This AR-1544 contains a cover mail and a copy of the Redacted Exhibit 4 as noted in the mail.

AR-1231 contains PSNH Comments including a Redacted Exhibit 4 with Normandeau's Attachment Report

**From:** linda.landis@eversource.com
**To:** Stein, Mark
**Cc:** Gaito, Danielle; Houlihan, Damien; Taylor, Spence; Barze, Bruce
**Subject:** Re: Request Either to Remove CBI Designation from, or Provide Redacted Copy of, Certain Records
**Date:** Wednesday, October 19, 2016 12:35:08 PM
**Attachments:** Redacted Exhibit 4.pdf

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Hi Mark. As requested, I am attaching a redacted copy of Exhibit 4 to PSNH's October 2014 comments on the revised portion of the draft NPDES permit for Merrimack Station. Exhibit 4 is Enercon Services' report entitled *Assessment of 2007 Response to U.S. EPA CWA 308 Lette*r, and includes as an attachment, Normandeau Associates' *Update of Impingement Abundance and Mortality Assessment for Merrimack Station*.

As you can see, only a few references were redacted from the Enercon report. The Normandeau attachment has a number of paragraphs redacted which should continue being treated as confidential, proprietary information.

Exhibit 4, other than the limited redactions indicated, may be considered non-confidential information.

Please let me know if you need clarification related to the confidential business information. Linda

Linda T. Landis
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From: "Stein, Mark" <Stein.Mark@epa.gov>
To: Linda T. Landis/NUS@NU,
Cc: "Houlihan, Damien" <houlihan.damien@epa.gov>, "Gaito, Danielle" <Gaito.Danielle@epa.gov>
Date: 09/09/2016 02:50 PM
Subject: Request Either to Remove CBI Designation from, or Provide Redacted Copy of, Certain Records

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Hi Linda –

I have been asked by our permitting staff to contact you about the Confidential Business Information (CBI) designation of a particular submission from PSNH (now Eversource) to EPA in connection with the Merrimack Station NPDES permit proceeding. The report was submitted as an Exhibit to PSNH's October 2014 comments submitted during the 2014 Public Notice Period for the Revised Draft NPDES Permit.

Specifically, the report is titled, *Assessment of 2007 Response to U.S. EPA CWA 308 Letter*. PSNH Merrimack Station. Prepared for PSNH by Enercon Services Inc. October 2014.

This 2014 Report includes, *Attachment 1: Update of Impingement Abundance and Mortality Assessment for Merrimack Station Response Supplement to U.S. EPA CWA 308 Letter*. Prepared for PSNH by Normandeau Associates, Inc. October 2014.

Every page of both the Report and Attachment states "This Document Contains Proprietary, Company Confidential Information Subject to Business Confidentiality Claim under 40 CFR Part 2 and Comparable State Law."

We suspect that this information, which does not include cost information, may no longer need to be considered as CBI.

We ask that you please either
- inform us that the Report and/or the Attachment no longer need to be considered CBI, or
- that you provide us with redacted copies of the documents that redact any information still regarded to be CBI.

Thank you for your assistance.

Sincerely,

Mark Stein

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**THIS DOCUMENT CONTAINS PROPRIETARY, COMPANY CONFIDENTIAL INFORMATION SUBJECT TO BUSINESS CONFIDENTIALITY CLAIM UNDER 40 C.F.R. PART 2 AND COMPARABLE STATE LAW**

# ASSESSMENT OF 2007 RESPONSE TO UNITED STATES ENVIRONMENTAL PROTECTION AGENCY CWA § 308 LETTER

## PSNH MERRIMACK STATION UNITS 1 & 2
## BOW, NEW HAMPSHIRE

**Prepared for**
**Public Service Company of New Hampshire**

Prepared by:

Enercon Services, Inc.
500 TownPark Lane
Kennesaw, GA 30144

**October 2014**

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# LIST OF ATTACHMENTS

# 1 Introduction

## 1.1 Background

Public Service Company of New Hampshire's (PSNH's) Merrimack Station electrical generating facility in Bow, New Hampshire is seeking a renewal of its existing National Pollutant Discharge Elimination System (NPDES) permit. To this end, an engineering and biological assessment was prepared by Enercon Services, Inc. (ENERCON) and Normandeau Associates, Inc. (Normandeau) and submitted by PSNH to the United States Environmental Protection Agency (EPA) in November 2007 ("2007 Response") that responded to EPA's request for certain technology and fisheries information to support development of the new permit for Merrimack Station.

Following a meeting with PSNH, Normandeau, and ENERCON regarding the 2007 Response in December 2008, EPA requested that PSNH further evaluate several technologies in more detail, and submit a supplement to the 2007 Response. The 2009 Supplemental Alternative Technology Evaluation ("2009 Report") presented this additional information to EPA. Technologies evaluated included wedgewire screens, aquatic filter barriers, fine mesh traveling screens, and upgraded fish handling and return systems (FHRSs).

Subsequent to this, EPA submitted a request for information which in some cases explained items in previous EPA requests, and in other cases requested additional information not previously requested to ensure items were presented clearly. In addition, EPA requested information regarding certain assumptions and/or calculations that were used as the basis for the information provided in the 2007 Response.

The information requested was submitted by PSNH to EPA in January 2010. ENERCON created a report that individually reviewed each information request, provided clarification of the information provided in the 2007 Response, and, where necessary, conducted new analysis to respond to EPA's information request. After receiving this information, EPA issued a draft NPDES permit for Merrimack Station in September 2011. During the comment period for the draft permit, PSNH provided comments to EPA in February 2012 ("2012 Response") (Ref. 5.12).

This assessment of the original 2007 Response is provided to identify changes that have occurred since the 2007 Response was provided. These changes include regulatory changes, environmental and biological changes, and technological changes. It is possible that cumulative effect of these changes will be a change to the Best Technology Available (BTA) for Merrimack Station. This is especially possible because the way in which the impingement and entrainment BTA is determined has changed with issuance of the new Clean Water Act (CWA) Section 316(b) regulations.

## 1.2 Executive Summary

This report serves as an additional assessment regarding potential technologies for reducing entrainment at Merrimack Station. Changes in regulations, changes in technologies, and changes in cost since the time of the 2007 Response are discussed, with a focus on additional study and analysis that has yet to be performed. The primary conclusions of this report are summarized below:

- The most significant regulatory change with regard to cooling water intakes that has occurred since the 2007 Response is the finalizing of the CWA Section 316(b) rule for existing facilities. Existing power generating facilities that are designed to withdraw greater than 2 million gallons per day (MGD) of water from waters of the United States, and that use at least 25 percent of this water exclusively for cooling purposes, are subject to the BTA standard for impingement mortality unless a *de minimis* demonstration can be made or an exemption is given for a low capacity utilization factor. Per the evaluation contained in Attachment 1, the impingement rate at Merrimack Station is *de minimis* and does not require further controls as stated in the rule.
- Facilities that have an actual intake flow (AIF) of 125 MGD or greater must submit §122.21(r)(9) through (r)(13) to EPA as to aid in determination of BTA for entrainment on a site-specific basis. Merrimack Station's AIF is currently less than 125 MGD; however, given the potential for the flow rates to increase closer to the DIF in the near future, this document preemptively evaluates potential technologies with a specific focus on reducing entrainment abundance.
- Wedgewire screens remain an available technology for reducing entrainment abundance at Merrimack Station. The Johnson Screens Half Intake Screen System provides screens that are specifically designed for shallow water applications, and could be used to optimize the design presented in the 2009 Report. Additionally, recent studies have been performed that have increased the understanding on the critical performance characteristics contributing to the biological effectiveness of wedgewire screens. A site-specific study is recommended to determine the optimal slot width for wedgewire screens and to accurately measure the ambient current directions and velocities. This would allow for an optimized slot width and through-screen velocity to minimize entrainment, while also gaining a better understanding of the potential for screen fouling and frazil ice formation.
- Aquatic filter barriers (AFBs) remain an available technology for reducing entrainment abundance at Merrimack Station. The conceptual design presented in the 2009 Report included an approximately 3,500-ft long barrier in the Merrimack River. This large size was required to achieve the target through-screen velocity of 0.5 fps. However, a design optimized for entrainment reduction is not necessarily required to meet the 0.5 fps through-screen velocity requirement. Laboratory testing has been performed on AFB systems over a range of flow rates, and the results have shown that

performance of AFBs is highly species-specific. Therefore, a site-specific study is recommended to determine the allowable flow rate per square foot. The allowable flow rate per square foot may significantly exceed that which was evaluated in the 2009 Report, which would lead to a significantly reduced length.

- Facilities that are subject to the BTA standard for entrainment compliance are required to submit a Comprehensive Technical Feasibility and Cost Evaluation Study under §122.21(r)(10). A portion of this submittal is required to discuss available sources of process water, gray water, waste water, reclaimed water, or other waters of appropriate quantity and quality for use as some or all of the cooling water needs of the facility. An investigation of alternative sources of cooling water has not yet been performed for Merrimack Station. Granite Ridge, a nearby power plant to Merrimack Station, successfully uses gray water for cooling. Investigation of potential alternative sources of water is required to comply with §122.21(r)(10), and is therefore recommended.
- Variable speed pumps (VSPs) remain an available technology for reducing entrainment abundance at Merrimack Station. The 2007 Report briefly discussed the use of VSPs, which may aid in reducing intake flows for the Station during certain times of the year. However, the extent to which this flow reduction can be achieved has not yet been determined. A detailed analysis of the plant thermal heat balance is recommended to determine the extent to which flow reductions can be achieved at Merrimack Station using VSPs.
- The cost estimates provided in the 2007 Response and 2009 Report are outdated and are required to be revised. For technologies and designs that have not experienced significant change, the costs should be updated to 2014 dollars using appropriate construction cost index estimation factors. For technologies and designs that have experienced changes since they were last discussed, new Class 5 estimates per ASTM E2516-11 (Ref. 5.10) should be performed that considers construction and engineering costs. It is recognized that the cost for certain materials and proprietary technologies may scale differently than what the cost indices will capture; however, given that these are Class 5 cost estimates per ASTM E2516-11 (Ref. 5.10), general cost index estimation factors are typically used.
- Several of the evaluations required to determine BTA for entrainment, including the Benefits Valuation Study and the Non-Water Quality Environmental and Other Impacts Assessment, have not yet been performed for Merrimack Station.

In summary, the analyses and studies performed to date have determined several feasible technologies for Merrimack Station. There are other technologies that may be feasible but have not yet been fully evaluated. Of the technologies deemed feasible, detailed assessments and studies (as shown in Attachment 2) necessary to determine BTA have not yet been performed. Therefore, if the EPA Director does determine that entrainment abundance and reduction controls must be further evaluated, it is premature to state that a BTA for entrainment has been determined.

# 2 Clean Water Act Section 316(b)

The most significant regulatory change that has occurred regarding cooling water intakes since the 2007 Response is the finalizing of the CWA Section 316(b) rule for existing facilities. The new 316(b) rule (referred to hereafter as "the rule") was pre-published by EPA on May 19, 2014, with final publication in the Federal Register occurring on August 15, 2014. The regulation became effective on October 14, 2014.

Clean Water Act Section 316(b) requires that NPDES permits for facilities with cooling water intake structures (CWISs) ensure that the location, design, construction, and capacity of the structures reflect the BTA to minimize harmful impacts to the environment. Existing large electric-generating facilities were addressed in the 2004 Phase II rule, but this was subsequently remanded on January 25, 2007. Several alterations have been made to the rule since the 2007 Response that may impact the technology assessment for Merrimack Station as a part of the NPDES permit renewal process. This is because the new final CWA 316(b) rule contains changes to the way in which facilities will meet the impingement and entrainment mortality standards.

The remainder of this section includes information taken from the 316(b) rule; citations are not provided after each sentence or paragraph for brevity. This Section provides a summary-level discussion on the new rule. For exact language and further detail, 40 CFR Parts 122 and 125 of the Federal Register should be consulted. Note that, for example, 40 CFR Part 122 and §122 are used interchangeably in this report for brevity.

## 2.1 Impingement Compliance

Existing power generating facilities that are designed to withdraw greater than 2 MGD of water from waters of the United States, and that use at least 25 percent of this water exclusively for cooling purposes, are subject to the BTA standard for impingement mortality. Compliance with the BTA standard for impingement mortality may be achieved using any one of seven options delineated in the rule, as described below in Section 2.1.1. Certain facilities may be exempt from the impingement mortality standard if they are determined to have *de minimis* rates of impingement or operate with a low capacity utilization factor. The impingement rate for a facility would be deemed *de minimis* based on impingement abundance numbers or age 1 equivalent[1] abundance in relation to mean annual intake flows.

[1] Age-1 equivalents are defined in the rule as the number of individual organisms of different ages impinged and entrained by facility intakes, standardized to equivalent numbers of 1-year old fish. A conversion rate between all life history stages and age 1 is calculated using species-specific survival tables based on the life history schedule and age-specific mortality rates.

### 2.1.1 Compliance Options

Option #1 – §125.94(c)(1): Operate a closed-cycle recirculating system as defined at §125.92. This is essentially a pre-approved technology requiring no demonstration, or only a minimal demonstration, that the flow reduction and control measures function as EPA envisions. Submittal of the information delineated in §122.21(r)(2) through (r)(6) and §122.21(r)(8) is required as a part of the permit application process. The monitoring required must include measuring cooling water withdrawals, make-up water flows, and blowdown flows. The facility is required to monitor actual intake flows (the average volume of water withdrawn on an annual basis) and cycles of concentration to confirm that make-up and blowdown flows have been minimized. Biological compliance monitoring is not required.

Option #2 – §125.94(c)(2): Operate a CWIS that has a maximum through-screen design intake velocity of 0.5 fps. This is a pre-approved technology requiring no demonstration, or only a minimal demonstration, that the flow reduction and control measures function as EPA envisions. Submittal of the information delineated in §122.21(r)(2) through (r)(6) and §122.21(r)(8) is required as a part of the permit application process. The facility must submit information demonstrating that the maximum design intake velocity passing through the screens cannot exceed 0.5 fps. This maximum water velocity must be achieved during all conditions, including periods of minimum water source elevations and during periods of maximum head loss across the screens. Biological compliance monitoring is not required.

Option #3 – §125.94(c)(3): Operate a CWIS that has a maximum through-screen intake velocity of 0.5 fps. The facility must submit information demonstrating that the maximum intake velocity as water passes perpendicularly through the screen does not exceed 0.5 fps. Submittal of the information delineated in §122.21(r)(2) through (r)(6) and §122.21(r)(8) is required as a part of the permit application process. This method is similar to Option #2 (design velocity) except that the intake's maximum design velocity can exceed 0.5 fps as long as the intake is operated in a manner such that the actual, measured velocity does not. One example given in the rule is a facility that was originally designed with an intake velocity of 1.0 fps, but has achieved an actual intake velocity 0.5 fps by retiring a portion of the plant. Monitoring of the velocity at the screen face or immediately adjacent to the screen face (not the approach velocity) must be conducted daily, or a calculation must be performed demonstrating this. Additionally, the facility may be granted permission to exceed the low velocity compliance alternative for brief periods of time, such as during backwashing or back-flushing. Biological compliance monitoring is not required.

Option #4 – §125.94(c)(4): Operate an offshore velocity cap as defined in §125.92 that is installed before the effective date of the rule. This is a pre-approved technology requiring no demonstration, or only a minimal demonstration, that the control measures function as EPA envisions. Submittal of the information delineated in §122.21(r)(2) through (r)(6) and §122.21(r)(8) is required as a part of the permit application process. The velocity cap must be located a minimum of 800 ft offshore, and must contain devices such as bar racks to exclude marine animals. Additionally, the velocity cap must be designed to change the direction of the water withdrawn from vertical to horizontal, and intake flow must be monitored daily. Biological compliance monitoring is not required. If facilities choose to construct a velocity cap at an offshore location after the effective date of the rule, they would be utilizing compliance options #6 or #7 below.

Option #5 – §125.94(c)(5): Operate a modified traveling screen that meets the definition at §125.92(s). The definition requires those features of a traveling water screen that provide an appropriate level of fish protection including:

- Collection buckets that minimize turbulence;
- Guard rails or barriers to prevent loss of fish from the collection system;
- Smooth or soft screen panel materials that protect fish from descaling;
- Continuous or near-continuous rotation of screens and operation of collection equipment to recover impinged fish as soon as practical;
- Low-pressure wash or vacuum to remove collected organisms from the screen; and
- An FHRS with sufficient water flow to return fish directly to the source waterbody in a manner that does not promote re-impingement of the fish, or a large vertical drop.

For this option, the facility is required to submit a site-specific impingement technology performance optimization study that includes two years of biological sampling. The study must demonstrate that the operation of the modified traveling screens has been optimized to minimize impingement mortality. EPA notes in the rule that modified traveling screens include, but are not limited to modified Ristroph screens with a FHRS, dual flow screens with smooth mesh, and rotary screens with fish returns or vacuum returns. Submittal of the information delineated in §122.21(r)(2) through (r)(6), §122.21(r)(6)(i), and §122.21(r)(8) is required as a part of the permit application process.

Option #6 – §125.94(c)(6): Operate any systems of technologies, best management practices, and/or operational measures that the Director determines is the BTA for impingement reduction. This option allows the facility to choose the technologies, practices, and operational measures that it believes will meet the impingement mortality standard. The facility is required to submit a site-specific impingement study including two years of biological data collection demonstrating that the operation of the system of technologies, operational measures and best management practices has been optimized to minimize impingement mortality. The estimated reductions in impingement must be based on comparison of the system to a once-through cooling system with a traveling screen whose point of withdrawal from the surface of the water is located at the shoreline of the source waterbody. Submittal of the information delineated in §122.21(r)(2) through (r)(6), §122.21(r)(6)(ii), and §122.21(r)(8) is required as a part of the permit application process.

Option #7 – §125.94(c)(7): Achieve the specified impingement mortality standard. This option requires that the facility achieve a 12-month impingement mortality performance of all life stages of fish and shellfish of no more than 24 percent mortality, including latent mortality, for all non-fragile species. The rule contains specific requirements relating to how impingement shall be calculated. Compliance may be demonstrated for either the entire facility or for each individual CWIS. Submittal of the information delineated in §122.21(r)(2) through (r)(6), and §122.21(r)(8) is required as a part of the permit application process.

### 2.1.2 Information Submittals

The items below are required to be submitted to EPA as a part of the permit renewal process based on the impingement compliance alternative selected by the facility. Note that the descriptions below are summary-level only; the rule itself should be consulted for more detailed information regarding the compliance requirements.

- §122.21(r)(2) Source Water Physical Data: This submission is required to characterize the facility and evaluate the type of waterbody that is potentially affected by the CWIS. Information including size and shape of the water body, depth, salinity and temperature regimes, and other documentation is listed in the rule as being potentially applicable data to be included in this submission. This was previously submitted to EPA in April 2005 and in the 2007 Response as discussed in Attachment 1.
- §122.21(r)(3) Cooling Water Intake Structure Data: This submission is used to characterize the CWIS and evaluate the potential for impingement and entrainment of aquatic organisms. The submission should include a description of the configuration of each cooling water intake structure, DIFs, daily hours of operation, months of operation, and engineering drawings of the intake structure, and other information related to the cooling water intake system. This was previously summarized for each intake and submitted to EPA in April 2005 and in the 2007 Response as discussed in Attachment 1.
- §122.21(r)(4) Source Water Baseline Biological Characterization Data: Facilities are required to characterize the biological community in the vicinity of the CWIS and to characterize the operation of the CWIS. This was previously summarized and provided to EPA in several submittals as described in Attachment 1.
- §122.21(r)(5) Cooling Water System Data: This submission should describe operation of the cooling water system(s) and its relationship to the CWIS, the proportion of design flow that is used for each purpose, description of reductions in total water withdrawal, the number of days the system is in operation, any seasonal changes in the operation of the system, and a description of any existing impingement and entrainment technologies along with their performance. This was

previously provided to EPA in October 2005 and in the 2007 Response as described in Attachment 1.

- §122.21(r)(6) Chosen Method of Compliance with Impingement Mortality Standard: The facility must identify which compliance alternative it has chosen to meet the impingement mortality standard. Facilities choosing to comply by operating a modified traveling screen (under Option #5) must submit an impingement technology performance optimization study under § 122.21(r)(6)(i). Similarly, facilities choosing to comply by operating a system of technologies (under Option #6) that will achieve the impingement mortality standard must submit a impingement technology performance optimization study under §122.21(r)(6)(ii).
- §122.21(r)(7) is addressed under Section 2.2, Entrainment Compliance.
- §122.21(r)(8) Operational Status: The facility must provide descriptions of each unit's operating status includes age of the unit, capacity utilization for the previous five years, any major upgrades completed in the past 15 years, a description of any completed or scheduled uprates, Nuclear Regulatory Commission (NRC) re-licensing status for nuclear facilities, plans or schedules for decommissioning or replacement of units, and a description of future production schedules for manufacturing facilities. This was previously provided to EPA in October 2005 and in the 2007 Response as described in Attachment 1.

## 2.2 Entrainment Compliance

For entrainment compliance, the rule does not prescribe a single nationally applicable entrainment performance standard, but instead requires that the BTA entrainment requirement be established on a site-specific basis.

All existing facilities must submit §122.21(r)(7) and §122.21(r)(8) to EPA. Facilities that have an AIF of 125 MGD or greater must submit §122.21(r)(9) through (r)(13) to EPA as described below to aid in determination of BTA for entrainment. The requirement to submit §122.21(r)(9) through §122.21(r)(13) may be waived on a site-specific basis.

The list of items below are required to be submitted to EPA as a part of the permit renewal process based on the AIF requirements above. The rule does not require that any of the information in this Section be submitted by facilities that have an AIF of 125 MGD or less. Note that the descriptions below are summary-level only; the rule itself should be consulted for more detailed information regarding the compliance requirements.

- §122.21(r)(7) Entrainment Performance Studies: The permit applicant must submit a description of any entrainment-related biological studies conducted at the facility and provide a summary of any conclusions or results. Studies that are older than 10 years or conducted at other facilities must contain an explanation of why the data are still relevant and representative of conditions at the facility. New studies are not required to fulfill this requirement.

- §122.21(r)(9) Entrainment Characterization Study: A two-year entrainment data collection study is required, including complete documentation of the data collection period and the frequency of entrainment characterization, and an identification of the organisms sampled. An entrainment characterization study was performed at Merrimack Station from June 29, 2005 through June 28, 2007, and provided the basis for conclusions in the 2007 Response.
- §122.21(r)(10) Comprehensive Technical Feasibility and Cost Evaluation Study: The facility must submit an engineering study of the technical feasibility and incremental costs of candidate entrainment control technologies. The study must include an evaluation of the technical feasibility of closed-cycle cooling, fine-mesh screens with a mesh size of 2 mm or smaller, reuse of water or alternate sources of cooling water, and any other entrainment reduction technologies. The 2007 Response provided a technical feasibility and cost evaluation study for a few impingement and entrainment reduction technologies.
- §122.21(r)(11) Benefits Valuation Study: The facility must submit a detailed discussion on the benefits of the candidate entrainment reduction technologies evaluated in (r)(10) using data from the Entrainment Characterization Study in (r)(9). Benefits should be quantified in physical or biological units and monetized using appropriate economic valuation methods. This study has not been performed as described in Section 3.6.
- §122.21(r)(12) Non-Water Quality Environmental and Other Impacts Assessment: The facility must submit a detailed discussion of the changes in non-water quality environmental and other factors attributed to the technologies, operational measures, or both, as applicable. These changes may include impacts such as additional energy consumption, air pollutant emissions, noise, safety concerns, potential for plumes, icing, availability of emergency cooling water, grid reliability, etc. This study has not been performed as described in Section 3.6.
- §122.21(r)(13) Peer Review: The facility must provide for a peer review of the permit application studies required under §122.21(r)(10) through §122.21(r)(12).

## 2.3 Compliance for Merrimack Station

Because Merrimack Station withdraws greater than 2 MGD of water from waters of the United States, and uses at least 25 percent of this water exclusively for cooling purposes, it is subject to the 316(b) rule in general. There are several technologies evaluated in this report, demonstrating ways in which Merrimack Station may be able to achieve compliance with this rule.

From Attachment 1, based the most recent and relevant intake flows from 2011 through 2013 applied to the weekly impingement rates from the 2005-2007 characterization study, the impingement rate at Merrimack Station is approximately 0.27 percent of the national average of facilities surveyed throughout the United States that had performed impingement characterization studies during the 2004 through 2007 period. Therefore, based on the evaluation performed in Attachment 1, Merrimack Station has a *de minimis* rate of impingement (see Attachment 1 for justification) and does not require further controls as stated in the rule.

Based on operating data from 2011 – 2013, the current AIF for Merrimack Station is approximately 113.8 MGD, which falls below the threshold of 125 MGD for submittal of information regarding entrainment. However, given the potential for the flow rates to increase closer to the DIF in the near future, this document preemptively evaluates potential technologies with a specific focus on reducing entrainment abundance.

# 3 Engineering Assessment

Based on the evaluation in Attachment 1 showing that the impingement rate at Merrimack Station is *de minimis*, this section does not evaluate impingement-reducing technologies as no further controls are required. Although Merrimack Station's AIF is currently less than the 125 MGD threshold, it may increase in the future above the threshold. Therefore, this section preemptively evaluates potential technologies with a specific focus on reducing entrainment abundance.

## 3.1 Wedgewire Screens

Wedgewire screens are designed to reduce entrainment and impingement by excluding organisms from passing through the screen and by achieving low velocities due to the large size of the screens. Hydraulic bypass also occurs as a result of the shape of the screen, particularly when oriented in the direction of prevailing flow. Additionally, due to the round shape of the screens, the velocity pulling the organisms toward the screen is quickly dissipated, increasing the avoidance by organisms.

Wedgewire screens were evaluated in both the 2007 Response and the 2009 Report, including a high-level conceptual design in the 2009 Report. A range of possible slot sizes was given, but an optimal slot size was not determined. Due to this, the number of screens was not precisely determined, as the slot size affects the number of screens required for a given intake flow rate. Generally, however, a large number of screens were evaluated due to the small diameter of the screens. Because the water depth in the region in front of the CWISs is only 6 – 10 ft, 2-ft diameter cylindrical wedgewire (CWW) screens were evaluated in the 2009 Report. Reference 5.3 states that at least one-half the diameter of the CWW screens should be provided as clearance above and below the screens. With a minimum water depth of 6 ft in front of the CWIS, the maximum recommended screen diameter would have been 3 ft. Therefore, as discussed in the 2012 Response (Ref. 5.12), based on currently available bathymetry data, water depth is not an issue for 2-ft diameter CWW screens in this area. As the result of this restriction, many wedgewire screens were presented in the design, which would occupy a large area of the river. However, other wedgewire screens are available besides those of the cylindrical shape that can improve the design.

A relatively new technology that could be investigated for Merrimack Station is the Johnson Screens Half Intake Screen System. These screens are marketed as a solution for shallow water intakes, and can be installed in water that is half the depth of traditional intake screen systems (Ref. 5.4). The screen contains one curved, semi-circular surface, and one downward-facing flat surface, as shown below in Figure 3-1.

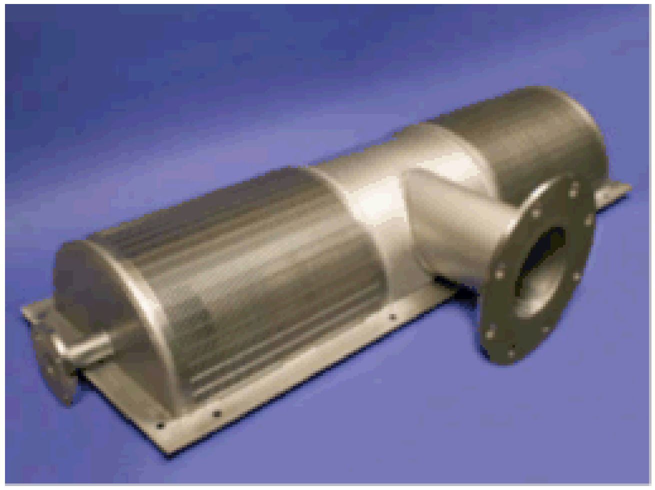

Figure 3-1: Johnson Screens Half Intake Screen System (Ref. 5.4)

One benefit to using half-cylindrical screens is that larger diameter screens can be utilized since the screens are flush with the bottom. This would likely result in fewer screens being required. Standard sizes for the half-cylindrical screens range from 12 – 96 in. diameter intake screens (Ref. 5.4). The number of screens would be determined by the size and slot width of the screens, in addition to the design through-screen velocity. A design through-screen velocity of 0.5 fps was used in the 2009 Report; however, since Merrimack Station is not subject to the BTA standard for impingement mortality as the result of a *de minimis* demonstration (see Attachment 1), this is no longer a design requirement. The slot size and design through-screen velocity can be optimized for biological efficacy and practicality of design. For the 2009 Report, a specific slot size was not selected, but a range of 1.5 – 9 mm was evaluated. Additional information that was not available at the time of the 2007 Response and 2009 Report can be utilized to further optimize the wedgewire screen design to reduce the number of screens required, thus increasing feasibility and practicality.

Recent studies (occurring subsequent to the 2007 and 2009 Reports) have been performed which have increased the understanding on the performance characteristics of wedgewire screens that can be used to increase biological efficacy of wedgewire screens. Recent research in a laboratory flume [redacted] and in the Hudson River Estuary [redacted] has demonstrated that the performance of CWW screens is related to three factors: physical exclusion by the slot width, behavioral avoidance of the intake flow by the fish, and the hydraulic bypass due to sweeping flow of river currents along the surface of the wedgewire screen in a direction perpendicular to the slot openings (i.e., parallel to the slot width). Wedgewire screens with slot widths of 2, 3, 6, and 9 mm were tested at flume velocities of

0.25, 0.50, and 1.0 fps, with through-slot velocities of 0.25 and 0.50 fps for a total of 24 combinations of slot width, flume velocity, and through-slot velocity. Physical exclusion exhibited a direct relationship to greatest body depth, and fish (eggs, larvae, or juveniles) with a greatest body depth larger than the slot width were physically excluded. Behavioral avoidance was typically higher for the smaller slot widths, and a lower through-slot velocity. Overall, avoidance and hydraulic bypass were higher at higher ratios of sweeping velocity to through-slot velocity, particularly when this ratio exceeded 1:1. These mechanistic studies demonstrated that hydraulic bypass and avoidance were the prevailing modes of effectiveness of cylindrical wedgewire screens. Exclusion also operated to reduce entrainment of organisms larger than the slot width. Therefore, an ambient current velocity of 1 fps is not necessarily required for wedgewire screens to be effective, as was presumed previously. This may allow for extension of the operating period for wedgewire screens beyond the April – July timeframe that was determined in the 2009 Report.

Based on these findings, it is recommended that a detailed study be performed to optimize the slot width for Merrimack Station. Additionally, the through-screen velocity can be designed to match that of the expected ambient currents. An optimal slot width would be that which allows for the most entrainment reduction without significant increases in the rates of fouling or clogging. Additionally, further insight can be gained on frazil ice formation to precisely quantify the available months for wedgewire screen operation. As discussed in the 2009 Report, wedgewire screens are susceptible to frazil ice formation during winter months. Therefore, the wedgewire screens would not be operated during the winter months. Based on the months in which entrainment abundance is highest, and based on the results of site-specific testing, a precise operating period would be determined based on all of the above.

A detailed study of the ambient river current direction and velocities using Acoustic Doppler Current Profiler (ADCP) or similar technology is recommended to precisely characterize the orientation of the screens and design through-slot velocities for optimal performance. Additionally, an optimal location may exist that would maximize the average sweeping current velocities. Once the ambient current velocities in front of the CWIS are well understood, the design through-screen velocity can be selected to achieve the 1:1 ratio of sweeping to through-screen velocity based on results from the studies performed. Once the optimum slot size and through-screen velocities are determined, a half intake screen system would be designed using larger diameter screens, up to 6-ft diameter screens. In combination with the potential for higher through-screen velocities, this would significantly reduce the number of screens required. A reduction in the number of screens required would serve to alleviate concerns regarding the large number of screens proposed in the 2009 Report, and the large area of the river that would be occupied by the wedgewire screens. Concerns related to interrupting recreational activities, and obstructing large areas of the river both during construction and in the final configuration, would be alleviated to an extent. As noted in Attachment 1, deployment of wedgewire screens with through-screen velocities above 0.5 fps may reduce impingement.

As noted above, a 1:1 ratio of sweeping flow to through-screen velocity is generally required for wedgewire screens to be effective. Because this requirement is less stringent than the 1 fps ambient current criteria evaluated in the 2009 Report, the operating period for the wedgewire screens can likely be extended to include periods of the year in which lower river flows have historically occurred. Additionally, the wedgewire screening system can be operated in parallel with a backup, or auxiliary intake system, that would allow for a continuous supply of water to Merrimack Station in the event that sudden blockage of the screens occurs. If such a system were included as a part of the design, the wedgewire screens could be operated during periods in which blockage may be expected. The water levels within the intake bay would be monitored continuously; and if necessary, the auxiliary intake system would be initiated to maintain plant operation. This would also prevent a large pressure differential from building up across the blocked screens, eliminating the potential for screen damage due to blockage. This would also serve to increase the potential operating period for wedgewire screens beyond the April – July timeframe that was determined in the 2009 Report.

The additional hydraulic resistance of the wedgewire screens and associated piping would also be a consideration. At low water levels, the submergence of the circulating water pumps may be challenged. Based on the results of site-specific studies, a realistic blockage factor would be applied to the wedgewire screens to ensure that sufficient screening area exists to maintain sufficient submergence for the circulating water pumps. Vortex suppression features, such as grating or modified features beneath the suction of the pumps may be required based on the expected intake water level. This would be evaluated during detailed design.

## 3.2 Aquatic Filter Barriers

As discussed in the 2007 Response and 2009 Report, AFBs are barriers that employ a filter fabric designed to allow for passage of water into a CWIS but exclude aquatic organisms. These systems are designed to be placed some distance from the CWIS within the source waterbody, and act as a filter that is impermeable to fish, shellfish, and ichthyoplankton. Therefore, it holds the potential for being an effective technology to reduce entrainment.

The 2009 Report evaluated implementation of an AFB system at Merrimack Station based on achieving a velocity of 0.5 fps through the filter. Because of the fine mesh size of AFBs, the small open area percentage led to a very large surface area needed to meet this intake velocity requirement. The 2009 Report estimated that a length of approximately 3,500 ft would be required to achieve this design velocity. This would potentially restrict activities on the water body due to the large amount of surface area that would be taken up by the AFB.

Because this assessment is focused solely on entrainment-reducing technologies, the AFB would not be required to achieve a through-screen velocity of 0.5 fps for impingement reduction purposes. This removes one of the design requirements that had previously served as a primary mechanism for selection of the very large size of AFB evaluated at Merrimack Station in the 2009 Report. Table 3-1 of the 2009 Report listed basic design considerations for the AFB system, including the flow per square foot. The conceptual design in the 2009 Report evaluated an AFB system with a flow of approximately 9 gpm/ft$^2$. However, AFB systems have been tested and shown to be effective at higher flow rates. Reference 5.9 tested the biological effectiveness of an AFB system using flow rates of 10 – 20 gpm/ft$^2$. The biological tests indicated that the ability of the AFB to prevent entrainment does decrease with increased flow rates; however, it was noted that the performance is highly species-specific. Pressure differential across the barrier was also noted to increase. This is an effect that would need to be evaluated for acceptability at Merrimack Station.

A study is recommended to determine an optimized perforation opening size and flow rate for an AFB system at Merrimack Station based on site-specific biological conditions and water source characteristics such as debris loading and biological fouling. An optimal perforation opening size and through-screen velocity would be determined based on maintaining a low level of entrainment while not increasing the impingement rate of entrainable organisms. Assuming that a flow rate between 10 – 20 gpm/ft$^2$ would provide sufficient entrainment reduction with acceptable biological fouling and pressure differential behavior, while not increasing the impingement rate, the length required for the AFB system could be considerably reduced. This would alleviate concerns regarding the length of the barrier and the large river area that would be occupied.

Additionally, a site-specific study would allow for further insight into the allowable months of operation for an AFB. As discussed in the 2009 Report, AFBs are susceptible to damage from ice floes and ice formation on the fabric panels during winter months. In order to avoid damage to the AFB system, it would need to be removed during the winter months. Based on the months in which entrainment abundance is highest, and based on the results of site-specific testing, a precise operating period would be determined.

## 3.3 Alternative Water Sources

As discussed in Section 2.2, facilities that are subject to the BTA standard for entrainment compliance are required to submit a Comprehensive Technical Feasibility and Cost Evaluation Study under §122.21(r)(10). A portion of this requirement includes discussion of available sources of process water, gray water, waste water, reclaimed water, or other waters of appropriate quantity and quality for use as some or all of the cooling water needs of the facility. Additionally, alternative sources of water, such as well water, are required to be investigated. Neither the 2007 Response nor the 2009 Report evaluated available alternative cooling water sources. Alternative water source usage is desirable in that it would reduce the amount of water withdrawn from the Merrimack River, thereby reducing entrainment mortality. Several alternative water sources that may hold promise at Merrimack Station are discussed in the subsections below.

### 3.3.1 Gray Water

Gray water can be wastewater, sewage, or other water streams that are discharged by another facility. A review of available gray water sources near Merrimack Station has not been performed, therefore it is not possible to state at this time whether this represents a feasible technology to reduce entrainment mortality by replacing a portion of the intake flow for the existing once-through system. However, there are several examples of successful uses of gray water for cooling purposes at power plants, including the largest power plant in the United States, and at least one nearby facility located on the Merrimack River.

Palo Verde Nuclear Generating Station is a three-unit nuclear power plant located near Phoenix, Arizona, and is the largest power plant in the United States by net generation (Ref. 5.14). The source of cooling water makeup for Palo Verde, including a source of makeup for the essential spray ponds, is treated sewage effluent primary from the city of Phoenix 91st Avenue treatment facility with effluent input capability also from other smaller facilities en route. The effluent is conveyed from the treatment facility to Palo Verde through approximately 35 miles of pipeline, and is treated at an onsite reclamation facility to meet the plant water quality requirements. Onsite makeup reservoirs provide for a continuous water supply in the event of temporary interruptions in the normal water source. Groundwater from onsite wells is used for other plant water uses as well (Ref. 5.15).

Granite Ridge is a 752 megawatt natural gas, combined-cycle power plant in nearby Londonderry, NH. The facility uses gray water from the nearby Manchester Sewage treatment plant to supplement its cooling water. Granite Ridge discharges the water to the Merrimack River following use (Ref. 5.8). A similar system, whereby wastewater from a nearby facility is used for direct cooling purposes, may be possible at Merrimack Station to reduce the AIFs and entrainment mortality if such a facility exists nearby.

The potential for gray water use at Merrimack Station to reduce the intake flow from the river for once-through cooling would be investigated by evaluating NPDES permits for other facilities proximal to Merrimack Station. Only facilities within a realistic distance would be investigated. The permitting implications of discharging another facility's wastewater would also need to be explored to ensure that Merrimack Station is not required to further treat the effluent beyond what the parent facility currently discharges.

### 3.3.2 Groundwater Wells

The development of groundwater supplies to reduce or replace the use of direct surface water withdrawals can be a viable option if the hydrogeologic conditions are favorable for the development of large capacity production wells. Source water for large capacity ground water supplies rely heavily on direct surface water recharge to the aquifer. The advantage of large capacity wells constructed near a surface water recharge source is primarily twofold:

- Reduced intake flows directly from the source water system; and
- Improved and/or stable water quality such as turbidity, total suspended solids, and temperature.

Generally there are two types of large capacity wells that are designed and constructed for this type of application; vertical wells and horizontal collector wells (radial wells). Because large yields are usually needed to reduce or eliminate surface water as the primary source of water, a sound understanding of the local hydrogeologic conditions is required as part of the design efforts associated with either vertical or radial collector wells.

Vertical Wells

The technology for constructing large capacity vertical wells is widely available. Depending on the local hydrogeologic conditions, vertical wells can produce between 1 – 5 MGD. In order to develop wells with larger pumping capacities, well casings would need to have diameters of 24 to 36 in. and be sufficiently deep to take advantage of local drawdown characteristics. In addition, a nearby source or recharge needs to be available.

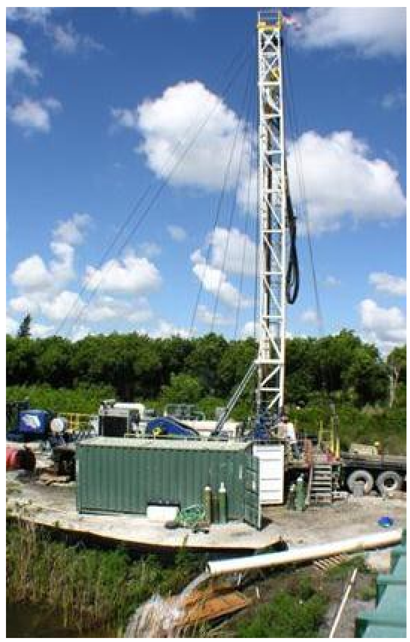

Figure 3-2: Vertical well during construction

The advantages of vertical wells are:

- Common well construction with many companies are available to construct these types of wells;
- Stable water quality and potentially improved water quality over surface water intakes; and

The disadvantages of vertical wells are:

- Each well is limited in terms of yield by the available drawdown in the aquifer and consistent source of recharge to the aquifer.

- If the desired yield is large, it can take a large number of vertical well to develop the necessary capacity and a large land area depending on the spacing requirements.
- There can be significant O&M associated with a large number of vertical wells.

In summary, vertical wells are a technology that could be explored to provide between 1 – 5 MGD of water per well, based on site-specific conditions. A study is recommended to investigate local hydrogeologic conditions to determine whether this technology is viable for Merrimack Station to reduce intake flows from the Merrimack River.

Radial Collector Wells

Radial collector wells consist of a vertical caisson with a diameter of 13 ft. or larger that is sunk to the base of the aquifer. Screens are projected from the caisson horizontally in a radial pattern. These screens extend as much as 250 ft. from the caisson in sand and gravel aquifer system. Typically, collector wells are designed to take full advantage of surface water recharge from a river or other source such as the ocean. Screens are projected under the river and water is filtered through the river bed, significantly improving water quality. If favorable hydrogeologic conditions are present, yields from radial collector wells can be greater than 40 MGD from a single well. To provide pumping redundancy and efficiency, several pumps can installed within the caisson of a radial well.

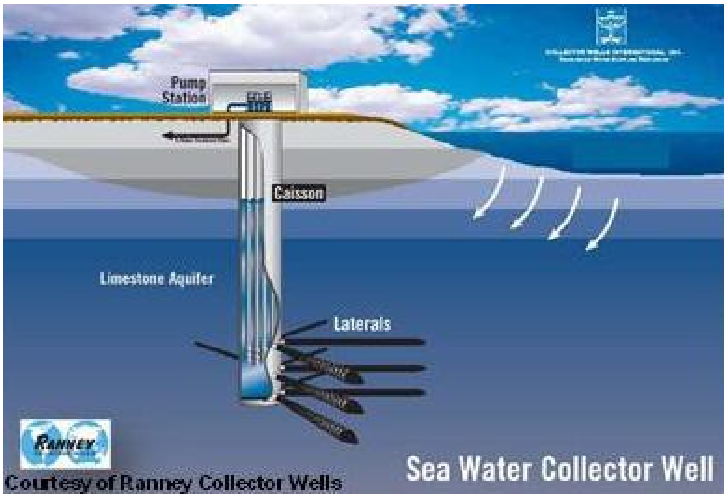


Figure 3-3: Diagram of a radial collector well

Advantages of radial collector wells are:

- High yield from a single well
- Water quality is stable and may improve over surface water intakes
- O&M is less than vertical wells on a per-gallon basis; and

Disadvantages of radial collector wells are:

- More expensive to construct than single vertical wells; however, this cost is made up in increased yield and long-term O&M;
- Wells are heavily dependent on direct surface water recharge to maintain large yields.

Grand Gulf Nuclear Generating Station, located on the Mississippi River, uses four radial wells to provide well water to the plant service water system during normal operation and normal shutdown conditions. The radial well system provides makeup to the standby service water system, but the radial well system is not nuclear safety-related. The radial wells are large reinforced concrete caissons installed vertically, that extend into the loose sediments adjacent to the Mississippi River. Water is derived from the Mississippi River via induced infiltration and enters the caisson through horizontal screened pipes (called laterals) that extend radially from the caisson into the sediments. Water is collected in the radial wells and pumps into a single underground main header which supplies the plant service water system during normal operation. During startup of the wells, the radial well collector flow may be diverted to the river to purge any sand or sediment that has collected in the wells from the laterals. Each of the four radial wells has two pumps, rated up to 5,000 gpm each. Therefore, up to 40,000 gpm (~58 MGD) can be collected from these wells if all pumps run at full capacity (Ref. 5.11).

In summary, radial collector wells are a technology that could be explored to provide up to 40 MGD of water per well based on site-specific conditions. A study is recommended to investigate local hydrogeologic conditions to determine whether this technology is viable for Merrimack Station to reduce intake flows from the Merrimack River.

### 3.3.3 Summary and Recommendations

A study is recommended to investigate possible sources of alternative cooling water to reduce the water withdrawn from the Merrimack River. Potential technologies include gray water, radial wells, and groundwater wells as discussed above. If a study is not performed in the near-term, the study may be required to be performed as a part of the 316(b) rule submittal process regardless.

## 3.4 Variable Speed Pumps

The 2007 Response briefly discussed VSPs as a potential technology for reducing intake flows from the Merrimack River on a seasonal basis. Several other methods for reducing the intake flows were explored, including two-speed pumps and throttling of the pump discharge; however, the use of VSPs is expected to be more cost-effective and provide a higher degree of operational flexibility. The four circulating water pump motors would be replaced with single-speed pump motors and variable frequency drives. The variable frequency drive would adjust the frequency of the alternating current power source supplied to the motor, thus controlling the speed of the motor and the resulting flow rate. A primary advantage of VSPs is that flow rate can be controlled over a continuous rather than discrete range (i.e., all possible speeds within the operating range are available).

Reductions in flow may be possible using VSPs at Merrimack Station, which will aid in reducing the AIFs for the Station during certain times of the year. However, the extent to which this flow reduction can be achieved has not been thoroughly studied. Permitting limitations and operational constraints limit the amount of flow that can be reduced on a site-specific basis. An analysis would be required to determine the allowable flow reduction that will maintain compliance with the NPDES permit limits while allowing for an appropriate buffer. A buffer is necessary because the Station cannot operate directly on the limit at all times. An instantaneous variation or transient would cause the limitation to be exceeded. Reducing cooling water intake flow reduces the efficiency of plant cooling systems. This reduces condenser cooling and negatively impacts power plant heat cycle efficiency in most cases. Additionally, there are condenser design criteria that need to be maintained during plant operation – the reduction of flow using VSPs would need to be evaluated against the condenser design criteria.

Detailed thermal analyses of the plant heat balances have not been performed. Due to the reduced condenser cooling efficiency, higher condenser pressures and condensate temperatures would result, impacting overall thermal efficiency of the Station. As mentioned in the 2012 response (Ref. 5.12), the impact to Station thermal efficiency cannot be precisely determined without detailed modeling of the plant power conversion system using a software program such as Performance Evaluation of Power System Efficiency (PEPSE) or General Electric's GateCycle plant performance monitoring software. Since the Station currently does not use VSPs, operational data on the performance of the Station across various condenser flow rates does not exist. The modelling software would enable one to take current plant configuration and operating parameters, and vary certain inputs to predict outputs such as power generation, and equipment operating parameters.

For VSPs, the PEPSE or GateCycle model of Merrimack Station would be run over a range of circulating water inlet temperatures, and at several different flow rates for each temperature. If a model of the Station does not currently exist, one would be created based on plant configuration and operating parameters and baselined against observed operating outputs to ensure that realistic model outputs are being achieved. Once the model is run over a range of circulating water temperatures and flow rates, analytical relations would be developed to allow for interpolation of plant performance operating data based on an input temperature and flow rate. A limiting parameter, such as a maximum condenser operating pressure, or maximum hotwell temperature, would be defined as the limiting parameter. Once this limiting parameter is defined, a maximum allowable flow reduction at each inlet circulating water temperature would be determined. With this information known, historical water temperature data would be used to characterize the performance of the Station over a period of multiple years.

This type of analysis would allow for precise characterization of the limitations of VSPs due to the plant heat cycle and condenser limitations, and determine the amount of cooling water flow required at various river temperature conditions. This would also allow for characterization of the allowable flow reductions to maintain compliance with the NPDES permit. Therefore, a detailed analysis is recommended to determine the potential entrainment benefits for VSPs.

## 3.5 Updates to Cost Estimates

The project engineering and construction cost estimates that were previously provided in Attachment 4 of the 2007 Response are out-of-date due to changes in construction cost indices, and advancements and lessons learned for each of the technologies. Furthermore, given the aforementioned recommended studies and conceptual designs for certain technologies (wedgewire screens, AFBs, etc.), the construction and engineering cost estimates should be revisited based on the refined conceptual designs.

The cost estimates that were previously provided in Attachment 4 of the 2007 Response are required to be updated. The cost estimate for technologies where no significant advances to the technology have been made, and where no changes are made to the conceptual design, should be reviewed and updated to 2014 dollars using construction cost index estimation factors. It is recognized that the cost for certain materials and proprietary technologies will scale differently than what the cost indices will capture; however, given that these are Class 5 cost estimates per ASTM E2516-11 (Ref. 5.10), use of general cost index estimation factors is an acceptable practice. For technologies where the conceptual design is revised to incorporate advances and lessons learned, a new Class 5 estimate per ASTM E2516-11 (Ref. 5.10) should be performed that considers construction and engineering costs.

## 3.6 Additional CWA 316(b) Requirements

In determining the BTA for entrainment mortality, certain information is required to be submitted to EPA that will aid in making an informed decision that incorporates site-specific conditions and characteristics. Certain technologies may be more cost beneficial or prohibitive based on certain characteristics of the facility in question, and there may be local or regional characteristics that rule out certain technologies. For example, a facility with a high capacity utilization factor may receive more benefit from a certain technology on a per-dollar basis than a similar facility with a low capacity utilization factor. A facility that is located near residential or commercial areas may face more difficulty in permitting a cooling tower due to icing or fogging concerns that may arise due to interaction with the surrounding roads, bridges, etc.

For this reason, the rule requires facilities with a DIF of greater than 125 MGD to submit additional information to characterize entrainment and assess the costs and benefits of installing various potential technological and operational controls. As discussed in Section 2.2, these facilities must submit information under §122.21(r)(11) Benefits Valuation Study, and under §122.21(r)(12) Non-Water Quality Environmental and Other Impacts Assessment. The Benefits Valuation Study would use data from §122.21(r)(9) to evaluate the benefits of each candidate technology evaluated in §122.21(r)(10). The benefits are to be quantified in physical or biological units and monetized using appropriate economic valuation methods. This would include incremental changes in the impingement mortality and entrainment of individual fish and shellfish for the exposed life stages, estimation of changes in stock and harvest levels of commercial and recreational species, and description of any economic monetization methods used. The study must also identify other benefits to the environment and nearby community, including improvements for mammals, birds, and other organisms and aquatic habitats. This evaluation is required to be peer reviewed by a qualified person or organization with the appropriate credentials. At this point, no such Benefits Valuation Study has been performed for any of the candidate technologies discussed. Therefore, it would be premature to state that a BTA for entrainment has been fully evaluated.

The facility is also required to submit an evaluation of Non-Water Quality Environmental and Other Impacts under §122.21(r)(12). The facility must discuss the changes in environmental and other factors not water quality-related that are attributed to the candidate technologies or operational measures. Potential impacts that are to be evaluated include, but are not limited to, the following:

- Energy consumption;
- Air pollution or emissions and their health and environmental impacts;
- Noise;
- Safety concerns, such as the potential for plumes and icing;
- Grid reliability;
- Plant reliability, including availability of cooling water;
- Consumptive water use;
- Impacts of construction, including navigation, traffic, noise, safety, air emissions, water ecology (sediment, underwater noise), nighttime lighting;
- Aesthetic impacts, both permanent and during construction;
- Environmental justice;
- Archaeological and historic resources;
- Other permitting impacts.

Without such an evaluation, it is possible that a technology that is better from a CWA perspective, but worse from an overall environmental perspective, could be prescribed as BTA for entrainment. Therefore, the rule requires a comprehensive evaluation of non-water quality related environmental impacts. Similar to the Benefits Evaluation Study, a peer review is required by a qualified person or organization holding the appropriate credentials. At this point, no such Non-Water Quality Environmental and Other Impacts Assessment has been performed for any of the candidate technologies discussed. Therefore, it would be premature to state that a BTA for entrainment has been fully evaluated.

# 4 Conclusion

According to the evaluation contained in Attachment 1, Merrimack Station has a *de minimis* rate of impingement. As described in the rule, these facilities with *de minimis* rates of impingement do not require further controls to address impingement mortality. Therefore, the candidate technologies evaluated for complying with the new 316(b) rule should not include consideration for impingement reduction.

The current AIF for Merrimack Station is below the threshold of 125 MGD for submittal of information regarding entrainment. However, given the potential for the flow rates to increase closer to the DIF in the near future, potential technologies are preemptively evaluated with the sole focus on reducing entrainment abundance. Given that essentially all of the entrainment occurs over a few months during the spring and summer (Ref. 5.1, p. 89), there are technologies available such as wedgewire screens or AFBs that could be seasonally deployed and provide substantial decreases in entrainment abundance comparable to closed-cycle cooling. Other technologies such as VSPs and alternative water sources may be available to provide reductions in intake flow from the Merrimack River to further reduce entrainment abundance; however, thorough evaluation of these technologies to quantify their effectiveness has not been performed. Given the likelihood that similar entrainment reduction to closed-cycle cooling can be achieved by these alternative technologies, additional study is warranted on these technologies as described in this report.

# 5 References

**5.1** Response to United States Environmental Protection Agency CWA §308 Letter, PSNH Merrimack Station Units 1 & 2. November 2007.

**5.2** Supplemental Alternative Technology Evaluation, PSNH Merrimack Station Units 1 & 2. October 2009.

**5.3** Johnson Surface Water Intake Screens, Product Application Guide.

**5.4** Johnson Screens Half Intake Screen System: A Solution for Shallow Water Intakes. http://www.johnsonscreens.com/content/half-screen-intake-flyer-us-english. Accessed October 3, 2014.

[redacted]

[redacted]

[redacted]

**5.8** Granite Ridge Energy Power to Londonderry and New England. http://www.londonderrynh.net/2009/08/granite-ridge-energy-power-to-londonderry-and-new-england/10474. Accessed October 5, 2014.

**5.9** EPRI Technical Report 1005534, Laboratory Evaluations of an Aquatic Filter Barrier (AFB) for Protecting Early Life Stages of Fish. December 2004.

**5.10** ASTM E2516-11, "Standard Classification for Cost Estimate Classification System," ASTM International, 2011.

**5.11** Grand Gulf Nuclear Station Updated Final Safety Analysis Report (UFSAR). May 28, 2013.

**5.12** Response to Environmental Protection Agency's Draft NPDES Permit, PSNH Merrimack Station Units 1 & 2. February 2012.

**5.13** Clean Water Act NPDES Permitting Determinations for the Thermal Discharge and Cooling Water Intake Structures at Merrimack Station in Bow, New Hampshire. NPDES Permit No. NH 0001465.

**5.14** U.S. Energy Information Administration (EIA), Largest Utility Plants by Net Generation (2012 Data). http://www.eia.gov/energyexplained/index.cfm?page=electricity_-in_the_united_states#tab3. Accessed October 16, 2014.

**5.15** Palo Verde Nuclear Generating Station Units 1, 2, and 3. Updated Final Safety Analysis Report. Revision 14, June 2007. Accession Number: ML072250202.

# Attachment 1: Update of Impingement Abundance and Mortality Assessment for Merrimack Station Response Supplement to United States Environmental Protection Agency CWA §308 Letter

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R-22240.038

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## Executive Summary

- The final 316b regulations (published 15 August 2014 and effective 14 October 2014) were reviewed with respect to their applicability to Merrimack Station.
- Annual total impingement abundance was reduced by 54% from 3,978 fish based on weekly impingement rates obtained from the impingement characterization study performed from 29 June 2005 through 28 June 2007 to 1,834 fish based on the three most recent years of AIF records (1 January 2011 through 31 December 2013) from Merrimack Station.
- By comparison with the largest data base of reported annual impingement rates presently available from 166 electric generating facilities representative of all source water bodies throughout the continental United States and Hawaii (EPRI 2011), and using annual total impingement rates for the three most recent years of AIF (1 January 2011 through 31 December 2013), impingement abundance at Merrimack Station of 0.27% of the national average is *de minimis*.
- [redacted] If a compliance option for entrainment reductions is needed to satisfy the BTA standards at Merrimack Station, a site-specific study would be performed to determine the ambient current flow and direction, debris loading, and biological efficacy of a partial-scale system during the 13-week period of peak entrainment from mid-May through the first week of August.
- The biological efficacy of an Aquatic Filter Barrier (AFB) as BTA for reducing entrainment abundance at Merrimack Station was evaluated by comparison with a four year study in the Hudson River estuary at Lovett Station. If a compliance option for entrainment reductions is needed to satisfy the BTA standards at Merrimack Station, a site-specific study of a partial-scale AFB would be performed to determine if similar biological efficacy to the Lovett AFB would be expected if an AFB was installed and operated at Merrimack Station during the 13-week period of peak entrainment from mid-May through the first week of August.

# 1.0 Introduction

Public Service Company of New Hampshire (PSNH) operates Merrimack Station using a once-through cooling water intake structure (CWIS) to obtain condenser cooling water from the Hooksett Pool section of the Merrimack River in Bow, New Hampshire, under an existing National Pollutant Discharge Elimination System permit (NPDES Permit NH0001465) issued by the United States Environmental Protection Agency (USEPA). On December 30, 2004, the USEPA sent an information request letter to PSNH under Section 308 of the Clean Water Act (CWA) regarding the Station's compliance with CWA §316(b), 33 U.S.C. §1326(b) (§308 Letter). In the §308 Letter, USEPA requested submission of a Proposal for Information Collection (PIC), and PSNH submitted this PIC in April 2005 describing impingement and entrainment studies proposed for Merrimack Station as requested by USEPA (PSNH 2005). PSNH performed impingement and entrainment studies during June 2005 through June 2007, and summarized the results in a final report (Normandeau 2007). USEPA also requested certain technology information from PSNH to support their evaluation of Merrimack Station's NPDES renewal application. In November 2007, PSNH submitted a response ("the 2007 Response") prepared by ENERCON Services, Inc. (ENERCON) and Normandeau Associates, Inc. (Normandeau) (PSNH 2007). The 2007 Response evaluated the engineering feasibility and estimated the biological effectiveness of certain technologies and operational measures that would be generally expected to reduce impingement mortality and/or entrainment mortality of fish and shellfish withdrawn from the Merrimack River in the cooling water used by Merrimack Station.

Following a meeting with PSNH, Normandeau, and ENERCON regarding the 2007 Response in December 2008, USEPA requested that PSNH further evaluate several technologies in more detail, and submit a supplement to the 2007 Response. The 2009 Supplemental Alternative Technology Evaluation ("the 2009 Response", PSNH 2009) presented this additional information to USEPA. Technologies evaluated included wedgewire screens, aquatic filter barriers, fine mesh traveling screens, and upgraded fish handling and return systems.

Subsequent to this, USEPA submitted a request for information which in some cases explained items in previous USEPA requests, and in other cases requested additional information not previously requested to ensure items were presented clearly. In addition, USEPA requested information regarding certain assumptions and/or calculations that were used as the basis for the information provided in the 2007 Response. The information requested was submitted to USEPA in January 2010 (PSNH 2010). ENERCON created a report that individually reviewed each information request, provided clarification of the information provided in the 2007 Response, and, where necessary, conducted new analysis to respond to EPA's information request. After receiving this information, USEPA issued a draft NPDES permit for Merrimack Station in September 2011. During the comment period for the draft permit, PSNH provided comments to USEPA in February 2012 ("2012 Response", PSNH 2012).

This assessment of the original 2007 Response is provided to identify changes that have occurred since the 2007 Response was provided. These changes include regulatory changes, environmental and biological changes, and technological changes. It is possible that cumulative effect of these changes will be a change to the Best Technology Available (BTA) for Merrimack Station. This is especially possible because the way in which the impingement and entrainment BTA is determined has changed with issuance of the new Clean Water Act (CWA) Section 316(b) regulations.

The USEPA published the final regulations to establish requirements for cooling water intake structures at existing facilities in the Federal Register on Friday, 15 August 2014 (40CFR Parts 122 and 125; Volume 79, No. 158, pages 48300-48439). The stated purpose of these final §316(b) regulations is to reduce impingement and entrainment of fish and other aquatic organisms at cooling water intake structures used by certain existing power generation and manufacturing facilities for the withdrawal of cooling water. These regulations are applicable to facilities like Merrimack Station that are designed to withdraw more than 2 million gallons per day (MGD) of surface water and use at least 25% of the water withdrawn exclusively for non-contact cooling purposes.

Normandeau reviewed the recent (15 August 2014) publication of the final §316(b) regulations (USEPA 2014) and the three most recent years of actual intake flow (AIF) records for the CWIS to prepare this Attachment 1 update of impingement abundance and mortality response supplement for Merrimack Station. This Attachment 1 Report does not seek to re-evaluate and update all technologies and operational measures examined in the §308 responses, just those options considered most feasible from an engineering perspective for application at Merrimack Station from among the compliance options specified in the final §316(b) regulations.

The objectives of this Attachment 1 response supplement were:

1. Review the final 316b regulations and their applicability to Merrimack Station,
2. Establish the annual impingement abundance of fish at Merrimack Station based on the three most recent years of AIF records (2011 through 2013).
3. Compare the magnitude of annual impingement abundance for Merrimack Station to the national and regional summary of annual impingement abundance provided in the Electric Power Research Institute (EPRI) Technical Report #1019861 (EPRI 2011) to determine if Merrimack Station has a *de minimis* rate of impingement;

4. Propose an evaluation of the potential biological efficacy of wedgewire screens as a Best Technology Available to Minimize Adverse Environmental Impact (BTA) for reducing entrainment abundance at Merrimack Station if a compliance option for entrainment reductions is needed to satisfy the BTA standards at Merrimack Station;
5. Propose an evaluation of the potential biological efficacy of an Aquatic Filter Barrier (AFB) as BTA for reducing entrainment abundance at Merrimack Station if a compliance option for entrainment reductions is needed to satisfy the BTA standards at Merrimack Station;

## 2.0 Overview of the Final §316(b) Regulations and their Applicability to Merrimack Station

The procedure for demonstrating compliance with §316(b) of the Clean Water Act is specified by 40 CFR §122.21 of the final §316b regulations. There are fourteen requirements specified in the final §316(b) regulations, and the applicable requirements will likely be addressed in the next NPDES permit for Merrimack Station. The table below presents a listing of all of these requirements, and the narrative that follows identifies and briefly explains those requirements that are expected to be applicable to Merrimack Station.

| §122.21(r) | Description |
|---|---|
| (1) | Applicable Facilities Definitions |
| (2) | Source Water Physical Data |
| (3) | Cooling Water Intake Structure Data |
| (4) | Biological Characterization Study |
| (5) | Cooling Water System Data |
| (6) | Proposed IM Reduction Plan |
| (7) | Performance studies |
| (8) | Operational status |
| (9) | Entrainment Characterization Study |
| (10) | Comprehensive Technology Feasibility Plan |
| (11) | Economic Benefits Evaluation |
| (12) | Non-Water Quality and Other Environmental Impacts |
| (13) | Peer Review for r10, r11, or r12 |
| (14) | New Units |

Applicable Facilities are defined in §122.21 (r) (1) as existing facilities to which the §316(b) regulations apply because they have a CWIS that supplies cooling water for the purpose of non-contact cooling withdrawn from the surface waters of the United States. Existing facilities are further distinguished into those withdrawing less than 2 MGD, those withdrawing between 2 and 125 MGD, and those withdrawing more than 125 MGD based on the AIF determined from the average intake flows over the three most recent years of operating records. New units at an existing facility are also distinguished from existing units.

Source Water Physical Data required by §122.21 (r) (2) were previously summarized in Section 2 of the PIC for Merrimack Station that was submitted to USEPA in April 2005 (Normandeau 2005) and also summarized in Section 3 of the 2007 Response (PSNH 2007). Source water physical data collected since preparation of the Merrimack PIC includes a thermal stratification study, and current velocity and flow direction data obtained from Hooksett Pool of the Merrimack River during the open water period of 2009, and a quantitative bottom substrate mapping study conducted in Garvins, Hooksett, and Amoskeag Pools of the Merrimack River during the fall of 2010 (Normandeau 2011a). PSNH also provided additional source water physical data in narrative and reports submitted as comments in response to the draft NPDES permit (PSNH 2012). Federal and state agency (NOAA, USGS, NHDES, etc.) and academic (UNH) data bases must also be reviewed to determine if any additional studies have been performed since these previous documents were prepared that describe the hydrological and geomorphological characteristics of the Merrimack River near Merrimack Station.

Cooling Water Intake Structure Data required by §122.21 (r) (3) were previously summarized for each intake (Unit 1 and Unit 2) at Merrimack Station in Section 3 of the PIC that was submitted to USEPA in April 2005 (Normandeau 2005) and also summarized in Section 3 of the 2007 Response (PSNH 2007).

Source Water Baseline Biological Characterization Data §122.21 (r) (4) were previously summarized for Merrimack Station in Section 6 of the PIC that was submitted to USEPA in October 2005 (Normandeau 2005). Since preparation of the Merrimack PIC, additional source water biological characterization data related to the fish community have been collected. A recent fish-related study collected and summarized information on the biocharacteristics of two resident fish species (Yellow Perch and White Sucker) during 2008 (Normandeau 2009), and the community composition of the benthic macroinvertebrate community was assessed during fall 2011 (Normandeau 2012). PSNH also provided additional source water baseline biological data in narrative and reports submitted as comments in response to the draft NPDES permit (PSNH 2012). Current Federal and State agencies (NOAA, USGS, NHFG, etc.) and academic (UNH) data bases must also be reviewed to determine if any new biological characterization studies have been performed since the previous reports were prepared that describe the baseline biological characteristics of the Merrimack River near Merrimack Station.

Cooling Water System Data §122.21 (r) (5) were previously summarized for Unit 1 and Unit 2 at Merrimack Station in Section 4 of the PIC that was submitted to USEPA in October 2005 (Normandeau 2005) and also summarized in Section 3 of the 2007 Response (PSNH 2007). Updated AIFs for each unit at Merrimack Station are provided for the three most recent years of data available (1 January 2011 through 31 December 2013) in Section 3 below.

A Proposed Impingement Mortality Reduction Plan §122.21 (r) (6) is required for Merrimack Station because the AIF for the three most recent years of available cooling water intake flows is above 2 MGD and less than 125 MGD. Compliance options for impingement mortality reductions include selection of one of the following:

1. Closed cycle recirculating system - §125.94(c)(1),
2. Design through-screen intake velocity <0.5 fps - §125.94(c)(2),
3. Actual through-screen intake velocity <0.5 fps - §125.94(c)(3),
4. Have an existing offshore velocity cap >800 feet offshore - §125.94(c)(4),
5. Install modified traveling screens - §125.94(c)(5),
6. Use a combination of technologies and operational measures such as flow reductions or scheduled outages - §125.94(c)(6), or
7. Demonstrate that the existing system meets the impingement mortality performance standard of 24% latent mortality (excluding fragile species) - §125.94(c)(7).

A case can also be made for some facilities that the existing level of impingement is *de minimis* based on impingement abundance numbers or age 1 equivalent abundance in relation to mean annual intake flows.

Entrainment Performance Studies §122.21 (r) (7) were previously performed at Merrimack Station and were submitted to USEPA to allow the Director to establish technology-based requirements for entrainment. Site-specific studies describing the efficacy of various technologies to reduce entrainment abundance, through-system entrainment survival studies of eggs and larvae, and entrainment abundance analyses were also provided previously and are considered relevant to, and representative of, the current conditions at Merrimack Station. Studies older than ten years may not be accepted if the source water body has changed significantly over that time period. An entrainment abundance and survival (through CWIS) characterization study was performed at Merrimack Station from 29 June 2005 through 28 June 2007 (Normandeau 2007), which provided the basis for an evaluation of the entrainment reduction performance of various alternative technologies or operational measures as described in Section 8 and Attachment 6 of the 2007 Response (PSNH 2007).

Operational Status §122.21 (r) (8) must be described for each unit at Merrimack Station. This information was previously summarized for Unit 1 and Unit 2 at Merrimack Station in

Section 4 of the PIC that was submitted to USEPA in October 2005 (Normandeau 2005) and also summarized in Section 3 of the 2007 Response (PSNH 2007). Updated operational status has been reviewed (by ENERCON) and any fundamental changes described for each unit at Merrimack Station by examining station records for the period since the two previous reports were prepared.

An Entrainment Characterization Study §122.21 (r) (9) was performed at Merrimack Station from June 2005 through June 2007 (Normandeau 2007) and is therefore considered current and complete. Furthermore, based on the observed AIF for Merrimack Station of less than 125 MGD for the most recent three-year period (1 January 2011 through 31 December 2013), an entrainment reduction is not currently required.

A Comprehensive Technical Feasibility Plan and Cost Evaluation Study §122.21 (r) (10) is also not required because this plan and study is applicable to facilities required to evaluate entrainment reductions, and the observed AIF of less than 125 MGD for the most recent three-year period (1 January 2011 through 31 December 2013) should exempt Merrimack Station from the entrainment reduction requirement of the new §316(b) regulations. The technical feasibility and costs of various impingement and entrainment reduction technologies considered candidates for application to Merrimack Station were described in the 2007 Response (PSNH 2007) and in subsequent responses.

An Economic Benefits Evaluation Study §122.21 (r) (11) is also not required because this study is applicable to facilities required to evaluate entrainment reductions, and the observed AIF of less than 125 MGD for the most recent three-year period (1 January 2011 through 31 December 2013) exempts Merrimack Station from the entrainment reduction requirement of the new §316(b) regulations.

The Non-Water Quality Environmental and Other Impacts Assessment §122.21 (r) (12) must be described for the impingement mortality reduction plan selected for Merrimack Station under §122.21 (r) (6) above. The non-water quality environmental and other impacts were described for the technologies considered candidates for application to Merrimack Station in the 2007 Response (PSNH 2007) and in subsequent responses. This assessment is not required for entrainment reductions, because the observed AIF of less than 125 MGD for the most recent three-year period (1 January 2011 through 31 December 2013) exempts Merrimack Station from the entrainment reduction requirement of the new §316(b) regulations.

A Peer Review §122.21 (r) (13) is specified for facilities that must provide studies to address entrainment and the applicable sections of §122.21 (r) (10) (11) and (12). However, we do not expect Merrimack Station to be required to address these sections because the observed AIF of less than 125 MGD for the most recent three-year period (1 January 2011 through 31

December 2013) exempts Merrimack Station from the entrainment reduction requirement of the new §316(b) regulations.

New Units §122.21 (r) (14) are not proposed for Merrimack Station.

## 3.0 Impingement Abundance at Merrimack Station during 2005 through 2007 and 2011 through 2013

An impingement characterization study was performed at Units 1 and 2 of Merrimack Station from 29 June 2005 through 28 June 2007, weekly during April through December and on alternate weeks during January through March (Normandeau 2007), providing recent and relevant data for estimating impingement abundance. Merrimack Station weekly AIFs have been reduced by about 50% since the 2005 through 2007 Study, by reducing the operation of Units 1 and 2, making the weekly average AIF from Merrimack Station from 1 January 2011 through 31 December 2013 the most current and appropriate CWIS operating regime to estimate impingement abundance and mortality for compliance with the new §316(b) regulations (Table A1-1).

Weekly impingement rates (density as number of fish impinged per million gallons of water sampled, adjusted for collection efficiency; Appendix Tables B-3 and B-4 of Normandeau 2007) at each Unit (1 or 2) from the 2005 through 2007 Study were multiplied by the associated weekly AIF from Merrimack Station for 1 January 2011 through 31 December 2013 (Table A1-1) to estimate the current weekly and annual impingement abundance of fish for the two units combined (Table A1-2). Fish species impinged at Merrimack Station during the 29 June 2005 through 28 June 2007 Study were also categorized as fragile or non-fragile species according to the specifications of §125.92(m) of the new §316(b) regulations. The only species impinged at Merrimack Station classified as a fragile species was Rainbow Smelt, which accounted for only 2.3% of the total estimated fish impingement over the two-year study (Table A1-3). Annual impingement abundance of total fish at Merrimack Station was reduced by 54% in 2011 through 2013 (compared to the 2005 through 2007 study (Table A1-2) due to the recent flow reductions. No Federally-listed threatened or endangered species were observed in the impingement collections from Merrimack Station (Table A1-3).

## 4.0 *De Minimis* Annual Impingement Rates at Merrimack Station

Annual impingement rates for Merrimack Station were examined in comparison to other facilities to determine if the existing level of impingement abundance and mortality is *de minimis* based on annual impingement abundance numbers or age 1 equivalent abundance in relation to mean annual intake flows. The new 316(b) regulations (published 15 August 2014, effective 14 October 2014) do not define *de minimis* impingement abundance or mortality as a fixed number of fish or shellfish impinged per year. However, based on a review and evaluation of data submitted under 122.21 (r), the documented rate of fish impingement at the Merrimack Station CWIS may be so low that no additional controls are warranted. Shellfish are not impinged at Merrimack Station and therefore were not considered in this evaluation. Merrimack Station is a candidate for consideration of *de minimis* impingement rates because it employs both trash racks and conventional traveling water screens (but no fish return), and because it reduces intake flows seasonally during the winter months (PSNH 2005). Furthermore, there are no threatened or endangered species present in Hooksett Pool, and no critical habitat is found in the Merrimack River source water body. Therefore, this impingement compliance option is evaluated in this section.

Merrimack Station Unit 1 has a design intake flow of 59,000 gallons per minute (gpm), or 131 cubic feet per second (cfs) (PSNH 2005). Merrimack Station Unit 2 has a design intake flow of 140,000 gpm, or 312 cfs (PSNH 2005). Compared to mean annual Merrimack River flow (MAF) passing by Merrimack Station of 4,927 cfs (1996-2003 average, PSNH 2005), the Unit 1 design intake flow (DIF) withdraws 2.67% of the MAF, and the Unit 2 DIF withdraws 6.33% of the MAF.

Merrimack Station Unit 1 had an AIF of 43,644 gpm during the 2005 through 2007 impingement characterization study (Normandeau 2007), equal to 97 cfs or 1.34% of the MAF of 7,241 cfs for the same period. Merrimack Station Unit 2 had an AIF of 112,662 gpm during the 2005 through 2007 impingement study, equal to 251 cfs or 3.47% of the MAF. During the most recent and relevant three years of Merrimack Station CWIS operations, 1 January 2011 through 31 December 2013, Unit 1 had an AIF of 25,124 gpm, equal to 56 cfs or 1.11% of the MAF of 5,021 cfs for those years. Merrimack Station Unit 2 had an AIF of 53,365 gpm during the 2011 through 2013, equal to 119 cfs or 2.37% of the MAF.

In addition to the Merrimack Station withdrawal rates and analysis of Merrimack River MAF data provided in the previous paragraphs, the following analysis of annual impingement rates supports a conclusion that the annual impingement mortality at Merrimack Station is indeed *de minimis*. The Electric Power Research Institute (EPRI) conducted a national and regional survey of impingement and entrainment of fish and shellfish based the Clean Water Act §316(b) characterization studies performed at large cooling water intakes in response to the 2004 regulations for Phase II facilities (EPRI 2011). Impingement and entrainment sampling performed in response to the 2004 regulations occurred over a four-year period from 2004 through 2007, and most of these studies followed standard methodologies including quality control (QC) and quality assurance (QA) procedures to ensure the accuracy of these data. The resulting national data base of 166 facilities responding to the EPRI survey (including Merrimack Station) provides a basis for comparing the observed impingement abundance and mortality from two years of studies performed at Merrimack Station from 29 June 2005 through 28 June 2007 (Normandeau 2007) to annual impingement rates at these other facilities during a comparable period. This national data base is robust with respect to the source water bodies represented, providing annual total impingement abundance for CWISs withdrawing once-through cooling water from the Great Lakes, Northeast coast, mid-Atlantic coast, Southeast coast and Gulf of Mexico, West coast, Midwestern reservoirs, Southeastern reservoirs, Southwestern cooling lakes, large rivers, small rivers, and Hawaii (EPRI 2011). Merrimack Station was considered to be located on a small river in this national survey. Annual total impingement rates ranged from a high of 69,000,000 fish to a low of 126 fish based on AIF, with a mean annual impingement rate of 1,483,331 fish (S.E. = 541,844) among all 166 facilities in the EPRI national data base.

The Merrimack Station annual impingement rate averaged over the two years of study (29 June 2005 through 28 June 2007) was 3,978 fish for Unit 1 and Unit 2 combined (Table A1-2), ranking 139$^{th}$ among the 166 facilities responding to the EPRI national survey (Figure A1-1). Merrimack Station had an annual total far below (0.27% of) the national average. In terms of rank this 2005 through 2007 annual average impingement rate places Merrimack Station in the lowest 17% of the facilities surveyed throughout the United States that had performed impingement characterization studies during the 2004 through 2007 period (Figure A1-1). Based on the most recent and relevant intake flows from 1 January 2011 through 31 December 2013 applied to the weekly impingement rates from the 29 June 2005 through 28 June 2007 Study (Section 3.0 above), the Merrimack Station annual impingement rate was 1,834 fish for Unit 1 and Unit 2 combined (Table A1-2), which was in the lowest 11% of the facilities surveyed throughout the United States that had performed impingement characterization studies during the 2004 through 2007 period. Therefore, by comparison with the largest data base of reported annual impingement rates presently available from 166 electric generating facilities representative of all source water bodies throughout the continental United States and Hawaii (EPRI 2011), and using annual total impingement rates for the three most recent years of AIF (2011-2013), impingement abundance at Merrimack Station of 0.27% of the national average is *de minimis*.

## 5.0 Wedgewire Screens as BTA at Merrimack Station

ENERCON (Section 3.1) proposes to preemptively evaluate the engineering feasibility of installing wedgewire screens if a compliance option is needed to satisfy the BTA standards for entrainment reductions at Merrimack Station. Installed wedgewire screens may also provide reductions in impingement mortality at Merrimack Station during their period of operation. [redacted] Entrainment is seasonal at Merrimack Station, and peak entrainment is limited to a

13-week period from mid-May through the first week of August when, on average, 97% of the annual entrainment occurs (Normandeau 2007). Therefore, a site-specific study would be performed to determine the ambient current flow and direction, debris loading, and biological efficacy of a partial-scale system during the 13-week period of peak entrainment from mid-May through the first week of August.

Recent research in a laboratory flume [redacted] and in the Hudson River estuary [redacted] has demonstrated that cylindrical wedgewire screen performance is related to three factors: physical exclusion by the slot width, behavioral avoidance of the intake flow by the fish, and the hydraulic bypass due to sweeping flow of river currents along the surface of the wedgewire screen in a direction perpendicular to the slot openings (i.e., parallel to the slot width). Cylindrical wedgewire screens with slot widths of 2, 3, 6, and 9 mm were tested at flume velocities of 0.25, 0.50, and 1.0 fps, with through-slot velocities of 0.25 and 0.50 fps for a total of 24 combinations of slot width, flume velocity, and through-slot velocity. Physical exclusion exhibited a direct relationship to greatest body depth, and fish (eggs, larvae, or juveniles) with a greatest body depth larger than the slot width were physically excluded. Behavioral avoidance was typically higher for the smaller slot widths, and a lower through-slot velocity. Overall, avoidance and hydraulic bypass were higher at higher ratios of sweeping velocity to through-slot velocity, particularly when this ratio exceeded 1:1. These mechanistic studies demonstrated that hydraulic bypass and avoidance were the prevailing modes of effectiveness of cylindrical wedgewire screens. Exclusion also operated to reduce entrainment of eggs and larvae with limiting dimensions larger than the slot width.

The Merrimack River location of Merrimack Station appears ideal for effective operation of wedgewire screens due to the relatively consistent high sweeping velocity along a predominant north-south axis observed in a preliminary survey performed during the peak entrainment periods of 2009 and 2010. Geo-referenced depth and current data were collected in the vicinity of Station N-5 (Merrimack Station intake) in Hooksett Pool using a SonTek Mini ADP 1.0 MHz Acoustic Doppler Current Profiler (ADCP) and a Trimble DSM-232 GPS during the four week periods from 17 May through 13 June 2009 and from 16 May through 12 June 2010. Data were collected twice weekly (Tuesday and Thursday) during each four week period (eight sampling events per year) and consisted of one daytime set and one nighttime set. The order in which the 10 stations (Figure A1-2) were sampled from the river cross section at Station N-5 was randomized independently within each of the eight daytime and eight nighttime sampling events, to avoid the potential bias of always sampling a particular stratum at the same time of day or night. Velocity data were summarized into seven vertical zones sequentially numbered along the cross section of the Merrimack River at Transect N-5 (Merrimack Station Intake) from the west (Stations 1 and 2 = zone 1) to east (Station 10 = zone 7) (Figure A1-2).

The frequency distribution of the Merrimack River velocities observed near the Merrimack Station intake (Station N-5) reveals that the average sweeping flow from north to south was 88 cm/sec (2.9 fps) along the west bank near the Merrimack Station intake, between 110 and 117 m/sec (3.6 and 3.8 fps) at mid-channel locations, and 75 cm/sec (2.5 fps) on the east bank of the Merrimack River (Table A1-4). A more detailed site-specific ADCP study would be required to characterize the Merrimack River sweeping flows and the consistency of the current direction to assist the engineering design of a half-diameter wedgewire screen array for Merrimack Station entrainment reductions to help maximize the alignment of the long axis of each screen and maximize the sweeping flow to slot flow ratio above 1:1 during the mid-May through July period of peak entrainment abundance.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

## 6.0 Aquatic Filter Barrier as BTA at Merrimack Station

ENERCON (Section 3.2) has performed a preliminary evaluation of the engineering feasibility of installing an Aquatic Filter Barrier (AFB) to completely surround the two separate CWISs at Merrimack Station if a compliance option is needed to satisfy the BTA standards for entrainment at Merrimack Station. An installed AFB may also provide reductions in impingement mortality at Merrimack Station during the period of effective operation. Accordingly, the narrative in this section describes a previous evaluation of an installed AFB from Lovett Station located on the Hudson River estuary (LMS 1998b, 2005) as an example of the potential biological efficacy of and AFB as BTA for reducing entrainment abundance at Merrimack Station. Entrainment is seasonal at Merrimack Station, and peak entrainment is limited to a 13-week period from mid-May through the first week of August when, on average, 97% of the annual entrainment occurs (Normandeau 2007). Therefore, a site-specific study would be performed to determine the performance characteristics and biological efficacy of a partial-scale AFB system during the 13-week period of peak entrainment from mid-May through the first week of August.

The efficacy of a deployed AFB is directly related to the amount of time it operates as designed. Continuous operation of a deployed AFB during the early May to early August of each year at Merrimack Station will be important for optimizing entrainment reduction benefits. Additionally, the water velocity drawn through the AFB fabric panels should be considered in the site-specific engineering design to reduce the impingement of entrainable life stages of fish (i.e., those that would pass through a mesh with a maximum opening dimension of 0.56 inches). A literature review of recent AFB applications would be performed as part of a complete engineering design and biological feasibility study to determine the relationship between water velocity through the AFB and the likelihood of impingement of fish eggs and larvae on the outer surface of the designed barrier for Merrimack Station relative to the maximum pore size or mesh openings.

The engineering design of the AFB for Merrimack Station must also account for the combination of debris and high ambient current velocities in the Merrimack River for effective operation during the deployment period, and each of these factors may individually or collectively affect the performance of the deployed AFB. To estimate debris loading, data from the traveling screens was quantified continuously in 6-day and 24-hour impingement samples during the 29 June 2005 through 28 June 2007 Study at Merrimack Station (Normandeau 2007, Appendix Table B-2). The highest periods of debris loading in the water filtered through the 3/8-inch traveling screens at Merrimack Station were during the autumn months of October and November 2005, when a maximum of 183 gallons of terrestrial vegetation were collected during 24 hours on 2 November, 158 gallons of terrestrial vegetation were collected during a 24-hour period on 26 October, and 94 gallons of terrestrial vegetation were collected during a 24-hour period on 19 October. Debris loads observed continuously during the 13 week periods of peak entrainment abundance at Merrimack Station from early May through early August averaged 30 gallons per day.

The AFB is permeable to water but it is relatively impermeable to fish and ichthyoplankton and, therefore, is one of only a few technologies capable of reducing both entrainment and impingement of aquatic organisms (USEPA 2004). The AFB system has a patented full-water-depth filter curtain composed of polyethylene or polypropylene fabric panels that is supported by flotation billets at the surface of the water and anchored to the bottom of the water body (LMS 1998b, 2005). The AFB completely surrounds a CWIS, preventing organisms from entering the intake.

The engineering performance of an AFB was evaluated at Lovett Generating Station ("Lovett") in each year 1994 through 2002 with the objectives of designing, installing and testing a full scale system that could be installed and reliably operated at Lovett to exclude fish eggs and larvae from entrainment into Lovett's cooling water intake system (LMS 1996, 1997, 1998a, 1998b, 2005). Biological effectiveness testing began in 2003 with an evaluation of sampling methodology and techniques (ASA 2003), followed by four consecutive years of complete seasonal sampling from May through October of 2004, 2005, 2006, and 2007 (ASA 2004, 2005, 2006, 2007). Lovett ceased operation in 2008 and was dismantled.

Lovett consisted of three fossil-fueled, steam electric units (Units 3, 4, and 5) having net generating capacities of 63 megawatts of electric power (MWe), 197 MWe, and 202 MWe, respectively, for a total of 463 MWe for all three units combined. The once through design cooling water intake flows were 42,000 gallons per minute (gpm) for Unit 3, 104,300 gpm for Unit 4, and 112,000 gpm for Unit 5, for a total of 258,300 gpm. Cooling water for each of the three Lovett units was withdrawn from the Hudson River estuary through shoreline intakes equipped with conventional 3/8-inch mesh traveling screens. The AFB installed and tested at Lovett was made from two layers of non-woven fabric (LMS 1998b) that encircled the shoreline bulkhead containing the CWISs for Unit 3, Unit 4, and Unit 5. The outer layer had 0.5 mm diameter perforations spaced on-center at 6.4 mm, and the inner layer was vented with horizontal 5.1 cm flaps spaced at 0.6 m (LMS 1998b).

Lovett Station was located on the west bank of the Hudson River estuary just north of Stony Point, New York, 41 miles upstream from the southern tip of Manhattan in New York City. Biological effectiveness was determined by comparing the percent difference in density of entrainable-sized ichthyoplankton from pairs of pumped samples collected inside and outside of a deployed AFB enclosing the Lovett CWIS. Post yolk sac larvae was the dominant life stage in all samples, contributing 91% (2,380) of the total ichthyoplankton collected at the test location (2,619) and 94% (17,661) of the total ichthyoplankton collected at the control location (18,730) over the four-year study. The Lovett AFB evaluation focused on six target taxa: Striped Bass, White Perch, river herring (Alewife and Blueback Herring), Bay Anchovy, American Shad, and Atlantic Tomcod. However, only the first four fish taxa were caught in sufficient numbers to estimate the exclusion effectiveness.

The AFB system installed and operated at Lovett during 2004 through 2007 exhibited an average exclusion effectiveness of 79% for all species and life stages of ichthyoplankton combined, with inter-annual variation ranging from a low of 40% in 2004 to a high of 95% in 2007 (Table A1-5). The Lovett AFB was estimated to exclude, on average among the four years, 89% of the Bay Anchovy (inter-annual range 68% to 100%), 89% of the Striped Bass (inter-annual range 85% to 94%), 85% of the White Perch (inter-annual range 62% to 97%), and 52% of the river herring (inter-annual range of -57% to 99%) over the four years of testing. Since no eggs or larvae exposed to the Lovett AFB were smaller than the 0.5 mm perforations of the outer fabric, the 79% overall average percent effectiveness suggests that performance of the Lovett AFB is directly related to its time of deployment with respect to the Hudson River fish spawning season, the proportion of the total intake flow drawn directly through the filtration mesh, and the density of ichthyoplankton in the volume of unfiltered water drawn into the intake when deployment fails. A similar performance to this Lovett AFB would be expected if an AFB was installed and operated effectively at Merrimack Station during the 13-week period of peak entrainment from mid-May through the first week of August. However, a site-specific study of an AFB test panel would be required to estimate the site-specific biological efficacy during the deployment period in the Merrimack River due to the differences in the ichthyoplankton species and river conditions between the two source water bodies.

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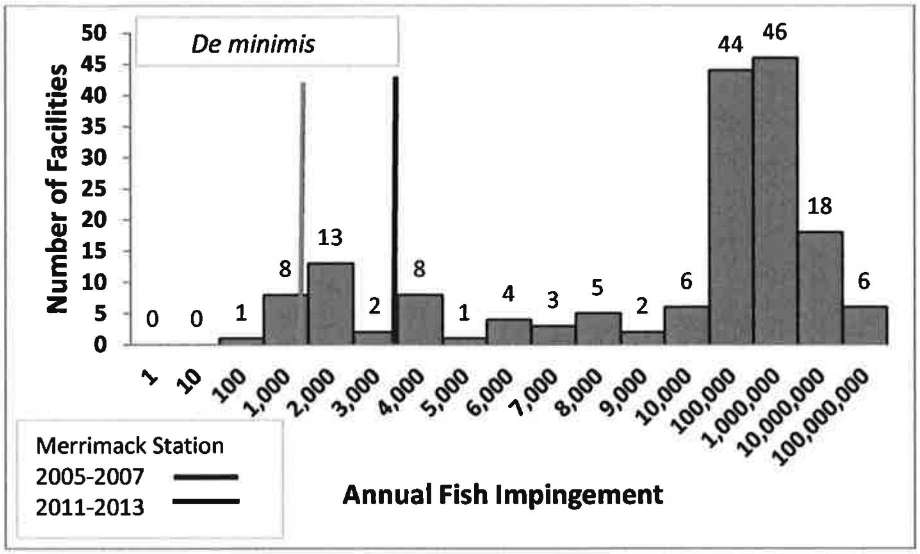


Figure A1-1. Annual fish impingement rates at Merrimack Station in 2005 through 2007 and 2011 through 2013 compared to annual impingement rates from EPRI's national and regional survey of 166 facilities performing Clean Water Act 316(b) characterization studies (EPRI 2011).

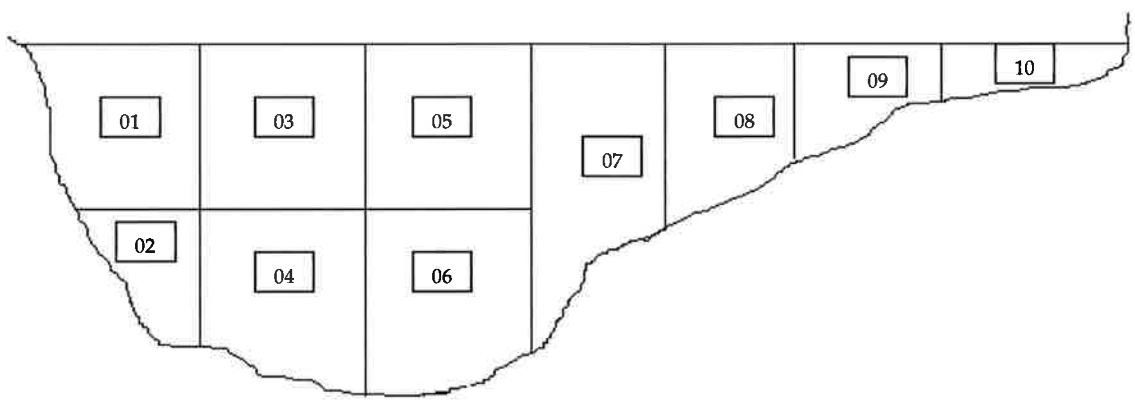


Figure A1-2. Cross sectional area at Station N-5 (Merrimack Station Intake) in the Merrimack River showing the horizontal and vertical subdivisions sampled for river current velocity during 17 May through 13 June 2009 and from 16 May through 12 June 2010. Note: River depth and width are not to scale.

**Table A1-1. Merrimack Station's weekly and annual total operating intake flow sampled from 29 June 2005 through 28 June 2007 compared to the corresponding weekly average actual intake flows for 1 January 2011 through 31 December 2013 (both expressed as millions of gallons per week).**

| Month | Week | 2005-2007 | 2011-2013 |
|---|---|---|---|
| January | 1 | 1,794.2 | 1,565.9 |
| | 2 | 1,740.5 | 1,450.7 |
| | 3 | 1,574.0 | 1,524.7 |
| | 4 | 1,506.1 | 1,279.1 |
| February | 5 | 1,720.2 | 1,406.1 |
| | 6 | 1,687.4 | 1,421.3 |
| | 7 | 1,736.6 | 1,385.2 |
| | 8 | 1,487.7 | 1,393.7 |
| March | 9 | 1,768.6 | 1,601.0 |
| | 10 | 1,789.1 | 1,301.9 |
| | 11 | 1,794.2 | 1,144.5 |
| | 12 | 1,663.9 | 927.5 |
| | 13 | 1,788.4 | 768.7 |
| April | 14 | 1,662.7 | 437.7 |
| | 15 | 1,786.3 | 323.6 |
| | 16 | 985.9 | 236.5 |
| | 17 | 482.1 | 1.7 |
| May | 18 | 445.9 | 0.0 |
| | 19 | 400.9 | 327.4 |
| | 20 | 674.5 | 295.1 |
| | 21 | 1,658.8 | 343.7 |
| | 22 | 1,664.6 | 785.3 |
| June | 23 | 1,790.5 | 807.6 |
| | 24 | 1,789.1 | 483.4 |
| | 25 | 1,638.2 | 759.6 |
| | 26 | 1,794.2 | 783.6 |
| July | 27 | 1,794.2 | 1,007.8 |
| | 28 | 1,794.2 | 1,478.1 |
| | 29 | 1,794.1 | 1,737.8 |
| | 30 | 1,791.7 | 1,289.2 |
| August | 31 | 1,789.5 | 1,227.5 |
| | 32 | 1,706.9 | 1,252.5 |
| | 33 | 1,793.1 | 319.3 |
| | 34 | 1,794.2 | 480.2 |
| | 35 | 1,576.8 | 161.3 |
| September | 36 | 1,657.9 | 92.1 |
| | 37 | 1,552.3 | 205.9 |
| | 38 | 1,388.2 | 0.0 |
| | 39 | 1,331.0 | 160.8 |

(continued)

## Table A1-1. (Continued)

| Month | Week | 2005-2007 | 2011-2013 |
|---|---|---|---|
| October | 40 | 1,720.8 | 17.5 |
| | 41 | 1,216.1 | 79.8 |
| | 42 | 1,468.1 | 161.3 |
| | 43 | 1,693.3 | 157.6 |
| November | 44 | 1,713.4 | 4.0 |
| | 45 | 1,758.3 | 119.2 |
| | 46 | 1,782.0 | 640.7 |
| | 47 | 1,793.0 | 876.1 |
| | 48 | 1,636.3 | 1,336.6 |
| December | 49 | 1,734.1 | 1,513.3 |
| | 50 | 1,794.2 | 1,436.2 |
| | 51 | 1,461.9 | 1,205.9 |
| | 52 | 1,794.2 | 1,538.0 |
| **Annual Total Flow** | | **82,154.7** | **41,254.2** |
| **Daily Actual Intake Flow** | | **225.7** | **113.3** |

**Table A1-2. Weekly and annual total impingement abundance of fish (Adj-I) estimated for Merrimack Station Units 1, 2, and both units combined based on actual average intake flows during 29 June 2005 through 28 June 2007 and during 1 January 2011 through 31 December 2013.**

| Month | Week # | 2005-2007 Abundance | | | 2011-2013 Abundance | | |
|---|---|---|---|---|---|---|---|
| | | Unit 1 | Unit 2 | Total | Unit 1 | Unit 2 | Total |
| January | 1 | 4 | 12 | 16 | 4 | 10 | 14 |
| | 2 | 17 | 18 | 34 | 14 | 15 | 28 |
| | 3 | 34 | 21 | 55 | 32 | 21 | 53 |
| | 4 | 19 | 12 | 31 | 15 | 10 | 25 |
| February | 5 | 2 | 2 | 4 | 1 | 2 | 3 |
| | 6 | 0 | 18 | 18 | 0 | 17 | 17 |
| | 7 | 2 | 42 | 44 | 2 | 33 | 35 |
| | 8 | 10 | 22 | 32 | 9 | 21 | 30 |
| March | 9 | 14 | 4 | 18 | 14 | 4 | 18 |
| | 10 | 25 | 9 | 34 | 25 | 6 | 31 |
| | 11 | 44 | 21 | 65 | 44 | 11 | 55 |
| | 12 | 15 | 6 | 21 | 17 | 2 | 19 |
| | 13 | 25 | 9 | 33 | 13 | 3 | 17 |
| April | 14 | 12 | 6 | 18 | 7 | 1 | 8 |
| | 15 | 8 | 28 | 36 | 2 | 5 | 6 |
| | 16 | 4 | 13 | 17 | 0 | 5 | 5 |
| | 17 | 0 | 0 | 0 | 0 | 0 | 0 |
| May | 18 | 13 | 0 | 13 | 0 | 0 | 0 |
| | 19 | 3 | 0 | 3 | 0 | 12 | 12 |
| | 20 | 70 | 8 | 78 | 10 | 10 | 20 |
| | 21 | 66 | 62 | 127 | 27 | 9 | 36 |
| | 22 | 25 | 22 | 47 | 14 | 10 | 24 |
| June | 23 | 149 | 443 | 593 | 64 | 204 | 268 |
| | 24 | 41 | 1,330 | 1,371 | 4 | 445 | 449 |
| | 25 | 15 | 27 | 42 | 5 | 13 | 18 |
| | 26 | 11 | 223 | 235 | 3 | 108 | 112 |
| July | 27 | 21 | 44 | 64 | 14 | 23 | 37 |
| | 28 | 5 | 35 | 40 | 4 | 29 | 33 |
| | 29 | 0 | 22 | 22 | 0 | 22 | 22 |
| | 30 | 10 | 6 | 16 | 7 | 4 | 11 |
| August | 31 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 32 | 0 | 10 | 10 | 0 | 8 | 8 |
| | 33 | 4 | 9 | 13 | 1 | 1 | 3 |
| | 34 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35 | 0 | 0 | 0 | 0 | 0 | 0 |

(continued)

## Table A1-2. (Continued)

| Month | Week # | 2005-2007 Abundance | | | 2011-2013 Abundance | | |
|---|---|---|---|---|---|---|---|
| | | Unit 1 | Unit 2 | Total | Unit 1 | Unit 2 | Total |
| September | 36 | 0 | 14 | 14 | 0 | 0 | 0 |
| | 37 | 3 | 0 | 3 | 1 | 0 | 1 |
| | 38 | 0 | 8 | 8 | 0 | 0 | 0 |
| | 39 | 4 | 16 | 19 | 2 | 0 | 2 |
| October | 40 | 0 | 9 | 9 | 0 | 0 | 0 |
| | 41 | 9 | 41 | 50 | 2 | 0 | 2 |
| | 42 | 22 | 74 | 96 | 7 | 0 | 7 |
| | 43 | 25 | 27 | 52 | 8 | 0 | 8 |
| November | 44 | 22 | 100 | 122 | 0 | 0 | 0 |
| | 45 | 8 | 40 | 49 | 2 | 0 | 2 |
| | 46 | 0 | 6 | 6 | 0 | 2 | 2 |
| | 47 | 2 | 23 | 25 | 2 | 8 | 10 |
| | 48 | 55 | 12 | 67 | 82 | 8 | 90 |
| December | 49 | 140 | 90 | 229 | 159 | 70 | 230 |
| | 50 | 8 | 28 | 36 | 8 | 20 | 28 |
| | 51 | 12 | 7 | 19 | 12 | 5 | 17 |
| | 52 | 8 | 11 | 19 | 8 | 9 | 17 |
| **Annual Total** | | **987** | **2,990** | **3,978** | **648** | **1,186** | **1,834** |

[1] Weekly and annual total impingement abundance for fish (Adj-I) was the density sampled (fish/million gallons), corrected for collection efficiency, and multiplied by the weekly actual intake flow (million gallons).

[2] The only fish species observed in the Merrimack Station impingement samples from 2005 through 2007 considered to be a fragile species according to §125.92(m) of the §316(b) regulations was Rainbow Smelt, which only accounted for 2.3% of the total estimated impingement during the two years.

**Table A1-3. Fish species annual abundance and percent composition and their designation as a "Fragile Species" by USEPA 316(b) regulations in the Merrimack Station impingement collections (Units 1 and 2 combined) based on actual annual average intake flows during 29 June 2005 through 28 June 2007.**

| Species | Annual Abundance | Percent of Total | Fragile Species |
|---|---|---|---|
| American Eel | 8 | 0.2 | |
| Banded Sunfish | 16 | 0.4 | |
| Black Crappie | 223 | 5.6 | |
| Bluegill | 2,482 | 62.4 | |
| Brown Bullhead | 20 | 0.5 | |
| Chain Pickerel | 8 | 0.2 | |
| Fallfish | 28 | 0.7 | |
| Golden Shiner | 76 | 1.9 | |
| Largemouth Bass | 175 | 4.4 | |
| Margined Madtom | 107 | 2.7 | |
| Pumpkinseed | 131 | 3.3 | |
| Rainbow Smelt | 91 | 2.3 | yes |
| Redbreast Sunfish | 24 | 0.6 | |
| Rock Bass | 8 | 0.2 | |
| Smallmouth Bass | 32 | 0.8 | |
| Spottail Shiner | 302 | 7.6 | |
| Sunfish family | 16 | 0.4 | |
| Tessellated Darter | 28 | 0.7 | |
| White Perch | 12 | 0.3 | |
| White Sucker | 12 | 0.3 | |
| Yellow Bullhead | 12 | 0.3 | |
| Yellow Perch | 167 | 4.2 | |
| **All Species** | **3,978** | **100.0** | |

**Table A1-4. Distribution of Merrimack River current velocity and discharge observed in a cross section at Station N-5 (Merrimack Station intake) in Hooksett Pool during 17 May through 13 June 2009 and from 16 May through 12 June 2010.**

| Zone | Avg. depth (UNITS) | Avg. Velocity (cm/s) | River Discharge (cfs) | Proportion |
|---|---|---|---|---|
| 1 (west) | 2.77 | 88.0 | 2,350.6 | 0.170 |
| 2 | 2.56 | 109.8 | 2,706.3 | 0.196 |
| 3 | 2.27 | 110.2 | 2,407.7 | 0.174 |
| 4 | 1.91 | 114.5 | 2,113.0 | 0.153 |
| 5 | 1.53 | 116.9 | 1,721.4 | 0.125 |
| 6 | 1.33 | 117.4 | 1,501.2 | 0.109 |
| 7 (east) | 1.41 | 75.0 | 1,015.2 | 0.073 |
| 1-7 | - | - | 13,815.4 | 1.000 |

**Table A1-5.Summary of annual percent exclusion effectiveness for fish larvae collected by simultaneous pairs of samples taken inside and outside of a deployed AFB at Lovett Station on the Hudson River, New York, from May through October 2004, 2005, 2006 and 2007.**

| Fish Taxon | Year | Percent of Catch | Percent Effectiveness |
|---|---|---|---|
| **Bay Anchovy** | 2004 | 34% | 68% |
| | 2005 | 32% | 99% |
| | 2006 | 39% | 89% |
| | 2007 | 52% | 100% |
| | **2004-07 Mean** | **39%** | **89%** |
| **Striped Bass** | 2004 | 35% | 85% |
| | 2005 | 43% | 94% |
| | 2006 | 21% | 90% |
| | 2007 | 22% | 88% |
| | **2004-07 Mean** | **30%** | **89%** |
| **White Perch** | 2004 | 2% | 62% |
| | 2005 | 3% | 97% |
| | 2006 | 8% | 89% |
| | 2007 | 1% | 92% |
| | **2004-07 Mean** | **4%** | **85%** |
| **River Herring** | 2004 | 1% | -57% |
| | 2005 | 1% | 84% |
| | 2006 | 4% | 81% |
| | 2007 | 2% | 99% |
| | **2004-07 Mean** | **2%** | **52%** |
| **All Species** | 2004 | 100% | 40% |
| | 2005 | 100% | 92% |
| | 2006 | 100% | 89% |
| | 2007 | 100% | 95% |
| | **2004-07 Mean** | **100%** | **79%** |