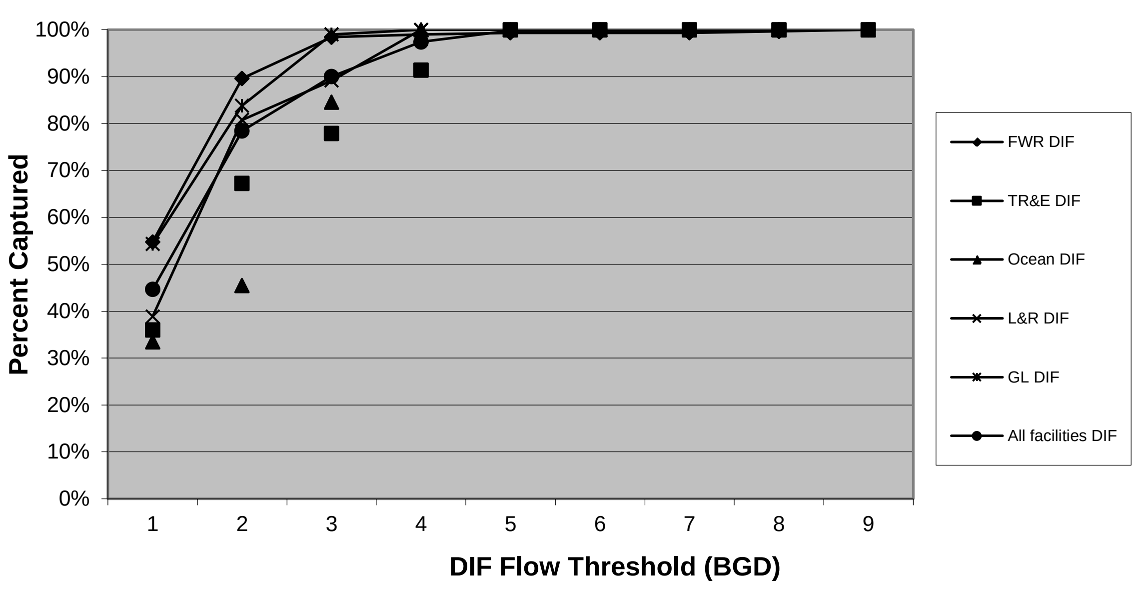


Exhibit 5-10. Distribution of DIF (non-normalized) for all electric generators



These exhibits show that the distribution of flow and facilities are generally similar across waterbody categories, although ocean facilities appear to use somewhat larger flows. The non-normalized data also reflect greater variation than the normalized data although the general distributions are similar.

Exhibit 5-11. Distribution of normalized AIF for all electric generators

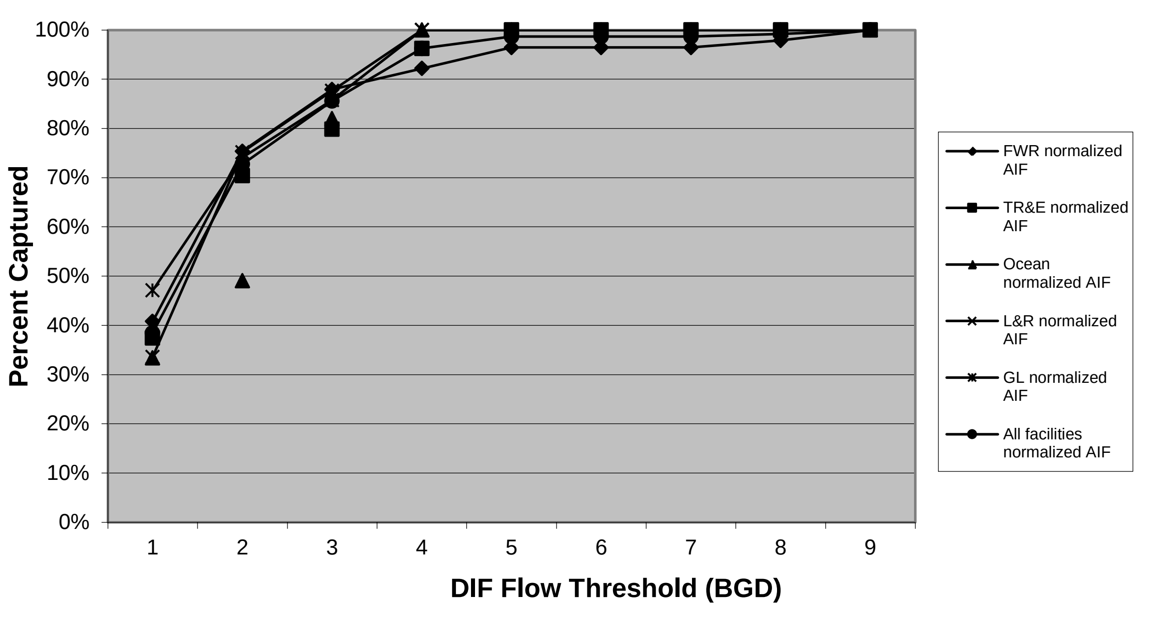
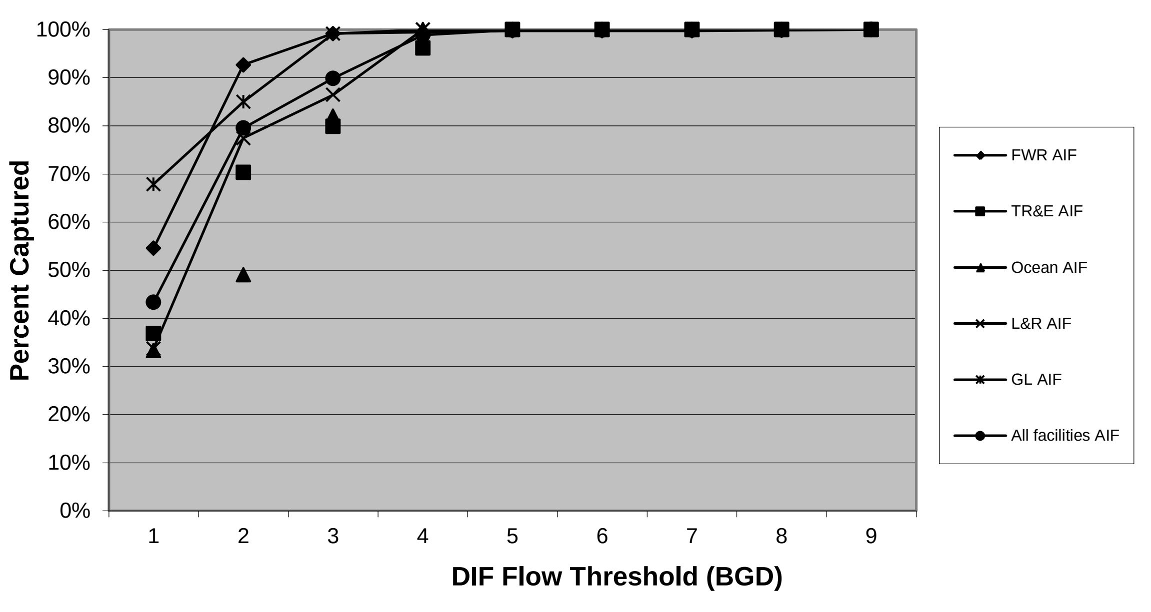


Exhibit 5-12. Distribution of AIF (non-normalized) for all electric generators



The AIF data do not show dramatic variation when compared with the DIF data for these plots. One difference is that 90 percent or greater of AIF is captured at a lower facility DIF threshold.

Exhibits 5-13 through 5-15 show the percentage of facilities (electric generator and manufacturer separately, and then all facilities) and the total DIF and AIF that would be addressed by various flow thresholds.

Exhibit 5-13. Electric generators and flow addressed by various flow thresholds

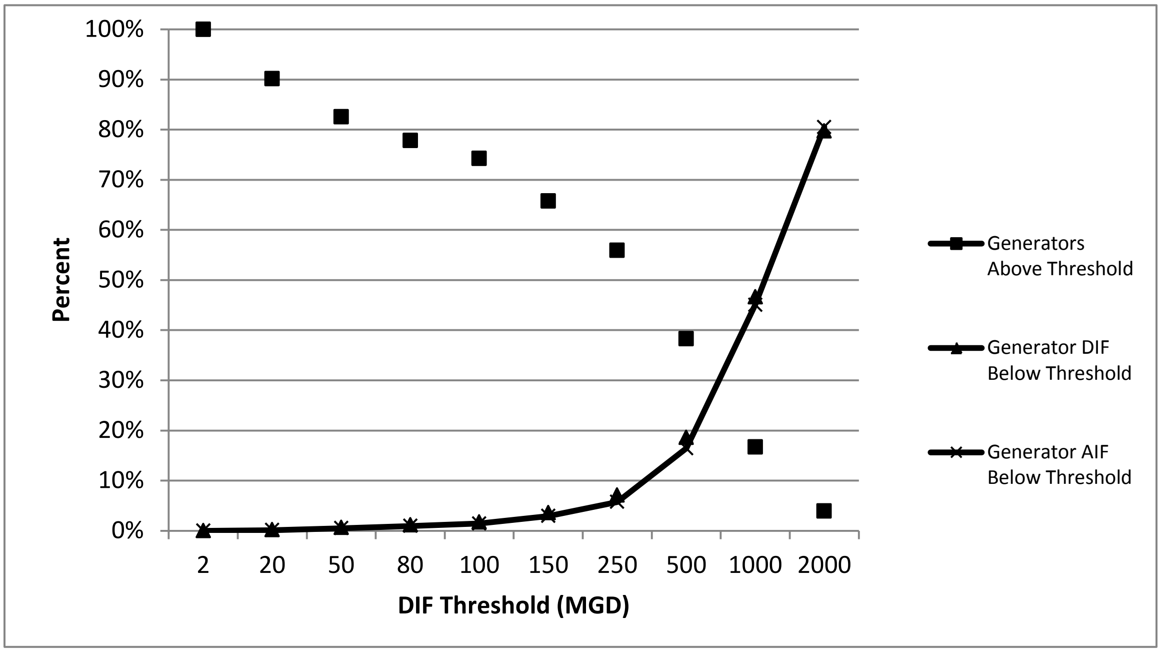


Exhibit 5-14. Manufacturers and flow addressed by various flow thresholds

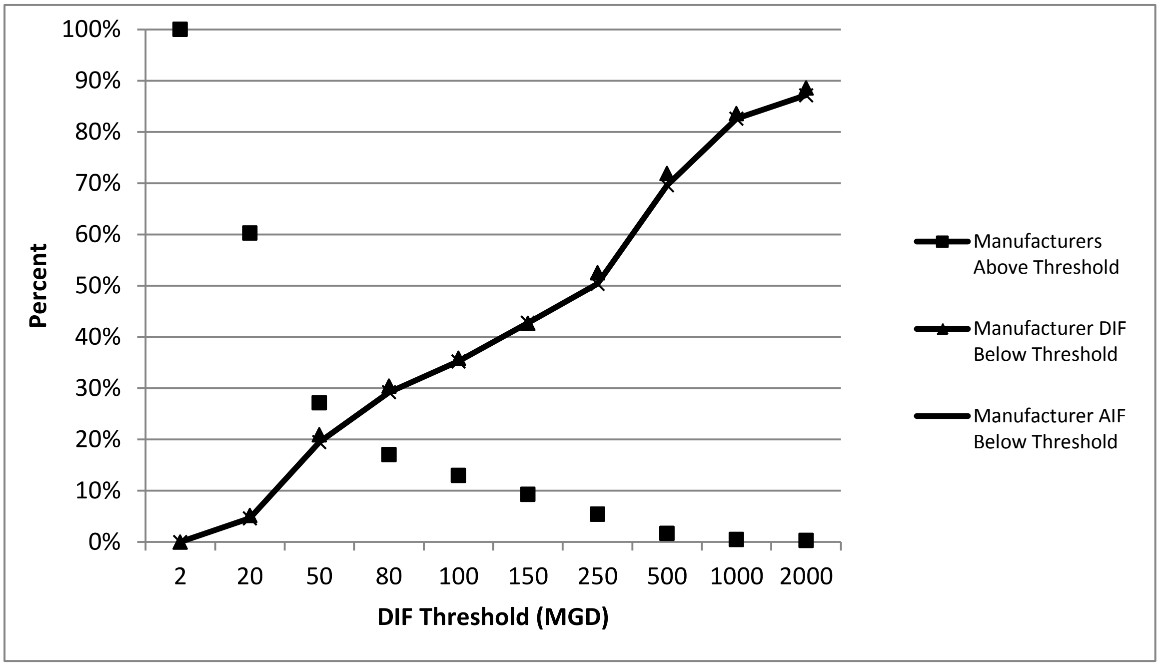
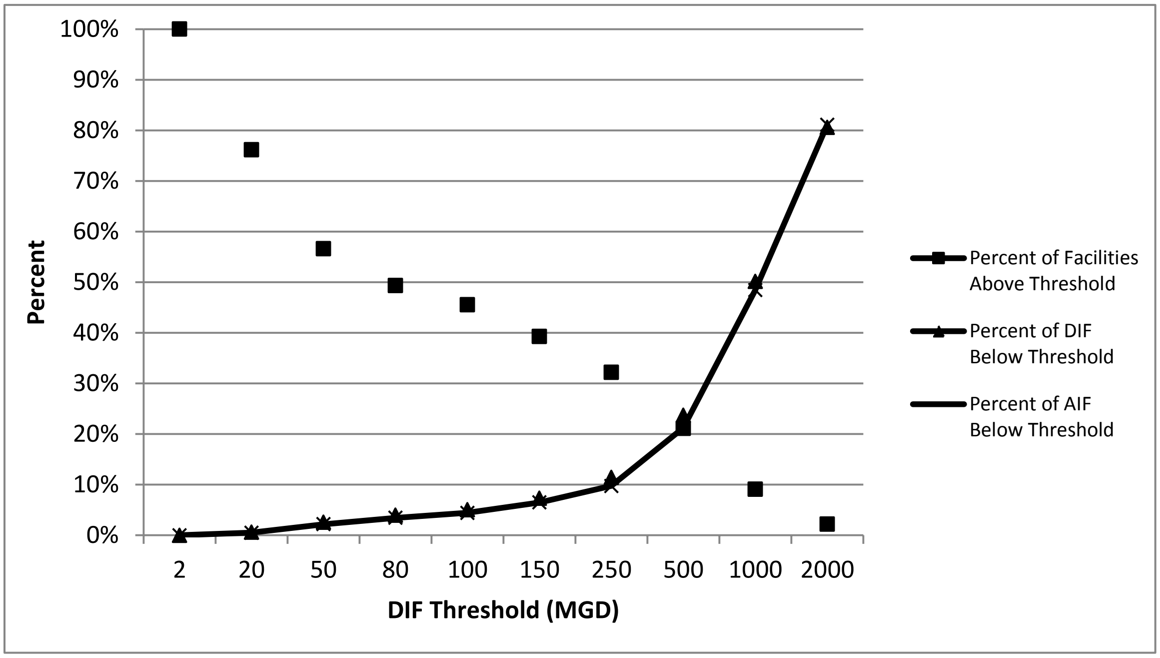


Exhibit 5-15. Facilities and flow addressed by various flow thresholds



5.7.2 Intake Flow and Impacts

EPA considered subcategorizing between large and small facilities, such as the 50 mgd design flow threshold that separated Phase II facilities from Phase III facilities. A common perception is that individual facilities with a smaller DIF will tend to have lower impingement and entrainment impacts since smaller volumes may affect fewer fish. This may be true for some on an individual basis, particularly when smaller facilities withdraw water from large waterbodies. But in other cases, the impacts may be significant since a facility can withdraw large portions of water from small waterbodies or may be contributing to a sizeable aggregate withdrawal between multiple facilities. A simple measure of this is the percent of a facility's total DIF to the waterbody mean annual flow (MAF) for facilities withdrawing from rivers and streams.[58] Exhibit 5-16 shows the distribution of surveyed facilities with data by percent DIF/MAF for all facilities compared to those with a DIF less than 50 mgd. Exhibit 5-17 shows this same distribution separately for generators and manufacturers for facilities with DIF less than 50 mgd. The data in these tables show that by themselves nearly 1/3 (32 percent) of all facilities withdrawing from rivers and streams withdraw more than 5 percent[59] of mean annual flow. For facilities with a DIF less than 50 mgd, at least 19 known manufacturers (16 percent) and 19 known generators (24 percent) withdraw more than 5 percent of the mean annual flow cooling water from freshwater rivers and streams.[60] Thus, even by themselves, many manufacturers and generators with smaller DIF volumes have the potential for significant impacts on freshwater rivers and streams.

Exhibit 5-16. Facility Design Intake Flows as a percentage of mean annual flow for all facilities on rivers/streams and those with DIF < 50 MGD

		DIF			
		All with DIF > 2 MGD		**DIF > 2 MGD and < 50 MGD**	
	Intake flow as a % of MAF	**No. of facilities**	**% of no. of fac. with data**	**No. of facilities**	**% of no. of fac. with data**
Manufacturers and Generators Combined	No data	12	-	13	-
	1-5%	222	67.1%	160	80.8%
	5-10%	33	10.0%	15	7.6%
	10-20%	36	10.9%	11	5.6%
	20-40%	17	5.1%	4	2.0%
	40-60%	4	1.2%	1	0.5%
	60-80%	2	0.6%	1	0.5%
	80-100%	6	1.8%	2	1.0%
	> 100%	11	3.3%	4	2.0%
	Total > 5%	109	32.9%	38	19.2%
	Total with Data	331	100.0%	198	100.0%

Note: All values are unweighted

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[58] As shown in Chapter 4, an estimated 52 percent of generators and 77 percent of manufacturers withdraw cooling water from freshwater rivers and streams as opposed to other waterbody types. Therefore, this metric is relevant to the majority of facilities.

[59] As discussed in Chapter 4, a 5 percent threshold was included in the 2004 Phase II rule to identify facilities subject to impingement mortality and entrainment requirements. While not included in this rule, this threshold may be indicative of the potential for significant impact.

[60] These numbers include only those facilities that completed the technical survey and since only a sample of manufacturers received a survey, the actual number of facilities may be much greater. For example, the 19 known manufacturers are estimated to represent 55 facilities.

Exhibit 5-17. Facility Design Intake Flows as a percentage of mean annual flow for all facilities and those with DIF < 50 MGD

		DIF			
		Generators		**Manufacturers**	
	Intake flow as a % of MAF	**No. of facilities**	**% of no. of fac. with data**	**No. of facilities**	**% of no. of fac. with data**
DIF > 2 MGD and < 50 MGD	No data	9	-	4	-
	1-5%	59	75.6%	101	84.2%
	5-10%	8	10.3%	7	5.8%
	10-20%	5	6.4%	6	5.0%
	20-40%	1	1.3%	3	2.5%
	40-60%	1	1.3%	0	0.0%
	60-80%	0	0.0%	1	0.8%
	80-100%	1	1.3%	1	0.8%
	> 100%	3	3.8%	1	0.8%
	Total > 5%	19	24.4%	19	15.8%
	Total with Data	78	100.0%	120	100.0%

Note: All values are unweighted

Another important consideration with regard to the potential impacts is that smaller flow facilities are often co-located on the same waterbody as other facilities (both large and small) with each contributing to the aggregate volume of cooling water withdrawn and the resulting cumulative impingement and entrainment impacts. In fact, EPA found that for all surveyed facilities that withdrew cooling water from a freshwater river or stream, 72 percent of all facilities (representing 78 percent of the total design flow) withdrew cooling water from a waterbody that had at least one, and often many, other facilities that were also withdrawing water from the same waterbody. For facilities with a DIF less than 50 mgd, 63 percent of facilities (representing 70 percent of total design flow) withdrew water from a freshwater river or stream that had at least one other facility withdrawing water from the same river/stream. Exhibit 5-18 presents a summary of the number of surveyed facilities that are located on the same river or stream and the number that are on rivers and streams where the cumulative DIF was greater than 5 and 50 percent of mean annual flow (MAF). These data show that for manufacturers and generators with a DIF less than 50 mgd, 57 percent are located on rivers and streams where they contribute to a cumulative withdrawal that is greater than 5 percent of the MAF of the waterbody and 9 percent are located on rivers and streams where they contribute to a cumulative withdrawal that is greater than 50 percent. This demonstrates that while the individual withdrawal may be small for some facilities, many (nearly two thirds) of the smaller flow facilities contribute to cumulative withdrawals on freshwater rivers and streams and that nearly one tenth contribute to potentially significant withdrawals with withdrawals of greater than 50 percent of mean annual flow.

Exhibit 5-18. Number of surveyed facilities located on the same river or stream as other facilities and number contributing to cumulative withdrawals greater than five percent and 50 percent of mean annual flow

		Generators		Manufacturers		Both	
		Count	% of Total	Count	% of Total	Count	% of Total
DIF > 2 mgd	Number of Facilities Located on the Same River/Stream as Other Facilities (Co-located)	257	75%	117	66%	374	72%
	Number of Facilities Co-located on River/ Stream where Cum Withdrawals of all Facilities on the Waterbody Exceed > 5% of MAF	229	67%	95	53%	324	62%
	Total Number of Facilities on River/Stream where Cum Withdrawals Exceed > 5% of MAF [a]	263	77%	115	65%	378	73%
	Total Number of Facilities on a River/Stream where Cum Withdrawals of all Facilities on the Waterbody Exceed > 50% of MAF[a]	51	15%	18	10%	69	13%
	Total Facilities on River/Stream	343	100%	178	100%	521	100%
DIF> 2 mgd and < 50 mgd	Number of Facilities Located on the Same River/Stream as Other Facilities (Co-located)	55	63%	77	62%	132	63%
	Number of Facilities Co-located on River/Stream where Cum Withdrawals of all Facilities on the Waterbody Exceed > 5% of MAF	38	44%	57	46%	95	45%
	Total Number of Facilities on River/Stream where Cum Withdrawals Exceed > 5% of MAF[a]	52	60%	68	55%	120	57%
	Total Number of Facilities on a River/Stream where Cum Withdrawals of all Facilities on the Waterbody Exceed > 50% of MAF[a]	10	11%	9	7%	19	9%
	Total Facilities on River/Stream	87	100%	124	100%	211	100%

a Includes data for waterbodies with only one facility

Note: All values are unweighted

As can be seen in Exhibit 4-2 in the previous chapter, the majority of facilities that use cooling water are located in the eastern portion of the United States. Exhibit 5-19 presents a map of the eastern half of the United States showing facility location for generators and known manufacturers.[61] The map shows that while facilities are located throughout the region, many are concentrated on the same waterbodies often in close proximity to one another. This proximity is better illustrated in Exhibit 5-20 which presents a graphical representation that shows the relative proximity of facilities by including for each facility five mile radius buffer zones for distances of 5, 10, 15, and 20 miles. Exhibit 5-21 presents the proportion of facilities that have one or more other facilities within the each buffer distance of 5, 10, 15, and 20 miles. As can be seen, a majority (69 percent) of the known facilities are located within a distance of 20 miles or less from other facilities and nearly half are within 10 miles or less. The actual proportions are likely larger since many manufacturing facilities locations (approximately 300) are not known and therefore are not included in this analysis. Certain regions show

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[61] Only those facilities that completed a technical survey are shown in Exhibits 5-19 and 5-20. While most generators completed either a short or detailed survey and thus their presence is shown, EPA estimates that there around 300 additional manufacturing facilities that are not represented in the graphics.

high concentrations of multiple facilities on the same waterway as shown by the considerable amount of overlap of buffer zones.

Exhibit 5-19. Location of facilities in eastern half of United States

Exhibit 5-20. Representation of facility location proximity in the Eastern US

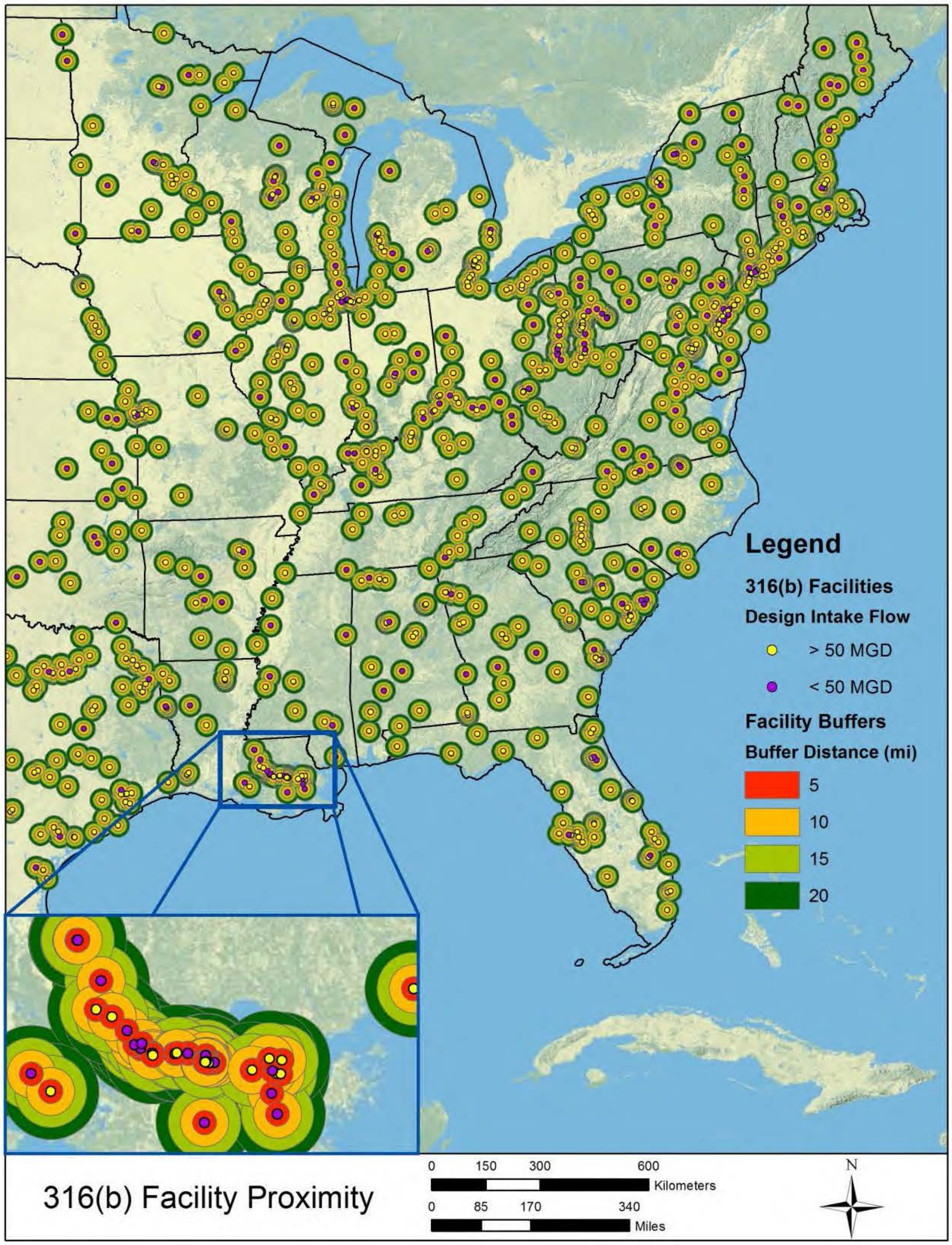

Exhibit 5-21. Proportion of facilities with known location one or more other facilities within each buffer distance

within 5 miles	within 10 miles	within 15 miles	within 20 miles	Not within 20 miles of another facility
30%	47%	62%	69%	31%

5.7.3 Intake Flow and Business Size

EPA considered flow thresholds of 50 mgd or less as possible thresholds for a subcategory that would be representative of most small businesses but found that facility DIF does not correlate well with the small business designation. Exhibit 5-22 shows the distribution of all facilities and small businesses and the corresponding total DIF by subgroups in the 2 to 50 mgd range. These data show that while roughly half of small business facilities had a DIF less than 20 mgd, 35 facilities (28 percent) had a DIF greater than 50 mgd. Also, there were many non-small businesses distributed throughout the less than 50 mgd subgroups. Thus, a subcategory based on low DIF flow would not capture a significant portion of small businesses and would include many large businesses.

Exhibit 5-22. Distribution of small businesses by DIF

	DIF 2-10	DIF 10-20	DIF 20-30	DIF 30-40	DIF 40-50	DIF > 50
All Facilities	172	119	111	73	56	651
DIF Total (MGD)	921	1,778	2,811	2,525	2,519	336,577
Small Business Fac.	34	29	8	14	6	35
DIF Total (MGD)	169	391	204	472	274	12,624

EPA has found that many facilities have a DIF less than 50 mgd because they already employ closed-cycle cooling. Fifty one percent of all facilities with a DIF less than 50 mgd employ closed-cycle cooling and 33 percent of manufacturers with a DIF less than 50 mgd employ closed-cycle cooling. Since closed-cycle cooling is generally compliant with BTA requirements, the permitting requirements are streamlined for many of the facilities in the less than 50 mgd subcategory. Exhibit 5-23 presents a summary of the number of small businesses (and those with a DIF less than 50 mgd) and all businesses with a DIF less than 50 mgd that were deemed to be compliant with the IM BTA standard. This data show that the proportion of facilities that are deemed IM compliant is high for all three groups. For the subset of small businesses with a DIF less than 50 mgd the proportion deemed IM compliant is higher. For facilities less than 50 mgd, small businesses are comparable but somewhat less compliant than all businesses. Thus, the overall financial burden is reduced for both small businesses and all businesses with a DIF less than 50 mgd, indicating that overall financial burden may not be a factor that supports subcategorization based on flow volume or business size.

Exhibit 5-23. Summary of number of small businesses and all businesses with a DIF less than 50 MGD that are deemed already compliant with the IM BTA standard

	Small Businesses			**Small Businesses <50 MGD**			**All Businesses <50 MGD**		
	EG	MN	Total	EG	MN	Total	EG	MN	Total
Number of Intakes (weighted)	43	102	145	13	87	100	129	466	595
Number that already meet the IM standard (weighted)	14	38	53	6	34	40	101	220	321
Number with no technologies in place (weighted)	5	1	6	5	1	6	8	14	22

EPA also examined the potential impact of the group of facilities that are small businesses with an AIF less than 50 mgd [62] with respect to whether the majority of those located on rivers and streams have the potential to contribute to cumulative impingement and entrainment impacts if they are included in the scope of the IM requirements. Exhibit 5-24 presents a graphical illustration showing the location and proximity of 15 of the 22 small businesses with known locations[63] that have an AIF less than 50 mgd and are located on rivers and streams. Only those that do not already employ closed-cycle cooling or do not withdraw greater than 5 percent of mean annual flow are identified separately from all of the other facilities.[64] As can be seen, nearly all of the facilities in this group are in fairly close proximity to other facilities and are likely to contribute to cumulative impingement and entrainment impacts. Therefore, EPA did not consider low flow and small business designation as a factor that supports subcategorization.

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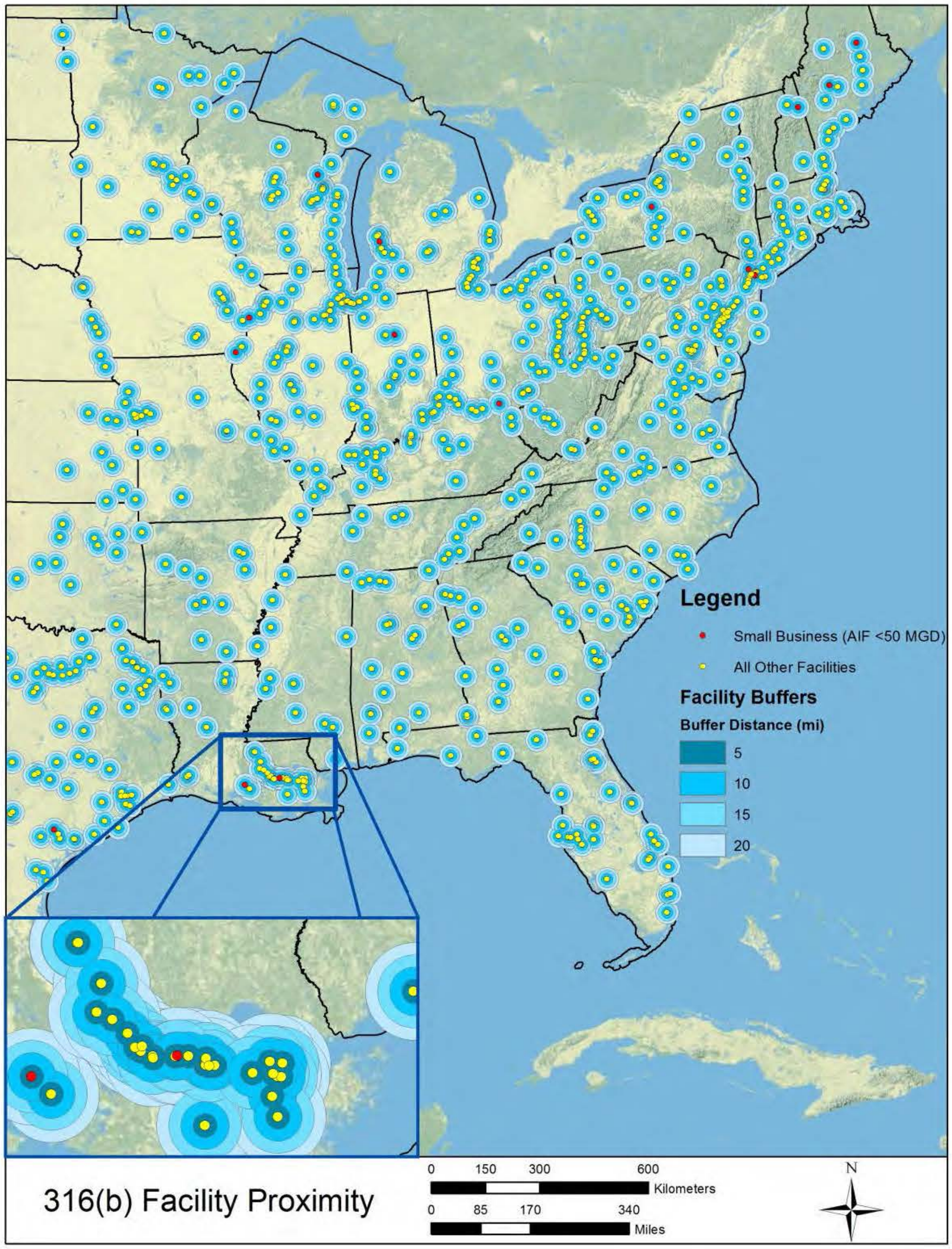
[62] In this subset of small businesses, the flow criteria AIF less than 50 mgd is used instead of DIF greater than 50 mgd which represents a larger group of small businesses than those facilities greater than 50 mgd shown in Exhibit 5-24.

[63] Only 15 of the 22 facilities are located in the eastern half of the US. The additional 7 are located mostly in Washington State with 5 of the 7 being located in close proximity to other facilities.

[64] The IM requirements will have no impact on those that employ closed-cycle cooling and those with an AIF greater than 5 percent of MAF have a significant impact regardless of proximity to other facilities.

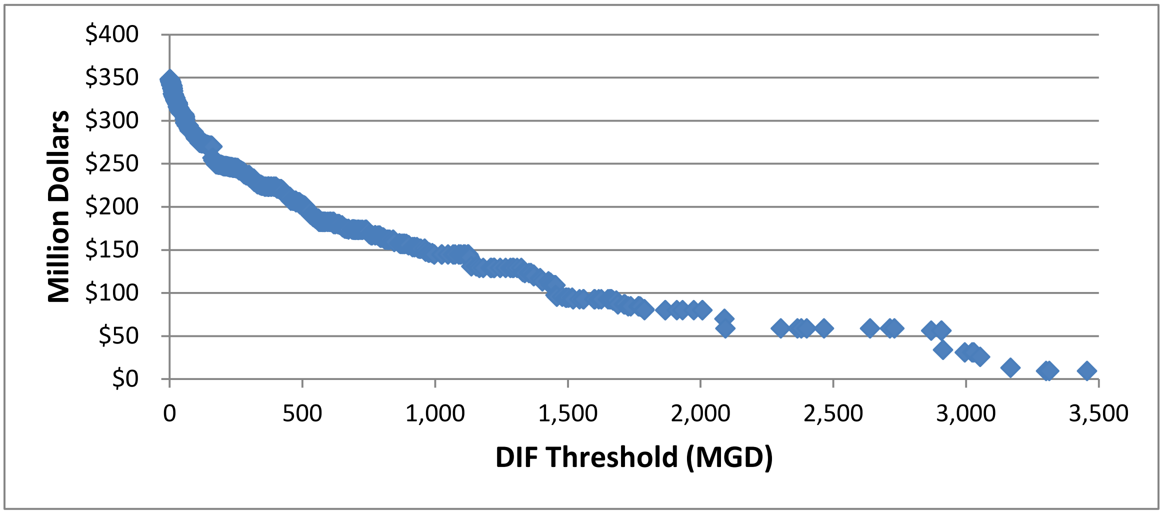
Exhibit 5-24. Representation of facility location proximity in the eastern US showing small businesses on rivers and streams with AIF< 50 MGD



5.7.4 Intake Flow and Cost

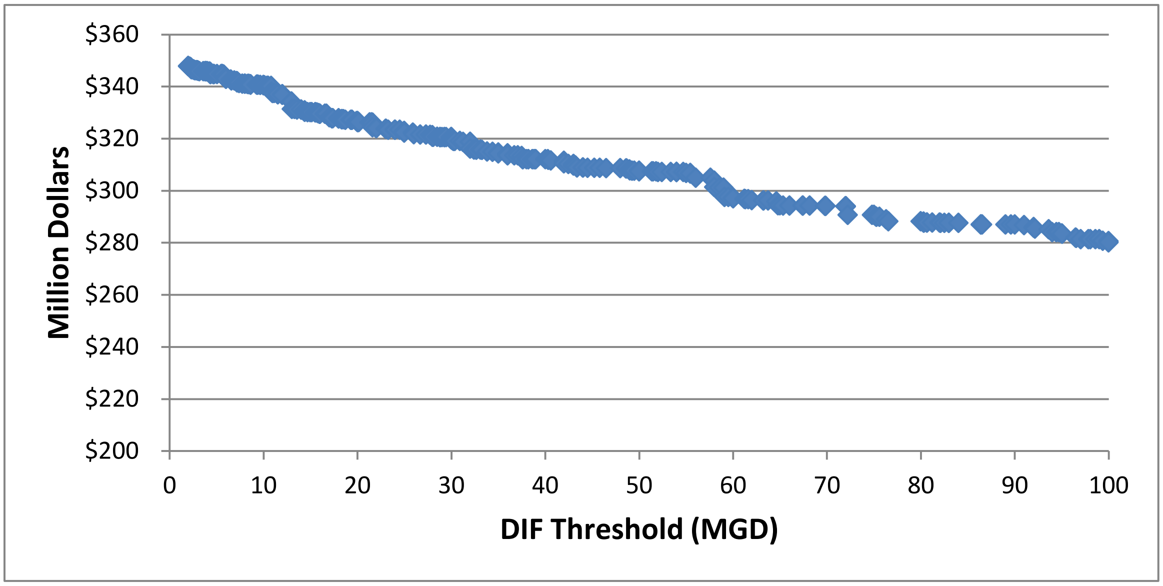
Exhibit 5-25 shows the estimated total annual pretax compliance costs for all facilities with a DIF above the DIF threshold.

Exhibit 5-25. Total annualized pretax compliance costs above DIF threshold



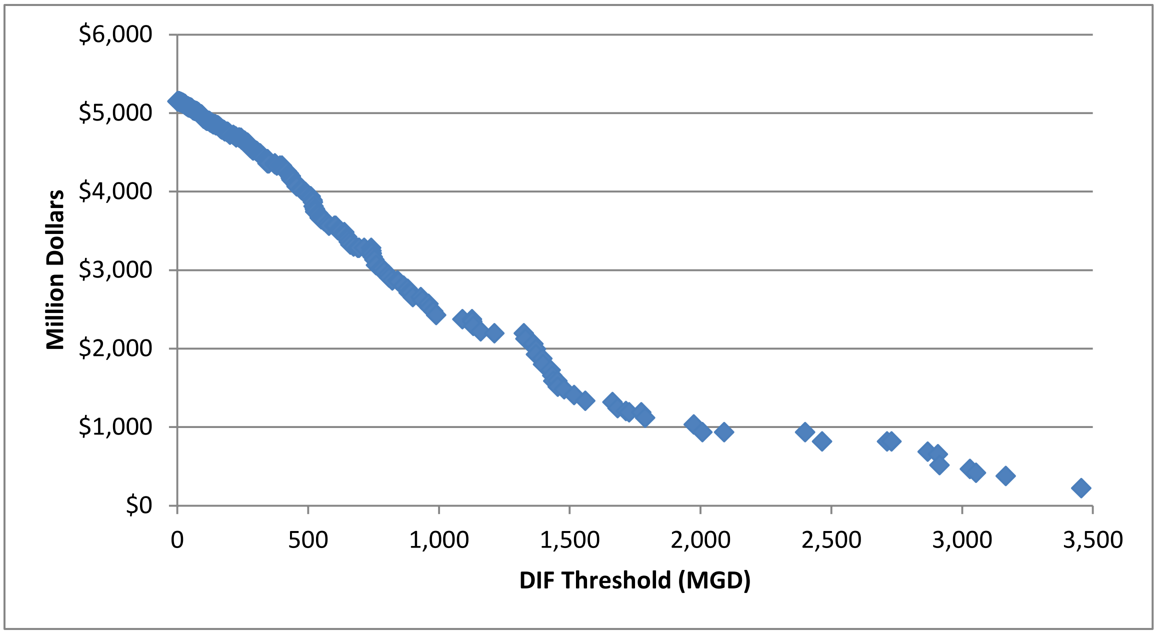
EPA examined total annual compliance costs for flow thresholds of 50 mgd or less to see if there were any noticeable differences between total costs below and above the threshold. Exhibit 5-26 shows that as would be expected total costs increase as of DIF threshold values decrease and the curve shows minor differences at about 12 mgd and 58 mgd but statistically significance along the curve does not support selecting any specific DIF value for subcategorization.

Exhibit 5-26. Total annualized pretax compliance costs above DIF thresholds of 2 to 100 MGD



EPA considered the possibility of establishing a flow threshold above which closed-cycle cooling would be required. EPA examined total entrainment compliance cost of requiring closed-cycle cooling at all facilities not currently employing closed-cycle for different flow threshold values. Preliminary estimates of facility level closed-cycle cooling capital and O&M cost were derived using the approach described in section 8.3. Variable O&M costs assume a technology utilization rate of 85 percent and auxiliary energy costs are based on a wholesale rate of $65/MWh. Capital costs are amortized at 3 percent over 30 years. The cost evaluated does not include downtime or heat rate efficiency loss. Exhibit 5-27 presents a plot of total annual cost above the DIF threshold. This plot generally shows a steady change in total costs at most thresholds as evidenced by the steady slope. Breaks in the curve at various thresholds greater than 1,000 mgd represent flow ranges that include fewer facilities. Thus, except for thresholds at the higher end of the range there does not appear to be any discernable difference based on costs and regardless of the threshold, the reasons for rejecting closed-cycle cooling as BTA remained the same. EPA also, examined flow threshold as it relates to closed-cycle costs for certain facility subsets, such as different fuel types and manufacturers as a group. EPA generally found similar cumulative cost curves for each subset with some exceptions. For nuclear plants, there were zero facilities with closed-cycle costs with a DIF less than 500 mgd and for manufacturers there were few facilities with a DIF greater than 700 mgd. These relatively high thresholds reflect design flow distributions for these subsets. EPA also considered requiring closed-cycle cooling for nuclear facilities that could have included a flow threshold. Annual costs were estimated to be approximately $1 billion dollars annually but would provide a high reduction for impingement and entrainment given that these facilities tend to have large flows and operate as baseload generators. However, long downtime and reliability are also concerns. Based on these data, EPA concluded that flow threshold as it relates closed-cycle cost does not support selecting any specific DIF value for subcategorization.

Exhibit 5-27. Total annualized pretax closed-cycle cooling compliance capital and O&M above DIF threshold



5.7.5 Generating Capacity

Exhibit 5-28 presents the distribution of nameplate generating capacity across normalized DIF.[65]

Exhibit 5-28. Distribution of nameplate generating capacity

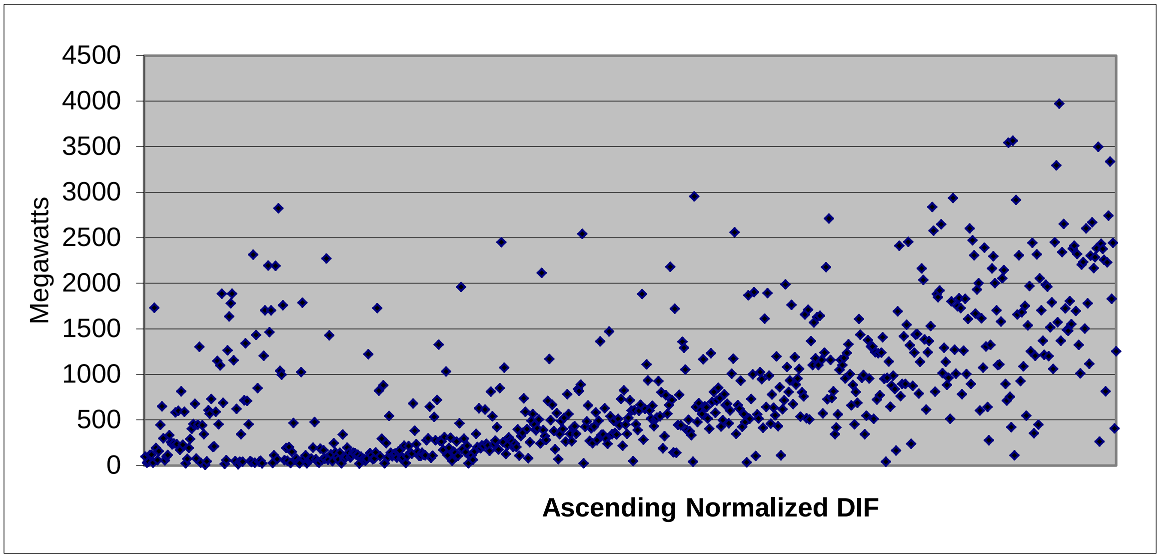


Exhibit 5-28 shows a general and somewhat variable correlation between DIF and electrical power output, and also indicates that some facilities, most likely more efficient operations, are able to produce a range of power at a lower DIF. However, such production is not necessarily correlated with CWIS technologies and the rule includes provisions that promote reductions in cooling water intake flow.

EPA also considered generating capacity as an aspect of facility size. Exhibit 5-28 above presents generating capacity plotted against normalized DIF and Exhibit 5-29 below presents generating capacity plotted against non-normalized DIF.[66]

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[65] Recall that normalized DIF as described earlier converts DIF for closed-cycle facilities to the equivalent once-through DIF.

[66] Non-normalized DIF is the actual reported design intake flow.

Exhibit 5-29. Distribution of nameplate generating capacity

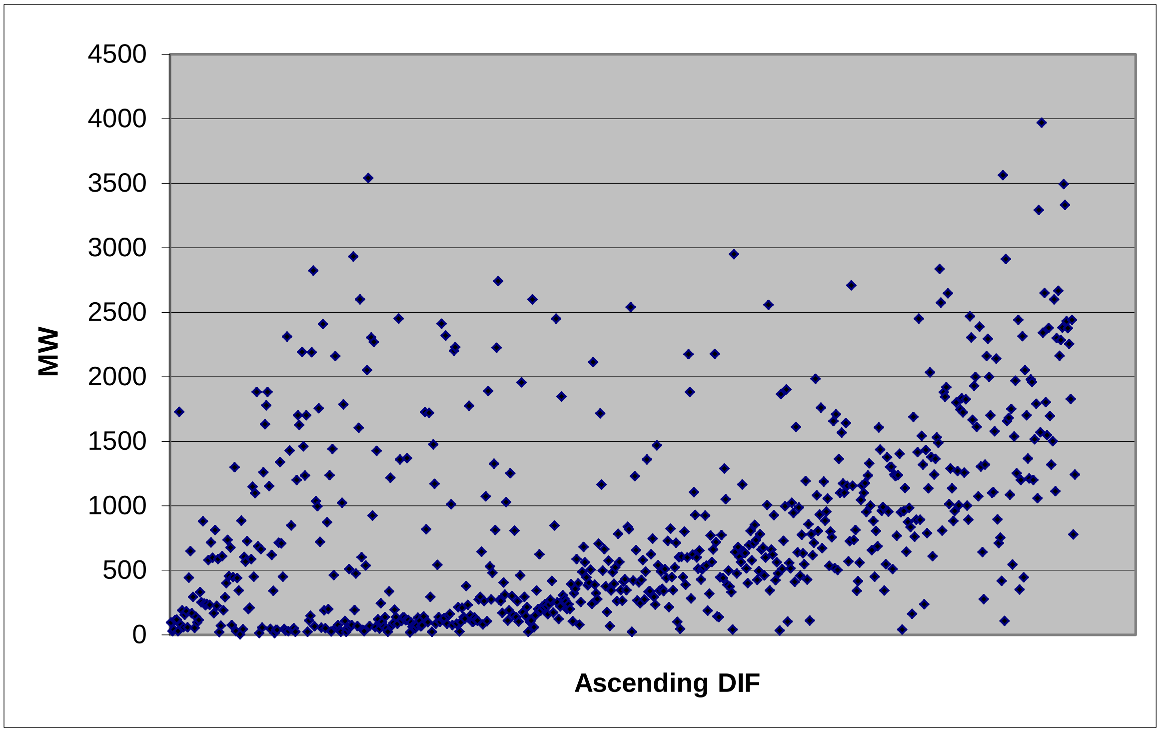

Exhibit 5-29 shows a similar pattern to Exhibit 5-28, with greater scatter of facilities, which suggests that closed-cycle cooling provides a range of flow reduction that is dependent on numerous factors.

As illustrated by the exhibits above, there are no clear trends for electric generating facilities based on intake flow relative to waterbody type, cumulative impacts, costs or generating capacity. As such, EPA determined that it could not establish any appropriate subcategories based on any of those categories.

5.8 Non-Water Quality Environmental Impacts

New or additional intake technologies will not lead to unusual non-water quality impacts.[67] Many of the technologies discussed in the rule are already in use at many facilities and do not fundamentally change the operation of intake technologies as a whole. EPA recognizes that requiring facilities to retrofit to closed-cycle cooling may incur additional non-water quality impacts that are not insignificant. These impacts are part of the reason that EPA did not identify closed-cycle cooling as the basis for BTA for this national rule. EPA did not identify any other significant non-water quality environmental impacts resulting from the engineering aspects of control technologies that provide a basis for establishing appropriate subcategories.

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[67] See Chapter 10 for a complete discussion of the non-water quality impacts.

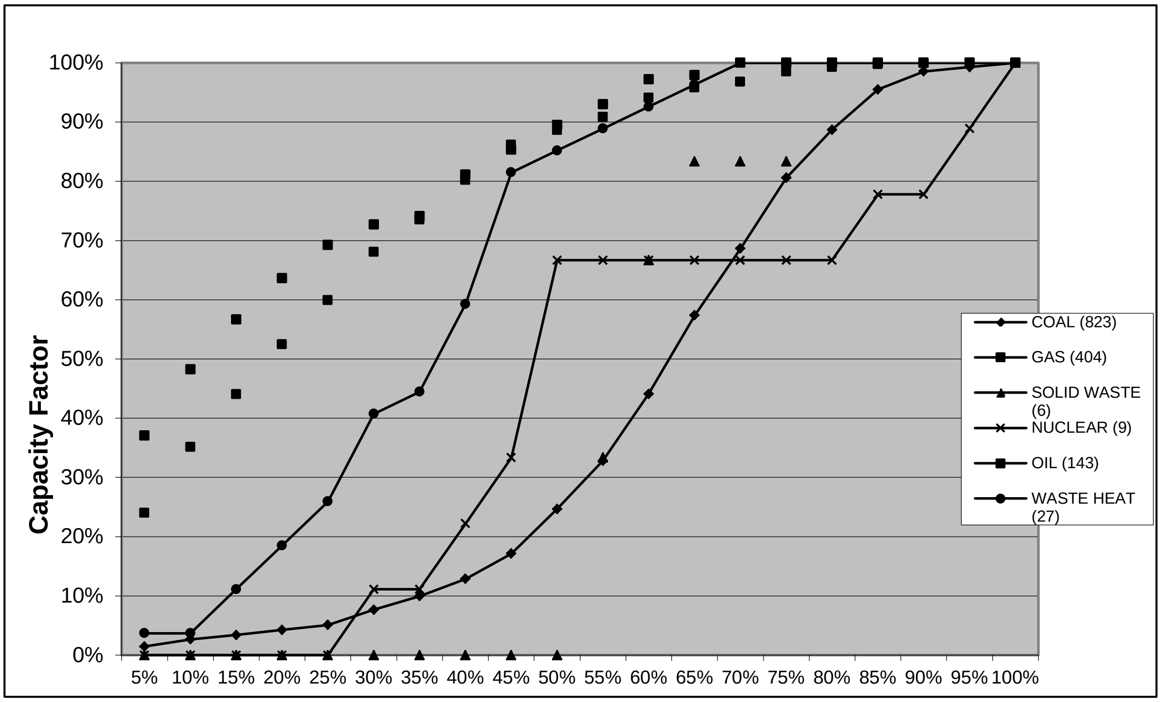
5.9 Other Factors

EPA conducted a series of additional analyses of existing facilities in order to attempt to determine if any additional subcategories were appropriate.

5.9.1 Capacity Utilization

EPA reviewed data on the capacity utilization rate (CUR) for Phase II facilities[68] using information from EPA's E-GRID database.[69] In order to best match the technology data from EPA's industry survey, EPA used the CUR data from the year 2000. Specifically, EPA compared the CUR data against data for fuel type (by individual generating unit and by facility), prime mover, total generating capacity (by individual generating unit and by facility), facility age, and waterbody type. As shown in Exhibits 5-30 to 5-36 below, there are no clear trends in any of these analyses that indicate that BTA should be different based on low usage. As such, EPA determined that it could not establish any appropriate subcategories based on capacity utilization.

Exhibit 5-30. Cumulative distribution of Phase II Facility year 2000 generating unit capacity factors by primary fuel type



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[68] The analysis was not repeated to incorporate Phase III facilities, as the distribution of facilities among capacity utilization rate, fuel type, and waterbody type is relatively consistent between the two groups.

[69] CUR was a factor in the 2004 rule and was considered in developing the final rule.

Exhibit 5-31. Distribution of Phase II Facility year 2000 generating unit capacity factors by generating unit prime mover

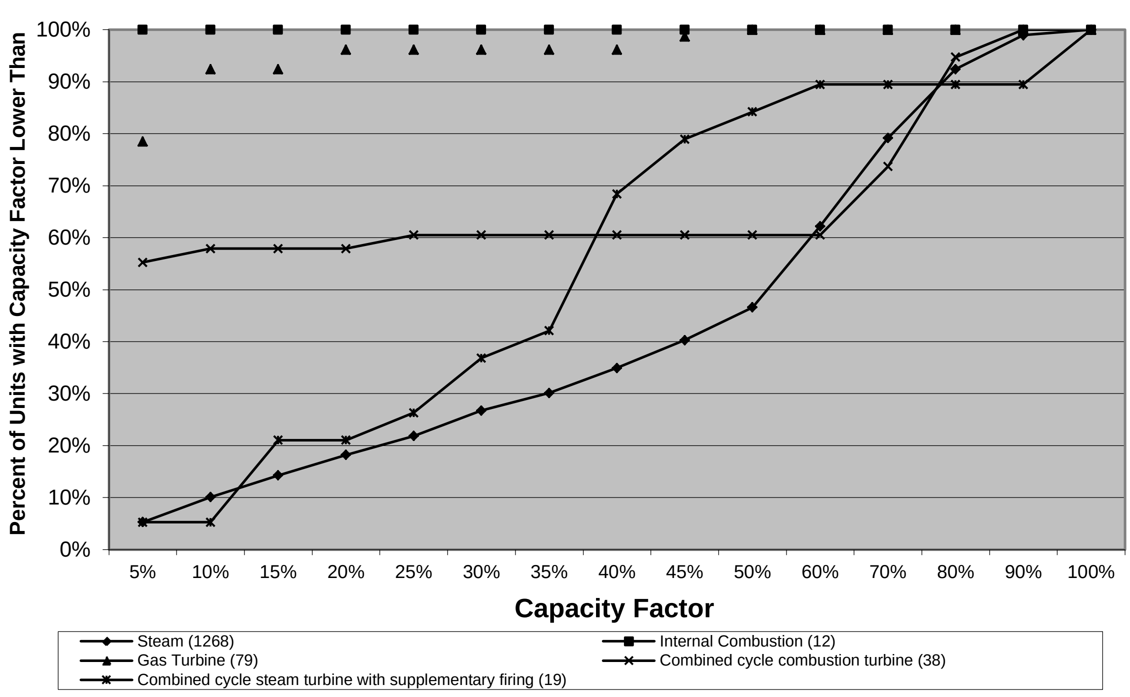


Exhibit 5-32. Phase II Facility year 2000 generating unit capacity factors versus nameplate generating unit capacity

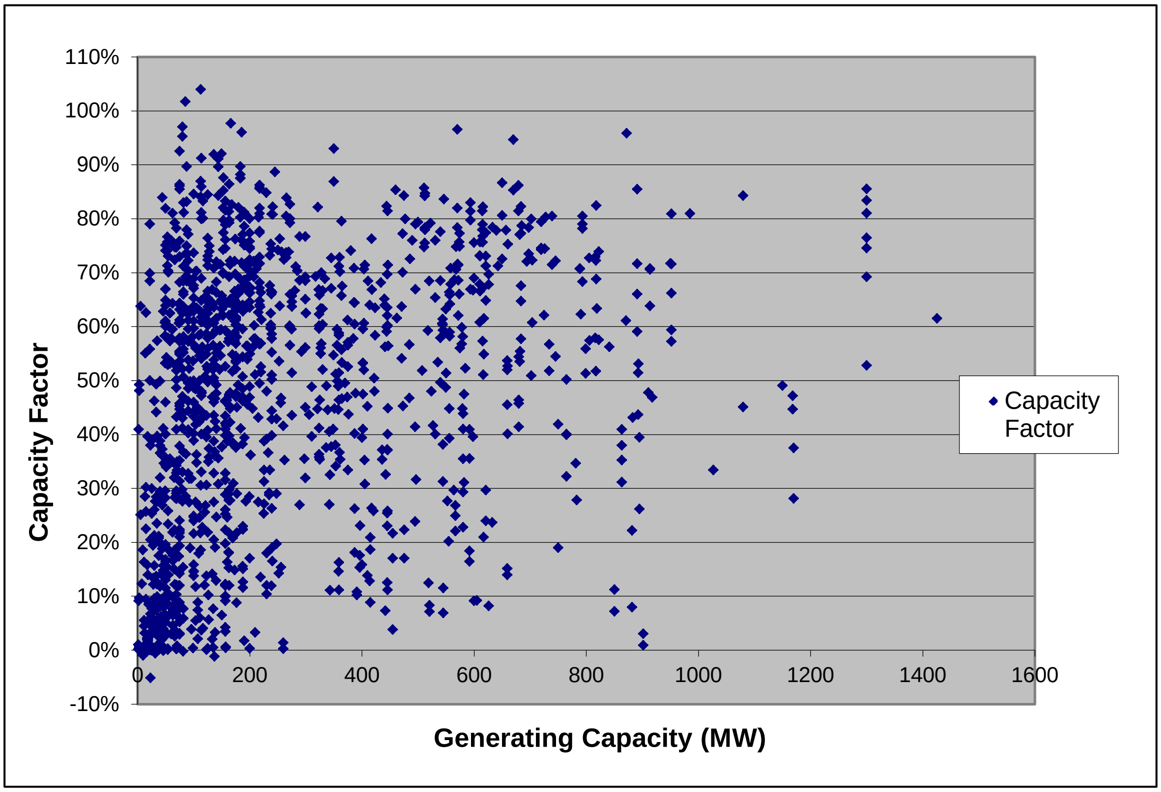


Exhibit 5-33. Phase II Facility generating unit year 2000 capacity factor versus year generating unit came online

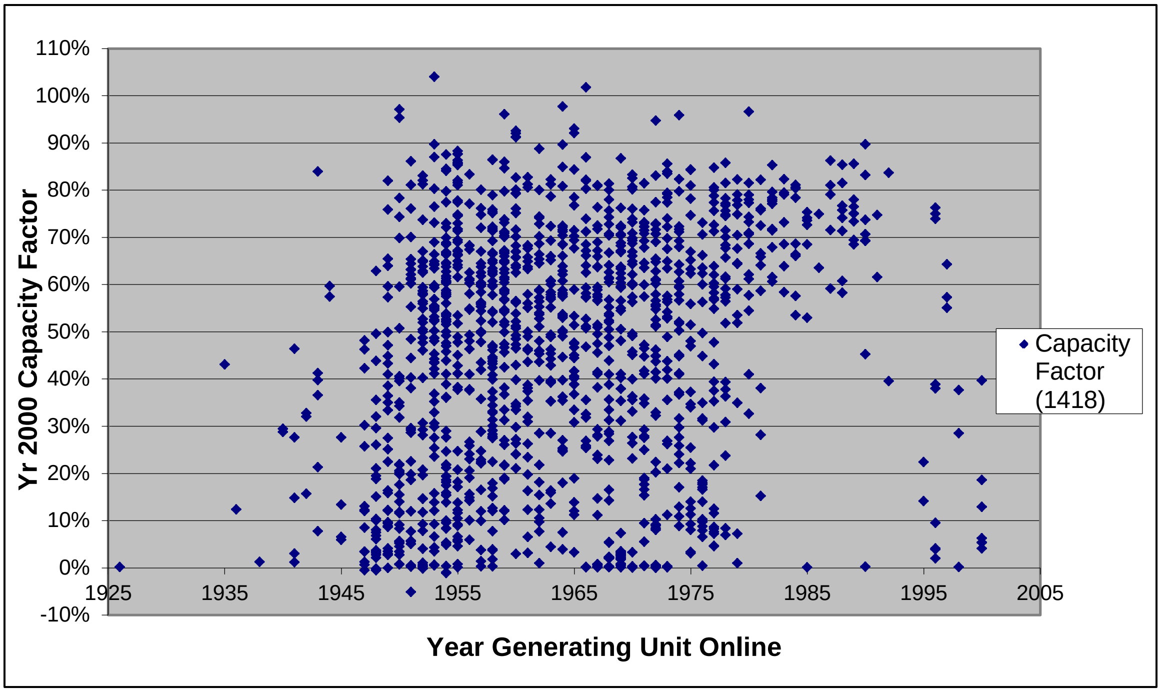


Exhibit 5-34. Distribution of Phase II Facility year 2000 total plant capacity factors by primary fuel type

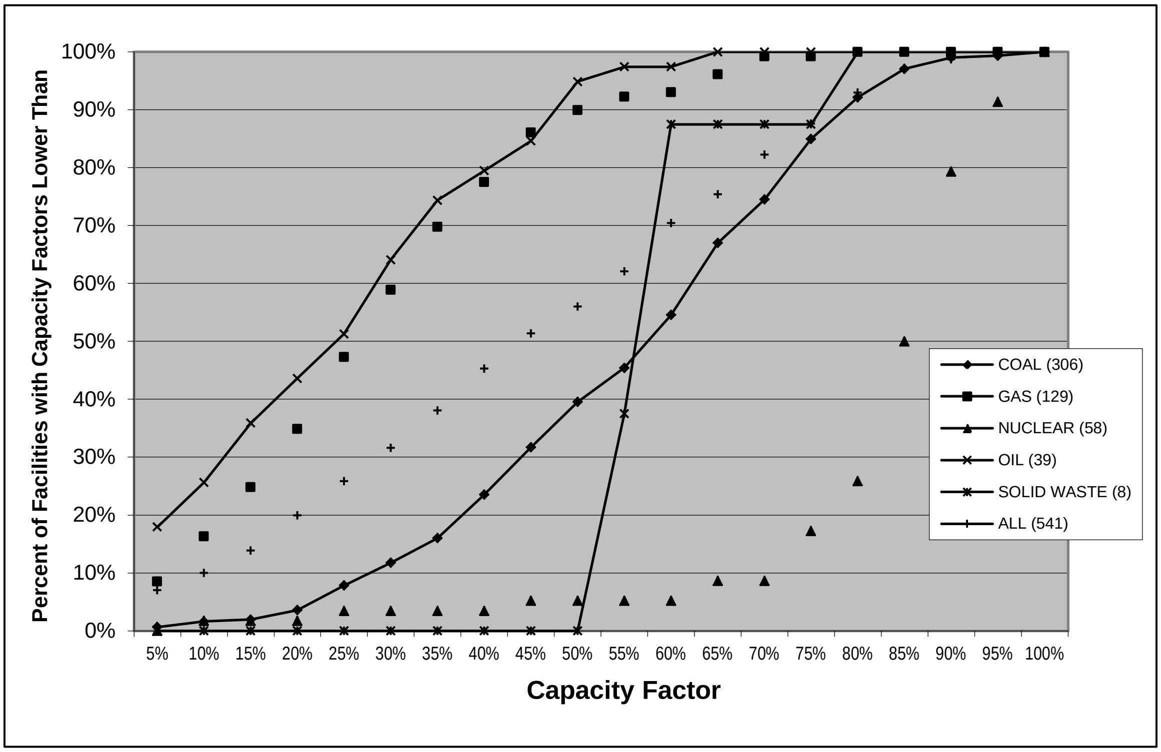


Exhibit 5-35. Distribution of Phase II Facility year 2000 total plant capacity factors by intake waterbody type

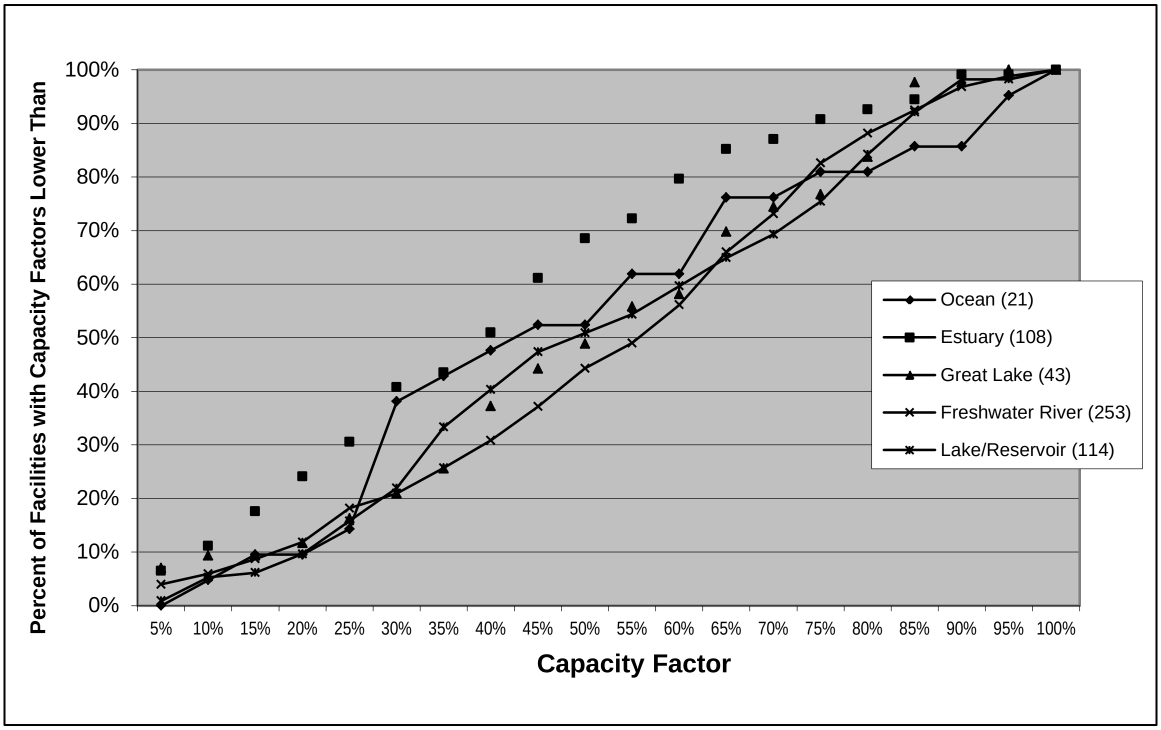
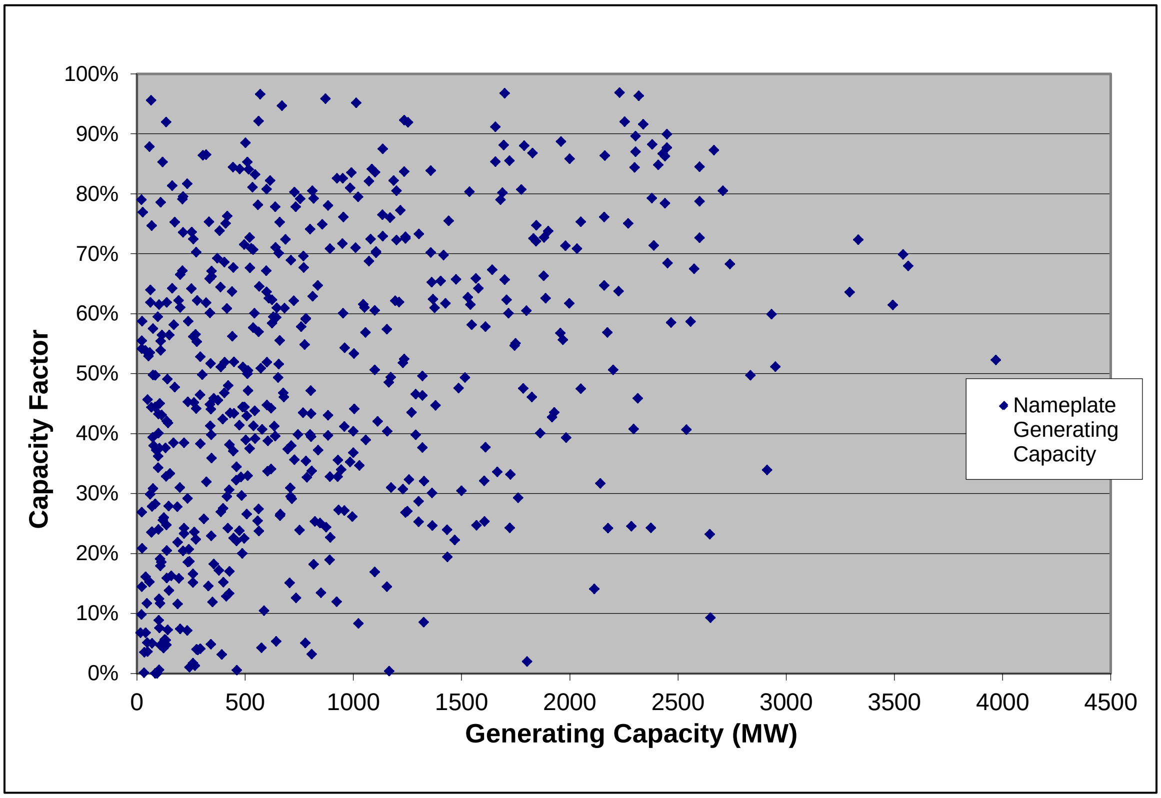


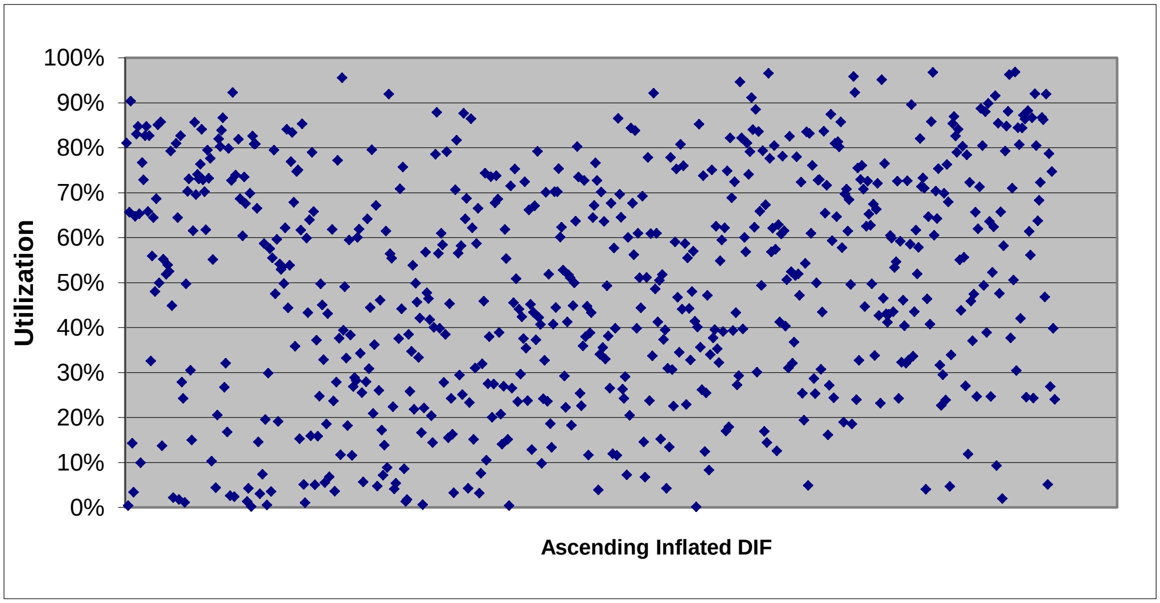
Exhibit 5-36. Phase II Facility year 2000 total plant capacity factor versus total generating capacity



5.9.2 CUR Versus DIF

EPA also examined the relationship between the design intake flow (adjusted for closed-cycle cooling, as described above) and the CUR for Phase II facilities. As shown in Exhibit 5-37 below, there is no clear relationship between a facility’s size (i.e., DIF) and it’s frequency of operation. As such, EPA determined that it could not establish any appropriate subcategories based on the relationship of CUR and DIF.

Exhibit 5-37. Distribution of capacity utilization



5.9.3 Low Capacity Utilization Compared With Spawning Seasonality

In the 2004 Phase II rule, facilities with a CUR below 15 percent were not required to meet entrainment requirements. As discussed in the preamble for the 2002 proposed rule (see 67 FR 17141, March 19, 2003), EPA found (at that time) that the reduced level of operations at these facilities would provide ample protection for aquatic organisms due to a substantial reduction in intake flows on an annual basis.

This final rule does not employ this same approach. This rule establishes IM standards, and EPA did not find that costs for low CUR facilities posed national level impacts. EPA has adopted this approach because low CUR facilities, while they do offer reduced flows on an annualized basis, typically operate at or near their full design capacity when they are in operation. If these periods of activity coincide with periods of high biological value (such as a spawning period), then these low CUR facilities may be having as much impact on aquatic organisms as a facility that operates more frequently. Furthermore, these low CUR units serve an important function for local energy reliability. Therefore the final rule allows that facilities with intakes that serve generating units with a CUR less than 8 percent over a contiguous 24 month period may request that the Director establish less stringent BTA standards for impingement mortality based on BTA. EPA adopted the 8 percent CUR cutoff to be consistent with the definitions of low CUR facilities in other programs, such as EPA's air regulatory efforts.

EPA reviewed the group of facilities with a CUR below 10 percent (38 facilities[70]) listed in Exhibit 5-38 below and compared the operational periods of these facilities[71] to key biological periods for fish species in the source waterbodies for these facilities. As

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[70] These 38 facilities represent approximately 5.4 percent of the total DIF of Phase II facilities.
[71] Derived from monthly flow data from the industry questionnaire.

expected, low CUR facilities are most active in the summer and winter, when electricity demand is generally highest.

Exhibit 5-38. Facilities with CUR less than 10 percent

Facility name	State	Waterbody region[1]	Waterbody type[2]
Conners Creek	MI	Great Lakes	Great Lakes
Marysville	MI	Great Lakes	Great Lakes
Oswego	NY	Great Lakes	Great Lakes
Edgewater	OH	Great Lakes	Great Lakes
Honolulu	HI	Hawaii	Ocean
Zuni	CO	Inland	Freshwater river or stream
Atkinson	GA	Inland	Freshwater river or stream
Plant Crisp	GA	Inland	Lake or reservoir
Collins	IL	Inland	Freshwater river or stream
Peru	IN	Inland	Freshwater river or stream
Kaw	KS	Inland	Freshwater river or stream
Monroe	LA	Inland	Freshwater river or stream
Austin DT	MN	Inland	Lake or reservoir
Fox Lake	MN	Inland	Lake or reservoir
M L Hibbard	MN	Inland	Freshwater river or stream
Hawthorn	MO	Inland	Freshwater river or stream
Burlington	NJ	Inland	Freshwater river or stream
Piqua	OH	Inland	Freshwater river or stream
Delaware	PA	Inland	Freshwater river or stream
Schuylkill	PA	Inland	Freshwater river or stream
Lake Pauline	TX	Inland	Lake or reservoir
North Texas	TX	Inland	Lake or reservoir
Sam Rayburn	TX	Inland	Freshwater river or stream
Blackhawk	WI	Inland	Freshwater river or stream
Menasha	WI	Inland	Lake or reservoir
Rock River	WI	Inland	Freshwater river or stream
Riverside	MD	Mid-Atlantic	Estuary or tidal River
Kearny	NJ	Mid-Atlantic	Estuary or tidal River
Linden	NJ	Mid-Atlantic	Estuary or tidal River
Sayreville	NJ	Mid-Atlantic	Estuary or tidal River
Sewaren	NJ	Mid-Atlantic	Estuary or tidal River
Indian Point	NY	Mid-Atlantic	Estuary or tidal River
Hookers Point	FL	Gulf of Mexico	Estuary or tidal River
Mason Steam	ME	North Atlantic	Estuary or tidal River
Henry D King	FL	South Atlantic	Estuary or tidal River
Indian River Plant	FL	South Atlantic	Estuary or tidal River
McManus	GA	South Atlantic	Estuary or tidal River
Riverside	GA	South Atlantic	Estuary or tidal River

[1] In this context, “region” is defined as the fisheries region used in the national benefits analysis in the Benefits Analysis for the Final Section 316(b) Existing Facilities Rule (BA).

[2] Waterbody type is a regulatory classification under the 2004 Phase II rule.

EPA then examined the spawning periods of common fish species in each region of the country. (See DCN 10-6702.) Since the facilities with a low CUR do not show any regional or geographic trends (i.e., no one region has disproportionately more low CUR facilities), it is reasonable to conclude that a broader review of fish species by region will adequately address the correlation between spawning season and CUR. Two conclusions are apparent:

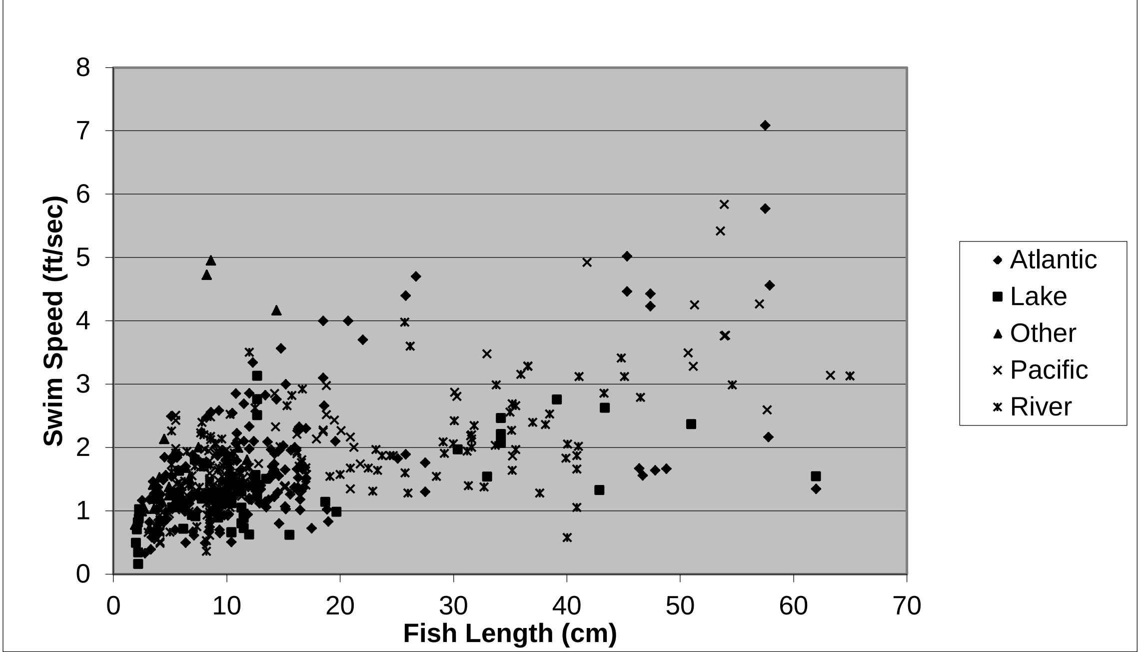
- For many waterbodies, there are few periods in the year when there is an absence of spawning activity, indicating that facility operations at any time of the year could have an impact on aquatic organisms.
- The operational periods of many low CUR facilities coincide with spawning periods of nearby fish species.

As such, EPA determined that low CUR facilities should not be categorically exempted from entrainment requirements but recognizing that the biological densities and timing will vary from facility to facility EPA provided the Director the flexibility to establish BTA impingement mortality standards for intakes serving generating units with a CUR less than 8 percent.

5.9.4 Fish Swim Speed

The swimming ability of fish is one key component in reducing impingement (and therefore impingement mortality). EPA reviewed data from an Electric Power Research Institute (EPRI) study on fish swim speeds (see DCN 2-028A) to determine if there was any difference in the swimming abilities of fish in different waterbodies. As shown in Exhibit 5-39, assemblages of fish in the various waterbodies did not demonstrate any clear superiority in swimming ability. As such, EPA determined that it could not establish any appropriate waterbody-based subcategories based on the fish swim speed in those waterbodies.

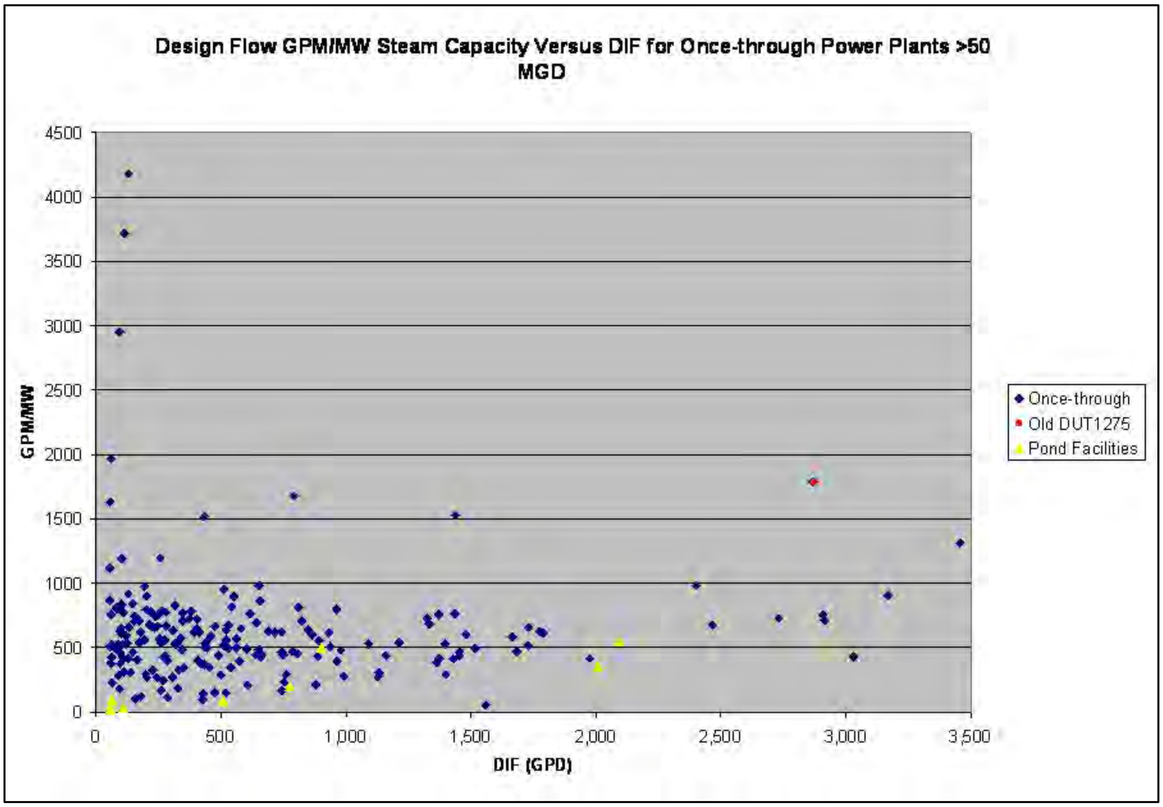
Exhibit 5-39. Swim speed versus fish length



5.9.5 Water Use Efficiency

EPA also analyzed power generating facilities' cooling water withdrawals and electricity generated as a measure of how efficient a given facility is in its use of cooling water. Initially, EPA examined the design intake flow for facilities above 50 mgd and compared it to their steam generating capacity as a way to identify the least efficient facilities. Exhibit 5-40 shows the results of this analysis, with cooling impoundment sites identified separately.

Exhibit 5-40. Design Intake Flow (gpm) / MW steam capacity for once-through power plants over 50 MGD



EPA expanded upon this analysis by using data from the industry surveys (actual intake flow) and compared it to the electricity generation from the corresponding period. Facilities were then sorted based on the calculated ratio of water use per megawatt generated. Exhibit 5-40 shows the median ratio for facilities with various cooling system types (once-through, closed-cycle, combination, and combined cycle[72]). EPA examined a range of analyses for water use efficiency, including variants that excluded facilities that utilize closed-cycle cooling, as these facilities clearly withdraw less water per megawatt than once-through facilities. Exhibit 5-41 shows the median efficiency for each type of facility, with a variety of horizontal lines that represent various thresholds; for example, the top 10 percent most efficient power plants (including closed-cycle) have approximately the same efficiency as closed-cycle systems, while the same ratio drops significantly when closed-cycle systems are excluded. See Chapter 7 for more discussion of how EPA considered this information.

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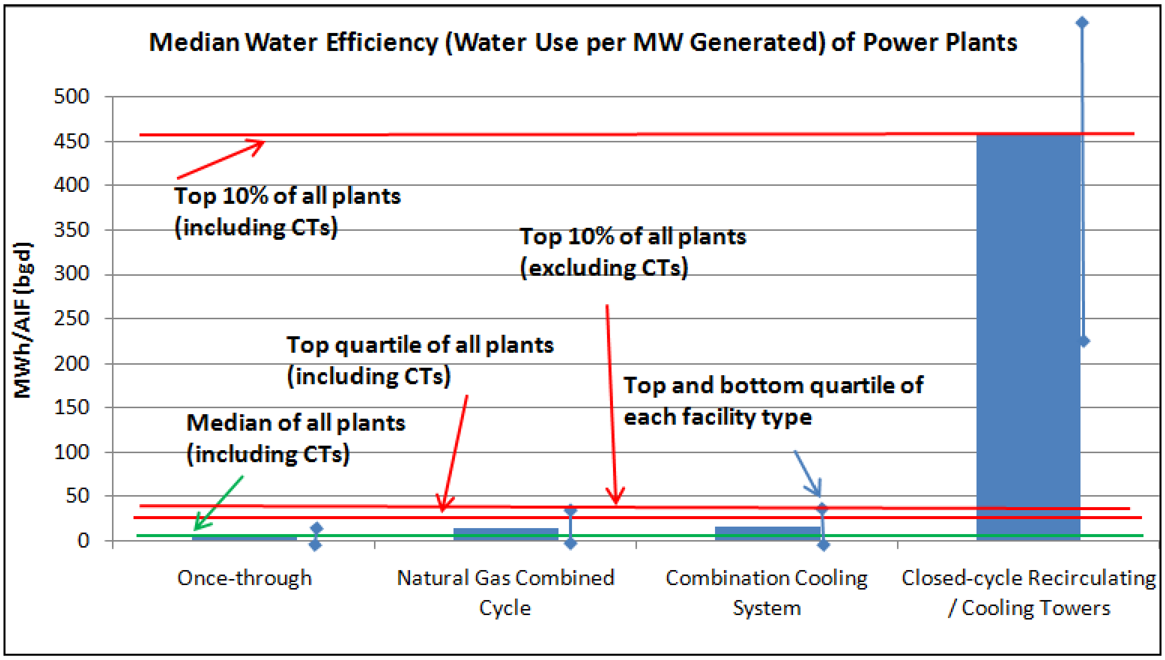
[72] The increased generating efficiencies of combined cycle plants warranted their separation into a different grouping.

Exhibit 5-41. Median water efficiency (water use per MW generated) of power plants (including CCRS)



5.9.6 Land Availability

While EPA has concluded that the vast majority of facilities have adequate available land for placement of cooling towers,[73] some facilities may have legitimate feasibility constraints. Based on site visits, EPA has found several facilities have been able to engineer solutions when faced with limited available land. EPA attempted to determine a threshold of land (one option explored a threshold of approximately 160 acres per gigawatt) below which a facility could not feasibly install cooling towers.[74] Based on such an approach, EPA projected an upper bound of 25 percent of facilities that may have insufficient space to retrofit to cooling towers. While EPA estimated that some facilities would not have enough space, EPA found some facilities with a small parcel of land were still able to install closed-cycle cooling by engineering creative solutions.[75] On the other hand, EPA found that some facilities with large acres still could not feasibly install cooling towers due to, for example, protected wetlands. While EPA was able to account for space constraints in its estimated compliance costs (see Chapter 8), there was not enough data to make a site-specific assessment of available land. As a result of the large uncertainty surrounding EPA's data and analysis of available space, EPA rejected land availability as a potential subcategory.

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[73] In the case of fossil fuel plants, scrubber controls may also be newly required to comply with air rules and standards.

[74] See DCNs 10-6671 and 10-6672.

[75] Facilities could also build cooling towers in elevated locations, such as building roofs but this is more expensive and is not feasible for many facilities.

5.9.7 Fish Species

EPA considered subcategorization based on different groups of fish species or species attributes. In an analysis of possible grouping strategies for fish species, EPA identified 1,279 of the 3,694 species in and around North America that could reasonably be expected to occur in the U.S. in the vicinity of CWISs and be exposed to IM&E related to those CWISs.[76] (See DCNs 10-6704 and 10-6704A.) After considering different taxonomic levels of classification for grouping similar species, EPA concluded that grouping by family classification (which resulted in 72 family groups) struck a good balance between the need to be general enough to minimize number of groups while specific enough to capture meaningful morphological and habitat-specific differences among the various species. EPA concluded that this grouping scheme would need further refinement as some families with similar characteristics could be grouped together while other more diverse families may require division. EPA considered conducting further investigation into habitat preferences, geographic ranges, and swim speed analyses in order to identify group characteristics but concluded that the analysis would be complex and the approach would be difficult to implement since it required consideration of multiple characteristics and possible development of separate standards for a large number of groups.

After careful consideration, EPA abandoned the fish species grouping approach and instead adapted a more simplified approach that grouped species by relative degree of fragility related to susceptibility to injury and death resulting from impingement. EPA initially identified species from the impingement mortality database list and divided them into three categories, fragile, somewhat fragile and hardy (see DCN 12-6700). This approach was consistent with stakeholder suggestions that EPA should establish different limitations for fish species with different degrees of potential for impingement survival. EPA compared the results of this analysis with an estimate of relative impingement survival for fish families provided by industry representatives (see DCN 12-6808) and found the two lists to be in general agreement with regard to fragile species (see DCN 12-6700). Since EPA was unable to identify any technology that reduces impingement mortality for fragile species that was widely available nationally,[77] EPA concluded that a separate impingement mortality standard for fragile species was unworkable.

EPA did incorporate grouping by species hardiness in the BTA requirements by grouping of fish into two hardiness classifications in the development and application of the percent impingement mortality standard. EPA was concerned that mortality data from fragile species might, in large part, reflect conditions other than technology performance and concluded that the IM performance of modified traveling screens is relatively predictable with respect to non-fragile species. As a result, EPA developed the 12 month percent impingement mortality standard based on the performance with respect to fragile species only and specified that the standard only applies to fragile species (see Chapter 11).

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[76] The difference includes species that do not occur in the U.S. (e.g., only in Canada or Mexico) and those that are unlikely to occur in near-shore waters.

[77] EPA did identify technologies that might be effective for fragile species (such as low velocity for salmonids or behavioral avoidance tailored for certain fragile species) but concluded that neither of these or other potential technologies are widely available.

EPA determined that additional regulatory requirements to document further distinction between species would be an unnecessary burden, as it would result in unnecessary complications and expense for facilities in monitoring and evaluating impinged fish species. In fact, EPA does not expect that many facilities will elect to comply with the impingement mortality BTA standard via 40 CFR 125.94(c)(7) due to the added monitoring burden. As illustrated in the discussion above, EPA evaluated subcategorization based on fish species or species attributes and concluded that separate standards based on fish species would be complex, burdensome, and likely unworkable.

5.9.8 Other Factors

EPA also explored (in varying degrees of depth) and ultimately rejected a number of other potential approaches to subcategories. These analyses included an evaluation of creating subcategories based on the following:

- Spawning period (see DCN 10-6702)
- Combined cycle (see DCN 10-6631)
- Cogeneration (see DCN 10-6630)
- Dry cooling (see DCN 10-6679)
- 7Q10 of the source waterbody
- Flue gas desulphurization (see DCN 10-6681)

Because these factors were only applicable to a limited number of facilities, EPA found these factors would not improve setting and implementing national standards.

5.10 Conclusion

As shown in the analyses above, EPA has examined numerous aspects of existing facilities, including both production-related and CWIS-related characteristics, and has determined that although these facilities exhibit a range of characteristics, these characteristics do not differ to the extent that different technologies are most effective or uniquely available to distinct subcategories of facilities. EPA's analysis demonstrates that several CWIS technologies are effective for existing facilities and that these technologies do not differ significantly across the various subcategory criteria considered. Therefore, EPA is not establishing any subcategories for the final rule.

Although no subcategories were identified, the rule does reflect the key factors and variability that are relevant to CWIS impacts. The rule establishes basic standards for the reduction of impingement mortality and entrainment. It also provides several compliance alternatives that reflect technologies that can be used to minimize adverse impacts and that are to be implemented on a site-specific basis in accordance with the characteristics of a specific facility (e.g., location, size, existing technologies, etc.). In this way, the structure of the rule is consistent with the data identified for existing facilities.

Chapter 6: Technologies and Control Measures

6.0 Introduction

In developing the 2004 Phase II rule and 2006 Phase III rule, EPA conducted a comprehensive review of technologies that reduce impingement and entrainment (I&E) at cooling water intake structures.[78] For the existing facility rule, EPA reconsidered existing information on these technologies, identified new technologies, and updated efficacy information based on new study data.[79] This chapter describes the primary technologies and operational measures considered in developing requirements for the existing facility rule. Each section provides an overview of the technology, a discussion of performance in reducing impingement and/or entrainment, and examples of facilities and/or laboratory studies that employ the technology.

In general, technologies and control measures can be divided into two major groups: flow reduction and screening or exclusion. Flow reduction is the clearest way to reduce impingement mortality and entrainment mortality, as lower intake flows will impinge and entrain fewer organisms, generally in proportion to the amount of flow reduction. Screens act to exclude organisms from the intake structure and return them to the source waterbody. Exhibit 6-1 lists the technologies and control measures discussed in this chapter.

In addition to this chapter, the Electric Power Research Institute's (EPRI) 2007 *Fish Protection at Cooling Water Intakes: A Technical Reference Manual* (DCN 10-6813) is a compilation of studies conducted at various sites throughout the country and serves as a comprehensive reference for cooling water intake technology performance. For additional discussion of cooling towers, see Chapter 8 of EPRI (2007) and the California Ocean Protection Council's *California's Coastal Power Plants: Alternate Cooling System Analysis* (DCN 10-6964).

In general, all of the technologies presented in this chapter can be effective at a given site and are equally available at both power plants and manufacturers, as well as for existing facilities (including new units at existing facilities) and new facilities. A cooling water intake structure is a technical apparatus that is designed to supply water; the end use of the water is of little importance when evaluating the CWIS's effectiveness or the feasibility of a given technology. There will certainly be site-specific factors that weigh heavily in evaluating technologies but the type of "downstream" user of cooling water is generally not relevant. In the case of manufacturers, there are also greater opportunities for flow reduction and reuse of cooling water.

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[78] See Chapter 3 of the 2002 Phase II proposed rule (DCN 4-0004), Chapter 4 of the 2004 Phase II final rule TDD (DCN 6-0004), and Chapter 8 of the proposed Phase III rule (DCN 7-0004).

[79] See Chapter 2 of the TDD for a discussion of data collection efforts.

Exhibit 6-1. List of technologies considered

Flow reduction technologies and control measures
- Closed-cycle recirculating systems
- Wet cooling systems
- Dry cooling systems
- Variable speed pumps/variable frequency drives
- Seasonal flow reductions
- Water reuse
- Alternate cooling water sources

Screening technologies
- Conventional traveling screen
- Modified coarse mesh traveling screen
- Geiger screen
- Hydrolox screen
- Beaudrey W Intake Protection (WIP) screen
- Coarse mesh cylindrical wedgewire screen
- Fine mesh traveling screen
- Fine mesh wedgewire screen
- Barrier net
- Aquatic filter barrier

Offshore intakes
- Intake location
- Velocity cap

Other technologies and operational measures
- Physical design
- Reduced intake velocity
- Substratum intakes
- Louvers

6.1 Flow Reduction Technologies and Control Measures

This section describes technologies and control measures used to reduce cooling water intake flows. By reducing the intake flow, a facility can reduce its I&E; impingement is related to intake flow (among other variables) and entrainment is directly proportional to flow. The largest reductions are usually realized by installing (or retrofitting) a closed-cycle recirculating cooling system but facilities may also employ variable speed pumps, seasonal flow reductions, water reuse, or use of alternate sources of cooling water.

6.1.1 Closed-Cycle Recirculating Systems

Closed-cycle cooling systems transfer a facility's waste heat to the environment and recycle the cooled water back to the condensers to be used again. These recirculating systems enable a facility to withdraw significantly smaller quantities of (or in some cases no) surface water. Closed-cycle cooling systems include cooling towers and cooling lakes/ponds.[80] Cooling towers are structures that recirculate water within the cooling system, while providing for the exhaust of excess heat. Towers are generally of two designs: mechanical draft, in which heated water is exposed to air currents driven by electrical fans, or natural draft, in which heated water is allowed to interact with naturally induced drafts within the tower. In both cases, water within the cooling system is cooled and sent back to the condenser to be used again. Approximately 28 percent of existing power producers and 35 percent of existing manufacturers use cooling towers.

Due to the evaporative processes involved (and the subsequent buildup of dissolved solids), cooling towers require that a certain portion of the circulating water be discharged (as “blowdown”) and replaced (makeup water).[81]

Cooling ponds (called “impoundments” in the final rule) are surface waterbodies that serve as both a source of cooling water and a heat sink. As with cooling towers, cooling ponds rely on evaporative cooling to dissipate the waste heat. Depending on local hydrology, cooling ponds may also require makeup water from another waterbody (the level of makeup water depends on numerous site-specific factors including size, inflow and outflow, and evaporation; EPA has not identified a source of data that describes cooling pond makeup flows). At many facilities, cooling ponds have evolved to be more than part of an industrial waste treatment process, as recreational fishing and other designated uses have been established. This has created some confusion as to whether they should be considered as part of a closed-cycle cooling system or as a source water. See the preamble for more discussion on this topic.

There are two main types of cooling towers, wet cooling and dry cooling. Each of these technologies is described below.

6.1.1.1 Wet Cooling Systems

In a wet cooling system, waste heat is primarily transferred through evaporation of some of the heated water into the surrounding air.[82] This process enables a facility to re-use the remaining water, thereby reducing the quantity of water that must be withdrawn from a waterbody. While the amount of water withdrawn from the water source is greatly reduced, it is not eliminated completely because makeup water is required to replace water lost through evaporation and blowdown. There are two main types of wet cooling systems: natural draft and mechanical.

A natural draft cooling tower is tall (up to 500 feet or more) and has a hyperbolic shape which resembles a wide, curved smoke stack (see Exhibit 6-2). The height of these towers creates a temperature differential between the top and bottom of the tower, creating a natural chimney effect. Because of this effect, natural draft towers do not need

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[80] Note that the term “cooling pond” (or “impoundment” as stated in the final rule) is often used or defined broadly, but under the final rule, not all cooling ponds are considered to employ closed-cycle cooling. See the preamble to the final rule for additional discussion.

[81] The frequency at which blowdown occurs depends on the source waterbody; fresh water requires less frequent blowdown than brackish water.

[82] In addition, a smaller portion of the heat is also removed through direct contact between the warm water and the cooler surroundings.

fans in order to operate efficiently and, while they tend to cost more to build than mechanical draft towers, natural draft towers cost less to operate due to reduced energy requirements. Unlike natural draft towers, mechanical cooling towers rely on motorized fans to draw air through the tower and into contact with the heated water. These towers may be much shorter than natural draft cooling towers, typically ranging from 30 to 75 feet in height (see Exhibit 6-3), but may require more land area and reduce a facility's net generating output due to the electricity required to operate the fans.

Inside both types of towers, cooling water is sprayed from nozzles and then passes through fill media that enhances contact between the air and water. In natural draft towers, the nozzles are located partway up the tower while in mechanical draft towers the nozzles are located near the top. Both natural draft and mechanical cooling towers can operate in freshwater or saltwater environments. Evaporation of cooling water in the towers results in an increased concentration of dissolved solids in the makeup water. The concentration in the recirculating water is controlled by constantly removing a portion as blowdown. As a result of higher dissolved salt concentration, saltwater applications typically require more blowdown and makeup water than freshwater applications, making them less efficient in reducing water withdrawals.

Exhibit 6-2. Natural draft cooling towers at Chalk Point Generating Station, Aquasco, MD

Exhibit 6-3. Mechanical draft cooling towers at Logan Generating Plant, Swedesboro, NJ

Alternative Configurations

Modular cooling tower units provide an additional cooling tower alternative. Modular cooling towers resemble mechanical cooling towers, but are portable, typically rented for short-term periods and quickly assembled (see Exhibit 6-4). Modular cooling tower units have been used as temporary replacements for existing cooling tower systems that need major repairs, for facilities that are subject to interruptions in the ability to withdraw sufficient quantities of cooling water, and for facilities that require supplemental cooling or flow reduction for only a portion of the year. EPA has determined that the use of modular towers (on a temporary basis) could substantially reduce the effects of downtime from retrofitting intake technologies at some facilities (see DCN 10-6677). Facilities that would be able to install the modular towers may actually face no downtime at all, which would eliminate a significant component of the costs of the rule and replace it with the smaller, temporary cost of modular tower rentals. (See the EA for a discussion of the role of downtime costs in EPA's estimation of national economic impacts.) Because EPA was not able to estimate how many facilities would be able to employ these modular towers, however, the Agency has not attempted to estimate the overall cost savings of using them. As a result, EPA did not adjust its national cost estimates to include the use of modular cooling towers.

Facilities also often utilize a "combination" cooling system, in which some portion of the cooling system uses closed-cycle cooling.[83] For example, a facility might have one unit

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[83] Approximately 8 percent of electric generators and 12 percent of manufacturers use combination systems.

operating with a once-through system and a second unit has a cooling tower. For the purposes of costing and consideration of cooling tower retrofits, EPA considered these facilities along with facilities that are fully once-through.

Exhibit 6-4. Modular cooling tower (image from Phoenix Equipment)[84]

Facilities that face significant challenges in meeting thermal discharge limits may operate "helper" cooling towers.[85] These are typically mechanical draft towers that are not associated with the cooling system itself; they simply withdraw heated effluent that is discharged by the facility, evaporate heat, and return the water to the discharge point. These systems do not reduce the overall intake flow. Harllee Branch is an example of such a facility. (See DCN 10-6537 for EPA's site visit report to this facility.)

6.1.1.2 Dry Cooling Systems

Dry cooling systems completely eliminate the need for cooling water withdrawals. Unlike wet cooling systems, in dry cooling systems, waste heat is transferred completely through convection and radiation rather than evaporation. Dry cooling systems are in use at a number of facilities in the United States and worldwide. (See DCNs 4-4023H, 10-6679

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[84] http://www.phxequip.com/equipment.4366/15-000-gpm-cooling-tower.aspx

[85] See DCN 10-6676 for a detailed discussion of helper towers.

and 10-6943.) Since 1990, dry cooling has been installed in at least one facility in every EPA Region, with many being installed in the northeast (states with historically more stringent regulatory regimes) and the west, where water resources (for once-through or wet towers) are more limited. In the 1990s, most of the facilities that installed dry cooling were small (less than 100MW for the dry-cooled unit). But in the past decade, dry cooling has become more prevalent at much larger facilities, with virtually all dry-cooled units being over 100MW and many 250MW and larger. According to data provided by vendors (see DCN 10-6680), Mystic (MA) and Midlothian (TX) are among the largest known dry-cooled units, at 500MW each (out of a plant-wide capacity of 1600MW and 1650 MW, respectively). Many inland facilities in California use dry cooling. The State of New York issued a cooling water policy (CP-#52 - Best Technology Available (BTA) for Cooling Water Intake Structures) in July 10, 2011 that sets dry cooling as the performance goal for all new industrial facilities sited in the marine and coastal district and along the Hudson River. Astoria II, a 575 MW combined cycle facility using dry cooling built was recently built along the Hudson. Additionally, many new facilities are being built with dry cooling, including the Warren County (VA) facility, a 1329 MW combined cycle facility.

There are two main types of dry cooling systems: direct and indirect. Direct systems function similar to a radiator in a car; the turbine exhaust steam passes to a fin tube array where air is drawn across and heat is rejected, ultimately producing a condensate that is returned for reuse in the turbine. The system is completely closed to the atmosphere and there is no contact between the outside air and the steam or the resulting condensate (see Exhibit 6-5). Indirect dry cooling requires a cooling tower but a surface condenser is placed between the turbine exhaust and the tower. Heat is transferred to the circulating medium in the condenser and dispersed to the atmosphere through the tower. However, the difference between indirect dry cooling and a wet tower is that the water is not exposed to the outside air.[86]

Dry cooling systems tend to be much more costly than wet cooling systems and experience higher turbine efficiency losses during periods of high dry bulb temperatures. Previous EPA estimates have put the relative capital costs of dry cooling at 5X to 10X that of mechanical wet cooling systems. Recent data indicates that these costs may be closer to the lower end of this range. A comparison of cost data for the Astoria II project to EPA estimates indicate that costs for the dry tower component alone are about 4X those for an equivalent wet cooling system.[87]

For the Phase II Rule, EPA estimated that the turbine efficiency loss penalty for dry cooling versus wet cooling could range from an annual average of about 4 percent to a summer maximum of 16 percent based on the increase in steam condensing temperatures. Also, steam turbines have a maximum turbine steam exhaust backpressure limit which should not be exceeded to prevent damage to the turbine blades. Most existing steam

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[86] Indirect dry cooling systems are substantially less efficient in rejecting heat than direct units; however, most facilities that would choose to retrofit dry cooling would select an indirect system, as it would be able to tie into the existing condenser at the facility.

[87] A comparison of the reported cost to construct and erect the Astoria II air-cooled condensers of 38 Million Euros to the costs of a comparably sized wet cooling system using the EPA estimate unit cost for the wet tower alone of $80/gpm results in a factor of approximately 4X.

turbines are designed for the expected maximum operating condensing temperature of the existing cooling system (e.g., once-through using surface water). During periods of high dry bulb temperatures, the turbine exhaust back pressure of a retrofitted dry cooling system would likely exceed the design value for existing turbines designed for once-through cooling. When this happens the operator must reduce the amount of power being generated to prevent damage. Such forced reductions in generating capacity (aka derate) can increase the amount of power generation loss toi levels higher than the maximum turbine efficiency losses described above which are based on differences in condensing temperatures alone. This problem may also occur in retrofitted wet cooling system but is much more pronounced for dry cooling. Replacement or upgrade of the steam turbines to a design with a higher maximum exhaust backpressure is necessary to minimize such generating capacity reductions.

Exhibit 6-5. Dry cooling tower (image from GEM Equipment)[88]

6.1.1.3 Performance of Cooling Towers

The use of cooling towers significantly reduces the withdrawals of cooling water, but some makeup water is still withdrawn in wet cooling tower systems. In the 2004 Phase II rule, EPA estimated facilities employing freshwater cooling towers and saltwater cooling

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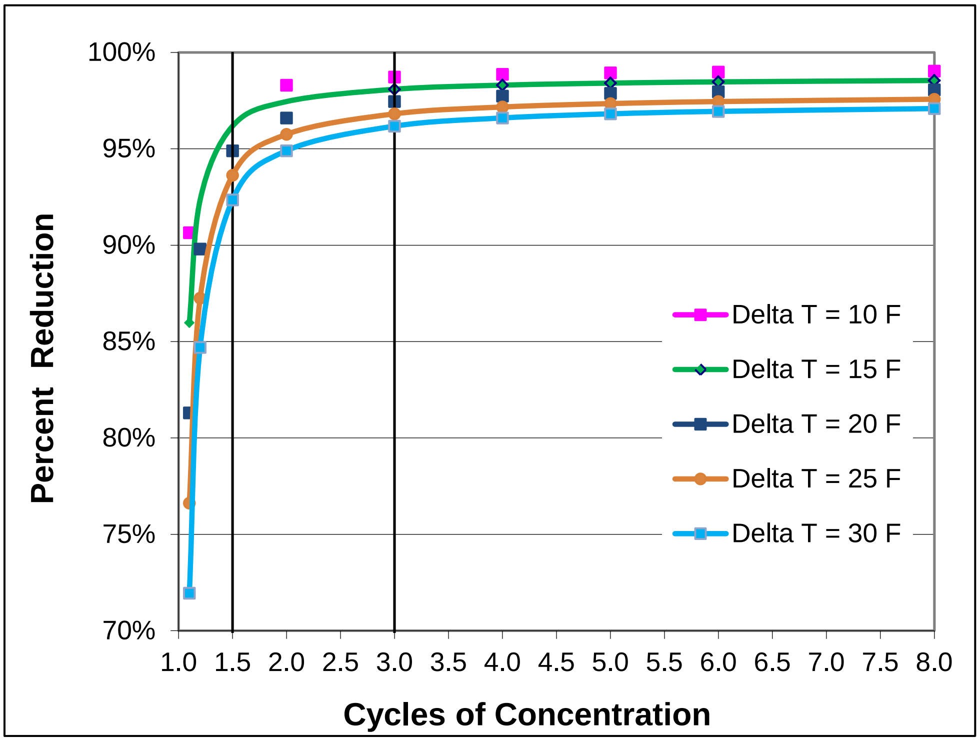
[88] http://www.gemindia.com/products/dct_h.png

towers would achieve flow reductions, and therefore associated entrainment and impingement mortality reductions, of 98 percent and 70-96 percent, respectively.[89]

Facilities can also optimize the reduction in flow by also minimizing the makeup flow withdrawals. The most common concept used to describe the level of optimization is cycles of concentration (COC). This represents the ratio of dissolved solids in the recirculated water versus that in the makeup water. Operating at a higher COC usually requires additional O&M, such as an increased use of chemicals. In the 2004 Phase II rule, EPA's record demonstrated saltwater cooling towers typically operated at 1.1-2.0 cycles of concentration.

However, more recent information demonstrates that, as a result of advances in design and operation, saltwater cooling towers typically operate at 1.5 cycles of concentration and 3.0 cycles for freshwater towers. See DCN 10-6964. These levels correspond to flow reductions of 94.9 percent and 97.5 percent respectively (at a delta T of 20°F, which is common for power plants and is in the center of the range observed by EPA).[90] Exhibit 6-6 shows the reductions in flow for various waterbody types, cooling system configurations and COCs; the vertical lines represent the two COCs used by EPA in its analyses. See DCNs 10-6673 and 10-6674 for a detailed discussion of cooling tower optimization.

Exhibit 6-6. Percent reduction in flow for various cooling system delta Ts



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[89] As discussed in the preamble to the rule, impingement mortality and entrainment reductions are proportional to flow reductions.

[90] In the final rule, EPA did not include explicit requirements for COC or for a percent flow reduction, but EPA continues to believe that these thresholds represent a properly operated and maintained cooling tower.

6.1.1.4 Retrofit Applications

EPA estimated retrofit costs as described in Chapter 8 of this TDD and in the preamble. Engineering factors affecting the retrofit from once-through systems to cooling towers include the following:

- Availability of space nearby;
- Need to remove or demolish existing structures;
- Whether the tower site elevation is higher than the existing cooling system intake bay so cold water can flow by gravity to the intake bay;
- Whether there are underground interferences in the path of the new circulating water lines or at the location of the hot water sump and new circulating water pumps;
- Whether the tower site has overhead interferences, including transmissions lines;
- Whether the tower design may have to work around excluded areas where activities that may not be moved or blocked occur (e.g., hazardous materials storage, large vehicle turn-around areas, and security areas);
- The degree of construction work needed to convert the existing intake to handle the much lower intake flow volume needed for makeup water;
- How difficult it will be to tie-in the towers to the existing cooling system;
- Whether the site has unfavorable soil or geological conditions;
- Whether the site has contamination that might require remediation;
- Nuclear safety concerns;[91]
- Effects to manufacturing processes;
- Potential for increased water treatment and effects on facility’s effluent; and
- Land use or zoning conflicts.

Net construction downtimes for retrofitting to cooling towers are estimated to be approximately four weeks for non-nuclear plants and seven months for nuclear plants (68 FR 13526). These estimates assume that the construction tie-in would be scheduled to coincide with the facility’s routinely scheduled maintenance (typically a four week outage), thereby reducing the total length of the downtime for tie-in. See Chapter 8 for a detailed discussion of how downtime is calculated and incorporated into the analysis of cost.

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[91] While nuclear safety remains a paramount concern, it is less clear that retrofitting a cooling tower would actually have any impact on the safety of the facility. Documentation submitted to the Atomic Energy Commission from Palisades Plant (the lone nuclear facility to undergo a closed-cycle retrofit) indicates that “[t]he existing cooling water system […] has no safety related functions and the modified system will likewise have no safety related functions.” See DCN 10-6888B.

The operation of cooling towers also leads to an energy penalty; an auxiliary power requirement due to operating the cooling fans and additional pumping requirements[92] and a turbine efficiency penalty based on the incremental loss of performance due to a change in the pressure of the steam produced within the generating unit.

As described in Chapter 10 of this TDD, non water-quality impacts may also result from the installation of cooling towers. These impacts may include noise, plume, and salt drift. See Chapter 10 for a discussion of these potential impacts.

EPRI has also released a document which quantifies environmental and social effects of conversions to closed-cycle for 24 facilities along with national estimates based on data for the 24 facilities and a questionnaire issued to the industry , *Net Environmental and Social Effects of Retrofitting Power Plants with Once-Through Cooling to Closed-Cycle Cooling*. EPRI Technical Report 1022760, July 2011 (DCN 12-6942)

Dry cooling towers (and the accompanying equipment) will generally occupy the same or greater footprint as wet towers, potentially exacerbating any issues with available space. Additionally, existing facilities might need to upgrade or modify existing turbines, condensers, and/or cooling water conduit systems, which are tasks that are typically not required for wet tower retrofits. As with wet towers, retrofitting a dry cooling tower at an existing facility would require extensive shutdown periods during which the facility would lose both production and revenues, and decrease the thermal efficiency of an electric generating facility. As stated in the preamble to the 2004 Phase II rule,[93] EPA does not believe that dry cooling is a viable alternative for reducing impingement and entrainment at a national scale; dry cooling offers substantial reductions in impingement and entrainment (exceeding the performance of wet cooling in that regard) but with a significantly higher cost and penalty to performance.

Factors To Consider In A Closed-Cycle Retrofit

As described in the preamble to the final rule, EPA is not requiring closed-cycle cooling on a national scale; in part, this is due to the impact of three factors: land availability, air increased air emissions, and remaining useful life of the facility. These factors, plus other considerations (including effects to reliability) affecting this determination, are discussed in detail in the preamble.

Land Availability: While the majority of facilities report what appears to be adequate available land for placement of cooling towers, some facilities may have legitimate feasibility constraints due to small sites, existing equipment, buildings, transmission yards, rail lines, challenging topography or other factors. Based on site visits, EPA has seen several facilities that have been able to engineer solutions when faced with limited available land. On the other hand, EPA found that some facilities with large sites that still could not feasibly install cooling towers due to, for example, protected wetlands. As described in Chapter 5, EPA attempted to numerically analyze land availability but lacks

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[92] Power plants already use a considerable amount of electrical energy for auxiliary purposes. The additional power required for cooling tower fans and pumping is equal to roughly 20 percent of the existing auxiliary power use.

[93] See 69 FR 41608.

adequate data to better analyze how land constraints can be accommodated at existing facilities.

Increased Air Emissions: Retrofitting to closed-cycle cooling results in an energy penalty, which in turn leads to increased air emissions. Fossil-fueled facilities may need to burn additional fuel (thereby emitting additional CO_2, SO_2, NO_X, and Hg) for two reasons: 1) to compensate for energy required to operate cooling towers, and 2) the slightly lower generating efficiency attributed to higher turbine back pressure. At new units, these impacts are much less, as the design of a new cooling system accounts for these issues. U.S. fleet efficiency will likely increase over the long term, resulting in lower base emissions on a per watt basis, and the turbine back pressure penalty will be further reduced resulting in lower incremental emissions. EPA is also aware that nuclear facilities would also need to compensate for energy required to operate cooling towers and for the turbine back pressure energy penalty. The impact of the increased emissions varies based on the local circumstances. For example, EPA's analysis suggests that increased emissions of $PM_{2.5}$ may result in difficulty in obtaining air permits in those localities designated as non-attainment areas. For PM_{10}, see DCN 10-6954, which states that emissions would be approximately 60 tons per year if all drift is PM_{10}. This document also noted minor drift management issues onsite at facilities using salt water cooling towers and no negative consequences off-site. See Chapter 10 of the TDD for more information.

Remaining Useful Life of the Facility: As described in the preamble, many existing facilities have been operating for 30 to 50 years or longer. Making major structural and operational changes (such as retrofitting to closed-cycle cooling) may not be an appropriate response for a facility or unit that will not be operating in the near future. The remaining useful life of many of these units is uncertain, as this relationship is not based solely on plant age, because plant age alone does not discern those facilities that have completed an uprate, recently repowered, or completed other major facility modifications to individual units.

6.1.1.5 Examples of Cooling Towers

An estimated 374 existing facilities currently employ either a fully or partially recirculating cooling system using wet cooling towers. EPA has identified a number of power plants that have converted to closed-cycle recirculating wet cooling tower systems. Many of these facilities (including Palisades Nuclear Plant in Michigan, Jefferies Generating Station and Canadys Station in South Carolina, McDonough and Yates in Georgia) converted from once-through to closed-cycle wet cooling tower systems after significant periods of operation utilizing the once-through system. Another facility, Pittsburg Unit 7, converted from a recirculating spray-canal system to a closed-cycle wet cooling tower system. In this case, the conversion occurred after approximately four years of operation utilizing the original design. Detailed case studies of these retrofit efforts are found in Chapter 4 of the TDD for the 2002 proposed Phase II rule (DCN 4-0004) and in the site visit reports available in the docket for the existing facility rule.

Additionally, Brayton Point Generating Station in Somerset MA completed construction of two natural draft cooling towers as part of its retrofit from once-through cooling to closed-cycle cooling.[94] The towers began operations in 2011 and 2012.

As discussed in DCN 3-3029-R6 from the Phase I docket, the data from the industry survey indicates that newer facilities and units are trending towards the use of closed-cycle cooling.

6.1.2 Variable Speed Pumps/Variable Frequency Drives

At their design maximum, a facility with variable speed pumps (VSPs) or variable frequency drives (VFDs) can withdraw the same volume of water as a conventional circulating water pump. However, unlike a conventional (i.e., single speed) circulating water pump, VSPs and VFDs allow a facility to reduce the volume of water being withdrawn for certain time periods. The pump speed can be adjusted to tailor water withdrawals to suit the cooling water needs for a specific time.[95] See DCN 10-6602 for more information.

A reduced flow volume will result in reduced O&M costs as a result of the reduction in pump energy requirements. Depending on site-specific conditions, this reduction may allow the facility to recover the initial capital investment sooner and produce savings thereafter. In fact, VSPs are often employed in industrial systems solely for their economic benefit. In the case of water intakes, the reduction in flow volume has the added benefit of reducing impingement and entrainment impacts.

VSPs can be used to reduce flow volume even during periods of peak power generation, but there are operational limitations and consequences associated with this flow reduction technology. These limitations include:

- Inherent limits of the technology that, based on system characteristics, may restrict pump operation to a specified flow range to prevent damage to the pump. The system hydraulic characteristics will also affect the amount of savings in pump energy cost;
- Limits in flow reduction associated with NPDES permit thermal discharge limits, since a decrease in flow will result in an increase in the temperature of the effluent; and
- Economic consequences of reduced plant generation output resulting from reduced turbine efficiency associated with higher condenser temperatures.

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[94] See http://www.epa.gov/ne/braytonpoint/index.html for details.

[95] Cooling systems are designed to enable the facility to meet its cooling needs at maximum operations under adverse environmental conditions (such as a warm source waterbody). The amount of heat the facility needs to reject is a known value; depending on several factors, the facility actually may not need to operate its pumps at full speed; there may be an intermediate flow rate that is sufficient to remove the heat being generated. Facilities with multiple pumps could also choose to operate fewer than normal pumps, perhaps reducing the value of VSPs.

The latter two limitations are more of a concern during periods when the source water is warmer, and will also tend to limit flow reduction during periods when the system is operating at peak capacity.

Retrofit Applications

A VSP retrofit involves replacing fixed speed intake pumps with variable speed pumps. At a minimum, this involves the installation of a variable frequency drive (VFD) and replacement of the pump motor, switches, and controller. In many cases, this may be all that is needed. A variable frequency drive is an electronic device that varies the pump motor speed by varying the electrical frequency of the AC power delivered to the pump motor. In some cases, the existing motor may not be designed to handle the added harmonic electric currents associated with this type of system. In such cases, the pump motor may need to be derated (the maximum power output and flow rate is reduced) or the motor will need to be replaced. Additionally, the pump itself may require replacement if the existing pump hydraulic characteristics place too many limitations on the amount of flow reduction that can be obtained. If multiple pumps are operated simultaneously and in parallel, it is best to retrofit all of the pumps.

The use of VFDs allows the flow through the pumps to be controlled over a range of flow volumes, thus allowing the flow volume to be tailored to the plant operating conditions. With proper control, the effect on turbine efficiency can be minimized and the effluent temperature can be maintained within the NPDES permit temperature limits. This allows the facility full flexibility to effect both small and moderate flow volume reductions when conditions allow.

During the winter months, use of flow reduction can actually result in an increase in turbine efficiency by eliminating subcooling in the condensers. Subcooling occurs when the steam condensate in the condenser is cooled excessively, resulting in the system's consumption of additional heat to bring the condensate back up to the boiling temperature when it is recycled back to the boilers. Excessive subcooling can also result in the formation of condensed water droplets within the last stage of the turbine, which can damage the turbine blades. Measures to control excessive subcooling include the flow reduction methods described above for fixed speed pumps, as well as piping configurations that can bypass a portion of the flow around the condensers and piping configurations that can recirculate condenser outflow back to the pump inlet. In the latter case, some flow reduction is already occurring but pumping energy requirements are not reduced. The control of subcooling, especially slight to moderate subcooling that might otherwise be tolerated, provides another economic benefit for VSP retrofits through increased plant power output.

6.1.2.1 Performance and Operational Limitations

There are technical limitations to the amount of volume reduction that can be achieved with VSPs. For any pump, as the speed is reduced, there is a point reached where the pump's output head is equal to the system's static head, resulting in zero flow. Continuous operation at such a condition must be avoided because the impeller will continue to spin and the water will recirculate within the pump casing, resulting in damage to the pump. The flow volume response to varying speed is unique for every combination of pump and system hydraulics, and thus the minimum safe speed must be calculated for each application to avoid operation at or even near the shutoff head. System controls are set such that the minimum pump speed will be well above that which produces zero flow conditions. Two power plants in California (Pittsburg and Contra Costa) have installed VSPs and documentation indicated that as much as a 50 percent reduction in flow was attainable. However, this level of flow reduction is usually high and typical flow reduction rates are from 8-15 percent, with some variability depending on whether the facility is baseload or load following.

One important system characteristic that affects the performance of VSPs is whether the total pumping head is predominantly the result of losses from friction or to static head. Where the pumping head is predominantly from friction losses, the flow reduction capability of VSPs is greater and overall system efficiency at reduced flows will be greater. An example of a system where friction losses are a large component of the pumping head would be a system that uses an inverted siphon configuration. Inverted siphon configurations are often used in once-through systems where the condenser elevation is close to the water surface, because they are well worth the savings in pump energy requirements associated with the siphon configuration. Such systems require vacuum pumps to remove the gases that collect in the high points. To prevent water vapor from forming under the vacuum conditions that form within the siphon, the height of the inverted siphon is limited. If the condenser elevation is above the maximum siphon height, then the siphon height is shortened by exposing the downstream end to the air at an elevation above that of the source water in a structure called a seal pit. Facilities where the condensers are located well above the water surface will have higher static components of the pumping head even when inverted siphons are used. Thus, the condenser elevation and piping configuration will affect the performance of VSPs.

In systems where the pumping head is predominantly static head, as the pump speed is reduced a point is soon reached where small changes in speed can result in large changes in flow rate, especially as the pumping head approaches the system static head as described above. Thus, the available range of flow reduction is much lower than in systems where the pumping head is mostly friction losses. Also, in systems where the pumping head is predominantly static head, the pump efficiency drops substantially with reduced speed. Such systems will experience much less power usage savings. Thus, use of VSPs in such systems is less advantageous. In these high static head systems, the pump and system hydraulic characteristics must be carefully evaluated before deciding whether the available benefits outweigh the costs.

When the turbine system is operating at a given generation rate (i.e., a constant steam load), a reduction of the cooling water flow volume will result in a proportional increase in the condenser temperatures. This will result in an increase in the difference in cooling water temperature between the condenser inlet and the condenser outlet (ΔT). Many facilities have NPDES permit conditions that set a maximum limit for the ΔT value. This effectively places a practical limit on the amount of flow reduction that can be achieved. During warmer months, the increase in condenser temperature will also result in a higher turbine exhaust pressure, resulting in a reduction in turbine efficiency. Thus, there is a competing economic incentive to maintain higher flow levels.

Many facilities have NPDES permit conditions that set a maximum effluent temperature, which may put additional limitations on the availability of flow reduction through variable speed pumping, especially during summer months, regardless of the economic considerations. In fact, under extreme summer conditions, some facilities may be required to maintain the cooling water flow at full capacity while having to reduce power output (derate) in order to meet temperature limits.

VSPs can reduce the facility’s intake flow, which is one of the most effective ways to reduce impingement and entrainment. However, as described above, the amount of flow reduction that can be achieved has both operational and seasonal limitations. In general, opportunities for flow reduction are greater during cooler months and thus the benefits of I&E reductions may be enhanced or reduced depending on the timing of the seasonal variations in the presence and behavior of the various life stages of the affected aquatic organisms.

Applicability

Flow reduction through the use of VSPs alone may not be sufficient to result in sufficient I&E reductions. Because of the economic benefit associated with reduced pumping energy requirements, VSPs may be useful even when the other technologies are fully capable of meeting the I&E requirements alone and when the presence of sensitive organisms coincides with the period when the source water is warmest.

The capital costs of VSP retrofit will be dependent on which components of the pumps need to be replaced; it should be assumed, at a minimum, that a retrofit will include replacement of the pump motors. Given the savings in pump energy costs associated with VSPs, the net operating costs should be negative in most applications (i.e., savings in pump energy costs will exceed any maintenance costs). Actual savings will be highly variable depending on the system hydraulic conditions, the plant operating schedule, and the degree of flow reduction attained. If conditions are favorable, the net operating savings will offset capital costs (i.e., the technology will pay for itself). However, if flow volume reduction is aggressively sought, then pump energy savings will be offset by reduced plant output associated with a reduction in turbine efficiency.

VSPs will be most effective when:

- Facility capacity utilization rates are not very high;
- Cooling pump head is predominantly from friction losses and not static head; or
- They are combined with other I&E reduction technologies.

Technologies that could benefit from being paired with VSPs may include:

- Traveling screens
- Fish barrier net
- Velocity cap

Since reduced flow volume will result in a reduction in the approach and through-screen velocities, VSPs will likely result in improved performance of velocity caps and traveling screens, particularly those with high approach velocities.

6.1.2.2 Examples of Variable Speed Pumps

Millstone Nuclear Plant

The Millstone Nuclear Plant on Long Island Sound in Connecticut has installed VFDs on its circulating pumps. The goal is to reduce impingement and entrainment of winter flounder which are present in greatest abundance in April and May (their spawning season). The plant agreed to reduce their 2.2 BGD flow by 40 percent during this period. Flow reduction is required from April 4 to June 5 or until the source water reaches 52°F (whichever happens first). To facilitate this, the facility's NPDES permit[96] allows for increase in discharge ΔT for this period (see Exhibit 6-7 below) while retaining the limit of 4°F increase outside mixing zone.

This example is noteworthy for several reasons: first, the facility is a nuclear plant and second, it is a baseload facility. As discussed in the preamble, nuclear facilities may have additional safety considerations when assessing technologies to minimize impingement and entrainment, but VSPs appear to not trigger any concern. Second, baseload plants are arguably the least able to reduce flow using VFD technology, as they are typically operating continuously and have relatively constant demands for heat rejection. However, Millstone appears to be able to capitalize on the cooler source water temperatures in these months and balance the needs of heat rejection and impingement and entrainment.

Exhibit 6-7 shows the revisions in permit's ΔT limits. Calculated reductions were supplemented with data from PCS (the reported actual monthly max ΔT during Apr-May period was in the low-mid 20s). Using a ΔT value of 24 compared to 41 results in a 41 percent reduction, assuming the facility is able to tailor their intake flow to operate close to the seasonal temperature limit.

Exhibit 6-7. Flow reduction at Millstone

Millstone Nuclear	Normal ΔT limit	Seasonal VFD ΔT limit	Calculated reduction in intake flow
	Deg F	Deg F	
Unit 2 Condenser	32	46	30%
Unit 3 Condenser	28	38	26%
Combined discharge	32	41	22%
Typical seasonal max from PCS	24	41	41%

6.1.3 Seasonal Flow Reductions

Seasonal flow reduction refers to the reduction or elimination of a quantity of water being withdrawn during certain biologically important time periods. Most facilities that practice seasonal flow reductions do so in order to reduce entrainment because entrainment often peaks during specific times of the year (i.e., during spawning season). Typically, this means that a facility produces less energy or no energy for some portion of the year

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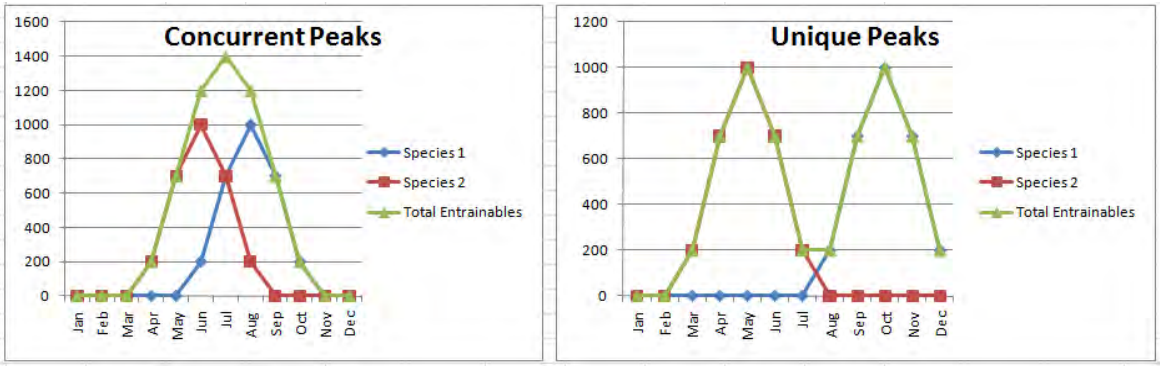
[96] See http://www.epa.gov/region1/npdes/permits/2010/finalct0003263permit.pdf.

thereby reducing or eliminating the volume of cooling water it requires. This may be accomplished through a variable speed drive or pump or shutting down some portion or all of the pumping system (and unit).

See DCN 10-6702 for specific examples of spawning periods at existing facilities. In these examples, there are often organisms that have some degree of spawning at all times of the year but peak spawning periods can be identified. If only certain species are examined, the spawning period analysis may appear very different than a broader analysis of all species present.

Additionally, the specific timing and abundance of organisms present may affect how seasonal flow reductions are achieved. As an example, Exhibit 6-8 below presents two possible scenarios that might be addressed differently under a seasonal flow reduction approach.

Exhibit 6-8. Examples of seasonal flow reductions



Because of the difficulty in projecting, on a national scale, which facilities might employ seasonal flow reductions (due to the species present, seasonal utilization rates, percentage of flow reduced and other factors); EPA did not include seasonal flow reductions in any formal analysis of compliance costs.

6.1.4 Water Reuse

EPA encourages any reduction in water withdrawals or water usage in general (see “EPA 2012 Guidelines for Water Reuse” DCN 12-6848). Throughout the 316(b) rulemaking process, EPA has included provisions for water reuse whereby a facility that uses water withdrawn for another purpose (e.g., contact cooling or process water) as cooling water, then said volume would not be considered in determining whether a facility is subject to the regulation.[97]

For power plants, water reuse (outside of closed-cycle cooling) is typically not an available option, as there is very little water that is used for purposes other than non-contact cooling; the “credit” would be extremely small. EPA has seen examples where cooling water is reused in air pollution control processes.

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[97] See, e.g., 40 CFR 125.83 (definition of cooling water).

Manufacturers, on the other hand, may realize substantial benefits from water reuse. As discussed above, a facility may avoid national 316(b) requirements if it reuses a significant portion of its cooling water and does not meet the 25 percent threshold. Additionally, the final rule provides that entrainment requirements at new units at an existing facility do not apply to cooling water that is reused for another purpose. See the preamble for the final rule for more information on how EPA considered water reuse in the regulatory framework.[98]

6.1.5 Alternate Cooling Water Sources

Cooling water need not be withdrawn from a surface waterbody. Groundwater, grey water (i.e., POTW effluent) or other sources of water may be used for once-through cooling or as makeup water for a closed-cycle system. EPA supports the use of alternative sources since they can often be used to displace (reduce) all or a portion of the requirement to withdraw surface water. Unfortunately, many facilities have cooling needs that substantially outpace the volume of water available to them from alternate sources, especially for once-through cooling systems. In the *California's Coastal Power Plants: Alternate Cooling System Analysis*, OPC analyzed alternate sources as cooling tower makeup water but concluded that even for power plants located in densely populated areas of southern California (where infrastructure to facilitate alternate sources such as grey water may already exist), alternate sources of cooling water were not a viable option for most, if not all, facilities (see DCN 6631). Similarly, EPA did not consider any regulatory analyses or alternatives that relied on alternative cooling water sources.

6.2 Screening Technologies

Screening technologies have been used on cooling water intake structures for more than 75 years to prevent debris and aquatic organisms from entering the condensers. These technologies include both traveling screens and passive screens. Over 93 percent of power plants and 73 percent of manufacturers use some sort of screening technology (see Chapter 4 of this TDD).

Exhibit 6-9 provides a generic diagram of a cooling water intake structure that employs traveling screens, with the power plant operations and cooling water discharge also shown.

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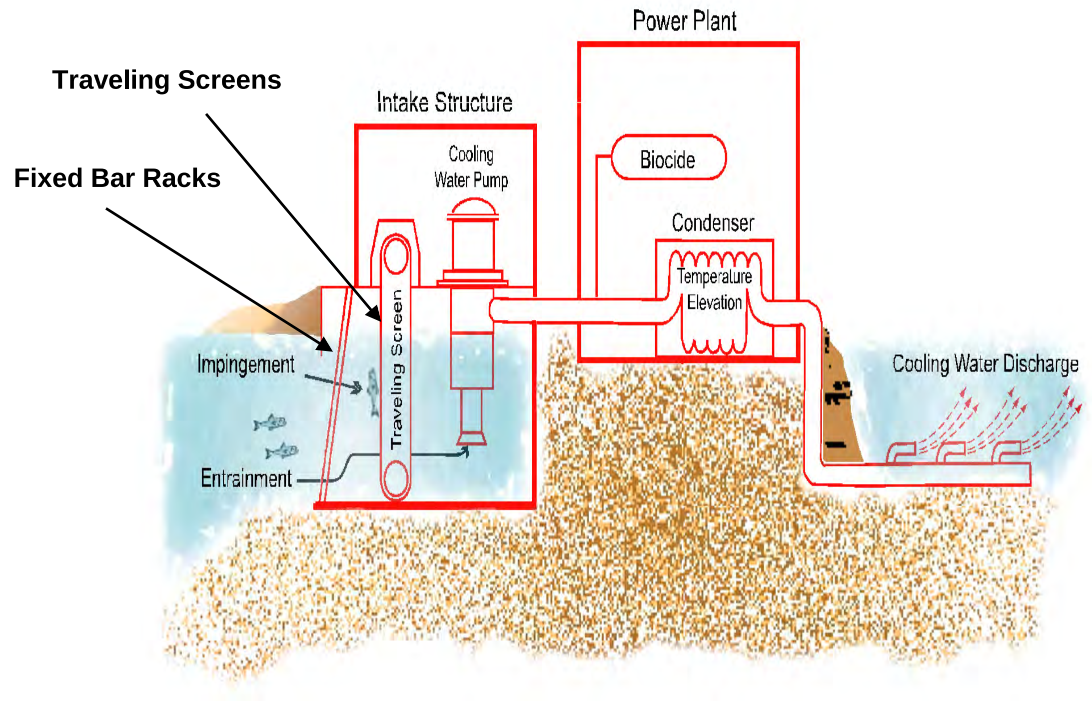
[98] Also see Chapter 8 of the TDD for information on how EPA considered the relationship between non-contact cooling water, contact cooling water, and process water flows in developing compliance costs.

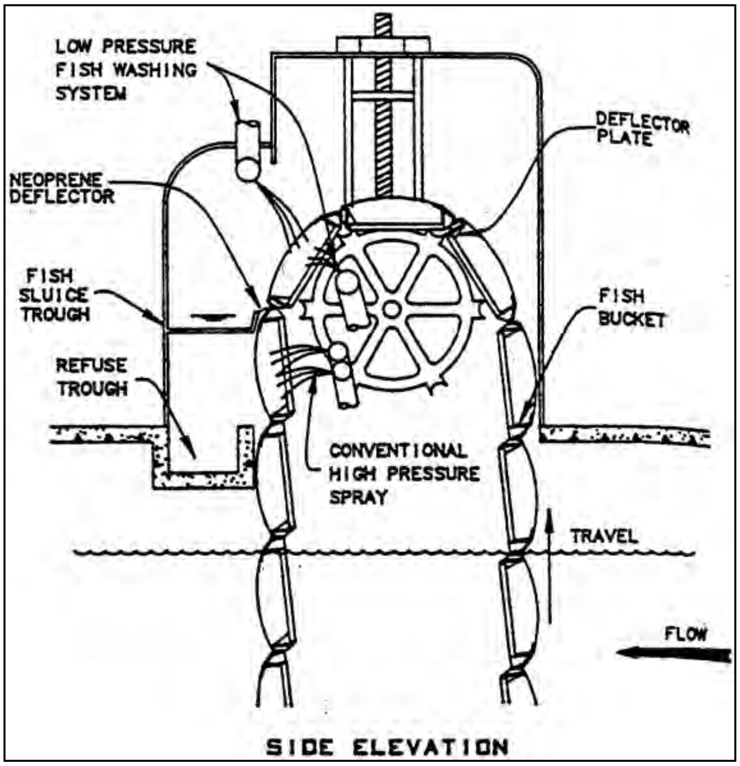
Exhibit 6-9. Generic CWIS with traveling screens



Traveling screens (see Exhibits 6-10 and 6-11) are used at most cooling water intake structures. These screens were originally designed for debris control, but also serve to prevent some fish and shellfish from entering the cooling system. Traveling screens have been installed in numerous environmental conditions: salt water, brackish water, fresh water, and icy water. There are many types of traveling screens (e.g., through-flow, dual-flow, center-flow). The most common design in the US is the through-flow system. The screens are typically installed behind bar racks (trash racks) but in front of the water circulation pumps. The screens rotate up and out of the water where debris (including impinged organisms) is removed from the screen surface by a high pressure spray wash. Screenwash cycles are triggered manually, on a timer, or by a certain level of head loss across the screen (indicating clogging). By design, this technology works by collecting (i.e., impinging) fish and shellfish on the screen.

Exhibit 6-10. Traveling screen at Eddystone Generating Station, Eddystone, PA

Exhibit 6-11. Traveling screen diagram



Passive screens are non-moving fixed screens that use physical exclusion and hydrodynamics to minimize debris and fish from entering the condensers and to prevent the buildup of debris and screen loading leading to head loss. Passive screens include wedgewire screens, perforated pipes, and porous dikes/leaky dam systems. Wedgewire screens are the most common type of passive screen and the most effective passive screen at minimizing impingement and entrainment (see Exhibit 6-12). Wedgewire screens are discussed in more detail later in this chapter.

Perforated pipes are pipes with holes bored in them, allowing water withdrawals to occur along the length of the pipe instead of at the open end. This technology is not common, as it may be prone to clogging. Due to the uncommon usage, EPA did not examine this technology in detail nor study its performance. See Chapter 4 of the 2004 Phase II TDD for more information.

Porous dikes and leaky dams are structures (such as a weir or jetty made of riprap) that physically separate the intake from the source water. Intake flow is drawn through the dike into a forebay or lagoon, where standard traveling screens or other technologies are used. This technology is not common, in large part due to the limited volume of water that can be drawn through the dike and the space required to build such a structure in the source water. Due to the uncommon usage, EPA did not examine this technology in detail nor study its performance. See Chapter 4 of the 2004 Phase II TDD for more information.

Exhibit 6-12. Cylindrical wedgewire screen

Traveling screens and passive screens are further defined by screen mesh size as coarse mesh or fine mesh. Coarse mesh screens usually have mesh sizes of 3/8” (about 9.5 mm) and fine mesh screens have mesh sizes typically ranging from about 0.5 mm to 3 mm, depending on the organisms to be protected. Coarse mesh screens are generally not protective of smaller organisms (such as eggs and larvae) that may become entrained by passing through the screen openings and into the cooling system. Coarse mesh systems may also cause mortality of impinged fish due to impact, stress, descaling, and suffocation against the screen. Fine mesh screens may prevent entrainment, but may also lead to increased mortality of impinged organisms (specifically eggs and larvae that would otherwise have been entrained).

The sections below discuss each screen type in greater detail.

6.2.1 Conventional Traveling Screens

Conventional traveling screens, also called coarse mesh traveling screens, are a common component of virtually all cooling water intake structures and provide essential debris and fouling control for pumps and condensers; over 83 percent of all existing facilities already employ this type of screen.[99] The screens are mounted on fixed-loop chains or belts that rotate through the water column and remove debris from the intake stream, preventing the entrainment of debris through the intake system where they can damage sensitive pumps and condensers. Objects collected on the screen are typically removed with a high-pressure spray (greater than 60 pounds per square inch [psi]) and deposited in a dumpster or debris return trough for disposal. Screens are rotated and washed periodically based on a set time interval or when the pressure differential between the upstream and downstream faces exceeds a set value. Intermittent rotation minimizes operational wear and tear and keeps maintenance costs relatively low. In the U.S., facilities employ multiple traveling screen types, including dual-, center-, and through-flow designs. The through-flow type—the most common at U.S. facilities—removes debris and screenings from the water on the upstream (ascending) side.

Conventional traveling screens were not originally designed with the intention of protecting fish and aquatic organisms that become entrapped against them. Marine life may become impinged against the screens from high intake velocities that prevent their escape. Insufficiently hardy species or life stages may suffocate after prolonged contact with the screens. Exposure to high pressure sprays and other screening debris may cause significant injuries that result in latent mortality, or increase the susceptibility to predation or reimpingement. Organisms that do survive initial impingement and removal are not typically provided with a specifically-designed mechanism to return them to the waterbody and are handled in the same fashion as other screening debris. These screens do not address organism entrainment, as eggs and larvae are typically swept through the screen and into the condensers.

Dual Flow Traveling Screens

Dual flow traveling screens, also known as double-entry single-exit screens, are a variation of conventional through-flow traveling screens that are positioned such that the screen face is parallel to the general direction of flow. Water enters through the outside and exits through the center. These screens function in a similar manner to conventional

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[99] The percentage is based on responses to the industry questionnaire. Upon further review of facilities that did not identify a traveling screen, EPA found that most of these facilities did in fact have traveling screens. As a result, EPA assumes that virtually all existing facilities have a traveling screen at some point in their cooling water intake system. The screen may be located in the forebay instead of at the cooling water intake structure, but some form of screening is almost always necessary.

traveling screens but have the advantage of screening water through the descending and ascending screen faces which prevents any debris from carrying over to the downstream side. Through-flow traveling screens can be replaced with dual-flow traveling screens and if sufficient space is available in front of the screens can result in an overall increase in screen area. Center-flow traveling screens, also known as single-entry double-exit traveling screens, are similar to dual flow screens except that water enters through the center and exists through the outside.

6.2.1.1 Technology Performance

Conventional screens are not used to mitigate the impacts of impingement and/or entrainment.

6.2.1.2 Facility Examples

Conventional screens are used at a large number of existing facilities.

6.2.2 Modified Coarse Mesh Traveling Screens

Following the 1972 Clean Water Act's requirement to use technology-based solutions to minimize adverse environmental impacts, some conventional coarse mesh traveling screen systems were modified to reduce impingement mortality by removing fish trapped against the screen and returning them to the receiving water with as few injuries as possible. The modified screens, also known as "Ristroph" screens or modified Ristroph screens, feature capture and release modifications that include a fish collection bucket or trough, a low pressure spray, and a fish return system. In the simplest sense, these screens are fitted with troughs (also referred to as buckets) containing water that catch the organisms as they are sprayed off of the screen. The return component consists of a gentle mechanism to remove impinged fish from the collection buckets, such as a low-pressure spray. The buckets empty into a collection trough that returns fish to a suitable area in the source waterbody. These modified "Ristroph" screens have shown significant improvements in reducing impingement mortality compared with unmodified screen systems. Of the 766 existing facility intakes that were reported in the detailed questionnaires, 9 intakes specifically reported "Ristroph" traveling screens, 16 additional intakes may qualify as having "Ristroph-type" traveling screens, 50 intakes reported having "Fish Buckets, Baskets, or Trays," and 130 intakes reported an inlet or through-screen screen velocity of ≤ 0.5 fps.

The first Ristroph screens, named for the lead engineer who developed the initial prototype, were installed at Dominion Power's Surry Station in Virginia in 1977. The existing screen panels were fitted with water-retaining collection buckets at the base of each panel that lifted impinged fish out of the main stream flow as the screens rotated. At the top of the screen assembly, buckets emptied into a collection trough that returned fish to a suitable area in the source waterbody. The initial survival rate for the modified screen at Surry Station, averaged across all species, was 93.3 percent (EPRI 1999). Bay anchovy had the lowest initial survival at 83 percent (White and Brehmer 1977, Pagano and Smith

1977). Notably, these survival rates did not account for latent mortality that may have resulted from injuries sustained during the collection and removal process.

Data from early applications of the “Ristroph” screen design showed that while initial survival rates might be high at some installations, latent mortality rates were higher than anticipated, indicating significant injuries could be sustained during the impingement and return process that were not immediately fatal. Many of these flaws were identified in an analysis of a modified screen design proposed for the Indian Point facility in New York by Fletcher (1990; see DCN 5-4387). This analysis identified points in the collection/removal process where latent injuries might be sustained, including poor debris removal, which became entangled with impinged fish and prevented their safe return; rough or corroded screen basket materials that increased descaling; and fish reimpingement occurring when fish escaped the ascending buckets by jumping over the outer bucket lip just prior to the bucket breaking the surface.

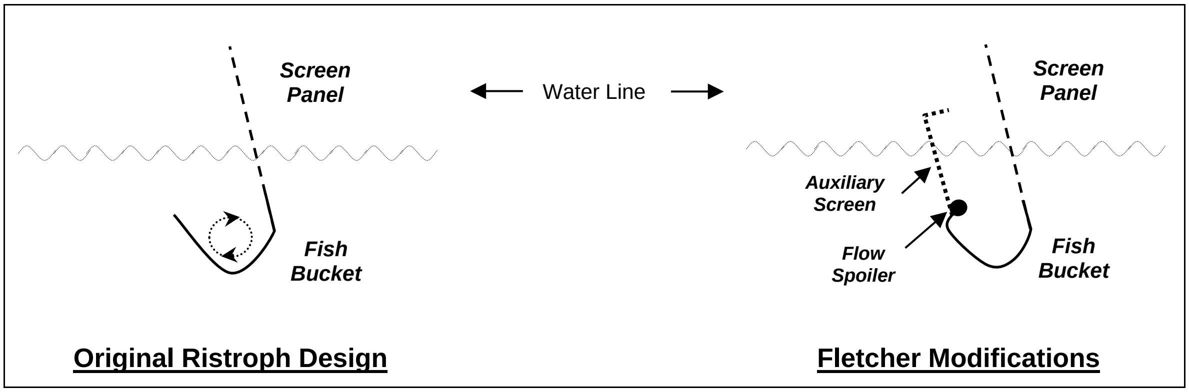
Most significantly, Fletcher identified a principal cause for many of the injuries sustained by impinged fish. Screen panels retrofitted with water-retaining buckets induced a secondary flow pattern in the bucket while it remained below the water line, creating turbulent conditions in the bucket that repeatedly buffeted any fish against the screen and bucket materials. Fletcher observed that fish caught in this flow pattern suffered far more significant injuries than those which only came in contact with the screen mesh.

Several critical modifications were proposed following this analysis, many of which have been adopted by other facilities, including:

- Redesign of collection buckets to address hydraulic buffeting with a new shape and inclusion of a flow spoiler on the outer bucket edge. These modifications minimize turbulence within the bucket area and prevent significant injuries during capture and retention.
- Addition of a fish guard rail/barrier to prevent fish from escaping the collection bucket and increasing their total impingement time. The fish guard rails extend above the water surface before the main bucket as the screens are rotated.
- Reordered fish and debris removal. At Indian Point, filamentous debris collecting on the screen panels was originally removed after impinged fish. This debris blocked the screen panels, however, and prevented the fish removal spray system from functioning properly. The modified design included a high pressure spray to remove debris on the ascending side prior to removing impinged fish.
- Replaced screen panel materials with smooth woven mesh. Significant descaling was observed with more abrasive screen designs such as crimped or welded wire.

A schematic comparison of each basket design type is shown in Exhibit 6-13.

Exhibit 6-13. Ristroph and Fletcher basket designs



The Fletcher study also evaluated impingement durations up to 30 minutes. Impingement durations of 10 minutes or less did not significantly affect survival, with mortality rates increasing with longer impingement times. Likewise, sufficient water retention in the buckets was shown to be essential. Exposure to the air and temperature extremes, even for a short duration, could negatively impact fish survival. These findings support the general assumption that modified Ristroph screens must be continually rotated instead of the periodic rotation schedule common with conventional screen systems.

6.2.2.1 Screen Design Elements

The collection portion of a modified Ristroph system comprises all CWIS elements geared towards fish protection up to the point where fish are removed from the screens/buckets. The collection system’s key function is to capture entrapped fish that cannot escape the intake screens and remove them from the intake flow for safe return to the source waterbody. This must be accomplished by sustaining all captured fish with sufficient water and minimizing potential injuries from screen interactions and turbulence. While the cooling water intake structure location and orientation may play a significant role in determining how many fish and shellfish are susceptible to impingement before coming in contact with the screens, this subsection focuses on the screens and fish return systems. EPA notes that a comprehensive design approach that carefully considers the cooling water intake location and orientation prior to installing a modified traveling screen system may yield significant benefits. At existing facilities, however, many of these modifications are more problematic due to space constraints and interference with existing systems, and may not be practical options given their cost and complexity.

Screen Type/Design

The screen itself is the first point at which any fish will come in contact with a physical element. When a conventional traveling screen is modified to include Ristroph and Fletcher modifications, many of the system’s existing elements may need to be upgraded to incorporate newer, more fish-friendly materials, or with more robust mechanical components that are better suited to the new operating conditions. New components like fish buckets or rails also require careful consideration to maximize the desired level of protection. All of these factors must be evaluated against the specific demands at a particular site such as water quality, intake velocity, and species composition and abundance. In some cases, it may be more economical, and ultimately more efficient, to replace the entire screen assembly rather than retrofit existing components. A comprehensive retrofit may mitigate other effects and better enable all components to work more efficiently with one another.[100]

Screen Mesh Material

The primary design focus for existing conventional traveling screen systems is the removal of smaller debris (i.e., debris not screened by a trash rack) that may clog or damage sensitive intake equipment like pumps and condensers. The screen panel material is selected to serve this function while remaining durable and functional with the lowest possible maintenance costs. Screen materials must be able to resist corrosion and degradation while being alternately immersed in water and exposed to air. They must also withstand potentially high debris loads that might compromise weaker materials and damage the intake system. Stainless steel is among the most common screen material used for traveling screen, although copper alloys are also used where screen fouling from colonial organisms is a concern. Likewise, advances in engineered polymer coatings have proven effective in resisting corrosion and degradation.

For a modified traveling screen system, materials and configurations that are smooth by design and can maintain a near-design condition will assist in minimizing any contact injuries sustained by impinged fish. Smoother configurations and materials, such as woven wire mesh (as opposed to punched or welded mesh) and SmoothTex flat wire, will also aid fish removal and limit descaling during transfer to the return system.

EPA is aware that some traveling screens utilize flat-panel wedgewire as the screen material, as opposed to woven wire mesh or other materials. This configuration is uncommon, however, and EPA did not examine this technology in detail nor study its performance.

Through-screen Area and Mesh Size

As noted above, many existing conventional screening systems were initially designed to remove debris from the intake stream to prevent damage to other equipment. The optimal mesh size prevents entrainment of any debris large enough to clog the condenser tubes while maximizing the through-screen area, and allows the facility to optimize its intake velocity-to-screen area ratio and install a properly sized system. Because many condenser tubes used in power plants are 3/4 or 7/8 inches in diameter, a 3/8-inch mesh size (i.e., coarse mesh) is found at a majority of facilities employing traveling screens.

The percentage of the screen mesh that is open (aka percent open area) is a function of both the size of the mesh openings and the area taken up by the mesh material. The mesh percent open area and the total screen size are key factors in determining the CWIS's intake velocity, which, in turn, influences the impingement mortality rate. Maintaining an

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[100] EPA's cost methodology for the existing facilities rule included full replacement costs for all screen components.

intake velocity as low as possible is critical to reducing the overall probability of impingement. See Section 6.6.2 for more details.

Retrofitting existing traveling screens to operate with a fish collection system may decrease the total through-screen area by blocking a portion of the screen face with fish bucket or rail. Any impact on intake velocities, however, will depend on the original screen design and the modifications made to incorporate new equipment. Advances in screen design, materials, and fabrication methods enable newer screen systems that have been designed with the fish protection measures to achieve comparable, and sometimes greater, through-screen areas than older equipment that is retrofitted. In some cases, it may be more advantageous to replace the entire screen assembly rather than retrofit the existing traveling screen (Gathright 2008).

Collection Buckets

One of the more critical elements, collection buckets incorporate several design elements to maximize safe capture of impinged fish. Buckets should extend across the screen panel's full length to prevent gaps where fish may fall through and be deep enough to hold sufficient water for the expected number and size of species impinged. Depending on screen's size and rotation interval, captured fish may held in these buckets for several minutes, often with other fish. Close proximity with other fish in a confined space, particularly with those of another species, may create stress and behaviors that result in additional injury. The selected bucket size and depth should reflect the target species and allow for sufficient space and water coverage to sustain them during transfer to the return system.

The design of pre-Fletcher collection buckets were found to cause significant turbulence within the buckets, leading to high mortality rates as fish were buffeted against the screen elements. The modifications described by Fletcher to minimize flow-induced turbulence in the collection bucket have become common practice for this system type. The bucket's shape was redesigned to include an additional lip or flow spoiler attached to the bucket's leading edge. Further, modifications to prevent fish from escaping the rising bucket as it nears the surface may also be necessary. A rail or guard that extends above the water surface before the rest of the bucket keeps capture fish in the bucket and prevents their re-impingement (Exhibit 6-13).

6.2.2.2 Removal and Return System Design Elements

The removal and return portion of the modified system comprises all elements that aid in the removal of fish from the screens and buckets and returns them to a safe location in the source waterbody.

Debris and Fish Removal

Traveling screen systems without specific measures to reduce impacts to aquatic organisms will collect impinged fish and debris without making a distinction between the two. One of the major advances associated with the Ristroph design is the inclusion of a separate fish removal system and return trough that sought to segregate aquatic species from other debris. Unavoidably, some debris will end up with fish return trough and, vice versa; the key is designing the system to separate the two as much as possible. Separate spray removal systems—a low pressure spray for removing fish and a high pressure spray for debris—are typically included as part of a two-stage removal process that sorts most fish and debris to their own dedicated troughs.

Using a low pressure spray (less than 20 pounds per square inch) is based on the assumption that fish will not become attached or entangled with the screen panels and thus require only a “gentle removal” from the screens and buckets. Removal in this manner is also aided by smooth materials and structural components that eliminate protrusions, sharp angles and rough surfaces that prevent fish release. Depending on the spray head’s position relative to the screen panel, it may be advantageous to remove debris before fish. Heavy debris loads might clog screen panels and block the low-pressure spray from functioning properly if the spray head is located behind the screen, as described in the Indian Point analysis (Fletcher 1990). In this instance, a high pressure spray (60 to 80 psi) placed ahead of the low pressure spray forcibly removes debris that has become attached to the screen panels and may increase fish removal efficiency. When low pressure spray heads are placed lateral to the screen instead of behind, it may be more effective to remove debris after any impinged fish. As noted above, deciding the order of low and high pressure spray must be carefully considered to optimize fish protection.

Fish Return

Mortality-inducing injuries are more likely to occur during the collection and removal portion of a modified traveling screen system. The return system, however, plays an important role in the overall effectiveness and has many critical design elements that must be considered to ensure safe return of healthy fish. Most criteria are universally applicable to any modified traveling screen system, and include:

- *Construction materials.* Structural components should be constructed using materials that minimize rough surfaces and protrusions that may cause abrasions, contusions, descaling, or more serious physical injury during the return process. Fiberglass-reinforced plastic, PVC, and stainless steel share this characteristic while also being resistant to biofouling. Joints between pipe sections should also be as smooth as possible.
- *Size and capacity.* As with the collection buckets themselves, the return trough should be able to accommodate the largest species in the maximum estimated number without overcrowding.
- *Transport velocity.* The water velocity in the return trough must be strong enough to overcome the swimming capacity of the strongest species and ensure their return to the water. A gravity return system will require a sufficient slope and water volume to induce the necessary flushing action. Pump-aided returns can adjust the return pressure accordingly.
- *Flow disruptions.* Where possible, the return should avoid sharp angles and short bend radius turns to reduce flow disruption and redirection. At all points, care should be taken to ensure a smooth, consistent return flow free from hydraulic jumps and flow separation areas.

- *Exposure.* Fish confined in a return trough have limited avenues of escape and, depending on the length of the return, may have long transit times back to the source waterbody. Because an open trough may unnecessarily expose these fish to predation from birds or other animals, the preference in most cases is to enclose the system entirely until fish are returned to the water. This has the added benefit of reducing exposure to air temperature extremes. In cold weather climates, even brief exposure to sub-freezing temperatures can increase mortality.
- *Flushing cycle.* Adequate flow must be maintained in the trough to clear all transported fish from the return trough and drain completely following the cycle's completion to prevent backflow and biofouling/deoxygenation. A consistent flow may also be maintained in lieu of draining the trough.[101]
- *Return Location*. The final return point in the waterbody must be located outside of the intake's radius of influence to prevent reimpingement. The final transition to the waterbody (i.e., the point of discharge from the return system) should be smooth and free of any significant hydraulic jump or located at a reasonable height.[102] Water quality and temperature should be comparable to conditions at the intake to prevent any contact shock upon return. Preferably, organisms are returned to the water quickly (i.e., to a nearby location) as longer exposure to the return system may cause descaling or other injuries. An ideal location will also avoid areas where predators congregate or attract increased predation.

Fish return systems may occasionally employ a fish pump, which transports organisms from one area of the intake structure (e.g., a well that impinged fish are washed into) to a discharge location. See DCN 10-6500 for an example. Fish pumps are not common, but may be used when return distances are long or can't rely on gravity. Due to the uncommon usage, EPA did not examine this technology in detail nor study its performance.

EPRI has conducted at least two studies on the survival of organisms within a fish return system. In a report published in 2010, EPRI studied the survival of organisms based on organism size, return flume velocity, drop height, and the length of the fish return. Except for early larval stages of fish, most tests showed very high survival regardless of the variable tested. In a recent technical update (see DCN 12-6801), EPRI's laboratory-based research suggested that survival for hardy species is usually exceedingly high within the return system and that the presence of debris in the return does not appear to have any effect on survival for these hardy species.

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[101] Facilities usually withdraw screenwash water from within the intake structure (i.e., after it has passed through the intake screens) or from a separate pump in the area of the intake structure. In either case, EPA envisions that any increase in flow to accommodate improved flushing of the return system would be small compared to the cooling water flow but nonetheless should generally not be included in calculating a facility's cooling water withdrawals (for calculating DIF or the percent of water withdrawn for cooling purposes).

[102] EPRI's "Evaluation of Factors Affecting Juvenile and Larval Fish Survival in Fish Return Systems at Cooling Water Intakes" (December 2010, Report No. 1021372) found that fish survival for a return system that discharged below the water's surface was virtually the same as survival of fish dropped from a height of up to 6 feet. See DCN 12-6822.

6.2.2.3 Operation and Maintenance

Routine maintenance and operating protocols enacted for each modified traveling screen installation also play a key role in determining the system's overall effectiveness. While some parameters are widely applicable (e.g., rotation interval), others are tailored to meet the specific needs at a particular location and may vary significantly from one facility to another. These parameters include:

- *Rotation interval.* Evaluations at many different facilities over the last 30 years have generally shown that impingement mortality rates are lowest when traveling screens are rotated continuously at a fixed speed instead of the intermittent rotation schedule more common with conventional traveling screens. Continuous rotation ensures that any impinged fish will be caught on the screens for a minimum time period, but in some cases may not be necessary, at least for all seasons. Periodic full rotation cycles may be sufficient (i.e., some number of complete rotations per hour) when impingement is dramatically lower or non-existent during certain times of the year (e.g., seasonal migrations may limit the critical time period to a few weeks or months of the year). Additionally, new designs use composite materials to frame the traveling screens which weigh less and reduce wear on chains and drives.
- *Rotation speed.* The longer a fish is impinged against a screen, the higher its probability for suffering significant injury. Continuously rotated screens should travel fast enough to minimize the impingement durations but be slow enough to prevent higher maintenance costs associated with a faster screen rotation. The rotation speed should also minimize the amount of time the fish are out of the water.
- *Preventative maintenance.* Modified screens that are rotated continuously will incur higher operating and maintenance costs than a conventional traveling screen that is cycled intermittently. Mechanical equipment may require more robust components to accommodate the increased rotation frequency and higher rotation speeds necessary to minimize the impingement duration. Likewise, the screen panels may require more intensive maintenance that minimizes corrosion and biofouling, which may increase mortality rates by creating a rougher or more unforgiving contact surface.

Retrofit/Downtime issues

Modified traveling screens with fish handling systems are among the oldest technologies developed specifically to address impingement and have been widely deployed and studied throughout the United States. Because so many existing facilities already use conventional traveling screens, modified traveling screens are broadly applicable and may not require significant changes to the CWIS to achieve high levels of performance. A successful installation is generally independent of factors such as waterbody type, climate zone, age, fuel type, or intake flow. In other words, a facility that has previously used a conventional traveling screen (nearly all facilities, operating under a wide variety of conditions) should also be able to employ a modified traveling screen.

Compared with other impingement design and construction technologies used as retrofit options, modified traveling screens are relatively easy to install and operate. Changes to the screens themselves are relatively straightforward and, in all but the most unique instances, do not require substantial modification or expansion of the screen houses and can be completed during normal maintenance outages without affecting the facility's generating schedule. Likewise, because this technology does not alter the cooling water flow *per se,* the facility's generating output is unaffected; no energy penalty is incurred save for the small increase in electrical usage due to continual or more frequent screen rotation.

6.2.2.4 Technology Performance

Conventional traveling screens that have been modified to include a fish collection and return system based on Ristroph and Fletcher designs have an extensive record of performance at numerous facilities. Data shows impingement survival values greater than 90 percent for many species. However, the actual performance of modified traveling screens is typically less than 90 percent when holding times are considered; in most cases, the longer an organism is held under observation after impingement, the less likely it is to survive. Additionally, larval impingement on fine mesh screens must also be addressed when reviewing technology performance. See Chapter 11 of the TDD and the preamble to the final rule for more information about how EPA assessed these data.

EPA also found that in many cases, only a few species comprise a large percentage of the impinged organisms. For example, at the Arthur Kill Station, Atlantic herring, blueback herring and bay anchovy composed over 90 percent of the impinged species during the course of the study as described below. In addition, some of the impinged species may not be typically considered highly valued commercial or recreational species or listed species. Examples include gizzard shad and bay anchovy as commonly impinged organisms reflected in study data. See TDD Chapter 11 for discussion of fragile species and naturally moribund species.

6.2.2.5 Facility Examples

Salem Generating Station

Salem Generating Station, on the Delaware Bay estuary in New Jersey, converted 6 of its 12 conventional traveling screen assemblies to a modified design that incorporated improved fish buckets constructed of a lighter composite material (which improved screen rotation efficiency), smooth-woven mesh material, an improved spray wash system (both low and high pressure), and flap seals to improve the delivery of impinged fish from the fish buckets to the fish return trough (EPRI 2007). The initial study period consisted of 19 separate collection events during mid-summer 1996. The configuration of the facility at the time of the study (half of the screens had been modified) allowed for a direct comparison of the effectiveness of the modified and unmodified screens on impingement mortality rates. The limited sampling timeframe enabled the analysis of only the species present in numbers sufficient to support any statistical conclusions. 1,082 juvenile weakfish were collected from the unmodified screens while 1,559 were collected from the modified structure. Analysts held each sample group separately for 48 hours to assess overall mortality due to impingement on the screens. Results showed that use of the modified screens had increased overall survival by as much as 20 percent over the use of the unmodified screens. Approximately 58 percent of the weakfish impinged on the unmodified screens survived, whereas the new screens had a survival rate approaching 80 percent. Both rates were based on 48-hour survival and not adjusted for the mortality of control samples.

Water temperature and fish length are two independent factors cited in the study as affecting overall survival. Researchers noted that survival rates decreased somewhat as the water temperature increased, possibly as a result of lower levels of dissolved oxygen. Survival rates decreased to a low of 56 percent for the modified screens when the water temperature reached its maximum of 80°F. At the same temperature, the survival rate on the unmodified screens was 35 percent. Differences in survival rates were also attributable to the size of the fish impinged. In general, small fish (less than 50 mm) fared better on both the modified and unmodified screens than large fish (greater than 50 mm). The survival rates of the two size categories did not differ significantly for the modified screens (85 percent survival for small, 82 percent for large), although a more pronounced difference was evident on the unmodified screens (74 percent survival for small, 58 percent for large).

Salem Generating Station conducted a second series of impingement sampling from 1997 to 1998. By that time, all screen assemblies had been modified to include Ristroph/post-Fletcher fish buckets and a fish return system. Additional modifications to the system sought to enhance the chances of survival of fish impinged against the screens. One modification altered the fish return slide to reduce the stress on fish being delivered to the collection pool. Flap seals were improved to better seal gaps between the fish return and debris trough, thus preventing debris from affecting returning fish. Researchers used a smaller mesh screen in the collection pools during the 1997-1998 sampling events than had been used during the 1995 studies. The study notes that the larger mesh used in 1995 might have enabled smaller fish to escape the collection pool. Since smaller fish typically have a higher mortality rate due to physical stress than larger fish, the actual mortality rates may have been greater than those found in the 1995 study. The second impingement survival study analyzed samples collected from October through December 1997 and April through September 1998. Samples were collected twice per week and analyzed for survival at 24- and 48-hour intervals. Six principal species were identified as constituting the majority of the impinged fish during the sampling periods: weakfish, white perch, bay anchovy, Atlantic croaker, spot, and *Alosa* spp. Fish were sorted by species and size, classified by their condition, and placed in holding tanks. For most species, survival rates varied noticeably depending on the season. For white perch, survival was above 90 percent throughout the sample period (as high as 98 percent in December). Survival rates for weakfish varied from a low of 18 percent in July to a high of 88 percent in September. Although the number of weakfish collected in September was approximately one-fifth of the number collected in July, a possible explanation for the variation in survival rates is the modifications to the collection system described above, which were implemented during the study period. Similarly, bay anchovy fared worst during the warmer months, dropping to a 20 percent survival rate in July while achieving a 72 percent rate during

November. Rates for Atlantic croaker varied from 58 percent in April to 98 percent in November. Spot were collected in only one month (November) and had a survival rate of 93 percent. The survival rate for the *Alosa* spp. (alewife, blueback herring, and American shad) remained relatively consistent, ranging from 82 percent in April to 78 percent in November. For all species in the study, with the exception of weakfish, survival rates improved markedly with the use of the modified screen system when compared to data from 1978-1982, when the unmodified system was still in use.

EPA conducted a site visit to Salem in January 2008. See DCN 10-6513.

Arthur Kill Station

The Arthur Kill Station is located on the Arthur Kill estuary in New York. To fulfill the terms of a consent order, Consolidated Edison modified two of the station’s dual-flow intake screens to include smooth mesh panels, fish-retention buckets, flap seals to prevent fish from falling between screen panels, a low-pressure spray wash system (10 psi), and a separate fish return sluiceway (EPRI 2007). One of the modified screens had mesh of 1/8-inch by 1/2-inch while the other had 1/4-inch by 1/2-inch while the six unmodified screens all had 1/8-inch by 1/8-inch mesh. Screens were continuously rotated at 20 ft/min during the sampling events. The sampling period lasted from September 1991 to September 1992. Weekly samples were collected simultaneously from all screens, with the exception of 2 weeks when the facility was shut down. Each screen sample was held separately in a collection tank where initial mortality was observed. A 24-hour survival rate was calculated based on the percentage of fish alive after 24 hours versus the total number collected. Because a control study was not performed, final survival rates have not been adjusted for any water quality or collection factors. The study did not evaluate latent survival beyond the 24-hour period. Atlantic herring, blueback herring and bay anchovy typically composed the majority (greater than 90 percent) of impinged species during the course of the study period. Bay anchovy alone accounted for more than 72 percent of the sample population. Overall performance numbers for the modified screens are greatly influenced by the survival rates for these three species. In general, the unmodified screens demonstrated a substantially lower impingement survival rate when compared to the modified screens. The average 24-hour survival for fish impinged on the unmodified screens was 15 percent. Fish impinged on the larger mesh (1/4") and smaller mesh (1/8") modified screens had survival average 24-hour survival rates of 92 percent and 79 percent, respectively. Most species with low survival rates on the unmodified screens showed a marked improvement on the modified screens. Bay anchovy showed a 24-hour survival rate increase from 1 percent on the unmodified screens to 50 percent on the modified screens. The study period at the Arthur Kill station offered a unique opportunity to conduct a side-by-side evaluation of modified and unmodified intake structures. The results for 24-hour post-impingement survival clearly show a marked improvement for all species that had fared poorly on the conventional screens. The study notes that lower survival rates for fragile species such as Atlantic herring might have been adversely affected by the collection tanks and protocols. Larger holding tanks appeared to improve the survival of these species, suggesting that the reported survival rates may under-represent the rate that would be achieved under normal (unobserved) conditions, though by how much is unclear.

Dunkirk Steam Station

Dunkirk Steam Station is located on the southern shore of Lake Erie in New York. In 1998 a modified dual-flow traveling screen system was installed on Unit 1 for an impingement mortality reduction study (EPRI 2007). The new system incorporated an improved fish bucket design to minimize turbulence caused by flow through the screen face, as well as a nose cone on the upstream wall of the screen assembly. The nose cone was installed to reduce the flow and velocity variations that had been observed across the screen face. Samples were collected during the winter months of 1998/1999 and evaluated for 24-hour survival. Four species (emerald shiner, juvenile gizzard shad, rainbow smelt, and spottail shiner) compose nearly 95 percent of the sample population during this period. All species exhibited high 24-hour survival rates; rainbow smelt fared worst at 83 percent. The other three species had survival rates of better than 94 percent. Other species were collected during the sampling period but were not present in numbers significant enough to warrant a statistical analysis. The results presented above represent one season of impingement sampling. Species not in abundance during cooler months might be affected differently by the intake structure. Sampling continued beyond the winter months, but data has not yet been reviewed by EPA.

Huntley Steam Station

Huntley Steam Station is located on the Niagara River in New York. The facility replaced four older conventional traveling screens with modified Ristroph screens on Units 67 and 68 (EPRI 2007). The modified screens are fitted with smoothly woven coarse mesh panels on a rotating belt. A fish collection basket is attached to the screen face of each screen panel. Bucket contents are removed by low-pressure spray nozzles into a fish return trough. High-pressure sprays remove remaining fish and debris into a separate debris trough. The study does not contain the rotation interval of the screen or the screen speed at the time of the study. Samples were collected over five nights in January 1999 from the modified-screen fish return troughs. All collected fish were sorted according to initial mortality. Four targeted species (rainbow smelt, emerald shiner, gizzard shad, and alewife) were sorted according to species and size and held to evaluate 24-hour survival rates. Together, the target species accounted for less than 50 percent of all fish impinged on the screens. (An additional 6,364 fish were not held for latent survival evaluation.) Of the target species, rainbow smelt and emerald shiners composed the greatest percentage with 57 and 37 percent, respectively. Overall, the 24-hour survival rate for rainbow smelt was 84 percent; some variation was evident for juveniles (74 percent) and adults (94 percent). Emerald shiner were present in the same general life stage and had a 24-hour survival rate of 98 percent. Gizzard shad, both juvenile and adult, fared poorly, with an overall survival of 5 percent for juveniles and 0 percent for adults. Alewife were not present in large numbers (*n* = 30) and had an overall survival rate of 0 percent. The study notes the low survival rates for alewife and gizzard shad and posits the low water temperature as the principal factor. At the Huntley facility, both species are near the northern extreme of their natural ranges and are more susceptible to stresses associated with extremes in water conditions. The water temperatures at the time of collection were among the coldest of the year. Laboratory evaluations conducted on these species at the same temperatures showed high degrees of impairment that would likely adversely affect post-impingement survival. A control evaluation was performed to determine whether mortality rates from the screens would need to be adjusted for waterbody or collection and handling factors. No discrepancies were observed, and therefore no corrections were made to the final results. Also of note in the study is the inclusion of a spray wash collection efficiency evaluation. The spray wash and fish return system were evaluated to determine the proportion of impinged fish that were removed from the buckets and deposited in the fish trough instead of the debris trough. All species had suitable removal efficiencies.

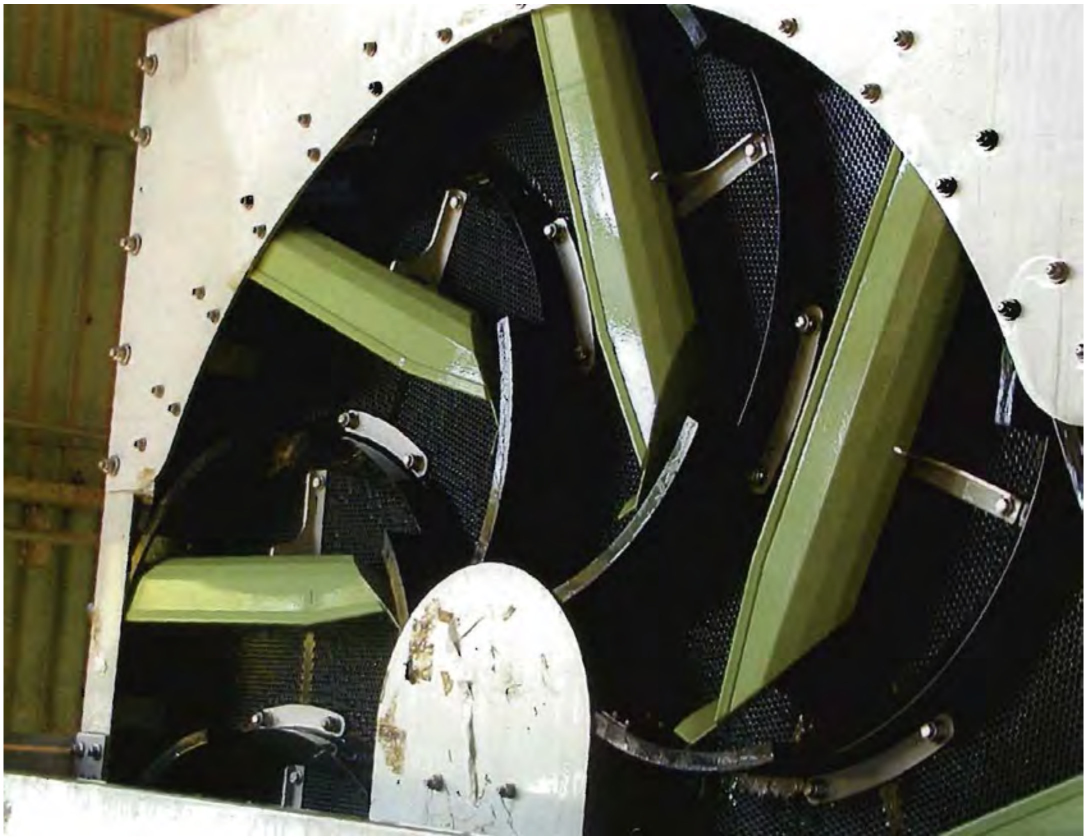
6.2.3 Geiger screens

Geiger screens are a relatively new type of traveling screen made up of a series of curved screen panels that rotate along the face of the intake screen along an oval path, much like a luggage carousel at an airport (see Exhibit 6-14). This configuration serves to virtually eliminate debris carryover. Geiger screens may be coarse mesh or fine mesh. The standard design is to use stainless steel for the construction, using different grades for freshwater and saltwater. As a result, capital costs for multi-disc screens may be higher for freshwater systems than conventional screens but comparable for saltwater systems. Standard screens have two drive chains and difficulty in maintaining equal tensioning on both often results in sprocket failure. O&M costs should be lower for multi-disc screens, as they only have one drive chain. Elimination of debris carryover can save on condenser cleaning O&M. In addition, because water passes through the screens only once, head loss across the screen is lower as compared to other types of screens.

The sickle-shaped screen panels can be fitted with different types of screen materials such as drilled plastic, nylon or metal screen mesh. One manufacturer has designed a fine mesh screen material that provides added strength for fine mesh by weaving in larger wire stands – about one every inch – among the finer strands to give strength while helping maintain a lower percent open area that using finer strands provides. Other manufacturers use screen backings instead.

EPA is aware of two facilities in the U.S. that have installed Geiger screens, but has found that the use of Geiger screens is more widespread in Europe. European Geiger screens often use screen mesh sizes in the 1 mm to 3 mm range, with some as low as 0.5 mm and very few exceeding 4 mm. Many are installed on large industrial rivers like the Rhine, which should have similar sediment and debris characteristics as large U.S. rivers. European intake designs, however, are somewhat different from U.S. designs in that they often use center-flow type screens and may have a three step screening process.

Exhibit 6-14. Geiger screen (image from EPRI 2007)



6.2.3.1 Technology Performance

Due to the relatively recent deployment of this technology, little performance data is available. Preliminary results from the Mirant Potomac Generating Station have shown impingement survival ranging from 0-100 percent depending on species. The most numerous species included bluegill, channel catfish, spottail shiner, and white perch. Representatives from EPRI and Mirant noted during the site visit at Potomac Generating Station that testing of a fine mesh Geiger screen was underway. EPRI also completed a laboratory study of the Multi-Disc screen in February 2013.

6.2.3.2 Facility/Laboratory Examples

Mirant Potomac Generating Station

Mirant Potomac is located on the Potomac River in Virginia. The facility previously used single-entry, single-exit traveling screens and installed Geiger screens on each of its cooling water intake structures in 2004 to reduce the debris carryover experienced by some of the vertical traveling screens. The new screens (mesh size of 3/8”) have virtually eliminated debris clogging in the condenser. However, due to high suspended sediment loads in the source water, the facility still regularly shuts down to remove sediment buildup in the condenser tubes. The Geiger screen for Unit 1 is also equipped with fish buckets, a low pressure spray wash, and the ability to add a fish return trough. Data generated in 2005 and 2006 showed mixed results. Bluegill impingement survival ranged from 95-100 percent; channel catfish ranged from 50-94 percent; spottail shiner ranged from 54-95 percent; and white perch ranged from 30-56 percent. The facility noted that major runoff events may have compromised some of the sampling and that additional data would need to be collected. (See DCN 10-6814.)

EPA conducted a site visit to Potomac in December 2007. See DCN 10-6512. The facility closed permanently on October 1, 2012.

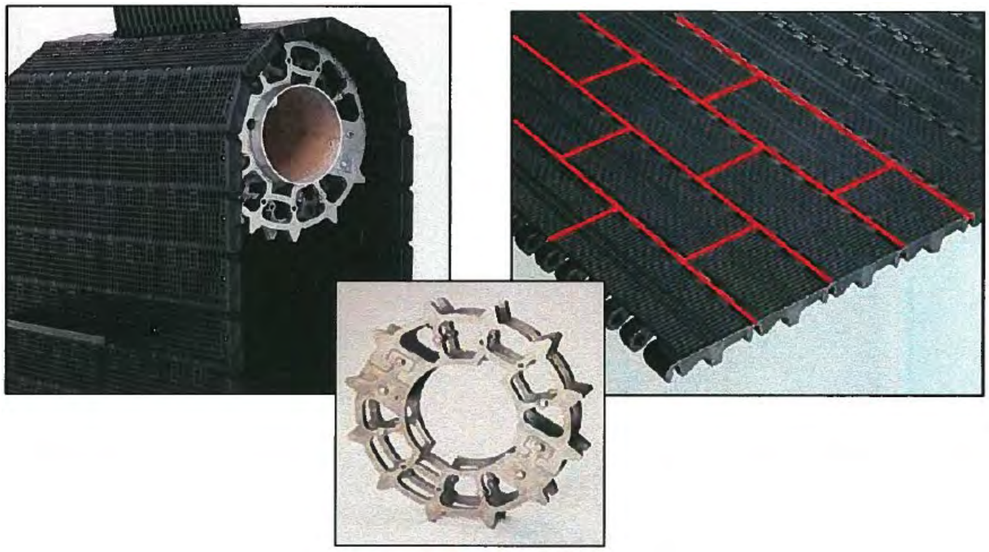
Donald C. Cook Nuclear Power Plant

Donald C. Cook Nuclear Power Plant is located in Michigan on Lake Michigan. From October 1, 2003 through the first week of January 2004, the facility conducted a pilot test of the Geiger Multidisc screens, using a drilled polyethylene disk, to minimize debris carryover. (See DCN 10-6811.) The plant tested the screens in two of 14 screens. The screens functioned well and were able to be maintained at the deck level as opposed to being transported off-site. Installation required about one week per screen and the retrofit could be completed without downtime. No fish protection data was available.

6.2.4 Hydrolox screens

The Hydrolox screen is a hinged vertical traveling screen made of an engineered polymer and consists of interconnected modules assembled in a bricklayed pattern for strength. (See Figure 6-15.) The Hydrolox screen has a smooth polymer surface and minimizes impingement mortality through the use of “fish scoops,” similar to fish buckets used in Ristroph screens. Debris carryover is reduced by using “flights” which may be interchanged with the fish scoops. Screen slot sizes are about ¼” or 6-7 mm. The Hydrolox screen fits into existing areas made for traditional vertical traveling screens. The modular components allow maintenance to be performed on-site without having to replace the entire screen. The engineered polymer is light, non-corrosive, and minimizes biofouling. This is a relatively new technology that underwent laboratory testing by Alden Laboratories in December of 2006 and full scale testing at Barrett Station, NY in 2007-2008.

Exhibit 6-15. Hydrolox screen (image from DCN 10-6831)



6.2.4.1 Technology Performance

Results of laboratory testing conducted in 2006 show over 90 percent impingement survival of golden shiner, common carp, bluegill, and channel catfish. (See DCN 10-6807.)

6.2.4.2 Facility Examples

Alden Laboratories Flume Testing

Alden Laboratories conducted impingement tests using a Hydrolox screen from July-August 2006. Flume tests were conducted using a 4 ft wide by 12 ft high Hydrolox screen installed perpendicular to the flow. The screening material was made of molded plastic with slot openings of 0.25 in. by 0.30 in. Five freshwater species were used in the experiment including the following: golden shiner, common carp, bluegill, striped bass, and channel catfish. The screen was rotated at either 5 ft/min or 10 ft/min with water flow velocities of 1 fps or 2 fps. Mortality rates were less than 10 percent for four of five species (golden shiner, common carp, bluegill, and channel catfish), and injury and scale loss were under 5 percent. Striped bass results seemed to be impacted by handling issues as mortality rates for both the test group and the control group were higher but did not seem to be caused by the Hydrolox screen (Alden 2006).

6.2.5 Beaudrey W Intake Protection (WIP) Screen

The Beaudrey W Intake Protection (WIP) screen is a screen wheel that faces the incoming flow, screening both debris and organisms into a backwash pump that transports debris and organisms back to the source water. (See Exhibit 6-16.) The WIP screen is installed in front of the recirculating water pumps and is easily retrofitted into existing traveling screen openings and guides. All components are mounted either on the deck plate or the WIP module itself. The WIP module can easily be raised for maintenance or inspection without disassembling the screen (see DCN 10-6810 and 10-6606). This reduces costs and no downtime is necessary.

Exhibit 6-16. WIP screen (image from Beaudrey)[103]

Beaudrey's Fish Protection System (FPS) works as part of the WIP and includes a Hidrostal® fish pump and backwash screens. The FPS also works with fine mesh screens and can be installed at the same time as the screens or added/retrofitted later. Fish are impinged for a maximum of 30 seconds, as the FPS operates at two revolutions per minute. With the FPS/WIP screen combination (rotating screening wheel with no chains

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[103] See DCN 10-6810A.

or sprocket teeth), there is no carry-over of debris or fish. The system works well for high, low, and mid-range water levels. The FPS/WIP screen is being tested at one site in the US, but is not in widespread use. The FPS system can be used in conjunction with other types of screens such as drum screens and traveling screens. There are multiple installations of the FPS system in Europe.

6.2.5.1 Technology Performance

System operational tests of the Beaudrey FPS_{TM} have shown strong capabilities to reduce impingement mortality; tests have demonstrated mean survival rates in excess of 90 percent across a range of fish species (see DCN 10-6810 and 10-6606). Preliminary impingement survival sampling results from May 2008, for bluegill, fathead minnow, and channel catfish ranged from 79.3 percent to 99.0 percent. A holding time of 48 hours was used for the study.

6.2.5.2 Facility/Laboratory Examples

Omaha Public Power District – North Omaha Power Station, Nebraska

The North Omaha Power Station is located in North Omaha, Nebraska. The facility completed a two-year pilot study (in coordination with EPRI) of the WIP/FPS screen in 2008 to study impingement mortality. Initial efforts were abandoned as researchers discovered that the number of fish normally impinged at the facility was too low to provide meaningful data. The study then shifted to introduce fish directly in front of the screen and study the subsequent impingement event. Hatchery fish representative of the species found in the Missouri River were used, as well as “wild” fish caught in a seine net near the facility. The study results showed impingement survival rates of 79 percent to over 90 percent, with no statistically significant difference between fish exposed to the screen versus the control group that was not exposed to any screens.

EPA conducted a site visit to North Omaha in March 2009. See DCN 10-6521.

Alden Laboratories Flume Testing

Alden Laboratories conducted impingement tests using a fine mesh Beaudrey WIP screen in 2011. The testing was intended to explore mesh size, approach velocity and spray wash pressure on the impingement survival of several species of fish. Survival ranged from 4.7 percent to 86 percent when intake velocity was varied. See DCN 12-6800.

6.2.6 Coarse Mesh Cylindrical Wedgewire

Cylindrical wedgewire screens, also called “V” screens or profile screens, unlike traveling screens, are a passive intake system. Their performance is largely dictated by conditions that are independent of the source waterbody’s biological composition. The typical design consists of wedge-shaped wires or bars welded to an internal cylindrical frame that is mounted on a central intake pipe, with the entire structure submerged in the source waterbody. When appropriate conditions are met, these screens exploit physical and hydraulic exclusion mechanisms to achieve consistently high reductions in impingement (and as a result, impingement mortality). Significant entrainment reductions may also be observed when the screen slot size is small enough to exclude egg and larval life stages (see below for a discussion of fine mesh wedgewire screens). Of the 766 existing facility intakes that were reported in the detailed questionnaires, 60 intakes used wedgewire screens.

Slot sizes for conventional traveling screens typically refer to a square opening (3/8” x 3/8”) that is punched or woven into the screen face.[104] Wedgewire screens are constructed differently, however, with the slot size referring to the maximum distance between longitudinally adjacent wires. These screens are designed to have a low, uniform through-slot velocity (less than 0.5 feet per second) and typically have smaller slot sizes than a coarse mesh traveling screen. The intake velocity quickly dissipates away from the screen due to the cylindrical shape, thus creating a relatively small flow field in the waterbody. This small flow field, together with optimal screen orientation, results in a small system profile and minimizes the potential for contact between the screen and any susceptible organisms that may come under the intake’s hydraulic influence. In addition, the ambient current crossflow (i.e., to maximize the sweeping velocity provided by the waterbody) carries most free-floating organisms and debris past the screen, removing organisms that are temporarily in contact with or pinned against the screen.[105] As such, screen orientation is also an important component of this technology’s overall performance. The low through-slot velocity in combination with the screen orientation and cross current flow carries organisms away from the screen allowing them to avoid or escape the intake current. Wedgewire screens may also employ cleaning and de-icing systems, such as air-burst sparging or may be constructed with nickel or copper alloys to discourage biofouling.

EPA believes that cylindrical wedgewire screens can be successfully employed by large intake facilities under certain circumstances. Although many of the current installations of this technology have been at smaller-capacity facilities, large water withdrawals can be accommodated by multiple screen assemblies in the source waterbody. The limiting factor for a larger facility may be the availability of sufficient accessible space near the facility itself because additional screen assemblies consume more space on the waterbody floor and might interfere with navigation or other uses of the waterbody. Consideration of the impacts in terms of space and placement must be evaluated before selecting wedgewire screens for deployment.

As with any intake structure, the presence of large debris poses a risk of damage to the structure if not properly managed. Cylindrical wedgewire screens, because of their need to be submerged in the water current away from shore, might be more susceptible to debris interaction than other onshore technologies. Vendor engineers and facility representatives indicated that large debris has been a concern at several of their existing installations, but the risk associated with it has been effectively minimized by selecting the optimal site and constructing debris diversion structures. Significant damage to a

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[104] See DCN 10-6604 for additional discussion on wedgewire slot sizes.

[105] Preliminary hydrodynamic studies suggest that at a through-slot velocity of 0.5 fps, the sweeping flow is dominant over the intake flow and when intakes are properly oriented with each other can even reduce the number of organisms entrained.

wedgewire screen is most likely to occur from fast-moving submerged debris. Because wedgewire screens do not need to be sited in the area with the fastest current, a less damage-prone area closer to shore or in a cove or constructed embayment can be selected, provided it maintains a minimum ambient current around the screen assembly. If placement in the main channel is unavoidable, deflecting structures can be employed to prevent free-floating debris from contacting the screen assembly. Typical installations of cylindrical wedgewire place them roughly parallel to the direction of the current, exposing only the upstream nose to direct impacts with debris traveling downstream. EPA has noted several installations where debris-deflecting nose cones have been installed to effectively eliminate the damage risk associated with most debris. Apart from the damage that large debris can cause, smaller debris, such as household trash or organic matter, can build up on the screen surface, altering the through-slot velocity of the screen face and increasing the risk of entrainment and/or impingement of target organisms. Again, selection of the optimal location in the waterbody might be able to reduce the collection of debris on the structure. Ideally, cylindrical wedgewire is located away from areas with high levels of submerged aquatic vegetation (SAV) and out of known debris channels. Proper placement alone may achieve the desired effect, although technological solutions also exist to physically remove small debris and silt. Automated air-burst systems can be built into the screen assembly and set to deliver a short burst of air from inside and below the structure. Debris is removed from the screen face by the air burst and carried downstream and away from the influence of the intake structure. Improvements to the air burst system have eliminated the timed cleaning cycle and replaced it with one tied to a pressure differential monitoring system.

Wedgewire screens are more likely to be placed closer to navigation channels than other onshore technologies, thereby increasing the possibility of damage to the structure itself or to a passing commercial ship or recreational boat. Because cylindrical wedgewire screens need to be submerged at all times during operation, they are typically installed closer to the waterbody floor than the surface. In a waterbody of sufficient depth, direct contact with recreational or commercial vessels is unlikely. EPA notes that other submerged structures (e.g., pipes, transmission lines) are preset in many waterbodies and are properly delineated with acceptable navigational markers to prevent accidents associated with trawling, dropping anchor, and similar activities. Such precautions would likely be taken for a submerged wedgewire screen as well.

6.2.6.1 Technology Performance

Cylindrical wedgewire screens have not been used extensively as an impingement control technology at facilities with large intake flows, but data describing their performance at several installations, as well as laboratory evaluations, suggest a strong potential to reduce impingement impacts when certain design and construction criteria are satisfied. Data from some studies have shown reductions in impingement of near 100 percent.

Other factors also influence this technology’s overall performance and must be considered during the system’s design phase. Some data suggest that orienting the screens perpendicular to the ambient flow can minimize contact injuries by reducing screen-organism contact times, but at the expense of increasing the screen’s profile. A parallel orientation offers the smallest possible profile but may raise screen-organism contact times as the organism has to travel the full length of the screen before returning to the waterbody. The optimal orientation may be further influenced by the sensitivity and abundance of the target species, as well as the probability for high debris loads in the waterbody or the potential for frazil/sheet ice buildup.[106]

6.2.6.2 Facility/Laboratory Examples

JH Campbell

JH Campbell is located on Lake Michigan in Michigan, with the intake for Unit 3 located approximately 1,000 meters from shore at a depth of 10.7 meters. The cylindrical intake structure has 9.5 mm mesh wedgewire screens and withdraws approximately 400 mgd. Raw impingement data are not available, and EPA is not aware of a comprehensive study evaluating the impingement reduction associated with the wedgewire screen system. Comparative analyses using the impingement rates at the two other intake structures (onshore intakes with conventional traveling screens) have shown that impingement of emerald shiner, gizzard shad, smelt, yellow perch, and alewife associated with the wedgewire screen intake has been effectively reduced to insignificant levels. Maintenance issues have not been shown to be problematic at JH Campbell because of the far offshore location in deep water and the periodic manual cleaning using water jets to reduce biofouling.

Eddystone Generating Station

Eddystone Generating Station is located on the tidal portion of the Delaware River in Pennsylvania. Units 1 and 2 were retrofitted to include wide-mesh wedgewire screens and currently withdraw approximately 500 mgd from the Delaware River. Pre-deployment data showed that over 3 million fish were impinged on the unmodified intake structures during a single 20-month period. An automatic air burst system has been installed to prevent biofouling and debris clogging from affecting the performance of the screens. EPA has not been able to obtain biological data for the Eddystone wedgewire screens but EPRI (2007) indicates that fish impingement has been eliminated.

EPA conducted a site visit to Eddystone in January 2008. See DCN 10-6507. Unit 1 was retired in 2011 and Unit 2 was retired in 2012.

6.2.7 Fine Mesh Screens

Both traveling screens and wedgewire screens can be designed to incorporate a fine screen mesh to reduce entrainment.

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[106] In the 2004 Phase II rule, use of a wedgewire screen (under certain parameters) was deemed to be a pre-approved technology for impingement requirements. This designation is no longer specifically included under the existing facilities rule, as installation of a wedgewire screen presumably already meets the intake velocity criteria at 40 CFR 125.94(c)(2).

6.2.7.1 Fine Mesh Traveling Screens

Fine mesh screens (mesh size of 5 mm or less[107]) are typically mounted on conventional traveling screen systems and are used to exclude eggs, larvae, and juvenile forms of fish from intakes.[108] Successful use of fine mesh screens is contingent on the application of satisfactory handling and return systems to allow the safe return of impinged organisms to the aquatic environment. Of the 766 existing facility intakes that were reported in the detailed questionnaires, 43 intakes reported using fine mesh screens with a mesh size of 5 mm or less.

A retrofit with fine mesh screens is more complicated than one with coarse mesh because the total through screen area will be decreased as a result of smaller screen slot sizes (assuming the same intake structure size). Because the intake volume remains unchanged, through-screen velocity will increase, perhaps significantly, unless the total intake structure area is also increased. The former is generally undesirable, as intake velocity is an important criterion in reducing impingement. The latter could result in a longer downtime period than for retrofitting to modified coarse mesh traveling screens. For example, replacing coarse mesh screens with a 68 percent open area with fine mesh screens of the same size with a 44 percent open area will increase the through-screen velocity by a factor of 1.55. If the retrofit analysis estimated that the total screen area required is greater than what is available at the existing intake (i.e., the compliance screen area factor is greater than 1.0), a new intake with a larger screen area would be needed. EPA assumed the new larger intake would have a through-screen velocity of 0.5 fps when estimating the screen area factor and technology costs for a new larger intake.[109] The size and cost of this new screen technology are directly related to the required screen surface area.[110] Velocity increases beyond a certain range would be unacceptable because they might increase impingement of other organisms and would increase the mortality of eggs and larvae captured on the fine mesh screen panels.

Fouling and clogging concerns may be more pronounced with fine mesh screens as well. With a smaller screen open area, the effects of fouling on through-screen velocity (and flow volume provided for cooling) may be affected.

As the desired mesh size decreases (i.e., as the screen compliance factor increases), the potential for problems associated with the availability of space to construct a larger intake increases. This is especially true for shore-based intake technologies, since water depth is generally relatively shallow, thereby requiring any screen expansion to cover a proportionally longer length of shoreline. The availability of additional shore space at many existing intakes may be limited due to existing structures and other

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[107] There is no widely accepted definition of "fine mesh." EPA's industrial surveys in 2000 used 5mm as the maximum spacing of fine mesh. Since that time, new data shows that fine mesh screens must be less than 2 mm to have a significant effect on total entrainment.

[108] Fine mesh screen overlays can also be used to attach to a coarse mesh screen.

[109] At proposal, EPA used a design through-screen velocity of 1.0 fps for new expanded intakes. For the final rule, this was changed to 0.5 fps; refer to Chapter 8 for more information.

[110] See Chapter 8 of the TDD, which describes the costing model used for the final rule. Module 3 contains the costs for expanding an existing intake structure.

considerations.[111] See DCN 10-6601 for further information on fine mesh screen feasibility, particularly with respect to debris handling and screen expansion.

EPA analyzed several options for fine mesh screens (see Chapter 7 and the preamble to the proposed rule) but ultimately did not adopt them as the technology basis. In its analysis, EPA found that many model facilities would be required to significantly expand their intake structures to accommodate the fine mesh screens and maintain a 0.5 fps through-screen velocity; in some cases, as many as 68 percent of facilities would need to expand the size of their intake by more than five times, leading EPA to believe that fine mesh screens would not be an available technology at those sites.

6.2.7.1.1 Technology Performance

Fine mesh traveling screens designed to reduce entrainment impacts have been used at a few large intake facilities, but data describing their performance is limited. Data demonstrates that entrainment typically decreases as mesh size decreases, particularly for eggs. In an August 2008 presentation to EPA, EPRI stated that field deployment of fine mesh traveling screens with favorable screen operating performance (i.e., can properly handle debris loading) included eight power plant sites in the US (Dixon 2008; DCN 10-6818).[112] These facilities represent various waterbody types, flows, fuel types, configurations, and locations throughout the country. The wide variety of operating conditions at facilities with fine mesh traveling screens suggests that with proper design and operation, these screens are technically feasible at most facilities.[113]

For the 2004 Phase II rule, EPA assumed that the mortality of entrained organisms would be 100 percent[114]. However, as mesh sizes are reduced to prevent entrainment, more and more entrainables become impinged on the screens (i.e., “converted” from entrainable to impingeable) and subjected to spray washes and return along with larger impinged organisms as well as debris from the screens. Under the 2004 Phase II rule, these “converts” would be classified as a reduction in entrainment, since the entrainment performance standard simply required a reduction in the number (or mass) of entrained organisms entering the cooling system. However, for some facilities the low survival rate of converts resulted in the facility have difficulty complying with the impingement mortality standards. By comparison, the performance standard for impingement was measured as impingement mortality. Organisms that were impinged (i.e., excluded) from the cooling water intake structure were typically washed into a return system and sent back to the source water. In this case, impingement mortality is an appropriate measure of the biological performance of the technology.

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[111] Examples might include limited ownership of shoreline property or conflicting uses of the shoreline.

[112] The facilities listed were Hanford Generating Project, Barney Davis, Indian Point, Big Bend, Brunswick, Somerset, Dunkirk, and Prairie Island.

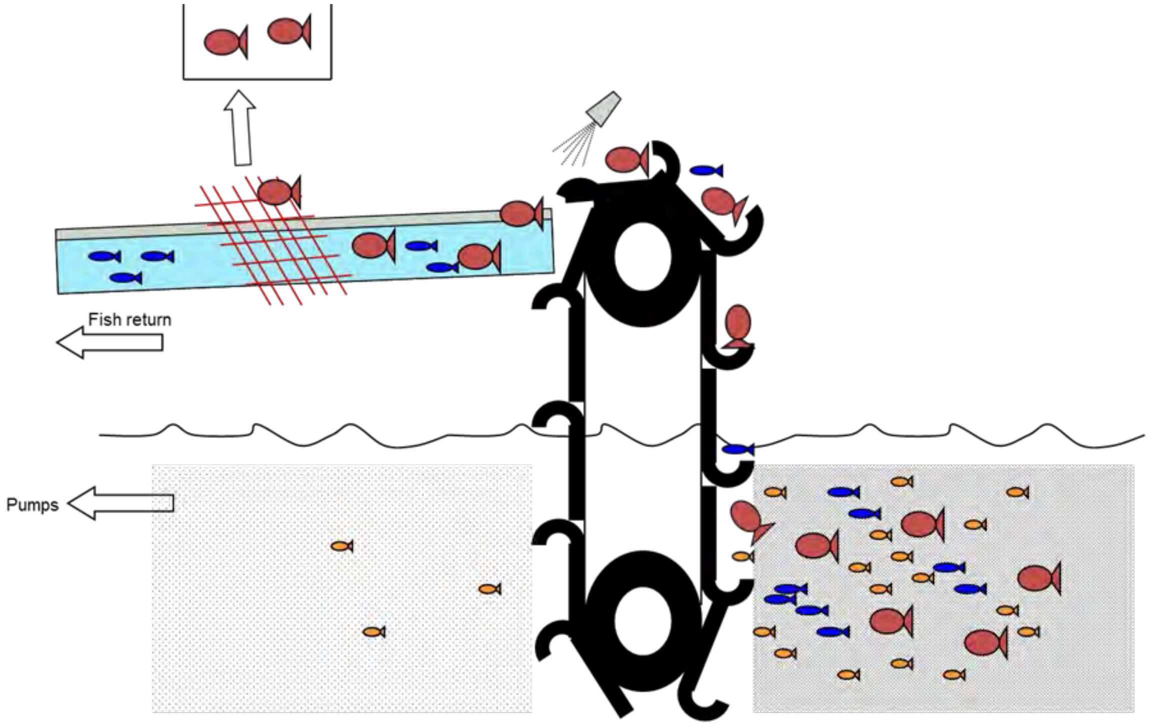
[113] Further, the technology vendors stated that the distribution of fine mesh traveling screens has been limited due to the fact that few facilities have been *required* to install fine mesh screens. EPRI also concluded that the potential for future use of fine mesh screens is favorable, as handling procedures and screen designs have continued to improve (Dixon 2008).

[114] Fine mesh screens were considered to be one technology that could be used to meet the entrainment performance standards under the 2004 Phase II rule

Through EPA's review of control technologies, the Agency found that the survival of "converts" on fine mesh screens was very poor, and in some extreme cases comparable to the extremely low survival of entrained organisms that are allowed to pass entirely through the facility.[115] More specifically, EPA found that nearly 100 percent of eggs were entrained unless the mesh slot size was less than 2 mm, and mortality of eggs "converted" to impingement ranged from 20 to 30 percent. More tellingly, the mortality of larvae collected from a fine mesh screen was usually greater than 80 percent. As a result, a facility with entrainment exclusion technologies such as fine mesh screens could approach 90 percent performance, but the subsequent survival of these organisms ranged from 0 to 52 percent (mean value of 12 percent survival) depending on life stage and species, and the facility's impingement mortality rates increased.

Exhibit 6-17 illustrates this concept. Organisms of all sizes are exposed to the screen face. Larger organisms (i.e., those that would be impinged by any mesh size) are impinged and sent to the fish return. "Converts" (i.e., those that would pass through a coarse mesh screen) are also impinged and sent to the fish return.[116] Small organisms and eggs that would not be impinged by any mesh size pass through the screen and are entrained.

Exhibit 6-17. Illustration of fine mesh screen operation and "converts"



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[115] Through-plant entrainment survival has been studied extensively, with EPRI's Review of Entrainment Survival Studies being amongst the most comprehensive. See DCN 2-017A-R7 from the Phase I docket.

[116] Exhibit 6-17 also shows a screen applied to the fish return. Consistent with EPA's definition of impingement in the final rule, this symbolizes that impingement standards would be applied to those fish that would have been impinged by a 3/8" screen (i.e., a graphic representation of the "hypothetical net").

So, a facility that simply excluded entrainable organisms (with no attention being paid to whether they survive or not) could be deemed to have met its entrainment requirements under the 2004 Phase II rule, when in fact it may be causing the same level of mortality as a facility with no entrainment controls at all. EPA's current review of entrainment and entrainment mortality shows the same trends identified in the research reviews by EPRI (see DCNs 10-6802 and 6-5004B). For fine mesh traveling screens, impingement of converts increases as mesh size is reduced, with survival of the converts being dependent upon species and intake velocity. For fine mesh wedgewire screens, entrainment decreases with increasing larval length, increased sweeping flow, decreasing slot (intake) velocity, and decreasing slot width; minimal impingement of converts was observed.

A representative for Eimco (a traveling screen vendor) stated that 0.5 mm fine mesh requires low screen velocities (i.e., approximately 0.5 fps) and that retrofitting a high velocity traveling screen with 0.5 mm mesh would be very difficult on large rivers such as the Mississippi and Missouri Rivers (Gathright 2008). The Missouri River is known for having high levels of suspended sediment, which can create problems in "blinding" of the intake screens. Blinding of the screens occurs when the sediment and debris accumulate on the screens at a rapid rate. If increased screen rotation and backwashing is not sufficient to remove the sediment, then the desired cooling pumping rate may not be sustained, which would force the facility to reduce the pumping rate or cease withdrawals, leading to a reduction (or cessation) of power generation. Typically, the problem of screen blinding in rivers with high sediment loading diminishes as the screen mesh size approaches 1.0 mm and does not present a problem if 2.0 mm screens are used (Gathright 2008).

The primary reason for the difference in performance of screens with different mesh sizes is due to the typical distribution of sand particle size in the river water. In a study of sand grain size distribution from the Fraser River Port in British Columbia, 90 percent of the sand particles were less than 0.5 mm in size, with the percent content increasing rapidly below 0.5 mm (see DCN 10-6601). The particle size distribution graph shows that 0.5 mm was somewhat of an inflection point where grain size content diminished more gradually as the size increased, approaching 0 percent at 2 mm. Thus, a screen with a mesh size of 0.5 mm would capture a significant portion of the suspended material, while a screen with a mesh size near 2.0 mm would capture very little of it.

Problems with larger, less-dense debris particles such as leaves will not be affected as much by mesh size, since such debris particles will be captured on the screen regardless of mesh size and, therefore, no changes in operation would be expected with finer mesh.

EPA recognizes that high sediment waterbodies pose a challenge for fine mesh screens. However, a mesh size of 2.0 mm has been shown to be effective in handling the high sediment loads. EPA also acknowledges that facilities located on high sediment rivers face constant challenges related to sediment regardless of screen mesh size, as existing intake screens may become clogged or suffer premature failure or condenser tubes may require more frequent cleaning.

6.2.7.1.2 Facility Examples

Big Bend

The most significant example of long-term use of fine-mesh screens has been at the Big Bend Power Plant in the Tampa Bay area. The facility has an intake canal leading to a shoreline intake with 0.5 mm mesh Ristroph screens that are used seasonally on the intakes for Units 3 and 4. During the mid-1980s when the screens were initially installed, their efficiency in reducing I&E mortality was highly variable (EPRI 2007). The operator, Florida Power & Light (FPL) evaluated different approach velocities and screen rotational speeds. In addition, FPL recognized that frequent maintenance (manual cleaning) was necessary to avoid biofouling. By 1988, system performance had improved greatly. The system's efficiency in screening fish eggs (primary species are drum and bay anchovy) exceeded 95 percent,[117] with 80 percent latent survival for drum and 93 percent for bay anchovy. For larvae (primary species are drum, bay anchovy, blennies, and gobies), screening efficiency was 86 percent,[118] with 65 percent latent survival for drum and 66 percent for bay anchovy. Note that latent survival in control samples was also approximately 60 percent. Although more recent data are generally not available, the screens continue to operate successfully at Big Bend in an estuarine environment with proper maintenance.

EPA conducted a site visit to Big Bend in March 2008. See DCN 10-6502.

Other Facilities

Although egg and larvae entrainment performance data are not available, fine mesh (0.5 mm) Passavant screens (single entry/double exit) have been used successfully in a marine environment at the Barney Davis Station in Corpus Christi, Texas. Impingement data for this facility show an overall 86 percent initial survival rate for bay anchovy, menhaden, Atlantic croaker, killfish, spot, silverside, and shrimp. EPA conducted a site visit to Barney Davis in March 2008. See DCN 10-6500.

Additional full-scale performance data for fine-mesh screens at large power stations are generally not available. However, some data are available from limited use or study at several sites and from laboratory and pilot-scale tests. Seasonal use of fine mesh on two of four screens at the Brunswick Power Plant in North Carolina has shown 84 percent reduction in entrainment compared to the conventional screen systems. Similar results were obtained during pilot testing of 1 mm screens at the Chalk Point Generating Station in Maryland.[119] At the Kintigh Generating Station in New Jersey, pilot testing indicated that 1 mm screens provided 2 to 35 times the reduction in entrainment over conventional 9.5 mm screens. Finally, Tennessee Valley Authority (TVA) pilot-scale studies performed in the 1970s showed reductions in striped bass larvae entrainment of up to 99 percent for a 0.5 mm screen and 75 and 70 percent for 0.97 mm and 1.3 mm screens,

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[117] The 95 percent value reflects the exclusion rate, the percentage of organisms prevented from entering the cooling water system and does not address entrainment mortality.

[118] As above, this value is a an exclusion rate.

[119] EPA conducted site visits to Brunswick and Chalk Point in January 2008 and December 2007, respectively. See DCNs 10-6559 and 10-6504.

respectively. A full-scale test by TVA at the John Sevier Plant showed less than half as many larvae entrained with a 0.5 mm screen than with 1- and 2 mm screens combined.

Alden Laboratories Flume Testing

Alden Laboratories conducted impingement tests using a fine mesh traveling screen in 2011. The testing was intended to explore mesh size, approach velocity and spray wash pressure on the impingement survival of several species of fish. Survival ranged from 4.7 percent to 86 percent when intake velocity was varied. See DCN 12-6800.

6.2.7.2 Fine Mesh Wedgewire Screens

Fine mesh wedgewire functions in the same way as coarse mesh wedgewire, but due to the reduced slot size also acts to exclude smaller organisms (including larvae and eggs), reducing entrainment. Physical exclusion is accomplished by designing the screens with a slot size that will prevent the entrainment of the smallest target taxa or life stage. In general, a smaller slot size will translate into larger or more numerous screen assemblies in order to maintain the desired through-slot velocity. Furthermore, small slots increase the debris clogging potential and associated maintenance needs.

6.2.7.2.1 Technology Performance

Fine-mesh applications (those designed to target eggs and larvae) have shown high potential to reduce entrainment if intake velocities are maintained. Reductions in entrainment exclusion of approximately 90 percent have been demonstrated. Due to difficulty in collecting entrainables from a fine mesh wedgewire screen, entrainment survival is not known.

6.2.7.2.2 Facility Examples

Laboratory Evaluation

EPRI published (May 2003; see DCN 6-5004B) the results of a laboratory evaluation of wedgewire screens under controlled conditions in the Alden Research Laboratory Fish Testing Facility. A principal aim of the study was to identify the important factors that influence the relative rates of impingement and entrainment associated with wedgewire screens. The study evaluated characteristics such as slot size, through-slot velocity, and the velocity of ambient currents that could best carry organisms and debris past the screen. When each of the characteristics was optimized, wedgewire screen use became increasingly effective as an impingement reduction technology; in certain circumstances it could be used to reduce the entrainment of eggs and larvae. EPRI notes that large reductions in impingement and entrainment might occur even when all characteristics are not optimized. Localized conditions unique to a particular facility, which were not represented in laboratory testing, might also enable successful deployment. The study cautions that the available data are not sufficient to determine the biological and engineering factors that would need to be optimized, and in what manner, for future applications of wedgewire screens.

Slot sizes of 0.5, 1.0, and 2.0 mm were each evaluated at two different through-slot velocities (0.15 and 0.30 m/s) and three different channel velocities (0.08, 0.15, and

0.30 m/s, corresponding to 0.25, 0.5, and 1.0 fps) to determine the impingement and entrainment rates of fish eggs and larvae. Screen open area increased from 24.7 percent for the 0.5 mm screens to 56.8 percent for 2.0 mm screens. The study evaluated eight species (striped bass, winter flounder, yellow perch, rainbow smelt, common carp, white sucker, alewife, and bluegill) because of their presence in a variety of waterbody types and their history of entrainment and impingement at many facilities. Larvae were studied for all species except alewife, while eggs were studied for striped bass, white sucker, and alewife. (Surrogate, or artificial, eggs of a similar size and buoyancy substituted for live striped bass eggs.) Individual tests followed a rigorous protocol to count and label all fish eggs and larvae prior to their introduction into the testing facility. Approach and through-screen velocities in the flume were verified, and the collection nets used to recapture organisms that bypassed the structure or were entrained were cleaned and secured. Fish and eggs were released at a point upstream of the wedgewire screen selected to deliver the organisms at the centerline of the screens, which maximized the exposure of the eggs and larvae to the influence of the screen. The number of entrained organisms was estimated by counting all eggs and larvae captured on the entrainment collection net. Impinged organisms were counted by way of a plexiglass window and video camera setup.

In addition to the evaluations conducted with biological samples, Alden Laboratories developed a Computational Fluid Dynamics (CFD) model to evaluate the hydrodynamic characteristics associated with wedgewire screens. The CFD model analyzed the effects of approach velocity and through-screen velocities on the velocity distributions around the screen assemblies. Using the data gathered from the CFD evaluation, engineers were able to approximate the “zone of influence” around the wedgewire screen assembly under different flow conditions and estimate any influence on flow patterns exerted by multiple screen assemblies located in close proximity to each other.

The results of both the biological evaluation and the CFD model evaluation support many of the conclusions reached by other wedgewire screen studies, as well as in situ anecdotal evidence. In general, the lower impingement rates were achieved with larger slot sizes (1.0 to 2.0 mm), lower through-screen velocities, and higher channel velocities. Similarly, the lowest entrainment rates were seen with low through-screen velocities and higher channel velocities, although the lowest entrainment rates were achieved with smaller slot sizes (0.5 mm). Overall impingement reductions reached as high as 100 percent under optimal conditions, and entrainment reductions approached 90 percent. It should be noted that the highest reductions for impingement and entrainment were not achieved under the same conditions. Results from the biological evaluation generally agree with the predictions from the CFD model: the higher channel velocities, when coupled with lower through-screen velocities, would result in the highest rate of protection for the target organisms.

Other Facilities

Other facilities with lower intake flows have also installed wedgewire screens, but there are limited biological performance data for these facilities. Unit 1 at the Cope Generating Station in South Carolina is a closed-cycle unit that withdraws about 6 mgd through a 2 mm wedgewire screen; however, no biological data are available. Westchester RESCO (design flow of 55 mgd) uses a wedgewire screen with 2.0mm slot size; however, no studies relating to reductions in impingement and entrainment have been conducted. The Logan Generating Station in New Jersey withdraws 19 mgd from the Delaware River through a 1 mm wedgewire screen. Entrainment data show 90 percent less entrainment of larvae and eggs than conventional screens. No impingement data are available.[120]

Wedgewire screens have been considered or tested for several other large facilities. In situ testing of 1 and 2mm wedgewire screens was performed in the St. John River for the Seminole Generating Station Units 1 and 2 in Florida in the late 1970s. This testing showed virtually no impingement and 99 and 62 percent reductions in larvae entrainment for the 1 mm and 2 mm screens, respectively, over conventional screen (9.5 mm) systems. In 1982 and 1983, the State of Maryland conducted testing using 1, 2, and 3 mm wedgewire screens at the Chalk Point Generating Station, which withdraws water from the Patuxent River in Maryland. The 1 mm wedgewire screens were found to reduce entrainment by 80 percent. No impingement data were available. Some biofouling and clogging were observed during the tests. In the late 1970s, Delmarva Power and Light conducted laboratory testing of fine-mesh wedgewire screens for the proposed 1,540 MW Summit Power Plant. This testing showed that entrainment of fish eggs (including striped bass eggs) could effectively be prevented with slot widths of 1 mm or less, while impingement mortality was expected to be less than 5 percent. Actual field testing in the brackish water of the proposed intake canal required the screens to be removed and cleaned as often as once every 3 weeks.

6.2.8 Drum Screens

Drum screens are a horizontally-oriented screen that rotate a cylindrical screen (the drum) along a shaft, with part of the screen exposed above the water’s surface. Much like vertical traveling screens, a spray wash cleans the screen when the screen is rotated above the water.

6.2.8.1 Technology Performance

Drum screens are not commonly used in the U.S., but are more common in Europe. Performance has been shown to range from 0 percent to 100 percent survival after 24 hours, depending on the hardiness of the impinged species. Much like screen systems in the U.S., facilities and screen vendors have worked over the years to improve the design and performance of these screens, including testing on spray wash systems, fish collection devices, filtration, and other aspects.

6.2.8.2 Facility Examples

Summary Study

EPRI conducted a review of the drum screen and its performance at several facilities in France over the past decades, including an assessment of impingement survival,

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[120] EPA conducted site visits to Westchester RESCO and Logan in April 2008 and January 2008, respectively. See DCN 10-6517 and DCN 10-6509.

improvements to the screens, and applicability for cooling water intakes in the U.S. See DCN 12-6803.

6.3 Barrier nets

Barrier nets are nets that encircle the point of water withdrawal from the bottom of the water column to the surface that prevent fish and shellfish from coming in contact with the intake structure and screens. Of the 766 existing facility intakes that were reported in the detailed questionnaires, at least eight intakes employ a barrier net. Barrier net mesh sizes vary depending on the intake configuration, level of debris loading, species to be protected, and other factors such as the waterbody, velocity and tides, and typically range from 4 mm to 32 mm (EPRI 1999). Relatively low through-technology velocities are usually maintained through the nets because the area through which the water can flow is usually large. Most barrier nets are designed to prevent impingement and do not prevent entrainment due to the large mesh size. Barrier nets are especially helpful in controlling impingement during seasonal migrations of fish and other organisms and to prevent impingement of shellfish on the intake traveling screen. Shellfish pose a unique challenge to the operation of traveling screens because they affix themselves to the screen; spray wash pressure is not able to remove them from the screen.[121] Barrier nets are often removed from the water in winter to prevent damage from ice and to make any necessary repairs. In some cases, the use of barrier nets might be further limited by the physical constraints and other uses of the waterbody, such as navigation.

6.3.1 Technology Performance

Barrier nets have clearly proven performance for controlling impingement (i.e., more than 80 percent reductions over conventional screens without nets) in areas with limited debris flows. High debris flows can cause significant damage to net systems. Biofouling can also be a concern but may be addressed through adequate maintenance.

6.3.2 Facility Examples

JP Pulliam Station

The JP Pulliam Station is located on the Fox River in Wisconsin. Two separate nets with 6 mm mesh are deployed on opposite sides of a steel grid supporting structure. The operation of a dual net system facilitates the cleaning and maintenance of the nets without affecting the overall performance of the system. Under normal operations, nets are rotated at least two times per week to facilitate cleaning and repair. The nets are typically deployed when the ambient temperature of the intake canal exceeds 37°F. This usually occurs between April 1 and December 1.

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[121] In the proposed rule, EPA proposed requirements for marine facilities to install a barrier net to address shellfish impingement. However, upon further study of the available impingement data for shellfish, EPA has concluded that a separate set of requirements for shellfish is not necessary. See the preamble for more information.

Studies undertaken during the first 2 years after deployment showed an overall net deterrence rate of 36 percent for targeted species (noted only as commercially or recreationally important, or forage species). Improvements to the system in subsequent years consisted of a new bulkhead to ensure a better seal along the vertical edge of the net and additional riprap along the base of the net to maintain the integrity of the seal along the bottom of the net. The improvements resulted in a deterrence rate of 98 percent for some species; no species performed at less than 85 percent. The overall effectiveness for game species was better than 90 percent while forage species were deterred at a rate of 97 percent or better.

JR Whiting Plant

The JR Whiting Plant is located on Maumee Bay of Lake Erie in Michigan. A 3/8-inch mesh barrier net was deployed in 1980 as part of a best technology available determination by the Michigan Water Resources Commission. Estimates of impingement reductions were based on counts of fish impinged on the traveling screens inside the barrier net. Counts in years after the deployment were compared to data from the year immediately prior to the installation of the net when over 17 million fish were impinged. Four years after deployment, annual impingement totals had fallen by 98 percent.

Bowline Point

Bowline Point is located on the Hudson River in New York. A 150-foot long, 0.95-cm mesh net has been deployed in a V-shaped configuration around the intake pump house. The area of the river in which the intake is located has currents that are relatively stagnant, thus limiting the stresses to which the net might be subjected. Relatively low through-net velocities (0.5 fps) have been maintained across a large portion of the net because of low debris loadings. Debris loads directly affecting the net were reduced by including a debris boom outside the main net. An air bubbler was also added to the system to reduce the buildup of ice during cold months. The facility has attempted to evaluate the reduction in the rate of impingement by conducting various studies of the fish populations inside and outside the barrier net. Initial data were used to compare impingement rates from before and after deployment of the net and showed a deterrence of 91 percent for targeted species (white perch, striped bass, rainbow smelt, alewife, blueback herring, and American shad). In 1982 a population estimate determined that approximately 230,000 striped bass were present in the embayment outside the net area. A temporary mesh net was deployed across the embayment to prevent fish from leaving the area. A 9-day study found that only 1.6 percent of the estimated 230,000 fish were ultimately impinged on the traveling screens. A mark-recapture study that released individual fish inside and outside the barrier net showed similar results, with more than 99 percent of fish inside the net impinged and less than 3 percent of fish outside the net impinged. Gill net capture studies sought to estimate the relative population densities of fish species inside and outside the net. The results agreed with those of previous studies, showing that the net was maintaining a relatively low density of fish inside the net as compared to the outside.

Chalk Point

Chalk Point is located on the Patuxent River in Aquasco, Maryland. The facility began using barrier nets in 1982 to address problems with blue crab impingement. Initially, a single net was used, but a second net was later added to improve performance. Currently, the outer net has a 1.25 inch square mesh and the inner net has a 0.75 inch square mesh. Facility studies estimate a reduction in impingement of over 82 percent.

EPA conducted a site visit to Chalk Point in December 2007. See DCN 10-6504.

Dallman

Dallman is located on Lake Springfield in Springfield, Illinois. Since 1981, the facility has used a barrier net at the mouth of its intake canal to reduce impingement at the traveling screens. A study has shown a 90 percent reduction in impingement mortality.

6.4 Aquatic Filter Barrier

Aquatic Filter (or microfiltration) Barriers (AFBs), also known under the trade name "Gunderboom," are similar to barrier nets in that they extend throughout the area of water withdrawal from the bottom of the water column to the surface (see Exhibit 6-18). However, AFBs consists of fabric panels with very small pores (less than 20 microns or 0.02 mm) manufactured as a matting of minute unwoven fibers. The full water-depth filter curtain is suspended by flotation billets at the surface of the water and anchored to the substrate below. Gunderboom systems also employ an automated "air burst" system to periodically shake the material and pass air bubbles through the curtain system to clean off sediment buildup and release any other material back into the water column. AFBs reduce both impingement and entrainment because they present a physical barrier to all life stages. These systems can be floating, flexible, or fixed. Because these systems usually have such a large surface area, the velocities maintained at the face of the permeable curtain are very low. EPA was aware of one facility that uses an AFB, but notes that this facility recently ceased operations (for reasons unrelated to its use of its AFB).

Exhibit 6-18. Gunderboom at Lovett Generating Station (image from Gunderboom)[122]

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[122] http://www.gunderboom.com/images/lovett.jpg

6.4.1 Technology Performance

To date, the only facility where the Gunderboom was used at a full-scale level is the Lovett Generating Station along the Hudson River in New York, where pilot testing began in the mid-1990s. Initial testing at that facility showed significant potential for reducing entrainment. Entrainment reductions of up to 82 percent were observed for eggs and larvae, and these levels were maintained for extended month-to-month periods from 1999 through 2001. At Lovett, some operational difficulties affected long-term performance. These difficulties, including tearing, overtopping, and plugging/clogging, were addressed, to a large extent, through subsequent design modifications. Gunderboom, Inc. specifically has designed and installed a microburst cleaning system to remove particulates. As noted above, the Lovett Generating Station recently ceased operations.

Each of the challenges encountered at Lovett could be of significant concern at marine sites, as these have higher wave action and debris flows. Gunderboom systems have been successfully deployed in marine conditions to prevent migration of particulates and bacteria, including in areas with waves up to 5 feet. The Gunderboom system is being tested for potential use at the Contra Costa Plant along the San Joaquin River (a tidal river) in northern California. An additional question related to the utility of the Gunderboom and other microfiltration systems is sizing and the physical limitations and other uses of the source waterbody. With a 20-micron mesh, 144 mgd and 288 mgd intakes would require filter systems 500 and 1,000 feet long (assuming a 20-foot depth). In some locations, this may preclude the successful deployment of the system because of space limitations or conflicts with other waterbody uses.

AFBs have been installed at other sites for sediment control and exclusion of small debris. More recent improvements to AFBs have reduced the effect of wave action and debris (see DCN 10-6830).

6.4.2 Facilities Examples

As described above, the technology was installed at the Lovett Generating Station which has ceased operations. EPA is not aware of any other existing industrial facilities employing an AFB.

6.5 Offshore Intakes

The location of an intake inlet is important because those fish that are in close proximity to the inlet are the most likely to be impinged and entrained. And since within waterbodies the densities of fish may vary with location, the location can have an impact on impingement and entrainment. Intakes at a submerged offshore location can utilize various inlet designs including open pipe, perforated pipe, cribs, wedgewire screens, and velocity caps. Of these, only velocity caps and wedgewire screens are designed to reduce impingement. By design, velocity cap technology is limited to application at submerged intakes and is often used to enhance the performance of submerged intakes.[123] See Sections 6.2.6 and 6.2.7.2 for discussions of wedgewire screens.

6.5.1 Intake Location

There are certain areas within every waterbody with increased biological productivity, and therefore where the potential for I&E of organisms is higher. In large lakes and reservoirs, the littoral zone (the shore zone areas where light penetrates to the bottom) serves as the principal spawning and nursery area for most species of freshwater fish and is considered one of the most productive areas of the waterbody. Fish of this zone typically follow a spawning strategy wherein eggs are deposited in prepared nests, on the bottom, or are attached to submerged substrates where they incubate and hatch. As the larvae mature, some species disperse to the open water regions, whereas many others complete their life cycle in the littoral zone. Clearly, the impact potential for intakes located in the littoral zone of lakes and reservoirs is high. The profundal zone of lakes and reservoirs is the deeper, colder area of the waterbody. Rooted plants are absent because of insufficient light, and for the same reason, primary productivity is minimal. A well-oxygenated profundal zone can support benthic macroinvertebrates and cold-water fish; however, most of the fish species seek shallower areas to spawn (either in littoral areas or in adjacent streams and rivers). Use of the deepest open water region of a lake or reservoir (e.g., within the profundal zone) as a source of cooling water typically offers lower I&E impact potential than use of littoral zone waters.

As with lakes and reservoirs, rivers are managed for numerous benefits, which may include sustainable and robust fisheries. Unlike lakes and reservoirs, the hydrodynamics of rivers typically result in a mixed water column and overall unidirectional flow. There are many similarities in the reproductive strategies of shoreline fish populations in rivers and the reproductive strategies of fish within the littoral zone of lakes and reservoirs. Planktonic movement of eggs, larvae, post larvae, and early juvenile organisms along the shore zone is generally limited to relatively short distances. As a result, the shore zone placement of CWISs in rivers might potentially impact local spawning populations of fish. The impact potential associated with entrainment might be diminished if the main source of cooling water is recruited from near the bottom strata of the open water channel region of the river. With such an intake configuration, entrainment of shore zone eggs and larvae, as well as the near-surface drift community of ichthyoplankton, is minimized. Impacts could also be minimized by controlling the timing and frequency of withdrawals from rivers. In temperate regions, the number of entrainable or impingeable organisms of rivers increases during spring and summer (when many riverine fishes reproduce). The number of eggs and larvae peak at that time, whereas entrainment potential during the remainder of the year can be minimal.

In estuaries, species distribution and abundance are determined by a number of physical and chemical attributes, including geographic location, estuary origin (or type), salinity, temperature, oxygen, circulation (currents), and substrate. These factors, in conjunction

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[123] See below for the interaction of an offshore location and the use of a velocity cap. EPA has included a provision in the final rule that deems some facilities with these criteria as employing BTA for impingement.

with the degree of vertical and horizontal stratification (mixing) in the estuary, help dictate the spatial distribution and movement of estuarine organisms. With local knowledge of these characteristics, however, the entrainment effects of a CWIS could be minimized by adjusting the intake design to areas (e.g., depths) least likely to affect concentrated numbers and species of organisms. In oceans, nearshore coastal waters are typically the most biologically productive areas. The euphotic zone (zone light available for photosynthesis) typically does not extend beyond the first 100 meters (328 feet) of depth. Therefore, inshore waters are generally more productive due to photosynthetic activity and due to the input from estuaries and runoff of nutrients from land.

During the development of the Phase III rule, EPA obtained data on densities of ichthyoplankton in the Gulf of Mexico from the Southeast Area Monitoring and Assessment Program (SEAMAP). This long-term sampling program collects information on the density of fish larvae and eggs throughout the Gulf of Mexico.[124] EPA's analysis showed that in general, ichthyoplankton densities are highest at sampling stations in the shallower regions of the Gulf and lowest at sampling stations in the deepest regions. Over 600 different fish taxa were identified in the SEAMAP samples, including species of commercial and recreational value.

In the proposed Phase I rule, EPA examined the possibility of limiting intakes being located in the littoral zone as a regulatory approach.[125] The Office of Naval Research defines the littoral zone (for oceans) to extend 600 feet from shore.[126] Other organizations also recognize the value of locating an intake in less productive waters.[127]

There are only limited published data, however, quantifying the locational differences in I&E rates at individual power plants. Some information, however, is available for selected sites. For example:

- For the St. Lucie plant in Florida, EPA Region 4 permitted the use of a once through cooling system instead of closed-cycle cooling by locating the outfall 1,200 feet offshore (with a velocity cap) in the Atlantic Ocean. This approach avoided impacts on the biologically sensitive Indian River estuary.
- In *Entrainment of Fish Larvae and Eggs on the Great Lakes, with Special Reference to the D.C. Cook Nuclear Plant, Southeastern Lake Michigan* (1976) (DCN 8-5249), researchers noted that larval abundance is greatest within the area from the 12.2-m (40-ft) contour to shore in Lake Michigan and that the abundance of larvae tends to decrease as one proceeds deeper and farther offshore. This finding led to the suggestion of locating CWISs in deep waters.
- During biological studies near the Fort Calhoun Power Station along the Missouri River, results of transect studies indicated significantly higher fish larvae densities

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[124] EPA analyzed SEAMAP data in considering requirements for offshore facilities in the Phase III rule. While this data is not directly relevant to existing facilities subject to the existing facility rule, it does offer similar insights to the importance of intake location. See 71 FR 35013.

[125] See 65 FR 49116 (August 10, 2000) for the proposed definition; generally speaking, the littoral zone is regarded as a highly productive area in fresh and marine waters.

[126] See http://www.onr.navy.mil/focus/ocean/regions/littoralzone1.htm.

[127] See http://www.watereuse.org/sites/default/files/u8/IE_White_Paper.pdf. DCN 12-6848.

along the cutting bank of the river, adjacent to the station's intake structure. Densities were generally were lowest in the middle of the channel.

- Wisconsin Energy's Elm Road facility was recently constructed with a submerged intake 1.5 miles offshore at a depth of 43 feet. The facility is using coarse mesh cylindrical wedgewire screens with a through-slot velocity of 0.5 fps.

As discussed above, intake location can play an important role in determining the potential for impingement and entrainment. However, for existing facilities, changing the intake location is very limited in practice; many facilities simply do not have the option available to them and when available, intake relocation tends to be among the most expensive alternatives. Selecting an appropriate intake location is best considered when siting a new intake or new facility.

6.5.2 Velocity Cap

Many offshore intakes are fitted with a velocity cap, a physical structure rising vertically from the sea bottom and placed over the top of the intake pipe. Intake water is withdrawn horizontally through openings in the velocity cap, converting the flow from a vertical direction to a horizontal one at the entrance to the intake (see Exhibits 6-19 and 6-20). The horizontal flow provides a physiological trigger in fish to induce an avoidance response thereby reducing impingement mortality. Velocity caps are also configured with supports and bar spacing designed to prevent larger aquatic organisms from entering the intake pipe and swimming to the forebay. Of the 766 existing facility intakes that were reported in the detailed questionnaires, velocity caps are used by at least 14 facilities. Velocity caps are sometimes used in combination with other technologies to optimize performance; often, the offshore intake will send water to a forebay at the shoreline, where a second CWIS with traditional traveling screens will further screen the cooling water. Because velocity caps operate under the principle that the organisms can escape the current, velocity caps alone do not offer a reduction in entrainment.

However, velocity caps also work to minimize impingement and entrainment by virtue of their location far offshore.[128] In some waterbodies, shoreline locations are thought to have the potential for greater environmental impact because the water is withdrawn from the most biologically productive areas. As such, some facilities elect to employ an offshore intake to withdraw from less productive areas in an effort to minimize impingement and entrainment. Depth of the offshore intake is also a consideration as deeper waters are often less biologically productive. Distance offshore and depth are very site-specific variables and must be carefully evaluated prior to siting the offshore intake.[129] When compared with a shoreline intake, an offshore location may reduce overall impingement and entrainment rates but may also alter the impingement and entrainment species profile.

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[128] Refer to DCN 12-6601 and the preamble for a discussion of how EPA concluded that existing velocity caps that meet certain criteria were determined to meet the impingement requirements of the final rule, including an analysis of data for offshore locations, velocity caps, and the combination of the two technologies.

[129] The section on intake location previously in this chapter discusses these factors.

Exhibit 6-19. Velocity cap diagram

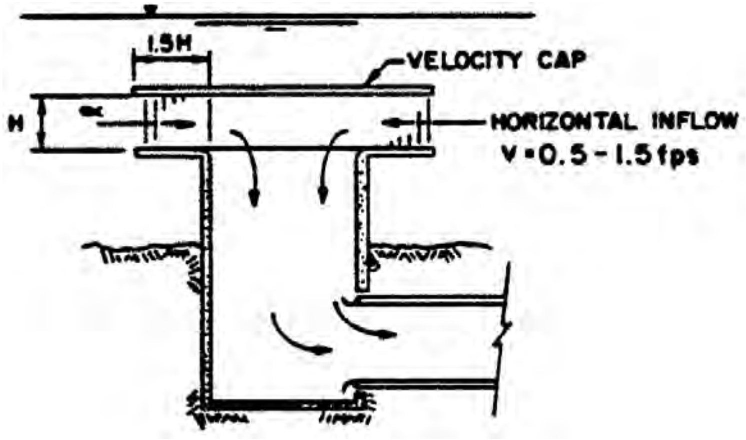
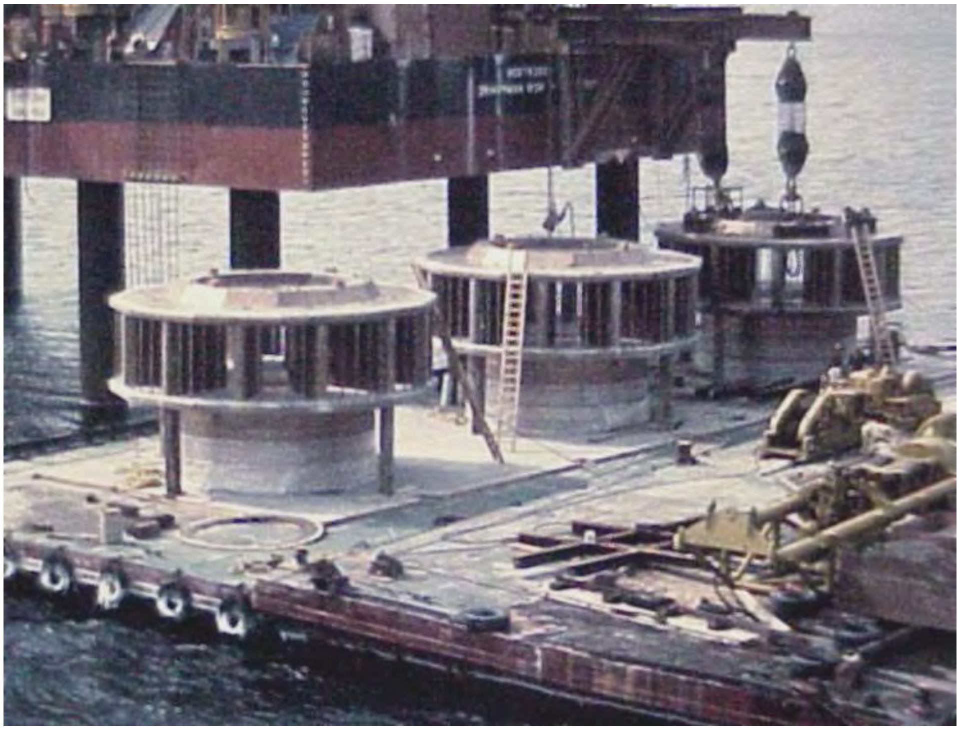


Exhibit 6-20. Velocity caps prior to installation at Seabrook Generating Station (Seabrook, NH)



6.5.3 Technology Performance

Relocating an intake from a shoreline location to a submerged offshore location can result in lower impingement and entrainment depending on the site-specific biological characteristics of the source waterbody. Impingement and entrainment reductions associated with location alone are difficult to establish because they require either the presence of both a shoreline intake and a submerged offshore intake without a velocity cap at the same facility or the collection of fish density data within the water at separate locations. Impingeable fish data was available from two facilities. One was for intakes located 850 ft. offshore in 22 ft. deep water in Lake Ontario and the other was located 1,200 ft. offshore in the Atlantic Ocean in 24 ft. deep water. Two estimates are provided for the second location. In both instances, the impingement reduction estimates are developed by comparing fish density data from gill net sampling conducted close to shore and close to the submerged intake. These limited data suggest that location alone can account for 60 percent to 73 percent reduction in impingement. However, it is not clear how this data relates to other waterbodies. These data suggest that impingement reductions associated with a submerged offshore location alone may not be sufficient to meet impingement standards.

Velocity caps reduce the number of fish drawn into intakes based on the concept that fish tend to avoid rapid changes in horizontal flow. This technology does not reduce entrainment of free-floating eggs and larvae, which are unable to distinguish flow characteristics or have sufficient swimming ability to avoid them. Estimates of the performance of the velocity cap alone involve comparing the performance of separate intakes located in the same general area or comparing the performance of the same intake with and without the velocity cap. Seven sets of impingement performance data for the velocity cap alone were available. For three of the intakes located in the Pacific Ocean in California, performance was evaluated by reversing the flow between the intake and the heated water discharge pipes, which are also located submerged far offshore and are open pipes (i.e., have no screening technology). For two intakes, data were collected before and after velocity caps were installed or replaced. For two intakes, data were collected for separate intakes located in the same general area. The summary data indicate that velocity caps alone can reduce impingement by 50 percent to 97 percent with an average of 78 percent and median of 82 percent. This data suggests that in more than half of the velocity caps evaluated the velocity caps alone may provide sufficient impingement reduction to meet the impingement reduction standard; however, for some intakes, the velocity cap alone may not be sufficient.

At Huntington Beach and El Segundo in California, velocity caps have been found to provide 80 to 90 percent reductions in fish entrapment.[130] (See DCN 10-6603 for more information.) At Seabrook Station in New Hampshire, the velocity cap on the offshore intake has minimized the number of pelagic fish entrapped except for Pollock with an estimated reduction for location and velocity cap combined of 76 percent based on comparison to the Pilgrim plant located 65 miles away. Two facilities in England each have velocity caps on one of two intakes. At the Sizewell Power Station, intake B has a velocity cap, which reduces impingement about 50 percent compared to intake A. Similarly, at the Dungeness Power Station, intake B has a velocity cap, which reduces impingement about by 62 percent compared to intake A.

Impingement reductions observed at velocity cap facilities along the southern California Bight have been generally been significant, with overall reductions ranging from 65 to 95 percent. These reduction values must be qualified, however, based on the methods

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[130] Entrapment refers to the number of impingeable fish drawn into the velocity cap. Under most circumstances, these organisms will eventually be impinged on the traveling screens at the facility.

used to collect and analyze the samples as well as the species on which the reduction is calculated. Earlier studies, such as the 1985 El Segundo report, tended to focus on commercially and recreationally important species only, leaving aside forage species that were presumed to be of little value at the time.

Velocity cap performance may vary significantly based on temporal or local factors. Significant diurnal fluctuations in impingement rates have been observed with nighttime performance often well below daytime values. At Huntington Beach Generating Station, for example, observed impingement rates were 12 to 37 percent higher during nighttime collection.

In addition, there are several factors that may influence velocity cap effectiveness and may be unique to southern California's facilities:

- It is worth nothing that coastal waters along the southern California Bight are subject to short and long-term periodic shifts in ocean temperatures that can affect the number and composition of species potentially affected by the intake. Two major climatic factors, the Pacific Decadal Oscillation (PDO) and the El Niño Southern Oscillation (ENSO), can significantly raise or lower water temperatures compared with long-term averages. During the El Niño phase of the ENSO, warmer waters from the south generally replace the cooler water of the California Current along the bight. During the La Niña phase, the pattern may shift and result in colder than normal temperatures. Each shift has the potential to alter the species mix in the vicinity of the intake, with El Niño cycles driving cold water species further from shore and into areas where they may be affected by the intakes. Effects of El Niño/La Niña events may be magnified or moderated depending on the concurring phase of the PDO, which may take 20-30 years to complete a full cycle. Temperatures may fluctuate by 2.5° F or more during the event peaks. Comparisons between historical and current information do show differences in species abundance, although a direct correlation is difficult.
- Benefits of offshore intakes with respect to entrainment have not been studied in as much detail as impingement, although recent sampling efforts by several facilities offer a substantial data set from which entrainment reductions may be calculated.
- At least one of southern California's coastal facilities with offshore intakes is located in areas with rocky substrates that support giant kelp forests. These kelp forests support larger nursery and spawning areas offshore than are generally found off the Atlantic coast.

The impingement reduction performance of intakes submerged far offshore with velocity caps is dependent on site-specific conditions. The available data suggests that locating an intake far offshore alone may not result in compliance with the impingement reduction standard. The available data also suggests that velocity caps alone may result in compliance but not in all cases. However, the data strongly supports an assumption that the combination of locating an intake far offshore (i.e., a minimum distance of 850 feet) in combination with use of a velocity cap will result in compliance with the impingement standard, especially in instances where an there is an expectation that the selected offshore location will result in reduced impingement compared to an intake located on the shore line. See the preamble and DCN12-6601for more information.

6.5.4 Facility Examples

Huntington Beach Generating Station

Huntington Beach has one intake (equipped with a velocity cap) located 1,500 feet from shore in Pacific Ocean. The intake is approximately 18 feet below Mean Lower Low Water (MLLW) and 5 feet above intake riser. The initial study was conducted by the University of Washington from 1978 through 1979. Velocity cap performance was calculated by comparing the relative impingement rates of a capped versus uncapped intake. This was done by reversing the intake and discharge locations, both of which are located offshore in the same general area. Results from the comparative tests showed the velocity cap was effective in reducing impingement by as much as 99 percent during the day but as low as 53 percent at night. Overall effectiveness averaged 82 percent for all sampling events regardless of time. As part of its NPDES permit requirements, the facility has continued impingement monitoring during all heat treatments and representative operating periods.

Entrainment analyses were not conducted at Huntington Beach in the late 1970s. Rather, data collected at two other SCE facilities (Ormond Beach and SONGS) were used to extrapolate Huntington Beach entrainment rates based on local conditions. Entrainment performance was not calculated because source water references were not developed on which any reduction could be based.

Huntington Beach conducted additional entrainment sampling in 2003 and 2004 as part of its relicensing agreement with the State. These samples included source water abundance monitoring at several reference monitoring stations located near the intake and along the shoreline. Because these data were considered representative of current conditions, Huntington Beach did not collect additional data in order to comply with requirements for the Comprehensive Demonstration Study (CDS) under the 2004 Phase II rule.

Various models were used to estimate entrainment impacts relative to the source water. Several models were used to assess entrainment data, including adult equivalent loss (AEL) model, fecundity hindcasting (FH), and empirical transport model (ETM); the latter was used to estimate the percent mortality, which, in turn, provided the basis for acres of production foregone (APF) estimates. Huntington Beach proposed to use this method to determine the calculation baseline and any existing design credits under the 2004 Phase II rule.

Huntington Beach concluded that I&E impacts were not significant. Presumably, data collected in 2003 and 2004 would be able to show entrainment rates relative to the source waterbody abundance. Huntington Beach also conducted an entrainment survival study (through condenser) in 2004.

Scattergood Generating Station

Scattergood has one velocity cap located 1,600 feet from shore in Santa Monica Bay, approximately 17 feet below MLLW. Site-specific evaluations of the velocity cap's impingement performance were first conducted in the early 1970s when a storm damaged the original velocity cap. The cap was removed and, at the request of California Department of Fish and Game, left off so as to allow a comparison of impingement rates between the capped and uncapped intake. The facility estimated the velocity cap's impingement reduction effectiveness at 83 percent compared with the uncapped intake. As part of its NPDES permit requirements, the facility has continued impingement monitoring during all heat treatments and representative operating periods. A 2006 study again compared the performance of a capped versus uncapped intake by reversing the operating flows; effectiveness was calculated at 95 percent using a biomass metric and more than 97 percent based on abundance.

Entrainment analyses at Scattergood were first conducted in 1978 and sampled commercially and recreationally important species, as well as several forage species. The study also examined the entrainment of invertebrate zooplankton. As part of its 2004 Phase II CDS compliance requirement, Scattergood conducted additional entrainment monitoring in 2006. Samples were collected from several reference stations along the shoreline and in the vicinity of the intake structure. In contrast to the 1978 efforts, all taxa were identified as accurately as possible.

Various models were used to estimate entrainment impacts relative to the source water. Several models were used to assess entrainment data, including adult equivalent loss (AEL) model, fecundity hindcasting (FH), and empirical transport model (ETM); the latter was used to estimate the percent mortality, which, in turn, provided the basis for acres of production foregone (APF) estimates. Scattergood proposed to use this method to determine the calculation baseline and any existing design credits under the 2004 Phase II rule. An aggregate "percent reduction" value is not explicitly presented in the final report, although raw data are available from both the intake and reference stations that would enable such a determination.

Scattergood bases its discussion of entrainment impacts on guidelines set forth in EPA's 1977 guidance document, which categorizes AEI as significant or insignificant relative to the known source populations. Scattergood concludes that the current intake's impacts are insignificant.

EPA conducted a site visit to Scattergood in August 2009. See DCN 10-6545.

El Segundo Generating Station

El Segundo has two intakes with velocity caps, located 2,600 feet from shore in Santa Monica Bay, but only one is currently operational. The velocity caps are approximately 15 feet below MLLW.

The original velocity cap effectiveness study at El Segundo was conducted in 1958 and consisted of a full year of impingement monitoring before and after the velocity cap was installed, showing an impingement reduction of 95 percent.

Entrainment analyses were not conducted at El Segundo in the late 1970s. Rather, data collected at Ormond Beach were used to extrapolate El Segundo's entrainment rates based on local conditions. These data are not considered reliable for El Segundo because of the distance separating the two facilities (60 miles) and the sample collection and analysis methods used that the time. Entrainment performance was not calculated because source water references were not developed on which a reduction could be based.

El Segundo did conduct additional entrainment monitoring as part of its 2004 Phase II CDS. Samples were collected at several reference monitoring stations along the shoreline, further offshore, and in the vicinity of the intake. [131] Total entrainment values were estimated based on actual and design flows.

Various models were used to estimate entrainment impacts relative to the source water. Several models were used to assess entrainment data, including adult equivalent loss (AEL) model, fecundity hindcasting (FH), and empirical transport model (ETM); the latter was used to estimate the percent mortality, which, in turn, provided the basis for acres of production foregone (APF) estimates. El Segundo proposed to use this method to determine the calculation baseline and any existing design credits under the 2004 Phase II rule.

El Segundo bases its discussion of entrainment impacts on guidelines set forth in EPA's 1977 guidance document, which categorizes AEI as significant or insignificant relative to the known source populations. El Segundo concludes that the current intake's impacts are insignificant.

EPA conducted a site visit to El Segundo in September 2009. See DCN 10-6552.

6.6 Other Technologies and Operational Measures

6.6.1 Physical Design

Several factors that are not directly related to the actual screen may play a significant role in determining how many fish and shellfish are susceptible to impingement before coming in contact with the screens. A comprehensive design approach that carefully considers these factors prior to installing a screen system may yield significant benefits. At existing facilities, however, many of these modifications are more problematic due to space constraints and interference with existing systems, and may not be practical options given their cost and complexity. One such factor, intake location, is discussed separately under Section 6.5.1.

6.6.1.1 Intake Screen Orientation

An intake screen's orientation, specifically the angle at which it is offset from the prevailing intake current, has been shown to aid motile fish from avoiding intake screens

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[131] The velocity cap transports water from offshore to a forebay, which is an area of water storage from which conventional intake technologies (such as traveling screens and circulating water pumps) withdraw cooling water for use in the facility.

altogether. Together with man-made guiding structures or diversions, angled screens minimize the initial impingement potential by diverting fish away from the screens to an escape area or removal system such as a fish elevator or pump. Angled screening systems have been effective in reducing impingement at SONGS, Oswego Harbor, and Brayton Point, and can be modified to include modified Ristroph traveling screen design elements to further reduce impingement mortality. These systems are not common, however, and EPA did not examine this technology in detail nor study its performance.

6.6.1.2 Behavioral Triggers and Obstacles

A CWIS's initial design and configuration may unintentionally create artificial localized environments that trigger behavioral responses in fish and may disorient or physically affect them such that they become more susceptible to impingement. The CWIS's induced flow may create shifting currents or quiescent zones leading to fish congregation in critical areas. Man-made structures such as submerged conduits or artificial coves may remove natural signals that allow fish to navigate and escape the intake flow.

At Moss Landing Power Plant in California, traveling screens were located at the end of a 300-foot submerged conduit, leaving many fish disoriented in total darkness and unable to escape despite their physical ability to outswim the current. Many of these fish ultimately tired and died on the traveling screens. The traveling screens were moved to the upstream entrance eliminating the potential for entrapment in the dark conduit. The facility reported a substantial decrease in the number of fish impinged on the screens.

6.6.2 Reduce Intake Velocity

Intake velocity may be categorized into two types: approach and through-screen. The approach velocity is generally defined as the localized velocity component perpendicular to the screen face measured at a distance from the screen (often three inches) or if the intake does not have a screen; it may be measured at the opening of the intake. Through-screen velocity, as the term implies, is the velocity of water passing through the screen mesh openings. This is difficult to measure in the field, but a reasonable velocity estimate can be calculated by dividing the intake structure's flow rate by the total screen open area submerged in the water column. Changes to either the water depth (tidal cycles or seasonal flooding) or screen open area (from fouling or clogging) affects both velocity values if the same intake flow is maintained. Likewise, sedimentation in front of the screens or intake structure constricts the flow channel and increases the approach velocity.

The relationship between intake velocity and impingement is well-established since EPA's Phase I rule (66 FR 65256). Impingement mortality can be greatly reduced by reducing the through-screen velocity in any screen. EPA compiled fish swimming speed data as it varies with the length of the tested fish and with water temperature into the graph presented in Exhibit 6-21[132]. These data show that a 1.0 fps velocity standard would protect 78 percent of the tested fish, and a 0.5 fps velocity would protect 96 percent of these fish.[133] For some

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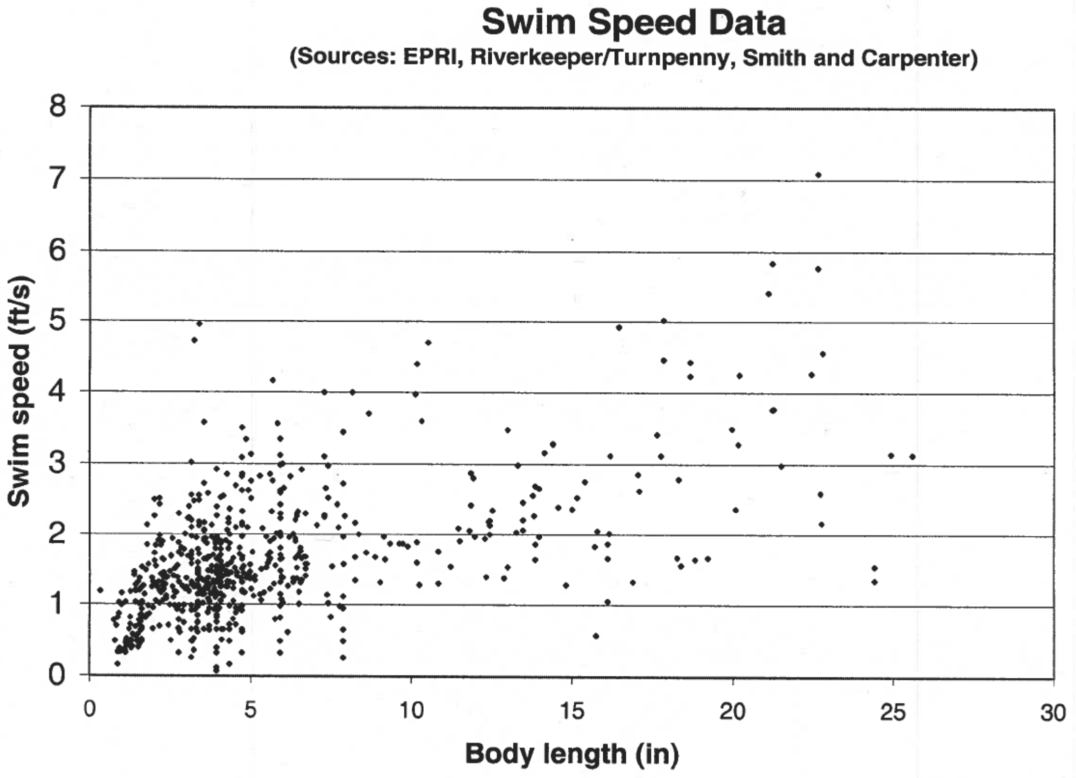
[132] This graph was originally developed in support of 316(b) Phase I and was presented in DCN 2-029 in the Phase I Docket)

[133] 66 FR 28864 (May 25, 2001).

species, a velocity less than 0.5 fps is necessary, e.g., the State of Alaska requires a velocity limit of 0.1 fps to protect salmonids.[134] Since screen fouling can increase the velocity in the screen areas that remain open, EPA concluded that a through-screen velocity of 1.0 fps may not be protective under the expected range of operating conditions and that a through-screen velocity of 0.5 fps would provide a reasonable safety margin. (See DCN 2-028A EPRI Technical Evaluation of the Utility of Intake Approach Velocity as an Indicator of Potential Adverse Environmental Impact Under Clean Water Act 316(b).) As a result, many existing facilities have designed and operate their modified traveling screens or wedgewire screens so as not to exceed a through-screen velocity of 0.5 fps. Reducing the intake velocity generally does not similarly reduce entrainment.

Exhibit 6-21. Graph of Swim Speed versus Body Length



6.6.3 Substratum Intakes

Studies and pilot projects are being conducted to investigate the viability of subsurface or substratum cooling water intake structures, also known as filter beds. Historically, substratum intakes have only been seriously considered for low flow facilities, smaller than 1 mgd. Desalination drinking water facilities appear to be the predominant industry utilizing substratum intakes in their operations. While extant in the United States, operation of desalination facilities has so far been concentrated in Europe, North Africa, and the Middle East. Some non-desalination drinking water facilities also use substratum

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[134] See DCN 1-5015-PR in the Phase I docket.

water intakes. These facilities most commonly make use of vertical or horizontal beach wells, which are shallow shoreline intake wells that use the overlying rock or sand layers as a filter medium. Early investigations for use as cooling water intake structures have yielded positive results, including 100 percent reduction of impingement and entrainment. See DCN 10-6609 for more information.

A pilot study using a substratum intake was planned for 2008 for a site in New York to withdraw about 245 mgd to operate a 400 MW power plant. The substratum intake was expected to eliminate impingement and entrainment, and offer other benefits by reducing operations and maintenance costs, requiring minimal downtime at installation, and reducing fuel use in the summer. No information about the progress or results of this pilot study is currently available.

6.6.4 Louvers

Louver systems are comprised of a series of vertical panels placed at an angle to the direction of the flow (typically 15 to 20 degrees). Each panel is placed at an angle of 90 degrees to the direction of the flow (Hadderingh 1979). The louver panels provide an abrupt change in both the flow direction and velocity. This creates a barrier that fish can sense and avoid. Once the change in flow/velocity is sensed by fish, they typically align with the direction of the current and move away laterally from the turbulence. This behavior further guides fish into a current created by the system, which is parallel to the face of the louvers. This current pulls the fish along the line of the louvers until they enter a fish bypass or other fish handling device at the end of the louver line. The louvers may be either fixed or rotated similar to a traveling screen. Flow straighteners are frequently placed behind the louver systems.

In its 2007 *Fish Protection at Cooling Water Intake Structures: A Technical Reference Manual,* EPRI concluded that the technology has produced variable results, but that well-performing louvers can divert over 80 percent of fish to a bypass. Louvers have also not been widely employed at power plant intakes; most installations are at hydroelectric or irrigation facilities.

While showing some promise for diverting fish (thereby reducing impingement), louvers have not been widely used at power plants and have a very limited history of successful deployment. Therefore, EPA has determined that this technology is unlikely to be utilized by many existing facilities.

6.6.5 Behavioral Technologies

This category encompasses a wide range of technologies that utilize behavioral responses in fish to induce an avoidance response and prevent the organism from entering the intake structure. There are numerous examples: sound barriers, air bubbles curtains, strobe or colored lights, chain link walls, and electric barriers. See Chapter 4 of the 2004 Phase II TDD for additional information.

Generally speaking, behavioral technologies have shown some ability to reduce impingement. (These technologies are not effective for entrainment.) EPA analyzed data from a number of studies in developing the impingement mortality standards; see Chapter 11 of this TDD. However, the performance tends to be species-specific; for example, certain frequencies of sound are most effective for a certain fish species. This characteristic makes these technologies difficult to employ on a wide scale, given that the goal of the final rule is to reduce impingement of all species. Additionally, behavioral technologies are not widely used. As a result, EPA did not study this class of technologies any further.

6.7 Summary of Technology Performance

Exhibit 6-22 presents a qualitative graphical representation of the relative impingement mortality reduction performance of many of the technologies described above that are capable of reducing impingement mortality. The values shown are representative of the median value and range of typical performance for properly-designed and well-operated systems. Some performance studies are estimates only, and care should be taken not to use this plot as a rigorous analysis of performance, but rather as a tool to show relative performance. As can be seen, many technologies exhibited similar or better performance than modified traveling screens (the selected BTA technology) but may be subject to differences in availability.

Exhibit 6-22. Relative Technology Performance for Impingement Mortality Reduction

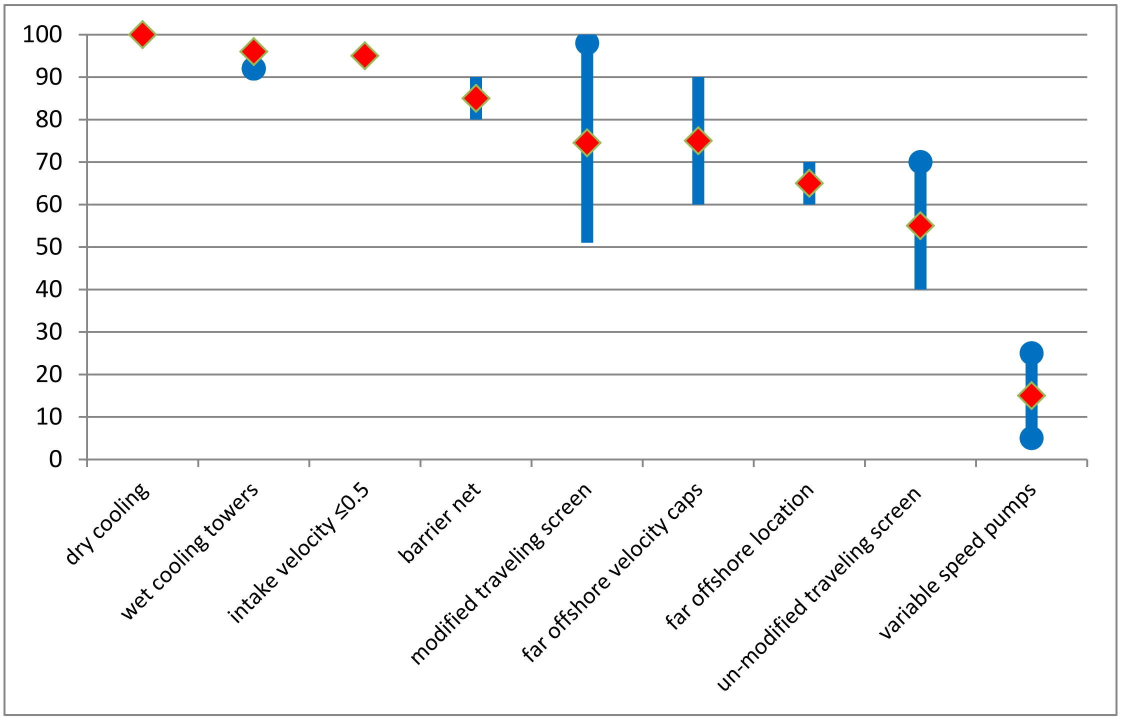
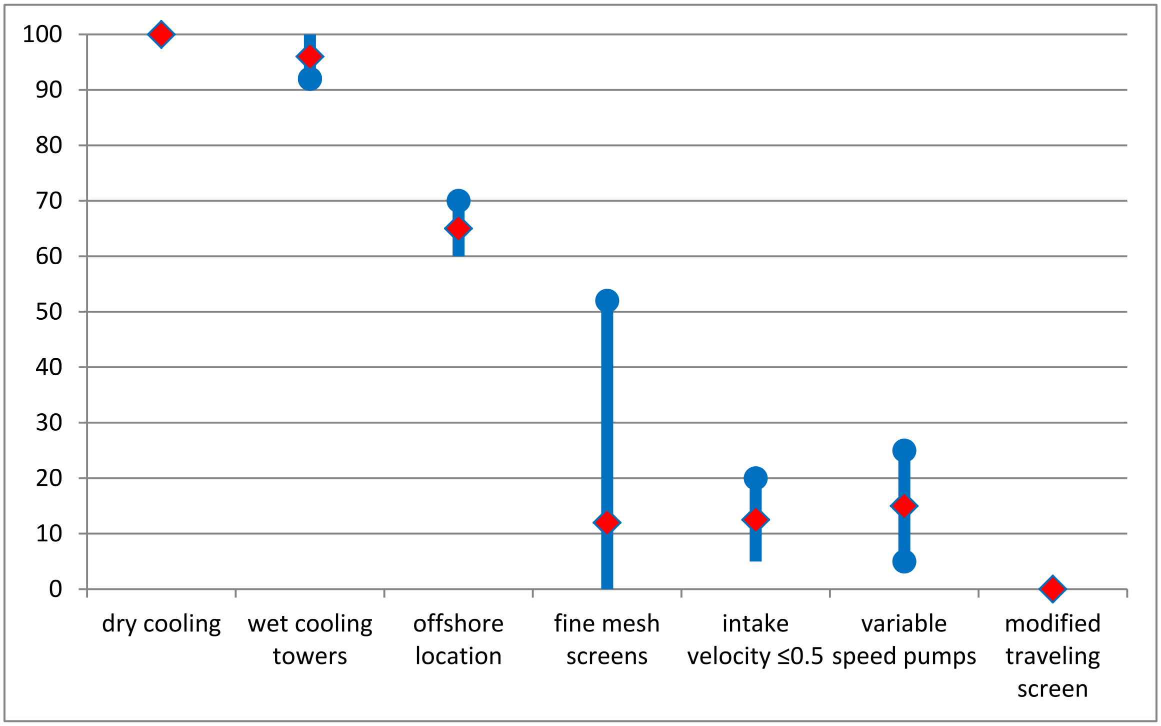


Exhibit 6-23 presents a similar graphical representation of the relative entrainment reduction performance of many of the technologies described above that are capable of reducing entrainment. Flow reduction via dry or wet cooling is clearly effective at reducing entrainment. Submerged offshore intakes can also provide moderate reductions in entrainment but the effectiveness and availability has limitations and the range of reductions shown in Exhibit 6-23 is limited to sites with favorable conditions such as relatively deep water applications in oceans and Great Lakes. Exhibit 6-23 shows that there are fewer high performing technologies that reliably reduce entrainment and all are subject to varying degrees of availability. Fine mesh screens are somewhat different from the other technologies shown in Exhibit 6-23, as entrainment exclusion may approach 90 percent, but entrainment survival may approach 0 percent. As discussed earlier in this chapter, the mean entrainment survival for 2 mm fine mesh is 12 percent, and therefore in most cases this would not be considered a high performing technology.

Exhibit 6-23. Relative Technology Performance for Entrainment Reduction



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Chapter 7: Regulatory Options

7.0 Introduction

This chapter briefly discusses the technology bases and regulatory options EPA considered for impingement and entrainment reduction controls. In the proposed rule, EPA discussed four primary options. EPA also described additional options being considered for impingement mortality controls to provide facilities greater flexibility in achieving a BTA impingement mortality standard in its June 11, 2012 NODA (77 FR 34317). After a careful review of these proposed options, additional data, and public comments on both the proposed rule and the two NODAs, EPA has opted to promulgate BTA standards for the final rule that are similar to, but a modification of, Proposal Option 1. The rule establishes the following BTA standards for Impingement Mortality and Entrainment: Uniform Impingement Mortality Controls at All Existing Facilities that withdraw over 2 mgd DIF; an Entrainment Standard based on Site-Specific Entrainment Controls determined by the EPA or the State NPDES permitting authority for Existing Facilities (other than New Units) that withdraw over 2 mgd DIF; Uniform Impingement Mortality and Entrainment Controls for All New Units at Existing Facilities. Refer to the preamble for a discussion of how the final rule varies from Proposal Option 1, as well as EPA's rationale for selecting this option for the final rule. Other options considered are described here.

7.1 Technology Basis Considered for the Proposed Regulation

As described in the preamble, EPA examined the full range of technologies that reduce impingement or entrainment or both, and evaluated these technologies on the basis of their efficacy in reducing impingement and entrainment, and their availability, which includes feasibility and cost. From an assessment of these factors, EPA identified two best performing technologies as the basis for today's final rule: modified traveling screens with a fish-friendly fish return for impingement at existing facilities, and mechanical draft wet cooling system for impingement and entrainment at new units.[135]

EPA did not identify any single technology or group of technology controls that it concluded were available and feasible as the basis for establishing the national performance standard for entrainment at existing facilities. Instead, EPA's national BTA entrainment standard puts in place a framework for establishing entrainment requirements on a site-specific basis. The framework includes the factors that must be considered in the Director's determination of the appropriate BTA controls as well as the standard for determining when an otherwise affordable control technology may be rejected as the basis for the BTA standard. As described in the preamble, other technologies are

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[135] EPA identified a number of other technologies that can also be effective (e.g., reduced velocity, offshore velocity cap) and has acknowledged this performance in creating several new compliance options in the final rule. However, these technologies are not widely available or feasible at most sites, and therefore are not part of the technology basis for the final rule.

demonstrated, but they are neither the best performing nor available technologies for the industry as a whole.

7.1.1 Impingement Mortality Standards for Existing Facilities

EPA has concluded that modified traveling screens, such as modified Ristroph screens and equivalent modified traveling screens with fish-friendly fish returns, are a best performing technology for impingement mortality. EPA based the BTA impingement mortality standard for existing units on the performance of traveling screens because EPA concluded that this technology is effective, widely available, feasible, and does not lead to unacceptable non-water quality impacts. These screens use 3/8 inch, or similar, mesh with collection buckets designed to minimize turbulence, a fish guard rail/barrier to prevent fish from escaping the collection bucket; “fish-friendly,” smooth, woven or synthetic mesh; and a low-pressure wash to remove fish before any high-pressure spray to remove debris. The fish removal spray must be of lower pressure, and the fish return must be fish friendly, such as providing sufficient water and minimizing turbulence, as well as return to the source water body in a manner that does not promote predation or re-impingement. Modified traveling screens generally must be rotated continually, which minimizes aquatic exposure to impingement or to the air, and thus obtains the best survival rates (correspondingly the highest reductions in impingement mortality).

Under one compliance option for impingement in the final rule, a facility may choose any technology and then must conduct biological compliance monitoring to demonstrate the 12 month percent impingement mortality performance standard is achieved. As discussed in Chapter 11 (see, for example, Exhibits 11-1 and 11-3), EPA based the impingement mortality standard at 40 CFR 125.94(c) on data from facilities with traveling screens modified with features to improve the post-impingement survival of organisms such as smooth mesh, continuous or near-continuous rotation of the screens, buckets with guard rails, low pressure sprays for collecting fish, and fish return systems. The statistical basis for the impingement mortality standard includes 22 annual averages across 17 facilities demonstrating average impingement mortality rates ranging from 1.6 to 48.8 percent under conditions of 18 to 96 hour holding times. EPA established the 12 month percent impingement mortality performance standard as 24 percent which is the arithmetic average of the impingement mortality rates from the 17 facilities. (This is consistent with EPA’s proposed rule use of expected value of the beta distribution which can be calculated as the arithmetic average.) EPA has occasionally used average annual limitations in the effluent guidelines program, most recently for the pulp and paper industry category (40 CFR 430, promulgated in 1998). In such instances, EPA has defined the annual average limitations to be the average level demonstrated by the technology. Thus, EPA’s approach to calculating the 12 month standard for impingement mortality is consistent with past practice.

EPA recognizes that variability in the technology performance occurs due to changes in seasons, differing intake locations, higher mortality of certain species, and speciation found in different water bodies. EPA has incorporated variability into the 12 month average impingement mortality standard by basing its value on the actual data from 17 facilities which collectively performed more than 1,500 sampling events beginning as early as 1977. EPA notes that seven facilities had mortality rates less than 10 percent which provides evidence that facilities can, and have, maintained and operated their systems in a manner consistent with the standard. Another four facilities demonstrated impingement mortality rates significantly greater than the standard of 24 percent, however, EPA notes these facilities were not required to optimize their technology performance as part of their study, and data collection was not required to achieve a certain level of performance.[136] In each study, EPA has identified elements of the technology operation that a facility could modify to achieve the impingement mortality standard. By using the average annual performance, EPA has ensured that the resulting standard reflects the widest range of potential conditions present in EPA's database. In addition to those studies meeting the criteria for use in the 12 month standard calculations, there are further studies in EPA's record that provide additional performance data showing facilities can, and have, maintained and operated their systems in a manner consistent with the standard. EPA's record includes approximately 250 total studies related to impingement (see TDD Exhibit 11A-1).

As explained in more detail in the preamble, the BTA technology for impingement does not minimize adverse environmental impacts associated with entrainment.

7.1.2 Entrainment Standards for Existing Units

As discussed in Chapter 6 EPA's analysis of technology performance data identified three technologies that performed well enough to serve as potential candidate best performing technologies for establishing BTA entrainment standards: dry cooling; wet closed-cycle cooling; and far offshore intake. As discussed in the preamble, EPA is not basing BTA for entrainment at existing units (that is, excluding new units at existing facilities) on a single technology such as closed-cycle recirculating cooling systems, the best performing technology, because this technology is not available nationally. Although EPA's record shows numerous instances of existing units that have performed a retrofit to closed-cycle, EPA has not identified it as BTA. The availability of dry cooling is even more restricted than wet closed-cycle cooling due to higher costs, higher turbine efficiency penalties, and technical limitations (see Chapter 6). EPA also has not identified any other available and demonstrated candidate technology for entrainment reduction that is available nationally. For other entrainment technologies that might be available on a site-specific basis, see the preamble and Chapter 6 of the TDD. EPA did not select the other flow-reduction technologies (such as variable-speed drives and seasonal flow reductions) as the technology basis for entrainment control measures because these technologies are not uniformly best performing and are not broadly available for most facilities. Further, EPA has not identified a basis for subcategorizing existing units at which flow reduction technologies are feasible. The availability and utility to a given facility of flow reduction methods depends on site-specific geographical and biological conditions as well as operations of the facility. For example, this is the reason that EPA

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[136] For example, the Indian Point study states "Because of the preliminary nature of this study, the effectiveness of the continuously operating fine mesh traveling screen has not been fully evaluated. Further studies incorporating controls for survival testing, regulation of spray wash pressures, collection efficiency tests, sampling during peak impingement periods for all important species, and better holding facilities, will provide more conclusive results."

did not select relocation of a shoreline intake to far offshore as a technology basis for the BTA entrainment standard because this technology is not widely available for most facilities.

7.1.3 Impingement and Entrainment Standards for New Units at Existing Facilities

In contrast to existing units, installing a closed-cycle cooling system at a new unit is far less complex. The technology is also highly effective, as mechanical draft (wet) cooling towers achieve flow reductions of 97.5 percent for freshwater and 94.9 percent for saltwater sources by operating the towers at a minimum of 3.0 and 1.5 COC, respectively. These reductions in flow (and the concurrent reductions in impingement and entrainment impacts) are among the highest reductions in impact possible at an intake structure.

As described in the preamble, EPA has concluded that new units, in contrast to existing units, have much greater flexibility in terms of cooling system design, construction scheduling, and other factors that help minimize many of the negative aspects associated with closed-cycle cooling.

On the basis of the high levels (greater than 95 percent on average) of flow reduction obtained by optimized cooling tower operation and the availability, feasibility and affordability of closed-cycle cooling at new units, EPA has identified wet cooling systems as the best performing technology for both impingement mortality and entrainment for new units at existing facilities.

7.2 Options Considered

EPA has promulgated a modified version of Proposal Option 1, as described in the proposed rule and modified by elements described in the NODAs. Refer to the preamble for additional discussion.

7.2.1 Final Rule

7.2.1.1 Impingement Mortality Requirements

The final rule requires that existing facilities and new units subject to this rule must comply with one of the following seven alternatives identified in the national BTA standard for impingement mortality at 40 CFR 125.94(c) (hereafter, impingement mortality standards):

(1) operate a closed-cycle recirculating system as defined at 40 CFR 125.92;
(2) operate a cooling water intake structure that has a maximum through-screen design intake velocity of 0.5 fps;
(3) operate a cooling water intake structure that has a maximum through-screen intake velocity of 0.5 fps;

(4) operate an offshore velocity cap as defined at 40 CFR 125.92 that is installed before the promulgation date of the final rule;

(5) operate a modified traveling screen that the Director determines meets the definition at 40 CFR 125.92 and that the Director determines is the best technology available for impingement reduction;

(6) operate any other combination of technologies, management practices and operational measures that the Director determines is the best technology available for impingement reduction; or

(7) achieve the specified impingement mortality performance standard.

Options (1) , (2) and (4) above are essentially “pre-approved technologies” requiring no demonstration and minimal compliance monitoring to show that the flow reduction and control measures are functioning as EPA envisioned. Options (3), (5) and (6) require more detailed information be submitted to the Director before the Director may specify it as the requirement to control impingement mortality. Because the technology basis for these three alternatives includes technologies known to be high performing technologies, these compliance alternatives are “streamlined” in that once the technology is installed and its performance optimized, there is little or no biological compliance monitoring required. The impingement mortality performance standard in Option (7) requires that a facility must achieve a 12 month impingement mortality performance for all life stages of fish and shellfish of no more than 24 percent mortality, including latent mortality, for all non-fragile species that are collected or retained in a sieve with maximum opening dimension of 0.56 inches and kept for a holding period of 18 to 96 hours.

7.2.1.2 Entrainment Requirements

The final rule establishes the national BTA standard for entrainment at existing facilities at 40 CFR 125.94(d) (hereafter, entrainment standards) for both existing units and new units at existing facilities. In the case of existing units, the rule does not prescribe a single nationally applicable entrainment reduction technology but instead requires that the Director must establish the BTA entrainment requirement for a facility on a site-specific basis. The requirements must reflect the Director’s determination of the maximum reduction in entrainment warranted after consideration of all factors relevant to the BTA determination at the site and must include consideration of the specific factors spelled out in 40 CFR 125.98(f). Facilities that withdraw greater than 125 mgd AIF must develop and submit an Entrainment Characterization Study (40 CFR 122.21(r)(9), as well as provide other information required at 40 CFR 122.21(r)(7) and (10), (12), (13) and, unless waived by the Director, (11)) that must include specified data pertinent to consideration of several of the factors identified in 40 CFR 125.98(f).

The owner or operator of a new unit at an existing facility must achieve one of two alternatives under the national BTA standards for entrainment for new units at existing facilities at 40 CFR 125.94(e) (hereafter, new units entrainment standards).[137] Under the

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[137] New units are also subject to impingement requirements at 40 CFR 125.94(b) but EPA expects that all new units will comply with these requirements through the installation of a closed-cycle cooling system, which is one of the compliant technologies identified in the final rule for impingement mortality.

first alternative new unit entrainment standard, the owner or operator of a facility must reduce AIF at the new unit, at a minimum, to a level commensurate with that which can be attained by the use of a closed-cycle recirculating system. The owner or operator of a facility with a cooling water intake structure that supplies cooling water exclusively for operation of a wet or dry cooling tower(s) and that meets the definition of closed-cycle recirculating system at 40 CFR 125.92 meets this new units entrainment standard. Under the second alternative new units entrainment standard, the owner or operator of a facility must demonstrate to the Director that it has installed, and will operate and maintain, technological or other control measures for each intake at the new unit that achieves a prescribed reduction in entrainment mortality of all stages of fish and shellfish that pass through a sieve with a maximum opening dimension of 0.56 inches. Like the Track II requirement in the earlier Phase I rule, the owner or operator of a facility must demonstrate entrainment mortality reductions that are equivalent to 90 percent or greater of the reduction that could be achieved through compliance with the first alternative entrainment standard for new units.

7.2.2 Other Options Considered

EPA considered several other options in developing today’s final rule, but ultimately rejected them. This section includes a discussion of these options, as well as some technologies that EPA considered, but did not include as alternatives to the impingement mortality standards. Refer to the preamble for additional discussion.

1. Closed-Cycle Recirculating Systems as National BTA to Address Impingement and Entrainment

As previously explained, EPA assessed a number of different technologies that reduce impingement mortality and entrainment as the possible basis for section 316(b) requirements. EPA concluded that closed-cycle recirculating systems (based on wet cooling towers) are a best <u>performing</u> technology for reducing impingement mortality and entrainment.

Notwithstanding that conclusion, EPA has decided not to establish a performance standard for entrainment based on closed-cycle recirculating systems. Closed-cycle cooling is not the “best technology <u>available</u> for minimizing adverse environmental impact” required by section 316(b). Closed-cycle cooling is indisputably the most effective technology at reducing entrainment given the direct relation between entrainment and flow. Closed-cycle reduces flows by 96 percent (on average) and consequently impingement mortality and entrainment are similarly highly reduced. Because of concerns over technical feasibility, EPA has rejected closed-cycle recirculating systems as the basis for national entrainment controls. Though closed-cycle cooling is effective and a high performing technology, it is neither widely available nor feasible, and has unacceptable non-water quality impacts in some instances. While EPA cannot identify with precision the extent of these limitations on installing closed-cycle cooling systems nationwide, the record indicates that the circumstances are neither isolated nor insignificant. EPA estimates that 25 percent of existing facilities may face some geographical constraints on retrofitting closed-cycle cooling. EPA also considered other forms of flow reduction including variable speed drives and seasonal outages. EPA found that these were not available and not BTA. Further, EPA has decided that 316(b) requirements should reflect consideration of costs and benefits.

EPA rejected a variant option of requiring uniform entrainment controls based on closed-cycle cooling, with the opportunity for individual facilities to show why such controls are not feasible. EPA's decision not to establish closed-cycle cooling as BTA with "off ramps" is broader than its consideration of a land threshold. Because of a combination of concerns over land availability, air emissions, and remaining useful life of the facility, EPA has rejected closed-cycle recirculating systems as the basis for national impingement and/or entrainment requirements. Nor is EPA able to identify a subcategory for which these concerns no longer apply. Moreover, the complex interaction of all of these factors at individual sites does not lend itself to other regulatory options that would require closed-cycle recirculating systems with an "off ramp" if any of the factors were shown to result in unacceptable impacts because this would create a presumption for closed-cycle cooling rather than an equal balancing of all relevant factors. EPA decided not to put its thumb on the site-specific scale by establishing any presumptive BTA entrainment outcome. EPA finds the entrainment standards framework in today's final rule will provide a consistent, more efficient, and more effective approach than standards with an "off ramp."

2. Proposal Option 3—Impingement Mortality Controls at All Existing Facilities that Withdraw over 2 mgd DIF; Require Flow Reduction Commensurate with Closed-Cycle Cooling at All Existing Facilities over 2 mgd DIF

Proposal Option 3 was, in many ways, the same as requiring closed-cycle cooling at all existing facilities. As described above, the rationale for rejecting closed-cycle cooling as BTA for entrainment would apply with equal force for Proposal Option 3. As a result, EPA has concluded Proposal Option 3, similarly, is not available at the national level as BTA for entrainment. EPA is not reporting in the preamble or support documents on any updates since proposal to the analysis of this option.

3. Proposal Option 2—Impingement Mortality Controls Similar to Final Rule at All Existing Facilities that Withdraw over 2 mgd DIF; Require Flow Reduction Commensurate with Closed-cycle Cooling by Facilities greater than 125 mgd DIF and Uniform Impingement Mortality and Entrainment Controls for All New Units at Existing Facilities

As described above, the rationale for rejecting closed-cycle cooling as BTA for entrainment would also apply in the case of Proposal Option 2, despite the smaller number of facilities that would be subject to a requirement to retrofit. As a result, EPA concluded that Proposal Option 2 is not available at a national scale as BTA for entrainment.

4. Proposal Option 4—Impingement Mortality Controls Similar to Final Rule at Existing Facilities with DIF of 50 mgd or more; BPJ Permits for Existing Facilities with Design Intake Flow between 2 mgd and 50 mgd; Uniform Impingement Mortality and Entrainment Controls for All New Units at Existing Facilities Similar to Final Rule

EPA ultimately rejected Proposal Option 4 because EPA found that the final rule is available, feasible, and demonstrated for all regulated facilities on a national basis. Moreover, EPA's analysis showed that the difference in the total compliance costs for the two options was nominal. Additionally, many facilities with a DIF under 50 mgd already use closed-cycle cooling and would have minimal burden under this approach. These facilities would have no difficulty complying with either the final rule or Proposal Option 4. Proposal Option 4, by not distinguishing between those facilities under 50 mgd that have already minimized adverse environmental impacts from those that have not, masks the actions that would have to be taken by the latter group to comply with today' final rule. In addition, the flexibilities introduced in the June 11, 2012 NODA and included in today's final rule are applied to all facilities, not just the facilities withdrawing smaller volumes of cooling water addressed by Proposal Option 4. EPA also concluded that the data collection activities required under the final rule will be more protective of threatened and endangered species because it provides information on a larger number of facilities than Proposal Option 4 for consideration by the Director in permitting decisions. Lastly, EPA acknowledges that Proposal Option 4 is more burdensome to permitting authorities than is the final rule, as it requires more site-specific decision-making, including site-specific determinations regarding permit application study requirements, monitoring requirements, and case-by-case decisions of BTA for impingement mortality.

Under Phase III, EPA co-proposed three options where requirements similar to those under Phase II would apply to all facilities with a DIF greater than 50 mgd (option 5), greater than 200 mgd (option 8), and greater than 100 mgd (Option 9)[138]. Requirements for all other facilities would be established on a case-by-case best professional judgment basis. EPA evaluated other alternative options under Phase III including Option 6 which expanded the coverage of regulatory requirements to include all facilities with a DIF greater than 2 mgd. While the subset of facilities subject to specific IM and E requirements in proposed Phase III option 5 (greater than 50 mgd) is similar to those subject to IM requirements under this rule's Option 4, the Phase III option 5 is not the same in that the requirements are different and, as a result, the compliance costs and burden to the facilities are lower. These differences under this rule include site-specific entrainment requirements, reduced biological monitoring requirements and flexibilities in selecting compliance alternatives for complying with BTA impingement mortality requirements. The difference in estimated total annualized costs for the two Phase III options (Option 5 and Option 6) of $69 million[139] (in 2013 dollars) is representative of what the Phase III requirement costs would have been for facilities in the 2 to 50 mgd subset. The comparable estimate for the impingement mortality requirements for 2-50 mgd facilities under this final rule is $25 million in 2013 dollars. Thus, EPA estimates that the changes in requirements considered in the proposed Phase III options to those in today's rule have reduced the potential for imposed financial stress on the 2 to 50 mgd facilities by an estimated $44 million dollars ($69 million minus $25 million).

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[138] IM and E requirements for Phase III option 9 (greater than 100 mgd) was limited to facilities located on oceans, estuaries and Great Lakes.

[139] $69 million is the inflation adjusted difference of $49.2 million between Phase III option 6 annualized cost of $94 million minus the Phase III option 5 (greater than 50 mgd) cost of $44.8 million adjusted to 2013 using ENR CCI. Option 6 costs are for an estimated 603 affected facilities including 91 small businesses.

The resulting estimated financial impact under today's rule results in no facilities with a cost-to-revenue ratio of 3 percent or greater (versus13 facilities for Phase III Option 6), and four facilities with a cost-to-revenue ratio exceeding 1 percent (versus 23 facilities for Phase III option 6); further the analysis for today's rule assumes zero cost pass-through to the consumer. See the EA for further details. Thus, EPA's conclusions under Phase III regarding costs are not relevant to EPA's rejection of Option 4. EPA has concluded that it does not have a rationale for excluding facilities in the 2 to 50 mgd range from the national uniform requirements because there are affordable, available, and feasible technologies for reducing impingement mortality.

5. Proposal Option 2 Variant

EPA also considered a variation of Proposal Option 2 that would have used 125 mgd AIF rather than 125 mgd DIF as the threshold. However, as described above, EPA rejected Proposal Option 2 and, for the same reasons, rejected this variant of Option 2.

6. Site-Specific Approach to Addressing Impingement

EPA considered a site-specific approach to addressing impingement mortality, similar to that employed for entrainment. Similarly, EPA considered an approach that would have established both impingement mortality and entrainment requirements fully on a site-specific basis taking into account for the particular facility, among other factors, those previously described as pertinent to EPA's 316(b) BTA determination. EPA rejected a fully site-specific approach for impingement controls principally because low-cost technologies for impingement mortality are available, feasible, and demonstrated for facilities nationally, and because a fully site-specific approach would place unnecessary burden on state permitting resources. Moreover, the final impingement mortality standard includes several alternatives that allow site-specific demonstration that a particular technology performs at a level representing the best technology available for the site. EPA is instead promulgating a modified version of the proposed rule, adding several elements of flexibility, and thus directly addressing many of the concerns raised by these commenters.

7. Closed-Cycle Cooling to Address Impingement Mortality

EPA did not select flow reduction commensurate with closed-cycle cooling as the technology basis for impingement mortality because, despite the incremental improvement in reducing impingement, the cost of closed-cycle cooling is more than 10 times that of modified traveling screens with a fish return system. As a result, modified traveling screens with a fish return system are more cost-effective than flow reduction commensurate with closed-cycle cooling at preventing impingement mortality.

8. Pre-approved Technologies

EPA considered an approach based on "pre-approved" technologies that, once installed, would obviate the need for extensive regulatory conditions such as biological monitoring. This is similar to the approach taken for cylindrical wedgewire screens in the remanded 2004 Phase II rule (see 40 CFR 125.99(a)). EPA has included several streamlined compliance alternatives in the form of technologies that may be approved following a demonstration of required performance, so long as the facility shows that its alternative technology is operating in a manner that minimizes adverse environmental impacts. As an option for achieving the impingement mortality standards, a facility may install and operate specified impingement controls that EPA has determined will comply with the numeric impingement mortality performance standard.

9. Barrier Nets

For estuaries and oceans, EPA proposed seasonal deployment of barrier nets on marine waters to address impingement mortality of shellfish (crustaceans). Following EPA's analysis of additional data described in the June 11, 2012 NODA, EPA has incorporated data regarding shellfish impingement survival rates into the numeric impingement mortality performance standard in the final rule, thereby eliminating the need to require barrier nets. However, EPA does recognize that barrier nets may be an appropriate measure for the protection of shellfish at some facilities and therefore has included a provision that gives the Director discretion to require additional measure for the protection of shellfish.

10. Cylindrical Wedgewire Screens

EPA did not select wedgewire screens as the technology basis for impingement mortality controls because wedgewire screens are not available and feasible for all existing facilities. EPA also did not need to include wedgewire screens as a pre-approved compliance alternative for impingement controls because wedgewire screens are typically designed with an intake velocity of 0.5 fps and therefore, can demonstrate compliance with the impingement mortality standard under the intake velocity compliance alternative. This approach results in wedgewire screens as potentially being approved in situations where the Phase II rule would not, such as in lakes or oceans or locations where the currents are not counter and perpendicular to the wedgewire screens.

11. No rule.

EPA considered a "no regulatory action" option. EPA determined that "no action" is inappropriate in this case because there are technologies that are available, demonstrated, feasible, and affordable for all facilities, and EPA has found the costs of such controls are justified by the benefits. EPA found this rule to be necessary to minimize AEI based on the record, noting the mortality of hundreds of billions of aquatic organisms that are impinged and entrained at cooling water intakes that withdraw water from waters of the United States each year.

12. Intake velocity

EPA considered an option based on intake velocity of 0.5 feet per second. The 0.5 fps velocity is based on the analysis of fish burst swim speeds, and is therefore based on the thousands of intake structures where such fish and shellfish may be located. However, this is not BTA because it is not available. See Chapter 6 regarding availability of this technology.

13. Cost-cost option

The inclusion of a cost-cost variance as a rule option was considered to avoid the irrational result of requiring a facility to install a technology where that facility has unique, site-specific characteristics that cause individual compliance costs to be many times greater than those compliance costs considered by EPA. EPA found that the cost-cost test it had adopted in the Phase II rule would have proved difficult to implement in part because the Appendix to the Phase II rule discussing how to apply the test was prone to uncertainty and error. EPA notes that the Phase II rule included requirements for entrainment reductions, and the final Phase II rule was more costly than today's rule even though it only addressed existing large flow electric generating facilities.

While not required to do so, the final rule includes sufficient flexibility to allow facilities to avoid exceptional costs. EPA accomplished this by structuring the final rule to allow facilities to choose from multiple impingement mortality compliance alternatives presenting facilities with a range of different costs associated with each alternative. Thus, facilities are free to choose the lowest cost alternative. These include streamlined alternatives based on modified traveling screens or a system of technologies that are intended to result in reduced long-term costs by reducing future monitoring requirements. Also the final rule allows the Director to conclude based on site-specific data that impingement mortality at the site is de minimis and therefore no additional controls are warranted to meet the BTA impingement mortality standard. EPA has determined that the available compliance alternatives provide sufficient flexibility, and that the costs of such controls is sufficiently low such that no facility will experience an exceptional level of cost and need a cost variance.

7.2.3 Existing offshore oil and gas extraction facilities and seafood processing vessels

There are three main technologies applicable to the control of impingement and entrainment of aquatic organisms for cooling water intakes at offshore industry sectors evaluated for this rulemaking: passive intake screens, velocity caps, and modification of an intake location. EPA did not identify any technologies that are demonstrated and feasible for the industry. Thus EPA did not develop options for these categories. See DCN 12-6621 and the Phase III rule TDD for more information.

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Chapter 8: Costing Methodology

8.0 Introduction

This section describes the methodology and assumptions used to derive the technology compliance costs for facilities required to meet the final rule. For existing facilities, the Agency developed costs for 723 intakes at 519 model plants and these were then used in the economic analysis to scale to the total universe of in-scope facilities[140]. For new units subject to impingement mortality and entrainment mortality reduction requirements, the Agency derived estimates of new unit capacity and cooling water requirements and derived estimated annual compliance costs. In many ways, EPA used a similar, standardized approach to what was used in the previous 316(b) rules. For regulatory options where facilities were required to meet impingement mortality requirements (for which the technical basis is modified Ristroph screens) or make intake technology upgrades, EPA used a revised version of the cost tool developed in the Phase III regulation (and largely based on the cost modules developed for the 2004 Phase II rule). For regulatory options where facilities were required to meet entrainment mortality requirements (for which the technical basis is wet cooling towers), EPA used a cost model developed by the Electric Power Research Institute (EPRI) to develop costs for retrofitting wet cooling towers. EPA used facility-specific data from each facility that completed a detailed technical questionnaire (DQ) to create model facilities. By providing facility-specific data as an input to the cost models, EPA determined model facility compliance costs for each intake structure based on data from each DQ.

EPA diverged from the cost methodology in the 2004 Phase II rule in one key respect: the costs derived for the final rule use a model facility approach.[141] In contrast, the 2004 Phase II rule used a facility-specific costing approach where compliance costs attributed to every facility were calculated. For reasons discussed below, EPA determined that a model facility approach (where costs for a set of model facilities are calculated and then scaled to a national level) was more appropriate in determining the compliance costs for the final rule. By costing each DQ facility as a model facility, and by using the survey weights developed for the DQ,[142] EPA is able to estimate total national costs.

EPA also developed costs for manufacturers and small power plants (formerly addressed under the Phase III rule), which are subject to the same requirements as large power plants under the final rule. The general process of developing costs for these facilities was the same as that for large power plants, with some differences as discussed below.

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[140] These totals include intakes at facilities determined to be baseline closures in the economic analysis.

[141] Model facilities are statistical representations of existing facilities (or fractions of existing facilities); only those facilities that completed a DQ in EPA's survey effort in 2000 were included in cost development.

[142] The weighting factors were statistically derived from the industry questionnaire data using survey sample sizes. Weights range from 1 to 8.7. By weighting each model facility, the traits of the model facility (e.g., flow, technology type, capital costs) are extrapolated to represent the entire universe of facilities.

EPA analyzed the compliance costs on two levels. First, as described in Chapter 7, EPA analyzed several regulatory options to address impingement mortality (IM) and entrainment mortality (EM), including intake screens and flow reduction commensurate with closed-cycle cooling. Second, EPA assessed the national economic impacts of each regulatory option. The sections below describe these costs further.

8.1 Compliance Costs Developed for the Final Rule

The final rule requires that all existing facilities must meet impingement mortality requirements. Entrainment requirements for existing units may be established on a best professional judgment basis by the Director. For new units not subject to Phase I, the final rule requires intake flow reduction commensurate with closed-cycle cooling. The cost methodology used to estimate compliance costs for new units is described in Section 8.4 below. EPA also considered two other options involving closed-cycle cooling: one where all existing facilities would be required to reduce their intake flow to that commensurate with closed-cycle cooling; and one where all existing facilities with an average intake flow (AIF) above 125 million gallons per day (mgd) would be required to reduce their intake flow to that commensurate with closed-cycle cooling. As described in the preamble to the final rule, the technology basis for these requirements is jointly based on the performance of modified traveling screens (for impingement mortality) and the performance of closed-cycle wet cooling towers (for entrainment mortality).

To develop appropriate compliance costs, EPA assigned costs for both sets of facilities. For facilities that are required to upgrade their screens, EPA used an updated version of the cost tool developed in the Phase III rule. For the facilities that are required to reduce their intake flow, EPA used a cost model developed by EPRI to develop capital and operation and maintenance (O&M) costs for retrofitting cooling towers at each model facility.[143]

8.1.1 Model Facility Approach

The model facility approach used in this effort involved calculating compliance costs for individual facilities for which EPA had detailed technical data regarding the intake design and technology. Specifically, these are the in-scope facilities that completed the year 2000 DQ survey. For facilities with screen upgrades, where facilities reported data for separate cooling water intake structures (CWISs), compliance costs were derived using the design intake flow for each intake and then these intake costs were summed to obtain total costs for each facility. For facilities required to reduce their flow, the EPRI model was applied to the maximum intake flow reported for each intake over the period 1996 to 1998. The facility's total costs were then multiplied by a weighting factor specific to each facility to obtain industry-wide costs for the national economic impacts analyses by extrapolating the impacts of the DQ facilities to all existing facilities.

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[143] In some cases, a facility may have been assigned costs for both cooling towers and screen upgrades; if a facility's characteristics suggested that, even after reducing flow, its intake velocity would still exceed 0.5 ft/sec, costs for Ristroph screens were also included. See Section 5 below.

The reasons for using a model facility approach include the following:

- Technical data for non-DQ facilities[144] was limited; specifically:
    - Design intake flow (DIF) volume was not requested, and values used previously by EPA were estimated on the basis of reported average flow.
    - Available intake technology data was generalized, and EPA could not be certain how reported technologies were distributed among multiple intakes.
    - Available intake technology data was not detailed enough to reliably ascertain whether the technology design met compliance requirements.
- EPA's industry questionnaire conducted a census of power plants expected to be within the scope of the regulations, but conducted a stratified sampling of manufacturers. As a result, EPA's survey data only encompasses a representative sample of manufacturers; information on unsurveyed facilities is not available.
- The survey sample frame did not include facilities in U.S. territories such as Puerto Rico and Guam, and the model facility approach allowed their inclusion using the weighting factors.
- Implementation of the 2004 Phase II rule revealed inconsistencies and errors in the costs for non-DQ facilities.

8.2 Impingement Mortality Compliance Costs

Compliance with IM requirements was based on the performance of an upgraded traveling screen technology—a modified Ristroph-type traveling screen or equivalent, plus a fish-friendly fish return system. Facilities may also comply with IM requirements by demonstrating that their design intake velocity is 0.5 feet per second or less; that the cooling water system meets the definition of closed-cycle cooling; or that they meet the definition of existing offshore velocity cap.

For both power generation and manufacturing facility intakes, IM reduction compliance technology costs were estimated on a per-intake basis using data from the model facilities' DQs in the cost tool. Other input data were derived primarily from the information used to develop the Phase II cost modules. As much as possible, EPA used similar input data and cost calculation methodologies as were used in the 2004 Phase II rule in developing the estimated compliance costs for assigned compliance technology modules.

Using the model facility's input data, the cost tool assigns a compliance intake technology to each facility (or intake). A detailed discussion of how the cost tool makes technology assignments is provided below. EPA notes that the assigned technology for each model facility intake in the final rule may be different than that assigned for the

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[144] Facilities were sent either a DQ or an abbreviated short technical questionnaire (STQ). The STQ requested much less detailed information about the facility, its CWIS, and its operations. Of the approximately 1,200 surveys that EPA sent to electric generators, approximately 62 percent were STQs. All surveys sent to manufacturers were DQ surveys. For more information, see DCN 3-3077 (Statistical Summary for the Cooling Water Intake Structure Surveys).

2004 Phase II Rule, because EPA made a number of revisions to the cost tool.[145] Through the cost tool, EPA also accounts for any model facilities that have already installed technologies that meet the performance requirements in the final rule.[146] These facilities are assigned no compliance costs.

The cost tool output includes capital costs, O&M costs, pilot study costs, and the duration of facility downtime.

8.2.1 Selection of Technology to Address IM

Since the 2004 Phase II rule, EPA has revised and simplified the method for selecting IM reduction compliance technology. The IM technology used for estimating compliance cost was selected for each facility intake based on criteria such as existing through-screen velocity, presence of traveling screens, intake location, water depth, and total intake flow.

Since the compliance standard is based on the performance of modified Ristroph traveling screens or on a through-screen velocity of 0.5 fps, for the purpose of estimating compliance technology costs, EPA limited the applied technology options to the following:

- Replacement of existing traveling screen(s) with (coarse-mesh) modified Ristroph traveling screen(s) with fish return
- Installation of near-shore coarse-mesh wedgewire screen(s) with a design through-screen velocity of 0.5 fps
- Installation of larger intake with modified Ristroph traveling screen(s) with a design through-screen velocity of 0.5 fps
- Installation of variable speed cooling water pumps for intakes with screen velocities close to 0.5 fps.
- Installation of fish barrier net(s) in addition to traveling screen(s) in certain marine environments.

The application of Ristroph screens is consistent with the levels of performance used to calculate the performance standard for IM. The Ristroph screen technology costs are based on the replacement/upgrade of existing traveling screens and, therefore, are only applied to intakes that currently employ traveling screens[147]. The other technologies (coarse mesh wedgewire and larger intakes) were not included in the calculations for the performance standard, but by design are capable of consistently meeting the alternative standard for intake velocity. Barrier nets are intended to provide additional protection with regard to impingement.

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[145] Revisions included adding more flexibility in assigning technology modules and revising some modules to reflect EPA's final regulatory framework.

[146] For example, a facility might already employ closed-cycle cooling or a technology that EPA deemed would meet the performance requirements.

[147] Under Phase III and at proposal, the application of this technology was not limited to intakes with existing traveling screens and was revised for the final rule due to the fact that the cost module does not include costs for modifications to the intake to accommodate traveling screens where none already exists.

At proposal, EPA applied velocity caps to certain existing submerged offshore intakes and, based on the Phase II record, assumed they would be compliant. Performance data showed that velocity caps alone did not consistently achieve a level of performance comparable to BTA. The performance of newly installed velocity caps would be highly dependent on location and other site-specific conditions, and therefore EPA did not assign velocity caps as a compliance technology.

8.2.2 EPA's Cost Tool

For the Phase III rule, EPA developed a cost tool to model the general methodology used in developing the compliance costs in the 2004 Phase II rule. For the final rule, this cost tool was further modified to mimic the 2004 Phase II rule cost methodology as much as possible, as well as to increase its versatility. The modified cost tool used for the final rule costs each intake structure independently, which could result in somewhat higher costs; facilities installing a technology at multiple intake structures would likely realize some economies of scale or other cost reductions. Also, while the cost tool accounts for existing intake technology that individually would meet the impingement mortality standard, technologies employed that provide partial reduction or may currently meet the standard when evaluated in combination are not accounted for. Since the final rule allows for facilities to take credit for the combined effect of multiple technologies, these costs estimate may result in an overestimation on costs since those already proving partial reductions may require a less costly technology than was assigned by EPA. For example, and existing intake may require only a fish barrier net, fish avoidance technology, or an upgrade to the intake screens to meet the standards rather than completely replacing the existing traveling screens.

The cost tool was used to develop costs for both power plants and manufacturers. The following modifications were made to the Phase III cost tool:

- The methodology for assigning compliance technology cost modules was modified (see below for more details).
- A model input value for Selected Technology Module was added to allow the user to specify which cost module(s) are applied.
- A model input value for Selected *Engineering News-Record* (ENR) Construction Cost Index (CCI) was added to allow the user to adjust costs for inflation.
- A model input value for Regional Cost Factor was added to allow specific regional cost factors to be used. Default values are average values for the state.
- Model inputs values for Total Plant Design Intake Design Flow and Total Plant Average Intake Flow were added to facilitate technology selection.
- Cost Modules 10, 10.1, and 10.2 were created to represent the costs for adding fish barrier nets (Module 5) to Modules 2, 2a, and 3 (combinations of fine mesh traveling screens and expanded intake structures). (See Exhibit 8-1 for a description of each module.)
- The same waterbody-specific default distances offshore were applied for relocating intakes to submerged offshore for all types of intake locations.

- The technology service life was added to the output.
- The input page was revised to allow selection of the Module 3 compliance screen velocity.
- An existing impingement technology code was added for wedgewire screens.
- The cost modules for new larger intakes (Module 3) and wedgewire screens (Modules 4, 7, and 9) were based on a design including fine mesh screens. However, compliance with the IM reduction technology requirements requires only coarse mesh. As a result, Module 3 was modified so that the traveling screens were sized based on a through-screen velocity of 0.5 fps and coarse (3/8-in) mesh instead of fine mesh screens. The cost for wedgewire screens, however, was not modified. Since smaller mesh sizes require larger screens due to the lower percent open area, the associated capital costs for Modules 4, 7 and 9 represent a conservative overestimate. Module 1 (replacing existing screens with modified Ristroph traveling screens and adding a fish return) always assumed use of coarse mesh and did not change.
- The capital costs for Ristroph traveling screens and fish returns (Module 1) was increased and a high cost traveling screen component was added to be applied under specific conditions.

A cost module for upgrading the existing once-through cooling water pumps from fixed speed to variable speed (Module 15) was added. A very important modification of the cost tool was the change to the methodology for selecting the compliance cost module for each model facility/intake. As noted above, facilities/intakes determined to already be in compliance were assigned no compliance technology costs. The methodology used to determine which facilities already met the compliance requirements is described below. All model facility intake structures determined to not be in compliance were assigned technology compliance modules as described below.

The addition of barrier nets to some technologies (e.g., Modules 10, 10.1, and 10.2) involved simply calculating the sum of the individual component cost modules. Because each cost module has a different O&M fixed factor, the fixed factor used in the combined modules was calculated as a weighted average using the gross compliance O&M for each component.

8.2.2.1 Compliance Technology Selection

Exhibit 8-1 presents a decision flow chart that shows how the IM compliance cost modules were assigned to each facility/intake structure by the cost tool. Exhibit 8-2 presents a decision flow chart that shows how the technology costs modules were assigned to each facility/intake structure by the cost tool. The subsequent text describes the decision points in the flowcharts (e.g., screen velocity) and other assumptions.

Intakes determined to already be compliant with impingement mortality standards are not assigned technology upgrade costs. Details regarding the method for making this determination are provided in Section 8.2.3.

Exhibit 8-1. Flow Chart for Determining Impingement Mortality Compliant Intakes Based on Meeting Performance of Modified Ristroph Traveling Screens

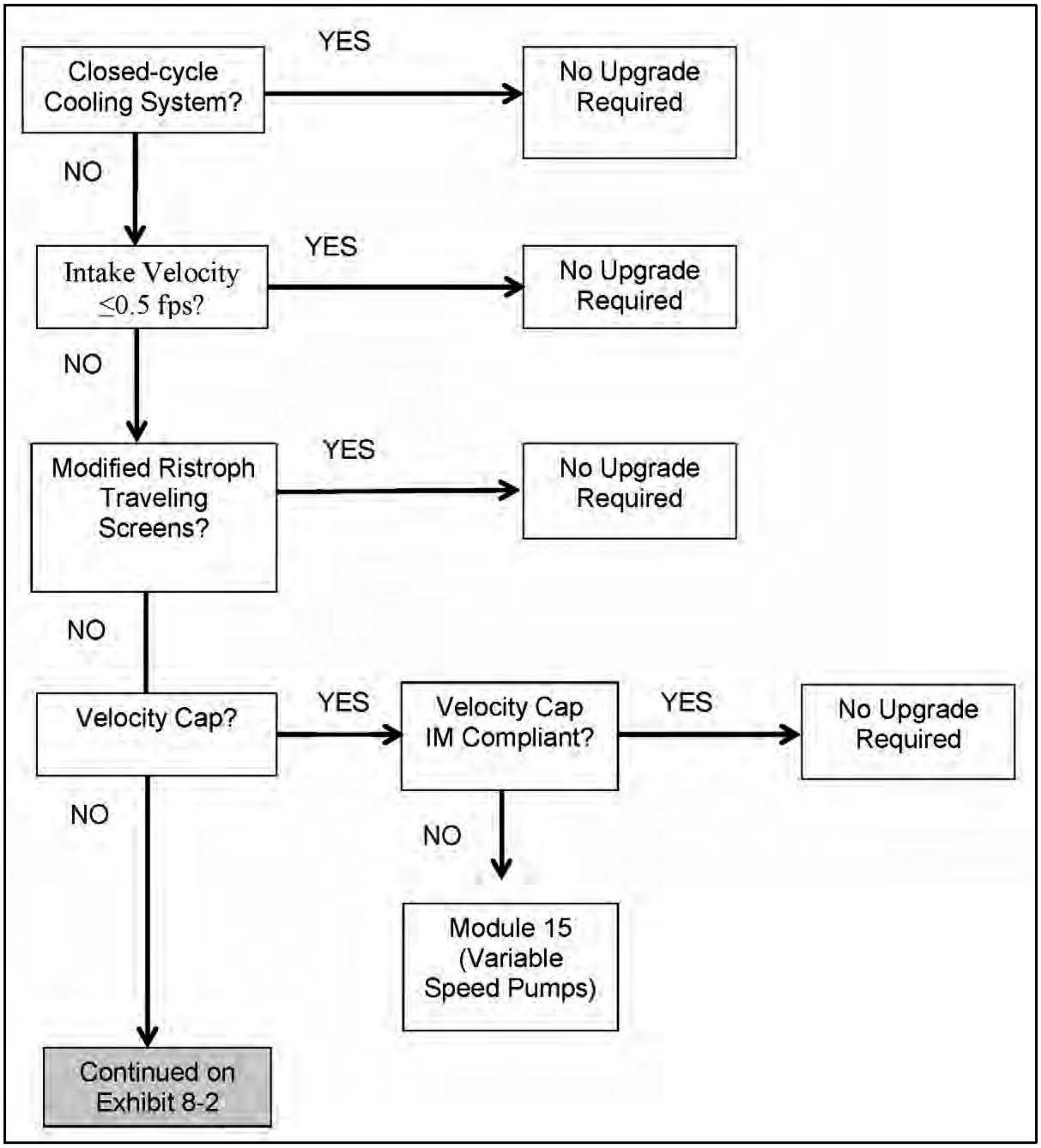
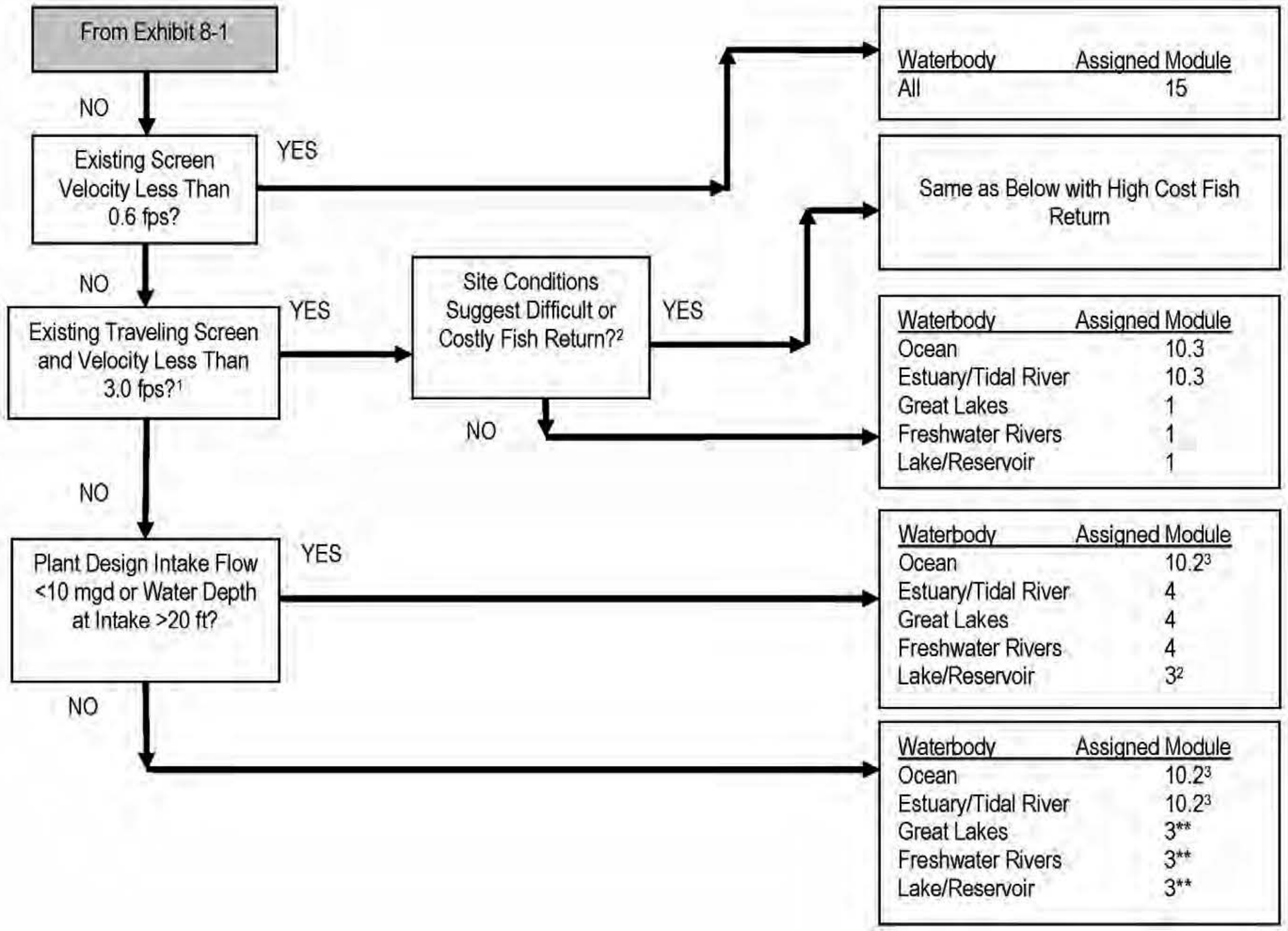


Exhibit 8-2. Flow Chart for Assigning Technology Cost Modules Based on Meeting Performance of Modified Ristroph Traveling Screens



Cost Module Legend

Module	Technology Description
1	Add Fish Handling and Return System (includes screen replacement)
3	Add New Larger Intake Structure with Fish Handling and Return
4	Relocate Intake to Submerged Near-shore (20 M) with passive wedgewire screen
5	Add Fish Barrier Net
10.2	Module 3 plus Module 5
10.3	Module 1 plus Module 5
15	Variable Speed Cooling Water Pumps

[1] Reported velocity is adjusted to reflect maximum reported flow or adjusted flow after closed-cycle retrofit for Closed-cycle Option.

[2] Add high cost fish return if intake is submerged offshore >500 ft or intake has canal length >5,000 ft.

[3] Larger intakes are sized using design screen velocity of 0.5 fps and 9.5 mm screen mesh.

The determination of whether an intake with velocity a cap where the inlet velocity is greater than 0.5 fps is IM compliant would require consideration of site-specific conditions. EPA determined that existing velocity caps located at least 800 ft from shore met the impingement mortality standard and thus were determined to be already compliant (see Section 8.2.3). The few that were not determined to be compliant for other reasons were assigned variable speed pumps (module 15). This is based on the assumption that the presence of velocity caps already provides a partial reduction and that the addition of variable speed pumps would provide the incremental reduction necessary for full compliance.

EPA concluded that facilities would chose to comply with IM requirements by way of the velocity standard wherever possible. The installation of variable speed pumps is an available option for intakes with fixed speed cooling water pumps that currently operate at flow rates that produce screen velocities slightly higher than the 0.5 fps standard. This technology option was selected for intakes that reported intake velocities close to but did not already meet the 0.5 fps standard. A threshold of 0.6 fps was selected for this technology option because it would result in a flow reduction of 17 percent or less which should be attainable by variable speed pumps under many circumstances. Since many intakes already operate at flow rates well under the design intake flow rates, this threshold was applied to the estimated actual screen velocity based on the "maximum reported intake flow rate" (new design intake flow) rather than the design intake flow[148]. Non-IM compliant intakes with traveling screens and an acceptable screen velocity are assigned upgraded modified Ristroph traveling screens with fish returns (Modules 1 and 10.3). Intakes with high screen velocities (greater than 3.0 fps) are assumed to be unable to meet IM requirement with Ristroph traveling screens alone and are assigned either new larger intakes or wedgewire screens.[149] The estimated actual screen velocity based on the "maximum reported intake flow rate" was used as the basis for this decision.

Recognizing that fish returns may be very costly to install at certain intakes, but lacking detailed data upon which to base decisions regarding costs of fish returns at specific locations, a small subset of intake assigned upgraded modified Ristroph traveling screens (about 3-4 percent) were assigned additional high-cost fish return capital cost components. Rather than randomly assigning these costs, intakes with very long intake canals (greater than 5,000 ft) and those with intakes submerged far offshore (greater than 500 ft) were selected as indicative of difficult and expensive installations. See Section 8.2.2 below for further discussion.

Intakes that are assumed to be unable to meet the IM requirements through the velocity requirements or with the use of Ristroph traveling screens alone and are assigned either new larger intakes or wedgewire screens based on total plant DIF, intake water depth, and/or waterbody type. Intakes at plants where the total plant DIF is less than 10 mgd or water depth greater than 20 ft and do not withdraw water from oceans or lakes/reservoirs

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[148] Screen velocities reported in the technical surveys are based on the design flow. Intakes that operate at lower flow rates will have proportionally lower screen velocities if flow is distributed across all screen surfaces. The installation of variable speed pumps should allow for the distribution of the reduced flow.

[149] This threshold value was revised from 2.5 fps at proposal to 3.0 fps in the final rule. See discussion for cost tool input 31.

are considered good candidates for submerged nearshore traveling screens and are assigned module 4. All other intakes are assigned new larger intakes. EPA recognizes that these technologies may not be the least cost, ideal, or most appropriate in each circumstance. However, these technologies, especially larger intakes, represent the most costly of the suite of technologies considered by EPA and therefore the costs are expected to be equal to or greater than the costs of the technology that may ultimately be selected by a facility. Exhibit 8-3 presents the number of model intakes assigned each technology module. These values are weighted totals.

Capital and O&M Costs

The modified cost tool provides individual facility/intake cost values for capital costs, fixed and variable O&M costs (baseline, gross, and net), estimated net construction downtime, and technology service life. The cost tool provides an inflation cost adjustment from the year 2002 dollars which were the basis for the 2004 Phase II rule. The data presented in this chapter are adjusted using the ENR CCI. Cost data presented are adjusted for inflation using the February 2009 ENR CCI (8532.75).

Exhibit 8-3. Number of Model Facility Intakes Assigned Each Compliance Module

Module ID	Description	Generator	Manufacturer	All
0	No Upgrade Required	316	254	570
1	Add Modified Traveling Screen with Fish Handling and Return System (includes screen replacement)	295	164	459
3	Add New Larger Intake Structure with Fish Handling and Return	26	108	134
4	Relocate Intake to Submerged Near-shore (20 M) with passive wedgewire screen.	9	45	53
5	Add Fish Barrier Net Only**	0	0	0
10.2	Module 3 plus Module 5	19	10	29
10.3	Module 1 plus Module 5	73	19	92
15	Variable Speed Cooling Water Pumps	30	50	80
	Total	768	650	1417

Note: All values are weighted totals and exclude baseline closures

** Shown to enable comparison to proposed rule where barrier nets were required for shellfish.

Pilot Study Costs

Pilot study costs were estimated in a similar manner as was done for the 2004 Phase II rule. Each technology is assigned a pilot study cost factor of either 0 or 0.1. The capital cost is multiplied by the pilot study cost factor to derive the estimated pilot study cost for the facility/intake.[150] A minimum pilot study cost of $150,000 in 2002 dollars was assigned if the calculated pilot study cost in 2002 dollars was lower than the minimum. For facilities with multiple intakes assigned the same technology, it was assumed that a pilot study would be performed at only one of the intakes and thus the highest individual intake pilot study cost was assigned to the facility.

For the final rule, few facilities were assigned pilot study costs. As described above, the process for assigning compliance technologies led many facilities to be projected to install Ristroph screens. This is a well-developed technology and typically does not require a pilot study. Note a pilot study is different from a technology optimization study, which was costed in the final analysis.Facilities that were projected to install Cost Module 4 (relocate the intake to an offshore location with a fine mesh passive screen) were assigned pilot study costs, as this is a significant shift in operations and may be well-served by conducting a pilot study.

Construction Downtime

Construction downtime estimates are based on the estimated total downtime defined for each technology cost module in the 2004 Phase II Technical Development Document. It is assumed that the construction downtime will be scheduled to coincide with the normally scheduled facility maintenance downtime. Net downtime values for generators are equal to the total estimated downtime minus the estimated average duration of the normally scheduled maintenance downtime period of 4 weeks.

The 2004 Phase II and Phase III downtime estimates generally focused on facilities with large intake flows, with the Phase II estimates being for facilities with DIF greater than 50 mgd. For manufacturers, these values were then adjusted downward based on structural, process, and operational differences but not necessarily size. Similarly, a design flow in the 2 to 10 mgd range would tend to involve smaller structures with pipes in the 10-in to 22-in diameter range, rather than the 4-ft to 6-ft or more range for the larger systems. Thus, the scope of these intake construction projects is much smaller and the duration of each task should be correspondingly smaller as well. Accordingly, the net construction downtime for wedgewire screens for design flows of 2 to 10 mgd was assumed to be 3 weeks based on BPJ. Exhibit 8-4 presents the downtime estimates used for the assigned compliance technology cost modules.

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[150] Typically, facilities with calculated capital costs below $500,000 (in 2002 dollars) are not assigned pilot study costs, because EPA assumes that facilities incurring smaller capital costs were unlikely to conduct a pilot study.

Exhibit 8-4. Net Construction Downtime for Impingement Mortality Compliance Technologies

Cost Module Number[1]	Power Generators (Weeks)				Manufacturers (Weeks)			
	Flow < 6,944 gpm	Flow 6,944 to 400,000 gpm	Flow 400,000 to 800,000 gpm	Flow > 800,000 gpm	Flow < 6,944 gpm	Flow 6,944 to 400,000 gpm	Flow 400,000 to 800,000 gpm	Flow > 800,000 gpm
1	0	0	0	0	0	0	0	0
3	2	2	3	4	0	0	1	2
4	3	9	10	11	3	7	8	9
5	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
10.2 (3 & 5)	0	2	3	4	0	0	1	2
10.3 (1 & 5)	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0

[1] See Exhibit 8-1 for key to module numbers.

8.2.2.2 Changes to Cost Module Costs

Traveling Screen Costs

The cost modules for modified traveling screens were developed for the Phase II Rule and are described as including costs for the following components:

- Spray systems
- Fish trough
- Housings and transitions
- Continuous operating features
- Drive unit
- Frame seals
- Engineering
- Freshwater versus saltwater environments

The capital costs derived from vendor supplied costs in 2002 also included a separate installation cost component. Since the engineering and contractor overhead costs were included in the equipment costs and these costs were higher than the inflation adjusted equipment costs derived for the Phase I Rule 2, EPA did not include any other indirect costs. However, these costs are based on the assumption that the screen replacement will not require any substantial modification of the screen house and support structure. A review of the cost data suggests that these costs represent easier situations and that there may be additional costs such as electrical/instrumentation and instances where modification to the screen house and other infrastructure may be necessary. To account for this the traveling screen capital costs have been increased by adding a contingency/allowance component equal to 20 percent. This cost component is applied to the total capital costs which include the installed traveling screens, installed fish return, and installed fish return pumps.

The traveling screen costs were derived using a range of different screen sizes including screens as small as 2 ft wide. Therefore the costs account for the economies of scale for smaller systems. Since the smallest screen used in the development of the cost curves for traveling screens was 2 ft wide, the cost tool was revised such that the minimum screen width that could be assigned was 2 ft.

Fish Return Costs

Fish returns comprise half of the function of the traveling screen technology and their ability to function properly is just as important as the Ristroph features on the traveling screen itself. Industry representatives have cited the following site-specific difficulties that may be encountered:

- Very long return lengths;
- Difficult access to the source water where submerged offshore intakes are used;
- Space constraints in the screen house;
- Obstructions in the path to a suitable release location;
- Interference from debris and debris discharge restrictions; or
- Access to a suitable release location capable of preventing re-impingement or preventing stress caused by releasing fish into the plant's thermal effluent.

Many of these problems can be resolved with engineering solutions. The Phase II traveling screen cost modules included costs for a simple 300-ft fish return for all intakes plus additional costs for a simple return that was equal to the length of the intake canal for intakes with canals. The 300 ft. length in the Phase II cost module is intended to account for the need to transport fish to a location far enough away from the intake to minimize re-impingement. The fish return flume component included an indirect cost component equal to 30 percent (10 percent each for engineering, allowance, and sitework). The traveling screen costs obtained from the vendors stated that it included the fish return flume but it was not clear what this included. As such, the cost module assumed that the flume started at the exit from the building. The costs of a fish return will vary with the degree of difficulty which will range from the low difficulty return design which is likely already included in the cost estimates to a more difficult return that may require engineering solutions associated with some of the potential problems described above. Since the average facility intake will include both easy and difficult return systems, the applied costs should fall somewhere in between the extremes.

The traveling screen modules also included costs fish return costs for the flume spray water pumps which included the installed cost of properly sized pumps plus 10 percent for allowance and 20 percent for intake modifications. Pump engineering costs were already included. As with traveling screens these costs do not appear to include necessary electrical or instrumentation components which may add 10 percent to 20 percent to the equipment costs.

The addition of the 20 percent contingency/allowance factor to the total traveling screen capital cost applies to the fish return system components as well and accounts for some of the added costs but since a new fish return requires construction of a new structure and not just the replacement and modification of existing equipment, EPA concluded that an additional cost adjustment was warranted.

Since site-specific conditions are unique at each intake location EPA decided to take a conservative approach to account for the range of difficulties that may be encountered. This approach involved adding an additional component equal to 100 percent of the fish return components already embedded in the traveling screen cost modules

This fish return cost increase component is derived using the following equation derived from costs data presented in Table 2-6 of the Phase 2 TDD:

Fish Return System Cost Increase (in 2002 Dollars) = -3.1538*W2 + 1407*W +24303

Where: “W” = total calculated traveling screen width in feet.

Difficult Fish Returns

EPA decided to include costs for a subset of intakes where site-specific conditions warrant even greater fish return system costs than those covered by the 100 percent increase in the return system costs. Two intake attributes that are identified as being more likely to be associated with conditions that would present greater engineering challenges and costs are those with remote inlet locations such as longer intake canals and intake submerged far offshore.

The design for the added length for intakes with canals assumes piling lengths of 15 ft. is on the low side and should be doubled for these longer returns. Also the indirect cost component of 30 percent of equipment costs is low and has been increased to 50 percent to account for transitions and other components. The result of these modifications is an increase in the cost per foot added length by a factor of 50 percent. Those intakes with very long canals however, may incur additional costs due to the possible need for fish pumps to provide sufficient gradient and/or increased costs for structural support beyond that described above.

Facilities with submerged offshore intakes, particularly those where the intake may have been built by tunneling to the offshore location, may have screen/pump houses that are located away from the waterbody. The screen and pump houses of cooling water systems that are originally built with submerged offshore do not need to be located directly adjacent to the source water or intake channel. In fact, location the screen and pump house some distance from the shoreline may be advantageous since the structure can be set in a location more protected from flooding and storm events. Because of this there is a greater likelihood that obstructions may be present in the most direct pathway from the screen house to a suitable fish return release locations. Thus, such intakes may require longer fish returns that may need to cross an obstruction (e.g., a roadway or public beach). Intakes submerged relatively short distances offshore are likely to have screen houses that are close to the shore as well. A review of the physical layout of several power plants with submerged offshore intakes suggest that a typical distance from the shore to the intake screens would be about 500 ft. For the purpose of assigning additional costs, those intakes with submerged intakes greater than 500 ft. offshore are assumed to incur additional costs equal to the combined cost for initial fish return flume (300 ft.) and spray water pump component.

The longest existing fish return identified by EPA is the 4,600 ft. return at the Brunswick Plant in North Carolina. This return transports fish from the elevated screen house deck along the shore of the intake canal to the discharge location using gravity alone. EPA assumes this is representative of an unusually lengthy fish return. For the purpose of assigning additional costs, those intakes with canals longer than 5,000 feet were assumed to incur additional costs equal to the combined cost for initial fish return flume (300 ft.) and spray water pump component.

Summary of Fish Return Cost Adjustments

- All fish return costs including those described below are increased by 20 percent to provide an additional contingency/allowance component;
- Combined cost for fish return flume (300 ft.) and spray water pumps was increased by a factor of 100 percent to account for a wider range of site-specific conditions and difficult and to account for electrical and instrumentation costs;
- The per foot cost of added fish return associated with intakes with canals was increased by a factor of 50 percent;
- An additional cost component equal to 100 percent of the initial combined cost for fish return flume (300 ft.) and spray water pumps was added to the costs of intakes with very long canal and intakes submerged far offshore to account for the added technology costs associated with solutions such as fish pumps, longer returns, and obstructions

Variable Speed Pump Costs

Cost module 15 for replacing existing fixed speed cooling water pumps with variable speed pumps was added as a compliance option. This module involves installing variable frequency drives for all cooling water pumps at an intake. In some cases, the pump motors and pumps may need replacement as well. Capital costs are estimated using cost factor of $15/gpm (in 2009 dollars). This value is based on the median unit value ($/gpm) of the total costs for several actual and estimated projects. For more details, see the Variable Speed Pump Memo (2012 update). For systems smaller than 10,000 gpm, a minimum cost of $150,000 was assigned. Net O&M costs are assumed to be zero due to the fact that the only new O&M requirements will be for maintenance of the variable frequency drives while O&M for the pumps may actually be reduced due to lower start-up stress on pumps and motors. Energy savings from reduced pumping energy requirements will likely more than offset any energy penalty since the module is applied only to intakes where the required flow reduction is low. The module is applied to intakes where flow reduction needed to meet the velocity requirement is estimated to be less than 20 percent. Thus, only capital costs are applied as part of this module. Service life is estimated to be 20 yrs.

New Larger Intake

The design through-screen velocity has been changed from 1.0 fps used at Proposal to 0.5 fps so that the new intake will be compliant with IM requirements based on velocity alone. As a result, the intake will not be required to include a fish handling and return system or the full suite of modified Ristroph traveling screen features. Therefore, the additional cost components for fish returns associated with traveling screen upgrades are not included in this cost module. The cost for the 300 ft simple fish return embedded in the traveling screen component is still included.

8.2.3 Identifying Intakes That Are Already Compliant With Impingement Mortality Requirements

Existing intakes that were considered to be IM compliant included those that:

- Employed modified Ristroph Traveling screens or equivalent[151] with a fish return
- Employed a closed-cycle cooling system for all cooling water
- Reported a through-screen or through-technology velocity of ≤ 0.5 fps
- Employed existing velocity caps with an intake located greater than or equal to 800 ft submerged offshore
- Employed wedgewire screens with a through-screen velocity of ≤ 0.5 fps.[152]
- Intakes located in the State of New York

Intakes located in the coastal region of California Data from the 2000 DQ survey were used to determine intake compliance. Velocity caps were not assumed to be IM compliant unless the inlet velocity was ≤ 0.5 fps or the location was ≥800 ft submerged offshore.

EPA excluded Electric Generators located in the State of New York and those in California that use coastal and estuarine waters for power plant cooling. These facilities are already required by the States of New York and California to comply with standards at least as stringent as the final rule and thus are not expected to incur any compliance technology costs.

8.2.4 Development of Cost Tool Input Data

This section describes the development of the data input file for calculating technology upgrade compliance costs using the modified version of the Phase III cost tool. Where available, the same data used to develop the compliance technology upgrade costs for the 2004 Phase II rule were used as the basis for this effort. It is important to note that, in the 2004 Phase II rule, separate costs were derived for different CWISs at the same facility where such detailed data were reported. Such data was available for facilities that

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[151] Traveling screens were considered as equivalent to modified Ristroph if the survey reported use of a fish return, fish buckets, and low pressure spray, regardless of whether they were specifically identified as Ristroph in the survey.

[152] If wedgewire screen velocity data was not reported, the wedgewire screens were assumed to be compliant; EPA's experience has been that wedgewire screens are typically designed with a through-screen velocity of 0.5 fps.

completed the DQ surveys. The use of multiple CWISs for costing has been retained in the final rule. Therefore, for the DQ survey facilities, multiple intakes were included in the cost data input list, and separate costs were derived for each intake structure. For power generation facilities, separate cost estimates were derived for 406 intakes at 284 facilities. For manufacturers, separate cost estimates were derived for 317 intakes at 235 facilities.

Data Sources and Assumptions

Exhibit 8-5 below describes the source data and assumptions used in deriving the data value for each cost tool input variable.[153] Data from the DQ surveys is generally denoted as being derived from Question Qxx, which corresponds to the question on the survey instrument.[154] The assumptions and analysis of several inputs are more complex than the others and are further discussed immediately following the table. Exhibit 8-5 includes a list of all input parameters evaluated and includes some that were not deemed appropriate for use in the final rule.

Exhibit 8-5. Input Data Sources and Assumptions

Input #	Description	Assumptions/Discussion
1	Facility type	All power generation facility/intakes are assigned Code 2 and manufacturers are assigned Code 3.
2	Cooling system type	Based on response to DQ question Q1d. Assigned Code 1 (Full Recirculation) if the only items checked are recirculating cooling systems. System consisting of recirculating impoundments were assigned Code 2. All else Code 0.
3	State	Data from Phase II and III Master.*
4	Waterbody type	Data from Phase II and III Master. Data was compared to survey data. Three facilities had portions of multiple intakes reassigned due to different waterbody types for different intakes.
5	Fuel type	Data from 2004 Phase II costing and confirmed with survey database. Primarily used to distinguish nuclear from non-nuclear facilities. Field not applicable to manufacturers.
6	Capacity utilization percent	Steam Capacity Utilization Rate (CUR) from Phase II Master with updates for facilities previously assigned CUR of 0 and with missing values. Updates are based on year 1999 EIA data. Field not applicable to manufacturers.
7	Input (intake) location	Coded using survey data. If multiple intake types were reported, then assigned codes using the following hierarchy: Submerged Offshore (Codes 4 or 5); Intake Canal; Embayment Bay, or Cove; Shoreline Intake (Codes 1 or 6). Two facilities did not report intake type and were assigned Shoreline Intake (Code 1).
8	Distance offshore, ft	Used survey data for DQ facilities with data in survey. Cost tool will assign defaults on the basis of the waterbody type if the survey value is zero or blank.
9	Canal length, ft	Used survey data for DQ facilities with data in survey. Cost tool will assign defaults on the basis of the waterbody type if the survey value is zero or blank.

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[153] See DCN 12-6651 for a blank cost tool with the input page.
[154] See http://water.epa.gov/lawsregs/lawsguidance/cwa/316b/index.cfm for blank copies of the surveys.

Input #	Description	Assumptions/Discussion
10	Waterbody use/ navigation	This field was not used for the final rule.
11	Mean intake depth, ft	Used data from 2004 Phase II Rule and Phase III Rule cost development spreadsheets and survey data. Default value is 18 ft for power generators and 19 ft for manufacturers.
12	Intake well depth, ft	See detailed description below.
13	Exceeds 5 percent mean annual stream flow (1=Yes)	This field was not used for the final rule.
14	Design intake flow, gpm	DIF data taken from Phase II and III Master. For facilities with multiple intakes, individual intake flow was obtained from survey database. Confirmed that sum was equal to total in Phase II and III Master.
15	New design intake flow, gpm	Used to estimate costs for Modules 3, 4, 7, 12, and 14. Set equal to maximum reported intake flow in DQ Question 25. Set equal to reduced intake flow if Closed-cycle cooling technology is applied.
16	Average intake flow, gpm	Average Intake Flow (AIF) data taken from Phase II and III Master. For facilities with multiple intakes, individual intake flow was taken from survey database. Confirmed that sum was equal to total in Phase II and III Master.
17	Design screen velocity (fps)	Values taken from 2004 Phase II Rule and Phase II Rule cost development spreadsheet and survey data. Default value is 1.5 fps for power generators and 1.2 fps for manufacturers.
18	Through-screen velocity flow basis	Survey requested design through-screen velocity. Therefore, Code 1 (Existing Equipment Design Intake Flow) was assigned to all.
19	Water type (1=marine, 0=fresh)	Code assigned according to waterbody type. Assumed Ocean and Estuary/Tidal River are marine. All others are fresh.
20	Debris loading (1=high, 0 = typical)	Values taken from 2004 Phase II and Phase III Rule costing. Blanks in spreadsheet were not assigned codes.
21	Impingement tech in-place	See detailed description below.
22	Qualified impingement?	See detailed description below.
23	Entrainment tech in-place	This field was not used for the final rule.
24	Qualified entrainment?	This field was not used for the final rule.
25	Avg annual Generation MWh (95-99)	This field was not used in the final rule.
26	Selected technology module	This field is used for specifying a compliance module for which costs are desired; if filled in, it will override the cost tool technology assignment.
27	Regional Cost Factor	Factors were developed from ENR data for Phase II. Default values based on Statewide averages are applied to Phase III intakes
28	Construction Cost Index	ENR Construction Cost Index can be selected to adjust costs for inflation
29	Compliance Screen Mesh (mm)	Selected screen mesh size determining screen percent open area and screen size for module 3. Coarse mesh (9.5 mm) was assumed.
30	Screen Velocity for Module 3 (fps)	Design screen velocity can be selected for module 3. A design velocity of 0.5 fps was assumed.
31	Maximum Acceptable Screen Velocity (fps)	Ristroph traveling screen upgrades (Modules 1 and 10.3 are not available for existing traveling screens with velocities greater than the selected value. A value of 3.0 fps was assumed.
32	Total Plant Design Intake Flow (mgd)	Used for technology module selections based on total plant design intake flow.

*The Phase II and III Master files are confidential business information (CBI) files containing the most recent information for data fields that have been revised, such as DIF or a facility's being subject to the rule. Other data fields (such as intake location, facility state, and so on) are unlikely to change and are maintained in the original survey database.

Screen Well Depth (Input #12)

Compliance modules involving replacement or modifications of existing traveling screens (including the baseline O&M costs) require a cost input value for the total height of the traveling screens from the base to the deck, which is referred to as the screen well depth. This data was not reported in the technical surveys and the previous estimates were derived using the sum of the distances between top and bottom of the intake opening and the mean water level, which was not necessarily a correct interpretation of the data, especially for submerged intakes.

In this revised approach, EPA reviewed available screen well design data including data from facilities that were visited. Waterbody type appeared to be an important factor, since screen decks are generally situated at elevations that exceed expected extreme high water levels and the degree of variation in water levels tends to be similar among similar waterbody types. The data indicated that the difference between extreme high and mean water levels tended to be greater for rivers and streams and lower for tidal applications.

Exhibit 8-6 presents the assumed distance from the mean water surface to the screen deck that was derived from trends in the available data. The estimated screen well depth of each traveling screen was derived by adding the distances shown in Exhibit 8-6 to the mean intake water depth (Input #11). The resulting values in most cases resulted in greater assumed well depths than those that were used to derive the previous compliance cost estimates for the Phase II and Phase III Rules. This resulted in generally higher cost estimates for cost modules involving replacement or upgrade of existing traveling screens and for new larger intakes with traveling screens.

Exhibit 8-6. Assumed Height of Traveling Screen Deck Above Mean Water Level

Waterbody	Assumed Distance from Mean Water Surface to Screen Deck (ft)
Ocean	15
Estuaries/Tidal Rivers	15
Great Lakes	15
Rivers and Streams	30
Lakes/Reservoirs	20

New Design Intake Flow (Input #15)

Depending on the selected compliance technology, the design flow used to estimate compliance technology costs was either the design intake flow for each intake (DIF) or the New Design Intake Flow. The New Design Intake Flow (NDIF) was set equal to the maximum flow volume that was reported for the years 1996 through 1998 in question 25 of the detailed survey or the DIF if no detailed flow data were reported. This maximum reported intake flow (MRIF) is assumed to be the maximum flow volume required for cooling and other purposes. For most intakes, the MRIF is smaller than the DIF because the reported DIF often included excess pump capacity that is either no longer needed or serves as backup. When calculating intake technology costs for compliance options that required closed-cycle cooling, the New Design Intake Flow was calculated by reducing the DIF by 93 percent of the non-contact cooling flow volume used to estimate the closed-cycle cooling system costs.

The DIF was used to estimate IM compliance if the selected compliance technology involved modification/replacement of the existing intake traveling screens (e.g., replace existing traveling screens with modified Ristroph traveling screens). The NDIF was used to estimate IM compliance if the selected compliance technology could be sized independently of the existing intake technology (e.g., wedgewire screens or a new intake).

In the current approach, the cost for Module 5 (barrier net) was developed as a technology for each separate intake. In the 2004 Phase II rule, the barrier net costs were developed using the combined flow of multiple intakes at the same facility. This is based on the assumption that the multiple intakes are close enough together that they can be protected by a single barrier net.

Impingement Technology In-place (Input # 21)

The following criteria were used to assign impingement technology codes:

- Assigned Code 1 (Traveling Screens) if answered Yes to Q19c Traveling Screen Codes E1, E2, E3, E4, E5, E6, F (Other) if description qualified.
- Assigned Code 5 (Wedgewire Screen) if answered Yes to Q21b Passive Intake Code G.
- Assigned Code 2 (Passive Intake) if answered Yes to Q21b Passive Intake Codes H, I, J, K.
- Assigned Code 3 (Barrier Net) if reported Fish Barrier Net Code P in Q22b.
- Assigned Code 4 (Fish Diversion or Avoidance System) if answered Yes to Q22 Fish Diversion or Avoidance System Codes M, N, O, Q, R, S, T, U, V.

Qualified Impingement? (Input # 22)

As described above, some intakes utilize technologies that were considered to already meet the performance standard for impingement mortality. The following criteria were used to make this assessment:

- Assigned Code 1 (qualified) if design screen velocity was ≤ 0.5 fps.
- Assigned Code 1 (qualified) if survey indicated there was a combination of technology components associated with a Ristroph-type, fish-friendly traveling screen, including a separate fish return trough present. Included only intakes answering Yes to Q20a (are screens used to reduce impingement and entrainment?) and reporting several of the following:
  - Q20b (I&E Reduction System-Spray Wash/Fish Spray);
  - Q20b2 (I&E Reduction System-Fish/Debris Troughs);
  - Q20b4 (I&E Reduction System-Fish Buckets/Baskets/Trays);
  - Q23b Code W (Fish Pump);
  - Q23b Code X (Fish Conveyance Systems);

  - Q23b Code Y Fish Elevators/Lift Baskets);
  - Q23b Code AA (Fish Holding Tank);
  - Q23b Code BB (Other) provided description qualified.
- Assigned Code 1 (qualified) if there was a qualifying Fish Diversion or Avoidance System intake technology reported in Q22b including:
  - Code M (Velocity Cap) if intake was located far offshore[155].
- Assigned Code 1 (qualified) if there was a qualifying Passive Intake System intake technology reported in Q 21b including:
  - Code G (Wedgewire Screen); and
  - The design intake velocity of the technology is 0.5 ft/sec or less.

If a technology applied to only a portion of parallel equipment (e.g., Ristroph screens on only a portion of screens), it was assumed that the lesser qualified technology was present on all equipment (i.e., the entire intake was designated as not qualified).

Maximum Acceptable Screen Velocity (Input 31)

EPA was concerned that some intakes with traveling screens may include design parameters that are outside the range typically employed or may have difficulty employing effective fish returns and therefore may not perform as well as the systems evaluated by EPA. While EPA expects the required optimization study would ensure appropriate operating parameters, it is also possible that existing traveling screens may need other modifications to meet the definition in the rule. EPA decided that a high through-screen velocity may be an example of such a situation and used a threshold through-screen velocity of greater than 3.0 fps as a criterion for identifying intakes with traveling screens under such conditions. EPA recognizes that such traveling screens (when upgraded) may perform satisfactorily, but to be certain the selected technology response would meet the performance standards for IM, EPA select a higher cost technology options for this subset of model facilities. EPA notes that at proposal this value was set at 2.5 fps based on recommendations from a technology vendor (see DCN 12-6657). However, a re-evaluation showed that this threshold was more applicable to fine mesh screens. EPA notes this velocity threshold is significantly higher than the upper end of the range of values for facilities used in the development of the numeric impingement standard. EPA increased the proposed value of 2.5 fps to a value of 3.0 fps.

8.3 Entrainment Mortality Compliance Costs

To estimate costs of entrainment mortality (EM) controls using flow reduction, EPA developed an option that would retrofit facilities with once-through cooling systems to closed-cycle recirculating systems in the form of mechanical draft wet cooling towers. Costs were derived for cooling systems associated with individual intakes.

In September 2007, EPA obtained an Excel spreadsheet from EPRI that contained a set of calculations for estimating cooling tower retrofit costs at existing steam power plants.

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[155] Only velocity caps with distance offshore greater than 800 ft. See DCN 12-6601

EPA compared the EPRI model to the methodology used in the Phase II NODA and found that the two methods produced similar costs. Because these methods produced similar costs and the EPRI method was simpler and more flexible, the EPRI methodology was chosen to develop the model facility cost equations for the final rule. In a 2011 technical report "Closed-Cycle Cooling System Retrofit Study - Capital and Performance Cost Estimates" (Technical Report #1022491), EPRI provided a closed-cycle cost estimate for electric generators with a design intake flow greater than 50 mgd. The basic methodology used in this more recent EPRI estimate was similar to the 2007 methodology but included a more detailed approach utilizing site-specific data not available to EPA. A comparison of the EPRI cost estimate to similar EPA estimates indicated that the cost methodology EPA adapted from the EPRI 2007 cost methodology produced comparable results. See TDD Chapter 12 for a more detailed discussion. The EPRI 2007 methodology distinguishes between three separate capital cost values related to the degree of difficulty associated with the cooling tower retrofit. The costs are representative of an *easy* (lowest cost), *average* (intermediate cost) or *difficult* (highest cost) retrofit. EPA derived model facility capital costs equations for both the *average* and *difficult* retrofit scenarios for use in the applicable cost analyses.[156] These different levels of costs were applied differently to power generators and manufacturers.

EPRI lists the factors that affect the selection of the degree of difficulty rating for capital costs as:

- Availability of tower space nearby
- Need to remove or demolish existing structures
- Whether the tower site elevation is higher than the existing cooling system intake bay so cold water can flow by gravity to the intake bay
- Whether there are underground interferences in the path of the new circulating water lines or at the location of the hot water sump and new circulating water pumps
- Whether the tower site has overhead interferences, including transmission lines
- Whether the tower design might have to work around excluded areas where activities that cannot not be moved or blocked occur (e.g., hazardous materials storage, vehicle turn-around areas, and security areas)
- The degree of construction work needed to convert the existing intake to handle the lower intake flow volume needed for makeup water
- How difficult it will be to tie the towers in to the existing cooling system
- Whether the site has unfavorable soil or geological conditions
- Whether the site has contamination that might require remediation

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[156] EPA used the average scenario for the power generator compliance cost scenarios that include closed-cycle cooling, because the costs were derived from power generation applications and are representative of costs on a national scale (i.e., some facilities might face a difficult scenario, but others will have an easy scenario, balancing costs on a national scale). For some IPM analyses, EPA used the difficult scenario because it represented the highest cost scenario and would provide an indication of worst case economic impacts. For more information, see the BA.

EPRI states that there is no simple way to determine how consideration of each of these items will translate into assigning the project into the easy, average, or difficult categories. If none of the items presents any obvious problems, an easy retrofit might be expected. If two or three do, average is probably appropriate. If more than three, then difficult is appropriate (DCN 10-6930).

EPA's costs for closed-cycle cooling include capital costs, O&M costs including auxiliary power requirements, heat rate penalty losses, and downtime costs.[157] EPA also included additional costs to account for noise and plume abatement, which will be required at some sites. Cooling tower costs were derived in a different manner than the intake technology costs (see below for more information). In the case of the intake technology costs, technologies were assigned to individual model facilities and the associated costs were calculated and scaled upward (using survey weights) to determine the national model facility costs. For the cooling tower costs, preliminary costs for individual DQ facilities were derived using the EPRI spreadsheet and then aggregated to generate cost equations representing the national average. The preliminary costs calculated for each intake using the EPRI calculation worksheet were then adjusted using the regional cost factor derived for that plant in the 2004 Phase II rule.[158] The model facility costs were then generated using these equations. As in the case of the intake technology costs, the model facility cooling tower costs were then multiplied by a weighting factor specific to each facility to obtain national model facility costs.

8.3.1 Capital Costs

Power Generators

Since the EPRI costs were derived from cooling tower retrofit costs for power generation systems, it is reasonable to select the "average" difficulty costs as the basis for the compliance costs for cooling towers for power generation cooling systems. It was assumed that the recirculating flow rate of the cooling tower would be equal to the MRIF of the existing cooling system. Intake-specific costs were derived for the facilities with once-through cooling water systems that provided design flow data in the 2000 detailed surveys. Facilities were included in this portion of the analysis regardless of the capacity utilization rate (CUR), as this rate does not affect the DIF.

The ratio of capital cost to DIF (dollars/gpm) was then calculated for each plant. Various methods for using this data to estimate costs were evaluated, including using cost curve trend lines that varied with flow derived using Excel (which uses a least squares method) and a linear approach using the between-facility average or median of the dollars/gpm ratios. So as not to make assumptions that would lead to underestimating costs, EPA assumed that a simple linear equation using the overall between-facility average of the individual facility capital cost to DIF ratios (dollars/gpm) represented a reasonable estimate for the national model facility costs.

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[157] There are no pilot study costs for cooling towers (i.e., pilot study factor = 0). These technologies are well studied, and the performance can be predicted using meteorological and other site-specific data.

[158] EPRI's cost methodology did not account for facility location. Construction costs do vary regionally, so EPA applied the regional cost factor.

EPA also evaluated whether applying the facility weighting factors to the calculation of the average had any effect on the resulting average ratio of dollars/gpm and found that the value changed by less than 1 percent. The same was true for the O&M cost components as well.

EPA also recognizes that some generators are situated in locations that may require plume and/or noise abatement. It is not clear from the EPRI tower calculation support documentation whether the mix of retrofit projects from which the "average" difficulty costs were derived are representative of the universe of facilities that would be required to install closed-cycle cooling under the final rule. One concern is that the compliance universe under an option that would require closed-cycle of all facilities will include a larger proportion of facilities requiring additional costs for requirements such as plume abatement, noise abatement, and space constraints.

EPA adopted a conservative approach to account for this possibility by modifying the cost for closed-cycle cooling systems at power generators. An analysis determined that approximately 25 percent of existing power generators may require additional costs associated with plume and/or noise abatement and space constraints. (See DCN 10-6671.) Rather than attempt to assign specific technology upgrade additional costs to specific facilities,[159] EPA spread these added costs throughout the entire universe of facilities that would be required to undergo closed-cycle cooling retrofits since the existing plant database did not contain sufficient detailed data to make a reliable determination regarding which specific facilities would be subject to these requirements. These added costs were spread across all facilities by adding the equivalent of 25 percent of the estimated additional costs for plume abatement technology to the cost assessed for all facilities. The estimated additional costs for plume abatement were considered as representative of the mix of costs associated with plume abatement, noise abatement, and/or space constraints. (See DCNs 10-6652 and 10-6653.)

Exhibit 8-7 presents the capital and O&M cooling tower cost formulas for the "average" difficulty cooling tower retrofit. Exhibit 8-8 presents the adjusted "average" retrofit cost factors modified to account for 25 percent plume abatement costs. The cost equations in Exhibit 8-7 were also used to estimate compliance costs for manufacturers where non-contact cooling water (NCCW) was used primarily for power generation purposes.[160] The cost equation factors in Exhibit 8-8 were used to estimate costs for power generating facilities.

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[159] EPA's concluded that the estimated costs of plume abatement was close to the capital cost of the EPRI "difficult" scenario and should be representative of the cost of the mix of additional abatement technologies.

[160] The NCCW flow was considered as being primarily for power generation if the answer to question 4a and 4b in the DQ survey indicated that greater than 85 percent of the cooling water was used for power generation purposes.

Exhibit 8-7. Cooling Tower Costs for Average Difficulty Retrofit

Costs and Generating Output Reduction	Equation	Constant (2009)
Capital Cost (CC)	CC = MRIF(gpm) x Constant	$263
Fixed O&M Cost (OMF)	OMF = MRIF(gpm) x Constant	$1.27
Variable O&M - Chemicals (OMC)	OMC= MRIF(gpm) x Constant	$1.25
Variable O&M - Pump & Fan Power (OMV)	OMV= MRIF(gpm) x Constant	0.0000237
Energy Penalty -Heat Rate (EP) Non-nuclear	EP=MWS[a] x Constant	0.015
Energy Penalty -Heat Rate (EP) Nuclear	EP=MWS x Constant	0.025

[a] MWS is the total steam generating capacity in MW.

Exhibit 8-8. Capital and O&M Cost Factors for Average Difficulty Cooling Tower Retrofit with 25 percent Plume Abatement

	Capital Cost (2009 Dollars)	Fixed O&M (2009 Dollars)	Variable O&M – Chemicals[a] (2009 Dollars)	Variable O&M - Pump & Fan Power
	Dollars/gpm	Dollars/gpm	Dollars/gpm	MW/gpm
Average Retrofit	**$263**	**$1.27**	**$1.25**	**0.0000237**
Add for Plume Abatement at a Single Facility	$120	$1.00	$0.00	0.0000031
Average Increase if Applied to 25 percent of Facilities	$30	$0.25	$0.00	0.0000008
Adjusted Constant	**$293**	**$1.52**	**$1.25**	**0.0000245**

[a] Non-power variable O&M costs are for additional treatment chemical for optimized tower operation at higher cycles of concentration

Manufacturing Facilities

For manufacturing facilities, EPA recognizes that cooling tower retrofits will need to be integrated into the existing manufacturing processes at different locations within the plant and it is expected that in many instances difficulties will be encountered to a greater degree and frequency than at power generators. Such difficulties may involve space constraints, reconfiguration of process piping, long piping runs, conflicts with existing piping and infrastructure, and utilities. These are some of the factors that EPRI cited as contributing to a “difficult” designation for a cooling tower retrofit. In addition, the cooling towers are likely to be installed as smaller units serving individual processes throughout the plant, thus reducing the opportunity for savings from economies of scale that may be achievable at power generators.

As a result of these considerations, EPA applied the “difficult” retrofit capital costs to any closed-cycle cooling system retrofit at a manufacturer, with the exception of instances where cooling water was used primarily for power generation purposes, as described above. In such cases, the “average” difficulty costs shown in Exhibit 8-7 were applied.

Exhibit 8-9 presents the “difficult” retrofit cost equations utilized for estimating closed-cycle cooling system costs for manufacturing facilities. Like power plants, the costs for manufacturers are also based on the MRIF; however, as described below, manufacturers have some key differences that were incorporated into determining the appropriate flow for designing a cooling tower system.

Exhibit 8-9. Cooling Tower Costs for Difficult Retrofit

Costs and Generating Output Reduction	Equation	Constant (2009)	Units
Capital Cost (CC)	CC = MRIF(gpm) x Constant	$411	Dollars
Fixed O&M Cost (OMF)	OMF = MRIF(gpm) x Constant	$1.27	Dollars
Variable O&M - Chemicals (OMC)	OMC= MRIF(gpm) x Constant	$1.25	Dollars
Variable O&M - Pump & Fan Power (OMV)	OMV= MRIF(gpm) x Constant	0.0000237	MW

[a] MWS is the total steam generating capacity in MW.

Intake Flow Used To Estimate Costs

Aside from the difficulty of installation and retrofit, there is generally little difference in the operation of cooling water intake structures and cooling systems between power plants and manufacturers. Both types of facilities use cooling water in similar ways. However, manufacturers have one notable difference—they tend to use more process water and contact cooling water. This results in opportunities for manufacturers to reuse process water as cooling water, to use cooling water later in the process, and ultimately to reduce overall withdraws. The cost analysis does not include the potential for cost savings due to these reuse opportunities. In many cases, process water is withdrawn via the same intake structure as cooling water, creating a more complicated water balance diagram.[161]

Cooling water can consist of both non-contact cooling water (NCCW) and process contact cooling water (CCW). Contact cooling water which comes into direct contact with process chemicals and materials can pick up contaminants during the cooling process and may require treatment to remove contaminants if it is to be recirculated through a cooling tower and reused in the process. In some cases (e.g., certain steel-making processes), the required treatment process may be minimal (e.g., settling), but in others, flow reduction is not possible without materially affecting the facility’s operations or products since the water quality requirements for the contact cooling water may render recirculation of CCW impractical since manufactured product quality and/or process performance may suffer without costly treatment. For this reason, EPA did not consider flow reduction using closed-cycle cooling as a readily available technology option for CCW or combined flows that included CCW or process water that could not be segregated. Therefore, closed-cycle cooling was only applied to the estimated NCCW component of the intake flow for manufacturers.

As a result, EPA reviewed a number of flow balance diagrams from the DQ industry questionnaires for facilities in multiple industrial sectors and developed an estimated proportion of total intake flow that is dedicated to cooling.

At power generators, the majority of intake water is used as non-contact cooling water for condensing steam and equipment cooling (service water). Only a small portion is used for

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[161] Reuse of cooling water as process water also presents a regulatory challenge, as these flows are no longer considered cooling water.

process water or contact cooling. Therefore, for cost estimation purposes, the NCCW flow was assumed to be the entire intake flow. For power plants that provided intake flow data in question 25 of the technical survey, the MRIF was used as the cooling tower design flow. Otherwise, the DIF was used.

For manufacturing facilities, the proportion of intake water used for process, NCCW, and CCW purposes varied widely between industry types and facilities within each industry. In order to determine water use trends at manufacturers, EPA examined data reported in the 2000 detailed technical surveys for the large flow facilities with DIF greater than 100 mgd. The detailed technical survey requested information concerning percent of cooling water flow used for: 1) electric generation; 2) air conditioning; and 3) contact or non-contact process cooling. Unfortunately the survey did not distinguish between contact and non-contact process cooling water, so schematic flow diagrams were also examined since they often contained additional data concerning flow volumes and specific water uses. All available data concerning the following items from both the survey responses and the schematic flow diagrams were then summarized in a database with the following components:

- Plant ID
- Design intake flow (DIF)
- Maximum reported intake flow (MRIF)
- Average intake flow (AIF)
- Cooling system type
- Industry type
- Non-contact cooling flow (NCCW)
- Non-contact cooling flow used mostly for electricity generation
- Process and/or contact cooling flow
- Answer to survey question 4a or 4b (percent cooling water used for electricity generation)
- Answer to survey question 3h (estimated percent of design capacity used for cooling)
- Detailed notes

“Type of cooling water use” and “flow volume” data was available in only a portion of the schematic diagrams. However, enough data was available to estimate NCCW flow for four or more facilities that could be categorized into one of the following industrial groups:

- Chemicals
- Paper
- Petroleum
- Metals
- Other

With NCCW flow data now available for this subset of facilities, a methodology was derived to estimate NCCW flows for other facilities in the database. In order to simplify the approach, it was assumed that the general mix of process water, NCCW, and CCW use would be somewhat similar within each of these major industry groups.

The NCCW flow for each facility was then compared to available flow data representing total flow. Three factors based on the total NCCW flow were then evaluated to see if they would be suitable for estimating the NCCW component at facilities where detailed data were not available. For each factor, the total NCCW flow value taken from the schematic diagrams was divided by the total process and cooling flow from the diagrams, the DIF and the MRIF. Facilities with low NCCW flow values that employed cooling systems other than once-through or where the total flow (from the flow diagram in the survey) was much lower than the AIF were not included in the analysis, since the NCCW flow data for these facilities may not have included the volume of recirculating cooling water. The remaining ratios were then averaged for all facilities with such data in each industry group. Exhibit 8-10 presents the results of this analysis.

Exhibit 8-10. Ratio of Non-Contact Cooling Water Flow to Total Facility Flow for Evaluated Manufacturing Facilities With DIF >100 MGD

Plant Type	NCCW /Diagram Total (%)	Number with Data	NCCW /MRIF (%)	Number with Data	NCCW /DIF (%)	Number with Data	Value Selected for Estimation
Chemicals	80.2%	5	**70.5%**	2	50.2%	5	**70.5%**
Other	96.0%	5	**75.5%**	3	65.4%	5	**75.5%**
Paper	77.6%	3	**64.0%**	1	33.9%	4	**64.0%**
Petroleum	81.6%	4	**82.4%**	3	31.6%	4	**82.4%**
Metals	83.8%	7	46.3%	2	**53.5%**	6	**53.5%**

As can be seen from Exhibit 8-10, the trend is for the ratio of “NCCW/Diagram Total” to be greater than the ratio of “NCCW/MRIF” which is greater than the ratio of “NCCW/ DIF.” EPA concluded that the ratios of “NCCW/Diagram Total” were less suitable for extrapolating to other facilities since the values were on the high side and corresponding diagram totals would not be available for the majority of facilities that were not evaluated. The ratio of NCCW/DIF tended to be lower than the ratio of NCCW/MRIF due to the fact that the MRIF was often lower, since the DIF often included intake capacity that was seldom, if ever, actually utilized. Therefore, with the exception of the metals category, the average ratio of NCCW/MRIF was selected as the factor to be used in estimating NCCW flows using MRIF data. In the case of the metals category, the ratio of NCCW/DIF was greater and was selected as the factor to be used in estimating NCCW flows since it was the median of the three values and was based on a larger number of data points.

The selected factors were then used to estimate the total NCCW flow for each manufacturing facility in their respective categories by multiplying the factor times the MRIF. In cases where MRIF data were not available, the DIF was used which may result in some overestimation of the NCCW flow volume. For those facilities used to derive these factors where actual NCCW data were derived from the flow schematics, the actual NCCW value was used instead.

8.3.2 O&M Costs

The EPRI Tower Calculation Worksheet also produces a general O&M cost on the basis of the facility's DIF. This cost is assumed to be a fixed O&M cost component consisting primarily of labor and materials. The general fixed O&M cost was then adjusted using the regional cost factor. Unlike the O&M costs calculated for intake technologies, the O&M costs for the baseline intake technology were not deducted (except as noted below under pumping height) for facilities converting to cooling towers. The use of a closed-cycle cooling system will still require an intake system for makeup water. Although the intake volume will be substantially smaller (at least 90 percent less volume), it will require O&M costs, which are assumed to be more than offset by the existing intake O&M costs.

The EPRI worksheet also generates an O&M cost associated with pump and fan energy requirements. This is assumed to be a variable cost component that would vary with the operation of the generating units. The value derived here is associated with generating units operating at full capacity. Unlike the fixed O&M cost, this component was not adjusted using the regional factor because it is expressed in units of power consumption, which is not dependent on the facility's region.[162]

As with the capital costs, the fixed O&M to DIF ratio (dollars/gpm) and variable O&M to DIF ratio (MW/gpm) were calculated. The Excel trend lines for the O&M costs and power requirements were plotted against DIF, and average and median ratios of costs and power requirements versus DIF were then compared. As with the capital costs, the average of the facility ratios of fixed O&M to DIF (dollars/gpm) and variable O&M to DIF (MW/gpm) represented reasonable estimates for the national model facility costs.

The EPRI worksheet contains numerous assumptions and default values that can be modified using site-specific data. Specific relevant assumptions and default values are listed below:

- Tower configuration was in-line rather than back-to-back, meaning towers are oriented in single rows rather than rows of two towers side by side.

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[162] The EPRI worksheet can also derive pump and fan energy costs in dollars using heat rate and fuel cost data, but this feature was not used. The input value for the national economic impacts analysis O&M pump and fan energy component is the electric energy requirement in MW, not the cost in dollars. The MW value derived from the equation represents the maximum energy requirement at full-capacity operation and is expected to be reduced when the plant is operating at less than full capacity.

- ΔH1 (Elevation rise from sump level to pump level) was set at 0 ft.[163]
- ΔH2 (Elevation rise from pump to tower site) was set at 0 ft.
- ΔH3 (Height of tower hot water distribution deck) was set at 25 ft.
- Recirculating water pipe flow velocity was set at 8 fps.
- Tower loading rate was 10,000 gpm/cell

The EPRI cost worksheet also assumes that O&M costs are the same for cooling towers with different retrofit difficulties. Thus, the same O&M costs were applied to all cooling tower retrofits, regardless of the difficulty of the retrofit. EPA assumed the EPRI O&M costs were based on current operating methods employed at power generators, which often involved minimal use of chemical treatment and operation at lower cycles of concentration. As described below, further adjustments to O&M costs were made for plume abatement and for optimized operation with regards to flow reduction.

Plume Abatement Costs

Adjustments to O&M for cooling towers with plume abatement technology included an increase in energy requirements and fixed O&M costs. The increase in energy requirements was based on an assumed 8 ft increase in pumping head and a 10 percent increase in fan energy to account for additional demands created by addition of the dry section coils. The increase in the fixed O&M component was based on an assumed 80 percent increase in O&M costs for the additional maintenance associated with the dry cooling section equipment. A more detailed discussion can be found in the "Cooling Tower Noise Abatement and Plume Abatement Costs." (See DCN 10-6652.) These costs are shown as the cost adjustment factors in Exhibit 8-8 above.

Optimization Costs

EPA found that current practice regarding chemical treatment of circulating water at power generators mostly involved treatment with biocides such as chlorine, and that there was often no incentive to optimize (reduce) makeup flows by operating at higher cycles of concentration. Operating a closed-cycle cooling system at higher makeup and blowdown volumes results in higher intake flow volumes and lower cycles of concentration. Lower cycles of concentration generally reduce the need for careful operational control and chemical treatment for scale formation or suspended solids deposition. EPA assumed that compliance with the regulatory options for flow reduction would include the operation of closed-cycle systems in an optimized manner, which may include operating at higher cycles of concentration.[164]

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[163] Although the default values of ΔH1 and ΔH2 were 5 ft and 10 ft, respectively (15 ft total), they were set equal to 0 in EPA's cost estimates to offset a portion of the baseline once-through surface water intake pumping energy requirement that would no longer be needed (i.e., the facility's intake structure will be withdrawing less water and will require less energy; these savings were recouped by using different assumptions for ΔH1 and ΔH2).

[164] As noted in the preamble, EPA assumed target optimal cycles of concentration of 3.0 and 1.5 for fresh and marine waters, respectively.

To account for this, EPA increased the O&M cost estimates derived from the EPRI model by adding another variable cost component to cover increased use of chemical treatment. This component included additional costs for both increased chemical treatment and added labor (see “Water Balance, Flow Reduction, and Optimization of Recirculating Wet Cooling Towers,” DCN 10-6673). Capital costs were not adjusted, since the estimated cost of flow monitoring and chemical feed systems was very small—equal to about 0.2 percent of the “average” difficulty retrofit cost. These costs are shown as the chemical treatment cost component equations and factors in Exhibits 8-7 and 8-9 above.

8.3.3 Energy Penalty

The term “energy penalty” as associated with conversion to closed-cycle cooling has two components. One is the extra power required to operate cooling tower fans and additional pumping requirements, referred to as the auxiliary power requirement penalty. The other is the lost power output due to the reduction in steam turbine efficiency due to an increase in cooling water temperature, referred to as the turbine efficiency penalty.

Auxiliary Power Requirement

The auxiliary fan and pump energy requirement is included as a separate component in the O&M costs described above and was applied in all cases. The auxiliary power requirement was estimated as MW of power required, which was then converted to costs in the economic model.

Turbine Efficiency Loss

The energy penalty associated with turbine efficiency loss due to the conversion from once-through to recirculating cooling towers is best expressed as a percentage of power generation.[165] To offset the efficiency loss, a facility can increase its fuel consumption if the steam boilers are operating below full capacity or it could experience a reduction in electricity generated if the steam boilers are operating at full capacity and are unable to increase steam output.

The turbine efficiency penalty is typically expressed as a percentage of power output. In the Phase I Rule, EPA estimated an annual average energy penalty of 1.7 percent for nuclear and fossil-fuel plants and 0.4 percent for combined cycle plants. The estimated maximum summer penalty was 1.9 percent. The EPRI supporting documentation for the 2007 methodology (DCN 10-6930) estimated the energy penalty to range between 1.5 percent and 2.0 percent. In their more recent cost estimate (Technical Report #1022491), EPRI performed a detailed analysis of turbine design and conditions for seven different regions that resulted in a time-weighted averages ranging from -0.2 percent to 2.3 percent for hot days assumed to occur for 10 percent of the year. In the analysis EPRI used a hot day penalty of 2 percent. The time-weighted annual average ranged from 0.6 percent to

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[165] Typically, cooling towers do not cool the circulating water to the same temperature as surface water used in once-through cooling. As a result, the steam is not cooled as effectively leading to a higher steam turbine backpressure and a loss of generating efficiency.

1.4 percent. In the analysis EPRI used an annual average of 1.0 percent for the remainder of the year.

To reflect the differences in steam pressure for facilities using different fuels,[166] EPA distinguished between nuclear and fossil plants. Fossil plants experience a lower turbine efficiency loss due to the higher system pressures, while nuclear plants would realize a higher efficiency loss. As a result, EPA selected a turbine efficiency loss value of 1.5 percent for fossil plants and 2.5 percent for nuclear facilities, which given the more recent EPRI estimates are representative of the upper end of the range of values that can be expected throughout the nation. These values apply directly to the generation rate of the steam generating units, and thus the cost will vary with the amount of electricity being generated. (See "Cooling Tower Energy Penalties" [DCN 10-6670] for a more detailed discussion.)

For closed-cycle cooling retrofits at manufacturing facilities or intakes that do not primarily generate electricity, no turbine efficiency energy penalty was assigned since no power is being generated. For manufacturing power generation systems, the energy penalty for turbine efficiency loss for non-nuclear power plants (i.e., 1.5 percent) was applied.

8.3.4 Construction Downtime

Power Generators

In addition to the costs described above, a facility might also incur downtime costs. In the Phase II NODA, EPA assumed net construction downtimes of 4 weeks for non-nuclear plants and 7 months for nuclear plants. These net values assume that the construction tie-in would be scheduled to coincide with the plant's routine scheduled maintenance event. Thus, the net value includes a deduction of the estimated maintenance downtime period (4 weeks for non-nuclear facilities) from the total estimated downtime. EPA asked for comments in the Phase II NODA regarding these assumptions but then did not make any conclusions regarding the comments because the cooling tower option was not included as part of the basis for the 2004 final rule. Therefore, at proposal EPA assumed net construction downtimes of 4 weeks for non-nuclear plants and 7 months for nuclear plants.

EPA considered revised downtime estimates for the final rule based on comments and new data. EPA notes that at the Canadys Station and Jefferies Station sites, the closed-cycle system hook-up was completed within the scheduled plant outage period. EPA found that net downtime may be zero, which is further supported by an estimate of zero net downtime for "easy" to "average" retrofits in a report attached to EPRIs comment to the proposed rule (Comment 2200 - Technical Report No 1022491). However, the single value used by EPA represents a national average and thus should be representative of the full range of downtime values that would occur. The EPRI estimated net downtime

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[166] Steam turbines at nuclear facilities tend to operate at lower steam temperatures and pressures; therefore the energy penalty associated with turbine efficiency is expected to be higher for nuclear power facilities than for fossil-fuel facilities.

duration ranged from 0 to 6 months depending on difficulty. The weighted average of the EPRI net downtime estimates which represent the full range of difficulties was 1.5 months (if the much longer estimates for re-optimization are excluded[167]). Also, EPA has obtained new data that supports the 2 month total (one moth net) estimate. During the site visits EPA learned that both the Mc Donough and Yates Plants in GA, experienced a tie-in outage for the cooling tower retrofit of 6-8 weeks (see DCN10-6536 McDonough and DCN 10-6537 Harllee Branch). These projects would be classified as average to difficult retrofits. This new information supports EPAs estimate used in the cost analysis of 4 weeks net (8 weeks minus the assumed 4 weeks of scheduled maintenance). Since there is a limited number of examples to draw from, EPA's estimate falls between the values, and the new data supports these assumptions, EPA concludes that its estimate is reasonable. The assumed net downtime for non-nuclear power plants remains 4 weeks.

Upon evaluation of additional data for nuclear facilities, EPA has revised the downtime estimates for closed-cycle retrofits that reduces the overall downtime estimate. In the revised approach, facilities are divided into two groups: those that have conducted or are currently planning to conduct an extended capacity uprate (ECU) and those that have not. An important characteristic of an ECU is that it involves considerably more construction activities compared to simple refueling outages (including replacement of portions of the generating system) and therefore involves outages much longer than those for refueling. These projects provide an ideal opportunity to further reduce downtime if the closed-cycle retrofit is performed concurrently. Data regarding ECU scheduling was readily available. The final rule gives the Director greater flexibility in establishing compliance schedules for entrainment requirements that would allow for scheduling of the closed-cycle retrofit to occur concurrently with an ECU. For those facilities where ECUs are unlikely to occur in the future (i.e., facilities where an ECU has been performed or is currently planned), EPA took an approach similar proposal but with the duration adjusted downward to a level consistent with this new information. For the final rule estimate, EPA evaluated the EPRI net downtime estimate of 6 months used in their cost estimate provided as an attachment to EPRI's comment (see comment 2200 - Technical Report No 1022491). In support of the 6 month estimate, EPRI cited engineering estimates for four nuclear plants that ranged from 5 to 22 months and noted that the expected downtime was difficult to predict since there was a great degree of uncertainty given the lack of actual data. A closed-cycle retrofit for these facilities that will not conduct an ECU would likely occur concurrently with a refueling outage which now typically takes about 4 to 6 weeks (see DCN 12-6876). Thus, the EPRI net downtime estimate of 6 months or 24 weeks would be consistent with a total retrofit downtime of about 28 weeks. EPA notes that this 28 week value is consistent with the duration of the first steam generator replacement project for SONGs Unit 2 and while this outage length is the higher of the two similar projects at SONGS, the difference demonstrates that complex projects for which contractors and engineers have little previous experience will tend to take longer. The actual duration of the outage required for a nuclear closed-cycle retrofit is still unknown

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[167] EPRI assumed in their analysis that a certain portion of plants would re-optimize the cooling system which includes replacement of steam condensers and reduction in cooling tower capital and operating costs. Over the long term these cost reductions tend to offset the lost generation costs associated with longer downtime. Since EPA did not include re-optimization in the economic analysis, a comparison to the EPRI estimate excluding re-optimization is more appropriate.

and will be influenced by site-specific factors. EPA determined that a 24 week estimate was reasonable and applied this value in the economic analysis.

For the remainder of facilities that are likely to conduct an ECU in the future, EPA estimates that under favorable conditions, ECUs typically have a duration of two to four months (see DCN 12-6875) but can also take much longer. For this analysis, EPA assumed that facilities performing an ECU would be capable of completing the retrofit concurrently with the ECU and that the scope of the ECU would be extensive enough to push the duration toward the longer end of the 2 to 4 month or longer range. For these projects, EPA assumed zero downtime. See the Economic Analysis for Final 316(b) Existing Facilities Rule for more details regarding the application. See also DCN 12-6656. Based on data from the NRC, EPA estimates that roughly one-third of existing nuclear generating units have already performed or have applied for an ECU and therefore are assumed the a 24 week downtime. As a result, the equivalent average net downtime across all nuclear units should be about 8 weeks (2 months).

Besides the type of plant, another factor investigated for consideration in estimating construction downtime was CUR. Presumably facilities with low CUR values would have greater opportunity to schedule cooling tower tie-in construction activities such that they coincide with downtime periods of greater duration than the 4-week scheduled maintenance period assumed in the 2004 Phase II rule. A review of monthly flow data reported in the surveys for a sample of facilities with year 2000 CUR values in the 15 percent to 30 percent range was conducted. The data indicated that the cooling water systems at most of these facilities operated at least a portion of every month during each of the three years reported in the survey (1996, 1997, and 1998). While it is not clear whether these facilities produced power each month, EPA assumed these facilities need to be available for power generation. Since these facilities cannot accurately predict when they would be dispatched, EPA did not presume additional downtime could be guaranteed. CUR was not considered further as an indicator of available downtime for these facilities.

Exhibit 8-11 below summarizes the net downtime estimates.

Exhibit 8-11. Net Construction Downtime for Closed-cycle Retrofit

Fuel type	Net Downtime (Weeks)
Nuclear – ECU already completed prior to retrofit [a]	24
Nuclear – Retrofit concurrent with ECU	0
Non-nuclear	4

[a] Units that have already conducted an ECU or are currently planning to conduct an ECU

Manufacturers

At proposal, EPA assumed that, unlike generating facilities, there would be no downtime costs for closed-cycle cooling retrofits at manufacturing facilities due to the fact that manufacturers are often more segmented in their production and use of cooling water and are more likely to be able to shut down individual intakes or process lines without interrupting the production of the entire facility. Given that the Phase III rule did not consider regulatory options requiring closed-cycle cooling, EPA has not previously developed estimates for downtime at manufacturers for cooling tower retrofits.

At some facilities, generating systems provide electricity or electricity and steam (cogeneration) to many processes within the plant and that interruption of the cooling water source and thus the operation of generating/cogenerating system could impact plant production. In response to comments received and an evaluation of new information, EPA has revised the compliance cost methodology used in evaluating closed-cycle cooling costs under proposal options 2 and 3 to include downtime costs for manufacturing facilities. The methodology employed uses the same approach that was employed for entrainment technology downtime, which assumes that the overall manufacturing process will not suffer significant production losses and that the effect of downtime is primarily associated with the effect on the generation system. These costs are assessed as the equivalent cost of replacement electricity and lost revenue for offsite sales of excess generation. For closed-cycle retrofits at manufacturing facilities, EPA derived a closed-cycle retrofit downtime duration of 4 weeks which is similar to that for non-nuclear generating facilities. This value was derived using a different basis.

At generating facilities, most of the power generated is distributed offsite and lost power due to downtime is replaced by other generating units and plants via the grid. Whereas, most of the power/steam generated onsite at manufacturing facilities is used onsite and this configuration requires that interruptions to the operation of the generating system must be accounted for using various contingencies including: offsite replacement sources (e.g., utility grid connections); redundant (spare) generating capacity; temporary replacement generating units; or temporary replacement cooling water sources. The availability of these various contingencies varies by plant type and location and insufficient data was available to enable EPA to assess availability of different contingency methods. Thus it was not possible to divide facilities into groups where costs could be assessed based on different contingency methods. Rather, EPA derived a single approach that represents the average cost. Since generating units, whether they are located at power generating facilities or at manufacturing plants, will require periodic maintenance, it is reasonable to assume that manufacturing facilities will have included within their design and operating schedule consideration of this contingency by including sufficient spare generating capacity, access to replacement power through utility connections, planned outages, that would allow for rotating maintenance downtimes for individual generating units at least during periods of reduced demand. At many of these facilities, the downtime costs will be minimal since the closed-cycle retrofit (which EPA estimates may take up to 8 weeks) can be performed on individual generating units in a manner that avoids interruption of the supply of electricity and steam. EPA expects that a large portion of manufacturing facilities fall within this category. For those facilities that rely upon replacement electric power from the grid, the costs would be for replacement power for the generating unit downtime duration that exceeds the normal downtime for generating unit maintenance which is estimated to be 4 weeks for power generating units and is expected to be similar for these facilities.

EPA recognizes that for those facilities that cannot rely upon multiple generating units and excess capacity or replacement power from offsite, that costs for replacement of electricity and steam generation capacity or replacement cooling water for the estimated 8 week retrofit duration may be necessary. While the cost of these temporary solutions may exceed the costs for replacement electricity EPA, concluded based on site visit data and the comments that such facilities are in the minority. The aggregate costs when balanced against those facilities where EPA expects the cost will be zero should result in an overall facility cost (average across all facilities) that is similar in magnitude to the 4 week electricity replacement costs. Since EPA was unable to distinguish which facilities would utilize the different types of contingency methods described here, EPA applied the 4 week electricity replacement downtime costs to all manufacturing facilities when evaluating compliance options that involved a closed-cycle cooling retrofit.

8.3.5 Identifying Intakes That Are Already Compliant With Entrainment Mortality Requirements

Existing intakes that were considered to be EM compliant included those that:

- Reported using a closed-cycle cooling system using towers only (i.e., not in conjunction with any other type of cooling system)

Data from the 2000 detailed technical survey were used to determine intake compliance.

Existing intakes for systems that employed closed-cycle cooling were not assumed to be IM-compliant and thus were assigned IM compliance technology costs unless the intake technologies also met the criteria for IM compliance.

Combination Cooling Systems

Intakes for cooling systems that reported using a combination of cooling system types (e.g., one intake is used to supply a once-through unit and a closed-cycle unit) were treated as if all cooling water flow was once-through. Intakes that reported closed-cycle cooling systems using impoundments were treated as if all cooling water flow was closed-cycle. This was done because there was insufficient data available to determine which portion of the intake water was used for once-through and which as makeup for existing closed-cycle cooling. This approach is expected to produce conservative cost estimates for these mixed cooling system facilities, since a portion of the flow may be makeup water and not amenable to application of closed-cycle cooling technology.

Exhibit 8-12 below summarizes the number of facilities and intakes that were determined to supply cooling water to closed-cycle cooling systems

Exhibit 8-12. Number of Model Facilities/CWISs Classified as Closed-Cycle

	Electric Generators		Manufacturers	
	Number of Model Facilities	Number of Model Intakes with Separate Cost Data	Number of Model Facilities	Number of Model Intakes with Separate Cost Data
Intakes with full or partial once-through in-place	221	319	186	267
Intakes with impoundment cooling system	12	26	7	7
Intakes with full closed-cycle recirculation in-place	51	61	42	43
Facilities with both full closed-cycle and full once-through intakes	7	8*	0	0
Total facilities or intakes	284	406	235	317

* Number of closed-cycle intakes.

8.4 Compliance Costs for New Units

Power generation and manufacturing units that meet the definition of a “new unit” will be required to meet impingement mortality and entrainment mortality reduction requirements. The costs for complying with the impingement mortality reduction requirements are assumed to be zero since these costs are included in the cost for complying with the entrainment mortality requirement (closed-cycle cooling or equivalent) or were already expended in the past as part of the cost estimate for the existing intake to comply with the existing facility impingement mortality requirements.

In order to comply with the entrainment mortality requirements, closed-cycle cooling or an equivalent reduction in entrainment for the cooling water component of the intake flow based on the design intake flow (DIF) will be required for new units. The estimates for compliance costs for such new units should be based on the net difference in costs between what cooling system technologies would have been built under the current regulatory structure and what will be built given the change in requirements imposed by the Final Regulation. Compliance costs are derived using estimates of the generating capacity that will be subject to the requirement.

Based on this definition of new unit, EPA expects that for manufacturers, net compliance costs associated with new unit will be negligible. A discussion of the rationale is provided in Section 8.4.2 below. The following section describes cost development for the new unit provision for Electric Generators only.

8.4.1 Compliance Costs for New Power Generation Units

New generating capacity at existing facilities can result from new units added adjacent to existing units, repowering/replacement and major upgrades of existing units, and minor increases in system efficiency and output. While a small portion of this new capacity may result from minor improvements in plant efficiency and output, this analysis assumes all new capacity will be associated with either new units, repowered units, or major unit rebuild/upgrades.

New Generating Unit Costs

The term "new units" consists of newly built units adjacent to existing units (aka stand-alone). In nearly all cases, the repowering of an existing unit will result in an increase in the generating capacity so the portion of new capacity associated with repowering must be accounted for. For the purpose of this analysis, the estimate of new capacity is divided into two categories: the stand-alone new unit capacity and the incremental increase in capacity of the repowered units. Thus, this cost methodology requires the development of annual estimates of the generating capacities for:

- Newly built unit capacity not subject to phase I (new stand-alone unit capacity)
- Increase in capacity for repowered units (new repowered capacity)

The analysis also considers the fuel type of new generating capacity. Generators that use different fuels types each have a different thermal efficiency and therefore different cooling water requirements in relation to generating capacity. Therefore, in order to use generating capacity as the input variable for costs and flow reduction, separate estimates are developed for each fuel type. For simplicity, the estimated generating capacities are divided into three fuel types: coal, combined cycle, and nuclear, with coal being broadly viewed as including all single cycle fossil and biomass generating systems. While nuclear new units were initially considered by EPA is the analysis, EPA concluded that nuclear new units would likely be compliant in the baseline 100 percent of the time and therefore are excluded from the analysis since compliance costs would be zero dollars.

Basic Assumptions

The following assumptions are described in the Proposed Rule TDD Section 8.4 and are retained for this analysis. The rationale for each is described in the TDD.

- Annual estimates of total new capacity (including both new stand-alone units and new repowered capacity) for each fuel type are developed using the IPM model.
- 70 percent of newly built unit capacity will occur at new facilities and will be subject to the 316(b) Phase I requirements.
- 10 percent of new coal and 85 percent of new combined cycle capacity will occur as additional capacity at repowered units (new repowered capacity).
- Cooling water requirements for new units are 390 gpm/MW and 200 gpm/MW for coal and combined cycle respectively.

The following additional assumptions were used in sizing a "typical" new unit:

- Average project size is 600 MW.
- Capacity utilization is 80 percent.
- 90 percent of stand-alone capacity at existing sites will be compliant in the baseline (i.e., will install closed-cycle cooling regardless of the Existing Facility

rule requirements). The exception is nuclear capacity which is assumed to be 100 percent compliant in the baseline.

Combining the two fuel types and three capacity estimate categories results in the following compliance technology cost components:

1. New stand-alone unit coal capacity
2. New stand-alone unit combined cycle capacity

Exhibit 8-13 presents the factors that will be used to derive the estimated generating capacity for each component.

Exhibit 8-13. Costs Factors for Estimating New Unit Capacity Values

	New Capacity			
Cost Component	**% Not Phase I**	**% Greenfield vs Repowered**	**% Non-comp. in Baseline**	**% of Total. New Capacity Non-comp.**
1. New stand-alone unit coal capacity	30%	90%	10%	2.7%
2. New stand-alone unit combined cycle capacity	30%	15%	10%	0.5%

Factors (1) and (2) are applied to estimated values of annual new capacity for each fuel type.

For each new unit that requires closed-cycle cooling, the estimated generating capacity serves as the basis for the compliance technology costs for each relevant component. Exhibit 8-14 presents the estimated annual capacity values for each cost category based on the assumptions described above.

Exhibit 8-14. Annual New Capacity Potentially Subject to New Unit Requirement by Cost Category

	Total Including Phase I	**Existing Facility New Units Only**	**Existing Facilities Non-compliant Only**[a]
	New Capacity	**Stand-alone**	**Stand-alone**
Fuel Type	**MW**	**MW**	**MW**
Fossil Fuel	295	80	8
Combined Cycle	3,264	147	15
Total	3,559	227	23

[a] Capacity estimated to be subject to closed-cycle requirement

Baseline Compliance

New units will either use once-through, closed-cycle, or dry cooling systems[168]. For the baseline condition, an estimate is needed for the occurrence of each type of system that would have been utilized if there were no change in the regulatory requirements for new units. The occurrence of each type in existing cooling systems can serve as a guide since both new and replaced units will, at a minimum, use a similar technology. EPA analyzed trends in use of cooling system type from Energy Information Administration data and determined that the trend in the 1990s was that 83 percent of new cooling systems installed closed-cycle cooling systems and that the current and future trend was that approximately 98 percent of new cooling systems would install a closed-cycle cooling system (see DCN12-6672). Considering only 30 percent of new unit capacity would occur at existing facilities, EPA concluded that a baseline closed-cycle compliance rate of 90 percent was reasonable.

Compliance Cost Estimation

Compliance costs were considered for new stand-alone units only. For new unit capacity, costs are derived using the new unit capacity in MW as the input variable. Compliance costs for new units use the EPA estimates for retrofitting a closed-cycle cooling system at existing facilities as the starting point. For the existing facility closed-cycle retrofit costs EPA used existing flow data and cost equations based on cooling flow in gpm. The cost equations for new units are instead based on capacity in MW, with costs derived using assumed cooling water requirements in gpm/MW. These cooling water requirements assume that the typical new unit once-through system is designed with a condenser temperature rise (ΔT) of 15 ^{o}F, and that the closed-cycle cooling system that replaces a once-though system will be optimized using a ΔT of 20 ^{o}F. The cooling water flow estimates are based on a ΔT of 20 ^{o}F and waste heat generation is based on plant efficiency values of 42 percent for coal (which is the average of values for super-critical and ultra-critical steam), and 57 percent for combined cycle.

Capital Costs

EPA has found that the total estimated capital costs for a once-through cooling system including a new intake are comparable to the capital costs of a closed-cycle cooling system. Therefore, the compliance capital costs are assumed to be $0 for new added units.

O&M Costs

The O&M costs include costs associated with the assumption that 25 percent of facilities will require plume abatement. Fixed and variable O&M costs are adjusted by deducting the O&M costs estimated for the traveling screens that would have been used in the baseline once-through system. The baseline O&M cost estimate is based on the cost tool output for gross O&M for once-through traveling screens (Cost Module 1) using design input values of: DIF = 132,500 gpm, screen velocity = 0.5 fps; well depth = 25 ft.; freshwater. The resulting gross O&M cost was equivalent to $1.6/gpm, which was then

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[168] Dry cooling is generally used in only a small portion of facilities in locations where water resources are limited. Estimates of closed-cycle cooling are assumed to include dry cooling.

reduced by 10 percent to account for the new makeup system O&M and then divided into fixed and variable components using a fixed factor of 0.4.

Energy costs are also adjusted to account for the reduced pumping volume associated with changing the ΔT from 15 ^{o}F to 20 ^{o}F and to account for an estimated increase in pumping head of 25 ft for closed-cycle versus once-through operation.

Exhibit 8-15 presents the new unit costs on a $/gpm basis. Exhibit 8-16 presents the equations used for estimating costs based on unit generating capacity derived from Exhibit 8-15 data using the gpm/MW values shown.

Exhibit 8-15. Costs for New Units Based on GPM

Costs and Generating Output Reduction	Equation	Constant Adjusted for Optimization (2009)	Add for 25% Plume Abatement	Baseline O&M Adjustment[a]	Total Adjusted Net Cost
Capital Cost – New Unit with Intake (CC)	CC = DIF(gpm) x Constant	$0	$0		$0
Fixed O&M Cost (OMF)	OMF = DIF(gpm) x Constant	$1.27	$0.25	-$0.58	$0.94
Variable O&M – Chemicals (OMC)	OMC= DIF(gpm) x Constant	$1.25	$0.00	-$0.86	$0.39
Variable O&M – Pump & Fan Power (OMV)	OMV= DIF(gpm) x Constant	0.0000190[b]	0.00000078		0.0000198
Energy Penalty – Heat Rate (EP)	EP=MWS x Constant	0.000	0		0

[a] Adjustment reflects deduction of O&M costs associated with traveling screens that would have been installed in the baseline once-through system.

[b] Net pump energy includes deduction of once-through pumping energy

Costs are in 2009 dollars

Exhibit 8-16. Costs for New Units Based on Generating Capacity

Costs and Generating Output Reduction	Equation	Units	Coal (42% Efficient)	Combined Cycle (57% Efficient)
		GPM/MW	390	200
Capital Cost – New Unit with New Intake (CC)	CC = MWS x Constant	Dollars	$0	$0
Fixed O&M Cost (OMF)	OMF = MWS x Constant	Dollars	$366	$188
Variable O&M – Chemicals (OMC)	OMC= MWS x Constant	Dollars	$151	$77
Variable O&M – Pump & Fan Power (OMV)	OMV= MWS x Constant	MW	0.0077	0.0040
Energy Penalty –Heat Rate (EP)	EP=MWS x Constant	MW	0	0

Costs are in 2009 Dollars

Downtime

Stand-alone units by definition are constructed somewhat independently of existing generating and manufacturing units which will tend to limit interference with the operation of existing production units. Some construction downtime may occur when new units must be integrated with existing production units, shared ancillary systems, utilities, and cooling water intake systems. However many of the construction activities resulting in downtime would occur regardless of the cooling system requirements. Further, as a new unit is defined as a stand-alone unit, by this definition EPA expects minimal integration and sharing resources will occur. EPA has concluded that requiring closed-cycle cooling should result in no net increase in downtime for the existing units. Thus, no downtime costs are assessed for new unit compliance.

Energy Penalty

Energy penalty costs associated with net changes in auxiliary power requirements between once-through and closed-cycle cooling are included in the O&M cost estimates shown in Exhibit 8-18. For the heat rate penalty, new unit construction will involve new steam turbines, condensers, and cooling towers using an optimized design. As such, the system design can be tuned such that heat rate penalty that would otherwise be associated with replacing the once-through system with a closed-cycle cooling system at an existing facility is assumed to be minimal. Thus, no costs are assessed for the heat rate penalty.

8.4.2 Compliance Costs for New Manufacturing Units

The projected baseline manufacturing unit process design and cooling water technology would be based on an estimate of the response to the permitting authorities’ application of existing requirements including 316(b), applicable industrial water use and discharge standards (e.g., categorical standards), and BPJ. Also, it has become standard practice for industries to adopt water use reduction and reuse practices wherever practical. The construction of a new unit provides a perfect opportunity to employ such measures to an extent that would not be possible for existing units. In many cases, it is likely that the existing regulatory requirements and practices would have resulted in a further reduction in the cooling flow than for similar but older units. Thus, the baseline cooling AIF for “new units” at manufacturers should, in most cases, be much smaller than the AIF for a comparable existing unit.

For new units in general, EPA has noted the following differences in costs between a closed-cycle cooling retrofit at an existing facility compared to closed-cycle cooling at a “new unit:”

- New units can incorporate closed-cycle cooling in a more cost-effective manner.
- The duration of new unit construction is sufficiently long that there would be, in nearly all circumstances, no net increase in “construction downtime.”
- Stand-alone unit would need minimal is any integration with existing processes.
- Where new intakes or major components of the existing once-through intake and cooling system must be constructed/upgraded, the capital costs of closed-cycle cooling for new units are comparable to the capital costs of once-through cooling.

- The cooling system costs usually comprise less than 1 percent of the total costs of a new unit.
- New construction allows the use of an optimized cooling system design that can minimize any system efficiency losses associated with conversion to closed-cycle.
- The fact that a large proportion of intake flow is used for process water and other non-cooling purposes greatly increases the opportunity to design and incorporate cooling water reuse strategies within the new unit.
- Where the new unit is not substantially larger than the existing plant, cooling water reduction may be accomplished through reuse at other units within the plant.
- The modular nature of closed-cycle cooling allows for the limited application of closed-cycle cooling only to the portion of cooling flow necessary to meet any additional reductions not accounted for by any other reuse/reduction strategies employed.
- The modular nature of closed-cycle cooling allows for the use of cooling system designs specifically tailored to process requirements and vice versa.
- The modular nature of closed-cycle cooling and the flexibility inherent in building a new process system allows for more optimum placement of cooling tower units, thus minimizing piping costs.
- New unit construction provides a lower cost opportunity to install variable speed pumps and other system controls in cooling system applications. Flow reductions associated with the use of variable speed pumps and other controls can result in benefits associated with reduced flow and pumping energy costs and better process control.

For power generation facilities that use once-through cooling, process water typically constitutes a few percent or less of the total intake volume and the majority of the intake flow is used for non-contact cooling purposes. A review of the responses to the detailed technical survey showed that the median and average values for the percent of design intake flow used for cooling purposes reported for each separate cooling water intake at power generation facilities were 100 percent and 85 percent, respectively.

In contrast, most industrial manufacturing operations utilize a substantial portion of intake water for non-cooling purposes and the same median and average values for manufacturing facilities were 50 percent and 52 percent, respectively. In addition, the cooling flow component at manufacturers will in many instances include contact cooling water which would not be subject to the “new unit” requirements, thus decreasing the proportion of cooling flow subject to the “new unit” requirements. This is consistent with the NCCW/DIF ratios shown in Exhibit 8-10 ranging from 32 percent to 65 percent. Given this, it is reasonable to assume a “typical” manufacturing unit may use less than 50 percent of flow for cooling purposes of the type that may be subject to the “new unit” requirements. Theoretically, this “typical” facility should be able to reuse 100 percent of the cooling water in place of the process component. Thus, the “typical” manufacturing facility should be capable of designing a “new” process that could meet the “new unit” requirements through water reuse alone. EPA observed extensive use of innovation and water reuse during site visits at some manufacturing facilities. Such reuse opportunities may be limited at facilities that use brackish or saltwater for cooling, but based on intake location EPA estimates that at most 7 percent of manufacturing plants do so.

Since this 50 percent value is the median of all reported manufacturing cooling water intake systems, at least half of manufacturing cooling water systems have the potential to meet the “new unit” requirements simply by reusing non-contact cooling water as process water. For the remainder, modifications to the process that reduce cooling water use (e.g., use of variable speed pumps) may provide additional reduction. For some, there may be a need to install cooling towers for the cooling flow component that cannot be reused. This, however, will in most instances be a small portion of the total intake flow. Also, in most cases the “new unit” will comprise only a portion of the entire manufacturing facility and there may be other process units and plant operations nearby that could reuse the cooling water in order to meet the flow reduction requirements.

For new units that would require building or rebuilding a once-through intake, EPA has found that the capital costs of the new intake and screen technology which may require additional costs to meet impingement mortality requirements such as a larger intake with deeper and wider pump and intake wells to accommodate source water depth variations will be comparable and possibly higher than the capital costs for closed-cycle technology. In these cases, closed-cycle may have slightly higher O&M costs for pump and fan energy, but these costs may be offset by other cost savings such as reductions in water treatment costs.

The definition of new manufacturing units limits the applicability of closed-cycle requirements to new units that involve construction of stand-alone units. As such, it is assumed that the construction activities involving any substantial downtime periods would be of similar or more likely greater duration than required for construction and tie-in activities associated with the closed-cycle cooling technology alone.

Given all of this, EPA concluded that only a small portion of new units would need to meet new unit flow reduction requirements through increased use of closed-cycle cooling over what would have been built under existing regulatory requirements. As a result, EPA concluded that the net (incremental) compliance costs would, on average, be zero.

8.5 Impingement Mortality Costs at Intakes with Cooling Systems Required to Install Closed-Cycle Cooling

EPA has deemed closed-cycle cooling technology as being compliant with the impingement mortality standard. This is based on the assumption that a flow reduction of greater than 90 percent would in nearly all cases meet the BTA impingement mortality standard of 24 percent. This would certainly be true for power plants with once-through cooling systems where the majority of the intake water is used as non-contact cooling water (NCCW). The same is true for most manufacturing facilities since as shown in Exhibit 8-10, the average NCCW component of most of the manufacturing facilities evaluated was greater than 77 percent of flow based on schematic flow diagrams. In most cases for those facilities that employ closed-cycle cooling for their NCCW flow component of greater than 77 percent should have little problem meeting the impingement mortality standard. These estimated NCCW component values are averages and it is expected that some facilities with lower NCCW components might not meet the impingement requirement based on flow reduction alone. However, in most cases the flow reduction associated with closed-cycle cooling for the NCCW component should allow them to meet the impingement mortality standard by either meeting the velocity standard as a result of the reduced flow or by the combined reduction of multiple technologies employed.

8.6 Costs for Each Regulatory Alternative

As described in the preamble, EPA evaluated four primary regulatory options during the analysis for the final rule. One option would require only impingement mortality at all facilities (i.e., modified Ristroph screens everywhere), a second would require impingement mortality and entrainment mortality at all facilities (i.e., wet cooling towers everywhere), a third would require impingement mortality at all facilities and entrainment mortality at facilities with a design intake flow greater than 125 mgd, and a fourth would require impingement mortality at facilities with a design intake flow greater than 50 mgd and site-specific BPJ for those less than 50 mgd. In addition, entrainment reduction is required for all “new units” as defined in the preamble.

The sections above describe how facility-level costs were derived for each set of requirements (either impingement mortality or entrainment mortality). To calculate the total cost for a regulatory alternative, the facility-level costs for the applicable requirements were simply summed. For example, for the option where cooling towers are required at each facility with a DIF greater than 125 mgd, EPA used facility-specific data to identify model facilities that fell above and below the flow threshold and used the cost that corresponded to the appropriate compliance response. These facility-level costs are then used to calculate national level economic impacts, as described below.

8.7 Compliance Costs Developed for Analysis of National Economic Impacts

To assess the national economic impacts of its regulatory options, EPA conducted several analyses; these are documented in the EA. As part of these analyses, EPA conducted a modeling analysis using the Integrated Planning Model (IPM) to develop a worst-case impact analysis for power generators.[169] EPA can conclude that if no national economic impacts were observed as a result of the worst-case option, then less costly regulatory options would also have no national economic impacts. This section describes the technical data used in developing the IPM modeling; for more information, see the EA.

In contrast to the model facility costing approach, the IPM model requires an estimate of facility-level costs for all existing facilities (including those facilities that completed an STQ).[170] Facility-level costs were calculated by first estimating costs for the same subset

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[169] For a detailed discussion of the IPM analysis, see the EA.

[170] The DIF for facilities that completed the short technical questionnaire was estimated on the basis of the average daily flow as described in the preamble to the 2004 Phase II final rule. See 69 FR 41650.

of facilities used in the model facility approach described above. To derive costs for STQ facilities, EPA then aggregated the data to derive cost equations that were used to calculate STQ facility-level costs using DIF as a scaling factor.

8.7.1 Selection of DIF as the Primary Scaling Factor for Power Plants

Several power plant attributes related to facility size were evaluated to determine which would best serve as input values for the IPM model cost equations. The use of plant generating capacity was evaluated by comparing the year 2000 steam generating capacity to the DIF reported in the detailed year 2000 surveys for plants with once-through cooling systems. It was concluded that there was insufficient correlation between steam generating capacity and the DIF to use the generating capacity as the sole basis for estimating cooling system size and costs.[171]

Because the cost derivation methodologies used by EPA in the past and by EPRI for developing cooling tower retrofit costs used the design cooling water flow rate (i.e., the DIF), the DIF was selected as the basis for estimating model facility costs. Where such data were not available, the DIF was estimated using the average ratio of DIF to steam generating capacity (gpm/MW) for those facilities with once-through cooling systems. The cost data used to derive the national average technology cost equations relied on data only from facilities that reported design cooling water intake flow volumes in the detailed surveys. Exhibit 8-17 below shows the equation used to estimate DIF on the basis of steam generating capacity for facilities where insufficient design or actual flow data were available to estimate the DIF. This equation was used only for facilities that did not complete a technical questionnaire (short or detailed) and was estimated using a formula based on the overall average DIF/MW ratio for power generators with once-through cooling systems with DIF greater than 50 mgd.

Exhibit 8-17. Estimation of DIF Where No DIF Data Exists

	Equation	Constant	Units
Design Intake Flow (DIF)	DIF = MWS x constant	707	gpm

MWS = Megawatts of steam = Total facility steam electric generating capacity.

The reported or estimated DIF volumes are used as input values in the cost-estimating equations so that the average national technology costs can be scaled to account for differences in plant/intake size.

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[171] Theoretically, for once-through cooling systems, cooling water flow should have correlated well with steam generating capacity, but it did not. The following are likely reasons for the lack of good correlation: the fact that the temperature rise across the condenser (ΔT) can vary between plants, the fact that even those plants considered as once-through can use varying amounts of closed-cycle cooling for some of the generating capacity, and the fact that reported design intake flow might include substantial volumes of water used for other purposes.

8.7.2 Development of IM&EM Control Costs for IPM Model

The IPM Model facility cost equations for IM&EM controls were derived using the intake technology cost data described above for each model facility intake. As described above, cost modules were assigned as shown in Exhibits 8-1 and 8-2.

The first step to derive the IPM model facility cost equations was to derive a single value for each cost item for each facility. Total costs for each facility were derived by summing the capital, O&M, and pilot study costs of each intake. For most facilities, the cost module was the same for all intakes, so single facility-level values were assigned for the net downtime and the service life on the basis of the most common cost module assigned to the intakes.

Various methods for using this data to estimate costs were evaluated, including using the between-facility average or median of the $/gpm ratios, and using trend lines derived by Excel (which uses a least squares method). It was concluded that a simple straight-line equation with Y-intercept equal to “0” using the overall between-facility average of the individual facility cost to DIF ratios ($/gpm) represented a reasonable estimate for the national model facility costs.

After deriving the facility-level costs, weighted averages of the cost to DIF ratio ($/gpm) were calculated for all facilities that had compliance costs (i.e., facilities with zero costs were not included). The same facility weights described above were used. Weighted average values for the facility net construction downtime and technology service life were also calculated. The net O&M fixed component was calculated as a portion of the net O&M costs using a factor derived from the weighted average of the ratio of fixed gross technology O&M to the total gross technology O&M. Exhibit 8-18 below present the model facility cost equations for IM reduction technology based on modified Ristroph traveling screens or. Exhibits 8-19 and 8-20 present the service life and calculated technology net construction downtime.

Exhibit 8-18. Cost Equations for Estimating Model Facility Costs of Impingement Mortality Controls for the IPM Analysis

Cost Item	Equation	Constant	Output Units
Capital Cost (CC)	CC = DIF(gpm) x Constant	$20	2009 Dollars
Pilot Study costs (PC)	PC = DIF(gpm) x Constant	$0	2009 Dollars
Net O&M Cost (OM)	OM = DIF(gpm) x Constant	$0.62	2009 Dollars
Fixed Net O&M Cost (OMF)[a]	OMF = DIF(gpm) x Constant	$0.31	2009 Dollars
Variable Net O&M (OMV)	OMV = DIF(gpm) x Constant	$0.31	2009 Dollars

[a] Fixed O&M component based on values for compliance gross O&M

Technology Service Life

Estimates of technology service life were also required for the economic models. In the 2004 Phase II economic analysis, EPA assumed a useful life of 10 years for nearly all of the compliance technologies, with the exceptions that a useful life of 30 years was used for cooling towers and a useful life of 20 years was used for condenser upgrades associated with the cooling tower retrofit. Also, one-time costs such as initial permitting and connection downtime were annualized over a 30-year period, which was the maximum time period for the technology cost analysis.

EPA has re-evaluated the estimated service life of each compliance technology based on various sources of information and BPJ. Exhibit 8-19 presents the revised service life estimates for all of the compliance technology modules used or considered for use in the economic analyses.

Exhibit 8-19. Estimated Technology Service Life

Module No.	Module Description	Service Life (Years)
-	Cooling Towers	30
1	Replace Screen with Coarse Mesh Ristroph Traveling Screen with Fish Handling and Return System	20
2	Replace Screen with Fine Mesh Ristroph Traveling Screen with Fish Handling and Return System	20
2a	Add Fine Mesh Overlay Screens Only	20
3	Add New Larger Intake Structure with Coarse Mesh Ristroph Traveling Screen and Fish Handling and Return	25
4	Relocate Intake to Submerged Near-shore (20 M) with Passive Screen (1.75 mm mesh)	30
5	Add Fish Barrier Net	30
6	Aquatic Fish Barrier (Gunderboom)	30
7	Relocate Intake to Submerged Offshore with passive screen (1.75 mm mesh)	30
8	Add Velocity Cap at Inlet	30
9	Add Passive Fine Mesh Screen (1.75 mm mesh) at Existing Inlet of Offshore Submerged	30
10	Module 2 plus Module 5	20
10.1	Module 2a plus Module 5	20
10.2	Module 3 plus Module 5	25
10.3	Module 1 plus Module 5	20
11	Add Double-Entry, Single-Exit with Fine Mesh, Handling and Return	20
12	Relocate Intake to Submerged Near-shore (20 M) with Passive Fine Mesh Screen (0.75 mm mesh)	30
13	Add 0.75 mm Passive Fine Mesh Screen at Existing Inlet of Offshore Submerged	30
14	Relocate Intake to Submerged Offshore with 0.75 mm Passive Screen	30

Exhibit 8-20 presents the model facility technology net construction downtime and service life.

Exhibit 8-20. Technology Downtime and Service Life for Model Facility Costs of Impingement Mortality Controls for the IPM Analysis

	Units	All Facilities
Net Construction Downtime	Weeks	0.3
Service Life	Years	20[a]

[a] Actual calculated values were 20.7 years for ≥10 mgd and 27.5 years for less than 10 mgd. Values were revised to obtain conservative rounded values more amenable to use with IPM model.

8.7.3 Development of Closed-Cycle Cooling Tower Costs for IPM Model

For the IPM analysis, the model facility costs for closed-cycle cooling have already been derived; they are the same equations from Exhibit 8-9. The difficult cooling tower retrofit capital costs were used to further reflect worst-case conditions. The net construction downtime estimates used to derive the IPM model costs are shown in Exhibit 8-11.

8.7.4 Cost to Comply with Streamlined Compliance and Alternative Provisions Option

The impingement mortality data presented in Chapter 11 indicate that nearly half of facilities employing modified traveling screens may have difficulty consistently complying with the impingement mortality BTA standards based on the performance of the modified traveling screens alone. While many of these facilities may be capable of making improvements to the operating conditions and screen design such that screen alone would meet the Director’s assessment of BTA compliance without additional capital outlay. Some may choose to rely upon the combined performance of a system of technologies such as traveling screens plus additional technologies and operational measures such as flow reduction, reduced facility operations other than maintenance outages, louvers, behavioral and avoidance technologies tuned for select species of concern, barrier nets, offshore intake location, seasonally based technologies or operational measures. To account for these costs, EPA included costs for the addition of barrier nets at all (unmodified) traveling screens at intakes located on oceans, estuaries and tidal rivers. As shown in Exhibit 8.21, 18 percent of intakes assigned upgraded traveling screens were also assigned barrier net costs. EPA assumed that the annualized barrier net costs are comparable or greater than the costs of the range of technologies that might actually be selected.

In some cases, additional IM reducing technologies may already be included in the existing technology suite and thus, their impact will be factored into the compliance determination. Exhibit 8-21 presents an estimate of the proportion of exiting intakes assigned costs for upgraded modified traveling screens that were assigned barrier nets or already employ additional technologies that may result in a further reduction in the impingement mortality rate beyond that of the traveling screen alone. As can be seen nearly 40 percent of intakes costed for traveling screen upgrades were either assigned or already employed an additional IM reduction technology that should provide an additional IM rate reduction sufficient to ensure the “system of technologies” meets the BTA IM standards.

Exhibit 8-21. Intakes Costed for Modified Traveling Screens that Include New Barrier Nets or Existing Other IM Reduction Technologies

Assigned and Existing Technologies	**Intake Count**	**% of Total**
Costed for Traveling Screens (1 & 10.3)	551	100%
Costed for Traveling Screens & Barrier Nets (10.3)	92	17%
Costed for Traveling Screens Only (1)	459	83%
Costed for Traveling Screens Only with Existing Fish Avoidance	17	3%
Costed for Traveling Screens Only with Existing >500 ft Offshore Intake	21	4%
Costed for Traveling Screens Only with Existing Combination Cooling (Partial Closed-cycle Cooling)	86	16%
Costed for Traveling Screens Only with at Least One Existing IM Reduction Tech	110	20%
Costed for Traveling with New Barrier Net or Traveling Screen with Existing IM Reduction Tech	202	37%

Chapter 9: Impingement Mortality and Entrainment Mortality Reduction Estimates

9.0 Introduction

This chapter presents impingement mortality and entrainment mortality reduction estimates associated with each of the regulatory options EPA considered in developing the Existing Facilities rule. EPA estimated impingement mortality and entrainment mortality reductions to evaluate the effectiveness of different treatment technologies. EPA also used this information in analyzing potential benefits associated with the final rule. See the BA for more details on these analyses.

9.1 Technology Reduction Estimates

EPA's regulatory options (see the preamble for discussion of the options) are based on the following technologies:

- Modified Ristroph traveling screens with a fish return or equivalent
- Low intake velocity
- Existing offshore velocity cap
- Flow reduction as achieved by wet mechanical draft cooling towers

EPA's methodology for estimating impingement mortality and entrainment reduction for these technologies varies depending on available data.

9.1.1 Screens

As explained in Chapters 2 and 11 of this document, EPA developed a performance database that analyzed quantitative data on the efficacy and impingement mortality and entrainment reduction associated with various technologies. This analysis formed the basis for establishing the performance standard for impingement mortality at 76 percent survival.

Since the proposed rule, EPA has also identified data that characterizes shellfish mortality reductions and has included them in developing the impingement mortality standards. As a result, EPA has eliminated the regulatory requirement for barrier nets at marine facilities.

9.1.2 Low Intake Velocity

A facility that reduces its intake velocity to 0.5 ft/sec or below is assumed to meet the performance standard for impingement mortality. Data collected by EPA (see DCN 10-6705) shows that 96 percent of studied fish can avoid an intake structure when the intake velocity is 0.5 ft/sec or less.

9.1.3 Existing Offshore Velocity Cap

A facility with an existing intake velocity cap that meets the definition of offshore velocity cap (i.e., a minimum distance of 850 feet) is assumed to meet the performance standard for impingement mortality. Data collected by EPA (see DCN 12-6601) shows that velocity caps in combination with a far offshore location are capable of meeting the performance standard for impingement mortality at 76 percent survival. Two studies identified a far offshore intake location alone as reducing impingement by 60 to 68 percent. Offshore intakes not meeting the minimum distance of 850 feet demonstrate considerably less reductions in impingement, some performing as low as 7 percent survival (see SEAMAP data). Eight studies at facilities with velocity caps showed the velocity caps alone provided anywhere from 50 to 95 percent reductions in impingement mortality. One additional study specifically identified the combined effects of location and velocity cap as 76 percent performance. Therefore, the data in the record concerning the 11 existing facilities with velocity caps show that a velocity cap alone is insufficient to achieve the BTA standard, but that a velocity cap in combination with a far offshore intake would perform equal or better than EPA's BTA performance standard. EPA provides for newly constructed offshore velocity caps the opportunity to make a demonstration that the facility specific performance of an offshore velocity cap would meet the performance standard using the combination of technologies approach at 40 CFR 125.94(c)(6).) The offshore component likely makes the velocity cap technology unavailable except to facilities in marine waters and certain Great Lakes locations; therefore, the technology is not BTA. Further, since location is an important aspect of velocity cap performance, and since the performance with respect to intake location and distance offshore could not be reliably predicted, EPA did not assign new retrofit velocity caps as a compliance technology.

9.1.4 Flow Reduction Commensurate with Closed-Cycle Cooling

As explained in Chapter 6, both entrainment and impingement (and associated mortality) at a site are generally proportional to the intake flow. In other words, if a facility reduces its intake flow by 50 percent, it similarly reduces the amount of organisms subject to impingement and entrainment by 50 percent. For the traditional steam electric utility industry, available data[172] demonstrate that facilities located in freshwater areas that have closed-cycle, recirculating cooling water systems can, depending on the quality of the makeup water, reduce water use by up to 97.5 percent from the amount they would use if they had once-through cooling water systems. Similarly, steam electric generating facilities that have closed-cycle, recirculating cooling systems using salt water can reduce water usage by up to 94.9 percent when makeup and blowdown flows are minimized.[173] On average, closed-cycle cooling employed across the nation would reduce intake flows by 96 percent.

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[172] See Chapter 6 of the TDD.

[173] See Chapter 2 of the TDD for additional discussion of how these flow reduction values were derived.

Accordingly, a facility that is required to reduce its flow commensurate with closed-cycle cooling would realize a significant reduction in its impingement and entrainment impacts. For purposes of calculating reductions in impingement mortality and entrainment, EPA correlates flow reductions to I&E reductions in a linear fashion. EPA applied the same approach to I&E reductions as a result of flow reduction provided such flow reductions are obtained throughout the year and represent an annual average basis. For example, variable speed drives reducing annual intake flows by an average of 7 percent would assume to result in a 7 percent reduction in annual I&E. On the other hand, seasonal flow reductions such as plant shutdown for 12 weeks in the late summer equating to a 25 percent annual flow reduction is not assumed to result in a 25 percent reduction in annual I&E. This is because the density of organisms and their susceptibility to I and E may vary over the year.

9.2 Assigning a Reduction to Each Model Facility

As explained in Chapter 8 of this document, EPA estimated costs for each model facility to comply with the regulatory options it considered for the final rule. In general, to develop model facility costs, EPA reviewed the impingement mortality and entrainment mortality requirements for a particular option and determined if each model facility would be able comply with the requirements based on their existing technologies (e.g., has existing intake technologies that serve as the basis for the option or exhibit equivalent performance). For each model facility that EPA projected would not be able comply with the regulatory option requirements, EPA estimated costs to install and operate additional impingement mortality and entrainment mortality minimization technologies. EPA's assignment of costs to model facilities is relevant to its impingement mortality and entrainment mortality reduction estimates because EPA only assigns reduction estimates to model facilities that incur compliance costs.

For example, if a facility is subject to impingement mortality requirements but has only a conventional coarse mesh traveling screen, it would have been assigned costs to replace the screen with a modified Ristroph screen (or similar technology). Accordingly, a reduction in impingement mortality of 75 percent was assigned to this facility to reflect the improved performance of the new screens.[174]

Once EPA determined a compliance response for each model facility under a given regulatory option, EPA similarly assigned impingement mortality and entrainment reductions, as applicable. EPA assigned impingement mortality and entrainment mortality reductions as illustrated in Exhibit 9-1 below.

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[174] Note that this does not imply an 75 percent improvement over conventional screens; it simply represents the improved survival of organisms.

Exhibit 9-1. Reductions in Impingement Mortality and Entrainment Mortality

Control Technology Assigned	Impingement Mortality Reduction	Entrainment Mortality Reduction
Modified Ristroph Screens or equivalent	75%[175]	0%
Reduced Intake Velocity	96%	0%
Closed-cycle cooling (fresh water)	97.5%	97.5%
Closed-cycle cooling (salt water)	94.9%	94.9%
Reduced Intake Velocity via Variable Speed Pumps	96%	20%

A facility may be subject to one or both requirements, as shown in the examples below:

- a facility that does not have compliant impingement mortality technologies (e.g., intake velocity of 0.5 ft./sec, qualified modified traveling screens, combination of technologies that meet the impingement mortality standard, or existing far offshore intakes) would reduce impingement mortality by retrofitting one or more technologies that comply with one or more of the impingement mortality requirements[176]
- under Proposal Option 2,[177] a facility with a design intake flow over 125 mgd with no flow-reduction technologies would be subject to both impingement mortality and entrainment mortality requirements

A large number of existing facilities use multiple intake structures. To account for this configuration, a flow-weighted average was used across each intake. As before, reductions are based on the engineering costs and compliance response for each intake; intakes that are assigned a new technology were also assigned a reduction. For example, if a facility has two intakes with equal design intake flows but one uses a modified Ristroph screen and one does not, the impingement mortality reduction would be 37.5 percent--the flow-weighted result of having one compliant intake and one non-compliant intake.

As such, there are a wide variety of compliance responses among the model facilities. Facilities may also exhibit partial compliance; for example, some facilities have a partial (or combination) closed-cycle system, where some units utilize a closed-cycle system and others use once-through cooling. Other facilities may have one intake with a modified

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[175] For the final rule, EPA calculated a revised 12 month impingement mortality performance standard of 24 percent; see Chapter 11. EPA did not revise the I&E reductions, instead noting that the change from proposal from 25 percent to 24 percent mortality is such a small change and a small source of uncertainty that it did not warrant a complete recalculation of the I&E reductions.

[176] Facilities can either reduce screen velocity to less than or equal to 0.5 fps, install modified traveling screens that are deemed equivalent to BTA by the Director, or employ a combination of technologies or operating conditions that together reduce impingement mortality rates to levels equivalent to or greater than the impingement mortality standard. Such technology combinations are assumed to have impingement mortality rate reductions equivalent to modified traveling screens.

[177] Proposal Option 2 which was considered but rejected in the final rule requires facilities with a design intake flow greater than 125 mgd to conduct an entrainment

Ristroph screen and another without. In these cases, EPA assumed that those intakes using the compliant technology would be considered as complying with impingement mortality or entrainment mortality requirements and calculated impingement and entrainment reductions using a flow-weighted average across all of the facility's intakes.

9.2.1 Entrainment Mortality

In the 2004 Phase II rule, EPA made the assumption that any entrained organism died (i.e., 100 percent mortality for organisms passing through the facility) and any organism not entrained survived. In other words, if a technology reduced entrainment by 60 percent, then EPA estimated 40 percent of the organisms present in the intake water would die in comparison to 100 percent in the absence of any entrainment reduction. As discussed in the preamble, EPA views entrainment (i.e., exclusion) and entrainment mortality as the same. The reductions discussed in this chapter reflect those changes.

9.2.2 In-Place Technologies

If a facility has already installed a technology that is compliant with the applicable IM or EM standards, it is not assigned a technology (i.e., it is not assigned technology costs) and therefore is not assigned a reduction in IM or EM. In all other cases, the full reduction for IM or EM is applied to that intake structure. See Exhibits 8-1 and 8-2 for a decision tree of how compliance technologies were assigned.

9.2.3 Summary of Options

Exhibit 9-2 summarizes the percent of flow and environmental impacts addressed by each option considered under the final rule.

Exhibit 9-2. Summary of Primary Options

	Percent of Design Flow Covered (%)		Applies To	
Option	Impingement Mortality	Entrainment Mortality	Impingement Mortality	Entrainment Mortality
Final Rule	100%	0%	X	
Proposal Option 2 (IM for All, EM for AIF> 125 MGD)	100%	87%	X	X
Proposal Option 3 (IM for All, EM for All)	100%	100%	X	X
Proposal Option 4 (IM For All, IM for DIF >50 MGD)	100%	0%	X	

Each of the model facilities used in costing (see Chapter 8) is then assigned a percent reduction corresponding to the technology assignment made to that model facility. For example, as discussed in 9.2.2 a facility that already has closed-cycle does not get assigned any reductions. These model facility level percent reductions for I and E are then matched with a baseline count of organisms depending on the "benefit region" in which the model facility intake is located; see the BA for methodology and results.

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Chapter 10: Non-water Quality Impacts

10.0 Introduction

For the 2004 Phase II rule, EPA conducted an analysis of non-water quality impacts resulting from the conversion of some facilities to recirculating wet cooling towers. These impacts include increased air emissions due to energy penalties, vapor plumes, noise, salt or mineral drift, water consumption through evaporation, and solid waste generation due to wastewater treatment of tower blowdown (see the 2002 proposed rule TDD Chapter 6, DCN 4-0004). For the Proposed Existing Facility rule, EPA reviewed these impacts and supplemented the air emissions, vapor plumes, noise, and evaporative consumption analyses as described in the following sections. EPA also briefly reviewed the data available on non-water quality impacts of thermal effluent discharges. Since the options involving closed-cycle cooling considered under the final rule are similar to those considered in the proposed rule, EPA concluded that no significant changes in the estimated non-water quality impacts is expected and therefore has not updated the analysis.

10.1 Air Emissions Increases

In developing the 2002 proposed Phase II rule, EPA estimated the incremental increases in emissions for 59 model power plants expected to retrofit from once-through cooling to recirculating wet cooling towers under the preferred alternative (see the 2002 proposed rule TDD Chapter 6, DCN 4-0004).[178] These model facilities included nuclear, combined cycle and fossil fuel-fired power plants. As described in the 2002 proposed rule TDD and in the BA for the Existing Facility rule, facilities retrofitting to recirculating wet cooling towers incur an energy penalty due to the increased electricity generation needed to compensate for the loss of efficiency caused by the retrofitted cooling towers. This results in a slight increase in emissions from the increased burning of fuel.[179,180] Note that the current emissions rate calculations discussed below do not reflect full implementation of the most recent air rule requirements. For today's rule, EPA used facility-specific power plant emissions (annual average) data to estimate increased emissions under the options presented in the preamble to the final rule. EPA also conducted a geographical information system (GIS) analysis of non-attainment areas and Phase II power plant locations to identify areas of potential increased impact.

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[178] The preferred alternative (Option 1) required facilities to meet performance standards based on waterbody type and proportion of flow withdrawn for cooling. Under this option, 59 facilities were estimated to comply through the installation of cooling towers.

[179] See Table 6-1 from the TDD for the 2002 Phase II proposal for the estimated incremental increase in emissions under the 2002 preferred alternative.

[180] Increased emissions are not caused by the recirculating wet cooling tower itself, but by the fuel deficit created by the additional energy needed for operation of the towers and a loss of turbine efficiency.

10.1.1 Incremental Emissions Increases

Facilities that retrofit to a cooling tower will experience a reduction in efficiency, as there is a loss of efficiency in the turbine due to the higher temperature condenser water within the cooling water system. The fans inside the tower also require electricity to operate. Collectively, these inefficiencies are known as the auxiliary power requirement. To compensate for the loss of electricity generation, a facility could either operate more frequently (if it is not already a baseload plant) or it could burn additional fuel. Both scenarios would lead to an increase in the emission of air pollutants from the combustion of fossil fuels.

For today's rule, EPA used a methodology similar to the one used in the 2002 proposed rule and TDD to estimate incremental increases in emissions under each of the options considered. The data source for the Agency's air emissions estimates of CO_2, SO_2, NO_x, and Hg is the EPA-developed database titled E-GRID 2005. This database is a compendium of reported air emissions, plant characteristics, and industry profiles for the entire US electricity generation industry in the years 1996 through 2005. The database relies on information from power plant emissions reporting data from the Energy Information Administration of the Department of Energy. E-GRID compiles information on every major power plant in the United States and includes statistics such as plant operating capacity, air emissions, electricity generated, and fuel consumed. This database provided ample data for the Agency to conduct air emissions increases analyses for the final rule. The emissions reported in the database are for the power plants' actual emissions to the atmosphere and represent emissions after the influence of any existing air pollution control devices.

E-GRID, however, does not provide information on emissions of particulate matter (PM). The data source for historic emissions rates of PM 2.5 and PM 10 is the EPA-developed database titled National Emission Trends (NET). The NET database is an emission inventory that contains data on stationary and mobile sources that emit criteria air pollutants and their precursors. The NET is released every three years (e.g., 1996 and 1999) and includes emission estimates for all 50 States, the District of Columbia, Puerto Rico, and the Virgin Islands. The database compiles information from EPA air programs and the Department of Energy, and the information it contains for other parameters was found to be consistent with the information found in E-GRID 2005.

The model facility universe for each regulatory option represents those power plants that are in scope for each option, for which some E-GRID and/or NET data is available for the desired parameters of CO_2, SO_2, NO_x, Hg, PM 2.5, and PM 10. Although manufacturing facilities are included in the universe of the final rule, there is no readily available data on air emissions from manufacturing facilities. In addition, nuclear power plants and facilities that already have closed-cycle cooling towers are excluded from the model universe, as they would not retrofit to cooling towers. Furthermore, facilities that did not have readily available air emissions data were also excluded from the model universe. Therefore, the model facility universe for this evaluation only encompasses those power plants for which air emissions data is available that do not already employ cooling towers, making it a subset of the total facilities expected to be affected by the final rule.

Site-specific models for calculating air emissions increases are not appropriate for estimating the national impact of the final rule and were not used in this analysis. In addition, some studies have suggested that certain methods (e.g., EPA's AP-42 method for estimating PM emissions from cooling towers) may overstate air emissions from recirculating wet cooling towers (SWRCB 2010). One approach to generating an upper bound estimate of air emissions increases at facilities included in the model universe under each option is presented in Tables 10A-1 (Proposal Option 2) and 10A-2 (Proposal Option 3) in the Appendix to this chapter. These tables represent facility-specific air emissions increases and are based on the estimated energy penalty for each facility, the facility's historic average electricity generation level, and its average historic emission rates.[181] The estimated incremental increases in emissions are not reported for facilities already employing (or partially employing) cooling towers, nuclear and retired facilities, and those facilities for which data is not available. Note that the discussions below on greenhouse gases do not reflect recent or proposed regulations for limiting greenhouse gas emissions, as the data is reported for 2005 and thus reflects operations prior to 2004. These data predate the implementation of recent air rules; therefore, EPA expects that, in most cases, these data do not reflect emissions after installation of scrubbers and other air pollution control equipment.

Carbon dioxide

Carbon dioxide is not a criteria pollutant under the National Ambient Air Quality Standards (NAAQS). Carbon dioxide is, however, a pollutant of concern on a global scale, as it is a greenhouse gas. In March 2012, EPA proposed a regulation that would limit carbon dioxide emissions from new power plants to 1,000 pounds per megawatt-hour. Several states, including California, Oregon, Washington, Montana and Illinois, currently have rules for limiting carbon dioxide emissions from electric generators. Nine The nine Northeastern states, Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont are currently participating in the Regional Greenhouse Gas Initiative which is a regional cap-and-trade program that limits carbon dioxide emissions from electric generators. Similar systems are in development in the West and Midwest. The cap and trade programs ensure that total emissions from all covered entities fall below a cap that typically declines over time; however, it does not mandate limits for individual entities, as is the case for performance standards (Pew Article 2010).

Sulfur Dioxide

Sulfur dioxide is one of the most regulated pollutants in the U.S. and is one of the criteria pollutants under NAAQS. Electricity generation is the highest-contributing source of sulfur dioxide emissions in the United States. Regional monitoring levels are generally below NAAQS threshold levels, except for events at three monitoring sites in Hawaii that have been suggested to be attributed to volcanic activity and therefore, as exceptional events, are not considered for regulatory purposes. Annual average ambient sulfur dioxide concentrations, as measured at area-wide monitors, have decreased by more than

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[181] Historic generation rates were obtained from E-GRID 2005. Historic emissions rates were obtained from E-GRID 2005 and NET.

70 percent since 1980. Currently, the annual average sulfur dioxide concentrations range from approximately 1 - 6 parts per billion, which is well below the quantities expected to affect human health (EPA 2010a).

Nitrogen dioxide

Nitrogen dioxide is one of the most regulated pollutants in the U.S. and is one of the criteria pollutants under NAAQS. Although electricity generation is the third-highest contributor to nitrogen dioxide emissions in the Unites States, regional monitoring levels have been well below NAAQS threshold levels, so no U.S. counties (as of the summary data collected at the national level through 2008) have been considered to be out of attainment in the past decade for this parameter (EPA 2010b). Annual average ambient nitrogen dioxide concentrations, as measured at area-wide monitors, have decreased by more than 40 percent since 1980. Currently, the annual average nitrogen dioxide concentrations range from approximately 10-20 parts per billion (ppb), which is not considered to be a sufficient quantity to affect human health (EPA 2010c).

EPA expects nitrogen dioxide concentrations will continue to decrease in the future as a result of a number of mobile source (the highest contributing source of nitrogen dioxide emissions in the United States) regulations that are taking effect in the past few years. Nitrogen dioxide is, however, one of the two molecules (with volatile organic compounds [VOCs] being the other) that facilitates the formation of ground level ozone, which is also a criteria pollutant and often exceeds the NAAQS criteria.[182] Therefore, in ground-level ozone non-attainment areas, point sources of nitrogen dioxide and VOCs are tightly controlled. In addition, more stringent controls for nitrogen dioxide and VOCs are expected in the future (Lavalee 2008).

Mercury

Mercury is not one of the criteria pollutants under NAAQS, but is known to cause human health impairments. However, mercury is typically not a pollutant that is sampled by the regional monitoring equipment in each Air Quality Control Region. Many states have begun efforts to inventory sources of mercury but have yet to set limits. Some states have emissions limits, but most are sufficiently high that they are not exceeded (Lavalee 2008).

Particulate Matter

PM is one of the criteria pollutants regulated under NAAQS. It is measured as PM 2.5, particles that are 2.5 micrometers in diameter and smaller, and PM 10, particles that are 10 micrometers in diameter or smaller. These are regulated pollutants because particles smaller than 10 micrometers can, once inhaled, enter the lungs and cause serious health effects. Electricity generation is the fourth highest-contributing source of PM in the United States, both at the PM 2.5 and PM 10 levels (EPA 2010d).

Regional monitoring levels for PM 10 have generally been below NAAQS threshold levels; PM 2.5 monitoring, however, has consistently indicated many areas of periodic

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[182] See the maps in Appendix 10A-3; ozone is the pollutant with the largest number of non-attainment areas.

nonattainment of NAAQS standards since national regional monitoring began in 1999. Even though annual average ambient PM has been steadily decreasing across the country, PM remains as a potentially significant environmental and human health concern (EPA 2010d).

As discussed in DCN 10-6954, increased emissions would be approximately 60 tons per year if all drift is PM_{10}. This document also noted minor drift management issues onsite at facilities using salt water cooling towers and no negative consequences off-site.

Total Emissions Increases

Emission increases consist of: (1) stack emissions from increased burning of fuel as a result of the energy penalty for retrofitting to a cooling tower (the turbine backpressure penalty); (2) stack emissions from increased burning of fuel as a result of the auxiliary power requirement for operating the cooling tower; (3) cooling tower emissions including water vapor (drift) and PM. For the options under which no facilities are required to retrofit to wet cooling towers (Proposed Options 1 and 4), there would be no incremental increase in air emissions. For those options under which EPA assumes a subset of facilities would retrofit to wet cooling towers, EPA expects an increase in the total air emissions. This increase excludes those facilities already employing cooling towers. As seen in Appendix A to this chapter, the estimated energy penalty for each facility would result in an increase over each facility’s historic emissions rates for average electricity generation levels.

Cooling tower particulate emissions can be mitigated through the use of drift eliminators—shaped materials that collect small water droplets as they exit the tower. Drift eliminators are capable of reducing drift to 0.0005 percent of the circulating water volume, or approximately 0.5 gallons per 100,000 gallons of flow (OPC 2008). EPA included capital costs for drift eliminators for all facilities expected to retrofit to wet cooling towers.

In addition, some number of fossil fuel-burning power plants might close due to the additional regulatory burden imposed the Existing Facility rule. See the EA for more information. Those facilities projected to close are (in general) the oldest, least efficient, and highest air emissions-producing sources. Therefore, the estimate of increased air emissions associated with the retrofit to wet cooling towers reflects an upper bound estimate.

Total Emissions Reductions

EPA believes projected total emissions from retrofits to cooling towers using currently available data (Appendix A) reflect an upper bound estimate for several reasons. The IPM modeling used in EPA’s economic analysis indicates baseload generating units and units forecast to continue production are generally comprised of the most efficient (and therefore the lowest emitting) units, resulting in a potential reduction in total air emissions. For example, the baseline closures are coal-fired units that are among the top 50 highest SO_2 emitting plants (Sourcewatch, DCN 10-6857). In addition, the current emissions rate calculations do not reflect full implementation of the most recent air rules or pending actions on greenhouse gases and global climate change. For example, the

2005 Clean Air Interstate Rule (CAIR) will reduce 2003 NOx level by 53 percent in 2009 and 61 percent in 2015. Similarly, 2003 SO_X levels would be reduced by 45 percent in 2010 and 57 percent in 2015. The Utility Maximum Achievable Control Technology rule would require utilities to install controls to reduce mercury emissions by 91 percent. Since the actual emissions data used in EPA's analysis does not reflect full implementation of these air rules, and since in many cases technologies to reduce emissions have yet to be installed, both the baseline and any potential increase in emissions are overstated. Finally, the latest tower fill materials and other cooling tower technology improvements provide increases in cooling capacity. In some cases, cooling towers provide cooling water at lower temperatures than available from the source water, particularly during the summer months, resulting in lower turbine back pressure in the summer when maximum power generation is desired. Despite these conservative estimates, EPA concludes there is the potential for an increase in total emissions. At this time, EPA lacks adequate data to conduct a more precise analysis of incremental emissions.

10.1.2 GIS Analysis

As part of its review of the analyses of increased emissions, EPA conducted a GIS analysis of expected pollutants from potentially affected facilities. Specifically, EPA created maps with the locations of all power plants that would have been covered under the 2004 Phase II rule overlaid with maps of non-attainment area designations for 2010 for the various criteria air pollutants.[183] At the time of the analysis, EPA did not have national data for manufacturers; therefore, manufacturers were excluded from this analysis.

EPA created maps to identify non-attainment areas for the following pollutants:

- Carbon monoxide (CO)
- Lead (Pb)
- Particulate matter (PM10 and PM2.5)
- Ozone
- Sulphur dioxide (SO_2)

Maps for each pollutant are found in Appendix 10A-3. For most pollutants, Phase II power plants are generally located in areas that meet the NAAQS standards (i.e., are in attainment).[184] There are, however, a significant number of facilities are located in nonattainment areas for PM2.5 and Ozone. Exhibits 10-1 and 10-2 show the data from the maps in a tabular format.

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[183] EPA used data layers from the EPA Office of Air and Radiation's AQS Database. These data layers reflect attainment status for criteria pollutants under NAAQS. Generally, concentrations of air pollutants are monitored in the ambient air, usually on a county-by-county level. Areas that exceed the pollutant levels specified by NAAQS can be classified by EPA as non-attainment. See www.epa.gov/air/criteria.html *for more details.*

[184] Facilities in Alaska and Hawaii are not shown; these states are in attainment for all criteria pollutants.

Exhibit 10-1. Phase II facilities in non-attainment areas (by pollutant)

Pollutant	Number of facilities
Carbon monoxide (CO)	0
Lead	1
PM 10	7
PM 2.5	145
Ozone (8 hr)	174
Sulphur dioxide (SO_2)	2

Exhibit 10-2. Phase II facilities in non-attainment areas (by EPA Region)

Pollutant	Number of facilities by EPA Region									
	I	II	III	IV	V	VI	VII	VII	IX	X
Carbon monoxide (CO)	0	0	0	0	0	0	0	0	0	0
Lead	0	0	0	0	0	0	1	0	0	0
PM 10	0	0	0	0	0	0	0	0	7	0
PM 2.5	4	22	37	18	53	0	4	0	7	0
Ozone (8 hr)	23	33	28	11	40	20	0	3	16	0
Sulphur dioxide (SO_2)	0	0	1	0	0	0	0	1	0	0

The geographic analysis shows that there not many Phase II power plants for which nonattainment of carbon monoxide, lead, PM 10, and sulphur dioxide NAAQS standards is likely to be a concern. There are some areas, however, where additional emissions of PM 2.5 and ozone (8-hr) could be a concern, particularly for facilities several in EPA Regions where there are significant numbers of Phase II facilities in non-attainment areas.

10.2 Vapor Plumes

In 2002, EPA's assessment of vapor plumes resulting from a retrofit from once-through cooling to recirculating wet cooling towers showed that these plumes have the potential for exacerbated fogging and icing. High levels of fogging and icing have the potential to create dangerous conditions for local roads and for air and water navigation. There are some cases of wet cooling towers being built in close proximity to airports and highways that could be susceptible to fogging and icing problems. In these cases, however, the potential for dangerous conditions were mitigated by the installation of plume abatement technologies during the construction of the cooling towers.

Plume abatement might also be necessary at certain types of locations, including situations in which local residents or governments object to the visible plume, as it may detract from a view that is valued by the community, or if the plume might create safety problems such as reduced visibility on nearby roadways or icing on roads and bridges. EPA included plume abatement technologies in its cost estimates for one-fourth of the facilities expected to retrofit to wet cooling towers. For adding plume abatement technology to a conventional mechanical draft cooling tower, the total cost of the tower component is estimated to increase by a factor of 2.0-3.5 with a 10 percent increase in the energy requirement and a 50 percent to 100 percent increase in non-energy O&M (see DCN 10-6652). A number of site-specific factors come into play to determine the selection of technology, but appropriate assumptions for estimating national-level compliance costs can be made regarding the impacts of these abatement technologies to the overall cost of the retrofit. A full discussion of the costing methodology and assumptions used for the Existing Facility rule is presented in Chapter 8 of this TDD.

10.3 Displacement of Wetlands or Other Land Habitats

As described in the 2002 proposed Phase II TDD, mechanical draft cooling towers can require land areas of up to 1.5 acres for an average-sized new cooling tower.[185] In 2002, the Agency concluded that existing Clean Water Act section 404 programs would more than adequately protect wetlands and habitats for these land uses. EPA also determined that the displacement of wetlands on an industrial site such as a large existing power plant is not a probable outcome of cooling tower construction at most facilities. EPA does not expect habitat displacement to be a significant problem for most facilities. EPA believes for the final rule that existing Federal, State, and local programs for maintaining and restoring wetlands are adequate to protect wetlands and no new analyses were conducted.

10.4 Salt or Mineral Drift

As described in the 2002 proposed Phase II TDD, the operation of cooling towers in either brackish or salt water environments can release water droplets containing soluble salts, including sodium, calcium, chloride, and sulfate ions. Salt drift may also occur in freshwater systems that operate recirculating systems at very high levels of concentration, but based on EPA's site visits and the higher O&M costs of operating at the highest cycles of concentration, EPA expects this is unlikely to occur at most facilities. Salt drift from towers may be carried by prevailing winds and settle onto soil, vegetation, and waterbodies. Under normal conditions drift does not carry very far from the originating source and would require sustained high winds and high humidity to reach distances of several hundred feet in any significant quantity (SWRCB 2010). In addition, drift-reducing technologies called drift eliminators are often used to minimize salt and mineral drift. (Also see the above discussion of particulate matter and EPA's assignment of drift eliminators.) A review of GIS mapping of nuclear facilities shows the safety perimeter and setback distances at nuclear facilities are large enough that drift reaching and settling on neighboring properties is highly unlikely. Additional site-specific studies at Chalk Point and St. Johns (Maulbetsch) suggest the impacts of drift are limited to the facility property. As such, EPA does not expect drift to be a significant problem for most facilities under any of the cooling tower options.

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[185] Size of "average" cooling tower is based on technology and cost assumptions used in developing the 2002 proposed Phase II rule.

10.5 Noise

Noise from mechanical draft cooling towers is generated by falling water inside the towers plus fan or motor noise or both. However, power plant sites generally do not result in off-site levels of noise more than 10 dB(A) above background (NRC 1996). The amount of noise abatement required is a function of both the local community noise code and the distance from the tower to the nearest sound receptor that must meet the specified noise code. Noise abatement costs will be highest if a tower must be located near areas with highly restrictive noise codes, such as residential areas.

Noise abatement features are an integral and inexpensive component of modern cooling tower designs. (See the 2002 proposed TDD, Appendix B, Charts 2-1 through 2-6 for a comparison of low-noise tower costs and other types of tower modifiers.) Facilities that make use of cooling towers might expect the typical noise level to be approximately 70 dB within 50 feet of the tower (SPX 2009).[186] Because sound levels diminish approximately 5 dB per doubling of distance, and 55 dB falls between the sound level of rainfall and normal conversation (and therefore would not be considered noise pollution), a buffer of 400 feet would suffice for noise abatement at most sites. In addition, EPA's "Protective Noise Levels" guidance found that ambient noise levels of 55 dB was sufficient to protect public health and welfare and, in most cases, did not create an annoyance (EPA 1978). As for noise pollution at the site itself, the New York State Department of Environmental Conservation's "Assessing and Mitigating Noise Impacts" policy states that 60-70 dB is the beginning of the threshold for annoyance in non-industrial sites and that noise can exceed 65 dB (and up to 79 dB) in commercial or industrial sites. A common goal is to keep new noise sources from increasing the overall noise levels by 5-10 dB. Given that noise is measured on a logarithmic scale, adding a cooling tower that operates with a sound level of approximately70 dB will be unlikely to add a significant level of noise to an already noisy industrial site (NYDEC 2000). Given that noise appears to dissipate relatively quickly (and the fact that many industrial sites are large and a 400 foot buffer would not be a significant limitation), effects from noise are not expected to be significant at most sites. There will certainly be some sites that require noise mitigation, but the number of sites is likely to already be represented by the site analyses for plume and population density. In addition, this issue is often a matter of adverse public reactions to the noise and not environmental or human health (i.e., hearing) impacts. The NRC adds further, "[n]atural-draft and mechanical-draft cooling towers emit noise of a broadband nature...Because of the broadband character of the cooling towers, the noise associated with them is largely indistinguishable and less obtrusive than transformer noise or loudspeaker noise."

The cost contribution of low noise fans comprises a very small portion of the total installed capital cost of a retrofitted cooling system (on the same order as drift elimination technologies). Where noise abatement materials maintenance costs are higher (such as for larger towers), O&M costs should be commensurately reduced. Thus, the net effect of this noise abatement technology design on cooling tower O&M costs is expected to be minimal. In order to account for the potential increased in costs, EPA assumed that 25 percent of cooling towers would require increased costs to account for noise and

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[186] For additional technical discussion of noise mitigation, please see DCN 10-6652.

plume abatement. EPA included additional costs for noise abatement at approximately 25 percent of existing facilities; see Chapter 8 of the TDD and DCNs 10-6671 and 6672. EPA found the costs of such controls to be nominal, therefore EPA concludes that the issue of noise abatement is not critical to the evaluation of the environmental side effects of cooling towers. As such, EPA does not expect noise abatement to be a significant problem for most facilities.

10.6 Solid Waste Generation

Recirculation of cooling water increases the volume of solid wastes generated because some facilities (including most manufacturers) treat the cooling tower blowdown in a wastewater treatment system before discharge, and the concentrated pollutants removed from the blowdown add to the amount of wastewater sludge generated by the facility. For facilities operating cooling towers in brackish or saline waters, the concentration of salts within the tower and blowdown are a primary design factor. As such, these systems can have elevated salt concentrations. However, the concentration of salts is generally a treatable condition for blowdown from towers. In general, manufacturers tend to have systems in place for treating this type of solid. EPA does not expect the impacts of solids waste disposal to be a significant problem and did not further evaluate impacts from solids waste disposal for the Existing Facility rule.[187]

10.7 Evaporative Consumption of Water

Cooling tower operation is designed to result in a measurable evaporation of water drawn from the source water. Depending on the size and flow conditions of the affected waterbody, evaporative water loss can affect the quality of aquatic habitat and recreational fishing. According to NUREG-1437 (NRC 1996), “water lost by evaporation from the heated discharge of once-through cooling is about 60 percent of that which is lost through cooling towers.” NUREG-1437 goes on to further state that “with once-through cooling systems, evaporative losses... occur externally in the adjacent body of water instead of in the closed-cycle system.” Therefore, evaporation does occur due to heating of water in once-through cooling systems, even though the majority of this loss happens downstream of the plant in the receiving waterbody due to the evaporation in the heated effluent plume.

EPA acknowledges that evaporative losses from closed-cycle cooling towers are likely greater than those from once-through cooling systems for a given site. Withdrawal and subsequent return of once-through cooling water to a large waterbody such as an ocean is likely to show the least amount of downstream evaporation. On the other hand, withdrawal of a majority of a river and the subsequent return of heated water can be expected to approach the same evaporative losses as a cooling tower sized for the same heat load. Cumulative effects such as multiple users of the waterbody will amplify the

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[187] EPA assumed no incremental costs for treatment of blowdown, as the issue is expected to be minor for most facilities. For example, facilities on brackish waters are already discharging to waters with elevated TSS. Additionally, many facilities (particularly manufacturers) already have wastewater treatment capabilities in place.

effect. When considered at the national level, EPA concludes the average rate of evaporation can increase by a factor of 1.5 to 2 in closed-cycle systems. This conclusion is consistent with research conducted by NUREG-1437 and the Electric Power Research Institute (EPRI) that concluded that losses in closed-cycle systems are approximately 60-80 percent greater (EPRI 2002).

The differences in evaporative losses are minimal in terms of gallons lost and in most cases are minor compared to river flow. In areas where water resources are limited (e.g., the desert southwest or the recently drought-stricken southeast), once-through cooling may not be a prudent option for new facilities and it may be a liability for existing facilities. Some facilities would not be able to withdraw sufficient volumes of water for once through cooling. These same facilities could withdraw sufficient makeup water for a cooling tower. EPA found this in site visits where several facilities retrofitted to closed-cycle cooling in spite of drought conditions (see, e.g., the site visit report for McDonough). Similarly, for facilities located on smaller waterbodies, evaporative losses from once-through cooling will be higher since the effluent comprises a larger percentage of the receiving stream, won't mix as quickly, and will remain heated longer, leading to additional evaporation. Smaller receiving streams are also more likely to be affected by thermal discharges from the perspective of 316(a), which requires that the discharge not affect the "balanced indigenous population."

Dry cooling and hybrid (wet/dry) cooling are available technologies that reduce evaporative losses. Dry cooling systems require virtually no water withdrawals and hybrid systems consume about 15 percent less water through evaporation. EPA's record shows these systems for reducing evaporative losses have been available and demonstrated for over 30 years.

While EPA did not attempt to identify or quantify the meteorological effects, the water vapor in the evaporative plumes does not simply disappear; it will be incorporated into the atmosphere and may return to the original watershed in the form of precipitation.

Finally, cooling water withdrawals are a very small component of consumptive uses nationwide. As noted in EPA's Closed-cycle Cooling Systems for Steam-electric Power Plants: A State-of-the-art Manual (DCN 10-6845F), consumptive water uses by the steam electric sector was 1.2 percent of consumptive uses nationwide in 1975; agriculture was 85 percent, drinking water was 7 percent and mining was 7 percent. The Nuclear Energy Institute presented similar data, noting that a closed-cycle power plant typically consumes 23 gallons of water per day per household served with electricity, while the same average household uses 94 gallons per day for domestic uses.

10.8 Thermal Effluent

EPA notes that section 316(a) of the CWA provides EPA the authority to deal with thermal effects and that technologies used to meet 316(b) standards may have impacts and/or benefits for meeting 316(a) requirements. Given the lack of specific data on the impact of thermal effects, EPA did not conduct a formal analysis or quantify the impacts of thermal effluent discharges, although the conversion to cooling towers clearly presents a significant reduction in the discharge of heat, a regulated pollutant. EPA did conduct an overview of thermal discharge data for a sampling of electric generator facilities in the Permit Compliance System, but excluded data from facilities that already use closed-cycle cooling. EPA has calculated that mechanical draft evaporative cooling towers are an effective technology for reducing the volume of surface water withdrawn for cooling and can reduce once-through intake flows by 93 percent to 99 percent depending on operating conditions such as the temperature rise and the cycles of concentration.

10.9 References

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Appendix to Chapter 10: Non-water Quality Impacts

10A.0 Air Emissions Data for Proposal Option 2

EPA assumed that the 136 power plants withdrawing 125 mgd or more for which air emissions data is available would retrofit to recirculating wet cooling towers (not including those facilities already employing cooling towers). This table represents facility-specific increases; the data are based on the estimated energy penalty for each facility, the facility's historic average electricity generation level, and its average historic emission rates.

Unit	Total increase in Annual CO_2 (tons)	Total increase in Annual SO_2 (tons)	Total increase in Annual NO_x (tons)	Total increase in Annual Hg (lbs)	Total increase in Annual PM2.5 (tons)	Total increase in AnnualPM10 (tons)
1	47,062.09	462.89	103.63	2.71	21.68	26.24
2	25,758.85	182.78	90.66	1.93	28.65	32.96
3	309.09	0.07	1.23		12.49	15.62
4	17,646.79	174.67	47.89	0.70	5.10	6.39
5	-	-	-		0.04	0.04
6	14,022.39	72.49	38.80	0.52	8.29	23.12
7	26,508.32	0.15	7.26		2.26	2.26
8	37,197.49	66.09	92.44	1.12		5.49
9	17,547.14	120.60	33.08	1.38	9.87	13.32
10	5,114.76	0.27	13.03		-	-
11	3,427.09	44.84	7.85		1.08	1.36
12	45,620.40	181.72	83.39	0.17	27.71	28.22
13	127.92	0.16	0.20		-	-
14	9,982.55	8.94	15.78		-	-
15	5,883.26	1.17	4.81		-	-
16	214,619.09	41.72	64.54		-	-
17	16,853.90	232.41	50.84	0.92	17.41	19.21
18	24,876.82	106.21	40.74	0.20	3.88	4.42
19	41,790.45	349.91	163.05	1.21		
20	38,635.50	551.81	149.18	4.89	5.96	7.86
21	15,647.31	256.38	55.88	0.58	10.84	12.31
22	112,328.50	273.52	51.91	14.10	21.15	27.82
23	2,957.93	0.32	1.53			
24	41,808.74	542.94	97.13	1.92	33.78	38.56
25	9,977.82	2.22	4.40			
26	15,885.15	11.59	25.09		2.30	2.37
27	89,591.31	106.55	82.10	3.80	10.45	17.70
28	41,438.63	107.78	66.59	2.41	6.75	8.98
29	5,627.19	0.03	3.91		0.32	0.32
30	148.85	0.18	0.23		-	-
31	6,955.23	15.62	12.49		0.93	1.22
32	51,350.22	238.61	128.75	1.25	11.88	16.62
33	6,312.31	0.03	1.20		0.25	0.25
34	551.25	0.03	0.47		0.22	0.22
35	98,796.63	209.09	276.70	2.31	13.93	18.60
36	128,643.03	664.68	209.76	5.53	24.91	30.44
37	104,088.03	451.36	456.50	2.28		3.02
38	3,316.93	0.04	3.72		0.32	0.32
39	29,456.81	152.77	57.76	0.87	4.31	5.03

Unit	Total increase in Annual CO_2 (tons)	Total increase in Annual SO_2 (tons)	Total increase in Annual NO_x (tons)	Total increase in Annual Hg (lbs)	Total increase in Annual PM2.5 (tons)	Total increase in AnnualPM10 (tons)
40	125,430.47	1,212.29	180.61	0.69	65.05	71.23
41	24,843.22	122.04	139.03		3.95	3.95
42	100,889.85	387.50	117.70	5.34	36.94	62.39
43	28,645.06	571.47	55.81	1.51	25.13	26.31
44	46,639.02	353.01	63.12		4.56	6.14
45	94,162.18	558.07	171.88	5.06	6.68	15.33
46	43,849.02	179.11	75.57	0.69	5.78	10.05
47	215,723.35	1,736.65	475.96	13.13	42.76	46.92
48	26,284.78	0.17	8.25		-	-
49	83,873.34	398.21	129.19	3.63	15.54	30.98
50	64,350.01	445.24	143.20	2.66	18.85	23.37
51	149,318.10	697.85	287.80	4.18	22.37	23.30
52	54,419.06	13.21	32.41			
53	-	-	-	-	1.33	1.33
54	73,506.91	461.34	129.32	4.77	25.35	29.76
55	33,331.51	209.74	100.16	2.07	11.34	14.04
56	14,929.32	0.09	6.66		1.33	1.33
57	13,141.93	4.91	14.04		1.54	1.54
58	71,845.14	501.61	93.99	3.47	25.92	29.26
59	465,996.64	1,351.75	557.28	8.93	53.92	72.16
60	126,653.35	126,653.35	208.98	11.26	109.14	109.21
61	112,406.67	2,034.33	190.48	4.89	88.06	91.90
62	84,840.09	135.58	277.76	2.39		8.69
63	120,257.80	169.46	442.70	6.48	19.21	28.00
64	109,150.28	495.24	326.70	4.34	7.14	7.65
65	31.63	-	0.01		0.04	0.04
66	86,409.28	396.89	118.42	4.77	17.30	17.91
67	29,407.30	50.62	36.82		7.25	7.25
68	73,475.45	589.60	156.50		16.59	21.11
69	172,555.52	1,356.09	240.19	9.37	104.11	150.21
70	82,741.51	996.05	104.63	9.32	33.03	38.34
71	154,976.34	508.53	243.02	9.37	16.33	21.76
72	47,713.04	106.61	71.76		8.22	10.45
73	151,309.02	972.71	123.17		8.33	8.33
74	21,922.20	0.11	26.27		2.51	2.51
75	11,196.38	1.80	22.64		1.83	1.83
76	41,876.76	0.23	11.94		1.40	1.40
77	14,759.60	23.50	18.14		1.08	1.26
78	55,712.41	149.93	57.41	6.75	8.36	11.74
79	179,421.18	1,251.65	234.68	8.64	59.34	66.27
80	212,738.66	420.00	172.87	33.94	37.44	46.02
81	189,651.05	1,470.08	333.25	5.63	56.97	58.66
82	65,809.54	378.27	156.37			
83	36,324.07	0.30	3.55		-	-
84	15,718.64	0.04	0.87		3.91	3.91
85	191,789.22	857.49	448.65	6.89	16.62	31.56
86	20,216.39	0.11	15.36		1.97	1.97
87	239,320.63	646.69	278.35	7.72	13.14	22.08
88	13,326.31	1.13	19.61		0.86	0.86
89	1.64	-	-		0.39	1.22
90	232,197.58	2,787.33	415.09	8.33	82.10	91.51
91	247,340.42	658.21	521.08	13.43	22.80	29.51

Unit	Total increase in Annual CO_2 (tons)	Total increase in Annual SO_2 (tons)	Total increase in Annual NO_x (tons)	Total increase in Annual Hg (lbs)	Total increase in Annual PM2.5 (tons)	Total increase in AnnualPM10 (tons)
92	133,651.85	1,528.41	413.44	9.32	74.03	74.82
93	181,036.27	1,093.83	345.40	8.97	3.95	7.83
94	3,492.64	0.32	2.92		0.14	0.18
95	318,582.91	932.07	198.31	21.10	28.43	34.54
96	323,849.40	3,755.21	500.13	20.83	168.05	219.49
97	193,434.16	2,397.29	323.89	7.39	100.77	108.27
98	150,672.13	79.21	25.52		7.04	7.43
99	40,719.17	84.37	65.79		6.00	6.79
100	223,448.67	1,630.73	298.85	9.66	54.21	63.36
101	8,555.80	0.04	1.20		10.77	10.95
102	299,311.78	755.68	181.28	12.00	22.33	27.97
103	176,410.50	503.87	247.99	9.53	16.48	22.55
104	74,228.78	355.64	224.72			
105	188,729.21	437.10	166.01	27.27	17.77	28.86
106	10,802.33	0.05	0.79		3.91	3.95
107	72,148.92	115.46	168.23	1.89	19.96	38.41
108	141,882.58	860.39	315.13	5.79	65.19	87.74
109	17,576.18	0.09	4.39		1.69	1.72
110	430,167.67	1,048.36	245.26	27.63	44.05	80.74
111	303,341.43	3,017.74	464.77	36.96	98.33	117.18
112	11,130.96	0.06	13.98		4.38	4.38
113	492,439.33	1,926.14	691.02	18.58	90.54	107.48
114	298,837.98	2,685.20	437.93	23.38	75.71	80.85
115	133,838.18	1,154.35	265.87	4.79	77.87	80.20
116	318,262.91	1,397.99	586.15	14.88	103.57	115.13
117	552,928.93	3,825.75	903.42	22.55	232.81	258.30
118	137,532.97	748.11	317.88			
119	280,145.79	1,444.56	393.03	7.66	57.19	58.05
120	361,319.89	408.45	857.18	5.65	62.47	91.04
121	279,371.93	1,167.42	382.51	9.55	53.17	60.81
122	620,697.97	1,992.54	342.07	32.76	35.43	62.29
123	319,700.75	2,680.25	812.09	18.87	25.49	36.94
124	510,476.19	3,475.57	733.05	19.32	177.96	205.31
125	49,502.38	0.25	13.41		5.89	5.89
126	102,624.92	1.38	251.19		14.25	14.25
127	934,864.48	2,975.95	651.78	56.86	90.00	102.28
128	395,263.14	1,234.25	651.74	16.94	88.53	113.80
129	2,957.39	0.01	3.52		-	-
130	17,817.23	0.09	29.71		1.08	1.08
131	236,556.23	463.21	166.69	10.06	11.99	12.28
132	627,946.34	2,861.15	507.50	77.30	105.22	171.57
133	650,275.69	3,959.99	1,270.78	45.12	101.06	108.63
134	743,242.36	1,985.06	178.47	20.97		
135	606,115.85	627.29	975.98	9.47	94.78	129.49
136	154,739.88	1,181.66	356.45			
TOTAL	18,360,926.72	214,741.34	26,591.23	873.51	3,653.08	4,495.65

10A.1 Air Emissions Data for Proposal Option 3

EPA assumed that all 167 power plants for which data is readily available would retrofit to recirculating wet cooling towers. This table represents facility-specific increases; the data are based on the estimated energy penalty for each facility, the facility's historic average electricity generation level, and its average historic emission rates.

Unit	Total increase in Annual CO_2 (tons)	Total increase in Annual SO_2 (tons)	Total increase in Annual NO_x (tons)	Total increase in Annual Hg (lbs)	Total increase in Annual PM2.5 (tons)	Total increase in Annual PM10 (tons)
1	9,603.30	89.47	41.47		-	0.04
2	-	-	37.27	8.21	-	-
3	2,188.80	30.98	9.56		0.07	0.25
4	-	-	-	2.63		0.22
5	289,758.55	936.94	210.06	12.83	18.92	22.08
6	91.61	-	0.02		-	-
7	-	-	25.95	2.32	-	-
8	-	-	23.40	5.06	-	-
9	5,488.98	0.05	1.45		0.86	0.86
10	121,821.75	382.08	495.89	3.33	14.93	14.93
11	20,355.14	23.25	26.52	0.62	1.01	1.33
12	28,787.97	397.72	53.05	1.85	30.98	33.03
13	1,496.18	0.41	2.84		-	-
14	5,718.97	0.03	4.17		19.49	22.04
15	-	-	0.11	0.23	-	-
16	39,262.67	0.60	2.43		-	-
17	321.24	0.01	0.52		-	-
18	15,690.00	110.42	29.83		-	-
19	15,871.58	333.43	39.55	0.71		
20	11,470.36	235.69	25.22	1.69	19.57	20.10
21	3,891.51	16.56	7.37		0.65	0.65
22	2,842.32	14.14	4.19		-	-
23	16,719.07	97.23	56.40	0.63		
24	277.81	0.01	0.45		-	-
25	25,010.72	156.42	52.03	0.71	3.23	5.85
26	24,760.44	85.60	43.78	1.55	8.26	14.75
27	39,923.88	191.76	85.00	1.80	11.34	14.11
28	-	0.01	33.98	0.76	-	-
29	6,312.31	0.03	1.20		0.04	0.04
30	2,136.46	30.26	6.25		-	-
31	2,974.80	7.91	4.96		0.25	0.32
32	47,062.09	462.89	103.63	2.71	21.68	26.24
33	25,758.85	182.78	90.66	1.93	28.65	32.96
34	309.09	0.07	1.23		12.49	15.62
35	17,646.79	174.67	47.89	0.70	5.10	6.39
36	-	-	-		0.04	0.04
37	14,022.39	72.49	38.80	0.52	8.29	23.12
38	26,508.32	0.15	7.26		2.26	2.26
39	37,197.49	66.09	92.44	1.12		5.49
40	17,547.14	120.60	33.08	1.38	9.87	13.32
41	5,114.76	0.27	13.03		-	-

Unit	Total increase in Annual CO_2 (tons)	Total increase in Annual SO_2 (tons)	Total increase in Annual NO_x (tons)	Total increase in Annual Hg (lbs)	Total increase in Annual PM2.5 (tons)	Total increase in Annual PM10 (tons)
42	3,427.09	44.84	7.85		1.08	1.36
43	45,620.40	181.72	83.39	0.17	27.71	28.22
44	127.92	0.16	0.20		-	-
45	9,982.55	8.94	15.78		-	-
46	5,883.26	1.17	4.81		-	-
47	214,619.09	41.72	64.54		-	-
48	16,853.90	232.41	50.84	0.92	17.41	19.21
49	24,876.82	106.21	40.74	0.20	3.88	4.42
50	41,790.45	349.91	163.05	1.21		
51	38,635.50	551.81	149.18	4.89	5.96	7.86
52	15,647.31	256.38	55.88	0.58	10.84	12.31
53	112,328.50	273.52	51.91	14.10	21.15	27.82
54	2,957.93	0.32	1.53			
55	41,808.74	542.94	97.13	1.92	33.78	38.56
56	9,977.82	2.22	4.40			
57	15,885.15	11.59	25.09		2.30	2.37
58	89,591.31	106.55	82.10	3.80	10.45	17.70
59	41,438.63	107.78	66.59	2.41	6.75	8.98
60	5,627.19	0.03	3.91		0.32	0.32
61	148.85	0.18	0.23		-	-
62	6,955.23	15.62	12.49		0.93	1.22
63	51,350.22	238.61	128.75	1.25	11.88	16.62
64	6,312.31	0.03	1.20		0.25	0.25
65	551.25	0.03	0.47		0.22	0.22
66	98,796.63	209.09	276.70	2.31	13.93	18.60
67	128,643.03	664.68	209.76	5.53	24.91	30.44
68	104,088.03	451.36	456.50	2.28		3.02
69	3,316.93	0.04	3.72		0.32	0.32
70	29,456.81	152.77	57.76	0.87	4.31	5.03
71	125,430.47	1,212.29	180.61	0.69	65.05	71.23
72	24,843.22	122.04	139.03		3.95	3.95
73	100,889.85	387.50	117.70	5.34	36.94	62.39
74	28,645.06	571.47	55.81	1.51	25.13	26.31
75	46,639.02	353.01	63.12		4.56	6.14
76	94,162.18	558.07	171.88	5.06	6.68	15.33
77	43,849.02	179.11	75.57	0.69	5.78	10.05
78	215,723.35	1,736.65	475.96	13.13	42.76	46.92
79	26,284.78	0.17	8.25		-	-
80	83,873.34	398.21	129.19	3.63	15.54	30.98
81	64,350.01	445.24	143.20	2.66	18.85	23.37
82	149,318.10	697.85	287.80	4.18	22.37	23.30
83	54,419.06	13.21	32.41			
84	-	-	-	-	1.33	1.33
85	73,506.91	461.34	129.32	4.77	25.35	29.76
86	33,331.51	209.74	100.16	2.07	11.34	14.04
87	14,929.32	0.09	6.66		1.33	1.33
88	13,141.93	4.91	14.04		1.54	1.54
89	71,845.14	501.61	93.99	3.47	25.92	29.26
90	465,996.64	1,351.75	557.28	8.93	53.92	72.16

Unit	Total increase in Annual CO$_2$ (tons)	Total increase in Annual SO$_2$ (tons)	Total increase in Annual NO$_x$ (tons)	Total increase in Annual Hg (lbs)	Total increase in Annual PM2.5 (tons)	Total increase in Annual PM10 (tons)
91	126,653.35	126,653.35	208.98	11.26	109.14	109.21
92	112,406.67	2,034.33	190.48	4.89	88.06	91.90
93	84,840.09	135.58	277.76	2.39		8.69
94	120,257.80	169.46	442.70	6.48	19.21	28.00
95	109,150.28	495.24	326.70	4.34	7.14	7.65
96	31.63	-	0.01		0.04	0.04
97	86,409.28	396.89	118.42	4.77	17.30	17.91
98	29,407.30	50.62	36.82		7.25	7.25
99	73,475.45	589.60	156.50		16.59	21.11
100	172,555.52	1,356.09	240.19	9.37	104.11	150.21
101	82,741.51	996.05	104.63	9.32	33.03	38.34
102	154,976.34	508.53	243.02	9.37	16.33	21.76
103	47,713.04	106.61	71.76		8.22	10.45
104	151,309.02	972.71	123.17		8.33	8.33
105	21,922.20	0.11	26.27		2.51	2.51
106	11,196.38	1.80	22.64		1.83	1.83
107	41,876.76	0.23	11.94		1.40	1.40
108	14,759.60	23.50	18.14		1.08	1.26
109	55,712.41	149.93	57.41	6.75	8.36	11.74
110	179,421.18	1,251.65	234.68	8.64	59.34	66.27
111	212,738.66	420.00	172.87	33.94	37.44	46.02
112	189,651.05	1,470.08	333.25	5.63	56.97	58.66
113	65,809.54	378.27	156.37			
114	36,324.07	0.30	3.55		-	-
115	15,718.64	0.04	0.87		3.91	3.91
116	191,789.22	857.49	448.65	6.89	16.62	31.56
117	20,216.39	0.11	15.36		1.97	1.97
118	239,320.63	646.69	278.35	7.72	13.14	22.08
119	13,326.31	1.13	19.61		0.86	0.86
120	1.64	-	-		0.39	1.22
121	232,197.58	2,787.33	415.09	8.33	82.10	91.51
122	247,340.42	658.21	521.08	13.43	22.80	29.51
123	133,651.85	1,528.41	413.44	9.32	74.03	74.82
124	181,036.27	1,093.83	345.40	8.97	3.95	7.83
125	3,492.64	0.32	2.92		0.14	0.18
126	318,582.91	932.07	198.31	21.10	28.43	34.54
127	323,849.40	3,755.21	500.13	20.83	168.05	219.49
128	193,434.16	2,397.29	323.89	7.39	100.77	108.27
129	150,672.13	79.21	25.52		7.04	7.43
130	40,719.17	84.37	65.79		6.00	6.79
131	223,448.67	1,630.73	298.85	9.66	54.21	63.36
132	8,555.80	0.04	1.20		10.77	10.95
133	299,311.78	755.68	181.28	12.00	22.33	27.97
134	176,410.50	503.87	247.99	9.53	16.48	22.55
135	74,228.78	355.64	224.72			
136	188,729.21	437.10	166.01	27.27	17.77	28.86
137	10,802.33	0.05	0.79		3.91	3.95
138	72,148.92	115.46	168.23	1.89	19.96	38.41
139	141,882.58	860.39	315.13	5.79	65.19	87.74

Unit	Total increase in Annual CO$_2$ (tons)	Total increase in Annual SO$_2$ (tons)	Total increase in Annual NO$_x$ (tons)	Total increase in Annual Hg (lbs)	Total increase in Annual PM2.5 (tons)	Total increase in Annual PM10 (tons)
140	17,576.18	0.09	4.39		1.69	1.72
141	430,167.67	1,048.36	245.26	27.63	44.05	80.74
142	303,341.43	3,017.74	464.77	36.96	98.33	117.18
143	11,130.96	0.06	13.98		4.38	4.38
144	492,439.33	1,926.14	691.02	18.58	90.54	107.48
145	298,837.98	2,685.20	437.93	23.38	75.71	80.85
146	133,838.18	1,154.35	265.87	4.79	77.87	80.20
147	318,262.91	1,397.99	586.15	14.88	103.57	115.13
148	552,928.93	3,825.75	903.42	22.55	232.81	258.30
149	137,532.97	748.11	317.88			
150	280,145.79	1,444.56	393.03	7.66	57.19	58.05
151	361,319.89	408.45	857.18	5.65	62.47	91.04
152	279,371.93	1,167.42	382.51	9.55	53.17	60.81
153	620,697.97	1,992.54	342.07	32.76	35.43	62.29
154	319,700.75	2,680.25	812.09	18.87	25.49	36.94
155	510,476.19	3,475.57	733.05	19.32	177.96	205.31
156	49,502.38	0.25	13.41		5.89	5.89
157	102,624.92	1.38	251.19		14.25	14.25
158	934,864.48	2,975.95	651.78	56.86	90.00	102.28
159	395,263.14	1,234.25	651.74	16.94	88.53	113.80
160	2,957.39	0.01	3.52		-	-
161	17,817.23	0.09	29.71		1.08	1.08
162	236,556.23	463.21	166.69	10.06	11.99	12.28
163	627,946.34	2,861.15	507.50	77.30	105.22	171.57
164	650,275.69	3,959.99	1,270.78	45.12	101.06	108.63
165	743,242.36	1,985.06	178.47	20.97		
166	606,115.85	627.29	975.98	9.47	94.78	129.49
167	154,739.88	1,181.66	356.45			
TOTAL	19,053,703.14	217,882.36	27,916.17	918.43	3,782.68	4,646.25

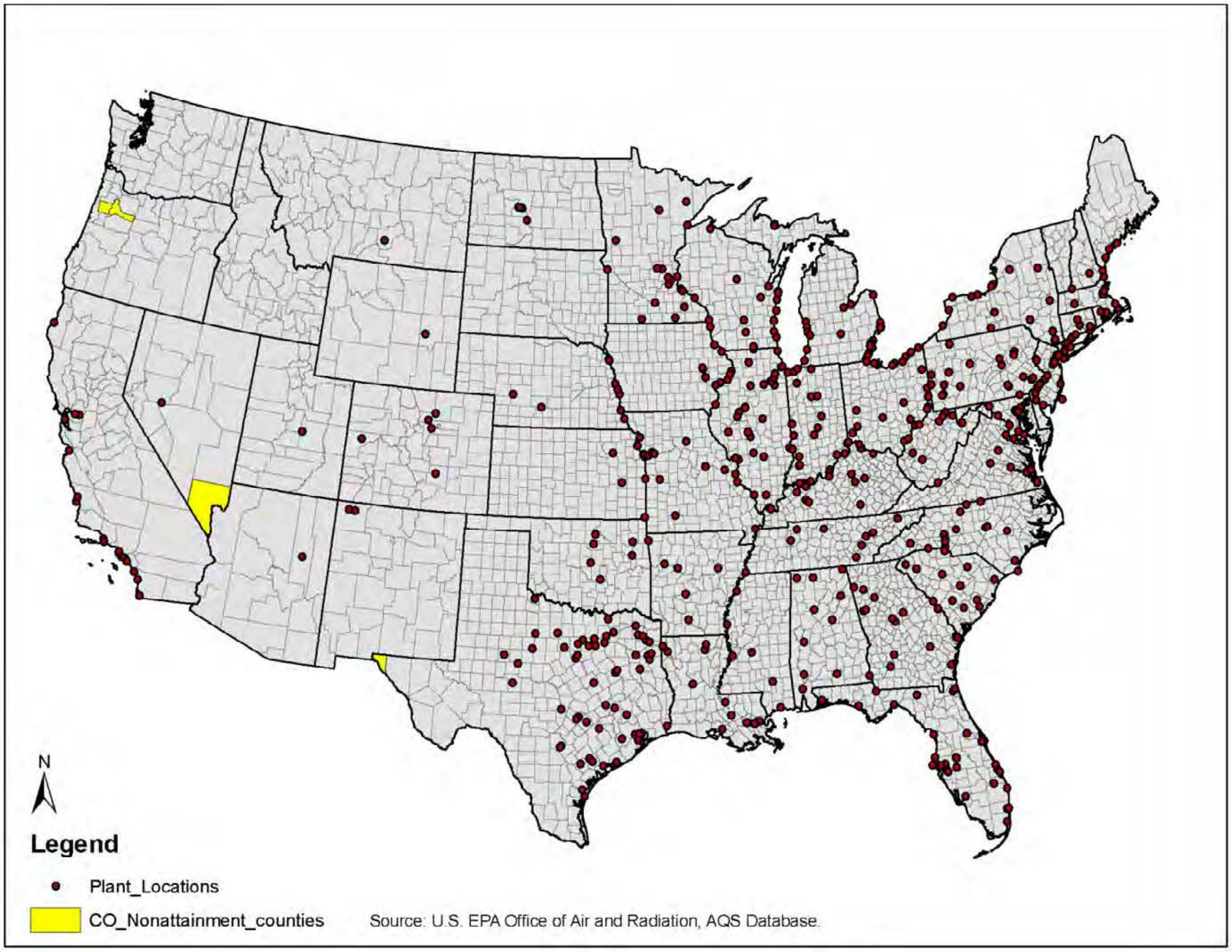
10A.2 GIS Analyses of Expected Pollutants from Potentially Affected Facilities

EPA created maps with the locations of all Phase II facilities (excluding manufacturers) overlaid with maps of non-attainment areas for the various criteria air pollutants:

- Carbon monoxide (CO)
- Lead (Pb)
- Particulate matter (PM2.5)
- Particulate matter (PM10)
- Ozone
- Sulphur dioxide (SO$_2$)

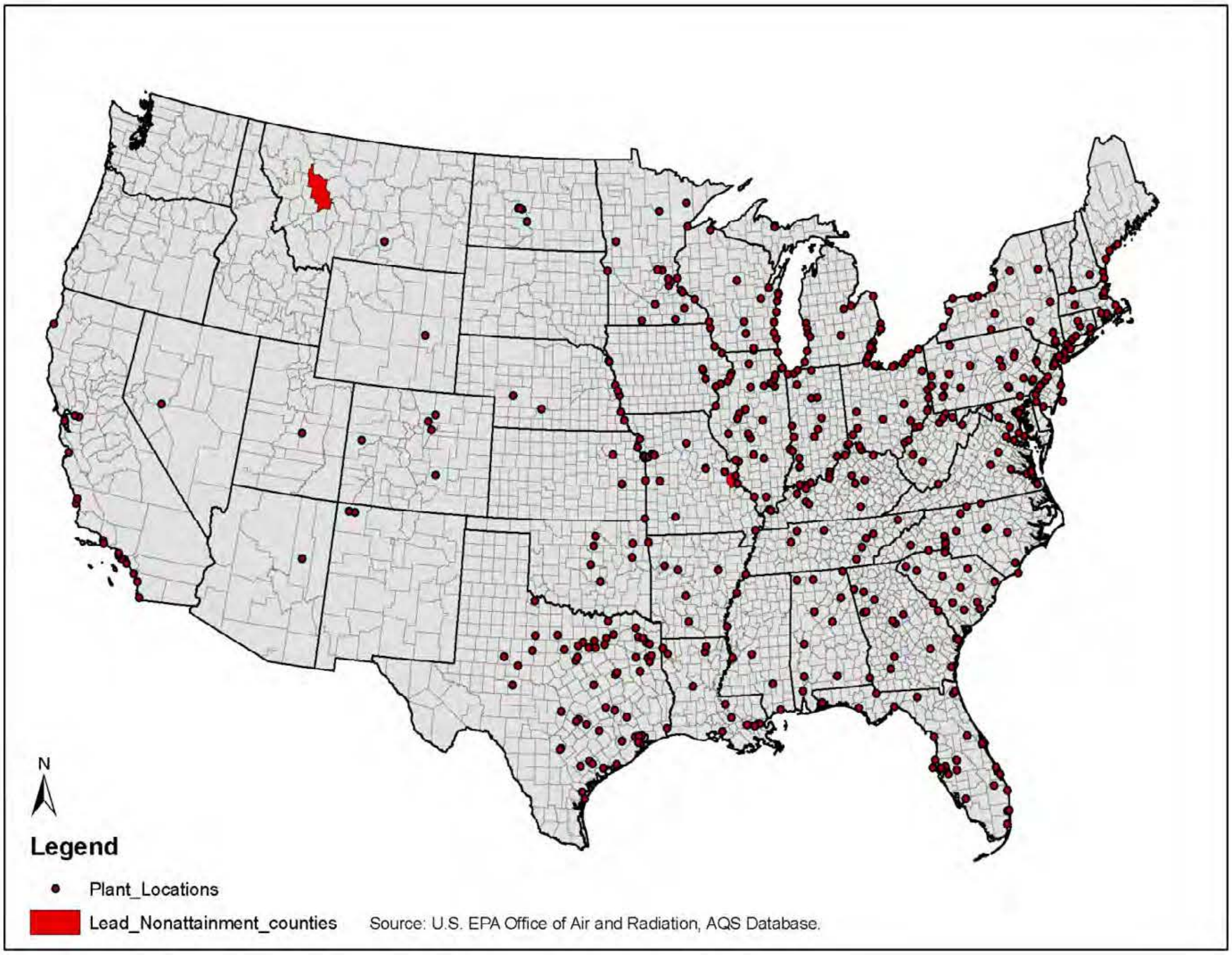
These maps present non-attainment areas designated by EPA in 2010.

CO Nonattainment Areas



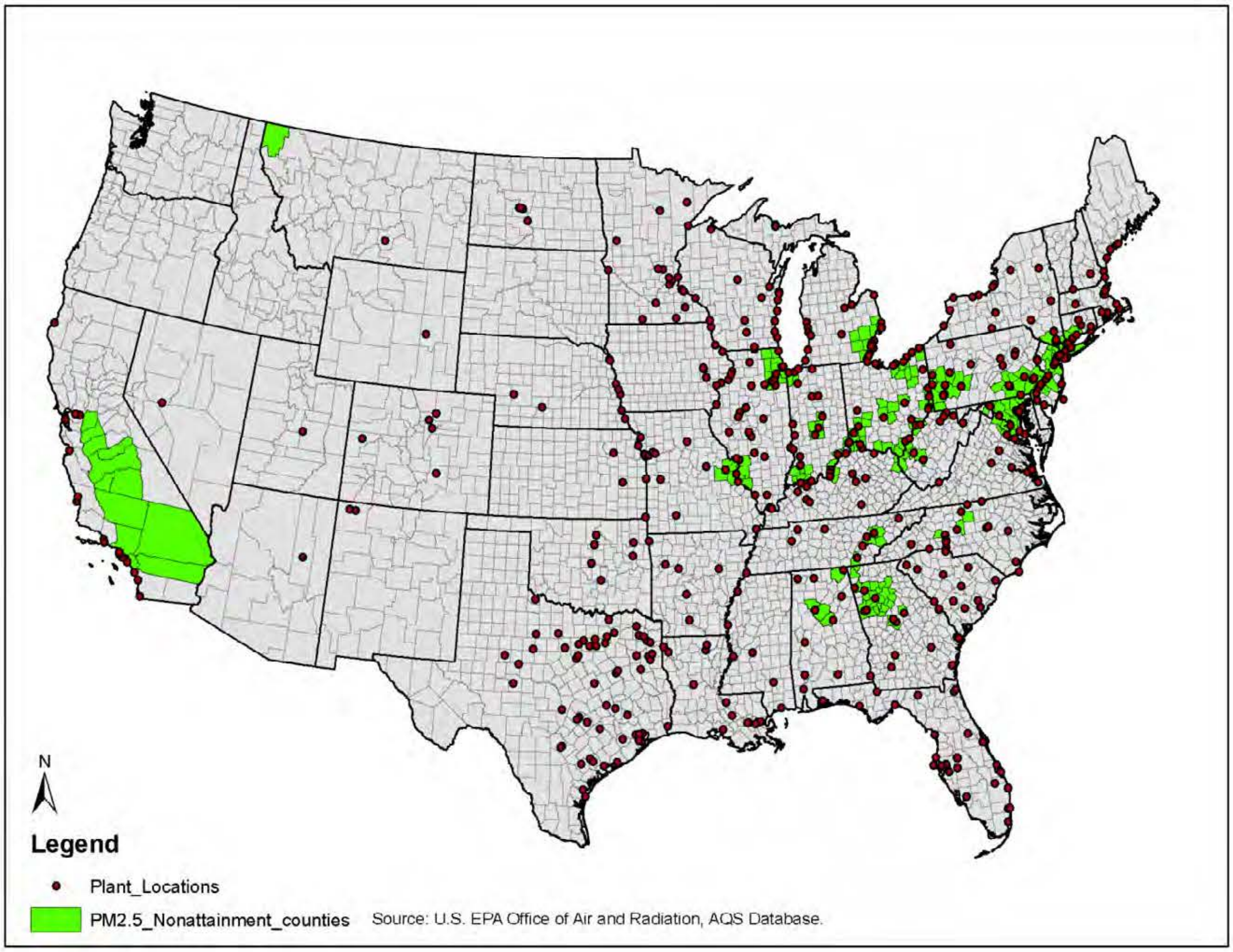
Source: U.S. EPA Office of Air and Radiation, AQS Database.

Pb Nonattainment Areas



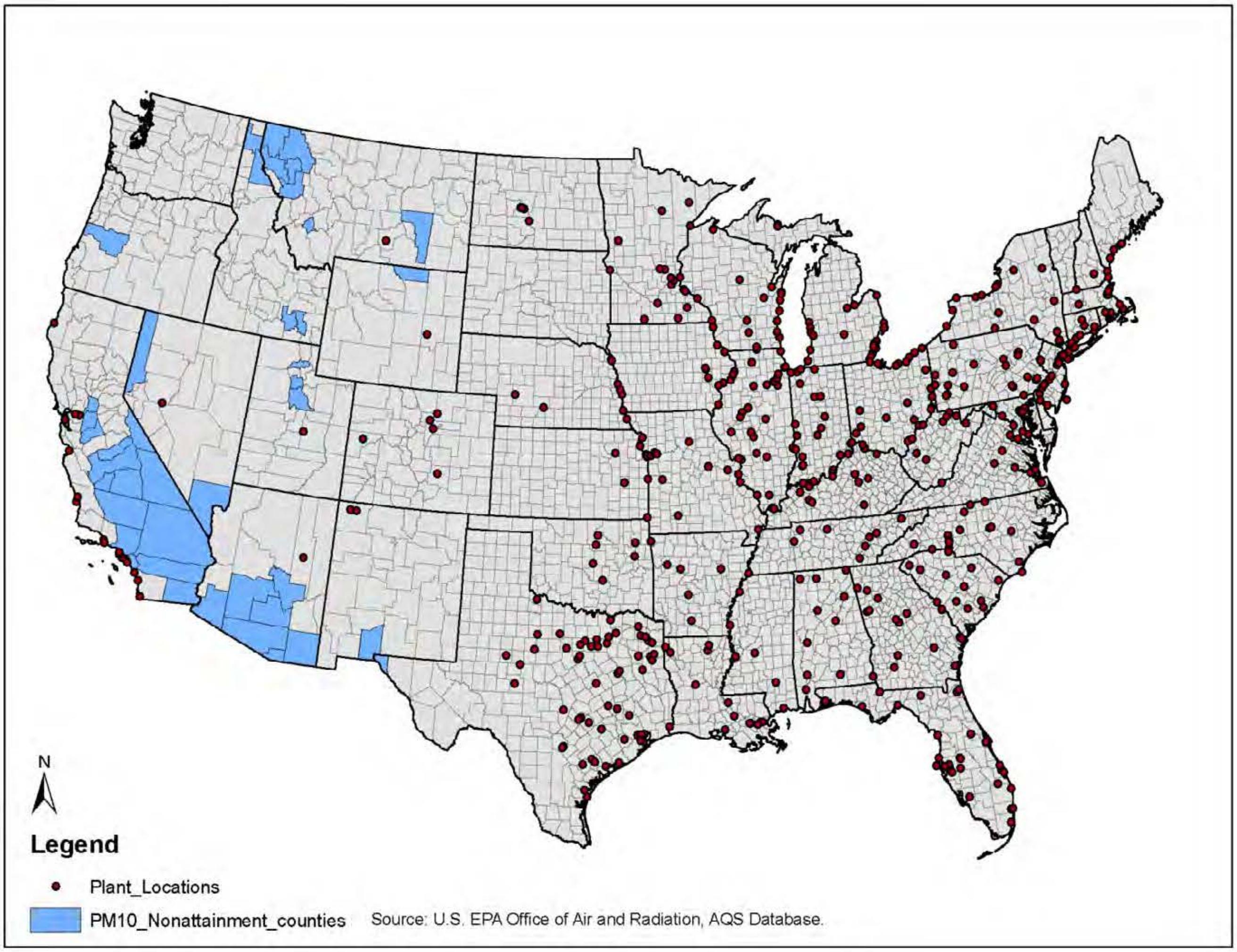
Source: U.S. EPA Office of Air and Radiation, AQS Database.

PM2.5 Nonattainment Areas



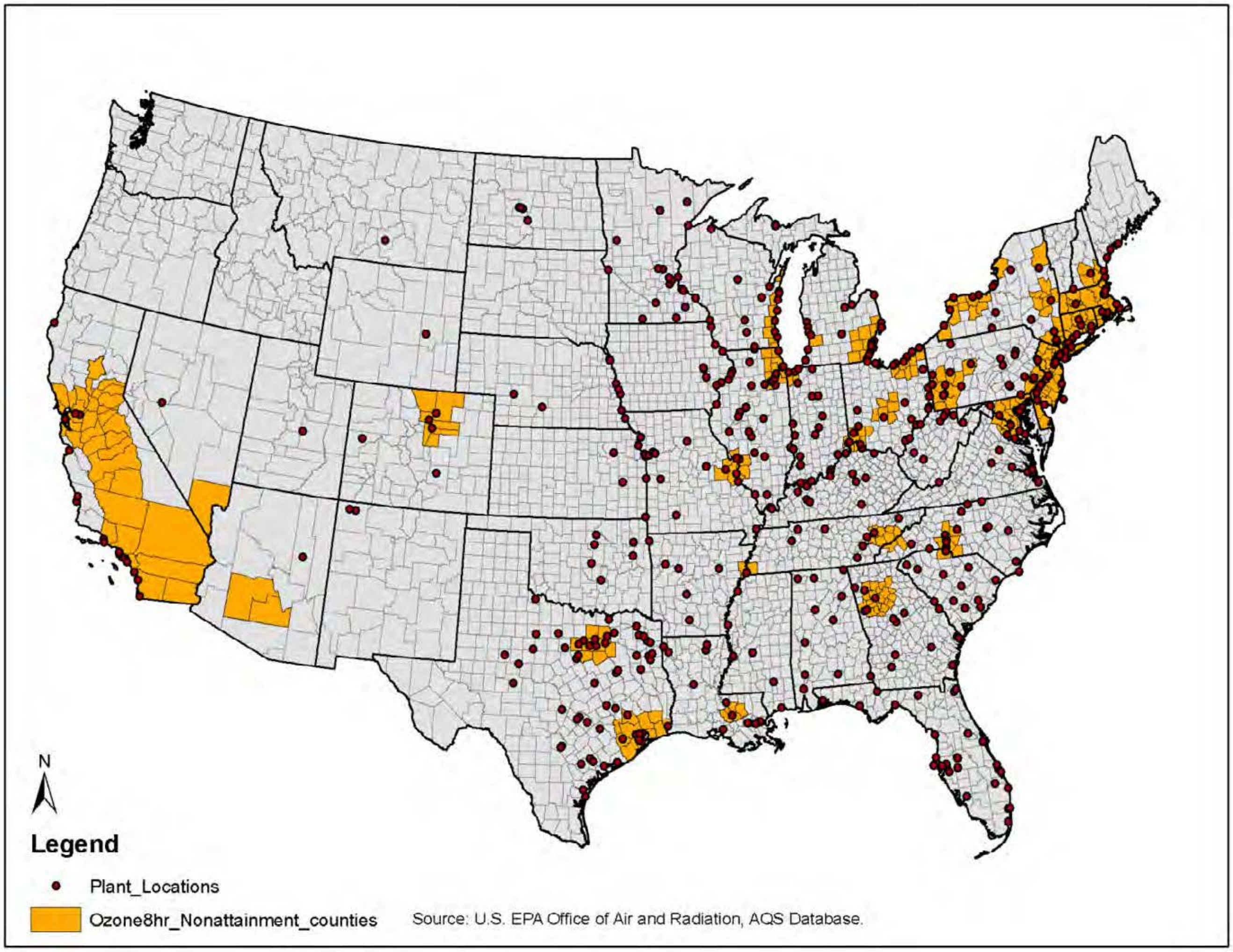
Source: U.S. EPA Office of Air and Radiation, AQS Database.

PM10 Nonattainment Areas



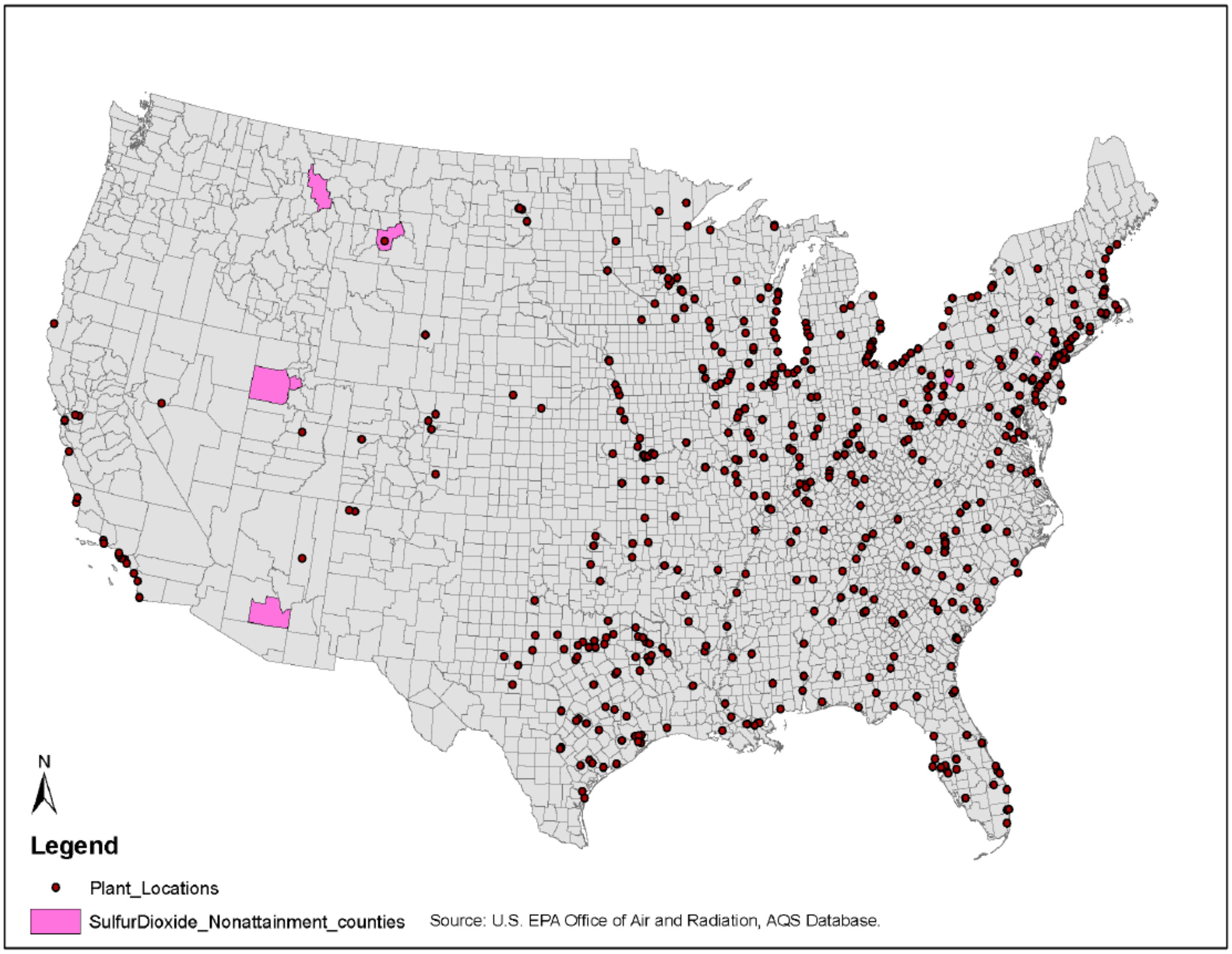
Source: U.S. EPA Office of Air and Radiation, AQS Database.

Ozone Nonattainment Areas



Source: U.S. EPA Office of Air and Radiation, AQS Database.

SO_2 Nonattainment Areas



Source: U.S. EPA Office of Air and Radiation, AQS Database.

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Chapter 11: 12 Month Percent Impingement Mortality Standard: Data and Calculation

11.0 Introduction

This section describes the data selection and calculations used by EPA in establishing the 12 month percent impingement mortality standard for fish and shellfish. As explained in the preamble to the rule, the impingement mortality standard applies only to certain facilities. For other facilities (e.g., facilities using compliant technologies), the value of the standard may be useful as a performance target to optimize impingement controls. Chapter 6 describes impingement control technologies in further detail.

Sections 11.1 and 11.2 provide an overview of the available impingement data and the data acceptance criteria. Section 11.3 identifies the facilities with data that met the criteria. Section 11.4 describes the data and the statistical methodology used as the basis for the impingement mortality standard. Section 11.5 provides the biological and engineering evaluation of the standard and facility characteristics used as the basis of the standard. Sections 11.6 and 11.7 describe alternative provision calculations and compliance monitoring.

11.1 Overview of Available Impingement Data

In its evaluations of impingement, EPA considered data from research studies, technology evaluations, and facility 316(b) demonstrations that spanned the past 40 years. While many of the documents had been collected during the Phase II rulemaking, EPA reviewed documents that were published up to 2011. The primary objective of the document review was to identify relevant information about the performance of different technologies in minimizing impingement of aquatic organisms.

This chapter uses the term “study” to refer to the collection of performance data at a single facility (or location) under a given set of testing conditions. For example, different studies may correspond to different screen mesh sizes or approach velocities that were tested at the same facility. A document can report performance data for one or more studies at one or more facilities. EPA focused on studies that provided specific performance metrics such as percent impingement mortality. It also obtained information about the facilities themselves, including operating conditions, species of organisms present in the intake, and time periods when the studies were conducted. Appendix A lists the 207 documents that EPA reviewed, notes those data that were selected for the calculations described in this section, and describes the reasons for excluding certain documents or studies from consideration.

11.2 Data Acceptance Criteria

In determining whether data were acceptable for the impingement analyses described in this chapter, EPA used the following criteria:

1. The data must provide information about one of the technologies shown in Exhibit 11-1.

The list is more comprehensive than those identified for the proposed rule. Because the list of technologies is more inclusive, more data were selected as the basis of the final standard than had been used as the basis of the proposed standards.

Exhibit 11-1. Technologies With Data Considered as Basis of the 12 Month Percent Impingement Mortality Standard

Technology	**Variation**	**Used in IM Standard**
Modified Traveling Screens[a]	Through-flow screen configuration	Yes
	Through-flow screen configuration combined with submerged offshore intake.	Yes
	Dual flow (double-entry single-exit) screen configuration. See TDD Chapter 6.2.1 for a detailed description.	Yes
	Geiger multi-disc traveling screen. See TDD Chapter 6.2.3 for a detailed description	Yes
	Fine-mesh screen where impingeable fish were sub-sampled[b]	Yes[b]
	Hydrolox screen. See TDD Chapter 6.2.4 for a detailed description	No
	Angled through-flow screen component of fish bypass system.	No
Rotary (WIP) screens.	See TDD Chapter 6.2.5 for a detailed description	Yes

[a] Includes fish protection features, which at a minimum include fish baskets, low pressure wash to remove fish prior to any high pressure spray to remove debris and a fish handling and return system with sufficient water flow to return the fish to the source water.

[b] A separate sub-sample of the impingeable fish were separated from smaller fish impinged on fine-mesh screens by passing collected fish through a 3/8 in mesh screen.

2. The reported data values must be actual measurements (e.g., fish counts) rather than estimates or model-based predictions.

3. The data must relate to impingement mortality of fish and/or shellfish. This criterion requires documents to report impingement mortality as numbers of fish or a percentage of impinged fish that were killed. EPA extracted impingement data in one of four different ways, depending on the type of impingement data reported in the documents. These four approaches are as follows, in decreasing order of application:
    a. Total number of impinged fish, along with numbers of impinged fish that were killed.
    b. Impingement survival counts and numbers of impinged fish.
    c. Percentage of impinged fish that were killed.
    d. Percentage of impinged fish that survived.

4. The data must reflect technology performance that is representative of conditions that may exist under actual facility operations. As a consequence of this criterion, EPA:
    a. Included data from studies conducted on existing structures at facilities;
    b. Included data from field tests conducted near intake locations (e.g., from a test barge). Before full-scale installation, facilities often test the suitability of technologies in conditions that they consider to mimic (or represent) typical facility conditions.
    c. Included data from facilities that ceased operations after the study was conducted, as long as the data met the other criteria.
    d. Excluded data from tests performed under controlled laboratory conditions. In contrast to the facility and field studies that generally are designed to represent normal conditions and operations, laboratory studies generally studied how impingement was affected by varying different components of the technology. In such studies, the laboratories sometimes operate the technologies with the intention of increasing impingement occurrences. As a consequence, data from these studies may not be representative of the types of fish typically impinged and the technology performance.
5. The impingement data must be for fish and shellfish species that are not classified as fragile. This criterion is less restrictive than the proposal's requirement for the data to include only fish species that were typical, and prevalent, at the facility location. EPA modified three parts of the criterion as follows:
    a. EPA excluded data for fragile species, because the observed mortality data from fragile species might, in large part, reflect conditions other than technology performance. Of the data that otherwise met the criteria in this section, Exhibit 11-2 lists the species that EPA classified as fragile and excluded as the basis of the standard.[188] Appendix B lists the non-fragile species that ultimately served as the basis of the standard.

Exhibit 11-2. Species Classified as Fragile in Data Otherwise Meeting Data Selection Criteria[a]

alewife
alosa spp.
american shad
atlantic herring
atlantic long-finned squid
atlantic menhaden
bay anchovy
blueback herring
bluefish
butterfish
gizzard shad
gray snapper
hickory shad
menhaden
rainbow smelt
round herring
silver anchovy

[a]Refer to DCN 12-6700 and 12-6808 for details on the derivation of this table.

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[188] EPA compared its own BPJ designation of fragile species to species in families designated by EPRI as having low impingement survival and found the two lists to be in general agreement. EPRI based the designations upon apparent survival from prior studies. Where the lists conflicted, EPA chose the EPRI designation.

   b. EPA eliminated a proposed requirement that the species were typically observed and predominant at the facility location. EPA made this change because technology performance does not depend on whether a species is typically observed or predominant in a particular location.
   c. EPA expanded the list of proposed species subject to the rule to include shellfish because the compliant technologies have demonstrated that they also control shellfish impingement.

6. The study must have measured total mortality from 18 to 96 hours following impingement. This criterion extends the proposal's restriction that data must be no later than 48 hours to 96 hours following impingement, because EPA received information that demonstrated that mortality rates were comparable to the proposed 48 hour holding time. See DCN 12-6703 for more details. As a consequence of this criterion, EPA excluded:
   a. Studies that reported only instantaneous mortality ("zero holding times") or holding times less than 18 hours. As it noted in the proposal, EPA considers that such counts may be understated because they only measure immediate deaths and not those organisms that were mortally harmed as a result of impingement. They also might reflect already injured, nearly dead, or already dead fish ("naturally moribund") that were impinged by the screen.
   b. Data associated with mortality that occurred in excess of 96 hours following impingement. Such counts may be overstated because these longer holding times may cause mortality for reasons not directly reflective of technology performance, such as conditions that do not adequately reflect the organisms' natural habitats.

7. Because compliance with the standard will be evaluated on a 12 month basis, EPA eliminated any data that did not represent a full year. In some instances, EPA was able to include data that covered representative impingement periods of approximately one year even if the data was not continuously collected over the 12 month period. For example, the study may have identified that during portions of the year insufficient organisms could be collected to conduct statistically valid monitoring. Such studies were not rejected because they still represent a full year of performance. This criterion does eliminate those data that covered only a few months, such as data representing a single season, and which therefore cannot be used to determine 12 month performance. This criterion also eliminates certain data that covered substantially more than a 12 month period if the dates of data collection were not sufficiently documented to determine which data coincides with a 12 month period. In such cases, EPA attempted to include data representing one year's worth of performance, but did not include the data for additional periods beyond one year. Further, this criterion eliminated data for which the collection period was unknown or the study documentation presented contradictory information about the collection period.

Criterion 1 indicates the screen technologies considered in the impingement mortality standard data set. Exhibit 11-2 presents a list of technologies that are likely compliant with today's impingement mortality requirements but were not included in the development of the impingement mortality standard. Performance data for these technologies were not used because they did not meet the above specified criteria for development of impingement mortality standard. Primary reasons for rejecting associated data are identified in the table.

Exhibit 11-2. Compliant Technologies Not Considered as Candidate for Basis of 12 Month Percent Impingement Mortality Standard

Technology	Reason	Used in IM Standard
Fine Mesh Modified Traveling Screens	Could not estimate mortality for just those impinged fish that are retained on a 3/8 inch square mesh	No
Existing Velocity Cap at Offshore Intake	Fish diversion difficult to measure and generally not quantified; no distinction made between reduced impingement by virtue of offshore location and reduced IM of the velocity cap	No
Cylindrical Wedgewire Screens	Fish diversion difficult to measure and impingement mortality difficult to sample; performance data from barges or labs did not meet criteria for acceptance	No
Screen velocity ≤0.5 fps	Fish diversion difficult to measure; distinction between impinged fish retained on a 3/8 inch square mesh and entrainable fish not made	No
Closed-Cycle Cooling	Species and counts data not collected by most facilities; reported reductions in flow could not be extrapolated to counts by species and age group	No

11.3 Facility Data Used As Basis of 12 month Percent Impingement Mortality Standard

Of the studies listed in Appendix A, impingement mortality data from 17 facilities met the criteria and thus were used as the basis of the impingement mortality standard. Exhibit 11-3 lists the facilities and the study identification number used in Appendix A. As shown in Exhibit 11-4, the facilities are geographically located throughout the Eastern seaboard and the Midwest. All waterbody types (oceans, lakes, rivers, and estuarine waters) are represented by the data. EPA notes that data for Arthur Kill (which had been included at proposal) and some (but not all) data for Salem are excluded because while the data was collected for one or more seasons, the data was not fully representative of time periods of approximately one year. The impingement mortality data used as the basis of the 12 month percent impingement mortality standard can be found in DCN 12-5400.

Exhibit 11-3. Facilities and Data Selected as the Basis of the Impingement Mortality Standard

Facility	Location	Time Period	Number of Sampling Events[a]	Holding Times	Document ID(s)[b]	Study ID(s)[c]
Barrett	Island Park, NY	Oct. 2007 - Jun. 2008	27	48 hr.	221	254
Brunswick	Southport, NC	Apr. 1984 - Apr. 1985	34	96 hr.	193, 201, 208	165, 166
Danskammer Point	Newburgh, NY	Winter/Spring 1980	16-32 (2 seasons)	84 hr.	239	270
Dunkirk	Dunkirk, NY	Dec. 1998 - Nov. 1999	32	24 hr.	44	8
Huntley	Tonawanda, NY	Jan. 1999 - Oct. 1999	10 (2 seasons)	24 hr.	51	1
Indian Point	Buchanan, NY	June 1977 - Dec. 1977	17 (3 seasons)	84 hr.	205-A	282
		Jan. 1985 - Dec. 1985	~115	96 hr.	193, 201, 240, 241	163, 271
JP Madgett	Alma, WI	May 1980 - Dec. 1980	35	96 hr.	242	274
Manchester Street	Providence, RI	Jan. 1996 - Feb. 1997	NS	48 hr.	228	284
Millstone	Waterford, CT	May 1986 - Apr. 1987	32	24 hr.	245	268
		Jan. 1993 - Dec. 1993	25	24 hr.	246	269
Mystic Station	Everett, MA	Oct. 1980 - June 1981	31 (3 seasons)	24 hr., 96 hr.	143	88, 89, 90, 283
North Omaha	North Omaha, NE	Apr. 2008 - Aug. 2008	2 months (2 seasons)	48 hr.	238	281
Northside	Jacksonville, FL	Mar. 1998 - Jan. 1999	Quarterly	48 hr.	249	276
Oyster Creek	Lacey Township, NJ	Feb. 1985 - Dec. 1985	48	96 hr.	248	277
Potomac	Alexandria, VA	Nov. 2005 - Dec. 2006	73	48 hr.	193, 201, 196	91
Prairie Island	Red Wing, MN	Apr. 1988 - Aug. 1988	63 (2 seasons)	48 hr.	193, 201	160
Roseton	Newburgh, NY	May 1990 - Nov. 1990	815 (3 seasons)	96 hr.	193, 201	70
		May 1994 - Nov, 1994	67 (3 seasons)	48 hr.	247	278
Salem	Lower Alloways Creek Township, NJ	Oct. 1997 - Sep. 1998	~78 (3 seasons)	18 hr.	193, 201	161
Somerset (Kintigh)	Somerset, NY	1985	NS	96 hr.	64	5
		1986	NS	96 hr.	64	5
		May 1989 - Dec. 1989	17 (3 seasons)	96 hr.	243	273

[a] NS = not specified. The sampling events are assumed to represent all four seasons unless specified in parentheses.

[b] See Appendix A for document titles and authors.

[c] See DCN 12-5400.

Exhibit 11-4. Geographic Distribution of Facilities Used as the Basis of the Impingement Mortality Standard

11.4 Statistical Basis of 12 Month Percent Impingement Mortality Standard

EPA applied statistical methods to develop the 12 month percent impingement mortality standard. Statistical methods are appropriate for dealing with impingement data because the mortality rates, even in well-operated systems, are subject to a certain amount of random fluctuation or uncertainty. Statistics is the science of dealing with uncertainty in a logical and consistent manner. Statistical methods, therefore, provide a logical and consistent framework for analyzing a set of impingement data and determining values from the data that form a reasonable basis for the impingement mortality standard. The following discussion describes the steps that EPA used to calculate the 12 month averages, apply the statistical methodology, and statistically evaluate the resulting standard value.

First, EPA used the data that met the criteria in Section 11.2 to calculate 12 month averages. Using each facility's data, EPA summed across sampling events as necessary to obtain the total number of fish that were impinged and the total number that were killed for each approximately 12-month period. The fourth and fifth columns in Exhibit 11-5 provide the total number killed and the number impinged that resulted from EPA's evaluation of the facility data. If the studies reported the number of fish that survived, then the number in the fourth column (number killed) was calculated by subtracting the number that survived from the total number impinged (fifth column) as shown in the equation below:

$$total\ number\ killed = total\ number\ impinged - total\ number\ survived$$

Second, EPA calculated the 12 month average percent impingement mortality (IM) as the ratio of the total number of fish killed to the total number of fish impinged. This calculation is shown in the following equation and the results presented in the sixth column of Exhibit 11-5:

$$annual\ average\ percent\ IM = \frac{total\ number\ killed}{total\ number\ impinged} \times 100$$

For one facility (Prairie Island) that reported its data as %IM for each species instead of the numbers of fish, the sixth column (average %IM) of Exhibit 11-5 is the average of the %IM for the non-fragile species.

The sixth column of Exhibit 11-5 shows that there are 26 12 month averages across 17 different facilities. Brunswick, Indian Point, Millstone, Roseton, and Somerset have multiple 12 month values as their impingement data span multiple 12 month periods.

Third, to avoid giving any one facility more influence than others in developing the standard,[189] EPA calculated the facility average %IM by averaging the facility 12 month

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[189] EPA believes that it is inappropriate to assign undue weight to facilities simply because they provided more data (i.e., data for multiple 12-month periods). Such an approach would allow facilities with the most data points to have an excessive influence on overall regulatory values.

averages. When only one 12 month value was associated with a given facility, the 12 month %IM is the same as the facility 12 month %IM. Exhibit 11-5 provides the facility averages in the last (seventh) column.

Exhibit 11-5. Impingement Mortality Data Used As a Basis for the Impingement Mortality Standard

Facility	Location	Time Period	Total Impinged Mortality	Total Impinged Fish	12 Month Average % IM[a]	Facility Average %IM
Barrett	Island Park, NY	Oct. 2007 - Jun. 2008	654	2,732	23.9	23.9
Brunswick		1984 (to Jan. 1985)	179,396	898,914	20.0	20.0
Danskammer Point	Newburgh, NY	Winter/Spring 1980	116	378	30.7	30.7
Dunkirk	Dunkirk, NY	Dec. 1998 - Nov. 1999	352	14,699	2.4	2.4
Huntley	Tonawanda, NY	Jan. 1999 - Oct. 1999	56	3,540	1.6	1.6
Indian Point	Buchanan, NY	June 1977 - Dec. 1977	29	41	70.7	48.8
		Jan. 1985 - Dec. 1985	3,373	12,514	27.0	
JP Madgett	Alma, WI	May 1980 - Dec. 1980	153	615	24.9	24.9
Manchester Street	Providence, RI	Jan. 1996 - Feb. 1997	161	654	24.6	24.6
Millstone	Waterford, CT	May 1986 - Apr. 1987	205	983	20.9	23.0
		Jan. 1993 - Dec. 1993	146	580	25.2	
Mystic Station	Everett, MA	Oct. 1980 - June 1981	60	349	17.2	17.2
North Omaha	North Omaha, NE	Apr. 2008 - Aug. 2008	91	1,133	8.0	8.0
Northside	Jacksonville, FL	Mar. 1998 - Jan. 1999	63	185	34.1	34.1
Oyster Creek	Lacey Township, NJ	Feb. 1985 - Dec. 1985	532	6,065	8.8	8.8
Potomac	Alexandria, VA	Nov. 2005 - Dec. 2006	1,054	2,925	36.0	36.0
Prairie Island	Red Wing, MN	Apr. 1988 - Aug. 1988	--	--	47.7	47.7
Roseton	Newburgh, NY	May 1990 - Nov. 1990	4,639	8,645	53.7	34.6
		1994	1,133	7,289	15.5	
Salem	Lower Alloways Creek Township, NJ	Oct. 1997 - Sep. 1998	2,840	7,543	37.7	37.7
Somerset (Kintigh)	Somerset, NY	1985	56	1,291	4.3	12.9
		1986	9	169	5.3	
		1989	14	48	29.2	

[a] EPA recognizes that these data indicate that several of the intakes as configured and operated at the time of sampling would not meet the standard. However, EPA believes that these facilities would be able to modify and optimize the traveling screens in a manner that would allow them to be deemed compliant with the impingement mortality BTA standard as discussed in Section 11.5. EPA has included additional costs for this in the compliance cost estimates. See TDD Section 8.3.4 for a detailed discussion.

Fourth, EPA modeled the distribution of the 17 facility average %IM values. As it had for the proposed standards, EPA selected the beta family of statistical distributions as the basis to model the values, because the distributions are continuous and bounded by 0 and 1. This is equivalent to the range of impingement mortality percentages between 0 and 100. By applying the beta distribution to the data in the last column of Exhibit 11-5, EPA calculated the statistical expected value of the distribution. Under the beta distribution, the expected value is the equal to the arithmetic average. As a result of applying the statistical methodology, EPA established the 12 month impingement mortality standard as 25 percent impingement mortality after rounding up from 24.3 percent.

Fifth, as an important step in evaluating the statistical methodology, EPA compared the standard to the data used to derive it. EPA performs this comparison to ensure that the statistical model is appropriate and that it used appropriate distributional assumptions for the data used to develop the standard (i.e., whether the curves EPA used provide a reasonable "fit" to the actual data). If the distribution were appropriate for the data, EPA would expect roughly half of the 12 month average values to be above 25 percent and half to be below; and the mean and median to be approximately equal. This is roughly what is observed. Seven of the facility values in Exhibit 11-5 are greater than the standard of 25%IM; and two values of 24.6 percent and 24.9 percent are relatively close to the standard. The observed median value is 24.6 percent. As a result of this comparison, EPA determined that the distributional assumptions appear to be appropriate for these data.

11.5 Biological and Engineering Reviews of 12 Month Percent Impingement Mortality Performance Standard

In conjunction with the statistical methods, EPA performed engineering and biological reviews which are yet another important step in verifying that the standard is reasonable based upon the design and expected operation of the technologies and the site conditions. As part of those reviews, EPA examines the technology and site description to ensure that the technology tested included important basic components of a modified traveling screen or its equivalent. EPA only included data from technologies where the mesh size was roughly equivalent to 3/8 inch coarse mesh which included 1/8 inch x ½ inch and ¼ by ½ inch mesh since the diagonal dimensions are within -3 percent to 5 percent of 3/8 inch mesh. EPA also included data from screens with a smaller (finer) mesh if the impingement data indicated that the data could be separated by life stage, and therefore EPA could approximate the categories of fish that would be impinged on a 3/8 inch screen versus impinged on the finer mesh screen. EPA also included data where a facility screened all impinged organisms with a 3/8 inch mesh to count only those organisms that would be impinged on a 3/8 inch mesh screen (i.e., the "hypothetical net"). Operating information was also examined to ensure that operating conditions (e.g., intermittent screen operation), did not degrade performance compared to a more optimum condition. Data for technologies that did not meet minimum design criteria were excluded from the standard calculation.

As part of the biological review, EPA reviewed the list of fish species contained in the data sets and evaluated them independently on the basis of fragility since the observed mortality data from fragile species might, in large part, reflect conditions other than technology performance. See DCN 12-6700 for a detailed discussion of the criteria used. EPA also examined whether the data reflected only fish that entered the intake directly from the source water and not those that were introduced[190]. EPA also evaluated the data

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[190] In some studies impingement rates were low and fish either captured from the waterway or obtained from another source (e.g., a fish hatchery) were introduced into the intake forebay in order to ensure the impingement sample size was large enough to evaluate screen performance.

to ensure that fish that were clearly dead or moribund prior to impinging on the screen were not counted in the impingement mortality totals.

Exhibit 11-6 illustrates the characteristics of the facility intakes and technologies selected for impingement mortality standard development.

Exhibit 11-6. Characteristics of Facilities Used As Basis for Impingement Mortality Standard

Facility Name	State	Waterbody Type	Predominant Species	Study Period	Generating Units/CWISs	Design Intake Flow	Technology
Brunswick	NC	Estuary	atlantic croaker, spot, bay anchovy, shrimp, blue crab	1984; 1985; 1986; 1987; 2008	2 generating units	596 mgd (Dec-Mar); 710 mgd (Apr-Nov)	3/8 in mesh diversion structure with traveling screens one half 3/8 in and one half 1mm with fish return (2 of 4 intakes use fine mesh screens)
Danskammer Point	NY	Bay	white perch, atlantic tomcod, alewife, blueback herring, american shad, gizzard shad, spottail shiner	Winter/ Spring 1980	4 generating units		3/8 in conventional front wash traveling screens that have been retrofitted with fish collection trough (with water) and low pressure spray
Dunkirk	NY	Great Lakes	alewife, shiners, rainbow smelt, white bass, white perch, yellow perch	Each season from December 1998 to November 1999.	Screenhouse #1, including Units 1 and 2	92.2 mgd	1/8 x 1/2 inch prototype modified traveling screen
Huntley	NY	Fresh-water River	alewife, gizzard shad, rainbow smelt, emerald shiner	January and October 1999	Units 67 and 68	82.8 mgd	1/8 x 1/2 inch prototype modified traveling screen
Indian Point	NY	River	catfish, smelts, gizzard shad	June 1977 - Dec. 1977	Unit 1	201 mgd	2.5 mm fine mesh modified Ristroph traveling screen
	NY	River	white perch, weakfish, atlantic tomcod, blueback herring	Jan. 1985 - Dec. 1985	Unit 2, 6 intake bays (#21-26)	201 mgd	Modified traveling screens, 3/8" mesh, low pressure wash, fish protection and collection features
JP Madgett	WI	River	gizzard shad, bluegill, logperch, flathead catfish, freshwater drum	May 1980 - Dec. 1980			Modified traveling screens with fish trays and sluiceways. Low pressure wash
Kintigh (Somerset)	NY	Great Lakes	alewife, gizzard shad, rainbow smelt, spottail shiner	1985; 1986; 1989		281 mgd	Fine mesh (1 mm) traveling screens with fish trays and return, low pressure spray, sluice trough. Includes 2000 feet off shore velocity cap intake.
Manchester Street	RI	River	atlantic menhaden, winter flounder, atlantic silversides, white perch, threespine stickleback, northern pipefish	Jan. 1996 - Feb. 1997	5 pumps		3/8 in Ristroph-type traveling screens continuous operation and separate fish return.

Facility Name	State	Waterbody Type	Predominant Species	Study Period	Generating Units/CWISs	Design Intake Flow	Technology
Millstone	CT	Bay/ Long Island Sound	pipefish, butterfish, bay anchovy, atlantic menhaden, rock crab	May 1986 - Apr. 1987	Unit 3 fish return	1355 mgd	3/8 in traveling screen with fish return spray pressure of 85 psi. Screen rotates based on pressure differential, or once every 8 hours.
	CT	Bay/ Long Island Sound	winter flounder	Jan. 1993 - Dec. 1993	Units 1, 2, and 3	2817 mgd (all 3)	3/8 in traveling screen with fish return
Mystic	MA	River	smelt, alewives, blueback herring, winter flounder	Oct. 1980 - June 1981	Unit 7		Coarse mesh traveling screen; fish buckets, low-pressure spray, fish return
North Omaha	NE	River	hatchery fish trial (bluegill, catfish, fathead minnow); native fish trial (shiners)	Apr. 2008 - Aug. 2008	Intake No. 3	730.4 mgd	Rotary screen (WIP screen)
Northside	FL	River	drum family (spotted and gray seatrout, spot, silver perch, red drum,star drum, and Atlantic croaker)	Mar. 1998 - Jan. 1999	Unit 3	827 mgd	Traveling screens with low pressure spray, fish pans spaced 4 ft
Oyster Creek	NJ	Bay	bay anchovy, atlantic menhaden, spot, atlantic silverside, smallmouth flounder, striped searobin	Feb. 1985 - Dec. 1985		659 mgd	Conventional screens replaced with Ristroph traveling screens with low pressure spray, fish buckets
Potomac	VA	River	white perch, bluegill, spottail shiner	Nov. 2005 - Dec. 2006	5 generating units, 10 pumps	438 mgd	Geiger TS, 9.5-mm plastic screening, fish buckets, 5 psi fish spray, fish return
Prairie Island	MN	River	freshwater drum, channel catfish, gizzard shad	Apr. 1988 - Aug. 1988	2 generating units	970 mgd	0.5mm fine mesh vertical traveling screens
Roseton	NY	River	blueback herring, bay anchovy, american shad, alewife	May 1990 - Nov. 1990	2 generating units	922 mgd	9.5-mm dual-flow TS; low pressure spray, collection buckets, and return trough
	NY	River	blueback herring, alewife, bay anchovy, brown bullhead, striped bass, white perch, american shad	May 1994 - December 1994	2 dual-flow screens		9.5-mm dual-flow TS (modified); low pressure spray, collection buckets, and return trough
Salem	NJ	River/ estuary	weakfish, white perch, bay anchovy, atlantic croaker, blue crab	Oct. 1997 - Sep. 1998	Units 1 and 2	1598 mgd	Modified Ristroph with improved baskets, 1/4 x 1/2 in smooth mesh, continuous operation, low pressure spray, separate smooth fiberglass return trough.

The facility distribution in the map in Exhibit 11-4 and data in Exhibit 11-6 above show that the data included in the standard development are representative of the wide range of waterbodies and fish species that might be expected to occur nationwide. Upon initial review of the data in Exhibit 11-5, the impingement mortality data represent performance ranging from 1.6 percent to 48.6 percent. The performance metric is comprised of biological elements (i.e., the behavior of fish) as opposed to the more certain performance and measurements of a physical or chemical system (e.g., concentration of copper). As is the case with any varied system performance, those facilities operating in the lower end of the spectrum of performance may require some changes to operation or upgrades in their existing technology in order to meet the standard that is based on the 12 month performance. The available data suggests that in the case of traveling screens this can be managed by optimized operation of the technology. Under the final rule, a facility is required to conduct 2 years of monthly impingement monitoring, during which the facility will seek to optimize the technology performance to minimize impingement mortality. This study is intended to determine the optimal configuration and operating conditions of modified traveling screens for that intake to be consistently protective of aquatic organisms. During the course of the study, EPA expects that a facility will evaluate the interim results and make changes to the technology or operating conditions as needed to identify the most appropriate set of operational characteristics to ensure long-term success. For example, a facility could adjust the spray wash pressure, adjust the rotating speed of the screens, rotate the screens more frequently, re-angle the fish sluicing sprays, ensure adequate water in the return flume, design the fish return to avoid avian and animal predation on the aquatic organisms, and locate the fish return in such a way to avoid predation. EPA notes that the IM data representing the lower end of performance can be identified as missing one or more of these operational characteristics during the periods of lowest performance. Further, many studies seek to assess current operations, and are not intended to optimize operation. EPA expects that when a facility actively seeks to optimize operation of the technology, it would achieve better long term performance. EPA’s record includes numerous performance studies that compare specific operational conditions as examples of the improvements EPA anticipates upon completion of an optimization study. Other studies in EPA’s record, while not meeting the criteria for use in calculating the standard, demonstrate the technology performs in a manner consistent with EPA’s calculated 12 month percent impingement mortality standard. The final rule requires the 2 year optimization study, and further requires that the Director impose permit conditions that reflect optimized operation. EPA expects implementation of these provisions will result in the best possible performance for each facility.

In addition to contingency cost factors and the incremental O&M costs described in Chapter 8, EPA further notes that the compliance costs consider added costs that may be incurred by facilities that perform below the average. These additional costs may be incurred by some facilities where the performance of technology with respect to biology (i.e. behavior of fish) may be insufficient, and thus the rule would impose additional compliance costs due to uncertainty or factors not adequately represented by currently available data. These costs include O&M costs such as adjustments and modifications to the design of the traveling screens, fish handling and returns, and operating conditions. In a worst-case scenario, EPA expects additional low-cost technologies such as barrier nets could be employed which would allow the facility to meet the impingement mortality BTA standard. Approximately 15 percent of facilities are assessed costs for barrier nets, consisting of predominantly marine intakes as they are the most likely intakes for higher rates of impingement. Facilities would not be required to use barrier nets, rather the costs of barrier nets may be considered a cost “allowance” for installing additional technologies. Finally, a facility could use supplemental technologies and practices, such as variable frequency drives and behavioral deterrents, which are combined to form a “systems” of technologies. The “systems” approach is discussed in Section 11.6 below. See TDD Chapter 8.7.4 for a more detailed cost discussion.

In conclusion, as a result of the combined statistical modeling (Section 11.4) and engineering/biological reviews (this section) used in developing the standard, each facility with the technologies is expected, on average, over a period of time, generally one year, to be capable of designing and operating their systems to meet the impingement mortality BTA standard. This conclusion is supported in part by the fact that several facilities with entrainment mortality data that was not used in the limitations development demonstrated compliance.[191]

11.6 Alternative Provision Calculations

One alternative for compliance allows a facility to use a system of technologies and/or operational measures to achieve the BTA standard for impingement mortality requirements. This system of technologies might employ screening technologies that can be directly monitored for impingement mortality plus other technologies and operational measures for which indirect methods of estimating impingement reduction may be used (e.g., fish avoidance technologies, intake location, and flow reduction). If the technology reduces impingement, the alternative provision calculations would increase the number of the observed impinged fish by the estimated number that would have been impinged without the technology. The facility then would compare the observed number of killed fish to the larger total number of impinged fish (i.e., the sum of observed and estimated number reduced by technology). This comparison would result in a lower impingement mortality rate than the unadjusted, observed value.

The following example from the Notice of Data Availability (77 FR 34323) illustrates how the alternative provisions would adjust for flow, location, and other technologies demonstrating that the facility’s performance is consistent with the impingement mortality standard. To demonstrate the application of the adjustments, the example is repeated below.

The example uses values that simplify the calculations to better illustrate the adjustments, and are not intended to reflect values that EPA expects at any facility. To simplify the example further, the facility has only fish and does not have shellfish in its source waters.

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[191] EPA identified three facilities employing modified traveling screens where latent mortality data presented in studies resulted in calculated mortality rates that would be compliant with the 12-month percent impingement mortality standard. The data from these facilities was not used in the standard development because it did not meet all of the data acceptance criteria. These facilities include Arthur Kill (DCN 10-5442), Brayton Point (DCN 4-1682, and Hudson (DCN 11-5530).

EPA also recognizes that facilities often examine the combined effect of two or more technologies (e.g., deterrents and offshore location) within a single study. In applying the alternative provision, the facility could use the outcomes associated with the combined performance of multiple technologies. However, for a more complete example, EPA has chosen a hypothetical facility that examined each change in a separate study.

The hypothetical facility is located at an offshore location, has a velocity cap, and installed variable speed drives. For the purposes of this example, assume its permit requires that it collect samples once a week, evaluate the impinged fish after 24 hours, and report on a monthly basis. The facility has just completed sampling at the forebay each week during June, and has identified the counts of the facility-specific species of concern as follows. The four samples had 1,500, 1,000, 500, and 1,000 impinged fish, for a total of 4,000 impinged fish. During the 24-hour holding period, 450, 250, 150, and 350 fish died, for a total of 1,200 dead fish. The facility then calculated the forebay's impingement mortality (IM) as 30 percent, using the equation provided in the proposed rule preamble (76 FR 22174, Section IX.F.1) as follows:

$$annual\ average\ percent\ IM = \frac{total\ number\ killed}{total\ number\ impinged} \times 100$$

= (1,200/4,000) x 100
= 30%

To adjust the observed percent impingement mortality for its offshore location and velocity cap, the facility first extracts information from its previously conducted studies related to performance and calculation baseline. For the offshore location adjustment, fish density and flow data show the offshore location reduces the rate of impingement for all species of concern by 30,000 fish annually, or, on average, 2,500 each month (i.e., calculated as 30,000 fish divided by12 months). For the velocity cap, performance data show the velocity cap reduces impingement of fish and shellfish by 42,000 organisms annually, or a monthly average of 3,500 organisms. Therefore, the facility has reduced impingement of all species of concern, on average each month, by 6,000 organisms (i.e., sum of 2,500 for offshore location and 3,500 for velocity cap). The facility then applies the reduction to the denominator of the percent IM calculations as follows:

$$= \frac{\text{(impinged fish that are killed)}}{\text{(total number impinged + reductions in fish impinged due to other technologies)}} \text{ x 100}$$

= ((1,200 / (4,000 + 6,000)) x 100
= 12%

In summary, calculating percent impingement mortality at the forebay yields a 30 percent IM, and then applying the alternative provisions for other technologies shows the effective percent IM is 12. Next, to adjust for the variable speed drives, the facility has determined from engineering and design calculations that the volume of cooling water flow has been reduced by 10 percent. The volume of reduced flow multiplied by the density of fish near the intake is calculated, and the facility projects that the reduced flow excludes, on average for each month, an additional 1,100 fish from impingement. Then the facility would apply the reduction in impinged fish to the denominator, as follows:

$$= \frac{\text{(impinged fish that are killed)}}{\text{(total number impinged + reductions in fish impinged due to other technologies)}} \times 100$$

$$= ((1{,}200) / (4{,}000 + 6{,}000 + 1{,}100)) \times 100$$

$$= 11\%$$

This example is intended to illustrate how facilities would obtain credit for existing technologies. While this example includes a velocity cap, it does not imply that a velocity cap is the appropriate technology for all facilities. EPA's data shows in most cases, a properly located velocity cap alone may be sufficient to achieve the impingement mortality BTA standard. In the case where a velocity cap (or any other technology) alone would not be sufficient to meet the BTA standard, EPA expects that each facility would identify and install a suite of cost effective technologies to achieve the IM requirements (i.e., variable speed drives in this example).

In summary, the hypothetical facility would observe a 30 percent IM rate for June; which would then be adjusted downward to 12 percent for its offshore location and velocity cap; and then further adjusted downward to 11 percent for its flow reduction. The value that the facility would report for compliance purposes would be the 11 percent value. At the end of the 12-month monitoring period, the facility also would use the 11 percent value for that month with the other 11 adjusted monthly values to calculate the 12 month average IM rate.

Appendix A to Chapter 11: Impingement Mortality Studies

The table in this appendix provides information about the studies and data evaluated for Chapter 11.

Exhibit 11A-1 identifies the documents and whether they:

- Included impingement data (i.e., counts or percentages)
- Were used to develop the impingement mortality standard, and reasons for using or not using the data
- Are included in the performance database (DCN 12-5400).

Exhibit 11A-1. List of Documents Reviewed for Data on Impingement For Use in Preparing Impingement Mortality Standard

					Impingement Data		
ID	DCN	Authors	Title	Date[a]	Data Pre-sent?	Used?	Reasons for Use/Non-Use
4	DCN 5-4053	CCI Environmental Services	Zooplankton Entrainment Survival at the Anclote Power Plant Near Tarpon Springs, Florida	1994	No		No impingement data
5	DCN 1-3019-BE	US EPA Region IV	In the Matter of Florida Power Corporation, Crystal River Power Plant, Units 1, 2 and 3, Citrus County Florida, NPDES Permit No. FL0000159, Findings and Determinations, per 33 USC 1326	1988	Yes	No	Brief mention of total annual impingement of two shrimp and crab species is given in tons. No impingement mortality data reported. Limited information available on technology, which is not modified traveling screens.
8	DCN 4-4002B	EPRI	Fish Protection at Cooling Water Intakes: Status Report	1999	Yes	No	Summary report containing data from various studies and facilities. Some acceptable impingement mortality data identified in this report were instead obtained from their original source or from a later update (2007) of this report instead.
16	DCN 5-4397	Lawler Matusky & Skelly Engineers	Intake Research Facilities Manual	1985	No		No impingement data. (Report contains only detailed descriptions of intake testing facilities.)
17 150	DCN 5-4313	AWH Turnpenny, R Wood, and KP Thatcher	Fish Deterrent Field Trials at Hinkley Point Power Station, Somerset, 1993-1994	1994	Yes*	No	Study of fish diversion using non-BTA technology (sound generating system)
18	DCN 5-4414	Ecological Analysts Inc.	Potrero Power Plant CWIS 316(b) Demonstration	1980	Yes*	No	Used course mesh traveling screens missing modified features to make it BTA.
38	DCN 5-4391	JB Hutchinson and JA Matousek	Evaluation of a Barrier Net Used to Mitigate Fish Impingement at a Hudson River Power Plant Intake	1988	Yes*	No	Data for barrier net, did not use modified traveling screen technology.
39	DCN 5-4389	J Homa, M Stafford-Glase, and ME Connors; Ichthyological Associates, Inc.	An Evaluation of the Effectiveness of the Strobe Light Deterrent System at Milliken Station on Cayuga Lake, Tompkins County, New York	1994	No		No impingement data.
40	DCN 5-4417	Lawler, Matusky, & Skelly Engineers LLP	Lovett Generating Station Gunderboom System Evaluation Program	1998	No		No impingement data.
41	DCN 5-4322	Lawler, Matusky, & Skelly Engineers LLP	Lovett Generating Station Gunderboom Deployment Program, 2000	2001	No		No impingement data.

ID	DCN	Authors	Title	Date^{a}	Impingement Data		
					Data Pre-sent?	Used?	Reasons for Use/Non-Use
42	DCN 5-4388	Stone and Webster Engineering Corporation	Evaluation of the Eicher Screen at Elwha Dam: Spring 1990 Test Results	1991	No		No impingement data. Data represent fish diversion associated with a prototype installation operated under highly controlled conditions.
43	DCN 5-4394	Roberto Pagano and Wade H.B. Smith - Mitre Corporation	Recent Developments in Techniques to Protect Aquatic Organisms at the Water Intakes of Steam-Electric Power Plants	1977	Yes*	No	Impingement data from Surry and Barney Davis Power Stations represent fish bucket screens and double-exit traveling screens, respectively but the holding time was too short since data only represent mortality immediately following impingement.
44	DCN 5-4327	Beak Consultants Incorporated	Post-Impingement Fish Survival at Dunkirk Steam Station 1998-1999	2000	Yes*	Yes	Mortality data were reported at 24-hour post-impingement for Ristroph-type dual flow traveling screens.
45	DCN 5-4419	Tennessee Valley Authority	A State-of-the-Art Report on Intake Technologies	1976	Yes	No	Data represent laboratory studies and do not represent traveling screens with BTA features.
46	DCN 4-4002V-R12	Lawler, Matusky & Skelly Engineers	Intake Technologies: Research Status	1989	Yes*	No	Summary report of impingement mortality data from various facilities. Typically, only immediate impingement mortality is provided, or technologies were not traveling screens with BTA features. Potentially useful data was duplicative of other study data.
47	DCN 10-5435	Stone and Webster Environmental Technology and Services	Evaluation of the Modular Inclined Screen at the Green Island Hydroelectric Project: 1995 Test Results	1996	No		No impingement data.
48	DCN 5-4314	AWH Turnpenny, JM Fleming, KP Thatcher & R Wood (Fawley Aquatic Research Laboratories, Ltd.)	Trials of an Acoustic Fish Deterrent System at Hartlepool Power Station	1995	Yes	No	Study measured how fish impingement rate (rather than mortality) is reduced when a non-BTA technology (acoustic deterrent system) is in place.
49	DCN 5-4396	David E. Bailey, Jules J. Loos, Elgin S. Perry	Studies of Cooling Water Intake Structure Effects at Potomac Electric Power Company Generating Stations	Unk.	Yes*	No	Impingement counts, but not mortality, are reported for several facilities. Technologies were not fully documented (but were clearly not traveling screens with BTA features).
50	Comment 1.32 in NFR	Drs. P.A. Henderson and R.M. Seaby	Technical Evaluation of USEPA's Proposed Cooling Water Intake Regulations for New Facilities	2000	Yes	No	Only estimated annual fish impingement reported to assess impact of pumping rate on impingement at various plants. Technologies not fully documented to verify use of BTA.
51	DCN 5-4325	Beak Consultants, Inc.	Post-Impingement Fish Survival at Huntley Steam Station (Winter and Fall, 1999)	2000	Yes*	Yes	Mortality data were reported at 24-hour post-impingement for Ristroph-type dual flow traveling screens.
52	DCN 5-4371	Mote Marine Laboratory	Fine Mesh Screen (FMS) Optimization Study	1987	No		No impingement data.

					Impingement Data		
ID	DCN	Authors	Title	Date[a]	Data Pre-sent?	Used?	Reasons for Use/Non-Use
53	DCN 5-4378	John S. Stevens, Jr., and Milton S. Love	Chapter 10: San Onofre Units 2 and 3 316(b) Demonstration, The Effectiveness of the Fish Return System	Unk.	Yes	No	Impingement mortality measured at 96 hours. Technology involved louvers and bypass angled screens. Fish survival evaluation was for all fish in bypass system with only a small portion being returned from screens. Technology is not BTA.
54 209	DCN 10-5442	Consolidated Edison Company of New York	Arthur Kill Generating Station Diagnostic Study and Post-Impingement Viability Substudy Report	1996	Yes*	No	Arthur Kill mortality data were collected at 24-hour post-impingement at Screens No. 24 and 31 which featured Ristroph-type dual flow traveling screens but data was not fully representative of time periods of approximately one year Mortality data reported in a chapter comparing performance at Arthur Kill and Indian Point plants were limited.
55	DCN 2-013L-R1	American Electric Power Service Corporation	Cardinal Plant Demonstration Document	1981	Yes	No	Impingement data consist solely of impinged fish, with no mortality information. Traveling screens were not modified.
56 66	DCN 5-4006 DCN 6-2074	TG Ringger, Baltimore Gas & Electric	Investigations of Impingement of Aquatic Organisms at the Calvert Cliffs Nuclear Power Plant, 1975-1995	2000	Yes*	No	Annual impingement counts and mortality are estimated. Traveling screens were not modified.
57	DCN 2-017A-R7	EPRI	Review of Entrainment Survival Studies: 1970-2000	2000	No		No impingement data.
58 97	DCN 5-4337	Delta Fish Facilities Technical Coordination Committee	Preliminary Design Criteria for the Peripheral Canal Intake Fish Facilities	1981	No		No impingement data.
59	DCN 5-4354 (also DCN 5-4003)	E.S. Fritz	Cooling Water Intake Screening Devices Used to Reduce Entrainment and Impingement	1980	No		No impingement data.
60	DCN 10-5448	Latvaitis et al. Edited by Loren Jensen	Third National Workshop on Entrainment and Impingement -- Impingement Studies at Quad-Cities Station, Mississippi River	1976	Yes*	No	Losses of standing crop to impingement are reported rather than impingement mortality. Data are estimated. Traveling screens were not modified.
61	DCN 5-4343	Department of Fish and Game and the Department of Water Resources	Memorandum Report on the Peripheral Canal Fish Return Facilities	1971	No		No impingement data.

					Impingement Data		
ID	DCN	Authors	Title	Date[a]	Data Pre-sent?	Used?	Reasons for Use/Non-Use
62	DCN 10-5448	Thomas & Miller. Edited by Loren Jensen	Third National Workshop on Entrainment and Impingement -- Impingement Studies at Oyster Creek Generating Station, Forked River, New Jersey, from Sept. to Dec. 1975	1976	Yes*	No	Traveling screens were not modified. Reported impingement mortality data appear to represent only immediate mortality, although report notes delayed mortality was examined.
63	DCN 5-4381	Ronald Raschke - US EPA	Finding of Fact for Biological and Environmental 316 Demonstration Studies	1983	Yes	No	Only total annual impingement counts were reported for selected species, and not impingement mortality. No information given to verify use of BTA.
64	DCN 5-4334	James B. McLaren	Fish Survival on Fine Mesh Travelling Screens	2000	Yes*	No	Potentially useful data was duplicative of other study data
65	DCN 10-5453	Richard Horwitz	Lecture Notes on Coastal and Estuarine Studies - Ecological Studies in the Middle Reach of the Chesapeake Bay - Impingement Studies	1987	Yes*	No	Traveling screens were not modified with BTA features. Only immediate mortality following impingement appears to be reported in most cases.
69	DCN 5-4346	Q.E. Ross; D.J. Dunning; J.K. Meneszees; M.J.Kenn Jr.; G.Tiller	Reducing Impingement of Alewives with High Energy Frequency Sound at a Power Plant Intake in Lake Ontario	1996	Yes	No	Study used non-BTA technology (sound generating system)
70	DCN 5-4347	Q.E. Ross; D.J. Dunning; J.K. Meneszees; M.J.Kenn Jr.; G.Tiller	Response of Alewives to High Frequency Sound at a Power Plant Intake on lake Ontario	1993	Yes	No	Study used non-BTA technology (sound generating system)
71	DCN 5-4374	N.J. Thurber and D.J Jude, Great Lakes and Marine Waters Center, University of Michigan	Impingement Losses at the DC Cook Nuclear Power Plant During 1975-1982 With a Discussion of Factors Responsible and Possible Impact on Local Populations	1985	Yes	No	Estimated annual impingement totals without noting mortality. Used non-BTA technology (traveling screens with no modification).
73	DCN 5-4301	A.W.H. Turnpenny	Fish Return at Cooling Water Intakes	1992	Yes*	No	Only ranges of impingement mortality are presented for one facility, for each of five levels of fish resistance/sensitivity. Insufficient information was available to assess BTA use.
74	DCN 5-4330	Rob Brown	The potential of strobe lighting as a cost-effective means for reducing impingement and entrainment	2000	No		No impingement data. Study used non-BTA technology (strobe lighting system)

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Present?	Used?	Reasons for Use/Non-Use
75	DCN 5-4302	A.W.H. Turnpenny	Exclusion of Salmonid Fish From Water Intakes	1988	No		No impingement data.
76	DCN 5-4303	A.W.H. Turnpenny	Bubble Curtain Fish Exclusion Trials at Heyshaam 2 Power Station	1993	Yes*	No	Data correspond to “fish catch on screens.” Study assessed non-BTA technology (bubble curtain, with no information on screens used).
77	DCN 5-4304	A. Turnpenny, J. Nedwell	Fish Behaving Badly	2002	No		No impingement data.
78	DCN 5-4300	A.W.H. Turnpenny, C.J.L. Taylor	An Assessment of the Effect of the Sizewell Power Stations on Fish Populations	2000	Yes*	No	Impingement data expressed as “losses to the fishery” as biomass rather than mortality. Facility does not appear to use BTA.
79	DCN 5-4357	Fish and Wildlife Service - US Department of the Interior	Impacts of Power Plant Intake Velocities on Fish	1977	No		No impingement data.
80	DCN 5-4307	H.H. Reading	Retention of Juvenile White Sturgeon, Acipenser Transmontanus, by Perforated Plate and Wedgewire Screen Materials	1982	No		Laboratory study that did not collect impingement mortality data.
81	DCN 10-5465	D.T. Michaud, E.P. Taft	Recent Evaluations of Physical and Behavioral Barriers for Reducing Fish Entrainment at Hydroelectric Plants in the Upper Midwest	2000	No		No impingement data.
82	DCN 10-5466	E.R. Guilfoos, R.W. Williams, T.E. Rourke, P.B. Latvaitis, J.A. Gulvas, R.H. Reider	Six Years of Monitoring the Effectiveness of a Barrier Net at the Ludington Pumped Storage Plants on Lake Michigan (Waterpower 95)	1995	No		No impingement data.
84	DCN 5-4335	C. Ehrler, C. Raifsnider	Evaluation of the Effectiveness of Intake Wedgewire Screens	2000	No		No impingement data.
85	DCN 5-4333	John P. Ronafalvy, R. Roy Cheesman, William M. Matejek	Circulating water traveling screen modifications to improve impinged fish survival and debris handling at Salem Generating Station	2000	Yes*	No	Impingement data for only one species (weakfish) were available. Data was not representative of one year.
86	DCN 6-5068	Lawler, Matusky, and Skelly	Lovett Generating Station Gunderboom Evaluation Program	1996	Yes	No	No mortality data. No information on type of traveling screens used (focus is on Gunderboom evaluation).

					Impingement Data		
ID	DCN	Authors	Title	Date[a]	Data Pre-sent?	Used?	Reasons for Use/Non-Use
94	DCN 5-4344	KeySpan Corporation	Screenwash return water modification study, Glennwood and Port Jefferson Power Stations	2002	Yes	No	Only monthly totals reported. No information given on type of technology. No mortality data.
95	DCN 5-4332	Andrew E. Jahn, Kevin T. Herbinson	Designing a light-meditated behavioral barrier to fish impingement and a monitoring program to test its effectiveness at a coastal power station	2000	No		No impingement data. Study used non-BTA technology (light used as stimulus for attracting fish to bypass).
96	DCN 5-4331	David R. Sager, Charles H. Hocutt, Jay R. Stauffer Jr.	Avoidance behavior of Morone americana, Leiostomus xanthurus and Brevooritia tyrannus to strobe light as a method of impingement mitigation	2000	No		No impingement data. Laboratory study that used non-BTA technology (strobe light and bubble curtain deterrents).
98	DCN 5-4338	Delta Fish Facilities Technical Coordinating Committee	Justification for Abandonment of Further Consideration of the Louver Fish Screen for an Intake Facility for the Peripheral Canal	1981	No		No impingement data
99	DCN 5-4339	Delta Fish Facilities Technical Coordinating Committee	Horizontal Traveling Fish Screen Status	1980	Yes	No	Laboratory study. No mortality data or information given on whether traveling screens were modified.
100	DCN 5-4340	Delta Fish Facilities Technical Coordinating Committee	Justification for Abandonment of Further Consideration of the Filtration Concept for an Intake Facility for the Peripheral Canal	1979	No		No impingement data
101	DCN 5-4341	Delta Fish Facilities Technical Coordinating Committee	Justification for Eliminating from Further Consideration the Horizontal Rotary Drum Screen for the Peripheral Canal	1979	No		No impingement data
102	DCN 5-4342	Delta Fish Facilities Technical Coordinating Committee	Justification for Proceeding with an "Off-River" Intake Concept for the Peripheral Canal	1979	No		No impingement data
103	DCN 5-4360	CD Goodyear, Great Lakes Fishery Laboratory	Evaluation of 316(b) Demonstration: Detroit Edison's Monroe Power Plant	1978	Yes*	No	No mortality data. No indication that traveling screens were modified. Data appear to be estimates.

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Pre-sent?	Used?	Reasons for Use/Non-Use
104	DCN 5-4362	LW Barnthouse et al, Oak Ridge National Laboratory	The Impact of Entrainment and Impingement on Fish Populations in the Hudson River Estuary (Volume II)	1982	Yes	No	Only estimated monthly data provided. No specific technology data provided.
105	DCN 5-4376	JH Balletto and HW Brown, American Electric Power	Kammer Plant Demonstration Document for PL 92-500 Section 316(b)	1980	Yes	No	Only estimated total impingement counts were reported, with no mortality data. Traveling screens were not modified to include BTA features.
106	DCN 6-5037	Stone & Webster Engineering	Biological and Engineering Evaluation of a Fine-Mesh Screen Intake for Big Bend Station Unit 4	1980	Yes*	No	Interim report of data originating from a controlled study involving a prototype. While technology involved dual flow traveling screens with baskets and mortality data were reported at 0 and 48 hours post-impingement, the fine mesh screen technology is not BTA. It is also not clear whether the 48-hour data correspond to the same organisms as evaluated at 0 hours.
107	DCN 6-5046O	John Young, William Dey, Steven Jinks, Nancy Decker, Martin Daley, John Carnright	Evaluation of Variable Pumping Rates as a Means to Reduce Entrainment Mortalities	2003	No		No impingement data
108	DCN 5-4409	Consumers Power Company	1991 Annual Report Describing Performance of Deterrent Net System at JR Whiting	1992	Yes*	No	No mortality data. Technology is not modified traveling screens.
109	DCN 5-4418	Tennessee Valley Authority, Division of Water Resources	A Biological Evaluation of Fish Handling Components of a Water Intake Screen Designed to Protect Larval Fish	1979	No		No impingement data
110	DCN 5-4305	New York Power Authority	Conditional Entrainment Mortality Rates for Seven Taxa of Fish at Water Intakes on the Hudson River	1998	No		No impingement data
111	DCN 5-4411	Southern Energy California	Best Technology Available 1999 Technical Report for the Pittsburg and Contra Costa Power Plants	2000	No		No impingement data
112	DCN 5-4336	California Departments of Fish and Game and Water Resources	A Fish Protection Facility for the Proposed Peripheral Canal	1981	No		No impingement data
113	DCN 4-1326	American Electric Power	Philip Sporn Plant Demonstration Project for PL 92-500 Section 316(b)	1980	Yes	No	No mortality data. Technology is not modified traveling screens.

ID	DCN	Authors	Title	Date[a]	Impingement Data: Data Present?	Impingement Data: Used?	Impingement Data: Reasons for Use/Non-Use
114	DCN 5-4306	Bay-Delta Fishery Project	Roaring River Slough Fish Screen Evaluation, 1984	1984	No		No impingement data
115	DCN 5-4008	Stephen B. Weisburg, William H. Burton, Eric A. Ross, Fred Jacobs	The Effects of Screen Slot Size, Screen Diameter, and Through-Slot Velocity on Entrainment of Estuarine Ichthyoplankton through Wedgewire Screens	1984	No		No impingement data
116	DCN 10-5491	HDR/LMS	Salem NJPDES Permit Renewal Application February 2006	2006	No		No impingement data
118	DCN 10-5492	Edward Taft, Thomas Horst, and John Dowling - Stone and Webster Engineering Corporation	Biological Evaluation of a Fine-Mesh Traveling Screen for Protecting Organisms	1981	Yes*	No	Data originate from a controlled study involving a prototype. While technology involved dual flow traveling screens with baskets the fine mesh screen technology is not BTA. Also, mortality data were reported at 0 and 48 hours post-impingement, it is not clear whether the 48-hour data correspond to the same organisms as evaluated at 0 hours.
119	DCN 10-5493	E. P. Taft - Stone and Webster Environmental Services	Evaluation of Strobe Lights for Fish Diversion at the York Haven Hydroelectric project	1992	No		No impingement data. (Technology focuses on avoidance/deterrence involving strobe lights, sound.)
122 123	DCN 5-4404	Versar, Inc.	Evaluation of the 316 Status of Delaware Facilities with Cooling Water Discharges	1990	No		No impingement data
124	DCN 6-5050	U.S. NRC, Office of Standards Development	U.S. Nuclear Regulatory Commission Regulatory Guide	1975	No		No impingement data
125	DCN 4-1516	NJ DEP; Prepared by ESSA Technologies	Review of Portions of NJPDES Renewal Application for the PSE&G Salem Generating Station	2000	Yes*	No	Non-BTA technology used (sound deterrent)
126	DCN 6-5046E	David Baily, Jules Loos, Ann Wearmouth, Pat Langley, Elgin Perry	Effectiveness, Operation and Maintenance, and Costs of a Barrier Net System for Impingement Reduction at the Chalk Point Generating Station	2003	Yes*	No	No mortality data. Focus is on evaluating barrier net effectiveness.
127	DCN 6-5046F	Steven M. Jinks, Nancy Decker, William Dey, John Young, Douglas Dixon	A Review of Impingement Survival Studies at Steam-Electric Power Stations	Unk.	Yes	No	Summary report. Studies/facilities and corresponding data not clearly identified.

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Present?	Used?	Reasons for Use/Non-Use
128	DCN 6-5043	David Bruzek, Selvakumaran Mahadevan, Mote Marine Laboratory	Fine Mesh Screen Survivability Study Big Bend Unit 4 Tampa Bay Electric Company	1986	Yes	No	Non-BTA technology (fine mesh traveling screens)
129	DCN 6-5046D	Mark F. Strickland, James E. Mudge	Selection and Design of Wedge Wire Screens and a Fixed-Panel Aquatic Filter Barrier System to Reduce Impingement and Entrainment at a Cooling Water Intake Structure on the Hudson River	2003	No		No impingement data
130	DCN 5-4361	J. Boreman, L.W. Barnthouse, D.S. Vaughan, C.P. Goodyear, S.W. Christensen, K.D. Kumar, B.L. Kirk, W. Van Winkle	The Impact of Entrainment and Impingement on Fish Populations in the Hudson River Estuary for Six Fish Populations Inhabiting the Hudson River Estuary	1982	No		No impingement data
131	DCN 5-4384	Dr. Y.G. Mussalli et al (Stone & Webster), M.P. McNamera et al (NUSCO)	Feasibility Study of Cooling Water System Alternatives to Reduce Winter Flounder Larval Entrainment at Millstone Units 1, 2, and 3	1993	No		No impingement data
132	DCN 5-4358	Douglas Hjorth, Fred Winchell, John Downing, Don Cochran, Rose Perry (Stone & Webster)	Preliminary Assessment of Fish Entrainment at Hydropower Projects - A Report on Studies and Protective Measures	1995	No		No impingement data
133	DCN 5-4386	Lawler Matusky & Skeller Engineers	Field Testing of Behavioral Barriers for Fish Exclusion at Cooling-Water Intake Systems	1988	Yes	No	No mortality data. Technology is non-BTA (various behavioral barriers).
134	DCN 5-4399	Tenera Environmental Services	Moss Landing Power Plant Modernization Project 316(b) Resource Assessment	2000	Yes	No	Mortality considered only for 4 minutes holding time. Data given for one species (striped bass).
135	DCN 5-4400	Tenera Environmental Services	Diablo Canyon Power Plant 316(b) Demonstration Report	2000	No		While impingement is noted in the report, no impingement data are summarized in tables. Traveling screens were not modified.

					Impingement Data		
ID	DCN	Authors	Title	Date[a]	Data Pre-sent?	Used?	Reasons for Use/Non-Use
136	DCN 5-4317	Lawler, Matusky & Skelly Engineers	Intake Debris Screen Postimpingement Survival Evaluation Study: Roseton Generating Station 1990 (Portion of Chapter 3 and selected tables from Chapter 5)	1991	Yes*	No	While impingement mortality was reported up to 48 hours post-impingement for dual-flow traveling screens with screen baskets, data is not representative of one year.
137	DCN 6-5016	Marine Resource Advisory Council	Effects of Power Plants on Hudson River Fish	2000	No		No impingement data
138	DCN 6-5046H	Isabel C. Johnson and Steve Moser	Fish Return System Efficacy and Impingement Monitoring Studies for JEA's Northside Generating System	Unk.	Yes*	No	Impingement mortality data presented in summary form only.
139	DCN 6-5046P	J R Nedwell, AWH Turnpenny, and D Lambert	Objective Design of Acoustic Fish Deterrent Systems	2003	No		No impingement data
140	DCN 6-5046Q	E. P. Taft, Thomas C. Cook, Jonathan L. Black, Nathaniel Olkien	Fish Protection Technologies for Existing Cooling Water Intake Structures and their Costs	2003	No		No impingement data
141	DCN 5-4363	R. H. Gray, T. L. Page, E. G. Wolf, M. J. Schneider (Batelle)	A Study of Fish Impingement and Screen Passage at Hanford Generation Project - A Progress Report	1975	Yes*	No	No impingement mortality data reported. Traveling screens are not modified.
142	DCN 5-4366	Thomas J. Edwards, William H. Hunt, Larry E. Miller, James J. Sevic	An Evaluation of the Impingement of Fishes at Four Duke Power Company Steam Generating Facilities	1976	Yes	No	No impingement mortality data reported. Traveling screens are not modified.
143	DCN 5-4369	Stone & Webster Engineering Corporation	Final Report: Biological Evaluation of a Modified Traveling Screen Mystic Station - Unit No. 7	1981	Yes*	Yes	Modified traveling screens. Mortality data reported for multiple holding times
144	DCN 5-4370	United Engineers & Constructors	Edgar Energy Park Clean Water Act Sections 316(a) & 316(b) Demonstration	1990	No		No impingement data
145	DCN 5-4372	Florida Power & Light Company	Assessment of the Impacts of the St Lucie Nuclear Generating Plant on Sea Turtle Species Found in the Inshore Waters of Florida	1995	No		No impingement data. (Only turtle species were considered.)

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Present?	Used?	Reasons for Use/Non-Use
146	DCN 6-5057	American Society of Civil Engineers	Design of Water Intake Structures for Fish Protection	1982	Yes*	No	Impingement mortality data present but information on technology used is insufficient to verify BTA.
147	DCN 5-4308	Ronald J. Decoto	1974 Evaluation of the Glenn-Colusa Irrigation District Fish Screen	1978	No		No impingement data (bypass data were reported instead).
148	DCN 5-4309	Brian D. Quevlog	An Inventory of Selected Fish Screens in California	1981	No		No impingement data
149	DCN 5-4310	Randall L. Brown, Dan B. Odenweller	A Fish Protection Facility for the Proposed Peripheral Canal	1981	No		No impingement data
151	DCN 5-4315	AWH Turnpenny, PA Henderson	Design and Testing Specification for a Deterrent Bubble Barrier for Heysham Power Stations 1 & 2	1992	No		No impingement data
152	DCN 5-4316	A W H Turnpenny, K P Thatcher, R Wood, P H Loeffelman	Experiments on the Use of Sound as a Fish Deterrent	1993	No		No impingement data
153	DCN 10-5523	Tom M. Pankratz	Screening Equipment Handbook	1995	No		No impingement data
154	DCN 10-5524	Stone & Webster Engineering Corporation	Assessment of Downstream Migrant Fish Protection Technologies for Hydroelectric Application	1986	No		No impingement data.
155	DCN 10-5525	Malcolm E. Brown	Progress Report on Profile Wire Intake Screen Testing Forked River, New Jersey	1979	No		No impingement data.
156	DCN 10-5526	Lawrence W. Smith, David E. Ferguson	Cleaning and Clogging Tests of Passive Screens in the Sacramento River, California	1979	No		No impingement data.
157	DCN 10-5527	T. E. Crumlish	Extended Abstract - Engineering Aspects of Screen Testing on the St. Johns River, Palatka, Fla.	1979	No		No impingement data.
158	DCN 10-5528	W. S. Lifton	Extended Abstract - Biological Aspects of the Screen Testing of the St Johns River, Palatka, Fla.	1979	No		No impingement data.
159	DCN 10-5529	Brian N. Hanson	Studies of Three Cylindrical Profile-wire Screens Mounted Parallel to Flow Direction	1979	No		No impingement data

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Pre-sent?	Used?	Reasons for Use/Non-Use
160	DCN 10-5530	James M. Wiersema, Dorothy Hogg, and Lowell J. Eck	Biofouling Studies in Gaslveston Bay - Biological Aspects - Abstract	1979	No		No impingement data.
162	DCN 10-5531	R. W. Crippen	Impacts of Three Types of Power Generating Discharge Systems on Entrained Plankton	1977	No		No impingement data.
163	DCN 10-5532	Lawrence R. King, Jay B. Hutchison Jr., Thomas G. Huggins	Impingement Survival Studies on White Perch, Striped Bass, and Atlantic Tomcod at Three Hudson River Power Plants	1977	Yes*	No	Technology description did not mention modified screen features.
164	DCN 10-5533	Thomas R. Thathom, David L. Thomas, Gerald J. Miller	Survival of Fishes and Macroinvertibrates Impinged at Oyster Creek Generating Station	1977	Yes*	No	Technology is not BTA. Traveling screens are not modified.
165	DCN 10-5534	T. L. Page, D. A. Neitzel, R. H. Gray	Comparative Fish Impingement at Two Adjacent Water Intakes on the Mid-Columbia River	1977	Yes	No	Technology is not BTA. Traveling screens are not modified.
166	DCN 10-5535	Yusuf G. Mussalli, Edward P. Taft, Peter Hoffman	Engineering Implications of New Fish Screening Concepts	1977	No		No impingement data.
167	DCN 10-5536	Brian N. Hanson, Wiliam H. Bason, Barry E. Beitz, Kevin E. Charles	A Practical Intake Screen which Substantially Reduces the Entrainment and Impingement of Early Life Stages of Fish	1977	Yes	No	Laboratory study
168	DCN 5-4379	L.S. Murray and T.S. Jinnette	Survival of Dominant Estuarine Organisms Impinged on Fine-Mesh Traveling Screens at the Barney M. Davis Power Station	1977	Yes*	No	Holding time is too short. Only immediate mortality was observed (for up to 10-15 minutes post-impingement).
169 206-A	DCN 5-4379	D.A. Tomljanovich, J.H. Heuer, and C.W. Voigtlander	Investigations on the Protection of Fish Larvae at Water Intakes Using Fine-Mesh Screening	1977	Yes*	No	While percent impingement mortality was documented, this is a laboratory study that did not involve evaluation of modified traveling screens.
170	DCN 5-4379	J.H. Heuer and D.A. Tomljanovich	A Study on the Protection of Fish Larvae at Water Intakes Using Wedge-Wire Screens	1987	No		Laboratory study. “Bypassed” data are reported rather than impingement data.
171	DCN 5-4379	B.N. Hanson, W.H. Bason, B.E. Beitz, and K.E. Charles	Practicality of Profile-Wire Screen in Reducing Entrainment and Impingement	1977	Yes*	No	Laboratory study.

					Impingement Data		
ID	**DCN**	**Authors**	**Title**	**Date[a]**	**Data Pre-sent?**	**Used?**	**Reasons for Use/Non-Use**
173	DCN 5-4350	EA Science and Technology	Results of entrainment and impingement monitoring studies at the Westchester RESCO facility, Peekskill, New York	1987	Yes	No	Only percentages of impinged data represented by certain species, and total fish impinged, were reported. No impingement mortality reported.
174	DCN 7-4561	Acres International Corporation	Report on fish entrainment study: November 1993 to November 1994, Glens Falls	1995	No		No impingement data
175	DCN 10-5543	Dames and Moore	Seminole Plant Units 1&2 316b Study Report	1979	Yes	No	Technology involved fixed screens rather than traveling screens. No impingement mortality data reported.
176	DCN 10-5544	Alliant Energy	Final Environmental Impact Statement: Ottumwa Generating Station	1978	No		No impingement data.
177	DCN 10-5545	B.D. Giese and K.N. Mueller	Section III Prairie Island Nuclear Generating Plant Environmental Monitoring Report - 2002 Annual Report	2002	Yes	No	No impingement mortality data. Traveling screens are not modified.
178	DCN 10-5546	Tennessee Valley Authority	Biological Effects of Intake Browns Ferry Nuclear Vol 1 Summary of the Evaluation of the Browns Ferry Nuclear Plant Intake Structure	1978	No		No impingement data.
179 180	DCN 10-5547	Tennessee Valley Authority	316(a) and 316(b) Demonstration Cumberland Steam Plant - Volume 5	1977	No		No impingement data
181	DCN 10-5548	Tennessee Valley Authority	316(a) and 316)b) Demonstration: John Sevier Steam Plant	1977	No		No impingement data
182	DCN 8-4501	Normandeau Associates, Inc.	Impingement and Entrainment at the Cooling Water Intake Structure of the Delaware City Refinery, April 1998-March 2000	2000	Yes	No	No impingement mortality data. Traveling screens are not modified.
183	DCN 10-5550	Industrial Bio-Test Laboratories, Inc.	A Baseline/Predictive Environmental Investigation of Lake Wylie	1974	No		No impingement data.
184	DCN 10-5551	Carolina Power & Light Company	Brunswick Steam Electric Plant Cape Fear Studies Interpretive Report	1985	Yes	No	Potentially useful data was duplicative of other study data
185	DCN 7-4507	Wisconsin Electric Power Company	Oak Creek Power Plant Final Report Intake Monitoring Studies	1976	Yes	No	No impingement mortality data. Traveling screens are not modified.

					Impingement Data		
ID	DCN	Authors	Title	Date[a]	Data Pre-sent?	Used?	Reasons for Use/Non-Use
186	DCN 7-4508	Wisconsin Electric Power Company	Port Washington Power Plant Final Report Intake Monitoring Studies	1976	Yes	No	No impingement mortality data. Traveling screens are not modified.
187	DCN 10-5554	Delmarva Power & Light Company	Vienna Power Station Prediction of Aquatic Impacts of the Proposed Cooling Water Intake A Section 316(b) Demonstration	1982	No		No impingement data.
188	DCN 7-4512	Applied Biology, Inc.	Impingement Monitoring Program South Carolina Public Service Authority Winyah Plant Final Report	1977	Yes	No	No impingement mortality data. Traveling screens are not modified.
189	DCN 7-4513	Geo-Marine, Inc.	316b Demonstration Report for the Arkansas Eastman Plant on the White River	1981	No		No impingement count or mortality data reported. Limited information is given on technology used.
190	DCN 10-5557	Equitable Environmental Health, Inc.	Meramec Power Plant Entrainment and Impingement Effects on Biological Populations of the Mississippi River	1976	Yes	No	No impingement mortality data. Traveling screens are not modified.
191	DCN 10-6806	EPRI	Field evaluation of wedgewire screens for protecting early life stages at cooling water intake structures: Chesapeake Bay studies	2006	No		No impingement data
192	DCN 10-6801	EPRI	Laboratory evaluation of modified Ristroph traveling screens for protecting fish at cooling water intakes	2006	Yes*	No	Laboratory study
193 201	DCN 10-6813	EPRI	Fish Protection at Cooling Water Intake Structures: A Technical Reference Manual	2007	Yes*	Yes	This is a summary report of data from multiple studies. Chapter 2 contains impingement data, some of which originate from other reviewed reports. Data appear from Brunswick, Indian Point, Potomac, Prairie Island, Roseton, Dunkirk and Huntley that were utilized in the impingement mortality limitations. Impingement mortality data from other sources were not used due to non-BTA technology or corresponding to 0 hours post-impingement.
194	DCN 10-6804	EPRI	Design considerations and specifications for fish barrier net deployment at cooling water intake structures	2006	No		No impingement data.

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Pre-sent?	Used?	Reasons for Use/Non-Use
195	DCN 10-6802	EPRI	Laboratory evaluation of fine-mesh traveling water screens for protecting early life stages of fish at cooling water intakes	2008	Yes*	No	Laboratory study
196	DCN 10-6814	EPRI	Latent impingement mortality assessment of the Geiger Multi-Disc screening system at Potomac River Generating Station	2007	Yes*	No	Potentially useful data was duplicative of other study data
197	DCN 10-6970	EPRI	The role of temperature and nutritional status in impingement of clupeid fish species	2008	No		No impingement data.
198	DCN 10-6971	EPRI	Cooling Water Intake Structure Area-of-Influence Evaluations for Ohio River Ecological Research Program Facilities	2007	No		No impingement data.
199	DCN 4-1682	Robert W. Davis, John A. Matousek, Michael J. Skelly, and Milton R. Anderson	Biological Evaluation of Brayton Point Station Unit 4, Angled Screen Intake	1988	Yes	No	Impingement survival data is reported as total for 18 month period. Data covers a period substantially more than 12 months and therefore not representative of one year.
200	DCN 10-5567	Applied Science Associates	Ichthyoplankton Monitoring Study Deployment of a Gunderboom System at Lovett Generating Station Unit 3, 1998	1999	No		No impingement data.
202	DCN 10-5568	S.L. Blanton, D.A. Neitzel, and C.S. Abernethy	Washington Phase II Fish Diversion Screen Evaluations in the Yakima River Basin, 1997	1998	No		No impingement data. Non-BTA screen technology used to promote fish diversion.
203	DCN 10-5569	W. Bengeyfield	Evaluation of a Temporary Screen to Divert Fish at Puntledge Generating Station	1992	No		No impingement data. Evaluation of temporary barrier net.
204	DCN 10-5570	M.D. Bowen, S.M. Siegfried, C.R. Liston, A.J. Hess and C.A. Karp	Fish Collections and Secondary Louver Efficiency at the Tracy Fish Collection Facility	1998	No		No impingement data.
205	DCN 10-5571	D.L.Breitburg and T.A.Thoman	Calvert Cliffs Nuclear Power Plant Finfish Survival Study	1986	Yes*	No	Assessed technologies included dual-speed, Beauderey, and control traveling screens. Impingement mortality data appear to represent only immediate post-impingement. Holding time is too short.

					Impingement Data		
ID	DCN	Authors	Title	Date^a	Data Pre-sent?	Used?	Reasons for Use/Non-Use
206	DCN 10-5572	V. Brueggemeyer, D.Cowdrick, K. Durrell, S. Mahadevan and D. Bruzek	Full-scale Operational Demonstration of Fine Mesh Screens at Power Plant Intakes	1998	Yes*	No	Mortality data are reported only immediately following impingement. Technology does not appear to be BTA.
207	DCN 10-5573	Beak Consultants Incorporated	Dunkirk Station Biological Studies	1988	Yes*	No	Impingement mortality data correspond to Beaudrey traveling screens with no modified features or fish return system.
208	DCN 10-5574	Carolina Power and Light Company	Brunswick Steam Electric Plant: 1984 Biological Monitoring Report	1985	Yes*	Yes	.3/8 in mesh fixed diversion screen at inlet; Impingement survival data includes fish fry captured on modified fine mesh screens
210	DCN 7-4504	NALCO Environmental Sciences	Dean H Mitchell Station 316(b) Demonstration	1976	Yes	No	Impingement mortality not reported. Traveling screen technology not modified.
211	DCN 9-4664	Wapora Inc	Studies of screen impingement and egg and fry entrainment at the Joppa Illinois Electric Generating Station	1976	Yes	No	Impingement mortality not reported. Traveling screen technology not modified.
212	DCN 10-5577	Hugh Barwick	Fish Impingement at Oconee Nuclear Station	1990	Yes	No	Impingement mortality not reported. Modified traveling screens not used.
213	DCN 10-5578	J. P. Buchanan, D.L. Dycus, H.R. Gwinner, and J.M. Roberts, Jr.	Aquatic Environmental Conditions in Chickamauga Reservoir During Operation of Sequoyah Nuclear Plant, Sixth Annual Report	1987	No		No impingement data.
214	DCN 10-5579	Stone and Webster Engineering Corporation, Boston, MA	Studies to Alleviate Potential Fish Entrapment Problems (Volume 1 of 2)	1977	No		No impingement data associated with field studies.
215	DCN 7-4511	Wapora	316 (a) and (b) Studies on the Grand River	1977	Yes	No	No impingement mortality data reported. No information given on technology used at the specified plants.
216	DCN 7-0009	Tetra Tech	Small facility ichthyoplankton entrainment sampling for the development of the 316(b) Phase III Rule for cooling water intake structures	2004	No		No impingement data.
217	DCN 7-4520	Western Illinois Power Cooperative	Fish impingement studies at Pearl Station--February 1977-January 1978	1978	Yes	No	Impingement mortality was not assessed. No information given on the technology used.

					Impingement Data		
ID	DCN	Authors	Title	Date[a]	Data Pre-sent?	Used?	Reasons for Use/Non-Use
218	DCN 7-4505	Foster Wheeler Environmental Corporation	Comanche Peak Steam Electric Station Units 1 and 2 316 (b) Demonstration	1995	Yes	No	Traveling screens are not modified. No impingement mortality results reported.
219	DCN 7-4516	Carolina Power and Light	HB Robinson Steam Electric Plant 316 Demonstration Study	1976	Yes	No	Traveling screens are not modified. No impingement mortality results reported.
220	DCN 7-4557	EA Science	Bayway Refinery impingement and entrainment study for 316(b) of the Clean Water Act	1995	Yes	No	Traveling screens are not modified. No impingement mortality results reported.
221	DCN 10-5586	Alden Research Laboratory and Stone & Webster Engineering Corporation	Laboratory Evaluation of Fish Protective Devices at Intakes	1981	No		No impingement data. Several technologies were evaluated under laboratory conditions, including fish diversion and bypass, and behavioral barriers, but not modified traveling screens. For angled screens, mortality associated with diversion was reported only at 96 hours.
200-A	DCN 11-5522	Stone & Webster Engineering Corporation	Alternative Intake Designs for Reducing Fish Losses, Mystic Station - Unit 7	1979	Yes	No	While this report documents the findings of several studies assessing impingement mortality associated with traveling screens. Screens utilized low pressure spray wash but used trash lips rather than fish buckets. Technology is not BTA
201-A	DCN 10-5588	Donald E. Clark and Douglas P. Cramer	Evaluation of the Downstream Migrant Bypass System - T.W. Sullivan Plant, Willamette Falls	1993	No		No impingement data – mortality data (>48 hour holding time) were associated with negotiating a downstream migrant bypass system rather than screen impingement.
202-A	DCN 10-5589	D.P. Cramer	Evaluation of a Louver Guidance System and Eicher Screen for Fish Protection at the T.W. Sullivan Plant in Oregon	1997	No		No impingement data – 48-hour mortality data were associated with negotiating a downstream migrant bypass system rather than screen impingement.
203-A	DCN 10-5590	P.M Cumbie and J.B. Banks	Protection of Aquatic Life in Design and Operation of the Cope Station Water Intake and Discharge Structures	1997	No		No impingement data.
204-A	DCN 10-5591	Stone & Webster Environmental Services	Proposal for Services to Perform 1992 Blueback Herring Environmental Studies at the Little Falls Hydroelectric Project, Little Falls, New York	1991	No		No impingement data.
205-A	DCN 10-5592	Texas Instruments Incorporated	Initial and Extended Survival of Fish Collected from a Fine Mesh Continuously Operating Traveling Screen at the Indian Point Generating Station	1978	Yes	Yes	Impingement mortality associated with Ristroph traveling screens are reported.

					Impingement Data		
ID	DCN	Authors	Title	Date[a]	Data Pre-sent?	Used?	Reasons for Use/Non-Use
207-A	DCN 10-5593	Larry E. Week, Victor C. Bird, and R. Eugene Geary	Effects of Passing Juvenile Steelhead, Chinook Salmon, and Coho Salmon Through an Archimedes' Screw Pump	1989	No		No impingement data. This report documents the outcome of controlled experiments of screw pump pass-through.
208-A	DCN 10-5594	Michael Wert	Hydraulic Model Evaluation of the Eicher Passive Pressure Screen Fish Bypass System	1988	Yes	No	Laboratory study of Eicher screens rather than modified traveling screens.
209-A	DCN 10-5595	Fred Winchell, Ned Taft, Tom Cook and Charles Sullivan	Research Update on the Eicher Screen at Elwha Dam	1993	No		“Passage survival” after 96 hours was reported rather than screen impingement survival or mortality.
210-A	DCN 10-5596	Thomas Plante, Michael Feldhausen, Dennis Olsen and David Michaud	Maintenance Requirements of a Fish Barrier Net System	1997	No		No impingement data. Focus was on assessing the functionality and performance (biofouling) of a prototype barrier net system.
	DCN 6-5004B	EPRI	Laboratory Evaluation of Wedgewire Screens for Protecting Early Life Stages of Fish at Cooling Water Intakes	2003	Yes	No	Laboratory study. No impingement mortality data reported.
221	DCN 11-5453	ASA Analysis & Communication, Inc.	Evaluation of Impingement Survival on the HydroloxTM Traveling Water Screen at the E.F. Barrett Generating Station October 2007 – June 2008 (2008)	2008	Yes	Yes	Hydrolox traveling water screen, 0.25" x 0.3" smooth plastic screen with modified screen features
222	DCN 11-5440	Carolina Power and Light Company	Brunswick Steam Electric Plant 1985 Biological Monitoring Report	1986	Yes	No	Survival data not representative of one year and 1985 data reported for selected species only
223	DCN 11-5441	Carolina Power and Light Company	Brunswick Steam Electric Plant 1986 Biological Monitoring Report	1987	Yes	No	Survival data not representative of one year and 1986 data reported for selected species only.
224	DCN 11-5442	Carolina Power and Light Company	Brunswick Steam Electric Plant 1987 Biological Monitoring Report	1988	Yes	No	Survival data not representative of one year and 1987 data reported for selected species only.
225	DCN 11-5443	Progress Energy Carolinas, Inc	Brunswick Steam Electric Plant 2008 Biological Monitoring Report	2009	Yes	No	Survival estimates based on previous study results.
226	DCN 11-5444	Progress Energy Carolinas, Inc	Brunswick Steam Electric Plant 2009 Biological Monitoring Report	2011	Yes	No	Survival estimates based on previous study results
227	DCN 11-5530	ASA	Hudson Generating Station 316(b) Study Report 2009-2011	2011	Yes	No	Timeframe of latent survival data is not be representative of one year

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Pre-sent?	Used?	Reasons for Use/Non-Use
228	DCN 11-5449	Marine Research Inc.	Post-impingement Survival Study Manchester Street Station January 1996 p February 1997	1997	Yes	Yes	3/8 in Ristroph-type traveling screens with fish buckets, low pressure spray continuous operation and separate fish return.
229	DCN 11-5450	Normandeau Associates, Inc.	Impingement Monitoring at Manchester Street Station 2005	2006	Yes	No	Impingement data only. No latent survival data presented
230	DCN 11-5451	Normandeau Associates, Inc.	Impingement Monitoring at Manchester Street Station 2006	2007	Yes	No	Impingement data only. No latent survival data presented
231	DCN 11-5532	PSEG/AKRF	Special Study Report--Salem Generating Station Estimated Latent Impingement Mortality Rates: Updated Pooled Estimates Using Data from 1995, 1997, 1998, 1999, 2000 and 2003	2011	Yes	No	Modified Ristroph screens, 1/4 x 1/2 mesh, smooth screens, baskets, etc. Aggregated data not representative of one year period.
232	DCN 6-5038	Carolina Power and Light Company	Brunswick Steam Electric Plant 2000 Biological Monitoring Report	2001	Yes	No	Survival data not representative of one year and 2000 data reported for selected species only
233	DCN 6-5039	Carolina Power and Light Company	Brunswick Steam Electric Plant 1999 Biological Monitoring Report	2000	Yes	No	Survival data not representative of one year and 1999 data reported for selected species only.
234	DCN 6-5040	Carolina Power and Light Company	Brunswick Steam Electric Plant 1998 Biological Monitoring Report	1999	Yes	No	Survival data not representative of one year and 1998 data reported for selected species only.
235	DCN 6-5041	Carolina Power and Light Company	Brunswick Steam Electric Plant 1997 Biological Monitoring Report	1998	Yes	No	Survival data not representative of one year and 1997 data reported for selected species only.
236	DCN 6-5042	Carolina Power and Light Company	Brunswick Steam Electric Plant 1996 Biological Monitoring Report	1997	Yes	No	Survival data not representative of one year and 1996 data reported for selected species only.
237	DCN 11-5531	New York State Gas and Electric (NYSEG)	Somerset Coal-Fired Power Station Aquatic Ecology Monitoring Program	1981	Yes	No	Report is a description of future study plans
238	DCN 11-5533	D.L. Bigbee, R.G. King, and K.M. Dixon	Survival of Fish Impinged on a Rotary Disk Screen	2010	Yes	Yes	Rotary screen (WIP screen)
239	DCN 11-5476	Ecological Analysts, Inc.	A Biological Evaluation of Modified Vertical Traveling Screens.	1982	Yes	Yes	3/8" front wash traveling screens that have been retrofitted with fish collection trough (with water) and low- and high-pressure wash systems.
240	DCN 11-5507	Consolidated Edison Company of New York, Inc.	Biological Evaluation of a Ristroph Screen at Indian Point Unit 2	1985	Yes	Yes	Modified traveling screens, 3/8" mesh, low pressure wash, fish protection and collection features.

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Pre-sent?	Used?	Reasons for Use/Non-Use
241	DCN 11-5508	Consolidated Edison Company of New York, Inc.	Survival of Fish Impinged on a Ristroph-type Traveling Screen at the Indian Point Generating Station, Summer and Fall, 1985	1986	Yes	Yes	Modified traveling screens, 3/8" mesh, low pressure wash, fish protection and collection features.
242	DCN 11-5499	Goeman, T J	Fish survival at a cooling water intake designed to minimize mortality	1984	Yes	Yes	Modified traveling screens with fish trays and sluiceways. Low pressure wash, followed by high pressure.
243	DCN 11-5482	New York State Electric and Gas Corporation, Stone & Webster Engineering Corporation, and Auld Environmental Associates.	Kintigh/Somerset Aquatic Monitoring Program 1989 Annual Report.	1990	Yes	Yes	Fine mesh (1 mm) traveling screens with fish trays and return, low pressure spray, sluice trough. Includes 2000 feet off shore velocity cap intake.
244	DCN 5-4334	McClaren, J.B. and L.R. Tuttle	Fish Survival on Fine Mesh Traveling Screens	1999	Yes	No	Summary of 1985, 1986, and 1989 studies. Potentially useful data was duplicative of other study data.
245	DCN 11-5463	Northeast Utilities Service Company	The Effectiveness of the Millstone Unit 3 Fish Return System	1987	Yes	Yes	Fine mesh (3/16"), fish trays, low and high pressure spray, fish sluiceway return
246	DCN 11-5500	Northeast Utilities Service Company	Progress Report on the MNPS Fish Return Systems	1994	Yes	Yes	"Fine" mesh (3/8"), fish trays, low and high pressure spray, fish sluiceway return. New screens and re-angled fish sprayers (per improvements made after 1986 study).
247	DCN 11-5490	Normandeau Associates, Inc.	Roseton Generating Station 1994 Evaluation of Post Impingement Survival and Impingement Abundance	1995	Yes	Yes	Dual flow traveling screens replaced 2 (2C & 2D) of 8 conventional screens in 1990. In April 1993 dual flow screen 2D was replaced with a dual flow screen modified to reduce impingement and increase survival. Dual flow screens are described as having low & high pressure spray; 3.2 x 12.7 mm smoothtex mesh, vortex suppressing fish buckets. The only difference described is the shape of the baffles that guide water to the screen surface
248	DCN 11-5461	EA Engineering, Science, and Technology, Inc.	Entrainment and Impingement Studies at Oyster Creek Nuclear Generating Station	1986	Yes	Yes	Conventional screens replaced with Ristroph traveling screens with low and high pressure spray, fish buckets, in 1983-4
249	DCN 11-5529	Golder Associates, Inc.	Fish Return System Optimization Study: Summary of Results and Discussion, Considerations, and Recommendations	1999	Yes	Yes	Traveling screens with high and low pressure spray, fish pans spaced 4 ft, continuous screen operation tested

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Pre-sent?	Used?	Reasons for Use/Non-Use
	DCN 11-5400	Burns & McDonnell Engineering Company, Inc	Section 316(b) Impingement Mortality Characterization Study for the Burlington Generating Station	2007	Yes	No	Does not evaluate BTA technology
	DCN 11-5401	Burns & McDonnell Engineering Company, Inc.	Section 316(b) Impingement Mortality Characterization Study for the Dubuque Generating Station	2007	Yes	No	Does not evaluate BTA technology
	DCN 11-5402	Burns & McDonnell Engineering Company, Inc.	Section 316(B) Impingement Mortality And Entrainment Characterization Study For The Edgewater Generating Station	2007	Yes	No	Does not evaluate BTA technology
	DCN 11-5403	Burns & McDonnell Engineering Company, Inc.	Section 316(b) Impingement Mortality Characterization Study for the Fox Lake Generating Station	2009	Yes	No	Does not evaluate BTA technology
	DCN 11-5404	Burns & McDonnell Engineering Company, Inc.	Section 316(b) Impingement Mortality Characterization Study for the Lansing Generating Station	2007	Yes	No	Does not evaluate BTA technology
	DCN 11-5405	Burns & McDonnell Engineering Company, Inc.	Section 316(B) Impingement Mortality Characterization Study For The M.L. Kapp Generating Station	2007	Yes	No	Does not evaluate BTA technology
	DCN 11-5406	Burns & McDonnell Engineering Company, Inc.	Section 316(b) Impingement Mortality Characterization Study for the Nelson Dewey Generating Station	2007	Yes	No	Does not evaluate BTA technology
	DCN 11-5407	Burns & McDonnell Engineering Company, Inc.	Section 316(B) Impingement Mortality And Entrainment Characterization Study For The Prairie Creek Generating Station	2007	Yes	No	Does not evaluate BTA technology
	DCN 11-5409	ENSR Corporation	Impingement Mortality and Entrainment Characterization Study (IMECS) Basin Electric – Leland Olds Station, ND	2008	Yes	No	Does not evaluate BTA technology
	DCN 11-5409B	Basin Electric Power Cooperative	Spreadsheet: "Basin_Database Missouri River CWISs (3)"	2006	Yes	No	Does not evaluate BTA technology
	DCN 11-5410	ENSR Corporation	Basin Electric Power Cooperative Bismarck, North Dakota - 316(b) Proposal for Information Collection Leland Olds Station	2005	Yes	No	Does not evaluate BTA technology

					Impingement Data		
ID	DCN	Authors	Title	Date[a]	Data Pre-sent?	Used?	Reasons for Use/Non-Use
	DCN 11-5411	Shaw Environmental, Inc.	LPDES SECTION 316(B) SUBMITTAL -Teche Power Station, 237 Newman Street Baldwin, St. Mary Parish, Louisiana 70514	2009	Yes	No	Does not evaluate BTA technology
	DCN 11-5412	Shaw Environmental & Infrastructure, Inc	LPDES SECTION 316(B) SUBMITTAL - Coughlin (Formally Evangeline) Power Station, 2180 St. Landry Highway, St. Landry, Evangeline Parish, Louisiana	2010	Yes	No	Does not evaluate BTA technology
	DCN 11-5413	ARCADIS	Consumers Energy Company Comprehensive Demonstration Study - J.H. Campbell Generating Complex	2008	Yes	No	Does not evaluate BTA technology
	DCN 11-5416	Golder Associates Inc.	Source Water And Cooling Water Data And Impingement Mortality And Entrainment Characterization For Belle River Power Plant	2008	Yes	No	Does not evaluate BTA technology
	DCN 11-5417	EPRI - ASA Analysis & Communication, Inc.	Belews Creek Steam Station - 2006-2007 Impingement Study And Assessment Of Adverse Environmental Impact	2009	Yes	No	Does not evaluate BTA technology
	DCN 11-5418	EPRI - ASA Analysis & Communication, Inc.	McGuire Nuclear Station - 2006-2007 Impingement Study and Assessment of Adverse Environmental Impact	2010	Yes	No	Does not evaluate BTA technology
	DCN 11-5419	EPRI - ASA Analysis & Communication, Inc.	Marshall Steam Station - 2006-2007 Impingement Study and Assessment of Adverse Environmental Impact	2009	Yes	No	Does not evaluate BTA technology
	DCN 11-5420	EPRI - ASA Analysis & Communication, Inc. - Alden	Information Submitted for Best Professional Judgment §316(b) Decision-making for Duke Energy's Oconee Nuclear Station	2008	Yes	No	Does not evaluate BTA technology
	DCN 11-5421	Randall B. Lewis, Greg Seegert	Entrainment and impingement studies at two power plants on the Wabash River in Indiana	2000	Yes	No	Does not evaluate BTA technology

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Pre-sent?	Used?	Reasons for Use/Non-Use
	DCN 11-5422	Georgia Power	Spreadsheet "Preliminary summary of impinged organisms at Georgia Power - Plant Hammond, 19-20 October 2004 through the 6-7 October 2005 sampling event."	2005	Yes	No	Does not evaluate BTA technology
	DCN 11-5423	Georgia Power	Spreadsheet "GA Power Impingement data - Ga Power - Harllee Branch 2004"	2004	Yes	No	Does not evaluate BTA technology
	DCN 11-5424	Georgia Power	Spreadsheet "GA Power Impingement data - Ga Power - Kraft 2005"	2006	Yes	No	Does not evaluate BTA technology
	DCN 11-5426	Georgia Power	Spreadsheet "GA Power Impingement data - Ga power - McManus 2004"	2005	Yes	No	Does not evaluate BTA technology
	DCN 11-5425	Georgia Power	Spreadsheet "GA Power Impingement data - Ga power - McIntosh 2005"	2005	Yes	No	Does not evaluate BTA technology
	DCN 11-5427	Georgia Power	Spreadsheet "GA Power Impingement data - Ga power - Mitchell 2004 "	2006	Yes	No	Does not evaluate BTA technology
	DCN 11-5429	ENSR Corporation	Fish Impinged at Basin Electric Leland Olds Station, GRE Stanton Station, and Minnkota M.R. Young Missouri River Station, Cooling Water Intake Structures - Final Data Summary (June 2005 to June 2006)	2006	Yes	No	Does not evaluate BTA technology
	DCN 11-5430	Burns & McDonnell Engineering Company, Inc.	Section 316(b) Impingement Mortality Characterization Study for the Carl E. Bailey Generating Station	2007	Yes	No	No holding time
	DCN 11-5431	Burns & McDonnell Engineering Company, Inc.	Section 316(b) Impingement Mortality Characterization Study for the John L. McClellan Generating Station	2007	Yes	No	Does not evaluate BTA technology

					Impingement Data		
ID	DCN	Authors	Title	Date[a]	Data Present?	Used?	Reasons for Use/Non-Use
	DCN 11-5432	Burns & McDonnell Engineering Company, Inc.	Section 316(b) Impingement Mortality Characterization Study for the Thomas B. Fitzhugh Generating Station	2007	Yes	No	Does not evaluate BTA technology
	DCN 11-5433	EA Engineering, Science, and Technology	Seminole Generating Station Konawa Lake 316(B) Assessment	2010	Yes	No	Does not evaluate BTA technology
	DCN 11-5434	EA Engineering, Science, and Technology	Seminole Generating Station Konawa, Oklahoma - Phase II 316(B) Impingement Mortality Characterization Study	2007	Yes	No	Does not evaluate BTA technology
	DCN 11-5435	HDR Engineering	Information Collection Data Report in Compliance with Section 316(b) Phase II-Requirements of the Clean Water Act For Hoot Lake Plant Otter Tail Power Company	2006	Yes	No	Does not evaluate BTA technology
	DCN 11-5436	Swanson Environmental, Inc.	Cooling Water Intake Monitoring Program - January 1976 - December 1976 - Otter Tail Power Company - Hoot Lake Generating Station	1977	Yes	No	Does not evaluate BTA technology
	DCN 11-5446	Mike Godfrey, Alabama Power	Letter from Mike Godfrey, Alabama Power, to Lisa A. Biddle, USEPA. Re: Proposed National Pollutant Discharge Elimination System Rule for Cooling Water Intake Structures at Existing Facilities and Phase I Facilities, Docket ID No. EPA-HQ-OW-2008-0667; Dated October 2, 2011	2011	Yes	No	No impingement data
	DCN 11-5447	Burns & McDonnell Engineering Company, Inc.	Section 316(b) Impingement Mortality Characterization Study for the Sunbury Generation Station	2008	Yes	No	Does not evaluate BTA technology
	DCN 11-5448	PBS&J and Texas Municipal Power Agency	TPDES 02120 For Texas Municipal Power Agency's Gibbons Creek Steam Electric Station Supplemental Information For 316(B) Determination Of Best Technology Available	2006	Yes	No	Does not evaluate BTA technology

					Impingement Data		
ID	**DCN**	**Authors**	**Title**	**Date**[a]	**Data Pre-sent?**	**Used?**	**Reasons for Use/Non-Use**
	DCN 11-5456	Jacobs Engineering UK Ltd	UK Best Practice fish screening trials study	Unk.	No	No	No impingement data
	DCN 11-5457	Kinectrics North America Inc.	Valley Power Plant: Impingement Mortality And Entrainment Characterization Study Report	2008	Yes	No	Does not evaluate BTA technology
	DCN 11-5452	Shaw Environmental, Inc.	2006-2007 Impingement & Entrainment Study NRG Huntley Power, LLC. Huntley Steam Station	2007	Yes	No	No holding time
	DCN 11-5408	ENSR Corporation	CWA §316(b) Impingement Mortality and Entrainment Characterization Study (IMECS): Astoria Generating Station	2007	Yes	No	No holding time
	DCN 11-5474	Horwitz, R. J.	Impingement Studies (Chapter 8) In: Lecture Notes on Coastal and Estuarine Studies. Ecological Studies in the Middle Reach of the Chesapeake Bay: Calvert Cliffs.	1987	Yes	No	Does not evaluate BTA technology
	DCN 11-5465	Public Service Electric and Gas Company	1999 Annual Report	2000	Yes	No	No holding time
	DCN 11-5466	Public Service Electric and Gas Company	1995 Annual Report	1996	Yes	No	No holding time
	DCN 11-5467	Public Service Electric and Gas Company	1996 Annual Report	1997	Yes	No	No holding time
	DCN 11-5468	Public Service Electric and Gas Company	1997 Annual Report	1998	Yes	No	No holding time
	DCN 11-5469	Public Service Electric and Gas Company	1998 Annual Report	1999	Yes	No	No holding time
	DCN 11-5516	White, J.C. and M.L. Brehmer	Third National Workshop on Entrainment and Impingement -- Eighteen-Month Evaluation of the Ristroph Traveling Fish Screens	1977	Yes	No	No holding time

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Pre-sent?	Used?	Reasons for Use/Non-Use
	EPA-HQ-OW-2008-0667-2989	Gulf Power	Plant Scholz 316(b) Impingement Mortality Characterization Study	2009	No	No	Does not evaluate BTA technology
	DCN 11-5513	Freshwater Physicians, Inc.	Belle River Power Plant Fish Entrainment and Impingement Study, 1990-1991	1991	Yes	No	Does not evaluate BTA technology
	DCN 11-5504	Dominion Nuclear Connecticut, Inc.	Millstone Power Station Survival Study Results for the Aquatic Organism Sluiceway at Unit 2	2001	Yes	No	Does not evaluate BTA technology
	DCN 11-5455	Kinectrics Inc.	Bay Shore Power Plant Fish Entrainment And Impingement Study Report	2007	Yes	No	Does not evaluate BTA technology
	DCN 11-5512	Lawler, Matusky & Skelly Engineers	Brayton Point Station Unit No. 4 Aquatic Biological Monitoring Program Angled Screen Intake Evaluation, First Annual Interim Report	1985	Yes	No	Duplicative of study already in the data
	DCN 11-5488	Texas Instruments Incorporated Ecological Services	Collection Efficiency and Survival Estimates of Fish Impingement on a Fine Mesh Continuously Operating Traveling Screen at the Indian Point Generating Station for the Period 8 August to November 1978	1979	Yes	No	Limited Impingement Data
	DCN 11-5528	Environmental Science and Engineering, Inc.	An Assessment of the Fish Return System at the Jacksonville Electric Authority Northside Generating Station, Jacksonville, Florida	1985	Yes	No	Limited Data
	DCN 11-5477	Environmental Consulting Services, Inc and Lawler, Matusky, and Skelly, Inc	1995 Supplemental Impingement Studies with an Assessment of Intake-Related Losses at Salem Generating Station.	1996	Yes	No	Data not representative of one year
	DCN 11-5458	First Energy	Impingement and Entrainment Data from Bay Shore	2008	Yes	No	Does not evaluate BTA technology
	EPA-HQ-OW-2008-0667-2955	Alabama Power Company	316(b) Impingement and Survivability Study: Plant Gorgas	2012	Yes	No	Draft report and limited data

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Present?	Used?	Reasons for Use/Non-Use
	DCN 11-5521	Anderson, R.D.	Impingement of Organisms at Pilgrim Nuclear Power Station	1985	Yes	No	Does not evaluate BTA technology
	DCN 11-5464	Northeast Utilities Service Company	The effectiveness of the Millstone Unit 1 Sluiceway in Returning Impinged Organisms to Long Island Sound	1986	Yes	No	Does not evaluate BTA technology
	DCN 11-5487	Ecological Analysts, Inc.	Impingement survival studies at the Roseton and Danskammer Point Generating Stations: progress report. August 1978	1978	Yes	No	Does not evaluate BTA technology
	DCN 5-4329	Tom Thompson	Intake modifications to reduce entrainment and impingement at Carolina Power & Light Company's Brunswick Steam Electric Plant Southport NC	2000	Yes	No	Duplicative of study already in the data
	DCN 11-5471	Ecological Analysts, Inc.	Bowline Point Generating Station Entrainment and Impingement Studies	1976	Yes	No	Holding time exceeded 96 hr
	DCN 11-5517	Ecological Analysts, Inc.	Moss Landing Power Plant Cooling Water Intake Structures 316(b) Demonstration	1983	Yes	No	Does not evaluate BTA technology
	DCN 11-5481	Lawler, Matusky & Skelly Engineers	Intake Technology Review Oswego Steam Station Units 1-6.	1992	Yes	No	Does not evaluate BTA technology
	DCN 11-5518	Love, M.S., M. Shandhu, J. Stein, K. Herbinson, R.H. Moore, M. Mullins, and J.S. Stephens	Analysis of Fish Diversion Efficiency and Survivorship in the Fish Return System at San Onofre Nuclear Generating Station	1989	Yes	No	Does not evaluate BTA technology
	DCN 11-5525	D.M. Chase	Survival Rates of Fishes and Macroinvertebrates Impinged on the Vertically Revolving Intake Screens of a Power Plant on Galveston Bay, Texas	1978	Yes	No	Does not evaluate BTA technology
	DCN 11-5486	Ecological Analysts, Inc	Bowline Point Generating Station entrainment abundance and impingement survival studies, 1981 annual report	1982	Yes	No	Holding time exceeded 96 hr

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Pre-sent?	Used?	Reasons for Use/Non-Use
	DCN 11-5491	Ecological Analysts, Inc.	Bowline Point Impingement Survival Studies 1975-1978 Overview Report	1979	Yes	No	Holding time exceeded 96 hr
	DCN 11-5462	Tatham, T. R., Danila, D. J., Thomas, D. L.	Ecological Studies for the Oyster Creek Generating Station Progress Report for the Period September 1975- August 1976 Volume One	1977	Yes	No	Does not evaluate BTA technology
	DCN 12-5457	Consolidated Edison Company of New York, Inc.	Preliminary Investigations into the Use of a Continuously Operating Fine Mesh Traveling Screen to Reduce Ichthyoplankton Entrainment at Indian Point Generating Station	1977	Yes	No	Duplicative of study already in the data
	DCN 11-5520	Reider, R.H.	Alternative Screen Wash Survival Study at the Monroe Power Plant April-September, 1983	1984	Yes	No	Does not evaluate BTA technology
	DCN 11-5495	Ecological Analysts, Inc.	Impingement Survival Studies at Roseton and Danskammer Point Generating Station Progress Report December 1977	1977	Yes	No	Does not evaluate BTA technology
	EPA-HQ-OW-2008-0667-2955	Alabama Power Company	Biological Information Collection Results: Plant Gadsden Steam Electric Generating Company	2008	No	No	Does not evaluate BTA technology
	DCN 11-5414	Consumer Power Company	An Evaluation of Cylindrical Wedge-wire Screens at Cooling Water Intakes in Lake Michigan	1979	No	No	No impingement data
	DCN 11-5415	Consumers Energy Company - The Detroit Edison Company	Consumers Energy Company and The Detroit Edison Company - Ludington Pumped Storage Project; Project No. 2680 - Annual Report of Barrier Net Operation for 2010	2010	No	No	Does not evaluate BTA technology
	DCN 11-5428	ENSR Corporation	Proposal for Information Collection Stanton Station	2006	No	No	Does not evaluate BTA technology

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Pre-sent?	Used?	Reasons for Use/Non-Use
	DCN 11-5438	Tom Thompson	Intake Technologies Used at the Brunswick Steam Electric Plant to Achieve a Reduction in Impingement Mortality to a Level Similar to Closed Cycle Cooling	2011	Yes	No	Duplicative of study already in the data
	DCN 11-5492	Ecological Analysts, Inc.	Comprehensive Study of the Survival of Fishes Commonly Impinged at the Bowline Point Electrical Generating Station Hudson River, New York	1982	Yes	No	Duplicative of study already in the data
	DCN 11-5519	Lawler, Matusky, & Skelly Engineers	Danskammer Point Angled Screen Facility: Evaluation	1986	Yes	No	No impingement data
	DCN 11-5496	Ecological Analysts, Inc.	Estimates of Impingement Mortality for Selected Fish Species at the Danskammer Point Generating Station 1975-1980	1982	Yes	No	No impingement data
	DCN 11-5485	Muessig, P. H.; Hutchison, J. B. Jr.; King, L. R.; Ligotino, R. J., and Daley, M	Survival of fishes after impingement on traveling screens at Hudson River power plants. IN: Science, Law, and Hudson River Power Plants: A Case Study in Environmental Impact Assessment. American Fisheries Society	1988	Yes	No	No impingement data
	DCN 11-5511	Ecological Analysts, Inc.	Evaluation of the Effectiveness of a Continuously Operating Fine Mesh Traveling Screen for Reducing Ichthyoplankton Entrainment at the Indian Point Generating Station	1979	Yes	No	Does not evaluate BTA technology
	DCN 11-5503	Ecological Analysts, Inc.	Impact of the Cooling Water Intake at the Indian River Power Plant: A 316 (b) Evaluation	1978	Yes	No	Does not evaluate BTA technology
	DCN 11-5478	Foster, J. R. and T. J. Wheaton	Losses of Juvenile and Adult Fishes at the Nanticoke Thermal Generating Station due to Entrapment, Impingement and Entrainment.	1981	Yes	No	Does not evaluate BTA technology
	DCN 11-5501	Stone & Webster Corp.	Larval Impingement Survival Study, Prairie Island Nuclear Generating Plant	1980	Yes	No	No impingement data

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Pre-sent?	Used?	Reasons for Use/Non-Use
	DCN 11-5480	Kuhl and Mueller	Annual Report on Fine Mesh Vertical Traveling Screens Impingement Survival Study.	1988	Yes	No	Not a representative study
	DCN 11-5470	Heimbuch, D.G.	Clean Water Act § 316 (b) Demonstration; Appendix F and Appendix G	1999	Yes	No	Duplicative of study already in the data
	DCN 11-5524	D.L. Breitburg and D.A. Reiher	Finfish and Blue Crab Impingement and Survival at the H.A. Wagner Generating Station for Baltimore Gas and Electric Company, Final Report	1988	Yes	No	No impingement data
	EPA-HQ-OW-2008-0667-2256	MACTEC Engineering and Consulting	Impingement Monitoring, Eastman Chemical Company (Kingsport, Tennessee)	2011	Yes	No	No impingement mortality data
	EPA-HQ-OW-2008-0667-2243	Tenera Environmental Services	Open Coastal Power Plants Using Once-Through Cooling	2011	Yes	No	No impingement mortality data
	EPA-HQ-OW-2008-0667-2229	ENSR Corporation/AECOM	Impingement Mortality and Entrainment Characterization Study (IMECS) Montana Dakota Utilities – RM Heskett	2008	Yes	No	No impingement mortality data
	EPA-HQ-OW-2008-0667-2140	Tenera Environmental Services	CWA §316(b) Impingement Mortality and Entrainment Characterization Study: 2009-2010 Summary Report (Year 4)	2011	Yes	No	No impingement mortality data
	DCN 12-5414	Donald R. Dummermuth	A Report on the Environmental Impact of the Cooling Water Intake Structure at the Dover Municipal Light Plant	1989	Yes	No	No impingement mortality data
	DCN 4-1327	John Balletto and Sheldon Zabel	Clifty Creek Station Demonstration Document	1978	Yes	No	No impingement mortality data
	DCN 12-5436	Loos, J.L.	Evaluation of Benefits to PEPCO of Improvements in the Barrier Net and Intake Screens at Chalk Point Station Between 1984 and 1985	1986	Yes	No	Does not evaluate BTA technology
	DCN 11-5480	Kuhl and Mueller	Fine Mesh Vertical Traveling Screens Impingement Survival Study	1988	Yes	No	Duplicative of study already in the data

					Impingement Data		
ID	DCN	Authors	Title	Date[a]	Data Pre-sent?	Used?	Reasons for Use/Non-Use
	DCN 2-013L-R10	Energy Impact Associates, Inc.	Fish Impingement and Entrainment Studies at Tanners Creek Power Plant	1978	Yes	No	No impingement mortality data
	DCN 5-4379	Sharma, R.K. and J.B. Palmer	Larval Exclusions for Power Plant Cooling Water Intakes	1978	Yes	No	Contains impingement mortality data (from other studies)
	DCN 9-4668	Tenera Environmental Services	Logan Generation Plant Intake Screen Performance Entrainment Study	1996	No	No	No impingement mortality data
	DCN 7-4515	Krueger, J.F., J.O. Rice, and R.G. Otto	Screen Monitoring at Allen Station	1974	Yes	No	Does not evaluate BTA technology
	DCN 10-5448	Loren D, Jensen	Third National Workshop on Entrainment and Impingement Section 316(b) Research and Compliance	1976	Yes	No	Duplicative of study already in the data
	EPA-HQ-OW-2008-0667-2140	Tenera Environmental Services	CWA §316(b) Impingement Mortality and Entrainment Characterization Study: 2010-2011 Summary Report (Year 5)	2011	Yes	No	Does not evaluate BTA technology
	EPA-HQ-OW-2008-0667-3080	Oklahoma Gas & Electric Company	Horseshoe Lake Generating Station 2006 Phase II 316(b) Impingement Mortality Characterization Study	2007	Yes	No	Does not evaluate BTA technology
	EPA-HQ-OW-2008-0667-3080	Oklahoma Gas & Electric Company	Muskogee Generating Station 2006 Phase II 316(b) Impingement Mortality Characterization Study	2007	Yes	No	Does not evaluate BTA technology
	EPA-HQ-OW-2008-0667-3080	Oklahoma Gas & Electric Company	Seminole Generating Station 2006 Phase II 316(b) Impingement Mortality Characterization Study & Assessment	2007	Yes	No	Does not evaluate BTA technology
	EPA-HQ-OW-2008-0667-3080	Oklahoma Gas & Electric Company	Sooner Generating Station 2006 Phase II 316(b) Impingement Mortality Characterization Study	2007	Yes	No	Does not evaluate BTA technology
	DCN 7-4522	Bruce, D.	1986 Newton Lake Impingement Monitoring: Progress Report	1986	Yes	No	No impingement mortality data
	DCN 12-5431	Commonwealth Edison Company	316(b) Demonstration La Salle Generating Station Makeup Water Intake System	1976	No	No	No impingement mortality data

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Pre-sent?	Used?	Reasons for Use/Non-Use
	DCN 7-4529	NUS Corporation	316(b) Demonstration for the Sherburne County Generating Plant Units 1 and 2 on the Mississippi River Near Becker, Minnesota	1976	Yes	No	No impingement mortality data
	DCN 7-4523	EA Engineering	316(b) Monitoring at Newton Power Station, 1983-84	1984	Yes	No	No impingement mortality data
	DCN 12-5423	Roy F. Weston, Inc.	An Ecological Study of the Effects of the Brunner Island SES Cooling Water Intakes	1977	Yes	No	No impingement mortality data
	DCN 12-5446	R. Goosney	An Efficient Diversion/Bypass System for Atlantic Salmon (Salmo Salar) Smolt and Kelt in Power Canals	1997	No	No	No impingement mortality data
	DCN 12-5430	Geo-Marine, Inc.	An Impingement Study at Kentucky Utilities' Pineville Electric Generating Station on the Cumberland River	1975	Yes	No	No impingement mortality data
	DCN 12-5445	Taft, E.P. and Y.G. Mussalli	Angled Screens and Louvers for Diverting Fish at Power Plants	1978	No	No	No impingement mortality data
	DCN 5-4349	Sunset Energy Fleet LLC	Application for Certification of a Major Electric Generating Facility	2000	No	No	No impingement mortality data
	DCN 12-5444	Ott, R.F. et al	Arbuckle Mountain Hydro Vertical-Axis Fish Screens	1988	No	No	No impingement mortality data
	DCN 7-4527	Alabama Power Company	Barry Steam Electric Generating Plant 316(b) Demonstration	1977	Yes	No	No impingement mortality data
	DCN 12-5443	Heimbuch, D.G.	Biological Efficacy of Intake Structure Modifications	1999	Yes	No	Duplicative of study already in the data
	DCN 12-5442	Stone & Webster Engineering Corporation	Biological Evaluation of a Modular Inclined Screen for Protecting Fish at Water Intakes	1994	Yes	No	No impingement mortality data
	DCN 8-4504	Parsons Engineering Science	Cooling Water Biofouling Control Study at Pfizer Inc. - Groton, Connecticut	1998	No	No	No impingement mortality data
	DCN 12-5411	South Carolina Public Service Authority	Cross Generating Station Cooling Water Intake Structure 316(b) Demonstration	1980	No	No	No impingement mortality data

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Pre-sent?	Used?	Reasons for Use/Non-Use
	DCN 12-5429	PBS&J	Draft Interim Report Barney M. Davis Power Station Impingement and Entrainment Nueces County, Texas	2007	Yes	No	No impingement mortality data
	DCN 12-5440	Lawler, Matusky, and Skelly	Effectiveness Evaluation of a Fine Mesh Barrier Net Located at the Cooling Water Intake of the Bowline Point Generating Station	1994	No	No	No impingement mortality data
	DCN 12-5441	Lawler, Matusky, and Skelly	Effectiveness Evaluation of a Fine Mesh Barrier Net Located at the Cooling Water Intake of the Bowline Point Generating Station 1994 Barrier Net	1996	No	No	No impingement mortality data
	DCN 12-5438	Northeast Utilities service Company	Effectiveness of a Louver Bypass System for Downstream Passage of Atlantic Salmon, Smolts, and Juvenile Clupeids in the Holyoke Canal, Connecticut River, Holyoke, MA	1997	No	No	No impingement mortality data
	DCN 5-4393	Martin Marietta Environmental Systems	Effects of Screen Slot Size, Screen Diameter, and Through-Slot Velocity on Entrainment of Estuarine Ichthyoplankton Through Wedge-Wire Screens	1984	No	No	No impingement mortality data
	DCN 12-5439	McIninch, S.P. and C.H. Hocutt	Effects of Turbidity on Estuarine Fish Response to Strobe Lights	1987	No	No	No impingement mortality data
	DCN 12-5435	Normandeau Associates, Inc.	Efficiency of the Louver System to Facilitate Passage of Emigrating Atlantic Salmon Smolts at Vernon Hydroelectric Station, Spring 1995	1996	No	No	No impingement mortality data
	DCN 7-4510	Ecological Analysts, Inc.	Elrama Power Station Entrainment and Impingement Data Report	1978	Yes	No	No impingement mortality data
	DCN 12-5437	Neitzel, D.A., T.J. Clune, and C.S. Abernathy	Evaluation of Rotary Drum Screens Used to Project Juvenile Salmonids in the Yakima River Basin, Washington, USA	1990	No	No	No impingement mortality data

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Pre-sent?	Used?	Reasons for Use/Non-Use
	DCN 12-5432	Patrick, P.H. and R.S. McKinley	Field Evaluation of a Hidrostal Pump for Live Transfer of American Eels at a Hydroelectric Facility	1987	No	No	No impingement mortality data
	DCN 12-5410	U.S. DOI Fish and Wildlife Service	Final Biological Opinion on Colorado-Ute Electric Association's Nuclear Station Upgrade	1992	No	No	No impingement mortality data
	DCN 12-5412	USDA Rural Electrification Administration	Final Environmental Impact Statement Related to the Proposed Clover Project	2004	No	No	No impingement mortality data
	DCN 12-5413	US NRC	Final Environmental Statement Related to the Operation of River Bend Station	1985	No	No	No impingement mortality data
	DCN 12-5428	Frey, P.J	Finding of Fact for Widows Creek and Colbert Stream Stations	1976	No	No	No impingement mortality data
	DCN 12-5419	Dames and Moore	Fish Entrainment Studies Final Report	1993	No	No	No impingement mortality data
	DCN 1-3075-BE	Taft, E.P.	Fish Protection Technologies: A Status Report	2000	No	No	No impingement mortality data
	DCN 7-4503	Texas Instruments Inc.	316(b) Demonstration at Bailly Station Units 7 and 8	1976	Yes	No	No impingement mortality data
	DCN 12-5417	Rittenhous, R.C.	Power Plant Cooling Systems: Trends and Challenges	1979	No	No	No impingement mortality data
	DCN 8-4510	Union Electric Co.	Callaway Plant Evaluation of Cooling Water Intake Impacts on the Missouri River	1986	Yes	No	No impingement mortality data
	DCN 12-5422	NALCO Environmental Sciences	The Evaluation of Thermal Effects in the Missouri River Near Cooper Nuclear Station 316 A and B	1975	No	No	No impingement mortality data
	DCN 12-5425	WAPORA, Inc.	316(b) Studies at E.D Edwards Station Final Report	1981	Yes	No	No impingement mortality data
	DCN 12-5424	Tampa Electric Co.	Big Bend Station 316 Demonstration	1977	No	No	No impingement mortality data
	DCN 2-013L-R5	The Cincinnati Gas and Electric Co.	316(b) Demonstration Walter C. Beckjord and Miami Fort Power Stations	1979	No	No	No impingement mortality data
	DCN 1-3022-BE	Geo-Marine, Inc.	316(b) Demonstration for the W.H. Sammis Generating Station	1978	No	No	No impingement mortality data

					Impingement Data		
ID	DCN	Authors	Title	Date[a]	Data Pre-sent?	Used?	Reasons for Use/Non-Use
	DCN 2-013L-R4	American Electric Power Service Corporation	Kyger Creek Station Demonstration Document	1981	Yes	No	No impingement mortality data
	DCN 1-3016-BE	EA Science and Technology	Final Report: Clifty Creek Station Impingement Study and Impact Assessment	1987	No	No	No impingement mortality data
	DCN 2-013L-R2	JH Balletto, American Electric Power	Tanners Creek Plant Demonstration Document	1978	No	No	No impingement mortality data
	DCN 7-4528	Alabama Power Company	Gorgas Steam Electric Generating Plant 316(b) Demonstration	1975	Yes	No	No impingement mortality data
	DCN 12-5433	Donald P. Jarrett	Hydraulic Evaluation of Traveling Belt Fish Screens at Weeks Falls	1989	No	No	No impingement mortality data
	DCN 12-5434	Schuler, V.J., and L.E. Larson	Improved Fish Protection at Intake Systems	1975	No	No	No impingement mortality data
	DCN 12-5427	Chas T. Main, Inc.	Informational Package on Water Use, Intake, and Discharge	1986	No	No	No impingement mortality data
	DCN 12-5460	McNabb, C.D., C.R. Liston, and S.M. Borthwick	In-Plant Biological Evaluation of the Red Bluff Research Pumping Plant on the Sacramento River in Northern California: 1995 and 1996	1998	No	No	No impingement mortality data
	DCN 7-4560	Equitable Environmental Health, Inc.	Labadie Power Plant Entrainment and Impingement Effects on Biological Populations of the Missouri River	1976	Yes	No	No impingement mortality data
	DCN 7-4519	Burton, W.H.	Larval Fish Entrainment at the Fort Drum HTW Cogeneration Facility, Fort Drum, New York	1993	No	No	No impingement mortality data
	DCN 10-5428	Lawler, Matusky, and Skelly	Lovett Generating Station Gunderboom Evaluation Program - 1998	1998	No	No	No impingement mortality data
	DCN 10-5469	Lawler, Matusky, and Skelly	Lovett Generating Station Gunderboom Evaluation Program - 1996	1997	No	No	No impingement mortality data

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Present?	Used?	Reasons for Use/Non-Use
	DCN 12-5421	MBC Applied Environmental Sciences	NPDES 1999 Receiving Water Monitoring Report Haynes and AES Alamitos LLC Generating Stations	1999	No	No	No impingement mortality data
	DCN 2-031A	Mussalli, Y.G., E.P. Taft III, and J. Larsen	Offshore Water Intakes Designed to Protect Fish	1980	No	No	No impingement mortality data
	DCN 5-4373	Hicks, D.B.	Finding of Fact: Green River Steam Electric Station	1976	No	No	No impingement mortality data
	DCN 5-4321	Consolidated Edison Company of New York, Inc.	Ravenswood Impingement and Entrainment Report	1993	Yes	No	No impingement mortality data
	DCN 5-4348	Normandeau Associates, Inc.	Bowline Point Generating Station 1998 Impingement Studies	1999	Yes	No	No impingement mortality data
	DCN 5-4328	Aronsson, Per Olof	Environmental Effects of Cooling Water From Ringhals Nuclear Power Plant	1993	No	No	No impingement mortality data
	DCN 5-4323	Barfuss, S.L. and B. Savage	Hydraulic Model Study of Dual-Flow and Thru-Flow Screens	1998	No	No	No impingement mortality data
	DCN 5-4319	Lawler, Matusky, and Skelly	Arthur Kill Impingement and Entrainment Report - September 1991-September 1992	1993	Yes	No	No impingement mortality data
	DCN 5-4318	Normandeau Associates, Inc.	East River Generating Station Impingement and Entrainment Report, January Through December 1993	1993	Yes	No	No impingement mortality data
	DCN 5-4320	Lawler, Matusky, and Skelly	Astoria Impingement and Entrainment Studies January 1993-December 1993	1994	Yes	No	No impingement mortality data
	DCN 5-4359	Dycus, DL	Effects of Various Intake Designs on Zooplankton Entrainment	1983	No	No	No impingement mortality data
	DCN 5-4356	Neitzel, D.A., M.A. Simmons, and D.H. McKenzie	A Guidance Manual for the Input of Biological Information to Water Intake Structure Design	1981	No	No	No impingement mortality data
	DCN 7-4556	Reserve Mining Company	One-Year Study for 316(b) Biological Monitoring Final Report	1982	Yes	No	No impingement mortality data

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Pre-sent?	Used?	Reasons for Use/Non-Use
	DCN 12-5455	Hugh Smith	Operating History of the Puntledge River Eicher Screen Facility	1997	No	No	No impingement mortality data
	DCN 12-5452	Federal Energy Regulation Commission	Order Approving Downstream Fish Passage	1997	No	No	No impingement mortality data
	DCN 12-5454	Kynard, B. and C. Buerkett	Passage and Behavior of Adult American Shad in an Experimental Louver Bypass System	1997	No	No	No impingement mortality data
	DCN 4-1488	Ecological Analysts, Inc.	Port Jefferson Generating Station Entrainment Survival Study	1978	No	No	No impingement mortality data
	DCN 10-5553	Wisconsin Electric Power Company	Port Washington Power Plant Final Report Intake Monitoring Studies	1981	Yes	No	No impingement mortality data
	DCN 12-5426	Alden Research Laboratory, Inc.	Potential Alternative Fish Protection Options for the R.E. Ginna Nuclear Power Plant with Respect to 316(b) BPJ Compliance	2008	Yes	No	No impingement mortality data
	DCN 10-5591	Stone & Webster Environmental Services	Proposal for Services to Perform 1992 Blueback Herring Environmental Studies at the Little Falls Hydroelectric Project, Little Falls, New York	1991	No	No	No impingement mortality data
	DCN 12-5456	Haider, T.R. and P.H. Nelson	Protection of Juvenile Anadromous Fish	1987	No	No	No impingement mortality data
	DCN 8-4567	Applied Biology, Inc.	Report on Studies Conducted in Compliance with Condition 21 of the Putnam Plant Site Certification	1979	No	No	No impingement mortality data
	DCN 7-4518	D.T. Turner	Report on the Results of Impingement and Entrainment Monitoring of Fishes and Fish Larvae at the Dexter Cogeneration Facility Windsor Locks, CT	1991	Yes	No	No impingement mortality data
	DCN 12-5458	Northeast Utilities service Company	Response of Atlantic Salmon Smolts to Louvers in the Holyoke Canal, Spring 1992	1992	No	No	No impingement mortality data
	DCN 12-5459	Northeast Utilities service Company	Response of Atlantic Salmon Smolts to Louvers in the Holyoke Canal, Fall 1992	1993	No	No	No impingement mortality data

ID	DCN	Authors	Title	Date[a]	Impingement Data		
					Data Present?	Used?	Reasons for Use/Non-Use
	DCN 12-5447	Patrick, P.H. and A.E Christie	Responses of Fish to a Strobe Light/Air-Bubble Barrier	1985	No	No	No impingement mortality data
	DCN 12-5448	P.H. Patrick	Responses of Gizzard Shad (dorosoma cepedianum) to Different Flash Characteristics of Strobe Light	1982	No	No	No impingement mortality data
	DCN 12-5449	Normandeau Associates, Inc.	The Vernon Bypass Fishtube: Evaluation of Survival and Injuries of Atlantic Salmon Smolts	1996	No	No	No impingement mortality data
	DCN 7-4506	Energy Impact Associates, Inc.	U.S. Steel Corporation Gary Works Fish Impingement-Entrainment Study Summary Data Report	1978	Yes	No	No impingement mortality data
	DCN 12-5461	American Society of Civil Engineers	Waterpower '95 Proceedings of the International Conference on Hydropower	1995	No	No	No mortality data, only passage survival data
	DCN 12-5450	Dorratcaque, D., W. Porter, and L. Swenson	White River Fish Screen Project - Hydraulic Modeling	1996	No	No	No impingement mortality data
	DCN 12-5451	McMillen, M.D. and W. Porter	White River Fish Screen Project - Planning and Design	1996	No	No	No impingement mortality data
	DCN 10-5420	CCI Environmental Services	Zooplankton Entrainment Survival Study - Anclote Power Plant Pasco County, Florida	1996	No	No	No impingement mortality data
	DCN 7-4555	Energy Impact Associates, Inc.	Fish Impingement and Entrainment at West Penn Power Company's Hatfield Ferry Power Station	1980	Yes	No	No impingement mortality data
	DCN 12-5420	Northern Environmental Services Division	Kammer Plant: Fish Impingement and Entrainment studies	1979	No	No	No impingement mortality data
	DCN 12-5416	Paul Frey and Charles Kaplan, EPA	Finding of Fact for Allen Steam Station	1978	Yes	No	No impingement mortality data
	DCN 7-4554	Wisconsin Electric Power Company	Pleasant Prairie Power Plant: Final Report on Intake Monitoring Studies 1980-1981	1981	Yes	No	No impingement mortality data
	DCN 12-5453	J. Craig Johnson and Robert Ettema	Passive Intake System for Shallow Sand-Bed River	1988	No	No	No impingement mortality data

					Impingement Data		
ID	DCN	Authors	Title	Date[a]	Data Present?	Used?	Reasons for Use/Non-Use
	EPA-HQ-OW-2008-0667-2391	Kinetrics	Bay Shore Power Plant Cooling Water Intake Structure Information and I&E Sampling Data	2008	Yes	No	Does not evaluate BTA technology
	EPA-HQ-OW-2008-0667-2391	Mayer, Christine	Effects of Bayshore Power Plant on Ecosystem Function in Maumee Bay, Western Lake Erie, Annual Progress Report to NOAA	2011	No	No	No impingement data
	DCN 11-5473	Serven, J. T. and Barbour, M. T.	C. P. Crane Power Plant: Impingement Abundance and Viability Studies Final Report January - December 1980	1981	Yes	No	Technologies not fully documented to verify use of BTA.
	DCN 11-5498	Ecological Analysts, Inc.	Danskammer Point Generating Station Impingement and Entrainment Survival Studies, 1975 Annual Report	1976	Yes	No	Does not evaluate BTA technology.
	DCN 11-5497	Ecological Analysts, Inc.	Danskammer Point Generating Station Impingement Survival Studies 1976 Annual Report	1977	Yes	No	Does not evaluate BTA technology
	DCN 11-5493	EA Science and Technology	Estimates of Impingement Mortality for Selected Fish Species at the Roseton Generating Station 1975-1977	1985	Yes	No	Does not evaluate BTA technology
	DCN 11-5494	Ecological Analysts, Inc.	Roseton Generating Station Impingement and Entrainment Survival Studies 1975 Annual Report	1976	Yes	No	Does not evaluate BTA technology
	DCN 11-5459	Ecological Analysts, Inc.	Roseton Generating Station: Near-Field Effects of Once-Through Cooling System Operation on Hudson River Biota	1977	Yes	No	Does not evaluate BTA technology

* Some of the impingement or entrainment data reported in this document (counts and/or mortality percentages) were entered in EPA's performance study database and were summarized within a meta-analysis.

[a] Unknown (not specified)

"Data Present?" = Yes if impingement data appear in the document.
"Used?" = Yes if the data were used by EPA to establish the impingement mortality standard.

Appendix B to Chapter 11: “Non-Fragile” Species

The table in this appendix provides information about the organisms evaluated for Chapter 11.

Exhibit 11B-1 identifies the species of organisms that are not considered “fragile” and were included in the data used to develop the impingement mortality limitation.

Exhibit 11B-1. Fish Species Classified as “Non-Fragile” in Data Selected as the Basis of the Impingement Mortality Limitation

american eel
american lobster
american sand lance
atlantic cod
atlantic croaker
atlantic silverside
atlantic tomcod
banded killifish
black crappie
black sea bass
blackcheek tonguefish
blackspotted stickleback
blue crab
bluegill
bluntnose minnow
brook silverside
brown bullhead
brown shrimp
buffalos
bullhead minnow
callinectes spp. (common/lesser)
carp
catostomidae
channel catfish
chub mackerel
codfish
conger eel
croaker
crystal darter
cunner
cyprinidae (carps)
darters
emerald shiner
fathead minnow
flathead carfish
flounder
fourbeard rockling
fourspine stickleback
freshwater drum
golden redhorse
golden shiners
goldeye
goldfish
goosefish
green crab
grubby
hardback shrimp
hogchoker
johnny darter
lady crab
largemouth bass
lepomis spp.
log perch
longnose dace
lookdown
lumpfish
mottled sculpin
mud crab
mud darter
mummichog
naked goby
northern pipefish
northern puffer
northern searobin
orange filefish
orangespotted sunfish
oyster toadfish
pagarus longicarpus
pagurus pollicaris
pea crab
penaeid shrimp
penaeus
penaeus spp. (pink and white)
percidae (perches)
plains minnow
planehead filefish
pollock
pomoxis
pumpkinseed
quilback sucker
rainbow trout
red hake
red shiner
redhorse sucker
river darter
river shiner
rock bass
rock crab
rock gunnel
rough scad
round goby
sand lance
sand shiner
sand shrimp
sauger
sculpin spp.
sea trout
searobin
shorthead redhorse
shrimp
shrimp spp. (pink and white)
silver chub
silver hake
silver perch
silver redhorse
smallmouth bass
smallmouth flounder
spider crab
spot
spotfin shiner
spottail shiner
spotted hake
star drum
stonecat
striped bass
striped cusk-eel
striped mullet
striped searobin
summer flounder
tautog (blackfish)
tesselated darter
threespine stickleback
trout perch
walleye
weakfish
white bass
white catfish
white crappie
white hake
white perch
white sucker
windowpane flounder
winter flounder
yellow perch

Chapter 12: Analysis of Uncertainty

12.0 Introduction

Any scientific analysis contains some degree of uncertainty. Data used to develop the analysis may have inherent flaws, assumptions may not be entirely accurate, or outside factors may unexpectedly influence the outcome. In many cases, uncertainty can be reduced by conducting parallel analyses or verifying conclusions via alternate pathways or data sources. This chapter presents EPA's efforts to identify sources of uncertainty, evaluate how those uncertainties might affect the analyses, and consequently minimize the effects of uncertainty associated with its analyses.

12.1 Uncertainty in Technical Analysis of Impingement Mortality

12.1.1 Technology in Place and Related Model Facility Data

The detailed technical questionnaires were conducted more than 10 years prior to this final rule. Changes may have occurred at individual facilities that would affect the cost and reductions analyses such as number of intakes, intake flow, operational status, and current technology in place. (EPA did collect more current financial information to update and revise the economic analysis; see EA for more information.) Based on site visits and discussions with industry, EPA believes the technical data is still sufficiently representative of industry operations and can be used to estimate national level costs and reductions of various regulatory approaches. However, during the past 10 years some facilities have installed impingement and entrainment technologies as a result of the Phase II rule initial implementation, state policies, or other local requirements, and these may not be accounted for in the database. EPA did attempt to incorporate newly installed technologies that have or will be installed as a result of state policy requirements for California and New York. However, requirements imposed in other states during the past 10 years are not accounted for and as a result the costs and reductions of the technologies considered in the final rule are potentially overstated.

12.1.2 Costs of Additional Impingement Mortality Controls

The economic analysis presented in the EA contains estimated compliance costs for impingement mortality technologies and, for one final rule option, entrainment mortality technologies. One uncertainty EPA identified in basing compliance costs on the industry detailed technical questionnaire is how many facilities already use modified traveling screens, other technologies, or a system of technologies that are compliant or nearly-compliant with the impingement mortality standard. Similar to 12.1.1, EPA expects facilities that have installed additional technologies will have lower compliance costs than those estimated by EPA.

Another uncertainty EPA identified is whether the intake velocities reported in the technical survey are representative of the actual measured velocity at the screen face that will determine compliance with the velocity standard. EPA expects that where facilities inaccurately or inadvertently measured velocity at a different location would provide a velocity that is slightly lower than the screen face. Where the velocity is sufficiently close to 0.5 fps, EPA expects variable speed drives provide a low cost method to reduce flow, and thus velocity (see Chapter 8). Thus such facilities will be able to use either the 0.5 fps compliance alternative or the system of technologies alternative.

Fish Handling and Return System Costs

The final rule requires that all facilities meet one of seven compliance alternatives that perform comparably or better than the 12 month impingement mortality standard calculated from modified traveling screens with a fish return and handling system. Facilities choosing modified traveling screens or a system of technologies that includes traveling screens incur costs to install new fish handling and return systems assuming all of these facilities employed existing traveling screen. EPA finds this to be a reasonable assumption given the predominance of unmodified traveling screen use; see Chapter 4 for more information.

However, EPA does not have current data on the number of traveling screens that would be deemed “modified” screens, such as Ristroph screens or post-Fletcher modifications. For example, EPA does not have data on the number of large power plants that have already modified their intakes as a result of the 2004 Phase II rule. As a result of this uncertainty, EPA conducted a sensitivity analysis on total costs by revising estimated costs to include fish handling and return systems (as well as new modified Ristroph screens[192]) to all facilities employing conventional traveling screens that were deemed to have met the 0.5 fps threshold.[193] In other words, EPA assumed zero facilities have modified screens with a fish return. Under this conservative assumption, EPA estimates the manufacturing sector as a whole would be assigned an additional $12.3 million and electric generators as a whole would be assigned an additional $50.7 million. Therefore, EPA estimates the total rule costs with the revised assumption that no facility has a modified traveling screen in place would be approximately 13 percent higher. Based on site visits and performance studies showing some facilities do in fact have a fish handling and return, EPA concludes the final rule approach is a more reasonable cost estimate. Facilities that have modified screens but do not have a fish return system would incur considerably less costs, and facilities that already have a fish return would incur no incremental costs as a result of this requirement. This is further likely a conservative estimate of costs because the rule does not preclude the use of different technologies to meet the requirements; for example, dual-flow screens and WIP screens would meet the rule definition of “modified traveling screens.” Where these technologies are feasible, vendor data and pilot studies suggest such technologies are less costly than a retrofit of existing traveling screens; however, these types of screens are not included in the cost methodology. See Chapter 6 for more information.

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[192] Technology module 1 was assigned; it includes both the screen replacement costs and costs for a new fish handling and return system.

[193] No additional costs would be assigned to facilities that met the velocity threshold with: modified Ristroph screens, an offshore intake location (velocity cap or wedgewire), perforated pipe, filter bed, or porous dike.

Capital Costs Influence on Annualized Costs

For those technologies with a 20 year lifespan, the annualized costs for any capital investment (or one time up-front cost) reflect 9.3 percent of the costs (at 7 percent interest) to 10.8 percent (at 9 percent interest). In other words, a 10 percent increase in the total capital costs of a compliance technology will result in a 1 percent increase in annualized costs. Many of the compliance technologies have a useful life greater than 20 years, or would require repair and upgrade versus total replacement. In these cases, EPA's costs are likely overstated. EPA's costs include a 10 percent contingency factor for the fish handling and return, and a 20 percent combined total cost contingency factor. Therefore the total annual costs are not heavily influenced by the uncertainty in the capital costs for compliance technology. See Section 12.4 for further discussion of annual cost components such as monitoring and reporting.

12.1.3 Cost Drivers for Impingement Mortality Controls

As part of its review of the compliance costs for impingement mortality, EPA also examined the cost drivers for impingement mortality. EPA identified several aspects of the cost methodology that are highly sensitive to variations in frequency of employment and/or their installation costs. None of the identified factors would have a significant impact on compliance costs, therefore EPA did not update the cost model further. See DCN 12-6652 for additional information.

12.1.4 Analysis of a "De Minimis" Provision

EPA has included a provision in the final rule that permits the Director to conclude that a site-specific determination of BTA for impingement mortality is warranted at sites with exceptionally low rates of impingement. While EPA has not included this provision in its final estimate for compliance costs, EPA did conduct a brief analysis to examine the cost implications of such a provision.

EPA intends that this provision would not be utilized often. EPA randomly selected 5 percent of the model facilities. This subset of facilities represents the facilities that either impinge an exceptionally low number of organisms or are located on a waterbody that has exceptionally low levels of impingeable organisms. With an even distribution of facilities, EPA would expect this provision would result in lower total rule compliance costs of approximately 5 percent. Because these same facilities have exceptionally low rates of impingement, this provision would have minimal effect on the estimated reductions in IE resulting from the rule requirements. This random method of classification is independent of operational and technological characteristics of the facility; as a result, some of the facilities identified as "compliant" under this hypothetical scenario were already compliant using some other compliance mechanism (e.g., intake velocity below, 0.5 fps, closed-cycle cooling, etc.). Exhibit 12-1 illustrates the breakdown of facilities.

Exhibit 12-1. Compliance Assessment of Randomly Selected De Minimis Intakes

	Number De minimis Intakes	Number De minimis Intakes IM Non-Compliant	Number De minimis Intakes IM Compliant
Generators	21	11	10
Manufacturers	18	8	10
Total	39	19	20

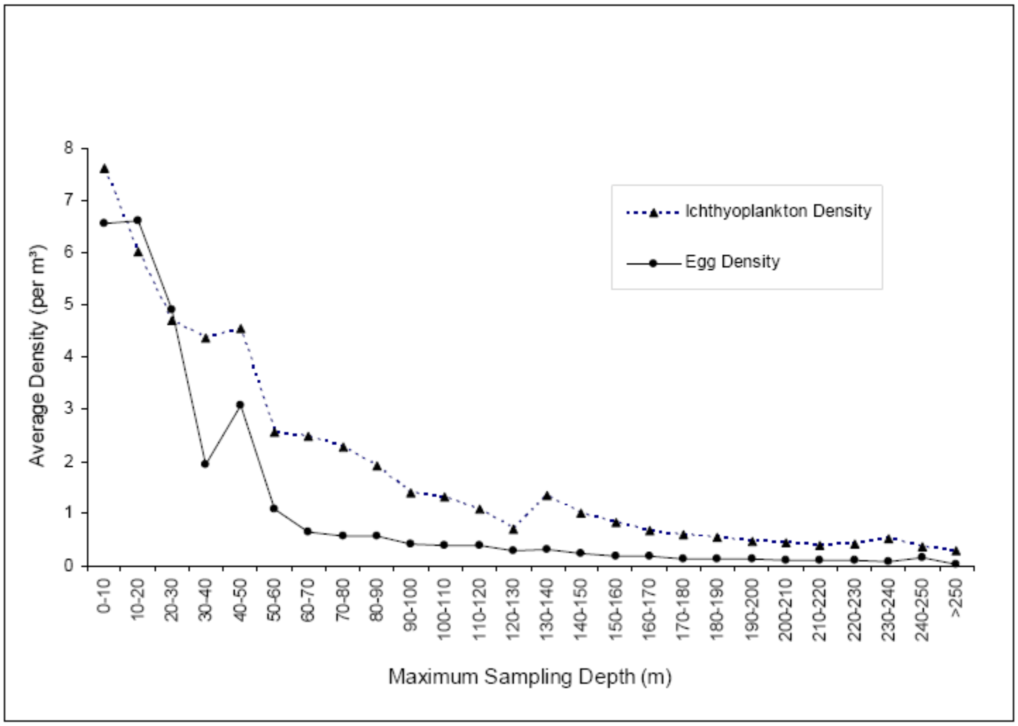
As seen in the table, in the random sample analyzed, approximately half of the facilities selected as compliant under a de minimis scenario were already compliant under a different compliance alternative. This analysis serves to suggest that EPA's cost estimates for impingement mortality is likely overstated by 2 to 5 percent as some facilities may achieve compliance under the de minimis provision.

12.2 Uncertainty in Technical Analysis of Entrainment Mortality

12.2.1 Intake Location

The ability of a facility to locate an intake structure to significantly reduce entrainment, and to a lesser extent impingement, depends on waterbody and species found at that site. Of particular interest is the relationship of ichthyoplankton density to water depth as a potential technology for reducing impingement and entrainment mortality. EPA used a Southeast Area Monitoring and Assessment Program (SEAMAP) database to characterize ichthyoplankton (fish eggs and larvae) presence, composition, and density within the Gulf (see DCN 9-5200; FDMS ID EPA-HQ-OW-2004-0002-1956). A plot of average ichthyoplankton densities against depth at 10 meter intervals (see Exhibit 12-2 below) shows general trends were similar between egg and larval fish densities. The densities of both declined most rapidly from 0 to 60 meters in depth. As depth increased past 60 meters, the decline in ichthyoplankton and egg densities was less pronounced. This is consistent with the understanding that the euphotic zone (zone light available for photosynthesis) does not extend beyond the first 100 meters (328 feet) of depth.

Exhibit 12-2. Average Densities (N/m3) of eggs and ichthyoplankton sampled at a given maximum depth intervals in the Gulf of Mexico



The findings of the SEAMAP analysis for the Gulf of Mexico are generally supported by the cited papers from the Pacific and British coasts and the data from the Gulf of Maine, i.e., that ichthyoplankton densities increase as depth and distance from shore decrease, and that abundance is greatest at depths less than 100 meters. These data did not show consistent I and E reductions, or in many cases did not result in a high level of IM and E performance as a result of intake location. Further, as a result of these analyses, EPA has determined only intakes far offshore in the ocean or Great Lakes could achieve such distances and depths, therefore the technology is not available for most facilities. Other facility data shows that substantial decreases in density are not observed even far offshore. Therefore, EPA did not further consider intake location as a high performing technology and thus did not consider location as a candidate technology for national standards. This analysis supports EPA's decision to consider existing offshore velocity caps at least 800 feet offshore; the performance data for these existing facilities shows equal or better performance than the BTA IM performance standard. This analysis also supports EPA's decision to require newly installed velocity caps to demonstrate the velocity cap in combination with the intake location meets or exceeds the BTA IM performance standard. EPA anticipates for some facilities, an intermediate distance/depth/density where an order of magnitude decrease in density would occur, and allows for such a site-specific demonstration under the "systems of technologies" compliance alternative.

12.2.2 Space Constraints

Chapter 10 discusses EPA's approach to estimating the number of facilities that would face space constraints (as well as constraints for noise and tower plume). At some facility sites, EPA believes retrofitting to closed-cycle cooling is extremely difficult or perhaps infeasible due to a lack of space for the cooling tower. Space constraints, in particular water-front acres, may preclude expanding an existing intake structure such as to reduce intake velocity by adding intake bays or due to fine mesh installations. In the majority of cases, EPA found dense urban locations simply have no space available on the site to locate a cooling tower of sufficient size. In many cases, the surrounding land is occupied, making it impossible (or prohibitively expensive) to acquire additional land. EPA did not assess the costs of additional land purchases in its analysis, because EPA does not have adequate data on which to predict the number of facilities with space constraints, their locations, and the availability and costs of neighboring land.

Based on site visits, permits, and other reports, EPA assumed an upper bound of one in four, or 25 percent, of facilities would face space constraints. EPA based this assumption on the observation that approximately 95 percent of the 47 known sites with a ratio of 160 acres per 1000 megawatt (MW) and above would have sufficient acreage to retrofit mechanical draft cooling towers. For the 25 observed sites with a ratio less than 160 acres per 1000 MW, as many as 20 percent of the facilities would likely be space constrained.

Another GIS-based approach EPA conducted (instead of the population density method presented in Chapter 10) was to use a data layer from the National Atlas that identified "urban" areas. Similar to the population density approach, this data layer would identify areas that are likely to have high densities of populated space and would be the most likely to face significant challenges in siting a retrofit cooling tower.

The urban GIS layer identified a similar profile for land availability. For example, it identified approximately 30 percent of facilities as located in an urban area (as examined by the number of facilities, percentage of total flow, and percentage of total cost).[194] Electric generators were identified as urban slightly less often and manufacturers were identified slightly more often. Small businesses were much less likely to be identified as urban.

The primary drawback of this data was that it was not clear how the urban identification had been designated. Given the similarities in the two approaches and their projected outcomes, EPA opted to use the population density approach, as it provides a better defined and more reliable algorithm.

EPRI reported at least 6 percent of sites (7 out of the 125 evaluated) were deemed "infeasible" on the basis that no space was available on which to locate a cooling tower (see DCN 10-6951, EPRI Technical Report 1023452). The 125 sites are not statistically representative, and it is impossible to ascertain any skew that may be present in the evaluated sites (for example, whether smaller sites or rural sites are overrepresented).

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[194] EPA also examined the universe of facilities by waterbody type, state, cooling system type, capacity utilization, fuel type, and manufacturing sector. In each case, there were no significant trends that would affect the broader assumption that approximately 30 percent of facilities are in an urban location.

Further, EPA does not have access to the facility level data, and is therefore unable to conduct further analysis of the 125 sites. Nevertheless, EPRI's report supports EPA's assertion that some sites have space constraints, and that there is significant uncertainty around the frequency with which space constraints for facilities would preclude installing or retrofit to closed-cycle cooling.

12.2.3 Development of Cooling Tower Costs

In the Phase I and 2004 Phase II rules, EPA used a cost estimation approach that it developed to calculate estimated costs for closed-cycle cooling. This approach was derived from cost modules that specify the necessary activities, materials, and contingencies that comprise the total cost.

In 2007, EPRI provided a new cost estimation tool to EPA. The EPRI tool calculated costs based on documentation for over 50 closed-cycle retrofits and/or detailed feasibility studies. EPA also used cooling tower engineering assessments conducted for California as part of the Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling. These detailed assessments were conducted on 19 existing coastal plants. Maulbetsch and others have documented cooling tower assessments and presented such findings in symposiums and proceedings; for example see "Issues Associated with Retrofitting Coastal Power Plants" (DCN 10-6955) and "Water Conserving Cooling Status and Needs" Energy-Water Needs" (DCN 10-6953).

Exhibit 12-3 provides a comparison of the cooling tower compliance costs derived using the EPRI Tower Calculation Worksheet to compliance costs derived using the EPA Methodology used in 2004 Phase II for an option where cooling towers were retrofitted to facilities on estuaries and oceans. For purposes of this sensitivity analysis, the costs shown are for a 350 MW facility with a cooling water flow of 200,000 gallons per minute (gpm) (288 million gallons per day [mgd]). The 2004 EPA costs are adjusted to 2009 dollars. It is assumed that the costs shown contain comparable structural components although it is not known whether the EPRI costs include condenser upgrades so this element of the 2004 EPA costs is shown separately (not all cooling tower retrofits require condenser upgrades therefore EPA's costs would not apply condenser upgrade costs to all facilities). The 2004 EPA costs shown do not include any intake modification costs. EPA operations and maintenance (O&M) costs are for gross O&M meaning they do not include reductions for baseline technology O&M such as once through pumping energy costs. Therefore EPA's O&M are potentially overstated.

Exhibit 12-3 shows that the two costing methodologies produce similar results. While the 2004 EPA non-nuclear and nuclear facility capital costs are comparable to the EPRI "easy" and "average" costs, the EPA's O&M cost are higher for nuclear facilities. The highest and lowest total annualized costs (based on 20-year service life and discount rate of 5 percent) cover a similar span for both methodologies especially if condenser upgrades are included. Thus, use of either method should produce comparable national costs.

Exhibit 12-3. Cost Comparison for a 350 MW Plant with Cooling Flow of 200,000 gpm (288 MGD)

	Tower Type	Capital Costs - Tower and Piping	Condenser Upgrade[1]	O&M	Tower Electricity Usage (Pumps & Fans)	O&M Total[2]	Annualized Capital Not Including Condenser Upgrade[3]	Annualized Condenser Upgrade	Total Annualized Cost Not Including Condenser Upgrade	Annual Heat Rate Penalty[4]
EPA Phase II	**Redwood Tower**	$27,000,000	$5,200,000	Included in O&M Total	Included in O&M Total	$2,900,000	$2,200,000	$400,000	$5,100,000	?
	Redwood Tower - Nuclear	$49,000,000	$9,400,000	Included in O&M Total	Included in O&M Total	$4,200,000	$3,900,000	$800,000	$8,100,000	?
EPRI Costs	**Easy**	$32,000,000	-	$260,000	$2,600,000	$2,860,000	$2,600,000	-	$5,460,000	$1,040,000
	Average	$53,000,000	-	$260,000	$2,600,000	$2,860,000	$4,200,000	-	$7,060,000	$1,040,000
	Difficult	$83,000,000	-	$260,000	$2,600,000	$2,860,000	$6,600,000	-	$9,460,000	$1,040,000

[1] EPA did not include full condenser upgrade costs at all facilities. Not sure If EPRI included them

[2] O&M shown does not include deduction for baseline O&M pumping energy

[3] Annualized Capital Cost Factor (20 yr at 5%) = 0.08

[4] Heat rate penalty not included in O&M total or Total Annualized Cost

The advantages of using the EPRI costing approach include:

- It can produce a range of capital costs (i.e., the ability to use easy, average and difficult settings);
- The underlying data is based on actual retrofits, and is likely a more robust representation of costs;
- The EPRI worksheet can be readily modified to generate facility costs while the EPA method is more complex and would require considerable spreadsheet development;
- Input variables can be readily generated; and
- The methodology generates all costs including the energy penalty costs.

12.3 Uncertainty in Benefits of I&E Controls

12.3.1 Reductions in Impingement and Entrainment by Region

EPA's analysis of reductions used data from studies across several EPA Benefits Regions (see the BA for further information). There are four major kinds of uncertainty that may lead to imprecision and bias in EPA's I&E mortality analysis: data, structural, statistical, and engineering uncertainty. These are discussed in detail in Section 1.1 of the BA. In response to these potential limitations, EPA conducted a sensitivity analysis exploring the extent to which baseline impingement and entrainment (I&E), and therefore the corresponding potential reductions in I&E attributable to installation of compliance technology, changes as a result of combining or isolating studies in the various benefits regions. The studies I and E losses on a per unit flow (mgd) basis are presented in terms of Age-1 Equivalents in Exhibit 12-4. The sensitivity analysis is based on the regions, studies, and methodology used for the proposal.

Exhibit 12-4. Impingement and Entrainment Losses Per Unit Flow

Region	Studies	AIF	Average Study I losses in A1E per MGD	Average Study E losses in A1E per MGD
(Freshwater Regions)				
Inland (all)	44	139,178	4,457	1,924
Great Lakes	11	19,047	2,489	569
subtotal	55	158,225	4,063	1,653
(Marine Regions)				
California Coastal	18	12,300	514	23,242
Mid-Atlantic	12	28,165	4,532	33,697
North Atlantic	6	7,037	113	11,919
Gulf of Mexico	3	13,246	8,073	9,722
South Atlantic	2	7,462	7,064	735
subtotal	41	68,210	2,504	22,558
Total for all regions[a]	96	226,435	4,249	7,648

[a] Average Study I losses in A1E per mgd for all regions are flow weighted.

It appears impingement dominates the total A1E in freshwater systems, and entrainment dominates the marine regions. Due to the limited number of studies in certain regions, EPA next combined studies in those regions and recalculated the national baseline I&E. Due to most studies being conducted on waterbodies in the inland region, EPA also combined all studies by salinity, i.e., a freshwater region and a marine region. Finally, EPA combined all studies into one national region. In each case, the weight of the study (based on the actual flows reported in each study) was kept the same. In all scenarios, EPA found the change in baseline I&E increased as shown Exhibit 12-5.

Exhibit 12-5. Changes in Baseline Impingement and Entrainment

Method of combining studies without changing the weight of each study	National baseline I (A1E)	National baseline E (A1E)	National baseline I&E combined (A1E)	% change in national baseline over current approach
7 regions (current approach)	9.49E+08	1.52E+09	2.47E+09	- - -
5 regions: CA, MA, INL, GL, GoM	1.01E+09	2.21E+09	3.23E+09	+31%
2 regions, AIF wtd avg	8.56E+08	1.86E+09	2.71E+09	+10%
all regions total value	1.01E+09	1.82E+09	2.83E+09	+15%
2 regions, freshwater and marine, study average	8.56E+08	1.86E+09	2.72E+09	+10%
6 regions (GoM and SA combined)	9.56E+08	1.58E+09	2.54E+09	+3%
5 regions (GoM + SA, NA+MA combined)	1.00E+09	1.80E+09	2.81E+09	+14%

This uncertainty analysis suggests potential bias is accentuated when combining studies from different waterbodies. In particular, the extremely small number of studies in the Gulf of Mexico and the South Atlantic regions, and the significantly lower I&E attributed to those regions, is highlighted. Studies in other waterbodies show higher I&E baseline estimates, suggesting the national baseline could be as much as one-third higher than the currently used approach to regional benefits analysis. Further, there is considerable variability observed in I, E, and I&E combined (as measured in A1E).

To reduce this uncertainty, EPA collected additional studies in all regions, solicited data in the proposed rule, and considered revising the baseline I&E calculations. EPA did receive additional studies, but found that the studies reported baseline I&E rates consistent with the averages EPA already reported in the proposed rule. As EPA already found the costs justify the benefits of the final rule, EPA determined no revision to the national baseline approach was warranted. However, based on this sensitivity analysis the I and E reductions of the final rule are most likely an underestimate because EPA is using the most conservative grouping of studies out of the seven approaches identified.

12.3.2 Air Emissions Associated with Closed-Cycle

Fossil-fueled facilities may need to burn additional fuel (thereby emitting additional CO_2, SO_2, NO_X, and Hg) for two reasons: 1) to compensate for energy required to operate cooling towers, and 2) slightly lower generating efficiency attributed to higher turbine back pressure. In general, EPA expects national level emissions may increase in the short term,[195] but decrease over the long term as facilities upgrade the oldest units by replacing condensers and boilers. U.S. fleet efficiency will likely increase over the long term, resulting in lower base emissions on a per watt basis, and the turbine back pressure penalty will be further reduced resulting in lower incremental emissions.

EPA’s projected emissions due to cooling tower energy penalties include several sources of uncertainty. EPA’s economic analysis of a cooling towers based rule indicates that some units and a few facilities may close as a result of the rule. The IPM modeling used in EPA’s economic analysis indicates any closures of generating units are generally comprised of the oldest and least efficient (and therefore the highest emitting) units, resulting in a potential reduction in total air emissions as a result of these closures; see the EA for more information on this specific assessment. Additional capacity brought online to replace these facility closures will be more efficient units. In addition, the current emissions rate calculations do not reflect full implementation of the most recent air rules. For example, the 2005 Clean Air Interstate Rule (CAIR) will reduce 2003 NOx level by 53 percent in 2009 and 61 percent in 2015. Similarly, 2003 SOX levels would be reduced by 45 percent in 2010 and 57 percent in 2015. The Utility Maximum Achievable Control Technology mercury rule would require utilities to install controls to reduce mercury emissions by 91 percent. Since the actual emissions data used in EPA’s analysis does not reflect full implementation of these air rules, and since in some cases technologies to

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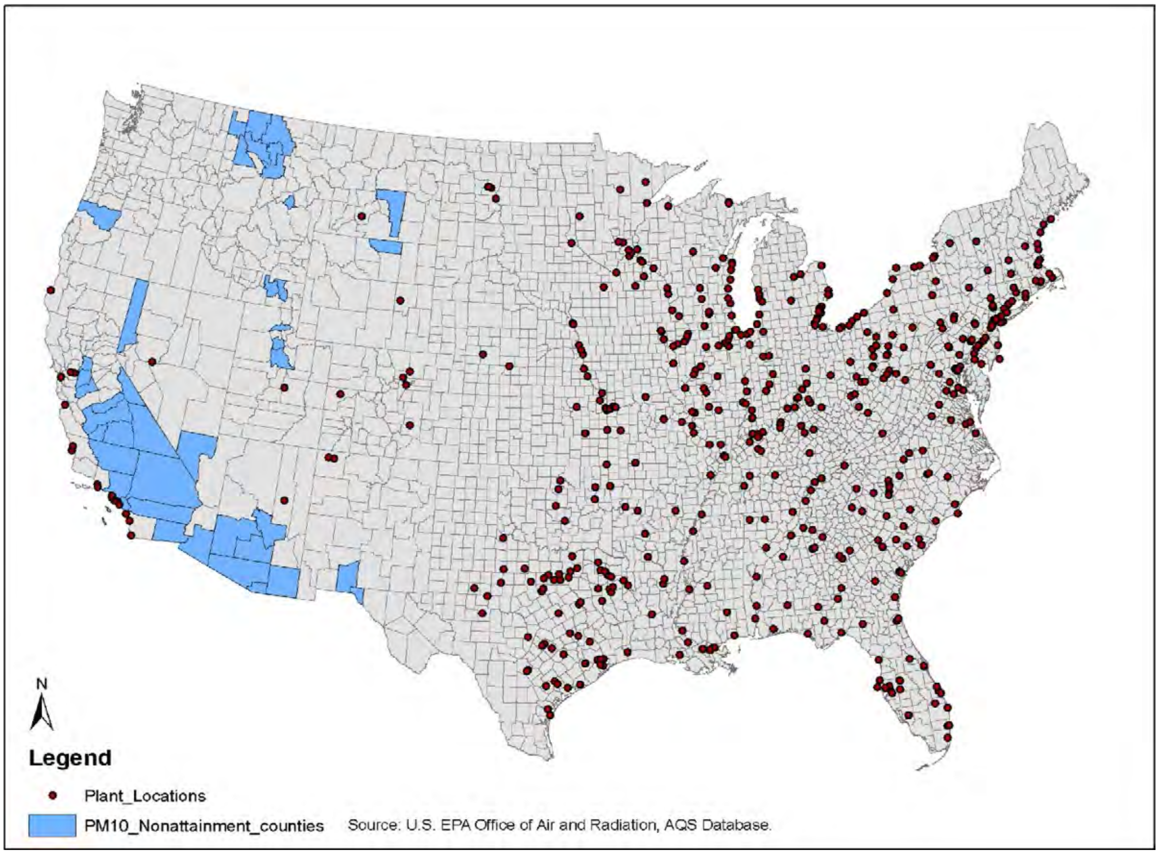
[195] In its comments on the Phase II rule (see DCN 6-5049, authors 316bEFR.211 and 316bEFR.214), the Department of Energy (DOE) predicts energy penalties ranging from 2.4 to 4.0 percent for conversion to wet cooling towers by Phase II facilities, i.e., electric generators with a DIF of greater than 50 mgd. DOE applied these penalties to case study regions and projected less than 1 percent emissions increases.

reduce emissions have yet to be installed, both the baseline and any potential increase in emissions are overstated. Finally, the latest tower fill materials and other cooling tower technology improvements provide increases in cooling capacity. In some cases cooling towers provide cooling water at lower temperatures than available from the source water, resulting in lower turbine back pressure in the summer when maximum power generation is desired.

EPA's emissions estimates also include emissions (drift) from the cooling towers themselves. Drift consists of water droplets exiting the cooling tower. Drift can result in formation of particulate matter (primarily PM_{10}) when the droplets evaporate before hitting the ground. Current cooling tower designs minimize drift to less than 0.1 percent of the circulation flow. Sustained winds and high humidity must be present for drift to reach distances of several hundred feet, therefore most power plants will not have any adverse impacts due to drift. The options considered include costs for drift eliminators – additional technology installed on the top of the cooling tower to further reduce drift to 0.0005 percent of the circulating flow. EPA has reviewed non-attainment areas for PM_{10} and has found many power plants in these areas are using dry cooling, which avoids any issues with drift.

Exhibit 12-6. Map of Non-Attainment Areas for PM10



Source: U.S. EPA Office of Air and Radiation, AQS Database.

Chapter 10 discusses the methodology to estimate incremental increases in such air pollutant emissions from retrofitting cooling towers. The approach used a generic modeling of particulate matter emissions from the cooling towers, but more site-specific analyses often use air quality modeling method AP-42. For example, Chapter 8 of EPA's "Emission Estimation Protocol for Petroleum Refineries" specifies ranked approaches to estimating losses from cooling towers. Methodology Rank 5 for cooling towers uses the total liquid drift emission factor given in AP-42 (U.S. EPA, 1995) of 1.7 lb of drift per 1,000 gallons of water (lb/10^3 gal) for induced draft cooling towers and the total dissolved solids (TDS) weight fraction to estimate PM-10 emissions. This is a conservative PM-10 emission factor in that it assumes that all TDS are in the PM-10 size range. Peer review of EPA's Office of Air Quality has further identified the method AP-42 frequently overestimates emissions.[196] The site-specific TDS fraction in the cooling water should be used when available, the site-specific TDS fraction can be estimated from the TDS of the makeup water and the cycles of concentration ratio (ratio of the measured parameter for the cooling tower water such as conductivity, calcium, chlorides, or phosphate, to the measured parameter for the makeup water), when these data are available. The following two examples of PM-10 emissions estimates calculations (DCN 10-6905) provide an additional method by which EPA can quantify an upper bound of PM emissions from cooling towers (see Exhibit 12-7 below).

In addition to the uncertainty over annual baseline emissions generated and the uncertainty over incremental increases in emissions, there is uncertainty over the environmental impacts of emissions. Four of the 15 largest users of cooling water obtain cooling water from a freshwater source; more than half of all existing facilities withdraw water from an inland fresh water river, stream, or lake. The potential for drift formation is highest where cooling water withdrawals are obtained from a saltwater environment. Further, sustained winds and high humidity must be present for drift to reach distances of several hundred feet. A review of EPA's technical questionnaires shows that 10 of the 15 largest users of cooling water (representing more than 12 percent of the total national potential withdraws) are nuclear facilities. Nuclear facilities tend to have setbacks, security perimeters, and other boundaries that are significantly distant from the generating facility that drift is unlikely to land beyond the facility property lines. However, due to the uncertainty of these site-specific factors, EPA is unable to conclude that drift will not result in an environmental impact.

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[196] See DCN 10-6905.

Exhibit 12-7. Examples of PM-10 Emissions Estimates Calculations

Example 8-6: Calculation for Methodology Rank 5 for Cooling Towers

Given: For PM-10 emissions from a cooling tower with a water recirculation rate of 25,000 gal/min, that is servicing a heat exchanger cooling a gasoline stream, and that is in service all year. Using the default average TDS weight fraction of 0.0206 (or 20,600 ppmw), the following equation should be used to calculate the annual emissions of PM-10, *EPM10*:

$$E_{PM10} = 1.7\,\frac{lb\,drift}{10^3\,gal} * 0.0206\,\frac{lb\,TDS}{lb\,drift}\,25{,}000\,\frac{gal}{\min} * 60\,\frac{\min}{hr} * 8{,}760\,\frac{hr}{yr} * \frac{1\,ton}{2000\,lb} = 230\,.\frac{ton\ PM-10}{yr}$$

Example 8-7: Calculation for Annual Emissions from Cooling Towers

Given: For PM-10 emissions from a cooling tower with a water recirculation rate of 25,000 gal/min and that is sampled monthly for TDS. Using the site-specific TDS fraction and the operating hours between measurements, equation (Eq. 8-9) should be used to calculate the annual emissions of PM-10, *E_{PM10}*.

Date	TDS Concentration (ppmw)	Hours	Emissions (ton/month)
Jan 10 (startup Jan 1)	360	96	0.044
February 4	520	600	0.398
March 4	780	672	0.668
April 4	1,100	720	1.01
May 4	1,260	720	1.16
June 4	2,300	744	2.18
July 4	3,500	720	3.21
August 4	5,500	744	5.22
September 4	4,600	744	4.36
October 4	1,700	720	1.56
November 4	2,100	744	1.99
December (shutdown Dec 1 - not operating in December)	(2,100 - Use value from previous month)	(648)	1.73
Total		7,872	24 ton/yr

Source: DCN 10-6905

12.4 Uncertainty in Model Facility Approach

Accompanying the detailed questionnaire data is a survey weight, a value that has been updated since the original survey to continue to reflect national level facility counts. Accordingly, the weights are not necessarily reflective (statistically) where subsets of the facilities less than the national level are used. EPA has updated the model facility weighting factors based on known unit and facility closures (see EA for more information on weighting factors). For example, if the total in-scope universe of affected facilities decreased from 1292 facilities down to 1265 facilities, the weighting factors changed by less than 1 percent. EPA notes this new weighting factor has no effect on individual facility costs or impacts, it merely adjusts (reduces slightly) the total national rule costs and total national rule benefits. Further, the facility weights for power plants are sufficiently close to a value of 1.0 that any variations in weight are expected to have a minimal impact on any analysis. In the case of manufacturing facilities, weights calculated for a given facility may be as high as 4, but are usually less than 2. As EPA's model facility approach is applied over such a large universe (several hundred model facilities), EPA again expects a minimal effect on any national level analysis. For transparency, this TDD identifies where facility counts and other related technical data based on the survey are provided as unweighted or weighted values.

12.5 References

Electric Power Research Institute (EPRI). 2007. Fish Protection at Cooling Water Intakes: A Technical Reference Manual.

U.S. EPA (Environmental Protection Agency). 1995. Compilation of Air Pollutant Emission Factors. Volume 1: Stationary Point and Area Sources. AP-42, Fifth Edition. Office of Air Quality Planning and Standards, Research Triangle Park, NC.