RESPONSE TO UNITED STATES ENVIRONMENTAL PROTECTION AGENCY CWA §308 LETTER

PSNH SCHILLER STATION PORTSMOUTH, NEW HAMPSHIRE

Submitted By

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The Northeast Utilities System

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Table of Contents

Attachments

Summary of Report Conclusions

Public Service Company of New Hampshire's (PSNH) Schiller Station (Station) electrical generating facility in Portsmouth, New Hampshire is seeking a renewal of its existing National Pollutant Discharge Elimination System (NPDES) permit (NPDES Permit NH0001473). This Report has been prepared to provide PSNH's response to an information request letter from the United States Environmental Protection Agency (EPA) under §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, EPA requested certain technology information from PSNH to support EPA's development of the new permit for Schiller Station. The conclusions of this Report are summarized in the following paragraphs.

An assessment of historical Station operation and associated flow data, as well as the biological data presented by Normandeau Associates, Inc. (Attachment 6) concludes that overall average annual reductions from baseline of 61.0% (Unit 4), 60.2% (Unit 5) and 60.9% (Unit 6) in equivalent adult (EA) entrainment mortality of fish, and 81.7% (Unit 4), 80.9% (Unit 5) and 80.6% (Unit 6) in EA entrainment mortality of macrocrustaceans, are attributable to the Station's historic operational flow reductions (based on operating flows from 2000 to 2007) and the EA entrainment survival rate associated with the existing CWIS configuration. Likewise, the existing CWIS configuration and operations, combined with the Station's historic operational flow reductions, are estimated to provide 34.7% (Unit 4), 18.4% (Unit 5) and 26.3% (Unit 6) average annual reductions in EA impingement mortality of fish and 73.9% (Unit 4), 68.4% (Unit 5) and 67.2% (Unit 6) average annual reductions in total impingement mortality of macrocrustaceans.

As required by EPA in the §308 Letter, this Report evaluates the technological feasibility of certain cooling water intake structure (CWIS) technologies and operational measures generally expected to reduce impingement and/or entrainment. On the basis of these conceptual-level engineering evaluations and the biological data from the Station's monitoring programs, the Comparative Matrix, included in Section 7.2 of this Report, ranks these CWIS technologies and operational measures according to their estimated ability to provide the greatest reductions in entrainment and impingement for the least associated initial capital and ongoing annual operating costs.

The CWIS technologies and operational measures identified for evaluation by EPA in the §308 Letter include:

- Mechanical draft cooling towers, utilizing either grey water or seawater, for use in a closed-cycle cooling configuration
- Various CWIS screening technologies, both coarse mesh and fine mesh
- Technological and operational flow reduction measures

This Report concludes that for Schiller Station, the addition of fine mesh wedgewire screens would provide reductions in both impingement and entrainment comparable to closed-loop cooling, at a fraction of the initial capital and ongoing operational and maintenance costs required for a closed-loop cooling conversion. This Report also draws the following general conclusions about the potential technological feasibility and biological effectiveness at Schiller Station for CWIS technologies and operational measures that that EPA identified for assessment in the §308 Letter.

The use of mechanical draft cooling towers in a closed-cycle cooling configuration was determined to be technologically feasible at Schiller Station and potentially provide the most biological benefits of the various technologies and operational measures evaluated; however, the initial and ongoing costs are both wholly disproportionate to these benefits and are significantly higher than the costs of the other technologies and operational measures considered. ███████████████████████████████████ ███ ████████████████████████ The operational cost burden is based on the additional parasitic losses associated with the cooling tower fans and booster pumps, significant operational efficiency losses due to higher cooling water inlet water temperatures to the condenser, increased water treatment costs, and increased maintenance costs.

Available screening technologies and associated biological benefits were identified and evaluated for the Schiller CWISs. Screening technologies that often cannot be utilized due to plant specific constraints were found to have near ideal applications at Schiller Station. Because of favorable CWIS and river conditions, fine mesh wedgewire screens are one of the highest ranked of the alternative CWIS technologies evaluated for this Report in terms of biological benefits, with estimated associated impingement reductions of 80-95%[1], and reductions in EA entrainment abundance for fish of 73-99%. ███████ ██ ████████████████████████████████████

A site specific study would be required to determine the appropriate wedgewire screen material and slot size to ensure that the screens would be able to withstand the aggressive marine environment at Schiller without becoming clogged. Although wedgewire vendors proposed fine mesh slot sizes as small as 0.6 millimeter for the Schiller application, proper selection of both material and slot size is essential to the long-term successful operation of wedgewire screens at the Station. Since the effectiveness in terms of reductions in EA entrainment abundance for fish would vary from 73-99% based on slot size, performance of a test installation would be essential to the selection of a slot size that would function in the Schiller aquatic environment and yet provide the maximum reductions in entrained organisms.

The primary biological benefit of retrofitting fine mesh wedgewire screens at Schiller Station would be the potential to achieve additional entrainment reductions from baseline for fish, for which the existing CWIS configuration and operational measures presently

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[1] Reducing through-screen velocity to 0.5 fps or less is equivalent to reducing impingement mortality by at least 80-95%, *See* 40 C.F.R. §§125.94(a)(1)(ii), 125.94(b)(1).

provide an average annual reduction of 60.7% in EA entrainment mortality. Although conversion to closed loop cooling has the potential to reduce entrainment and impingement mortality from baseline by 100% or 96.9%, depending on the use of grey water or seawater for make-up water, the fine wedgewire screens have to potential to provide comparable biological benefits for significantly less cost.

Technological and operational flow reduction measures were assessed with respect to annual impingement and entrainment reduction. Although the Station was determined to be somewhat tolerant of minor technological flow reductions (i.e., flow reductions via variable speed pumps are condenser limited to a 14% reduction), the associated capital costs ██████████████████████ and increases in the Station thermal discharge temperatures likely would overshadow the relatively low impingement and entrainment reduction benefits. Any appreciable reduction in flow during the summer months would result in significant operational losses as well as increasing thermal discharge temperatures to levels in excess of current NPDES permit requirements.

Operational flow reductions were evaluated relative to maintenance outage scheduling. A spring outage schedule for each unit would coincide with the optimum available period for EA fish entrainment reduction. However, as the aggregate benefit of an outage shift is minimal, any change in the current outage schedule for Schiller is not expected to significantly reduce entrainment and impingement mortality.

1 Background, Introduction, and Scope

1.1 Background and Introduction

Public Service Company of New Hampshire's (PSNH's) Schiller Station electrical generating facility in Portsmouth, New Hampshire is seeking a renewal of its existing National Pollutant Discharge Elimination System (NPDES) permit (NPDES Permit NH0001473). The following Report has been prepared to provide PSNH's response to an information request letter from the United States Environmental Protection Agency (EPA) under Section 308 of the Clean Water Act (CWA) regarding the Station's compliance with CWA §316(b), 33 U.S.C. §1326(b). In the §308 Letter, EPA requested certain technology and fisheries information from PSNH to support EPA's development of the new permit for Schiller Station.

1.2 Scope

The content of this Report reflects the information requested by EPA in the §308 Letter. As a result, the following information is contained in this Report:

- Source waterbody flow information that includes a discussion of the hydraulic zone of influence for Schiller Station's cooling water intake structure (CWIS) and a calculation of the intake volume (based on design flow) over one tidal cycle of ebb and flow as a percentage of the volume of water centered at the opening of the intake defined by one tidal excursion and a depth based on mean low water (MLW).

- A detailed description of Schiller Station's cooling system.

- A response regarding projected retirement date for Schiller Station's existing operation.

- A description of the processes employed at Schiller Station with regard to the operation of the boiler, condenser, CWISs, and effluent treatment.

- A description of the engineering analysis involved with converting the Schiller Station cooling system from the current once-through cooling to closed-cycle cooling for the generating Units and service water system.

- An analysis of barrier technologies or alternate CWIS screening systems that would minimize entrainment, impingement, and impingement mortality, including a discussion of the major components and major modifications that would be required to retrofit Schiller Station with these technologies.

- A discussion of the potential for use of "grey water" for cooling purposes.

- An analysis of reducing cooling water flow by implementing variable speed pumps (VSPs).

- A description of the combination of existing and proposed technologies and operational measures that potentially reflect the Best Technology Available for minimizing adverse environmental impacts.

Note that information taken from the Proposal for Information Collection (PIC) (Ref. 8.15) prepared for Schiller Station by Normandeau Associates, Inc. (Normandeau) has been previously provided to the EPA. However, it is included in this Report for completeness.

2 Schiller Station and Cooling System Description

2.1 Schiller Station Overview

PSNH owns and operates Schiller Station. The primary activity of Schiller Station is the generation of electric power. Schiller Station is located in Portsmouth, New Hampshire on the southwestern (New Hampshire) bank of the Piscataqua River, which forms the boundary between coastal New Hampshire and Maine.

Schiller Station has four generating Units; Unit 3, Unit 4, Unit 5, and Unit 6; however, Unit 3 was removed from service in 1991. Units 4, 5, and 6 have a rated capacity of 50 MW each, and became operational in 1952, 1955, and 1957, respectively. Units 4 and 6 are coal-fired Units that also have the capability to burn oil. In 2006, the coal-burning boiler for Unit 5 was replaced with a fluidized bed wood-fired boiler. The three Units withdraw once-through cooling water from the Piscataqua River via two separate CWISs located on the Piscataqua River. Unit 4 draws water from an intake tunnel approximately 30 ft offshore from the north bulkhead (Screen House #1), that was originally designed to supply water to Unit 3 and Unit 4. The CWIS for Units 5 and 6 is located within the south bulkhead (Screen House #2). The two CWISs have a combined total maximum design intake flow in excess of 50 million gallons per day (50 MGD), where at least 25% is used exclusively for cooling purposes. The current expected operating mode for Schiller Station over the next ten years is as a base-loaded facility at a capacity utilization rate in excess of 15% (Ref. 8.15).

Schiller Station also operates one combustion turbine with an Electric Machine generator that went into service in 1970 that generates 18 MWe in winter and 17 MWe in summer. The FT4A Unit was manufactured by Pratt and Whitney and currently burns Grade A jet fuel. The Unit is also capable of burning natural gas.

2.2 Source Waterbody

2.2.1 Source Waterbody Description

Schiller Station is located on the southwestern bank of the lower Piscataqua River. The source water body type for Schiller Station, for purposes of EPA's now suspended Phase II Rule promulgated under CWA §316(b) (Phase II Rule), is an estuary (Ref. 8.2). The Great Bay Estuary system is made up of three physiographic sub-regions: Piscataqua River, Little Bay, and Great Bay. The lower Piscataqua River covers approximately 9.5 square miles, and has a high water volume of 4.6×10^9 cubic feet (ft^3) with a tidal prism (i.e., the volume of water that is drawn into the bay from the ocean through the inlet during flood tide) of 0.8×10^9 ft^3. In the vicinity of Schiller Station (within a 0.5 mile radius), the center river channel depths range from 42 ft to 75 ft below MLW with a median depth (as defined by area) of 18 ft. Also within the lower Piscataqua River, the river has maximum sweeping flow velocities of approximately 4.9 feet per second (fps) during ebb tide and 4.4 fps during flood tide. The peak tidal flows are approximately 117,000 cubic feet per second (cfs) and the average freshwater discharge rate is approximately 1570 cfs (Ref. 8.3).

The Great Bay Estuary has seasonal and diurnal temperature variations. Typical maximum temperatures are reached during July or August, and the lowest temperatures occur from

November through early March. From April through September, the Great Bay Estuary is warmer than the Gulf of Maine, and hence the ebb tide temperatures are usually higher than the flood temperatures. In early autumn, the estuary and coastal water temperatures are similar, and there is little difference in tidal temperatures. However, by November, the estuary's water is colder, which leads to lower ebb tide temperatures than flood tide temperatures. Ambient water temperature data collected at Simplex Pier, a continuous monitoring station near Schiller Station, showed that temperatures in the Piscataqua varied from 29°F in winter to a high of 73.4°F in mid-summer (Ref. 8.3).

Salinity within the Piscataqua River is controlled by freshwater discharge and the intrusion of oceanic waters, and varies both seasonally and with tidal stage. The maximum salinity occurs during the late summer and early fall, and the lowest salinities occur in the early spring. Salinity measurements at Simplex Pier ranged from 14 to 35 ppt. Salinities in the vicinity of Schiller Station are typical of coastal waters an average of 72% of the time. During the flood tide, coastal water salinities occur 86.5% of the time, where salinities during ebb tide are typical of coastal waters 57% of the time. The salinities are more typical of estuarine conditions only during the spring freshet (i.e. the freshwater runoff resulting from snow and ice melt) or the fall secondary runoff periods (Ref. 8.3).

2.2.2   Hydraulic Zone of Influence

As requested by EPA, an evaluation of the hydraulic zone of influence (HZOI) at Schiller Station was considered. The HZOI establishes where the source of water entering the intake originates. This hydraulic information is used to quantify the affected volume of the source water body as well as to determine the degree to which it is affected. While the maximum intake rate for Schiller Station is approximately 194 cfs (87,290 gpm), the peak tidal flows surrounding that area are approximately 117,000 cfs. As stated by Normandeau in the 1973 Newington Station 316 Demonstration (Ref. 8.3), a maximum intake rate of less than 1% is deemed insignificant when compared to peak tidal flow rates. As the maximum intake rate of 194 cfs is approximately 0.17% of the peak tidal flow rate, further delineation of the HZOI is not necessary.

2.2.3   Intake Volume

EPA requested a calculation of the total design intake flow over one tidal cycle of ebb and flow, as a percentage of the volume of water column within the area centered about the CWIS opening, with a diameter defined by the distance of one tidal excursion at MLW. Under 40 C.F.R. §125.83, the tidal excursion is defined as "the horizontal distance along the estuary or tidal river that a particle moves during one tidal cycle of ebb and flow." The tidal currents in the vicinity of Schiller Station have an average 12.42 hour tidal cycle of ebb and flow (Ref. 8.3). For one tidal cycle, the intake volume based on the maximum design flow of 194 cfs (87,290 gpm) is calculated to be approximately 8.7×10^6 ft^3. The tidal excursion, calculated to be approximately 196,000 ft, is a function of the maximum flow velocity of 4.4 fps and the tidal period. The volume of water defined by one tidal excursion is 2.72×10^{11} ft^3. The intake volume based on design flow makes up 0.0032% of the volume of water defined by one tidal excursion.

2.3   Cooling Water Intake Structure Description

2.3.1   Physical Description, Location and Depth of CWIS

Schiller Station has two once-through CWISs located on the southwestern bank of the lower Piscataqua River in Portsmouth, NH. ███

Unit 4

The Schiller Station Screen House #1 contains the CWIS for Unit 3 (now retired) and Unit 4. This CWIS is not a typical shoreline intake structure, ███████████████████████████ ███████████████████ Figures 5-1 and 5-2 of Attachment 5 show plan and elevation views of Screen House #1.

The inlet to the offshore intake of Screen House #1 is a concrete manifold that has a coarse bar rack with 12 inch by 12 inch grating, which prevents large submerged debris from entering the cooling water intake tunnel. Another fixed screen is installed on the Unit 4 offshore intake to prevent lobsters from entering the intake. The screen interior is constructed of 1.5 inch fiberglass mesh, anchored by two 3-inch stainless steel corner posts and is located in front of the Unit 4 intake pipe. The screen is attached to the existing trash rack guides with 2-inch angle iron and extends approximately 4 ft up from the bottom of the offshore intake. An 8-inch pipe is attached to the bottom of the fiberglass screen to divert lobsters from crawling into the intake pipe.

There are three 6.5 ft I.D. pipes available to provide cooling water to Screen House #1 from the offshore submerged intake; the south pipe provides cooling water to Unit 4, while the other two pipes were designed for Unit 3, and are currently offline. The floor of the offshore intake is at an elevation of approximately 18 ft below mean sea level (MSL). The Piscataqua River bottom is approximately 20 ft below MSL in the vicinity of the intake. Thus, the river bottom grade is approximately 2 ft below the floor of the offshore intake, which provides a vertical barrier to the movement of bottom-oriented fish and shellfish into the CWIS. The river bottom is maintained by dredging to preserve the 2 ft elevation difference between the river bottom and the floor of the intake.

Screen House #1 has one traveling water screen that services the two circulating water (CW) pumps (pumps 4A and 4B). The CW pumps provide non-contact cooling water to the Unit 4 condenser. The floor of Screen House #1 is at an elevation of 18 ft below MSL, and the deck is at an elevation of 10 ft above MSL. The Unit 4 traveling water screen is located on the south side of the Screen House; the north side of the Screen House was previously occupied by the Unit 3 CWIS and two traveling water screens; however, the Unit 3 CWIS is currently out of operation and the traveling water screens and related equipment have been removed.

The two CW intake pumps for Unit 4 are not located in Screen House #1. ███████████ ███

The circulating water supplied to Schiller Station Unit 4 is serviced by one traveling water screen that provides basic debris and fish handling. The traveling water screen is a REX (Chain Belt Company) screen with standard 3/8-inch square copper wire mesh panels (basket segments). The screen is 5.5 ft wide and 28 ft high, and has 34 basket (tray) segments. A screenwash system consisting of pumps and associated piping and spray nozzles is used to keep the screen clean. The screenwash system uses five overlapping spray nozzles with 40 psi spray pressure to remove any fish and/or debris from the traveling water screen into the fish return trough that runs along the CWIS. The fish return trough then funnels through a 14 inch diameter chute to discharge all fish and/or debris at an elevation of 4 ft above MSL. Fish and debris are discharged directly into the Piscataqua River at all tidal stages. Section 2.3.1.1 further details the traveling water screen and fish return trough for Unit 4.

Units 5 and 6

The Schiller Station Screen House #2 contains the CWISs for Unit 5 and Unit 6. Figures 5-3 through 5-5 of Attachment 5 show plan and elevation views of Screen House #2.

Screen House #2 is situated ███
████████████████████████████████ The Screen House has a total of four CW pumps and four traveling water screens. The two CW pumps located on the north side of Screen House #2 (pumps 5A and 5B) supply non-contact cooling water to the Unit 5 condenser cooling system, while the two CW pumps on the south side of Screen House #2 (pumps 6A and 6B) supply non-contact cooling water to the Unit 6 condenser cooling system. All four CW pumps withdraw water from the Piscataqua River. Each set of pumps withdraws cooling water through forebays that are separated by a partition wall and protected by a set of bar racks with $4^3/_8$ inch by 4 inch grating and traveling water screens. Pumps 5A and 5B are serviced by traveling water screens 5A and 5B, while pumps 6A and 6B are serviced by traveling water screens 6A and 6B. The partition wall also separates the flow such that the fish and debris collected from the Unit 5 traveling water screens represents the collection withdrawn through intake pumps 5A and 5B, and the fish and debris collected from the Unit 6 traveling water screens represents the collection withdrawn through intake pumps 6A and 6B.

The floor of Screen House #2 is at an elevation of 18 ft below MSL, and the deck is at an elevation of 10 ft above MSL. The river bottom elevation is 20 ft below MSL in the vicinity of the intake. Thus, the river bottom grade is approximately 2 ft below the floor of the intake, which provides a vertical barrier to the movement of bottom-oriented fish and shellfish into the CWIS. Also, the river bottom in front of Screen House #2 is covered with a rip rap to maintain the floor of Screen House #2 CWIS at an elevation of 2 ft above the river bottom.

The CW pumps in Screen House #2 are serviced by vertical single entry/exit traveling water screens that provides basic debris and fish handling. Each of the traveling water screens are REX (Chain Belt Company) screens with standard 3/8-inch square copper wire mesh panels (basket segments). Each traveling water screen is 5.5 ft wide and 29 ft high, and has basket (tray) segments. A screenwash system, consisting of pumps and associated piping and spray nozzles, is used keep the screen cleans. The screenwash system uses five overlapping spray nozzles with 40 psi spray pressure to remove any fish and/or debris from the traveling water screen into the fish return trough that runs along the length of Screen House #2. The outlet to the fish return trough is located on the north side of Screen House #2 at an elevation of 8 ft above MSL. Fish and debris are discharged directly into the Piscataqua River at all tidal stages.

Sections 2.3.1.1 and 2.3.1.2 further detail the traveling water screen and fish return trough, respectively, for Units 5 and 6.

2.3.1.1 Traveling Water Screens

Traveling water screens are automatically cleaned screening devices that are used to remove fish and/or floating or suspended debris from a channel of flowing water. Schiller Station's traveling water screens consist of a continuous series of wire mesh panels bolted to frames and attached to two matched strands of roller chains. As described in Section 2.3.1, there is one traveling water screen for Unit 4 and four traveling water screens for Units 5 and 6 (screens 5A, 5B, 6A, and 6B). Each of the five traveling water screens is a REX (Chain Belt Company) screen. The traveling water screen in Screen House #1 services Unit 4, and is 5.5 ft wide by 28 ft high, whereas the traveling water screens in Screen House #2 service Unit 5 and Unit 6, and are 5.5 ft wide by 29 ft high. The heights are measured from the center of the head shaft to the center of the tail shaft. Each screen is installed in a channel with the screening surface oriented perpendicular to the water flow with each screen including 34 basket (tray) segments. The chain operates in a vertical path over head and foot sprockets, carrying the panels down into the water and around the foot sprockets, then back up through the water and over the head sprockets. Raw water passes first through the ascending and then the descending screen baskets, which are constructed of 14 gauge copper wire mesh. The basket mesh has 3/8-inch square spacing with a total open area of 68%. The ascending basket is located on the upstream portion of the screen and collects fish and debris as it passes up through the water. The fish and/or debris are retained on the upstream face of the wire mesh panels. Fish and larger particles of debris are collected on a lifting shelf that forms the lower, or trailing, edge of the mesh frame. The basket continues to revolve and descends into the water on the downstream side. Any fish and debris that were not originally washed off the screen basket may be washed off in the flow of water. This is considered to be 'carryover' and will travel into the intake screen well and potentially enter the CW pump intake. Figure 2.1 shows a schematic of the traveling water screen operation.
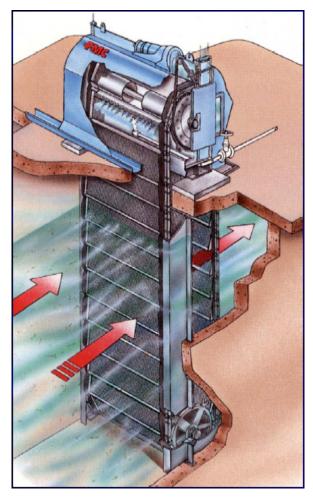
Figure 2.1   Traveling Water Screen Operation

2.3.1.2 Fish Handling and Return System

The fish and/or debris-laden mesh panels and shelves are lifted out of the flow and above the operating floor where a pressurized water spray is directed outward through the mesh to remove impinged fish and debris. Each screen manifold has 5 spray nozzles that operate at 40 psi and cover the entire width of the tray in order to wash fish and debris off of the traveling screens. The spray wash water and fish and/or debris are collected in a rectangular fish return trough. The fish return trough in Screen House #1 has dimensions varying from 18 to 24 inches wide by 10 to 18 inches deep. The trough runs along the CWIS then funnels through a 14 inch diameter chute to discharge all fish and debris into the Piscataqua River at an elevation of 4 ft above MSL. The fish return trough in Screen House #2 has dimensions 24 inches wide by varying depths of 12 to 18 inches. The trough runs along the length of the CWIS and discharges all fish and/or debris out the side of Screen House #2 into the Piscataqua River at an elevation of 8 ft above MSL. Each fish return trough discharges fish and debris directly into the Piscataqua River at all tidal stages.

2.3.2   CWIS Flow Description

As detailed above, two separate CWISs supply the generating Units with cooling water; one CWIS supplies cooling water to Unit 4, and the other CWIS supplies cooling water to Unit 5 and Unit 6. There are two distinct flow values: the baseline (i.e., design intake) capacity and the average actual intake flow rate. The design intake capacity is the flow rate that is shown on the pump design documents and is considered to be the baseline value. This value is used to design all CWIS screening technologies. The average actual flow rate, conversely, is the average historical amount of flow entering the CWIS. The average actual flow rate is smaller than the design flow rate due to periods of lesser flows resulting from outages.

2.3.2.1 Cooling Water Pumps

Unit 4

The following sets of pumps take their suction from the Screen House #1 intake screenwell:

- The Unit 4 CW pumps, which, when running, supply once-through cooling water for the CW system. Each of the two CW pumps has a capacity of 14,100 gpm, combining for a total of 28,200 gpm. The CW pumps supply the following:

    - Unit 4 Condenser

    - Unit 4 Salt Water Heat Exchangers

- The Unit 4 salt water pump, which can supply the salt water heat exchangers of any/all of the Units that are not running. The salt water pump has a capacity of 950 gpm.

- The Unit 4 screen wash pump, which supplies water to the Unit 4 screen wash system and can be routed to supply Units 5 and 6 screen wash systems and supply plant cooling water needs. The screen wash pump has a capacity of 140 gpm.

Pump Specifications

Circulating water pumps (2)

- Hayward-Tyler Model 30mn

- Each pump is rated for 14,100 gpm (for a total of 28,200 gpm) at 28 ft of total head. The motors are rated 150 hp at 440 rpm, 440 volts, three phase, 60 Hertz.

Salt water pump (1)

- WDM Pumps Model bn2021 size 12c-110

- The pump is rated for 950 gpm at 50 ft of total dynamic head (TDH)

Screen wash pump (1)

- Goulds Pump Model 3796

- The pump is rated for 140 gpm at 220 ft TDH

Units 5 and 6

The following sets of pumps take their suction from the Screen House #2 intake screenwell:

- The Unit 5 CW pumps, which, when running, supply once-through cooling water for the CW system. Each of the two CW pump has a capacity of 14,500 gpm, combining for a total of 29,000 gpm. The CW pumps supply the following:

    - Unit 5 Condenser

    - Unit 5 Salt Water Heat Exchangers

    - Units 5 and 6 Screen Wash Pumps

- The Unit 6 CW pumps, which, when running, supply once-through cooling water for the CW system. Each of the two CW pumps has a capacity of 14,500 gpm, combining for a total of 29,000 gpm. The CW pumps supply the following:

    - Unit 6 Condenser

    - Unit 6 Salt Water Heat Exchangers

    - Units 5 and 6 Screen Wash Pumps

Pump Specifications

Circulating water pumps (4)

- Hayward-Tyler Model 30mo

- Each pump is rated for 14,500 gpm at 25 ft of total head. The motors are rated 125 hp at 590 rpm, 440 volts, three phase, 60 Hertz.

Screen wash pumps (2)

- Aurora Model 364a size 2x2.5x9

- Each pump is rated for 280 gpm at 205 ft of total head.

2.3.2.2 Design Intake Capacity

The now suspended §316(b) Phase II Rule regulates cooling water but not process water. Cooling water is " ...water used for contact or non-contact cooling, including water used for equipment cooling, evaporative cooling tower makeup, and dilution of effluent heat content." (See 69 Fed. Reg. 41576, 41684 (July 9, 2004); 40 CFR Part 125, §125.93). Process water, such as the water supplied to the screen wash pumps, is not regulated by the §316(b) Phase II Rule.

Unit 4

Under normal power generating operation, the salt water pump, the screen wash pump, and the CW pumps can draw in 29,290 gpm of water from the CWIS, which includes water used for both cooling water and process water as follows:

Cooling Water (Up to 29,150 gpm)

- Up to 28,200 gpm is used as non-contact cooling water in the condenser.

- Up to 950 gpm is used as non-contact cooling water in the salt water heat exchangers.

Process Water (Up to 140 gpm)

- Up to 140 gpm is supplied to the screen wash pump during regular operation.

Unit 4 accounts for approximately 34% of the total design intake capacity for Schiller Station.

Units 5 and 6

Under normal power generating operation, each of the four CW pump draws in 14,500 gpm of water from the CWIS, which includes water used for both cooling water and process water as follows:

Cooling Water (Up to 58,000 gpm)

- Non-contact cooling water in the condenser.

- Non-contact cooling water in the salt water heat exchangers.

Process Water (Up to 560 gpm)

- Up to 560 gpm (2 pumps at 280 gpm) is supplied to the screen wash pumps during regular operation. The screen wash pumps take suction from the CW pump discharge.

Units 5 and 6 each account for approximately 33% of the total design intake capacity for Schiller Station.

2.3.2.3 Flow Reductions from Baseline

2.3.2.3.1 Maintenance Outages

At Schiller Station, the maintenance outages are staggered so that all Units are not offline at the same time. There is generally no flow entering the CWIS for whichever Unit is in the outage (Ref. Attachment 1, Section 7).

Unit 4

For Unit 4, maintenance outages occur every 18 months and last approximately four weeks.

Unit 5

For Unit 5, maintenance outages occur every 12 months and last approximately three weeks, with a six week outage scheduled every five years for turbine/generator repairs.

Unit 6

For Unit 6, maintenance outages occur every 18 months and last approximately four weeks; however, a six week outage is planned for Unit 6 in 2012.

2.3.2.3.2 Historic Operational Intake Flow Rate

In a typical calendar year, barring unusual circumstances, the number of operating days for each Unit (i.e., the number of days a CWIS was operational during a calendar year) ranges from 339 to 355 (Ref. 8.2). Both planned and unplanned periods of reduced power decrease the actual amount of flow entering the CWIS. This flow reduction is considered a reduction in

the baseline flow and, therefore, is considered to be an operational measure to reduce impingement/entrainment. Accordingly, an evaluation of historical data for Station operation and associated flows for the past eight years (2000-2007) indicates a historic operational flow reduction from baseline of 11.7% for Unit 4, 8.3% for Unit 5, and 8.5% for Unit 6.

Schiller Station supplied eight years (2000-2007) of measured discharge data for Units 4, 5, and 6, in millions of gallons per day (MGD), identical to that provided for NPDES permit compliance. Table 2.1 shows the monthly and annual average historic flows for Schiller Station. The annual average historic (2000-2007) intake flow rate for Unit 4 is 37.3 MGD, which represents an 11.7% reduction in flow from the baseline flow value of 42.2 MGD. For Unit 5, the annual average historic intake flow rate is 38.3 MGD, which represents an 8.3% reduction in flow from the baseline flow value of 41.8 MGD. Unit 6 has an annual average historic intake flow rate of 38.2 MGD, which represents an 8.5% reduction in flow from the baseline flow value of 41.8 MGD.

Table 2.1 Schiller Station Average Historic Flows (MGD)
(2000-2007)

Month	Unit 4	Unit 5	Unit 6
January	40.0	40.2	40.0
February	40.8	37.0	41.8
March	35.6	30.8	28.2
April	23.0	36.0	29.4
May	37.2	34.2	32.0
June	40.8	40.5	40.0
July	39.0	40.2	41.3
August	39.9	41.0	41.8
September	37.4	39.2	41.5
October	36.0	40.2	40.5
November	37.6	40.0	41.2
December	39.9	40.7	41.5
Annual	37.3	38.3	38.2

2.3.2.4 Through-screen Velocity

At the critical low water elevation of -9.25 ft, the traveling water screens are capable of handling a flow rate of 35,000 gpm with a corresponding through-screen velocity of 2.71 fps (Ref. 8.14). However, based on the maximum design intake capacity, the maximum flow rate through each screen at Schiller Station is substantially lower than 35,000 gpm. Based on the maximum design intake capacity of each Unit and a MLW elevation of -3.67 ft, the through-screen velocity can be approximated by using the following equation and design inputs (Ref. 8.6):

$$\text{Through-Screen Velocity} = Q/(BW*LW*POA*K)$$

where

Q is the flow rate in gpm

BW is the screen width in feet

LW is the mean low water depth in feet (14.3 ft)

POA is the "percent open area" of the screen basket

K is a conversion factor based on screen type (396 for through flow screens)

Unit 4

The maximum design intake capacity for Schiller Station Unit 4 is approximately 29,290 gpm. The single traveling water screen in Screen House #1 has a screen width of 5.5 ft and a percent open area of 68%. Based on these inputs, the through-screen velocity is 1.38 fps at MLW.

Units 5 and 6

The maximum design intake capacity for Schiller Station Units 5 and 6 combined is approximately 58,000 gpm. The four traveling water screens in Screen House #2 each have a screen width of 5.5 ft and a percent open area of 68%. Based on these inputs, the through-screen velocity is 0.68 fps at MLW.

2.3.2.5 Seasonal Changes in CWIS Operation

There are no seasonal changes in CWIS operation at Schiller Station.

2.3.3 Biocide Treatment

The CW systems for all three Units at Schiller Station (Unit 4, Unit 5, and Unit 6) are protected from marine growth (micro-fouling) and mussels (macro-fouling) with biofouling control. The biofouling control is implemented by the application of sodium hypochlorite through an injection manifold that is located in the intake forebays in front of each of the traveling water screens and before the CW pumps. All three air operated diaphragm pumps (injection pumps) are run on a timer sequence and are located in the southeast corner of Screen House #1, which also houses the sodium hypochlorite tank.

In accordance with the NPDES permit, the sodium hypochlorite system is operated for a maximum of two hours per day for each Unit. Each injection pump is set to run for 15 minutes per hour from 7 am until 3 pm. If one of the Units is offline, then biocide is not used to treat the intake for the corresponding Unit because the circulators are turned off.

Based on an hourly pumping schedule, Unit 4 runs from 0015-0030 minutes on the hour, Unit 5 runs from 0030-0045 minutes on the hour, and Unit 6 runs from 0045-0060 minutes on the hour. The injection pumps are run at a pumping rate of approximately 630 mL/minute during the 8 hours of sodium hypochlorite injection. Therefore, the rate of sodium hypochlorite injection is approximately 60 gallons per day for each Unit at Schiller Station (Ref. Attachment 1, Section 7).

2.3.4 Equipment Used to Chill Cooling Water

Schiller Station does not utilize any equipment to chill the cooling water before the water enters the Piscataqua River.

2.4 Discharge System

Unit 4

The CW system provides once-through cooling water to the condenser. Water passes from the Unit 4 intake structure in Screen House #1 through the condenser and is then discharged via ████ ███████████████████ From Unit 4, the reinforced concrete pipe travels northeast approximately 290 ft before it runs into the Unit 4 weir structure. The weir structure is designed to keep the concrete pipe full of water, causing a siphon flow in the CW system. The outfall from the Unit 4 weir discharges directly into the Piscataqua River, approximately 185 ft northeast of Screen House #1. The separation between the intake and the discharge is designed to minimize recirculation of warmed discharge effluent (Ref. 8.3).

Unit 5

Water passes from the Unit 5 intake structure in Screen House #2 through the condenser and is then discharged via a 60" I.D. reinforced concrete pipe. From Unit 5, the reinforced concrete pipe travels approximately 60 ft southeast, then 155 ft south before it runs into the Unit 5 weir structure. The weir structure is designed to keep the concrete pipe full of water, causing a siphon flow in the CW system. The outfall from the Unit 5 weir discharges directly into the Piscataqua River, approximately 145 ft southwest of the Screen House #2 intake. The separation between the intake and the discharge is designed to minimize recirculation of warmed discharge effluent (Ref. 8.3).

Unit 6

Water passes from the Unit 6 intake structure in Screen House #2 through the condenser and is then discharged via a 60" I.D. reinforced concrete pipe. From Unit 6, the reinforced concrete pipe travels approximately 45 ft east, then approximately 125 ft south before it runs into the Unit 6 weir structure. The weir structure is designed to keep the concrete pipe full of water, causing a siphon flow in the CW system. The outfall from the Unit 6 weir discharges directly into the Piscataqua River, approximately 150 ft southwest of the Screen House #2 intake. The separation between the intake and the discharge is designed to minimize recirculation of warmed discharge effluent (Ref. 8.3).

2.5 Cooling Water Process Flow Diagram

Refer to Figure 5-6 of Attachment 5, which shows the flow of cooling water through Unit 4, Unit 5, and Unit 6, respectively.

2.6 Recent and Planned Plant Modifications

2.6.1 Modifications Since January 2001

No significant modifications that would have changed the design or operation of the CW system, CWIS, or service water system have been made since January 2001; rather, only maintenance and preventative maintenance activities have occurred. Currently, there are no formalized design changes or modifications planned.

2.6.2 Age of Cooling System Equipment

Table 2.2 shows the age of the equipment used in Schiller Station's cooling system:

Table 2.2 Historical Modifications and Repairs at Schiller Station

Equipment	Originally Installed	Most Recent Major Repairs or Modifications
Unit 4 Traveling Screens	1952	1980 - The existing frame and screens were replaced with a steel frame and copper wire mesh screens with fiberglass baskets.
Unit 5 Traveling Screens	1954	1980 - The existing frames and screens were replaced with steel frames and copper wire mesh screens with fiberglass baskets.
Unit 6 Traveling Screens	1956	1980 - The existing frames and screens were replaced with steel frames and copper wire mesh screens with fiberglass baskets.
Unit 4 Spray Wash Pump	1952	1992 - Existing pump replaced with Goulds pump Model 3796.
Unit 5 and Unit 6 Spray Wash Pump	1954	2006 - Unit 5 Replaced with Aurora pump Model 364. 2007 - Unit 6 Replaced with Aurora pump Model 364.
CW Pumps 4A & 4B	1952	2004 - 4A pump overhaul. 2003 - 4B pump overhaul.
CW Pumps 5A &5B	1954	2007 - Shortened column between pump and motor and overhauled pump
CW Pumps 6A & 6B	1956	2007 - Shortened column between pump and motor and overhauled pump.
Units 4, 5, and 6 Hypochlorite Injection Pumps	2000	Replaced with Williams Instrument LD400-TFExTFE with a maximum flow of 45 gpm and a maximum pressure of 90 psi.
Unit 4 Bar(Trash)Rack	1952	1990 - Replaced with composite type trash (bar) rack
Unit 5 and Unit 6 Bar (Trash) Racks	1954 1956	2003 - Replaced with composite type trash (bar) rack
Unit 4 Lobster Corral	2002	2004 - Lobster corral (coffer dam) equipment modification to decrease lobster impingement

2.7 Projected Retirement Plans

There are no plans to retire Schiller Station at this time because it provides critically needed reliable, affordable power to New Hampshire customers. In fact, under state law (RSA 369-B:3-a), PSNH must continue to own and operate Schiller Station so long as it is in the economic interest of retail customers to do so.

3 Description of Plant Processes

3.1 Boiler Operation

Schiller Station generates steam power through three Units (Unit 4, Unit 5 and Unit 6). Units 4 and 6 are Foster-Wheeler pulverized coal/oil fired boilers, while Unit 5 is an Alstom wood/coal fluidized bed boiler. Unit 4 went into commercial operation in 1952 and has a gross generation of 50 MWe with a main steam flow of 420,000 lb/hr, an outlet steam temperature of 950°F, and a pressure of 1370 psig. Unit 6 went into commercial operation in 1956 and has a gross generation of 50 MWe with a main steam flow of 420,000 lb/hr, an outlet steam temperature of 950°F, and a pressure of 1370 psig. Unit 5 went into commercial operation in 1958 with a Foster Wheeler pressurized coal/oil boiler. However, in 2004 that boiler was replaced with an Alstom wood/coal fluidized bed boiler which commenced commercial operation in 2006 and has a gross generation of 50 MWe with a main steam flow of 450,000 lb/hr, an outlet steam temperature of 950°F, and a pressure of 1370 psig. Condensate makeup to the boilers is provided by two condensate tanks utilizing de-mineralized water from the City of Portsmouth.

3.2 Condenser Operation

River water is primarily used to cool the turbine exhaust steam in the condensers and provide cooling for the heat exchangers in the closed cooling water systems. As reflected in Figure 5-6 of Attachment 5, which shows the flow of cooling water through Schiller Station, the condensers pass river water through tubes that are used to cool exhaust steam from the turbines. Both the condenser and the heat exchangers are non-contact. The cooling water is discharged directly to the Piscataqua River via the three outfalls.

3.3 CWIS Operation

A detailed description of the CWIS systems at Schiller Station can be found in Section 2.3.

3.4 Effluent Treatment Operations

All station wastewater is collected in the Fireside Basin (FSB), which has a capacity of approximately 250,000 gallons and is divided into two equal sections connected by a partition and an overflow weir. The basin fills with wastewater, which may consist of any or all of the following: demineralized regeneration wastes, effluent from the oil/water separator, ash handling runoffs and plant operating drains, dirty water sumps, boiler blowdowns, cooling water system drainage, and wood boiler drains. Waste treatment consists of the removal of oily residues, particulates and neutralization of wastewaters.

Pumps are used to transport the wastewater from the basin to the wastewater treatment facility at a maximum flow rate of approximately 100 gpm. Incoming wastewater enters into the oxidation tank whereupon air is added and the pH range adjusted to 10.0 – 11.0 with either caustic or sulfuric acid. The wastewater then flows into the flash mix tank. The mixed flow then proceeds to the gravity plate settler, where solids fall to the settler bottom while the flow proceeds into the neutralization tank, where the pH is lowered, using sulfuric acid, to 6.5 – 8.0 for final discharge from any one of the three existing cooling water discharges (Outfalls 002, 003, 004) of any operating Unit. The cycle is repeated as necessary.

The Schiller Station wastewater system was originally designed with a gravity drain and valved directly to the river. However, in 2005, after discussions with EPA, a pumping station was installed on the discharge side of the existing neutralization tank in order to reroute that discharge (Outfalls 016 and 017) to the discharge side of either of three (3) existing cooling condensers (Outfalls 002, 003 and/or 004). As a result, Outfalls 016 and 017 no longer discharge directly to the Piscataqua River, but instead, discharge through either Outfalls 002, 003 and/or 004, thus obtaining significantly more dilution from the combined availability of condenser cooling water of any operating Unit and receiving water, in accordance with NPDES Permit No. NH0001473.

In addition, a detailed description of the sodium hypochlorination system can be found in Section 2.3.3.

4 Evaluation of Existing CWIS Technologies and Operational Measures

EPA prescribes a uniform baseline configuration (40 C.F.R. §125.93) designed to ensure consistent decision-making among different facilities nationwide as follows:

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

This Section discusses the following existing CWIS technologies and operational measures that Schiller Station uses to reduce impingement mortality and entrainment beyond the EPA baseline.

- CWIS location
- Lobster corral
- Traveling screens
- Fish handling and return system
- Lobster separation procedure
- Maintenance outages/flow reduction

Based on the fish and macrocrustacean survival data provided by Normandeau in Attachment 6, as well as the historic operational intake flow reductions, Schiller Station's existing CWIS technologies and operational measures produce quantifiable reductions from baseline in impingement and entrainment at the Station. While data is not available to estimate the impacts on impingement and entrainment for each specific component of the existing CWIS, assessments of the qualitative features of each component of the existing CWIS are provided.

The reductions in impingement and entrainment at Schiller Station, while treated in this Report as percentage reductions, are characterized by Normandeau in terms of equivalent adult (EA) fish and macrocrustaceans to ensure comparable raw data is properly understood and evaluated. Tables 4.4 through 4.9 in Section 4.2, based on information provided by Normandeau (see Attachment 6), which show baseline fish and macrocrustacean impingement and entrainment losses and monthly fractions during recent representative years, demonstrate that entrainment accounts for approximately 99% of the losses.

For Units 4, 5, and 6, the four months with the most EA fish entrainment are January through April, accounting for approximately 70% of the annual EA fish entrainment. The four months with the most EA macrocrustacean entrainment for Units 4, 5, and 6 are June through September, accounting for approximately 88% of the annual macrocrustacean entrainment.

For Unit 4, the four months with the most EA fish impingement are January, April, November, and December, which account for more than 71% of the annual Unit 4 EA fish impingement, and makes up less than 1% of the total annual abundance (i.e., the combined EA impingement and entrainment)

for Unit 4. The four months with the most macrocrustacean impingement are April, June, November, and December, which account for more than 58% of the annual Unit 4 macrocrustacean impingement, although annual Unit 4 macrocrustacean impingement makes up less than 3% of the total annual abundance for Unit 4.

For Unit 5, the four months with the most EA fish impingement are April, August, September, and October, which account for approximately 59% of the annual Unit 5 EA fish impingement, although annual Unit 5 EA fish impingement makes up less than 1% of the total annual abundance for Unit 5. The four months with the most macrocrustacean impingement are April, May, October, and November, which account for approximately 52% of the annual Unit 5 macrocrustacean impingement, although annual Unit 5 macrocrustacean impingement makes up less than 1% of the total annual abundance for Unit 5.

For Unit 6, the four months with the most EA fish impingement are January, April, October, and November, which account for more than 84% of the annual Unit 6 EA fish impingement, although annual Unit 6 EA fish impingement makes up less than 1% of the total annual abundance for Unit 6. The four months with the most macrocrustacean impingement are May through July, and November, which account for approximately 56% of the annual Unit 6 macrocrustacean impingement, although annual Unit 6 macrocrustacean impingement makes up less than 1% of the total annual abundance for Unit 6.

4.1 Evaluation of the Existing CWIS

4.1.1 CWIS Location/Lobster Rack

The intake for each Unit of Schiller Station is maintained at an elevation of 2 ft above the river bed by dredging, in order to provide a vertical barrier to the movement of bottom-oriented fish and shellfish into the CWIS (Ref. 8.15). In addition, Unit 4 has a submerged offshore intake with an additional 1.5 inch mesh panel bar rack screening structure and a lobster diversion pipe designed to prevent bottom-oriented fish and lobsters from entering the intake tunnel.

4.1.2 Existing Traveling Water Screens

The purpose of evaluating the existing traveling water screens is to determine how well the screens minimize impingement and entrainment of marine life. The following desirable design features of traveling water screens minimize impingement and entrainment (Ref. 8.6):

- Approach and through flow velocities less than 1 fps
- Open or short intake channels with 'escape routes'
- Small mesh openings
- Provisions to gently handle impinged fish
- Continuous operation
- Low-pressure wash system to gently remove impinged fish

Unit 4

The existing traveling water screen in Screen House #1 has some, but not all, of these desirable design features:

- The approach velocity is approximately 0.8 fps, and the through-screen velocity is approximately 1.38 fps at MLW for the traveling water screen. The approach velocity falls within the desired 1 fps.

- ███

- All traveling screens have square 3/8 inch openings. Therefore, they are considered coarse mesh screens, which minimize impingement.

- A rubber mat is installed on the back wall of the screen housing to soften the impact to aquatic life during transfer from the traveling water screens to the return sluiceway.

- The screens are not rotated continuously, but are typically washed once per every twelve hour shift for approximately 30 to 45 minutes.

- The current system is a low pressure spray wash system. Each screen has a 40 psi spray wash system that is used to clean the screens and remove impinged fish.

Due to the fact that all of the desirable design features mentioned above are not met by the current configuration and operation of the traveling water screens, updated screening systems are analyzed in Sections 6.1 and 6.2.

Units 5 and 6

The existing traveling water screens in Screen House #2 have some, but not all, of these desirable design features:

- The approach velocity is less than 0.5 fps, and the through-screen velocity is approximately 0.68 fps at MLW for the traveling water screen. Both the approach velocity and through-screen velocity fall within the desired 1 fps.

- The CWIS has a short intake channel.

- All traveling screens have square 3/8 inch openings. Therefore, they are considered coarse mesh screens, which minimize impingement.

- A rubber mat is installed on the back wall of the screen housing to soften the impact to aquatic life during transfer from the traveling water screens to the return sluiceway.

- The screens are not rotated continuously, but are typically washed once per every twelve hour shift for approximately 30 to 45 minutes.

- The current system is a low pressure spray wash system. Each screen has a 40 psi spray wash system that is used to clean the screens and remove impinged fish.

Due to the fact that all of the desirable design features mentioned above are not met by the current configuration and operation of the traveling water screens, updated screening systems are analyzed in Sections 6.1 and 6.2.

4.1.3   Existing Fish Return System

The main objective of any fish return system is to return captured fish to the waterbody with a minimum amount of stress. A state-of-the-art fish return system usually consists of a trough designed to maintain a water velocity of 3 to 5 fps and with a minimum water depth of 4" to 6". The trough should avoid sharp radius turns and should discharge slightly above the water level. The trough should be covered with a removable cover to prevent access by birds or other predators.

Unit 4

The current fish return system incorporates several features that improve fish survival. The fish return trough for Screen House #1 is either an enclosed pipe, or located within the screen house. The trough has one segmented turn (i.e., a 90° turn composed of two segments) within the screen house and another turn exterior of the screen house before discharging directly into the Piscataqua River at 4 ft above MSL. There is no minimum water level as the trough is normally empty, unless the traveling screen is operating. Due to the fact that existing fish return system does not meet all of the current guidelines for an optimized fish return system, an updated fish return system is considered in Section 6.1.2.

Units 5 and 6

The current fish return system incorporates several features that improve fish survival. The fish return trough for Screen House #2 is located entirely within the screen house and has no turns before discharging directly into the Piscataqua River at 8 ft above MSL. There is no minimum water level as the trough is normally empty, unless the traveling screens are operating. Due to the fact that the existing fish return system does not meet all of the current guidelines for an optimized fish return system, an updated fish return system is considered in Section 6.1.2.

4.1.4   Lobster Separation Procedure

Although lobster impingement has previously been a recurring issue at Schiller Station, plant operators have historically implemented special procedures in an attempt to reduce impingement mortality. Based on these procedures, lobsters are manually identified, separated, and transported alive from the fish return trough back into the Piscataqua River. Combined with the other lobster deterrent features implemented at Schiller Station, lobster impingement has been drastically reduced.

4.1.5   Maintenance Outages/Flow Reductions

Impingement and entrainment abundance are generally assumed to be proportionally based on the amount of cooling water entering the CWIS; therefore, reductions in intake flow would also reduce impingement and entrainment. Reduction in flow is considered to be an operational measure. For Schiller Station, the reduction in flow from baseline is based on the percent reduction from the total design intake capacity of 87,290 gpm (29,290 gpm for Unit 4, 29,000 gpm for Unit 5, and 29,000 gpm for Unit 6).

Both planned and unplanned periods of reduced power decrease the actual amount of flow entering the Station's CWISs. This flow reduction is considered a reduction in the baseline flow and, therefore, is considered to be an operational measure to reduce

impingement/entrainment. The average monthly baseline flows (in millions of gallons per month) and the monthly historic operational flow provided by Schiller Station are shown in the tables below, along with the corresponding flow reduction percentages. Utilizing historical data for Station operation and associated flows for the past eight years (2000-2007) has indicated a historic operational flow reduction of 11.7% for Unit 4, 8.3% for Unit 5, and 8.5% for Unit 6 (this historic reduction in flow is also discussed in Section 2.3.2.3.2).

Table 4.1   Unit 4 Flow Reduction from Baseline

Month	Baseline Flow (MG/month)	Historic Operating Flow (MG/month)	Flow Reduction
January	1,308	1,239	5.3%
February	1,182	1,142	3.3%
March	1,308	1,104	15.6%
April	1,266	691	45.4%
May	1,308	1,152	11.9%
June	1,266	1,224	3.3%
July	1,308	1,210	7.5%
August	1,308	1,237	5.5%
September	1,266	1,122	11.4%
October	1,308	1,116	14.7%
November	1,266	1,129	10.8%
December	1,308	1,235	5.6%
Annual	15,403	13,600	11.7%

Table 4.2   Unit 5 Flow Reduction from Baseline

Month	Baseline Flow (MG/month)	Historic Operating Flow (MG/month)	Flow Reduction
January	1,296	1,246	3.8%
February	1,170	1,037	11.4%
March	1,296	955	26.3%
April	1,254	1,079	14.0%
May	1,296	1,060	18.2%
June	1,254	1,215	3.1%
July	1,296	1,246	3.8%
August	1,296	1,271	1.9%
September	1,254	1,176	6.2%
October	1,296	1,246	3.9%
November	1,254	1,201	4.2%
December	1,296	1,263	2.6%
Annual	15,257	13,995	8.3%

Table 4.3   Unit 6 Flow Reduction from Baseline

Month	Baseline Flow (MG/month)	Historic Operating Flow (MG/month)	Flow Reduction
January	1,296	1,239	4.3%
February	1,170	1,170	0.0%
March	1,296	873	32.6%
April	1,254	882	29.7%
May	1,296	992	23.4%
June	1,254	1,200	4.3%
July	1,296	1,280	1.2%
August	1,296	1,296	0.0%
September	1,254	1,244	0.8%
October	1,296	1,256	3.1%
November	1,254	1,236	1.4%
December	1,296	1,285	0.8%
Annual	15,257	13,954	8.5%

4.2   Biological Effectiveness of Existing CWIS Technologies and Current Operational Measures

All inferences about biological effectiveness of the existing CWIS technologies and current operational measures are based on the fish and macrocrustacean values provided by Normandeau in Attachment 6. Throughout this Report, the Equivalent Adult (EA) values will be used for fish entrainment, fish impingement, and macrocrustacean entrainment. The number of EA macrocrustaceans impinged is not available due to the lack of age information in both the impingement data for Schiller Station and the published literature; therefore, the total number of impinged macrocrustaceans, irregardless of age, is used throughout this Report. All fish and macrocrustacean values in Attachment 6 were calculated by Normandeau based on the baseline flows (design intake capacity) for each Unit at Schiller Station.

4.2.1   Baseline Entrainment and Impingement Abundance

The Phase II Regulations, now suspended, measured impingement mortality and entrainment reductions against a 'calculation baseline' that assumed once-through cooling with 3/8-inch mesh intake screens oriented parallel to the shoreline and without any structural or operational controls for reducing impingement mortality or entrainment. For the purpose of this Report, potential percentage impingement and entrainment reductions were calculated based on the assumption that EPA will require Schiller Station to attain reductions from impingement and entrainment levels reflecting the above described 'calculation baseline'.

Unit 4

The estimated baseline monthly equivalent adult (EA) entrainment is shown in Table 4.4 (Attachment 6; Tables 6-4 and 6-7). For fish, the months with the highest estimated baseline EA entrainment abundance would be January through April; however, these months would have no macrocrustacean EA entrainment abundance.   While all of the estimated baseline

macrocrustacean EA entrainment abundance would occur during the months of May through November, only 29.4% of baseline EA entrainment of fish would occur during these months. Overall, under baseline conditions at Unit 4, approximately three times more EA fish would be entrained annually than EA macrocrustaceans.

Table 4.4   Unit 4 Baseline Monthly Entrainment

Month	Monthly EA Fish Entrainment		Monthly EA Macrocrustacean Entrainment	
	Abundance	Fraction	Abundance	Fraction
January	35,000	13.4%	0	0.0%
February	45,000	17.2%	0	0.0%
March	70,000	26.7%	0	0.0%
April	33,000	12.6%	0	0.0%
May	11,000	4.2%	4,000	4.9%
June	6,000	2.3%	16,000	19.8%
July	22,000	8.4%	34,000	42.0%
August	23,000	8.8%	15,000	18.5%
September	4,000	1.5%	6,000	7.4%
October	0	0.0%	5,000	6.2%
November	11,000	4.2%	1,000	1.2%
December	2,000	0.8%	0	0.0%
Annual	262,000	100.0%	81,000	100.0%

The estimated baseline monthly EA fish and total macrocrustacean impingement is shown in Table 4.5 (Attachment 6; Tables 6-2 and 6-5). For fish, 71.3% of the estimated baseline EA impingement abundance would occur during the months of January, April, November, and December. For the estimated baseline macrocrustacean impingement abundance, 69.6% would occur during the months of April, May, June, November and December. Overall, under baseline conditions at Unit 4, approximately ten times more macrocrustaceans would be impinged annually than EA fish.

Table 4.5   Unit 4 Baseline Monthly Impingement

Month	Monthly EA Fish Impingement		Monthly Total Macrocrustacean Impingement	
	Abundance	Fraction	Abundance	Fraction
January	116	11.1%	886	8.6%
February	33	3.1%	176	1.7%
March	25	2.4%	141	1.4%
April	302	28.8%	1,981	19.1%
May	19	1.8%	1,182	11.4%
June	73	7.0%	1,251	12.1%
July	26	2.5%	593	5.7%
August	5	0.5%	497	4.8%
September	25	2.4%	336	3.2%
October	97	9.3%	508	4.9%
November	149	14.2%	1,277	12.3%
December	180	17.2%	1,523	14.7%
Annual	1,048	100.0%	10,350	100.0%

Unit 5

The estimated baseline monthly equivalent adult (EA) entrainment for Schiller Station Unit 5 is shown in Table 4.6 (Attachment 6; Tables 6-4 and 6-7). For fish, the months with the highest estimated baseline EA entrainment abundance would be January through April; however, these months would have no macrocrustacean EA entrainment abundance. While 98.9% of the estimated baseline macrocrustacean EA entrainment abundance would occur during the months of May through October, only 25.1% of estimated baseline EA entrainment of fish would occur during these months. Annually, under baseline Unit 5 conditions, approximately three times more EA fish are entrained than EA macrocrustaceans.

Table 4.6   Unit 5 Baseline Monthly Entrainment

Month	Monthly EA Fish Entrainment		Monthly EA Macrocrustacean Entrainment	
	Abundance	Fraction	Abundance	Fraction
January	35,000	13.5%	0	0.0%
February	44,000	17.0%	0	0.0%
March	69,000	26.6%	0	0.0%
April	33,000	12.7%	0	0.0%
May	11,000	4.2%	4,000	5.0%
June	6,000	2.3%	15,000	18.8%
July	22,000	8.5%	34,000	42.5%
August	23,000	8.9%	15,000	18.8%
September	3,000	1.2%	6,000	7.5%
October	0	0.0%	5,000	6.3%
November	11,000	4.2%	1,000	1.3%
December	2,000	0.8%	0	0.0%
Annual	259,000	100.0%	80,000	100.0%

The estimated baseline monthly EA impingement is shown in Table 4.7 (Attachment 6; Tables 6-2 and 6-5). For fish, the majority of estimated baseline EA impingement abundance would occur in April through October. For macrocrustacean impingement, the estimated baseline monthly abundance would spread fairly evenly throughout the year, with lows in January through March. Annually, under baseline Unit 5 conditions, three times more macrocrustaceans would be impinged than EA fish.

Table 4.7   Unit 5 Baseline Monthly Impingement

Month	Monthly EA Fish Impingement		Monthly Total Macrocrustacean Impingement	
	Abundance	Fraction	Abundance	Fraction
January	29	5.2%	49	2.9%
February	5	0.9%	7	0.4%
March	20	3.6%	21	1.2%
April	67	11.9%	185	10.9%
May	34	6.0%	244	14.4%
June	34	6.0%	183	10.8%
July	57	10.1%	175	10.3%
August	85	15.1%	113	6.7%
September	117	20.8%	117	6.9%
October	64	11.4%	215	12.7%
November	29	5.2%	237	14.0%
December	22	3.9%	147	8.7%
Annual	563	100.0%	1,694	100.0%

Unit 6

The estimated baseline monthly EA entrainment for Schiller Station Unit 6, shown in Table 4.8 (Attachment 6; Tables 6-4 and 6-7), is identical to the estimated baseline monthly EA entrainment for Unit 5, shown in Table 4.6. While the months with the highest estimated baseline EA fish entrainment abundance would be January through April, these months would have no macrocrustacean EA entrainment abundance. Approximately 98.9% of the estimated baseline macrocrustacean EA entrainment abundance would occur during the months of May through October, while only 25.1% of estimated baseline EA entrainment of fish would occur during these months. Under baseline Unit 6 conditions, three times more EA fish would be entrained annually than EA macrocrustaceans.

Table 4.8   Unit 6 Baseline Monthly Entrainment

Month	Monthly EA Fish Entrainment		Monthly EA Macrocrustacean Entrainment	
	Abundance	Fraction	Abundance	Fraction
January	35,000	13.5%	0	0.0%
February	44,000	17.0%	0	0.0%
March	69,000	26.6%	0	0.0%
April	33,000	12.7%	0	0.0%
May	11,000	4.2%	4,000	5.0%
June	6,000	2.3%	15,000	18.8%
July	22,000	8.5%	34,000	42.5%
August	23,000	8.9%	15,000	18.8%
September	3,000	1.2%	6,000	7.5%
October	0	0.0%	5,000	6.3%
November	11,000	4.2%	1,000	1.3%
December	2,000	0.8%	0	0.0%
Annual	259,000	100.0%	80,000	100.0%

The estimated baseline monthly EA impingement for Unit 6 is shown in Table 4.9 (Attachment 6; Tables 6-2 and 6-5). For fish, 74.7% estimated baseline EA impingement abundance would occur during the months of January, October, and November. For macrocrustacean impingement, the estimated baseline monthly abundance would be spread fairly evenly throughout the year, where the lowest abundance occurrences would be in January through March. Under baseline Unit 6 conditions, three times more macrocrustaceans would be impinged than EA fish, annually.

Table 4.9   Unit 6 Baseline Monthly Impingement

Month	Monthly EA Fish Impingement		Monthly Total Macrocrustacean Impingement	
	Abundance	Fraction	Abundance	Fraction
January	144	38.7%	14	1.1%
February	20	5.4%	14	1.1%
March	0	0.0%	0	0.0%
April	35	9.4%	120	9.7%
May	2	0.5%	176	14.3%
June	9	2.4%	144	11.7%
July	10	2.7%	175	14.2%
August	0	0.0%	121	9.8%
September	0	0.0%	92	7.5%
October	92	24.7%	91	7.4%
November	42	11.3%	194	15.7%
December	19	5.1%	91	7.4%
Annual	372	100.0%	1,232	100.0%

4.2.2   Reduction from Baseline Entrainment and Impingement Mortality

Using the assumptions that (1) there is a direct linear (1:1) relationship between flow reductions and the number of fish impinged or entrained (a fundamental assumption of the now suspended Phase II Rule), and (2) there is 100% mortality of impinged or entrained fish at each Unit, the impingement and entrainment abundance data presented in Attachment 6, can be used to evaluate the impingement and entrainment reductions that Schiller Station achieves from baseline by employing its existing CWIS technologies and current operational flow reduction measures.

Impingement and entrainment are not uniform throughout the year, so flow-weighted annual impingement and entrainment reductions were calculated based on the results of the studies performed by Normandeau during 2006 through 2007 (Ref. 8.1) and the actual or expected pattern of intake flows at each Unit in each month throughout the year. The calculation of these impingement and entrainment reductions was performed using the actual observed timing of operational flow reductions and the daily, weekly and monthly impingement rates at Schiller Station shown in the tables in Attachment 6.

The historical operating flows from 2000 to 2007 were used to calculate each Unit's monthly and annual average operational flow reductions from baseline. In addition, monthly and annual EA entrainment and impingement survival rates were calculated for each Unit using the mortality and estimated baseline abundance data provided by Normandeau in Attachment 6. These estimated monthly EA survival rates were then combined with the monthly operational flow reductions from baseline to calculate each Unit's monthly cumulative EA entrainment and impingement reductions. The cumulative reductions were then weighted using the baseline monthly EA entrainment and impingement abundance values to determine the overall monthly and annual reductions in entrainment mortality associated with the Station's existing CWIS configuration and current operational measures as compared to baseline. A summary of the

annual reductions in entrainment and impingement mortality associated with each Unit's existing CWIS configuration and current operational measures is shown in Table 4.10.

Table 4.10   Summary of Schiller Station's Annual Reductions in EA Entrainment and Impingement Mortality from Baseline

	Unit 4	Unit 5	Unit 6
EA Fish Entrainment	61.0%	60.2%	60.9%
EA Macrocrustacean Entrainment	81.7%	80.9%	80.6%
EA Fish Impingement	34.7%	18.4%	26.3%
Total Macrocrustacean Impingement	73.9%	68.4%	67.2%

Unit 4

Based on the mortality and estimated baseline abundance data provided by Normandeau (Attachment 6; Tables 6-2, 6-4, 6-5, 6-7, 6-9, 6-11, 6-12, and 6-14), the existing fish return system at Schiller Station Unit 4 has an 18.9% EA impingement survival rate for fish and a 68.4% impingement survival rate for macrocrustaceans. The EA entrainment survival rate for fish is 55.0% while the EA entrainment survival rate for macrocrustaceans is 79.0%.

As discussed in Section 2.3.2.3.1, operational flow reductions at Schiller Station are mainly due to maintenance outages. Schiller Station Unit 4 has an average historic (2000 to 2007) annual flow reduction of 11.7% from the baseline flow (design intake capacity) of 29,290 gpm. The greatest reductions in flow occur in March through May and September through November, due to the timing of outages. The other reductions from baseline flow correspond to periods of lesser flows due to unplanned outages.

To calculate the overall average annual reductions in EA entrainment mortality for fish and macrocrustaceans at Unit 4 that are associated with the Station's existing CWIS configuration and operational measures, these historical operational flow reductions are combined with the monthly EA entrainment survival rates weighted by the monthly abundance of entrainment and compared to the design flows as shown in Table 4.11 and Table 4.12. Overall average annual reductions of 61.0% in EA entrainment mortality for fish and 81.7% in EA entrainment mortality for macrocrustaceans are attributable to the Station's operational flow reductions and the EA entrainment survival rate associated with the existing CWIS configuration.

Table 4.11   Unit 4 Baseline EA Entrainment Mortality Reduction of Fish by Month

| Month | Monthly EA Entrainment | Monthly EA Entrainment Reduction | | | EA Entrainment Reduction |
		Flow Reduction	Survival	Cumulative	
January	13.4%	5.3%	51.4%	54.0%	7.2%
February	17.2%	3.3%	57.8%	59.2%	10.2%
March	26.7%	15.6%	55.7%	62.6%	16.7%
April	12.6%	45.4%	57.6%	76.9%	9.7%
May	4.2%	11.9%	54.5%	60.0%	2.5%
June	2.3%	3.3%	16.7%	19.4%	0.4%
July	8.4%	7.5%	72.7%	74.8%	6.3%
August	8.8%	5.5%	78.3%	79.4%	7.0%
September	1.5%	11.4%	25.0%	33.5%	0.5%
October	0.0%	14.7%	0.0%	14.7%	0.0%
November	4.2%	10.8%	0.0%	10.8%	0.5%
December	0.8%	5.6%	0.0%	5.6%	0.0%
Annual	100.0% (Total)	11.7% (Average)	55.0% (Average)	60.2% (Average)	61.0% (Total)

Table 4.12   Unit 4 Baseline EA Entrainment Mortality Reduction of Macrocrustaceans by Month

| Month | Monthly EA Entrainment | Monthly EA Entrainment Reduction | | | EA Entrainment Reduction |
		Flow Reduction	Survival	Cumulative	
January	0.0%	5.3%	0.0%	5.3%	0.0%
February	0.0%	3.3%	0.0%	3.3%	0.0%
March	0.0%	15.6%	0.0%	15.6%	0.0%
April	0.0%	45.4%	0.0%	45.4%	0.0%
May	4.9%	11.9%	75.0%	78.0%	3.9%
June	19.8%	3.3%	81.3%	81.9%	16.2%
July	42.0%	7.5%	79.4%	81.0%	34.0%
August	18.5%	5.5%	80.0%	81.1%	15.0%
September	7.4%	11.4%	83.3%	85.2%	6.3%
October	6.2%	14.7%	80.0%	82.9%	5.1%
November	1.2%	10.8%	100.0%	100.0%	1.2%
December	0.0%	5.6%	0.0%	5.6%	0.0%
Annual	100.0% (Total)	11.7% (Average)	79.0% (Average)	81.5% (Average)	81.7% (Total)

In addition to flow reductions due to the actual operational flow, there is some impingement survival due to the existing CWIS technologies and operational procedures implemented by Schiller Station to reduce entrainment and impingement mortality. As shown in Table 4.13 and

Table 4.14, both a 34.7% reduction in EA impingement mortality of fish and a 73.9% reduction in total impingement mortality of macrocrustaceans are attributable to the operational flow reductions combined with the impingement survival rates due to Unit 4's existing CWIS technologies and operational procedures.

Table 4.13   Unit 4 Baseline EA Impingement Mortality Reduction of Fish by Month

| Month | Monthly EA Impingement | Monthly EA Impingement Reduction | | | EA Impingement Reduction |
		Flow Reduction	Fish Return System	Cumulative	
January	11.1%	5.3%	30.2%	33.9%	3.7%
February	3.1%	3.3%	30.3%	32.6%	1.0%
March	2.4%	15.6%	20.0%	32.5%	0.8%
April	28.8%	45.4%	17.5%	55.0%	15.9%
May	1.8%	11.9%	21.1%	30.5%	0.6%
June	7.0%	3.3%	0.0%	3.3%	0.2%
July	2.5%	7.5%	0.0%	7.5%	0.2%
August	0.5%	5.5%	0.0%	5.5%	0.0%
September	2.4%	11.4%	16.0%	25.6%	0.6%
October	9.3%	14.7%	15.5%	27.9%	2.6%
November	14.2%	10.8%	14.8%	24.0%	3.4%
December	17.2%	5.6%	29.4%	33.4%	5.7%
Annual	100.0% (Total)	11.7% (Average)	18.9% (Average)	28.4% (Average)	34.7% (Total)

Table 4.14   Unit 4 Baseline Total Impingement Mortality Reduction of Macrocrustaceans by Month

Month	Monthly Total Impingement	Monthly Total Impingement Reduction			Total Impingement Reduction
		Flow Reduction	Fish Return System	Cumulative	
January	8.6%	5.3%	89.6%	90.2%	7.7%
February	1.7%	3.3%	89.8%	90.1%	1.5%
March	1.4%	15.6%	60.3%	66.5%	0.9%
April	19.1%	45.4%	60.0%	78.2%	15.0%
May	11.4%	11.9%	60.0%	64.8%	7.4%
June	12.1%	3.3%	53.8%	55.3%	6.7%
July	5.7%	7.5%	53.8%	57.3%	3.3%
August	4.8%	5.5%	53.9%	56.4%	2.7%
September	3.2%	11.4%	71.7%	74.9%	2.4%
October	4.9%	14.7%	71.7%	75.8%	3.7%
November	12.3%	10.8%	71.7%	74.8%	9.2%
December	14.7%	5.6%	89.6%	90.2%	13.3%
Annual	100.0% (Total)	11.7% (Average)	68.4% (Average)	72.1% (Average)	73.9% (Total)

Unit 5

Based on the mortality and estimated baseline abundance data provided by Normandeau (Attachment 6; Tables 6-2, 6-4, 6-5, 6-7, 6-9, 6-11, 6-12, and 6-14), the existing CWIS technologies and operational procedures at Schiller Station Unit 5 have a 12.3% annual impingement survival rate for EA fish, while a 65.8% annual impingement survival rate exists for macrocrustaceans. The EA entrainment survival rate for fish due to the existing CWIS technologies and operational procedures is 54.8% while the EA entrainment survival rate for macrocrustaceans is 78.8%.

Schiller Station Unit 5 has an average historic (2000 to 2007) annual flow reduction of 8.3% from the baseline flow of 29,000 gpm. The greatest reductions in flow occur in February through May, due to the timing of outages. The other reductions from baseline flow correspond to periods of lesser flows due to reduced cooling demands and to unplanned outages.

To calculate the average annual reductions in EA entrainment mortality for fish and macrocrustaceans at Unit 5 that are associate with the Station's existing CWIS configuration and operational measures, these historic operational flow reductions are combined with the monthly EA entrainment survival rates and weighted by the monthly abundance of entrainment, as shown in Table 4.15 and Table 4.16. Overall average annual reductions of 60.2% in EA entrainment mortality for fish and 80.9% in EA entrainment mortality for macrocrustaceans are attributable to the Station's operational flow reductions and the EA entrainment survival rates associated with the existing CWIS configuration.

Table 4.15   Unit 5 Baseline EA Entrainment Mortality Reduction of Fish by Month

Month	Monthly EA Entrainment	Monthly EA Entrainment Reduction			EA Entrainment Reduction
		Flow Reduction	Survival	Cumulative	
January	13.5%	3.8%	51.4%	53.3%	7.2%
February	17.0%	11.4%	56.8%	61.8%	10.5%
March	26.6%	26.3%	55.1%	66.9%	17.8%
April	12.7%	14.0%	57.6%	63.5%	8.1%
May	4.2%	18.2%	54.5%	62.8%	2.7%
June	2.3%	3.1%	16.7%	19.3%	0.4%
July	8.5%	3.8%	72.7%	73.8%	6.3%
August	8.9%	1.9%	78.3%	78.7%	7.0%
September	1.2%	6.2%	0.0%	6.2%	0.1%
October	0.0%	3.9%	0.0%	3.9%	0.0%
November	4.2%	4.2%	0.0%	4.2%	0.2%
December	0.8%	2.6%	0.0%	2.6%	0.0%
Annual	100.0% (Total)	8.3% (Average)	54.8% (Average)	58.6% (Average)	60.2% (Total)

Table 4.16   Unit 5 Baseline EA Entrainment Mortality Reduction of Macrocrustaceans by Month

Month	Monthly EA Entrainment	Monthly EA Entrainment Reduction			EA Entrainment Reduction
		Flow Reduction	Survival	Cumulative	
January	0.0%	3.8%	0.0%	3.8%	0.0%
February	0.0%	11.4%	0.0%	11.4%	0.0%
March	0.0%	26.3%	0.0%	26.3%	0.0%
April	0.0%	14.0%	0.0%	14.0%	0.0%
May	5.0%	18.2%	75.0%	79.5%	4.0%
June	18.8%	3.1%	80.0%	80.6%	15.1%
July	42.5%	3.8%	79.4%	80.2%	34.1%
August	18.8%	1.9%	80.0%	80.4%	15.1%
September	7.5%	6.2%	83.3%	84.4%	6.3%
October	6.3%	3.9%	80.0%	80.8%	5.0%
November	1.3%	4.2%	100.0%	100.0%	1.3%
December	0.0%	2.6%	0.0%	2.6%	0.0%
Annual	100.0% (Total)	8.3% (Average)	78.8% (Average)	80.5% (Average)	80.9% (Total)

In addition to operational flow reductions, there is some impingement survival due to the existing CWIS technologies and operational procedures implemented by Schiller Station to reduce entrainment and impingement mortality. As shown in Table 4.17 and Table 4.18, both

an 18.4% reduction in EA impingement mortality of fish and a 68.4% reduction in total impingement mortality of macrocrustaceans are attributable to the operational flow reductions combined with the impingement survival rate due to Unit 5's existing CWIS technologies and operational procedures.

Table 4.17   Unit 5 Baseline EA Impingement Mortality Reduction of Fish by Month

Month	Monthly EA Impingement	Monthly EA Impingement Reduction			EA Impingement Reduction
		Flow Reduction	Fish Return System	Cumulative	
January	5.2%	3.8%	31.0%	33.7%	1.7%
February	0.9%	11.4%	40.0%	46.9%	0.4%
March	3.6%	26.3%	20.0%	41.1%	1.5%
April	11.9%	14.0%	17.9%	29.4%	3.5%
May	6.0%	18.2%	17.6%	32.6%	2.0%
June	6.0%	3.1%	0.0%	3.1%	0.2%
July	10.1%	3.8%	0.0%	3.8%	0.4%
August	15.1%	1.9%	0.0%	1.9%	0.3%
September	20.8%	6.2%	14.5%	19.8%	4.1%
October	11.4%	3.9%	14.1%	17.4%	2.0%
November	5.2%	4.2%	17.2%	20.7%	1.1%
December	3.9%	2.6%	31.8%	33.6%	1.3%
Annual	100.0% (Total)	8.3% (Average)	12.3% (Average)	19.5% (Average)	18.4% (Total)

Table 4.18   Unit 5 Baseline Total Impingement Mortality Reduction of Macrocrustaceans by Month

Month	Monthly Total Impingement	Monthly Total Impingement Reduction			Total Impingement Reduction
		Flow Reduction	Fish Return System	Cumulative	
January	2.9%	3.8%	89.8%	90.2%	2.6%
February	0.4%	11.4%	85.7%	87.3%	0.4%
March	1.2%	26.3%	61.9%	71.9%	0.9%
April	10.9%	14.0%	60.0%	65.6%	7.2%
May	14.4%	18.2%	59.8%	67.1%	9.7%
June	10.8%	3.1%	54.1%	55.5%	6.0%
July	10.3%	3.8%	53.7%	55.5%	5.7%
August	6.7%	1.9%	54.0%	54.9%	3.7%
September	6.9%	6.2%	71.8%	73.5%	5.1%
October	12.7%	3.9%	71.6%	72.7%	9.2%
November	14.0%	4.2%	71.7%	72.9%	10.2%
December	8.7%	2.6%	89.8%	90.1%	7.8%
Annual	100.0% (Total)	8.3% (Average)	65.8% (Average)	68.6% (Average)	68.4% (Total)

Unit 6

Based on the mortality and estimated baseline abundance data provided by Normandeau (Attachment 6; Tables 6-2, 6-4, 6-5, 6-7, 6-9, 6-11, 6-12, and 6-14), the existing CWIS technologies and operational procedures that were implemented to reduce entrainment and impingement mortality at Schiller Station Unit 6 have a 21.5% annual impingement survival rate for EA fish, while a 64.2% annual impingement survival rate exists for macrocrustaceans. The EA entrainment survival rate for fish is 54.8%, but the EA entrainment mortality for macrocrustaceans is 78.8%.

Schiller Station Unit 6 has an average historic (2000 to 2007) annual flow reduction of 8.5% from the baseline flow of 29,000 gpm. The greatest reductions in flow occur in March through May. The other reductions from baseline flow correspond to periods of lesser flows due to unplanned outages.

To calculate the average annual reductions in EA entrainment mortality for fish and macrocrustaceans at Unit 6 that are associated with the Station's existing CWIS configuration and operational measures, these historical operational flow reductions are combined with the monthly EA entrainment survival rate and weighted by the monthly abundance of entrainment, as shown in Table 4.19 and Table 4.20. Overall average annual reduction of 60.9% in EA entrainment mortality for fish and 80.6% in EA entrainment mortality for macrocrustaceans are attributable to the Station's operational flow reductions and the EA entrainment survival rate associated with the existing CWIS configuration.

Table 4.19   Unit 6 Baseline EA Entrainment Mortality Reduction of Fish by Month

Month	Monthly EA Entrainment	Monthly EA Entrainment Reduction			EA Entrainment Reduction
		Flow Reduction	Survival	Cumulative	
January	13.5%	4.3%	51.4%	53.5%	7.2%
February	17.0%	0.0%	56.8%	56.8%	9.7%
March	26.6%	32.6%	55.1%	69.7%	18.6%
April	12.7%	29.7%	57.6%	70.2%	8.9%
May	4.2%	23.4%	54.5%	65.2%	2.8%
June	2.3%	4.3%	16.7%	20.2%	0.5%
July	8.5%	1.2%	72.7%	73.1%	6.2%
August	8.9%	0.0%	78.3%	78.3%	6.9%
September	1.2%	0.8%	0.0%	0.8%	0.0%
October	0.0%	3.1%	0.0%	3.1%	0.0%
November	4.2%	1.4%	0.0%	1.4%	0.1%
December	0.8%	0.8%	0.0%	0.8%	0.0%
Annual	100.0% (Total)	8.5% (Average)	54.8% (Average)	58.7% (Average)	60.9% (Total)

Table 4.20   Unit 6 Baseline EA Entrainment Mortality Reduction of Macrocrustaceans by Month

Month	Monthly EA Entrainment	Monthly EA Entrainment Reduction			EA Entrainment Reduction
		Flow Reduction	Survival	Cumulative	
January	0.0%	4.3%	0.0%	4.3%	0.0%
February	0.0%	0.0%	0.0%	0.0%	0.0%
March	0.0%	32.6%	0.0%	32.6%	0.0%
April	0.0%	29.7%	0.0%	29.7%	0.0%
May	5.0%	23.4%	75.0%	80.9%	4.0%
June	18.8%	4.3%	80.0%	80.9%	15.2%
July	42.5%	1.2%	79.4%	79.7%	33.9%
August	18.8%	0.0%	80.0%	80.0%	15.0%
September	7.5%	0.8%	83.3%	83.5%	6.3%
October	6.3%	3.1%	80.0%	80.6%	5.0%
November	1.3%	1.4%	100.0%	100.0%	1.3%
December	0.0%	0.8%	0.0%	0.8%	0.0%
Annual	100.0% (Total)	8.5% (Average)	78.8% (Average)	80.6% (Average)	80.6% (Total)

In addition to flow reductions due to the actual operational flow, there is some impingement survival due to the existing CWIS technologies and operational procedures implemented by Schiller Station to reduce entrainment and impingement mortality. As shown in Table 4.21 and

Table 4.22, both a 26.3% reduction in EA impingement mortality of fish and a 67.2% reduction in total impingement mortality of macrocrustaceans are attributable to the operational flow reductions combined with the impingement survival rate due to Unit 6's existing CWIS technologies and operational procedures.

Table 4.21   Unit 6 Baseline EA Impingement Mortality Reduction of Fish by Month

| Month | Monthly EA Impingement | Monthly EA Impingement Reduction | | | EA Impingement Reduction |
		Flow Reduction	Fish Return System	Cumulative	
January	38.7%	4.3%	29.9%	32.9%	12.7%
February	5.4%	0.0%	30.0%	30.0%	1.6%
March	0.0%	32.6%	0.0%	32.6%	0.0%
April	9.4%	29.7%	17.1%	41.7%	3.9%
May	0.5%	23.4%	0.0%	23.4%	0.1%
June	2.4%	4.3%	0.0%	4.3%	0.1%
July	2.7%	1.2%	0.0%	1.2%	0.0%
August	0.0%	0.0%	0.0%	0.0%	0.0%
September	0.0%	0.8%	0.0%	0.8%	0.0%
October	24.7%	3.1%	15.2%	17.8%	4.4%
November	11.3%	1.4%	14.3%	15.5%	1.7%
December	5.1%	0.8%	31.6%	32.1%	1.6%
Annual	100.0% (Total)	8.5% (Average)	21.5% (Average)	28.2% (Average)	26.3% (Total)

Table 4.22   Unit 6 Baseline Total Impingement Mortality Reduction of Macrocrustaceans by Month

Month	Monthly Total Impingement	Monthly Total Impingement Reduction			Total Impingement Reduction
		Flow Reduction	Fish Return System	Cumulative	
January	1.1%	4.3%	92.9%	93.2%	1.1%
February	1.1%	0.0%	92.9%	92.9%	1.1%
March	0.0%	32.6%	0.0%	32.6%	0.0%
April	9.7%	29.7%	60.0%	71.9%	7.0%
May	14.3%	23.4%	60.2%	69.5%	9.9%
June	11.7%	4.3%	53.5%	55.5%	6.5%
July	14.2%	1.2%	53.7%	54.3%	7.7%
August	9.8%	0.0%	53.7%	53.7%	5.3%
September	7.5%	0.8%	71.7%	72.0%	5.4%
October	7.4%	3.1%	71.4%	72.3%	5.3%
November	15.7%	1.4%	71.6%	72.0%	11.3%
December	7.4%	0.8%	90.1%	90.2%	6.7%
Annual	100.0% (Total)	8.5% (Average)	64.2% (Average)	67.3% (Average)	67.2% (Total)

5 Mechanical Draft Towers for Closed-Loop Cooling

As EPA directed in the §308 Letter, this section evaluates the retrofitting of mechanical draft cooling towers at Schiller Station for all three operating Units. Conversion of existing operating power stations from once-through to closed-cycle cooling is largely unprecedented. Even without this uncertainty, conversion of an existing, operating power plant from once-through condenser cooling to closed-loop condenser cooling represents a massive engineering and construction undertaking, even when site conditions are conducive to the required configuration changes.

5.1 Conceptual Design

The fact that Schiller Station is located on a seawater estuary presents special challenges relative to conversion to closed-cycle cooling. Although cooling towers can operate in salt water cooling systems, both initial capital and ongoing operational and maintenance (O&M) costs significantly increase, and numerous operational issues are created. The initial capital cost increase is largely due to the special materials needed resist corrosion in a salt water operating environment; this will be discussed in detail in Section 5.2, and the associated Attachment 4. Regarding operational issues, salt water towers require appreciably greater makeup and blowdown flows than fresh water systems, as they must utilize very low cycles of concentration due to the salt water mineral content. Additionally, cooling tower drift rates must be maintained as low as possible to minimize salt deposition on surrounding areas. Within the plume travel boundaries, salt deposition is damaging to plant life, and also causes significant corrosion damage to plant features like the switchyard; this will be discussed in more detail in Section 5.3.

A less costly and more operations friendly alternative to salt water cooling for the Schiller application is utilizing a 'fresh water' cooling system with makeup provided by 'grey water'. Preliminary assessments of nearby sources indicate that the closest wastewater treatment facility with an adequate amount of grey water to provide the needed make-up flow rate is Pierce Island WWTF (discussed in more detail in Section 6.5). Utilizing this makeup source would eliminate the problems associated with salt water cooling systems, eliminate water withdrawal from the Piscataqua River, and minimize blowdown flow to the river. However, using this grey water source would also create some new challenges, including verification that the grey water is available for PSNH use, routing of the transfer piping up to approximately 4 miles to the Schiller site, and close control of cooling tower drift; nonetheless, the potential benefits warrant consideration of this water source. Since the availability of grey water for this application will not be ascertained by the time this Report is submitted, subsequent sections will consider both salt water and grey water closed-cycle cooling systems.

Another site-specific consideration for the Schiller site is the ability to provide needed cooling for all three Units in the most efficient manner. There are two ways to go about this, either utilizing a Unit-specific dedicated cooling tower for each Unit, or combining the cooling flows of the three Units and cooling all three Units via a common cooling tower. As will be discussed in more detail in Section 5.1.1.1.2, the most efficient configuration for Schiller Station would be to utilize a common tower to provide the necessary cooling for the combined flows of all three Units. This common cooling tower would consist of multiple cells, with a control system capable of providing the necessary load-following via shutting down individual cells if one or more Units at the site were shut down for outage(s).

While the cumulative impact of all the possible factors cannot be fully estimated for Schiller Station at this initial engineering analysis stage, the critical "big picture" measures that would play a significant role in determining the feasibility and the appropriate configuration of any closed-cycle system for the Station are discussed in the following sections.

5.1.1   Major Components

Other alternatives for heat rejection with the necessary capacity to support closed-loop cooling, such as evaporative ponds, spray ponds, or cooling canals, all would require significantly more real estate to implement than exists at the Schiller Station site. Hence, and in accordance with EPA's direction in the §308 Letter, this section will address only cooling towers and the associated required major components, specifically the booster pumping station, and interconnecting runs of CW piping.

5.1.1.1 Cooling Towers

5.1.1.1.1 Dry Cooling Towers

Dry cooling towers, which rely totally on sensible heat transfer (i.e., no heat is transferred via phase change), lack the efficiency of wet or hybrid towers using evaporative cooling, and thus require a far greater surface area than is available at the Schiller Station site. Additionally, due to their lower efficiency, dry towers are not capable of supporting condenser temperatures and associated backpressures necessary to be compatible with the Station's turbine design, and therefore, their implementation at Schiller Station is not considered technologically feasible.

5.1.1.1.2 Evaporative Cooling Towers

Evaporative cooling tower types and configurations are discussed below:

Natural Draft Towers

Of the types of evaporative cooling towers, the natural draft "wet tower" is comparatively efficient, quiet, moderate to high in initial cost, and moderate in footprint (i.e., up to 450 feet in diameter), and under appropriate circumstances, can be less costly to operate than comparably sized mechanical draft cooling towers. Thus, given suitable site conditions, the natural draft tower can be a sound engineering choice.

However, natural draft towers rely on the "chimney effect" of the tower to create the required draft; hence, such towers must be very tall - approximately 450 to 550 ft in height. Local zoning restrictions often preclude the use of natural draft towers. Additionally, natural draft towers require adequate heat load provided by the CW system to fuel the thermal differential required to create and sustain the "chimney effect". Because of the relatively small capacity of cooling water (i.e., CW) flow at Schiller Station, implementation of natural draft towers is technologically infeasible.
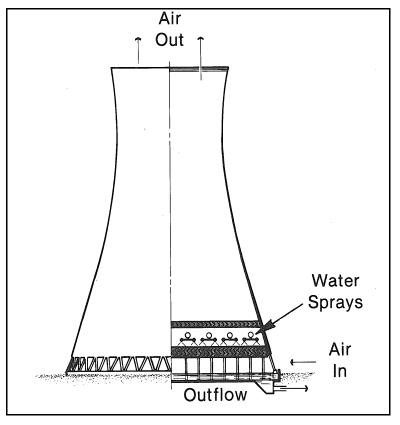
Figure 5.1 illustrates a typical natural draft cooling tower.

Figure 5.1   Counterflow Hyperbolic Natural Draft Cooling Tower (Ref. 8.4)

Air flow through the tower is produced by the density differential that exists between the heated (less dense) air inside the stack and the relatively cool (more dense) ambient air outside the tower. Since these towers depend on their geometric shape rather than fans for required air flow, they have low operating costs.

Mechanical Draft Towers

Compared to the other types of evaporative cooling towers, a mechanical draft wet cooling tower can be efficient, typically lowest in initial cost, moderate in footprint, and has moderate operating costs. Due to the need for forced draft fans, this type of tower has slightly higher noise levels than a natural draft tower, although attenuation to acceptable levels is possible, at an added cost.

To minimize operational losses due to higher intake water temperature, a tower with an 8°F approach (see Figure 5.2 for definition of "approach" (Ref. 8.4)) is considered the largest that could be effectively utilized at Schiller Station. The 8°F approach tower design point is considered the optimum trade-off between total capacity and performance, size, initial cost, and operating costs.

Figure 5.2 indicates the relationship between cooling tower design approach to wet bulb and tower size. The 8 °F approach to wet bulb tower design point is very close to the theoretical limit in performance, generally acknowledged to be a 7°F approach to wet bulb. Utilizing a tower this large, with this approach to wet bulb, would result in the least operational losses for Schiller Station.

Figure 5.2, left diagram:

- 85°F — Hot water to tower
- Cooling range (85°F to 70°F)
- All temperatures used are illustrative only and subject to wide variation
- 70°F — Cold water from tower
- Approach (70°F to 65°F)
- 65°F — Wet-bulb temperature

Figure 5.2, right graph: TOWER SIZE FACTOR (0.5 to 2.5) vs APPROACH—°F (5 to 30)
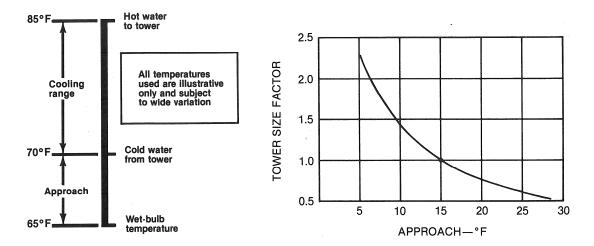
Figure 5.2   **Definition of "Approach," "Cooling Range," and relationship of approach to tower size (Ref. 8.4)**

The graph on the left shows the relationship of range and approach as the heat load is applied to the tower. Although the combination of range and gpm is fixed by the heat load in accordance with Heat Load = gpm x 8.33 lbs./gal. water x range = Btu/min., approach is fixed by the size and efficiency of the cooling tower.

The graph on the right indicates how given two towers of equal efficiency, with proportionate fill configurations and air rates, the larger tower will produce colder water; i.e. have a closer approach. Important to note, from a tower cost standpoint, is the fact that the base 15°F approach tower would have had to be twice as large to produce a 7°F approach, whereas it could have produced a 25°F approach at only 60% of its size.

Figure 5.3 illustrates the air flow path through a cell of a typical mechanical draft wet cooling tower, and the applicable simplified psychrometric chart (Ref. 8.4).

Figure 5.3 diagram: Left — cooling tower cross-section with OUTLET AIR (② or ④), HOT WATER, INLET AIR (① or ③), EVAPORATIVE FILL SECTION, FILL, COLD WATER. Right — psychrometric chart with SPEC. HUM. GR./LB. DA vs DRY BULB TEMPERATURE (°F), showing SATURATION CURVE, SUPER SATURATION (Fog) AREA, MIXING AIR ABOVE TOWER, MIXING AIR WITHIN TOWER, SUPER HEAT (Non-Fog) AREA, and points 1, 2, 3, 4.
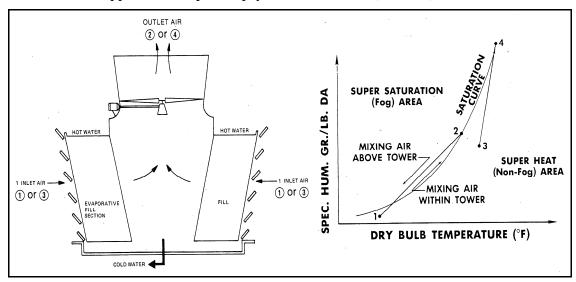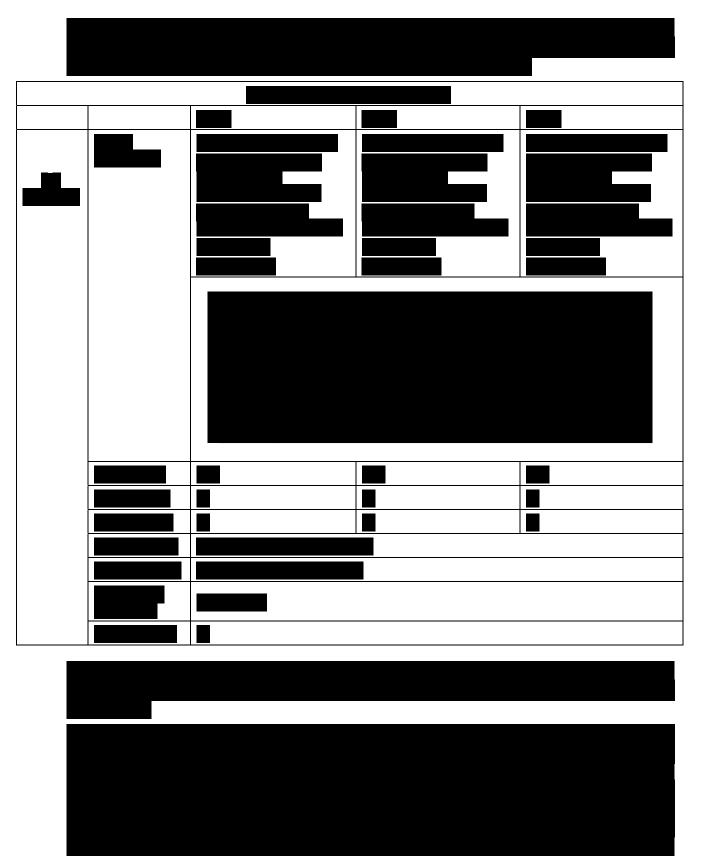
Figure 5.3   **Saturation of Air In Typical Mechanical Draft Wet Cooling Tower (Ref. 8.4)**

Two cases are depicted in the above figure. Case 1 - During summertime, ambient air enters the tower at condition 3 and exits saturated at condition 4. After leaving the tower, this saturated air mixes with the ambient air along line 4-3, such that most of the mixing occurs in the invisible region below the saturation curve of the psychrometric chart. Case 2 - In the winter, ambient air enters the tower at condition 1, exiting saturated at condition 2 and returning to ambient conditions along line 2-1. As can be seen, most of this mixing occurs in the region of super-saturation, which causes a visible plume.

than the single shared tower selected, demanding much more real estate than is available at the Schiller site.

<u>Hybrid Towers</u>

A hybrid cooling tower, also referred to as a "plume abated" cooling tower, addresses some of the plume-related issues associated with the tower types previously evaluated. Basically, a hybrid tower is the combination of the wet tower, with its inherent cooling efficiency, and a dry heat exchanger section used to eliminate visible plumes in the majority of atmospheric conditions. After the plume leaves the lower "wet" section of the tower, it travels upward through a "dry" section where heated, relatively dry air is mixed with the plume in the proportions required to attain a non-visible plume. Hybrid towers are slightly taller than comparable wet towers, due to the addition of the "dry" section, and may require a larger footprint. They are also appreciably more expensive, both in initial costs and in ongoing operating and maintenance costs.

Although much higher in both initial capital cost and ongoing operational costs, a hybrid tower is the most appropriate for the evaluation that EPA has directed Schiller Station to undertake. Since a cooling tower would operate any time the Units would operate, including during the winter months when visible plumes occur, the plume abated characteristics of a hybrid tower are considered essential. Refer to additional discussions of plume abatement in Section 5.1.3.1.

Figure 5.4 (Ref. 8.4) illustrates the air flow path through a cell of a parallel path linear hybrid tower, and the applicable simplified psychrometric chart.
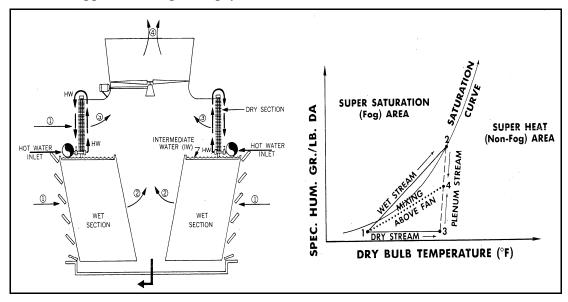
Figure 5.4   Partial Desaturation of Air in a Parallel Path Hybrid Tower (Ref. 8.4)

A hybrid cooling tower is designed to drastically reduce both the density and the persistency of the plume. Incoming hot water flows first through the dry heat exchanger (finned coil) sections, then through the wet (evaporative cooling) fill section. Parallel streams of air flow across the coil sections and through the fill sections, leaving the coil sections at dry condition 3, and leaving the fill sections at saturated condition 2. These two separate streams of air then mix together going through the fans, along the lines 3-4 and 2-4 respectively, exiting the fan cylinder at sub-saturated condition 4. This exit air then returns to ambient conditions along line 4-1, avoiding the region of super-saturation (visible plume) altogether in most cases.

Hybrid towers are available in different configurations, most often either linear or round. Round towers offer the most concise footprint, but are more expensive. For the Schiller Station application, available space would be adequate for a linear configuration. Therefore, this Report evaluates a linear hybrid cooling tower design, specifically, a five cell linear mechanical draft cooling tower. Refer to Attachment 2, Sketch PSNH002-SK-001, for a simplified site layout with a single five cell cooling tower supporting the operation of all three Units.

5.1.1.2 Pumping Station

Aside from the cooling tower, the most significant components in converting Schiller Station to a closed-loop condenser cooling configuration would be new CW booster pumps and a new 'booster' pumping station. Whereas the existing once-through configuration requires only enough pumping head (pressure) to overcome flow losses in passing water from the River through the condenser and returning to the River, any of the above configurations would require significantly increased pump head to pump the circulating water up to the elevated cooling tower spray headers and dry heat exchanger coils and overcome the significant internal flow resistance of the cooling tower. As the existing CW pumps are designed for 28 feet of head, the new booster pumps would be required to produce approximately 36 to 40 feet of head. Since the condenser inlet water flow rate would remain largely constant with the closed-loop arrangement, single speed/flow rate pumps would be adequate and appropriate for the new configuration. The cooling tower pumping station would use an impounded area, of what is now the river, for suction to the pumps.

Note: The conceptual design placement (refer Attachment 2, Sketch PSNH002-SK-001) of the dikes necessary to provide the required impounded and segregated discharge and intake embayments assumes that the necessary permits and approvals can be obtained.

Attachment 1, Section 2, contains reference information on the new CW booster pumps that would supply cooling water for all three Units at Schiller Station.

The existing CW pumps for each Unit (from Section 2.3.2.1) are as follows:

- Each of two Unit 4 CW pumps is rated for 14,100 gpm at 28 ft of total head, combining for a total of 28,200 gpm. The motors are rated 150 hp at 440 rpm, 440 volts, three phase, 60 Hertz. Additionally, the Unit 4 salt water pump provides a 950 gpm supply to the salt water heat exchangers of any/all of the Units.

- Each of two Unit 5 and two Unit 6 CW pumps is rated for 14,500 gpm at 25 ft of total head, combining for a total of 29,000 gpm. The motors are rated 125 hp at 590 rpm, 440 volts, three phase, 60 Hertz.

The four new CW booster pumps, three operating and one standby, would each require an estimated 900 BHP motor (Attachment 1, Section 2).

The new CW booster pumps for each Unit would be as follows:

- Each of the four CW booster pumps is rated for 29,200 gpm at 85 ft of total head, combining for a total of 116,800 gpm. The motors are rated 900 hp at 900 rpm, 460 volts, three phase, 60 Hertz.

Because the cooling tower and CW booster pumps would represent significant additional electrical loads (i.e. cooling tower fans), a new substation, fed directly from the switchyard, would be required to supply electrical power to the tower and the booster pumping station.

5.1.1.3 Primary Circulating Water Pipe

The new booster pumping station would be located on the newly impounded discharge canal to provide the CW system pumping head to adequately overcome the cooling tower head and flow resistance. This would require new runs of CW piping from the booster pumping station to the cooling tower location, and then returning to the newly impounded Station intake area where the cooled water would be returned to the existing CW pumps suction. The cooling tower supply would be a 72 inch diameter, AWWA specification, concrete-lined steel pipe and the return to the newly impounded intake area would be two 54 inch diameter, AWWA specification, concrete-lined steel pipes.

5.1.2   Site Layout for Conversion

Refer to Attachment 2, Sketch PSNH002-SK-001, for a simplified site layout of the evaluated closed-loop cooling configuration.

5.1.2.1 Cooling Tower Location

The evaluated cooling tower location is south of the plant between the railroad track and the coal pile runoff basin. This location would provide adequate space, be relatively close to the Station powerhouse (minimizing the required length of CW piping and associated pumping losses), and require minimal earthwork to be suitable for the tower erection. The basin elevation of the tower would be dictated by the required head for gravity flow back to the newly impounded CW pump intakes, and preliminary analysis indicates a differential elevation of approximately five feet would be required. In actuality, the existing elevation difference between the cooling tower basin proposed site and the River is well in excess of five feet.

Associated electrical power supply modifications are also shown on Sketch PSNH002-SK-001 in Attachment 2. Due to the appreciable power requirements of the new cooling tower and booster pumping station, a dedicated substation would be required. A pre-fabricated metal building, shown on Sketches PSNH002-SK-002 and -003 in Attachment 2, would be required to house the substation transformers, switchgear, and tower control system. The substation for the tower would have to be located as close as practicable to the tower to reduce cable runs from the substation to the tower.

5.1.2.2 Intake Pumping Station Location

The locations of the existing CW pumphouses (i.e., current CWISs) are expected to remain unchanged on the inlet side of the condenser (intake pumping station). The new cooling tower booster pumphouse would be located at the newly impounded plant discharge embayment as shown on Sketch PSNH002-SK-001 in Attachment 2. The cooling tower booster pumps in the new cooling tower pumphouse would supply CW to the new cooling tower via a 72 inch diameter, AWWA specification, concrete-lined steel pipe. As discussed previously, the

necessary head for CW return flow to the existing CW pump intakes would be provided by the static head achieved from the elevation of the cooling tower basin.

5.1.2.3 Primary Circulating Water Pipe Routing

The new cooling tower booster pumphouse would be located on the discharge side of the condenser at the newly impounded plant discharge embayment as shown in Attachment 2, PSNH002-SK-001. There would be new runs of CW piping from the cooling tower booster pumphouse to the cooling tower located south of the plant, and then returning to the newly impounded station intake area embayment where the cooled water would be returned to existing CW pumps suction.

5.1.3   Operational Features and Schemes

To efficiently utilize a hybrid tower, an automated control system would be required. For the Schiller Station application, the tower would likely operate at maximum capacity for each of the three Units (all fans running) during the summer months to maintain condenser inlet water temperatures as near as possible to current design operating parameters. However, the need to operate all the tower cell fans during the cooler seasons would be totally dependent on ambient conditions. A programmable logic control (PLC) system would be utilized to reduce tower operating cost (parasitic losses) to a minimum, while maintaining condenser inlet water temperatures at the design point for the most efficient Station operation.

Additionally, since the common five-cell tower would serve all three Units, the ability to drop un-needed cells with load drops, i.e., when one or more Units are out of service due to maintenance or other outages, would need to be provided. The automated PLC system could appropriately provide this control ability.

5.1.3.1 Plume Abatement

The cooling tower type evaluated, a linear hybrid tower, has specific attributes that would minimize the visual impact of the tower's plume. Also termed a plume abated tower, the evaluated model would generate no visible plume under the conditions for which it is designed, which correlates to 90% of the projected operating conditions. The evaluated design "plume point" is 27°F at 90% relative humidity; i.e., the plume would start to become visible when the design plume point is exceeded, although the plume would be much less dense and/or persistent than if generated by a non-plume abated tower.

For the Schiller Station application, with the close proximity of the Station to roads and heavily populated commercial areas, plume abatement is considered an essential feature. The cost adder for a plume abated cooling tower of this type is 100-150% of the 'base' cooling tower cost (i.e., a plume abated cooling tower costs approximately double to two and one-half times that of a non-plume abated tower). For seawater applications, the dry heat exchanger must be constructed from titanium, so the costs further increase, typically about 300% or three times that of a non-plume abated cooling tower.

5.1.3.2 Noise Abatement

When located in close proximity to residential areas or other noise-sensitive locations, cooling tower noise abatement features are often required. There are two types of noise abatement;

water noise abatement and fan noise abatement (low-noise fans). Each can be provided as options for a mechanical draft tower. The proposed cooling tower for the Schiller Station would be located directly across the river from a residential area, hence stringent noise abatement would be required.

The cost adder for the required noise abatement features would be twofold. The water noise abatement would represent a 15% increase in cost over the 'base' tower, and the fan noise abatement would represent an additional 20% increase in cost over the 'base' tower.

5.1.3.3 Make-up and Blowdown

In a closed-loop cooling configuration with cooling towers providing the heat rejection, the evaporation from the towers tends to concentrate the intake water contaminant levels and total dissolved solids (TDS). A "blowdown" flow is required to maintain a design level of "cycles of concentration" by constantly bleeding off some cooling water back to the River. The "make-up" flow must be adequate to replenish water lost to evaporation and drift (entrained water particles carried out in the tower plume), plus the blowdown flow. The cycles of concentration are predetermined based on intake water quality, and suitability of materials in the cooling tower and the condenser. For the Schiller Station application, the cycles of concentration and corresponding makeup flow would be dependent upon whether the tower were to utilize seawater or grey water for cooling.

Blowdown is calculated as follows (Ref. 8.4):

$$B = \frac{E - [(C-1) \times D]}{(C-1)}, \quad \text{where B = blowdown, E = evaporation, D = drift, and C = cycles of concentration}$$

Drift can be approximated as Water Flow $_{Total}$ x 0.00002 gpm.

Cooling Tower range is approximately 19ºF

Evaporation $_{Wet\ Summer}$ can be approximated as Water Flow $_{Total}$ x R $_{Range}$ x 0.0008 gpm

For Schiller Station, since the intake water quality varies based on Piscataqua River flow rate, an acceptable cycle of concentration would be dependent on the current intake water quality. For the purpose of this Report, at worst case intake seawater water quality, blowdown and makeup would be based on 2 cycles of concentration. Required makeup flow would thus be:

$$\text{Makeup = B + E + D (Ref. 8.4), where B = } \frac{E - [(C-1) \times D]}{(C-1)}, \text{ and C = 2,}$$

Assume Unit 4 Water Flow = 29,000gpm (29,150 gpm equals Unit 4 flow w/ maximum seawater supply to heat exchangers). Therefore use 29,000 gpm for all three Units.

Unit 4, 5 & 6 Water Flow = 87,000gpm

E $_{Wet}$ = 0.0008 x R x Water Flow = 1322 gpm

D = Water Flow x 0.00002 gpm = 1.74 gpm

B = 1320 gpm

M = 2644 gpm

> Plant seawater makeup from the River during tower operation would hence equal:
>
> Unit 4, 5, and 6 M $_{Wet}$ = 2644 gpm = 3.8 MGD

If grey water instead of seawater were utilized, the cycles of concentration could be significantly increased. For a closed-cycle cooling system with grey water makeup, the blowdown and makeup would be based on 6 cycles of concentration:

$$Makeup = B + E + D \text{ (Ref. 8.4), where } B = \frac{E - [(C\text{-}1) \times D]}{(C\text{-}1)}, \text{ and } C = 6,$$

Assume Unit 4 Water Flow = 29,000gpm (29,150 gpm equals Unit 4 flow w/ maximum seawater supply to heat exchangers). Therefore use 29,000 gpm for all three Units.

Unit 4, 5 & 6 Water Flow = 87,000 gpm

E $_{Wet}$ = 0.0008 $\times$ R $\times$ Water Flow = 1322 gpm

D = Water Flow $\times$ 0.00002 gpm = 1.74 gpm

B = 263 gpm

M = 1586 gpm

> Plant makeup from grey water sources during tower operation would hence equal:
>
> Unit 4, 5, and 6 M = 1586 gpm = 2.3 MGD

5.1.3.4 Condenser Cleaning and Maintenance w/ Closed-Loop Cooling

Current Station design does not incorporate a condenser cleaning system. The installation of a condenser tube cleaning system would provide two advantages:

- Eliminating the need to take a condenser out of service for tube cleaning.

- Allowing maintaining the tubes at a consistently low level of fouling.

Since the presence of fouled tubes would have a greater impact on Station output once converted to closed-loop cooling (due to higher condenser inlet water temperatures), installation of a condenser tube cleaning system would be an imperative part of the Station redesign. The design of the revised CW pump house for each Unit would thus incorporate the requirements for a permanently installed condenser tube cleaning system.

5.2 Cost Estimates

As EPA directed in the §308 Letter, this section provides estimates of the costs that would be involved in converting Schiller Station Units 4, 5, and 6 to closed-loop condenser cooling.

- The capital costs of the initial conversions are quantified, including design, procurement, implementation, and startup activities, based on the conceptual design previously identified and discussed.

- The duration of the required Unit outages, based on a timeline of critical milestones that would have to be worked with the associated Unit off-line, is utilized to determine the resulting lost generating capacity, expressed in $MW_{HOURS-ELECTRIC}$.

- The new cooling towers and CW pumps would require operations and maintenance personnel support as well as service, repair, and replacement of components; since the estimates are based on input from potential supplying vendors, these costs are approximated.

- Additionally, the new towers and CW pumps would require an appreciable amount of power to operate, herein referred to as "parasitic losses", which effectively would reduce Station output power to the distribution grid. Power consumption of the required new components can be estimated from preliminary vendor data, and hence total $MW_{ELECTRIC}$ parasitic losses determined.

- Finally, the conversion would create less than optimum operating parameters for the existing turbines/condensers, resulting in reduced output to the grid under most operating conditions. Based on historical operating performance data, evaluated cooling tower performance data, applicable heat balance diagrams, and 15 years of meteorological data (1993 through 2007), the annual average reduction in performance due to operational efficiency losses in generator output averaged over the entire calendar year would be significant, approximately 21.6 $MW_{ELECTRIC}$; additionally, the reduction in performance due to operational efficiency losses occurring during the peak load conditions in June through August would be very impactive at approximately 35.9 $MW_{ELECTRIC}$ (See Attachment 3).

5.2.1   Initial Capital Costs

An accurate assessment of the capital costs associated with the closed-loop cooling conversion that EPA has directed PSNH to evaluate is a critical goal of this Report. Minimizing assumptions and relying instead on well-developed, detailed conceptual designs greatly increases the accuracy of the ensuing estimates. In broad terms, conceptual design engineering outlines system scope definition, evaluates detailed layout and equipment specification/criteria, and assists in gathering site-specific historical data. Attachment 2 to this Report includes some of the conceptual drawings utilized for subsequent construction estimates. This information was used to develop greater detail regarding associated tasks and logistics that would be required as a minimum to successfully perform the construction for the conversion. The resulting Direct Capital Cost Estimate and Project Schedule represent the level of detail necessary to generate an accurate capital cost assessment.

The estimating basis relies on cost factoring and solicitation from various assets capable of providing real world solutions. Vendors were contacted for quotations on various equipment and material components, while established construction cost estimating tools were utilized in developing the labor, equipment, and scheduling requirements.

- RS Means (Factored Construction Cost Data)

    The Means catalogue is one of the nation's most respected guidelines for estimating construction-related cost of building. When other resources were unclear or not available, Enercon used the typical factored cost per commodity for the portion of work.

- Construction Industry Institute (CII)

  CII focuses on the industrial construction and maintenance contracting industry as a trade organization devoted to continuous improvement of the means and methods used in construction. Their ideas related to the minimization of field required labor through modularization and prefabrication were considered as the construction strategies were built and as the cost estimates were prepared.

- Engineering News Record (ENR)

  Construction Cost Index, Building Cost Index, and Materials Cost Index, which are updated monthly, provided some trending analysis with regard to the industry in general.

Attachment 1 includes vendor data and budgetary cost estimates for major equipment components. Few allowances were applied and only when time did not permit further task development or reasonable vendor contact and quotation.

Attachment 4 provides the capital cost assessment for the conversion of Schiller Station to closed-loop cooling.

5.2.2   Costs Due to New Condenser Operating Parameters

As discussed in Section 5.1.1.1.2, cooling towers operate under an approach to wet bulb condition, and are therefore reliant on the ambient wet bulb temperature to effectively cool the condenser inlet. As the current once-through operation of Schiller Station relies solely on the moderately cold and stable temperatures of the Piscataqua River, modification to a warmer and more variable temperature derived from ambient weather conditions would pose an operational risk for the Station. The following discussion, detailed further in Attachment 3, assesses the operational impacts to Schiller Station associated with the conversion from once-through to closed-loop cooling.

Conversion of the Station to closed-loop cooling would directly impact a wide range of equipment relying on the moderately cold temperatures of the Piscataqua River. Likewise, the Station's overall operation would be indirectly impacted as the performance of this equipment is subsequently degraded. The main condensers would be the primary drivers of this reduction in Station performance, as operation of the condensers beyond the design point of 1.5 in-Hg abs. (Attachment 1, Section 7) would result in increased fuel consumption and increase the potential for extensive equipment damage throughout the Station (e.g., boiler tube failure, overheating of turbine/generator bearings, forced draft fan bearings, gas recirculation fan bearings, main boiler feed pump hydraulic coupling oil, etc.).

To quantify the impacts that increased condenser input temperatures would have on Station operation, baseline once-through performance was modeled using analytical correlations derived from daily measured data, including the condenser inlet and discharge water temperatures, condenser flow rate and pressure, and Station net power generation. Closed-loop performance was calculated by inputting the estimated cooling tower outlet temperature into the baseline performance model of the Station. The cooling tower outlet temperature was estimated

using SPX provided performance curves[2] and fifteen years (1993 - 2007) of National Weather Service (NWS) measured wet bulb temperatures from Pease International Tradeport Airport[3], located approximately two miles from the Station.

Using the calculated closed-loop cooling performance values as inputs into the baseline performance model for the Station allows accurate prediction of the power loss due to the increased fuel consumption above the condenser design point (i.e., the loss of potential power generation from the increased fuel consumption above 1.5 in-Hg abs. as compared to current once-through cooling). In this analysis, power reductions required to decrease the condenser pressure below the alarm set point of 1.5 in-Hg abs. are conservatively ignored, and operation above this pressure is restricted solely by the power loss due to increased fuel consumption. It should be noted that a degree of uncertainty is added when calculating closed-loop performance at inlet temperatures above the once-through values used in the baseline analysis (i.e., uncertainty exists due to the lack of condenser inlet temperature data above approximately 82°F). Likewise, plant configuration may limit the availability of increasing fuel consumption to offset a reduction in condenser vacuum (i.e., increased condenser pressure); therefore, the closed-loop cooling analysis conservatively assumed this capability, avoiding a plant shutdown. This uncertainty is inherent to any analysis performed at theoretical levels significantly above measured conditions. With all of these conservative (i.e., weighted toward conversion to closed-loop cooling) assumptions about Station performance as a basis, Table 5.1 summarizes the average monthly power losses from design Station performance that would be incurred as a result of converting Schiller Station to closed-loop cooling.

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[2] The performance curves provided by SPX are for linear hybrid cooling towers with an 8°F approach to wet bulb.
[3] The NWS meteorological station at Pease International Tradeport Airport is a first order NWS station (i.e., staffed by NWS employees) providing quality controlled data

Table 5.1   Schiller Station
Closed-Loop Performance
(Estimated from historic wet bulb
temperatures, 1993-2007)

Month	Power Loss (MWe)		
	Unit 4	Unit 5	Unit 6
January	1.12	4.09	3.74
February	1.14	4.14	3.79
March	1.57	5.36	5.00
April	2.35	7.49	6.96
May	3.59	10.68	10.39
June	5.30	14.68	14.60
July	5.88	15.84	16.00
August	5.51	14.75	15.12
September	4.73	12.96	13.29
October	3.24	9.75	9.43
November	2.17	6.99	6.62
December	1.41	4.90	4.54
Annual	3.17	9.30	9.12

Overall, using the empirical analysis for the defined time period, Schiller Station would experience an annual average power loss of 3.17 MWe, 9.30 MWe, and 9.12 MWe at Units 4, 5, and 6, respectively, with a maximum monthly power loss of 5.88 MWe (July) at Unit 4, 15.84 MWe (July) at Unit 5, and 16.00 MWe (July) at Unit 6, due to the increased fuel consumption as compared to current once-through cooling. Note that since the duration and magnitude of power reduction required would be reliant on elevated ambient weather conditions, power reduction occurrences would generally take place during daylight hours of the summer months when power demand is at its peak.

5.2.3   Parasitic Losses (Costs) Attributable to New Components

An estimate of fan and pump horsepower requirements for the evaluated cooling tower and new CW booster pump house was developed in order to estimate additional Station parasitic losses due to conversion to closed-loop cooling.

The existing CW pumps and the new CW booster pumps would be a constant load; i.e., there would be no operational variations in power consumption, as all pumps for each Unit would operate at full capacity at all times. To address the total CW pump load due to the conversion to

closed-cycle cooling, the power requirements of the existing pumps are simply added to that of the additional booster pumps required for the closed-loop configuration.

Parasitic Electrical Load, CW Pumps	
Existing CW Pumps (2 @ 150 hp)+(4 @ 125 hp)	Additional Closed Loop Booster Pumps (3 @ 900 hp)
0.60 MW	2.01 MW

Likewise the cooling tower fans would be a constant load; i.e., there would be no operational variations in power consumption, as all fans for the cooling tower would operate at full capacity. This load would represent a corresponding new parasitic loss to the output of the Station estimated as follows:

Tower Usage $_{Each Tower}$ = Fan Usage (MW)

Schiller Station Tower Usage (MW) = (4) 250 HP fans =   0.75 MW

Schiller Station Total Usage = 2.01 MW $_{New CW Pumps}$ + 0.75MW $_{Tower Fans}$

5.2.4   Lost Generating Capacity During Implementation

From the construction schedule provided in Attachment 7, the approximate duration that the Station would be in a forced outage to accommodate the conversion to closed-loop cooling would be 12 weeks. This represents optimum performance during the construction phase, with no contingencies or allowances for emergent activities or overruns, and assumes the maximum possible portion of the work scope being performed either pre-outage or post-outage. Additionally, as will be discussed in following paragraph, the forced outage to accommodate the conversion to closed-loop cooling will be scheduled concurrent with a maintenance outage and the cost adjusted (reduced) accordingly.

Based on projections from the PSNH Generation - Long Term Maintenance Overhaul Plan, all three Units at Schiller are never scheduled for a maintenance outage at the same time, and the longest two Units are scheduled out of service concurrently is five (5)weeks. Based on this very conservative basis, the best possible scenario for any closed-loop conversion forced outage would be concurrent with a 5-week long maintenance outage on two of the Schiller Units. For purposes of this Report, it will be assumed that 5 weeks of the 12-week forced outage for the conversion will be utilized for required maintenance of two Schiller Units. The remaining 7 weeks for two Units (Units 4 & 5 assumed) and 12 weeks for one Unit (Unit 6 assumed) conservatively represent the period of lost generating capacity for the Station.

The estimated lost generating capacity from a forced implementation outage as described above, based on a typical Schiller Station Unit 4, 5, and 6 generator output of ~50 MW$_E$, would be as follows:

Schiller Station Unit 4, 58,800 megawatt hours

Schiller Station Unit 5, 58,800 megawatt hours

Schiller Station Unit 6, 100,800 megawatt hours

Although generating capacity as well as wholesale cost of electricity vary, the approximate dollar cost of the outages, based on replacement power costs ($ / MWhr) for each Unit as identified in Attachment 9 and noted below:

5.2.5   Operational and Maintenance (O&M) Cost

Additional Station O&M costs for the components that would be added due to the conversion to closed-loop cooling can be best estimated by identifying the general tasks for each component, and then based on operational experience and input from vendors, quantifying the estimated required man-hours and associated costs.

The conversion to closed-loop cooling would be complex. Significant new/modified Station components requiring O&M would include the cooling towers with their fans and booster (vacuum) pumps (for the 'dry' sections), and the new CW booster pumps.

The tower selected for this analysis of Schiller Station is a SPX/Marley linear configuration hybrid FRP (fiberglass reinforced plastic) tower, designed with noise and plume abatement features. This design uses 5 wet section fans with motor output power of 250 HP. Due to the large number of active components, as well as the size of the towers and their hot water distribution system, appreciable Operations support would be anticipated. For purposes of this assessment, chemistry personnel (for water quality maintenance) man-hours are included/encompassed under Operations.

The anticipated manpower required for operational support of the cooling tower is tabulated below:

	Activity Description	Group	Est. Cost
Daily	• Check fans, motors, driveshafts, gear reducers • Check gear reducer oil level • Check electrical substation, transformers, switchgear • Monitor local control panel and alarm displays • Check water level in cold water basin and hot water distribution system • Check booster pumps and associated instrumentation • Sample water quality	Ops	
Cost Basis	2 hrs/day × 12 months		$36,500
Weekly	• Inspect hot water distribution system • Inspect fill for fouling • Check gear reducer for leakage • Adjust water quality	Ops	
Cost Basis	20 hrs/week × 12 months		$52,500
Notes: Cost based on PSNH O&M labor estimates of $50/hour (hourly wage + benefits)			
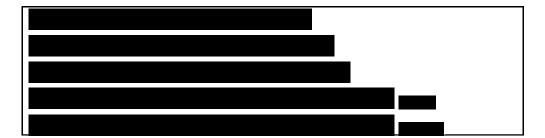
Maintenance Cost

The anticipated cost for preventive and corrective maintenance, including both labor and parts, for the evaluated cooling tower is tabulated below:

	Activity Description	Group	Est. Cost
Monthly	• Inspect drift eliminators and fill for clogging • Check gear reducer oil seals, oil level, and oil condition	Maint.	
Periodic (Quarterly estimated)	• Clean and repaint fans and drivers, drift eliminators, fill, hot water distribution system • Rebalance fans and driveshafts • Lighting inspection or replacement	Maint.	
Semi-annual Inspection	• Inspect keys, keyways, set screws & tighten bolts for fans and drivers • Change oil and check vent condition for gear reducers • Check fan blade clearances • Check for leakage in fill, basin and hot water distribution system • Inspect general condition and repair as necessary all tower components including cranes and hoists	Maint.	
Annual Inspection and Corrective Maint.	• Inspect general condition of basin, suction screen and tower casing • Inspect/repair fans and drivers, and tower access components, including stairs, ladders, walkways, doors, handrails • Transformer Inspection • Starting at year 16, replacement of fan blades, fan motors, fan gearbox, fill, drift eliminators	Maint.	
Quarterly	Lighting Inspection or Replacement	Maint.	
	██████████████		███
	██████████████		███
	██████████████		███
███████████████████████			

Booster pumping station maintenance, long-term rehabilitation, and replacement costs include those costs for replacement of components such as pump impellers, motors, or entire assemblies. Major equipment rehabilitation or replacement is usually estimated to occur between 20 to 40 years after placing the equipment into operation. Rehabilitation costs for major equipment can be estimated to be 35 to 45 percent of replacement costs depending on the condition of the equipment. Other items of equipment may be replaced several times during the Station life, depending on their use, or may require only partial replacement. It is most likely that equipment, except for pump and motor, may not be replaced in kind. Therefore, the replacement cost should include all engineering and structural modification costs as well as the equipment costs (Ref. 8.5).

5.2.6   Water Treatment Costs

When a plant is designed for or converted to closed-loop cooling via the addition of cooling towers, it is cost effective to impose a high level of water treatment to ensure high quality water is supplied to the towers. This allows cooling tower designers to utilize a higher-efficiency film-fill without fear of fill-fouling. Using a higher efficiency fill allows a smaller tower size and appreciably lower associated initial cooling tower capital cost as well as lower cooling tower operating cost.

The Station's existing once-through circulating water cooling system receives a minimum of water treatment. The chlorination system is operated to minimize impact upon entrained organisms by limiting application to two hours or less in any one day, and by chlorinating only when necessary. An aqueous solution of concentrated (15%) sodium hypochlorite is injected for a period of up to two hours; 15 minutes an hour over 8 hours (0700-1500). For Schiller Station this corresponds to approximately 21,900 gallons of 15% sodium hypochlorite per year.

With the evaluated closed-loop cooling system, either seawater or grey water, water treatment requirements would be dramatically increased. The cooling tower fill would be subject to fouling without enhanced water treatment. Both the quantities and frequency of biocide injections would have to be increased significantly to maintain the tower fill in proper condition.

Additionally, increased water treatment would be necessary due to the higher concentrations of dissolved solids, chemicals, and biological agents in the system resulting from constant recirculation of the condenser cooling water. The cooling towers would act as air washers as well as distilleries, constantly evaporating large quantities of water and leaving behind the non-volatile residues. The actual concentrations of these agents would be wholly based on the cycles of concentration (cycles of concentration is discussed in Section 5.1.3.3) being used in the circulating water system.

Unlike the simple injections of biocide required for the once-through configuration, a closed-loop configuration typically utilizes a veritable cocktail of chemicals, each with specific attributes. Chemical treatment is broken into three subsections; deposition, corrosion, and biological.

Deposition

There are two forms of deposition, one being sedimentation, which is usually mitigated through piping design, and the second being scaling. Scaling is a complicated condition and requires an educated approach to mitigation. In some cases scaling is necessary and useful in a piping system to prevent corrosion. For example, a thin uniform coating of calcium carbonate provides

corrosion protection for internal surfaces of piping; therefore, this type of scaling is desirable and should be left intact where possible. The major problems arise when scaling becomes too thick and reduces heat transfer with the condenser or cooling tower. Scaling is kept under control through the use of pH control and dispersants.

Corrosion

Corrosion control is a complex science, requiring considerable knowledge of corrosion chemistry and of the system being evaluated. Corrosion is best mitigated through piping design and an aggressive chemical treatment program using pH control and corrosion inhibitors.

Biological

Biological growth or biofouling is the most difficult chemical challenge to a cooling water system since it involves a dynamic biological process. The biological process also promotes corrosion through the breakdown of chemical components and the creation of localized acids. In a closed-loop where the concentration of nutrients has increased, biofilms tend to increase on the piping internal surfaces and cooling tower fill. Control of the biofilms usually involve combining biocides with surfactant-type biodispersant to disrupt the biomatrix, allowing better penetration of the antimicrobial. Additional chemical treatments such as biodetergents may also be necessary depending on local biologicals and conditions.

Major cooling water chemicals would typically include the following:

Chemical type	Use/Function
sodium hypochlorite	biocide
surfactant	biocide aid
sulfuric acid	PH control
dispersant	scale prevention
phosphate	corrosion control

Appreciably increased costs are associated with this increased level of water treatment. Local conditions can greatly affect annual costs, but an annual cost for the Station of $120,000 would be extremely conservative.

Note: (1) Disposal costs of potentially toxic silt from the cooling tower basin is conservatively ignored due to unknowns; however, there would typically be appreciable disposal costs. (2) The various chemical treatments for corrosion and biofouling necessary for cooling towers would impose additional NPDES permit modifications and monitoring/reporting requirements.

5.3 Environmental Considerations

As EPA directed in the §308 Letter, this section identifies, qualifies and quantifies, to the extent possible, the environmental impacts of retrofitting a mechanical draft cooling tower at Schiller Station Units 4, 5, and 6. Considerations and evaluations will include the long term positive and negative environmental benefits and impacts.

Resulting changes to the River intake flow will be quantified and specifically addressed in detail, and the associated effect on entrainment and impingement of aquatic organisms is addressed subsequently in Section 7.2.

5.3.1   Cooling Tower Plume

Although the cooling tower evaluated for Schiller Station is a plume abated tower, a visible plume would still exist during certain environmental conditions. To best identify plume path and trajectory, a computer code can be utilized to model the plume under site typical environmental conditions. The behavior of the plume can be modeled using the SACTI code under environmental conditions typical of Portsmouth, NH. However, without the benefit of plume modeling, reasonable predictions of plume travel can be made based on the local prevailing wind directions and frequency of occurrence (i.e., site wind rose). Based on the Schiller Station site wind rose, as shown in Attachment 2, sketch PSNH002-SK-001, the predominant direction of plume travel would be up or down the Piscataqua River. The potential environmental impacts attributed to a cooling tower plume can be categorized as visual impact and physical impact.

The visual impact of such a cooling tower plume would be both aesthetically displeasing and hazardous. When atmospheric conditions are conducive to a visible plume, typically anytime during the winter months when the ambient air temperature is below the 27°F 'plume point', a dense plume would exit from the tower fan discharge shrouds. Depending upon the wind direction, thermal conditions, and other factors, the plume could extend skywards for hundreds of feet, or become inverted as a ground-level fog. Local shopping malls and residences would either view the plume intruding high into the sky, or be immersed in a dense fog obscuring their view altogether. Driving on nearby roads and highways, in particular the nearby Rt. 95 bridge, could be significantly impacted, with the possibility of 'black ice' formation during winter months, and visibility severely compromised.

The potential physical impacts from a tower plume would arise primarily from the (1) moisture content, which could cause icing and fogging during winter conditions, (2) the mineral content (including salt if seawater cooling system) of the entrained moisture which could damage vegetation in the vicinity of the Station, and (3) the heat content, which could potentially degrade Station heating, ventilating and air conditioning (HVAC) systems. Additionally, the presence of the warm moist plume over a period of time would cause degradation of plant and switchyard structures and components, as well as nearby structures such as the Rt. 95 bridge, due to corrosion. It is important to note that a hybrid tower produces an invisible plume under most conditions; however, the plume still exists at all times and creates the above noted physical impacts. Although difficult to quantify, and conservatively neglected in this Report, all of the above stated tower plume impacts represent significant additional costs to the Station.

5.3.2   Cooling Tower Noise

Without the benefit of noise attenuation, mechanical draft cooling towers produce relatively high levels of constant noise. The noise emanating from a cooling tower is due both to the cascading water, and to the large mechanical draft fans.

The hybrid cooling tower evaluated for Schiller Station would be equipped with sound attenuators. With sound attenuators, the noise level is expected to be less than 30 dB(A) at one-

half mile distance from the tower. As a point of comparison, this sound level corresponds to the typical late-night noise levels in a small town. The noise standard for many townships is in the range of 45-50 dB(A), which would be met at approximately 350 ft from the evaluated tower. Although the noise level would increase on the River in close proximity to the Station, adjacent commercial and residential areas would be only moderately affected by the noise generated from the cooling tower assuming a noise-abated tower design is utilized.

5.3.3   Reduced Intake Flow

PSNH assumes that EPA's overall objective in directing PSNH to evaluate the conversion of Schiller Station Units 4, 5, and 6 from once-through condenser cooling to closed-loop condenser cooling is to obtain information about the potential reduction of the Station intake flow that could result from such a conversion. Hence, the quantification of the reduction in River intake flow is a significant assessment.

Current once-through River intake flow for Schiller Station is as follows:

Unit 4 CW $_{Maximum}$	29,290 gpm
Unit 5 CW $_{Maximum}$	29,000 gpm
Unit 6 CW $_{Maximum}$	29,000 gpm
Total Intake Flow $_{Once\ Through}$	87,290 gpm

Estimated River intake flow reduction for the Station following the evaluated conversion to closed-loop cooling would be dependent on whether a seawater or grey water CW system is utilized. Thus they will both be addressed.

Intake flow rate, grey water CW system

CW/Cooling Tower Makeup $_{From\ River}$	0 gpm
Total Intake Flow $_{Once\ Through,\ Maximum}$	87,290 gpm
Reduction In River Intake Flow $_{Maximum}$	100 %

Intake flow rate, seawater CW system

CW/Cooling Tower Makeup $_{From\ River}$	2644 gpm
Total Intake Flow $_{Once\ Through,\ Maximum}$	87,290 gpm
Reduction In River Intake Flow $_{Maximum}$	96.9 %

Assuming a direct linear (1:1) relationship between flow reductions and the number of fish impinged or entrained (a fundamental assumption of the now suspended Phase II Rule) yields a 100% reduction in impingement and entrainment when utilizing grey water. When using seawater for the circulating water/cooling tower makeup, there would be a 96.9% reduction in impingement and entrainment.

5.3.4   Loss of River Water Due to Evaporation

Cooling towers evaporate large quantities of water which are effectively lost from the source water body. In the case of Schiller Station, for a conversion to closed-cycle cooling utilizing seawater from the River, the estimated daily water loss from the Piscataqua River due to evaporation by the evaluated cooling tower can be calculated as follows:

Evaporation $_{Wet\ Summer}$ can be approximated as Water Flow $_{Total}$ x R x .0008 gpm (Ref. 8.4)

Water Flow = ~87,000 gpm

$E_{Wet} = .0008$ x R x gpm = 1322 gpm

> Estimated total loss of river water due to evaporation by evaluated cooling tower = 1322 gpm, or 1.9 million gallons/day.

5.3.5   Site Aesthetics

Aesthetics are an important issue at Schiller Station since it is located on the Piscataqua River, a recreational use area for many boaters. Potential impacts to tourism at nearby malls and in Portsmouth must also be considered. Any closed-loop cooling conversion-related aesthetic degradation of the area must be considered a negative environmental impact.

5.3.5.1 Tower Size

A cooling tower sized for the needs of Schiller Station would be a significant structure. A hybrid mechanical draft tower would be approximately 302 feet in length, with a discharge elevation of approximately 65 feet.

5.3.5.2 Cooling Tower Plume

Although a hybrid, or plume abated, tower was evaluated to reduce the visible plume most of the time, a visible plume would occur during the colder periods of the year. The plume could potentially extend hundreds of feet into the sky, and travel for up to a few miles horizontally. Considering the site wind rose (Attachment 2, PSNH002-SK-001), the plume would primarily be blown upriver, although it would sometimes travel directly toward the River. Under appropriate weather conditions, the plume would stay at ground level and create a dense fog that would significantly degrade visibility on the River.

5.3.5.3 Construction Would Require Permanent Modification of the Terrain Along the Shore of the Piscataqua River

Any evaluated cooling tower would be located in close proximity, within about 120 ft of the bank of the Piscataqua River, and would have a substantial aesthetic impact. An area approximately 302 feet in length and 68 feet in width would be required for the tower. Views from the Piscataqua River would be impacted. The Station is an industrial facility already visible from these vantage points; however, the addition of the tower would make the entire facility more visible as the tower would rise 65 feet above the riverbank for a distance of over 300 feet.

5.3.5.4 Environmental Impact due to Efficiency Losses

In addition to the adverse air quality and aesthetics impacts that would be associated with a cooling tower's visible water vapor plume, operation of a cooling tower at Schiller Station would increase the amount of combustion-related air emissions and pollutants produced per net unit of electricity generated. The increase in combustion-related air emissions would have three primary causes: (1) the increased Station parasitic load resulting from the tower's electricity demands (which would also decrease the Station's net output electricity generated), (2) the reduction in Station condenser/turbine efficiency due to warmer condenser water input temperatures, and (3) the increased amount of consumables used to operate the Station near the condensers' operational thresholds (i.e., the increase in condenser cooling water temperature associated with cooling tower operation would reduce cycle efficiency, requiring more fuel to be fired to achieve the same gross electrical output of a more efficient cycle). Moreover, other electric generating facilities would have to increase their generation to compensate for any reduction in the Station's net electrical output, in order to satisfy consumer demand, with potential adverse regional air quality impacts. In summary, closed-loop operation of the Station would generate more stack emissions and material waste per net unit of electricity generated than the Station's current cooling water system.

6 Alternative Impingement/Entrainment Reduction Technologies

6.1 Alternate Technologies that Reduce Impingement and Impingement Mortality

6.1.1 Unit 3 Intake Renovation

The initial design of Screen House #1 included a plugged opening (currently closed off with gate valves) located downstream of the traveling water screens between the Unit 3 and 4 forebays. Before its retirement, Unit 3 used two intake pipes, similar to the one used by Unit 4, to draw water from the Piscataqua River at the same offshore location as the Unit 4 pipe. If the existing valves were refurbished or replaced and new traveling water screens and a fish return system were installed, these former Unit 3 pipes could be used by Unit 4. The use of these two intake pipes would potentially reduce the through-screen velocity in Screen House #1 to approximately 0.46 fps at MLW, thus satisfying the now suspended Phase II Rule for reducing impingement mortality. However, during the retirement of Unit 3, physical alterations were made to the intake (e.g., removing the original traveling water screens and filling in the open area left in the floor of the screen house with concrete) that would complicate any attempt to re-use the Unit 3 intake. As such, a detailed engineering assessment would be necessary to determine the extent of the exact civil and structural modifications required to restore the Unit 3 intake and connect it to the Unit 4 forebay. In addition, an extended outage could be required in order to complete these civil and structural modifications. Any extended outages or forced outages would greatly increase the overall conversion cost.

To accomplish this Unit 3 intake renovation, two new traveling water screens, trash (bar) racks, lobster diversion pipes, and a consolidated fish protection and return system would need to be installed. The traveling water screens would be modified Ristroph screens, as discussed in Section 6.1.2.3. A new trough would need to be constructed to collect the fish, and merge downstream with the original sluiceways. Also, a new spray wash system would need to be installed to provide low and high pressure screen washes.

Maintenance

By running the new traveling water screens and fish protection and return system, Schiller Station would increase its current maintenance costs by approximately $20,000.

Cost

Biological Benefit

Under the now suspended Phase II Rule, if a facility could reduce its maximum through-screen velocity to 0.5 fps or less, it would be considered to have satisfied the standard for reducing impingement mortality. This is because impingement levels are lower at slower intake velocities. The relationship between impingement and intake flow is probably not linear below a certain flow rate, reflecting the belief that there is a threshold velocity below which most fish can swim fast enough to avoid being impinged by the lower intake flow. It is generally

accepted that impingement is negligible when the maximum intake through-screen velocity is below 0.5 fps, providing the basis for EPA's assessment that reducing through-screen velocity to 0.5 fps or less is equivalent to reducing impingement mortality by at least 80 to 95%. The use of the two Unit 3 intake pipes would decrease the through-screen velocity through all three traveling water screens in Screen House #1 to below 0.5 fps.

6.1.2   Modified Traveling Screens and Fish Handling and Return Systems

Conventional traveling water screens can be altered to incorporate modifications that improve survival of impinged fish. These modifications minimize fish mortality associated with screen impingement and spray wash removal.

There are four features that improve the survivability of impinged fish. They are as follows:

- Continuous operation of traveling screens to minimize impingement time.

- A state-of-the-art fish trough which ensures that the fish can be returned to the water body with a minimum of stress.

- Low pressure spray wash systems to gently remove the impinged fish before the high pressure fish spray is used to clean debris off the screens.

- Alternative bucket configurations that include provisions to minimize damage to the fish upon entering the fish bucket, while they are in the fish bucket, while they are being transported from the fish bucket, and to keep them from escaping from the safety of the fish bucket.
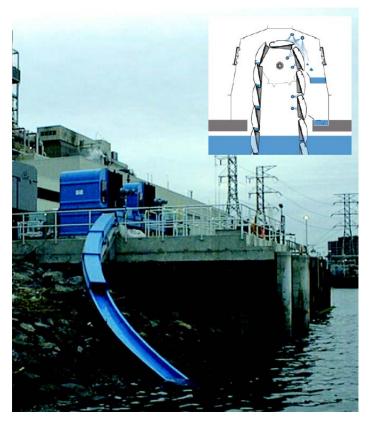
Figure 6.1   State-of-the-Art Fish Return System (www.glv.com)

6.1.2.1 Continuous Operation of Screens with Upgraded Fish Return System

Schiller Station's existing traveling screens are currently designed to operate intermittently, unless debris levels are high. However, an essential feature of any fish protection system is its ability to operate continuously.

Continuous operation of the Station's traveling screens would reduce impingement of fish. This is because the fish and/or debris would be continuously removed, avoiding accumulation of fish and/or debris that reduces available surface area for the flow of water. When such accumulation occurs, the same amount of water must pass through a smaller surface area, increasing both the velocity and the differential head loss. As the head losses and velocities increase, it is more likely that fish cannot escape the screen area and can become impinged.

Maintenance

Cost

Currently, there is only one screen wash pump per Unit. Therefore, only one traveling screen per Unit can be run continuously at a time. In order to run all of the traveling water screens continuously, two additional screen wash spray pumps would need to be purchased; one for Unit 5 and one for Unit 6. No additional pumps would be required for Unit 4. It is estimated

that the total capital cost to purchase and install two additional screen wash spray pumps is approximately $15,000 - $20,000.

Biological Benefit

Screenwash interval has been shown to be a major factor influencing impingement survival (Ref. 8.10). For example, the average extended post-impingement survival for the sculpin family with continuous washes was approximately 5% higher than with intermittent washes every hour and approximately 20% higher than when the wash frequency was every three hours. Although the trend was clearly higher survival with continuous washing, there was an increased degree of uncertainty in the estimates for several of the wash frequencies in EPRI's comparison, which would make it difficult to quantitatively assess the biological benefit of continuous washes for Schiller Station. Considering the fairly low survival with the current operation mode of intermittent washes at Schiller Station, it would be expected that continuous washes would provide some improvement in impingement survival.

6.1.2.2 Upgraded Fish Return Trough

The main objective of any fish return system is to return live impinged fish to the water body with a minimum of stress. Per Section 4.1.3, a quality fish return system usually includes a trough designed to maintain a water velocity of 3 to 5 fps and a minimum water depth of 4 to 6 inches. The trough should avoid sharp radius turns and should discharge slightly above the low water level. The trough should be covered with a removable cover to prevent access by birds or other predators. In addition, returning impinged fish downstream of the intake would reduce re-impingement.

The existing fish return trough in Screen House #1 is located in the deck of the intake structure and consists of a rectangular trench with dimensions ranging from 18 to 24 inches wide by 10 to 18 inches deep. The trough begins adjacent to the Unit 4 traveling water screen, at an elevation of 8 ft, 2 inches, and funnels to a 14 inch diameter chute to discharge all fish and/or debris into the Piscataqua River at an elevation of 4 ft above MSL.

The existing fish return trough in Screen House #2 is located in the deck of the intake structure and consists of a rectangular trench with dimensions of 24 inches wide by depths ranging from 12 to 18 inches deep. The trough begins adjacent to traveling water screen 6B at an elevation of 9 ft, 2 inches, then runs along the length of the CWIS and discharges all fish and/or debris out the north side of Screen House #2 into the Piscataqua River at an elevation of 8 ft above MSL.

A new fish return slide is considered for the exterior of each screen house as the fish are currently discharged via a fish return slide outside of Screen House #1 at an elevation of approximately 7 ft above MLW and the fish are discharged out the side of Screen House #2 at an elevation of approximately 11 ft above MLW. Per EIMCO Water Technologies, the optimal slope for maximum survivability is a 1/16 ft drop per linear ft. At a slope of 1/16, the new slides outside the screen houses would need to be approximately 170 ft and 180 ft for Screen House #1 and #2, respectively. Each new slide would discharge slightly above the mean low water level. However, the space available between the two Screen Houses is not adequate to accommodate 350 ft of fish return slide. At a slope of ¼ (not optimal, but acceptable due to practical considerations), each slide would be approximately 45 ft long. The

slope of each existing fish return trough within each screen house is acceptable, with a slope of 1/24 ft within Screen House #1 and a slope of 1/48 ft within Screen House #2. At a slope of 1/16, the upgraded troughs inside the screen houses would need approximately 25 ft and 135 ft for Screen House #1 and #2, respectively. Therefore, the total combined lengths of the upgraded troughs and slides would be 250 ft.

Note that although a short fish return trough and slide is the most beneficial for impingement survival, an evaluation of re-impingement would be required to identify the best return sluice discharge locations relative to tidal flow. In order to address tidal flow and storm condition concerns, additional evaluation would be required assess protection of the slide and determine the feasibility of an adequate support structure.

<u>Maintenance</u>

No increased operation and maintenance activities for the upgraded fish return trough and slide would be expected.

<u>Cost</u>

<u>Biological Benefit</u>

There is no quantitative data specific to Schiller Station with which to evaluate the potential biological benefit of replacing the Schiller Station fish return system with a more state-of-the-art system. Good survival was demonstrated for a state-of-the-art fish return system at Indian Point Nuclear Power Plant (Indian Point), but at Schiller Station the return sluice would likely be considerably shorter (i.e., only 25% of the length) compared to Indian Point (Ref. 8.11). The benefit of releasing impinged fish in the direction of the tidal flow relates mostly to re-impingement, which must be determined on a site specific basis. However, there is no data specific to Schiller Station. Considering, however, that impingement mortality with the existing screens and fish return system at Schiller Station is fairly high (as shown in Attachment 6, Tables 6-2 and 6-9), mortality due to re-impingement would likely be reduced significantly by installing an improved fish return system. As macrocrustacean mortality with the existing system (as shown in Attachment 6, Tables 6-5 and 6-12) is lower than that for fish, replacement of the fish return system would provide less benefit to impinged crabs and lobsters.

6.1.2.3 Coarse Mesh Ristroph Screens

It is possible to retrofit modified Ristroph screens onto the existing traveling water screens. The replacement screens could be designed to work in conjunction with the debris removal function of the existing traveling water screens.

The coarse mesh Ristroph screen replacement was evaluated as part of an integrated system that would remove fish and macrocrustaceans unable to escape from in front of the screen, and safely transport and return them to the source water downstream of the screen intake.

The following features are integral to modified Ristroph screens:

- The screen mesh ought to minimize harm to the fish.

- The basket ought to maximize the screening area available.

- The fish bucket opening ought to be designed to encourage fish to enter the bucket.

- The fish bucket ought to be large enough to safely retain fish in the bucket.

- The bucket ought to provide a hydraulically stable, "stalled" fluid zone which attracts the fish, prevents damage to the fish while in the bucket and prevents the fish from escaping the bucket.

- The bucket ought to be shaped to allow gentle and complete removal of impinged fish.

- The bucket ought to maintain a minimum water depth while transporting the fish.

Note that the screen and bucket portion of the traveling water screen could be replaced without replacing the entire traveling water screen.

The replacement traveling water screens would match the existing through-screen velocity of the existing traveling water screens. With the addition of Ristroph screens, the fish trough for the sluiceway would need to be restructured. The Ristroph screen would unload the impinged fish to a location opposite to where they are currently unloaded. This is because the current traveling screens unload fish while they are ascending, but the Ristroph modified screens are unloaded while the screens are descending. Therefore, a new trough would be constructed to collect the fish, and merge downstream with the original sluiceways. Also, the existing spray wash system would need to be updated to provide low and high pressure screen washes.
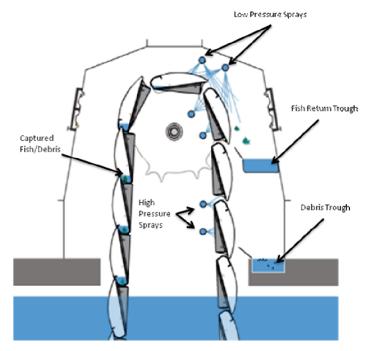
Figure 6.2   Ristroph Screen Arrangement (www.glv.com)

Maintenance

The upgraded Ristroph screens should not have appreciably higher maintenance than the existing traveling screens.

Cost

The total estimated capital cost for the replacement of the existing traveling water screens with through flow traveling water screens incorporating Ristroph screens design with modified existing fish return is $3,432,800 (Attachment 4).

Biological Benefit

Tables 6-15 and 6-16 of Attachment 6 assess the monthly and annual total impingement mortality and equivalent adult impingement mortality for Schiller Station at baseline flow (29,290 gpm for Unit 4, 29,000 gpm for Unit 5, and 29,000 for Unit 6) and for each 5% reduction in flow, assuming installation of Ristroph screens. With the installation of Ristroph screens, EA fish impingement survival was estimated to be 75.5%, 73.5%, and 75.3% for Units 4, 5, and 6, respectively. Additionally, the use of the two Unit 3 intake pipes would decrease the through-screen velocity at Unit 4 to below 0.5 fps, which, according to the now suspended Phase II Rule, is equivalent to reducing impingement mortality by at least 80-95%.

Impingement mortality rates estimates for Ristroph screens (Ref. 8.11) were only available for fish species, so the potential change in impingement mortality of macrocrustaceans at Schiller Station after installation of Ristroph screens could not be quantified. However, macrocrustacean impingement mortality on Schiller's existing screens is known to be lower than fish mortality, approximately 32% of the annual total impinged, compared to 81% for fish (estimated from data in Attachment 6). Therefore, there is some potential for reducing macrocrustacean mortality by installing Ristroph screens, although the proportional benefit would be less than for fish.

6.1.3 Traveling Water Screens

6.1.3.1 Dual Flow Conversion Traveling Screens

Many existing through flow traveling screen installations can be retrofitted to use a dual flow traveling water screen. A dual flow traveling water screen is mechanically similar to a through flow screen but has been rotated ninety degrees in the channel.
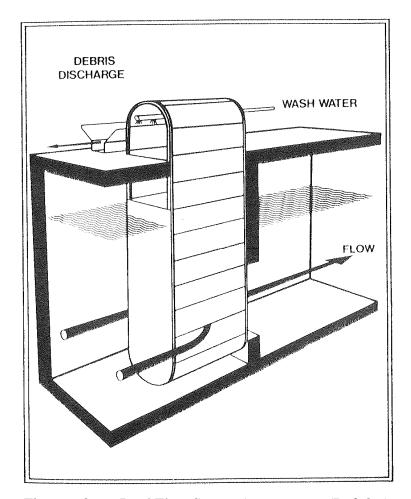
Figure 6.3   Dual Flow Screen Arrangement (Ref. 8.6)

The modification includes the installation of a special wall plate mounted perpendicular to the flow in place of the existing screen. The dual flow is then lowered into the well, with baskets parallel to the flow, on the upstream side of the wall plate. An inlet opening in the wall plate allows screened water to pass to the pumps. An alternative arrangement uses a specially constructed screen mainframe that includes a wall plate made as an integral part of the screen frame with extensions or "wings" that fit into existing embedded guides.
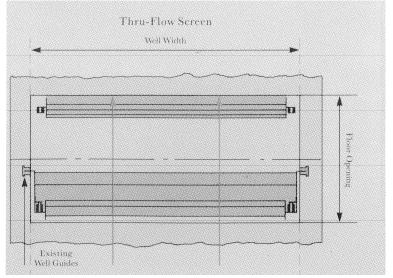
Figure 6.4 compares a through flow screen with a dual flow conversion screen.
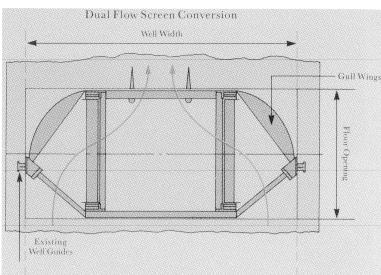
Figure 6.4   Plan view of through flow to dual flow retrofit (Ref. 8.6)

A through flow to dual flow retrofit provides increased flexibility and has the following benefits:

- Potential to decrease the velocity through the screens. The flow pattern of the dual flow screen allows the entire submerged screen surface to be an active screen area. This means that a dual flow screen of a given width would pass almost twice as much water at the same velocity as a through flow screen of the same width, assuming there is adequate space within the CWIS for the conversion. Conversely, the same amount of flow can pass through a dual flow screen at approximately half the velocity as a through flow screen of the same width.

- Elimination of debris carryover. With traditional through flow traveling water screens, any fish and/or debris that are not washed off the screen basket would be washed off

into the flow of water and carried through the cooling water system. Since dual flow screens do not rotate over into the downstream flow, and all flow must pass through the screen before entering the screenwell and ultimately the condenser, the potential for debris carryover is eliminated.
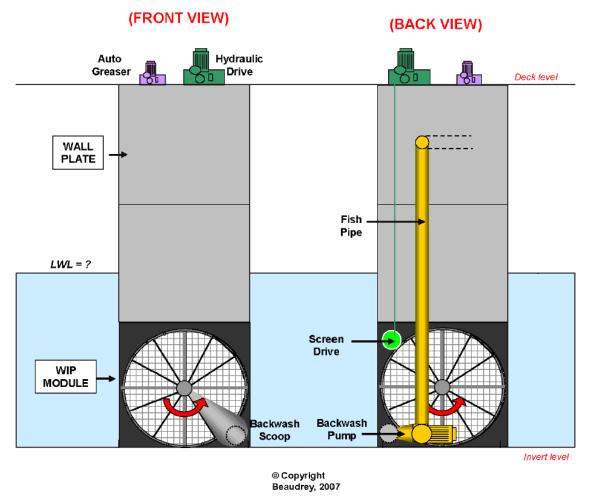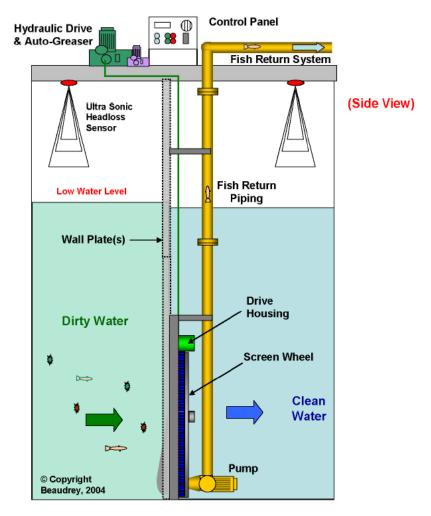
At Schiller Station, the existing penetrations in the CWIS deck for the traveling screens are not of adequate size to accommodate dual flow conversion traveling water screens (Attachment 4). Dual flow conversion traveling water screens are physically larger than the existing Units because of the screen configuration. New CWISs or extensive modifications to the existing CWISs would have to be designed for dual flow screens to be implemented. This cost is estimated to be many times the cost of the traveling screens themselves. As a result, the implementation of dual flow conversion traveling water screens at Schiller Station is determined to be technologically infeasible.

6.1.3.2 MultiDisc Screens

MultiDisc screens are oriented in a manner similar to traditional through flow screens (i.e., installed in a channel with the screening surface oriented perpendicular to the intake flow). However, they have different designs. MultiDisc screens are comprised of circulating sickle-shaped mesh panels that are connected to a frame via a revolving chain. The linked mesh panels are guided on each side forming a unit together with the support. The forces applied by the flowing water to the center of the mesh panels are transmitted via supporting beams into the intake structure. In the center, the mesh panels are supported by rollers. Water flows directly through the mesh panels. The debris retained at the face of the ascending mesh panels is transported with debris carriers to floor level. There it is removed by means of a spray-water device.
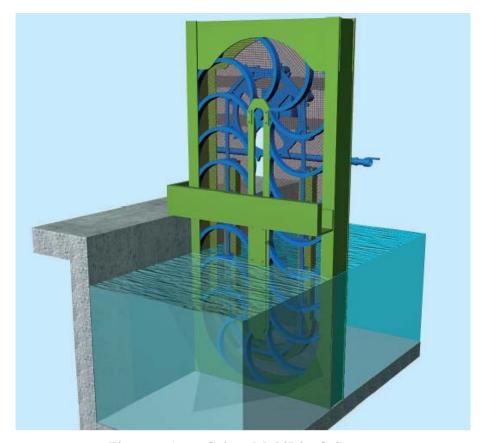
Figure 6.5   Geiger MultiDisc® Screen

MultiDisc screens include provisions for the protection of fish and aquatic species that become impinged. Fish buckets attached to the screen panels retain some of the water during its upward travel, thereby allowing any captured fish to survive within the water once the fish buckets exit the water level. The fish buckets are surface treated with a sliding composite material to allow the fish to be flushed from the buckets. A low pressure spray header recovers organisms which are transported upwards on the screen surface into the bucket. Organisms impinged on the screen surface below this bucket are led via an opening in the lower panel frame into the bucket of the following mesh panel. Due to the turning system of the mesh panels at the drive unit, the fish buckets are discharged and the retained water and fish are funneled into a trough.

Due to the installation across the intake structure, the Geiger MultiDisc® Screens could be retrofitted into the existing space of the current traveling water screens, minimizing required civil structure modifications. Therefore, there would be no civil modifications required to the intake, other than the modifications required to install two additional screens in the Unit 3 intake, discussed in Section 6.1.1. It should be noted that since MultiDisc screens are only available in certain widths, a screen that is narrower than optimal would be installed; therefore, the same volume of water would pass through a smaller area and would result in a higher through-screen velocity.

With traditional through flow traveling water screens, any fish and/or debris that are not washed off the screen basket would be washed off into the flow of water and carried through the cooling water system. Since MultiDisc screens do not rotate over into the downstream

flow, and all flow must pass through the screen before entering the screenwell and ultimately the condenser, the potential for debris carryover is eliminated.

Maintenance

The MultiDisc screens should have lower maintenance than the existing traveling screens since each MultiDisc screen can be removed individually. In addition, since the MultiDisc screens would eliminate debris carryover into the condensers, there would be reduced maintenance associated with cleaning the condensers.

Cost

Biological Benefit

With the expansion of the Unit 4 intake to include the two additional intake pipes in the abandoned Unit 3 intake and the installation of traditional traveling water screens, the through-screen velocity at Unit 4 would be 0.46 fps, as discussed in Section 6.1.1. Per Section 2.3.2.4, the through-screen velocity through the existing traveling water screens at Units 5 and 6 is 0.68 fps. Installing two new MultiDisc screens in the renovated Unit 3 intake and replacing existing screens for Units 4, 5, and 6 with MultiDisc screens would effectively decrease the intake channel width, resulting in a through-screen velocity of 0.55 fps for Unit 4 and 0.82 fps for Units 5 and 6. Since the increased through-screen velocities would likely increase impingement mortality, retrofitting MultiDisc screens to reduce impingement mortality is determined to provide no biological benefits.

6.1.3.3 WIP System

Beaudrey USA supplies a W Intake Protection Screen (WIP) for retrofit into intakes that currently have through flow traveling water screens.

The WIP is a modified revolving disc screen. The traditional revolving disc screen consists of a flat disc covered with screening material that rotates about a horizontal axis, perpendicular to the water flow. As water flows through the submerged portion of the disc, solids are retained on the screening media. On a traditional revolving disc screen, the rotation of the disc lifts the solids above the water surface where they are removed by a series of spray nozzles.

The WIP system consists of stacked circular "No-Cling" screening wheels which rotate within a frame at 2 revolutions per minute, and a fish protection system. Both fish and debris are removed from the screen surface below the waterline by a fish safe pump and suction scoop. The aquatic life does not leave the water and is returned downstream of the intake structure. However, compared to traditional through flow traveling water screens, the WIP system does not utilize the entire available screen area, as shown in Figure 6.6. This decreased active screen area results in an increased through-screen velocity and likely increase impingement mortality.

With traditional through flow traveling water screens, any fish and/or debris that are not washed off the screen basket would be washed off into the flow of water and carried through the cooling water system. Since WIP screens do not rotate over into the downstream flow, and

all flow must pass through the screen before entering the screenwell and ultimately the condenser, the potential for debris carryover is eliminated.

(FRONT VIEW)

(BACK VIEW)

Auto Greaser

Hydraulic Drive

Deck level

WALL PLATE

Fish Pipe

LWL = ?

Screen Drive

WIP MODULE

Backwash Scoop

Backwash Pump

Invert level

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Figure 6.6   Beaudrey Single Wheel WIP Design

Figure 6.7   Beaudrey WIP System

The WIP System is designed to fit into the existed traveling water screen guides, therefore there would be no civil modifications required to the intake, other than the modifications required to install two additional screens in the Unit 3 intake, discussed in Section 6.1.1. It should be noted that since the screen area of the WIP screen is circular, the amount of available through-screen area is limited to the circular screen. Hence, the same volume of water currently passing through the width and height of the water level would pass through a smaller area, resulting in higher through-screen velocities.

Maintenance

The WIP System should have appreciably easier maintenance than the existing traveling screens, because the WIP screens can be raised out of the water for maintenance activities. In addition, since the WIP screens would eliminate debris carryover into the condensers, there would be reduced maintenance associated with cleaning the condensers.

Cost

Biological Benefit

Tables 6-17 and 6-18 in Attachment 6 show the monthly and annual total impingement mortality and EA impingement mortality (all fish species combined) by Unit for Schiller Station at baseline flow (29,290 gpm for Unit 4, 29,000 gpm for Unit 5, and 29,000 for Unit 6) and for each 5% reduction in flow, assuming installation of Beaudrey WIP screens and fish protection system (FPS). Based on Beaudrey FPS system survival testing at Le Blayais Nuclear Power Station in France, screen survival rates represent continuous screen washes and were estimated at 89% for all species[4].

Installing two new WIP screens in the renovated Unit 3 intake and replacing existing screens for Units 4, 5, and 6 with WIP screens would effectively decrease the available screen area, resulting in increased through-screen velocities. Since the increased through-screen velocities would likely increase impingement mortality, retrofitting WIP screens to reduce impingement mortality is determined to provide no biological benefits.

Impingement mortality rate estimates for Beaudrey WIP screens were only available for fish species, so the potential change in impingement mortality of macrocrustaceans at Schiller Station after installation of WIP screens could not be quantified. However, macrocrustacean impingement mortality on Schiller's existing screens is known to be lower than fish mortality, approximately 32% of the annual total impinged, compared to 81% for fish (see Attachment 6). Therefore, there is some potential for reducing macrocrustacean mortality by installing WIP screens, although the proportional benefit would be less than for fish.

6.1.4   Fish Net Barriers

Fish net barriers are coarse mesh nets that are installed in front of intake structures. The water entering the intake must first pass through the openings in the mesh. The size of the mesh openings limits the size of the organism that can pass through the net. In order to be successful, the nets must have a large surface such that the velocity through the net is very small (less than 0.5 fps). Otherwise, organisms impinged on the net would become damaged.

Barrier nets have been deployed at several large power plants. The success of the technology is dependent upon the following site-specific requirements: (a) the intake must be located on a source waterbody that allows for the deployment of a large net, (b) recreation on the waterbody must be limited so as to not interfere with the nets, (c) the waterbody must have limited debris flows so that the net is not damaged, (d) if freezing is a possibility, the net can only be deployed seasonally, when ice is not an issue. In addition, biofouling may be a concern unless rigorous maintenance is performed.

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[4] A pilot study has recently been completed at North Omaha Power Station testing the impacts of WIP screens on freshwater fish. The conditions of the Missouri River and the species of fish tested in the pilot study are not representative of the conditions and fish within of the Piscataqua River, which is part of a seawater (brackish) estuary.

Fish net barriers would have sizing and physical limitations and the potential to interfere with existing uses of the source waterbody. Schiller Station has a total combined design intake flow rate of approximately 87,290 gpm, and the source waterbody directly adjacent to the site is approximately 16 ft deep at MLW. However, the North Dock at Schiller Station is located directly in front of Screen House #2 and less than 150 ft from Screen House #1. The position of the North Dock eliminates any potential location for a fish net barrier. Therefore, there are significant space limitations at Schiller Station that would preclude the successful deployment of a fish net barrier. In addition, since the water temperature can approach freezing in the winter, an implementation of this type of barrier would only be seasonal, in order to prevent any freezing or clogging of the barrier.

Thus, with these considerations in mind, fish net barriers are determined to be technologically infeasible for implementation at Schiller Station.

6.1.5   Wide-slot Wedgewire screens

Wedgewire screens are stationary cylindrical screens that are positioned in a water body parallel to the current. They have no moving parts for debris handling or debris disposal. They are designed to have low through-screen velocity (i.e., less than 0.5 fps) (Ref. 8.6).
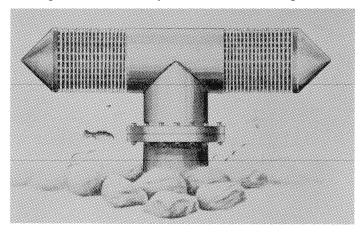
Figure 6.8   Wedgewire Screen (Ref. 8.6)

The outside of the wedgewire screens provides a screening surface consisting of trapezoidal "wedge wire" bars that are formed to maintain a uniform screen opening as shown in Figure 6.9.
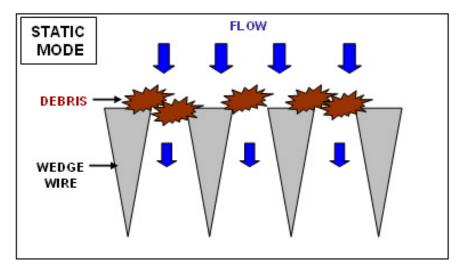
Figure 6.9   Wedge wire screening material (Beaudrey USA)

Wedgewire screens are designed to reduce impingement and entrainment in two ways. First, large organisms (e.g., fish and macrocrustaceans) cannot pass through the small slot size in the screen, thereby stopping them from being entrained into the circulating water pumps and condenser. Secondly, the cylindrical shape of the screen makes it easier for the fish to swim away before they become impinged. Due to the screen's cylindrical configuration, the velocity pulling the organisms toward the screen is quickly dissipated. This allows organisms to escape the flow field. Additionally, a low through-slot velocity is possible because of the large surface area of the cylindrical screen.

Wide-slot wedgewire screens are designed to limit the size of organisms that can enter the intake. At Schiller Station, the existing traveling water screens have a mesh size of 3/8 inches (0.375 inches). All of the wedgewire screens being considered have a slot size equal to or smaller than 0.4 inches. Therefore, the slot size would be small enough to exclude all organisms that are currently impinged at Schiller Station. However, since organisms subject to entrainment are smaller than those impinged, the sizing of the wide-slot wedgewire screens are not considered further; narrow slot wedgewire screens, which provide both impingement and entrainment reduction, are discussed in Section 6.2.1.

6.2   Alternate Technologies that Reduce Entrainment

6.2.1   Narrow-slot Wedgewire Screens

As discussed in Section 6.1.5, wedgewire screens are designed to reduce impingement and entrainment in two ways. First, organisms cannot pass through the small slot size in the screen, thereby stopping them from being entrained into the circulating water pumps and condenser. Secondly, the cylindrical shape of the screen makes it easier for the fish to swim away before they become impinged. Due to the screen's cylindrical configuration, the velocity pulling the organisms toward the screen is quickly dissipated. This allows organisms to escape the flow field. Additionally, a low through slot velocity is possible because of the large surface area of the cylindrical screen.

To attain the optimal reduction in impingement and entrainment, narrow-slot wedgewire screens must meet certain conditions.

- First, the slot size must be small enough to physically prevent the organisms from passing through the screen. Tables 6-19 through 6-30 in Attachment 6 assess the potential reduction in entrainment according to the slot size of the proposed wedgewire screens. Per Normandeau, the measurements of limiting dimensions of fish eggs, larvae and macrocrustacean larvae taken from published drawings were used to establish the relationship between slot opening and reduction in entrainment abundance based on the actual species composition and life stages of organisms observed to be present in sampling from Schiller Station. The slot sizes evaluated were 1, 0.8, 0.69, and 0.6 mm.

- Second, a low through-slot velocity must be maintained to minimize the hydraulic zone of influence surrounding the screen assembly. Typically, a lower through slot velocity will achieve greater reductions in entrainment and impingement mortality. All slot sizes evaluated are based on a maximum through-screen velocity of 0.5 fps.

- Third, a sufficient ambient current must be present in the source waterbody to aid organisms in bypassing the structure and to remove debris from the screen face. A constant current also aids in the automated cleaning systems common to most cylindrical wedgewire screen assemblies. The tidal currents within the lower Piscataqua River are reversing. The average maximum ebb velocity (seaward flow) is 4.89 fps and the average maximum flood velocity (landward flow) is 4.39 fps. Although the screens would be located in an area of reduced water velocity, the ambient current would be sufficient to ensure adequate fish protection as well as to facilitate adequate cleaning of the wedgewire screens.

Large installations utilize multiple screen arrays manifolded to provide equal flow through each screen. The total design flow drawn through the intake at Schiller Station is 87,290 gpm (29,290 gpm for Unit 4, 29,000 for Unit 5, and 29,000 for Unit 6), which would require a system with one manifold per screen house to provide equal flow through each screen. The manifold for Screen House #1 would consist of 2 screens, and the manifold for Screen House #2 would consist of 4 screens.

Figure 6.10 shows a typical 'T' shaped wedgewire screen:

A = Overall Screen Length
B = Screen Diameter
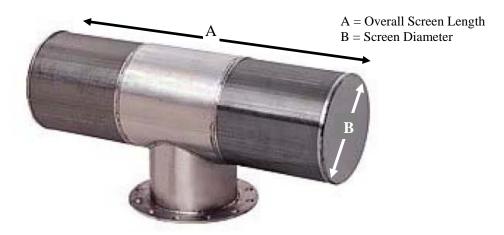
Figure 6.10   'T' Shaped wedgewire Screen (Source: Hendrick Water Intake Screens www.waterintake.com)

The following slot sizes were provided to a leading wedgewire screen manufacturer along with the requirement that the through slot velocity must be less than 0.5 fps: 1 mm (0.040"), 0.8 mm (0.031"), 0.69 mm (0.027"), 0.6 mm (0.024").

Table 6.1 shows the number and size of screens that would be required to provide the necessary flow while still maintaining a maximum 0.5 fps through slot velocity.

Table 6.1   Screens Required to Maintain Minimum Through-Screen Velocity

Slot Size	# of screens	Screen length (A)	Screen dia. (B)	Max. Slot Velocity (fps)
1 mm (0.04")	6	166"	54"	0.478
0.8 mm (0.031")	6	190"	60"	0.462
0.69 mm (0.027")	6	190"	60"	0.473
0.06 mm (0.024")	6	190"	60"	0.493

Sketch PSNH002-SK-005 shows a conceptual layout drawing of the potential wedgewire screen systems. The sketch also depicts the detailed configuration of Screen House #2, since the manifold for Screen House #2 would service both Unit 5 and Unit 6. It is important to note that PSNH002-SK-005 is a conceptual layout only, and the final design would need to meet the approval of the governing authorities regulating this portion of the Piscataqua River.

In order to periodically clean the wedgewire screens, an airburst system would be utilized. As shown in Figure 6.11, an airburst cleaning system would be made up of a pre-assembled package that includes an air compressor and accumulator, distribution manifold, control system, and an individual screen air distributor.
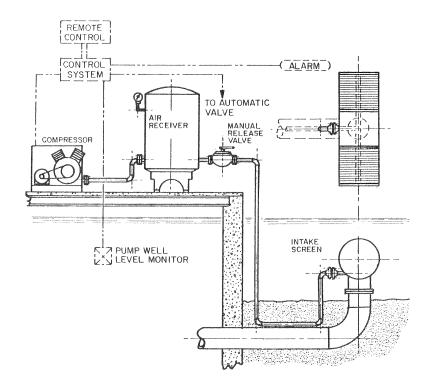
Figure 6.11   Passive screen backwash system (Source: Ref. 8.6)

When cleaning is required, two to three volumes of air would be released rapidly, cleaning accumulated debris from the screen and carrying it up and away from the screen.

Figure 6.12   Airburst Cleaning System (Source: Hendrick Screening Co.)

Schiller Station is situated on a brackish water estuary that contains calcareous algae. Per Normandeau, calcareous algae are encrusting algae that coat inert surfaces with cement-like deposits. Calcareous algae are considered primary colonizers in the northwestern Atlantic in that they colonize clean, hard substrates and then attract an entire biofouling community

including macroscopic algae, barnacles, and mussels. Currently, copper nickel alloy is used for the traveling water screens. Copper nickel alloy wedgewire screens are available. Per Reference 8.13, biofouling and clogging is a significant issue of concern for the long term performance of wedgewire screens. Generally, as aquatic organisms and plants grew on such screens, some mesh openings could become blocked, thereby restricting the flow of water through the screen. This would increase the velocity through the unclogged portions of the screens. In addition, less open area would equate to higher pressure drop through the screens, which could reduce the performance of the Station's circulating water pumps. If the screens were to become substantially blocked, the force from the Station's circulating water pumps could cause the screens to implode.

Beaudrey USA and Hendrick Screen Co. (via EIMCO Technologies), leading suppliers of wedgewire screens, provided the following information on biofouling of wedgewire screens (Attachment 1):

1. Intake structures built along coastal and brackish water ecosystems are subject to extremely aggressive marine life fouling that can quickly and catastrophically impact cooling water screening systems. Specifically, barnacles and numerous species of mollusks could rapidly colonize screening baskets, bars, grates, and meshes, thus impeding the passage of cooling water flow and interfering with the cleaning and operation of the intake screening equipment itself. Colonization of submerged screening components would begin almost immediately upon installation. Gap-bridging growth could occur even on coarse screens with bar spacing of 3 or more inches (i.e., Crystal River Nuclear Plant trash rakes are made of stainless steel and require quarterly removal and scrapping to remove barnacles and mollusks that completely close the gap between bars).

   In the case of Schiller Station, the preferred screen design (i.e., cylindrical wedgewire) would have bar spacing of 1 mm or less. This mesh aperture is highly susceptible to catastrophic blockage from marine life. Marine growth would begin first on surfaces tangential to flow and then bridge the mesh aperture. The airburst cleaning cycle would not be sufficient either to prevent barnacle/mollusk larvae adhesion or to clean subsequent colonization of screen surfaces. Mechanically cleaning with scrapping tools or high-pressure hydro-lancing would be required on a quarterly basis to maintain the screens in operation. The most effective method to address this problem would be prevention through either (1) the regular application/injection of biocides, or (2) screen material selection.

   Material selection for intake screening equipment is critical in determining long term performance. The four criteria that dictate material selection are tensile strength, corrosion resistance, fouling resistance, and price. Per Beaudrey USA, if price is the criterion given the most weight during the design selection phase, a material may be selected that does not meet the performance and maintenance expectations of the end user. In the case of Schiller Station, the selection of anything other than a copper-based alloy (either aluminum bronze or a copper nickel alloy) would result in inferior performance from both an operability and longevity standpoint.

2. As the slot size decreases, the potential for clogging of the screen increases. When using finer (0.6 mm) slotted openings, the surface may foul from finer debris (i.e., algae) at a faster than normal rate, even under low velocity (i.e., less than 0.5 fps) due to the neutral buoyancy of the material. Therefore, the velocity and location of the screens should be

carefully considered to avoid heavy algae blooms and similar type debris. The use of such fine openings (i.e., 0.6 mm) may also have an effect on the ability of the airburst system effectiveness. The airburst system would function, but with such fine openings the system would need to be operated at a higher than normal frequency (i.e., three times per day vs. once per day) to assist in fine particle removal, even though a significant head loss may not exist. This would slightly increase the operational cost.

Given the magnitude and expense of this project, a one year pilot study involving the installation and operation of a 1/10 scale size wedge-wire screen and backwash system (e.g., applicable to 1/10 the flow rate of one CW pump) would be recommended. This would allow the Station to evaluate the performance of the system, material selection, and various slot sizes. Moreover, multiple alloys could be evaluated to assess the bio-fouling rates and bio-fouling resistance of the equipment. Such a test would allow the Station to assess the proper material and design of the equipment.

Maintenance

Passive screens are relatively maintenance free, with the potentially significant exception of periodic inspection and cleaning. The use of fine openings (0.6 mm) dictates that the screens should be inspected at more frequent intervals. When the screens are initially installed, they should be inspected on a quarterly basis for the first twelve to fifteen months of operation to monitor fouling/growth. The conditions of the screens should be well documented so that fouling/growth can be closely monitored. Once the rate of fouling has been established, the inspection frequency may be altered to coincide with the rate.

The surface of the screens (both internal and external), would also require cleaning (brushed or water blast) on occasion, depending on the rate of growth. A man-way could be installed in the screen to allow for internal access if the screens are sufficient size. A removable design (i.e., slide rails) would allow the screens to be cleaned from the surface as opposed to below water. This would require some form of structure for the screens to attach as well as guide rails and an extraction hoist.

When debris accumulates on the screen body, the screens could be cleaned with an airburst system daily, weekly, monthly or any predetermined time specified. Airburst piping should be designed for initial installation of an intake screen, even though the airburst system purchase could be deferred or delayed. The air manifold could be uncapped and connected when required.

Mechanically cleaning with scrapping tools or high-pressure hydro-lancing would also be required on a quarterly basis to maintain the screens in operation.

Cost

The following wedgewire screen slot-sized systems were analyzed:

- Option A – 1 mm slot size
- Option B – 0.8 mm slot size
- Option C – 0.69 mm slot sizes
- Option D – 0.6 mm slot size

The total estimated capital costs for the replacement of the existing traveling water screens with either stainless steel or copper nickel narrow-slot wedgewire screens with airburst cleaning system is shown in Table 6.2 (see Attachment 4).

Table 6.2   Total Estimated Capital Cost of Wedgewire Screens

Slot Size	Cost
1 ███████	██████
██████████	██████
██████████	██████
██████████	██████

Biological Benefit

All slot sizes evaluated are based on a maximum through-screen velocity of 0.5 fps. Under the now suspended Phase II Rule, if a facility could reduce its maximum through-screen velocity to 0.5 fps or less, it would be considered to have satisfied the standard for reducing impingement mortality, effectively reducing impingement mortality by at least 80 to 95%. Additionally, due to the screen's cylindrical configuration, the velocity pulling the organisms toward the screen is quickly dissipated, allowing organisms to escape the flow field.

Tables 6-19 through 6-30 of Attachment 6 display the reduction in entrainment mortality of EA fish and macrocrustaceans from baseline that could be achieved through the installation of wedgewire screens for with slot sizes of 1 mm, 0.8 mm, 0.69 mm, and 0.6 mm. A summary of the information included in the tables is shown below.

Table 6.3   Biological Benefit of Wedgewire Screens

Slot Size	Entrainment Reduction EA Fish	Entrainment Reduction EA Macrocrustaceans
1 mm (0.04")	73.3%	100%
0.8 mm (0.031")	89.6%	100%
0.69 mm (0.027")	94.2%	100%
0.60 mm (0.024")	98.9%	100%

6.2.2   Fine Mesh Ristroph Screens

In addition to the fish handling equipment previously described, traveling water screens can be further modified to incorporate screen meshes with openings as small as 0.5 mm to collect fish eggs and larvae and return them to the source waterbody. For many species and early life stages, mesh sizes of 0.5 to 1.0 mm are required for effective screening. Various types of traveling screens, such as through flow, dual flow, and center flow screens, can be fitted with fine mesh screen material. Because entrainment is usually a seasonal occurrence, some fish baskets can be furnished with quick-change mesh inserts that can be customized for seasonal

operating requirements. For example, an operator can replace the coarse mesh with a fine mesh during the breeding season to prevent the entrainment of eggs.

The primary concern with fine mesh screens is that they function by impinging early organism life stages that are entrained through coarse mesh screens. Depending on species and life stage, mortality from impingement can exceed entrainment mortality. In order for fine mesh screens to provide a meaningful benefit in protecting fish, impingement survival of target species and life stages must be substantially greater than survival through the circulating water system. In addition, at Schiller Station, in order to maintain existing through-screen velocities and head loss across the screen, the size of the intakes would need to be greatly expanded to accommodate fine mesh screens. This is due to the fact that much larger fine mesh screens would be required to provide the same total open area as the existing coarse mesh screens.

For all of these reasons, fine mesh screens are determined to be technologically infeasible for implementation at Schiller Station.

6.2.3 Aquatic Microfiltration Barriers

Aquatic microfiltration barrier systems are barriers that employ a filter fabric designed to allow for passage of water into a CWIS, but to exclude aquatic organisms. These systems are designed to be placed some distance from the CWIS within the source waterbody and to act as a filter for the water that enters the cooling water system. These systems may be floating, flexible, or fixed. Since these systems generally have a large surface area, the velocities that are maintained at the face of the permeable curtain are very low. One company, Gunderboom, Inc. (Gunderboom), has a patented full-water-depth filter curtain comprised of polyethylene or polypropylene fabric that is suspended by flotation billets at the surface of the water and anchored to the substrate below. The curtain fabric is manufactured as the matting of minute unwoven fibers with an opening size of 20 microns. Gunderboom systems also employ an automated "air burst" system to periodically shake the material and pass air bubbles through the curtain system to clean it of sediment buildup and release any other material back into the water column.

At Schiller Station, Gunderboom and other microfiltration systems would have sizing and physical limitations as well as the potential to interfere with or prevent other existing uses of the source waterbody. With a 20 micron mesh, 100,000 and 200,000 gpm intakes would require filter systems 500 and 100 ft long (assuming 20 ft depth). The Station has a total combined intake flow rate of 87,290 gpm (29,290 gpm for Unit 4, 29,000 gpm for Unit 5, and 29,000 gpm for Unit 6). Also, the source water body directly adjacent to the site is approximately 16 ft deep at MLW. Therefore, assuming a linear correlation between flow rate and filter length, the Gunderboom would need to be at least 550 ft long.

In addition, the location of the North Dock – directly in front of Screen House #2 and less than 150 ft from Screen House #1 – would obstruct any potentially effective location of the Gunderboom at the Station. If the dock were to be relocated, the remaining available space would still be less than 550 ft. Therefore, there are significant space limitations at the Station that would preclude the successful deployment of an aquatic microfiltration barrier. Also, since the water temperature can approach freezing in the winter time, an implementation of this type of filter barrier would only be seasonal, in order to prevent any freezing or clogging of the barrier.

Therefore, an aquatic microfiltration barrier is determined to be technologically infeasible for implementation at Schiller Station.

6.3 Behavioral Barriers

Behavioral barriers use a fish's natural reaction to stimuli to deflect it away from the intakes. The three main behavioral barrier systems are bubble barriers, artificial lighting arrays, and underwater acoustic fish deterrence systems. In general, studies of behavioral barriers have been inconclusive or have shown no significant reduction in impingement or entrainment (Ref. 8.9, Chapter 4, Section 2.10). However, there are at least two installed and successfully operating acoustic fish deterrence systems; one at the D. C. Cook Nuclear Plant in Bridgman, Michigan (Lake Michigan), and the other at the J. A. FitzPatrick Nuclear Power Plant (JAFNPP) near Oswego, New York (Lake Ontario).

To efficiently guide fish away from a CWIS, an acoustic fish deterrence system (FDS) has an array of sound projectors typically installed along the face of the CWIS (i.e., the screen house). The conical beam of each transducer must overlap each adjacent projector to provide a sound pressure level at a distance from the CWIS that is consistent and of a magnitude to elicit the desired avoidance behavior far enough from the intake to prevent the fish from being entrained in the intake flow. Aiming the projectors outward along the face of the CWIS causes fish to experience a necessary directional stimulus encouraging the fish to avoid the sound by swimming away from the intake.

The JAFNPP FDS is utilized to keep primarily alewife (the most abundant species in terms of impingement potential at the time the FDS was installed) from entering the intake structure and eventually becoming impinged on the intake screens. The alewife is a delicate species that does not survive the mechanical stresses of impingement well – even from modified traveling intake screens. The FDS system emits a high frequency broadband sound (122 - 128 KHz) at a source level of 190 decibels. Alewife and other clupeid fish avoid this high frequency broadband sound. Because all fish in the order of Clupeiformes (Clupeid fish) have swim bladders and inner ear specializations that function together, enabling the fish to detect sounds (Ref. 8.16), the high frequency sound triggers an avoidance mechanism in such species. Therefore, the site-specific feasibility of a FDS is highly dependent on the impinged species and their contribution to historical impingement, as well as their response to sound.

At Schiller Station, the two species that contributed most to EA fish impingement from 2002 through 2007 were grubby (25.8%; order Scorpaeniformes) and northern pipefish (33.7%; order Syngnathiformes) (Ref. 8.1, Table 5-13). The two species that contributed most per Unit were grubby 38.5%; order Scorpaeniformes) and northern pipefish (16.4%; order Syngnathiformes) at Unit 4, cunner (35.3%; order Perciformes) and northern pipefish (37.8%; order Syngathiformes) at Unit 5, and cunner (14.8%; order Perciformes) and northern pipefish (64.7%; order Syngathiformes) at Unit 6. Clupeid fish that contribute contributed to EA fish impingement (i.e., Atlantic herring and Atlantic menhaden) represent only 0.6% of recent EA fish impingement (0.8% for Unit 4, 0.0% for Unit 5, and 0.3% for Unit 6). Therefore, a FDS installed at Schiller Station would not significantly reduce impingement and a technological evaluation of FDS feasibility is not warranted.

6.4   Alternative Intake Location

As discussed in Section 2.3.1, Schiller Station has two once-through CWISs. Screen House #1 draws water from the Piscataqua River through an offshore intake, and Screen House #2 has draws water from the Piscataqua River through a nearshore intake.

The offshore intake for Schiller Station Unit 4 ██████████████████████████. If the Unit 4 intake were converted to a nearshore intake it would be located within Screen House #1. The inlet to Screen House #1 is located less than 100 ft from the inlet to Screen House #2. The biological data from Schiller Station Units 5 and 6 is therefore used for a comparison of estimated fish and macrocrustacean impingement levels at offshore and nearshore intake structures on the Piscataqua River in the vicinity of the current CWISs. Because entrainment data was not collected for Unit 4, an entrainment comparison cannot be made.

Table 6.4 compares impingement counts based on historical operating flow from 2002 to 2007 at Schiller Station (Ref. 8.1, Table 5-9). As shown in the table, the number of both EA fish and total macrocrustaceans impinged was significantly higher for Unit 4 (i.e., the offshore intake) than for Schiller Units 5 and 6 (i.e., the nearshore intake). For EA fish, the Unit 4 impingement was approximately two times the average of Units 5 and 6. For macrocrustaceans, the Unit 4 impingement was approximately six times the average of Units 5 and 6.

Table 6.4   Impingement Comparison by Unit

Measure	Unit	Number	Fraction
EA Fish Impingement	Unit 4	758	46%
	Unit 5	518	32%
	Unit 6	357	22%
	Combined	1,633	100%
Macrocrustacean Impingement	Unit 4	8,871	76%
	Unit 5	1,576	14%
	Unit 6	1,164	15%
	Combined	11,611	100%

Unit 4

Relocating the Unit 4 offshore intake at Schiller Station to a nearshore location has the potential to reduce impingement, especially for macrocrustaceans. However, detailed field studies would be required to establish (1) the potential biological benefits of a nearshore location with regard to entrainment, and (2) the technological feasibility of relocating the existing offshore intake to a nearshore intake. Given the potential for impingement reduction, a biological evaluation of the entrainment at both the offshore intake and the Unit 5 and 6 nearshore intakes would be warranted, based on the existing biological data obtained from the studies performed as specified in Schiller Station's PIC (Ref. 8.15).

Units 5 and 6

While relocating the Unit 4 offshore intake at Schiller Station to a nearshore location has the potential to reduce impingement, relocating the Unit 5 and/or 6 intakes to an offshore intake has the potential to increase impingement. Moreover, detailed field studies would be required to establish (1) the potential biological benefits of offshore locations versus nearshore locations with regard to entrainment, (2) the optimal location for Unit 5 and/or 6 offshore intakes, if any, and (3) the technological feasibility of such an offshore intake. Given the potential for increased impingement, a site-specific biological and technological evaluation of relocating the Unit 5 and 6 intake is not warranted based on the existing biological data obtained from the studies performed as specified in Schiller Station's PIC (Ref. 8.15).

6.5   Use of Grey Water as Cooling Water

Consideration has been given to the use of treated recycled water, frequently referred to as grey water, as an alternative to using seawater for thermal rejection from the plant's condenser. To fulfill the heat transfer requirements using grey water as an alternative to Piscataqua River water, the approximate volume and flow required would have to be the same or greater than the volume and flow needed when using Piscataqua River water as the CW source.

The NPDES Water Discharge Permit flows for all wastewater treatment facilities in Rockingham County are included in the table below (see Attachment 8).

Facility	Flow	% Red'd CW Flow	Driving Distance to Schiller (approx.)	Direct Distance (approx.)
Pierce Island WWTP	4.8 MGD (3,333.3 gpm)	3.82%	4 mi.	3 mi.
Hampton WWTP	4.7 MGD (3,263.9 gpm)	3.75%	16 mi.	15 mi.
Derry WWTP	4 MGD (2,777.8 gpm)	3.19%	48 mi.	33 mi.
Exeter WWTP	3 MGD (2083.3 gpm)	2.39%	17 mi.	11 mi.
Durham WWTF	2.5 MGD (1736.1 gpm)	1.99%	7.5 mi.	6 mi.
Seabrook WWTP	1.8 MGD (1,250 gpm)	1.43%	18 mi.	15 mi.
Pease Development Authority WWTF	1.2 MGD (833.3 gpm)	0.96%	2 mi.	1 mi.
Newmarket WPCF	0.85 MGD (590.3 gpm)	0.68%	13 mi.	7 mi.
Epping WWTF	0.5 MGD (347.2 gpm)	0.40%	25 mi.	12 mi.
Rockingham County WWTF	0.178 MGD (123.6 gpm)	0.14%	22 mi.	15 mi.
Newfields WWTF	0.115 MGD (80 gpm)	0.09%	12 mi.	9 mi.
Newington WWTP	0.087 MGD (60.2 gpm)	0.07%	<1 mi.	0 mi.
Total	**23.73 MGD (16,480 gpm)**	**18.91%**	**184.5 mi.**	**127 mi.**

The closest wastewater treatment facility, Newington Wastewater Treatment Plant, is located less than 1 mile away from Schiller Station and discharges on average only 60.2 gpm. Pierce Island Wastewater Treatment Plant discharges 3,333.3 gpm, more than any other plant in Rockingham County, and is located approximately 4 miles away. However, the plant only discharges 3.82% of the 87,150 gpm required for normal CW flow. Furthermore, if the discharge from every wastewater treatment facility in Rockingham County was combined, it would reduce the amount of river water needed as a circulating fluid by only 18.91% and would require between 127 and 184.5 miles of pipeline.

The limited sources of grey water in the vicinity of Schiller Station for use as a circulating fluid for condenser heat transfer in the current once-through cooling configuration would eliminate grey

water from being a viable and available alternative to Piscataqua River water, which is currently a reliable and unlimited source of cooling water.

An alternative use for grey water at Schiller Station would be as make-up to the CW system operating in a closed-loop configuration. The necessary make-up flow rate to CW in closed-loop configuration is significantly less than that required to replace seawater in a once-through configuration. For the cooling tower evaluated in Section 5.1.3.3, the necessary make-up flow rate would be 1586 gpm. This volume of make-up flow could be provided by grey water sources in relatively close proximity to Schiller Station.

Preliminary assessments of nearby sources indicate that the closest wastewater treatment facility with an adequate amount of grey water to provide the needed make-up flow rate is Pierce Island WWTF. Additional investigation would be required to confirm availability of these grey water sources, finalize pipeline routing, and confirm that necessary easements and permits can be obtained. Although use of grey water cannot be assured until the above outlined activities are completed, the potential use of grey water for Schiller Station make-up when operating in a closed-cycle cooling configuration offers significant advantages, as discussed in Section 5, and should be further evaluated and pursued.

6.6   Flow Reduction

This Report assumes, for purposes of performing the evaluation required by EPA, that a reduction in intake flow yields a proportional reduction in entrainment and impingement mortality. By replacing the existing CW pumps with variable speed pumps (VSPs) or two-speed pumps, the CW system may be capable of reducing flow through the CWIS under certain operating conditions.

6.6.1   Variable Speed Pumps

The flow through the Station's CWISs could be reduced by replacing the existing CW pump motors associated with each Unit and installing variable frequency drives (VFDs). Control of the resulting VSPs would allow a reduction of entrainment and impingement through reduced flow through the Unit's condenser, without exceeding condenser design limitations.

6.6.1.1 VSP Design Details

Variable flow control would be achieved by replacing the two existing CW pump motors associated with each Unit with new single-speed pump motors and converting them to VSPs through installation of VFDs. The VFD would control the speed of the motor by alternating the frequency of the electrical power supplied to the motor. An inverter switching circuit inside the drive would convert the sinusoidal input power using pulse width modulation. Pulse width modulation utilizes a series of narrow voltage pulses with modulated widths would control the power available to the motor, and therefore regulate the speed of the motor. The interface would allow for an external signal to automatically control the variable frequency drive as well as allowing for manual control by an operator. The startup of the motor would occur when a low voltage and frequency signal is applied by the VFD. Similarly, the motor would be shut down when the variable frequency drive ramped down the applied frequency and voltage. A braking circuit would dissipate the braking energy in order to apply additional torque to facilitate faster shut off of the motor. The ramping nature of the voltage and frequency input would allow the pump speed to be reduced to approximately 20%

of its rated speed. This would effectively make the new single-speed pumps VSPs with almost any level of flow reduction possible down to the operating limits of the Station.

6.6.1.2 VSP Operational Parameters/Methodology

In order to ensure adequate plant reliability and safety, Schiller Station equipment operation is governed by a set of administrative limits. Schiller Station is required to operate under various levels of restriction, whereby the Station decreases the net power generated if it is anticipated that these administrative limits may soon be exceeded.

6.6.1.2.1 Condenser Design Limitations

As discussed in Section 5.2.2, operation of the condenser of any of the Units at Schiller Station beyond the design limit of 1.5 in-Hg results in increased fuel consumption and increases the potential for extensive equipment damage throughout the Station.

Per Heat Exchange Institute standards (Ref. 8.8), water velocities of less than 3 fps through the condenser tubes do not build up enough flow resistance within the condenser to ensure uniform quality of water through all tubes. Condenser performance under such conditions cannot be accurately predicted and any correlation using an input velocity below 3 fps cannot be regarded as a valid analysis. Under design flow conditions, each Unit at Schiller Station operates with a condenser tube water velocity of 3.5 fps. Limiting the condenser tube water velocity to 3 fps results in a 14% reduction in flow through the condenser; therefore, the available reduction in flow through the condenser is bounded by this 14% maximum flow reduction.

6.6.1.2.2 Input Parameters

Schiller Station provided 8 years (2000-2007) of measured maximum daily data, including the condenser inlet and discharge water temperatures, condenser flow rate and pressure, and Station net power generation.

6.6.1.3 Impacts at the Operating Limit

As described in Section 5.2.2, the condenser for each Unit has a design pressure limit of 1.5 in-Hg. Operation beyond this limit results in increased fuel consumption and increases the potential for extensive equipment damage throughout Schiller Station. Each Unit has an inlet water temperature that corresponds to the design pressure limit; the limit is 61.9°F for Unit 4, 58.2°F for Unit 5, and 61.0°F for Unit 6. When the inlet temperature exceeds the inlet water temperature limit, power losses occur (i.e., fuel consumption increases). Table 6.5 shows the monthly condenser flow reduction available for each Unit without incurring any power losses.

Table 6.5   **Flow Reduction Available Without Power Loss**
(2000 – 2007)

Month	Unit 4 (61.9°F)	Unit 5 (58.2°F)	Unit 6 (61.0°F)
January	14.0%	14.0%	14.0%
February	14.0%	14.0%	14.0%
March	14.0%	14.0%	14.0%
April	14.0%	14.0%	13.8%
May	13.5%	10.7%	13.2%
June	3.2%	0.3%	2.8%
July	0.0%	0.0%	0.0%
August	0.0%	0.0%	0.0%
September	1.4%	0.0%	1.4%
October	12.6%	6.3%	12.4%
November	14.0%	14.0%	14.0%
December	14.0%	14.0%	14.0%
Annual	9.3%	8.2%	9.1%

6.6.1.4 VSP Cost Assessment

Although specific installation/modification details are not known at this time, the likelihood of requiring an extended outage to replace the existing CW pump motors and install VFDs is minimal (i.e., the typical tie-in procedure for VSPs is bounded by the length of a routine maintenance outage). Any extended outages or forced outages would greatly increase the overall cost.

Maintenance

While VFDs are new components requiring the development and implementation of new maintenance procedures, the new motors would require similar maintenance to what is currently required. Periodic inspection would be required to determine that the motors are clean and the stator and rotor ventilation passages remain unobstructed as clogging of the ventilation passages could cause excessive rises in temperature. The load and winding temperature would need to be continually monitored to assure that each remains below the rating or service factor. If the insulation resistance were to drop below the recommended minimum, the winding would have to be dried out with sufficient heat in order to raise the insulation resistance. The motor would have to be monitored to ensure the maximum voltage variation from the rating does not exceed 10% and the maximum frequency variation does not exceed 5% with the total of both variations not exceeding 10%. The bearing lubricant would have to be clean and maintained at the proper level. Additionally, by reducing flow through the condenser, there would be an increased probability of condenser tube fouling due to lower flow velocities. A mechanical condenser cleaning system to supplement the existing hypochlorite injection would be necessary to prevent tube fouling similar to that utilized by closed-loop cooling, as described in Section 5.1.3.4.

Each VFD would require minor additional maintenance separate from the motor maintenance. Dust or other objects would need to be periodically removed to prevent loss of airflow, which could negatively impact the performance of the drives. If dust were allowed to build up on the electrical equipment, malfunction or failure would be likely to occur. A dehumidifier is often required to prevent moisture from causing corrosion of the circuits within the VFD. Periodic inspection of the connections would be required to ensure proper performance. If connections were to become loose, performance could become erratic and arcing could occur, resulting in damage to the components of the VFD. Each component would have to be regularly maintained and checked for signs of wear or failure. Direct current (DC) bus capacitors would have to be periodically checked for any leakage or bulging, which would indicate electrical misuse or component stress and could lead to fluctuations in the DC bus voltage measurements. In addition, the VFD heat sink temperatures would need to be regularly monitored to maintain optimum operating conditions.

Capital Cost

VFDs can be very expensive for high voltage motors, but because Schiller Station would utilize low voltage motors, incorporating variable frequency drives would add only approximately 10% to the price of each single-speed motor. █████████████████████ ███ ██ Also included in the estimated cost is the freight for the VFDs and the required implementation tasks (i.e., existing motor removal, installations, testing and commissioning, as well as mechanical and electrical modifications to support the VFDs).

Parasitic losses for the new CW pump motors and VFDs would be approximately equivalent to the parasitic losses for the current CW pump motors. A combined power load of 4.7 MWe would be necessary to operate the new CW pump motors and VFDs at full flow; however, as flow would be reduced via VSP operation, the power necessary to operate the CW pumps would be proportionally reduced. Since the maximum flow reduction possible is 14%, the maximum power saved through this load reduction would be approximately 0.2 MWe per Unit, with the combined maximum power saved across all three Units approximately 0.6 MWe.

6.6.1.5 Biological Benefit

The biological benefit of replacing the existing CW pump motors with new single-speed motors and VFDs would depend on the amount of flow reduction that could be attained as well as the time of year in which the flow reduction could occur. As discussed in Section 6.6.3, the thermal discharge limitations contained in Schiller Station's NPDES permit would limit the use of flow reduction as a means of reducing impingement or entrainment to a greater extent than would any engineering limitations. Also, the benefits of VSPs would not be available at times of scheduled maintenance outages (discussed in Section 2.3.2.3.1).

6.6.1.5.1 Entrainment Reduction Analysis

Using the EA entrainment abundance estimates included in Attachment 6 (Tables 6-4 and 6-7), along with the available average monthly condenser flow reduction percentages (Table 6.5), a correlation was developed between flow reduction, power loss, and entrainment

reduction. Each month contributes a defined percentage of annual entrainment. The condenser flow reduction was used to calculate the total flow reduction for each month. For the condenser limits, incremental entrainment reductions from baseline are presented in Figure 6.13 and Figure 6.14, which show the maximum available reductions in fish and macrocrustacean entrainment from baseline for each Unit without power losses. As shown in Figure 6.13, the maximum reductions in annual EA entrainment of fish would occur in January through April for each Unit. The reductions in entrainment of fish for these months would be 9.4%, 9.8%, 9.8% for Units 4, 5, and 6, respectively, with the EA fish entrainment reductions for the entire year 10.7% for Unit 4, 10.9% for Unit 5, and 11.1% for Unit 6. For macrocrustaceans, however, the maximum reductions in annual EA entrainment would occur in May, June, October, and November, as shown in Figure 6.14. The EA macrocrustacean entrainment reductions for these months would be 2.2% for Unit 4, 1.2% for Unit 5, and 2.1% for Unit 6, with the EA macrocrustacean entrainment reductions for the entire year 2.3%, 1.2%, and 2.3% for Units 4, 5, and 6, respectively.
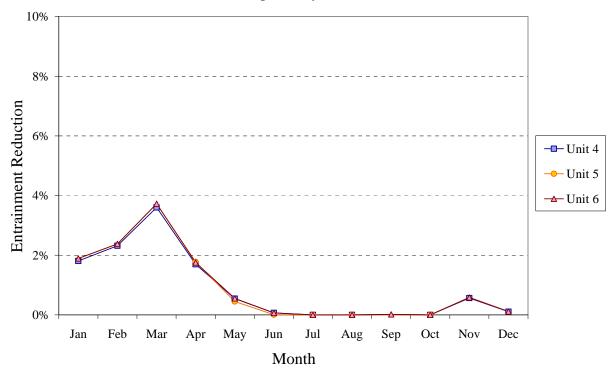
Figure 6.13   Incremental Reduction in Annual EA Fish Entrainment Using VSP Operation Flow Reduction without Power Losses
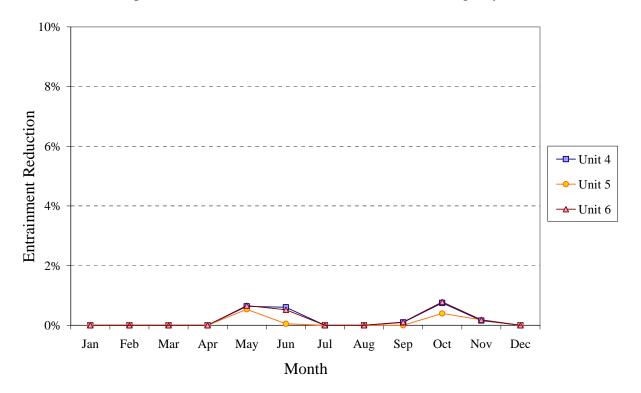
Figure 6.14   Incremental Reduction in Annual EA Macrocrustacean Entrainment Using VSP Operation Flow Reduction without Power Losses

6.6.1.5.2 Impingement Reduction Analysis

Similar to entrainment, the impingement abundance estimates in Attachment 6 (Tables 6-2 and 6-5) are used with the average power losses associated with various condenser flow reduction percentages (Table 6.5) to develop a correlation between flow reduction, power loss, and impingement reductions. The reductions in flow through the condenser were used to calculate the total flow reductions through the CWIS, which were used to scale the monthly impingement abundance in order to determine the monthly percentage of the annual impingement reduction from baseline. For the condenser limits, incremental impingement reductions are presented in Figure 6.15 and Figure 6.16, which show the maximum available reductions in fish and macrocrustacean impingement from baseline for each Unit without power losses. As shown in Figure 6.15, the maximum reductions in annual EA fish impingement would occur in April, and November through January for Unit 4, and January, April, October, and November for Units 5 and 6. The combined reductions in EA fish impingement for these months would be 9.6%, 3.8%, and 11.4% for Units 4, 5, and 6, respectively, with the EA impingement reductions for the entire year 12.0% for Unit 4, 5.7% for Unit 5, and 13.0% for Unit 6. For macrocrustaceans, the maximum reductions in annual impingement would occur in April, May, November, and December for all three Units, as shown in Figure 6.16. The macrocrustacean impingement reductions would be 7.7% for Unit 4, 6.2% for Unit 5, and 6.5% for Unit 6, with the overall macrocrustacean impingement reductions for the entire year 10.3%, 7.7%, 8.1% for Units 4, 5, and 6, respectively.
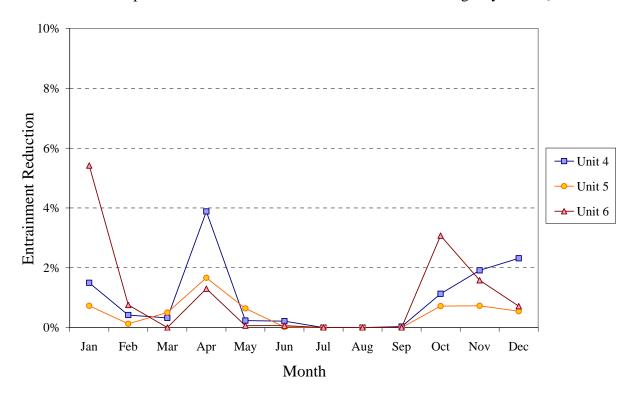
Figure 6.15   Incremental Reduction in Annual EA Fish Impingement Using VSP Operation Flow Reduction without Power Losses
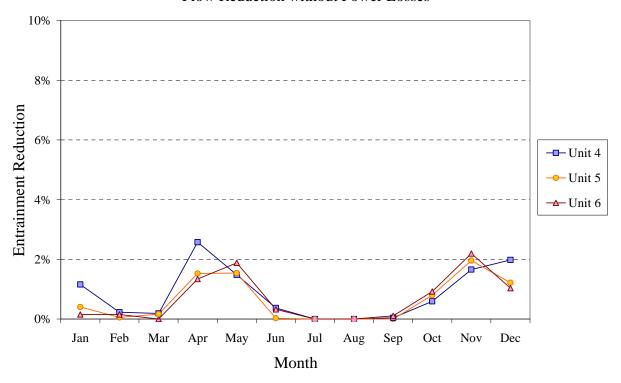
Figure 6.16   Incremental Reduction in Annual Macrocrustacean Impingement Using VSP Operation Flow Reduction without Power Losses

97

6.6.1.5.3 Summary of VSP Effectiveness

Table 6.6 summarizes the potential annual fish EA entrainment and EA impingement reductions from baseline available with the installation of VSPs without power losses. The annual EA fish entrainment would be reduced by approximately 10.7% for Unit 4, 10.9% for Unit 5, and 11.1% for Unit 6, and the annual EA fish impingement would be reduced by 12.0%, 5.7%, and 13.0% for Units 4, 5, and 6, respectively.

Table 6.6   Summary of VSP Operation - Fish

Month	EA Entrainment Reduction			EA Impingement Reduction		
	Unit 4	Unit 5	Unit 6	Unit 4	Unit 5	Unit 6
January	1.8%	1.9%	1.9%	1.5%	0.7%	5.4%
February	2.3%	2.4%	2.4%	0.4%	0.1%	0.8%
March	3.6%	3.7%	3.7%	0.3%	0.5%	0.0%
April	1.7%	1.8%	1.8%	3.9%	1.7%	1.3%
May	0.5%	0.4%	0.6%	0.2%	0.6%	0.1%
June	0.1%	0.0%	0.1%	0.2%	0.0%	0.1%
July	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
August	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
September	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
October	0.0%	0.0%	0.0%	1.1%	0.7%	3.1%
November	0.6%	0.6%	0.6%	1.9%	0.7%	1.6%
December	0.1%	0.1%	0.1%	2.3%	0.5%	0.7%
Annual	10.7%	10.9%	11.1%	12.0%	5.7%	13.0%

Table 6.7 summarizes the potential annual macrocrustacean EA entrainment and impingement reductions from baseline available with the installation of VSPs without power losses. The annual EA macrocrustacean entrainment would be reduced by approximately 2.3% for Unit 4, 1.2% for Unit 5, and 2.3% for Unit 6, and the annual macrocrustacean impingement would be reduced by 10.3%, 7.7%, and 8.1% for Units 4, 5, and 6, respectively.

Table 6.7   Summary of VSP Operation - Macrocrustaceans

Month	EA Entrainment Reduction			Impingement Reduction		
	Unit 4	Unit 5	Unit 6	Unit 4	Unit 5	Unit 6
January	0.0%	0.0%	0.0%	1.2%	0.4%	0.2%
February	0.0%	0.0%	0.0%	0.2%	0.1%	0.2%
March	0.0%	0.0%	0.0%	0.2%	0.2%	0.0%
April	0.0%	0.0%	0.0%	2.6%	1.5%	1.3%
May	0.6%	0.5%	0.7%	1.5%	1.5%	1.9%
June	0.6%	0.1%	0.5%	0.4%	0.0%	0.3%
July	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
August	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
September	0.1%	0.0%	0.1%	0.0%	0.0%	0.1%
October	0.8%	0.4%	0.8%	0.6%	0.8%	0.9%
November	0.2%	0.2%	0.2%	1.7%	2.0%	2.2%
December	0.0%	0.0%	0.0%	2.0%	1.2%	1.0%
Annual	2.3%	1.2%	2.3%	10.3%	7.7%	8.1%

6.6.2   Two-Speed Pumps

As stated in Section 6.6.1.2.1, the available reduction in flow through the condenser is bounded by a 14% maximum flow reduction. By replacing the existing CW pump motors with two-speed motors, the flow could be reduced to 95% flow, 91% flow, and 86% flow. The overall cost for two-speed motors for this application would be greater than the overall cost for conversion to VSPs (as shown in Attachment 4), while two-speed motors would provide significantly less flow control flexibility than VSPs. In addition, the power load necessary to operate two-speed pumps at reduced flow would be equal to that required to operate the pumps at full flow, unlike for VSP operation where, as flow is reduced, the power necessary to operate the CW pumps would be proportionally reduced. For these reasons, the use of two-speed motors is determined to be a less effective technology and operational measure for flow reduction at Schiller Station than the use of VSPs, and was not evaluated further.

6.6.3   Discharge Thermal Impacts of Flow Reduction

In response to the EPA's request to provide "an estimate of the most stringent thermal discharge limits that Schiller Station would be able to comply with utilizing the technology in question", a review of the potential thermal discharge effects of VSP implementation is provided.

The maximum allowable rise in discharge temperature (i.e., the temperature increase across the condenser) for Schiller Station has been established by EPA in NPDES Federal Permit No. NH0001473 (Ref. 8.12). Under this permit, the maximum allowed temperature rise is 25°F and the discharge temperature shall at not time exceed 95°F at the point of discharge to the Piscataqua River.

Assuming complete heat rejection from the condenser to the CW flow, the thermal discharge temperatures were calculated from eight years of measured data (2000 – 2007). This analysis indicates that an increase in temperature rise across the condenser would be expected under the

flow reduction conditions that would occur as a result of VSP implementation, because decreasing the amount of water passing through the condenser while operating at near design power increases the amount of heat rejected per water volume. Table 6.8 lists the monthly and annual available flow reductions for each Unit, without exceeding the permitted thermal discharge temperatures.

Table 6.8   Schiller Performance - Current NPDES Permit[*]
(2000 – 2007)

Month	Available Flow Reduction		
	Unit 4	Unit 5	Unit 6
January	13.4%	11.2%	11.6%
February	13.4%	11.2%	11.6%
March	13.4%	11.2%	11.6%
April	13.4%	11.2%	11.6%
May	13.3%	11.1%	11.6%
June	13.2%	11.2%	11.5%
July	12.1%	10.4%	11.1%
August	10.9%	9.5%	10.7%
September	13.2%	10.8%	11.6%
October	13.4%	11.2%	11.6%
November	13.4%	11.2%	11.6%
December	13.4%	11.2%	11.6%
Annual	13.0%	10.9%	11.5%

[*]Based on a maximum inlet/discharge temperature differential of 25°F and a maximum outlet temperature of 95°F.

According to Table 6.8, the available flow reduction discussed in Section 6.6.1.3 would be additionally limited by the thermal discharge limits imposed by the Station's existing NPDES permit. The available flow reduction would be bounded by these additional limits in the months of November through May at Unit 4, November through April at Unit 5, and October through May at Unit 6. Given the results of this preliminary thermal discharge analysis, further analysis would be required to determine the specific impacts of VSP operation.

6.7   Outage Timing

During a maintenance outage at Schiller Station, there is no flow entering the CWIS for whichever Unit is in the outage. For Unit 4, maintenance outages occur every 18 months and last approximately four weeks. For Unit 5, maintenance outages occur every 12 months and last approximately three weeks. For Unit 6, maintenance outages occur every 18 months and last approximately four weeks. The outages are staggered so that the Units are not offline at the same time. Since there is no flow, there is a 100% reduction in impingement and entrainment associated with each individual Unit during that Unit's outage.

The current outage schedule for Schiller Station, which extends until 2012, calls for spring outages for Unit 5 and rotating spring and fall schedules for Units 4 and 6. Typically, the outages last approximately three to four weeks; however, extended outages are scheduled for equipment

upgrades and other longer-duration maintenance (e.g., in 2012 there is a 6 week outage scheduled for Unit 5). As stated in Section 2.3.2.3.1, exact outage dates are filed one year in advance with ISO New England, which reviews the list and approves or disapproves the dates.

Outage time is usually scheduled in between seasons of peak electrical demand, after the high use winter months (December, January, and February) and well before the high use summer months (June, July, and August). If a peak season outage were allowed by ISO New England, Schiller Station would be penalized dramatically. The exact magnitude of any penalties for selecting a peak season outage is a time-varying combination of replacement power and capacity costs and is not further considered here.

As discussed in Section 4.2, the periods of maximum EA fish and macrocrustacean impingement and entrainment do not coincide. For example, at each Unit, the month with the most EA fish entrainment is March while the month with the most EA macrocrustacean entrainment is July, as shown in Figure 6.17, Figure 6.18, and Figure 6.19. The periods of maximum EA fish and macrocrustacean impingement do coincide in April for Unit 4. However, for Unit 5, the month with the most EA fish impingement is September and the month with the most macrocrustacean impingement is May. Similarly, for Unit 6, the month with the most EA fish impingement is January while the month with the most macrocrustacean impingement is November.
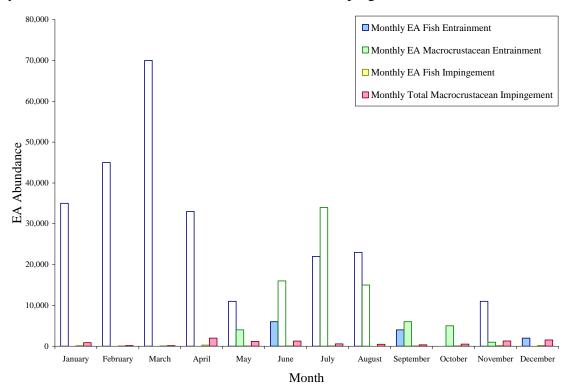
Figure 6.17   Unit 4 Baseline Monthly EA Abundance
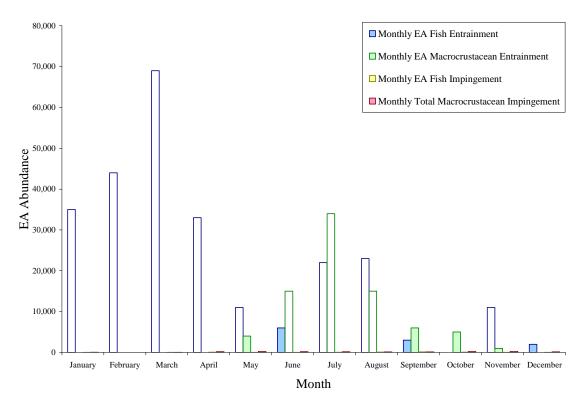
Figure 6.18   Unit 5 Baseline Monthly EA Abundance
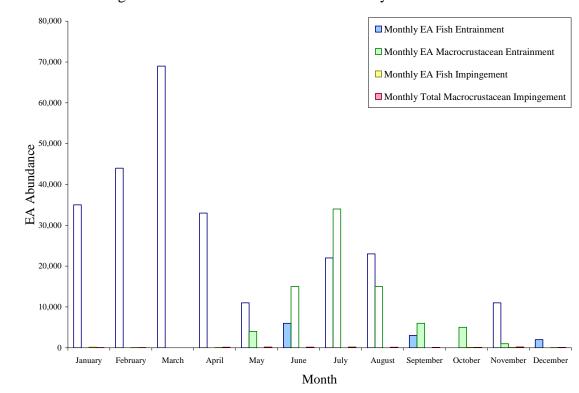
Figure 6.19   Unit 6 Baseline Monthly EA Abundance

For example, a March maintenance outage would reduce EA fish entrainment as measured from baseline approximately 24% for each Unit on an average annual basis (i.e., a 4 week outage over the 4.4 weeks in March weighted by the monthly percentage of EA fish entrainment abundance (27%) would yield an annual 24% reduction in EA fish entrainment). However, the baseline reductions in EA macrocrustacean entrainment would be 0%, and baseline reduction in EA fish and macrocrustacean impingement would be 2.2% and 1.2%, respectively.

A spring outage schedule for each Unit would coincide with the optimum available period for EA fish entrainment reduction. Assuming that only one Unit would be in outage at a time, a thirteen week period of staggered back-to-back-to-back outages would last from the beginning of March to the end of May. However, while April has the fourth largest reduction in EA fish entrainment (13% at each Unit), May does not account for a large portion of entrainment (4% of EA fish entrainment, 5% of EA macrocrustacean entrainment). As the aggregate benefit of an outage shift would be minimal, a change in the current outage schedule for Schiller Station is not expected to significantly reduce entrainment and impingement mortality.

7 Comparison of Alternatives Considered

7.1 Comparative Matrix

The following comparative matrix identifies the various technologies and operational measures that PSNH evaluated for CWA §316(b) compliance enhancements at Schiller Station as required by EPA in the §308 Letter. The matrix provides the estimated total costs and biological (i.e., entrainment and impingement reduction) effectiveness of each technology and operational measure, and ranks the technologies and operational measures by their biological cost effectiveness.

Comparative Matrix of Technologies or Operational Measures Utilized for CWA 316b Compliance
(Note 1)

Technology or Operational Measure	Cost		Biological Effectiveness % Reduction (Note 8)				Biological Cost Effectiveness Ranking (High/Med/Low)	Comments
			Fish		Macrocrustacean			
	Initial	Annual* *Note 4	EA Impingement	EA Entrainment	Impingement	EA Entrainment		
Cooling Towers								
1. Conversion to Closed Loop Cooling – Grey Water	$▮	▮	100	100	100	100	Low	Initial costs = Initial capital costs and lost generating capacity during implementation Annual costs = Average operational efficiency loss, parasitic loss, O&M, and water treatment (Section 5) *Note 4
2. Conversion to Closed Loop Cooling – Seawater	$▮	▮	96.9	96.9	96.9	96.6	Low	Initial costs = Initial capital costs and lost generating capacity during implementation Annual costs = Average operational efficiency loss, parasitic loss, O&M, and water treatment (Section 5) *Note 4
Coarse Mesh Screening Technologies								
3. Ristroph screens	▮	▮	Unit 4 - 75.5 Unit 5 - 73.5 Unit 6 - 75.3	0	Note 6	0	Med	Considering that macrocrustacean impingement mortality with the existing screens and fish return system at Schiller Station is fairly high, mortality due to impingement would likely be reduced by installing Ristroph through flow traveling screens. Includes Unit 3 intake renovation (Section 6.1.2.3).
4. Dual flow conversion screens	NA	Note 2	NA	NA	NA	NA	NA	Due to the screen configuration, the implementation of dual flow conversion traveling water screens would require new CWISs or extensive modifications to the existing CWISs, and is therefore determined to be infeasible. (Section 6.1.3.1)
5. MultiDisc® screens	▮	Note 3	NA	NA	NA	NA	NA	Because replacing existing screens with MultiDisc screens would effectively decrease the intake channel width, which would increase through-mesh velocity and likely increase impingement mortality, retrofitting MultiDisc screens to reduce impingement mortality is determined to provide no biological benefits (Section 6.1.3.2).
6. WIP screens	▮	Note 3	89	0	Note 6	0	NA	This technology has not been tested for site conditions or fish species representative of Schiller Station in the US. Therefore, any biological benefit is considered to be preliminary and, as such, it cannot be recommended until completion of testing (Section 6.1.3.3).
7. Wedgewire screens	NA	Note 2	80-95[Note 5]	0	80-95[Note 5]	0	NA	Since fine mesh wedgewire screens produce the impingement reduction benefit of coarse mesh screens as well as entrainment reduction benefits for relatively similar costs, only fine mesh screens have been fully evaluated (Section 6.1.5).
Fine Mesh Screening Technologies								
8. Wedgewire screens – Option A: 1.0 mm Wedgewire screens – Option B: 0.8 mm Wedgewire screens – Option C: 0.69 mm Wedgewire screens – Option C: 0.6 mm	▮	Note 2	80-95[Note 5]	73.3 89.6 94.2 98.9	80-95[Note 5]	100 100 100 100	Med High High High	Given the magnitude and expense of this project, a one year pilot study is recommended, allowing the Station to evaluate the performance of the system and material selection. Would not require significant intake structure modifications (Section 6.2.1).

Technology or Operational Measure	Cost		Biological Effectiveness % Reduction (Note 8)				Biological Cost Effectiveness Ranking (High/Med/Low)	Comments
	Initial	Annual* *Note 4	Fish		Macrocrustacean			
			EA Impingement	EA Entrainment	Impingement	EA Entrainment		
Fish Return Systems								
9. Unit 3 intake renovation	▇	▇	Unit 4 - 80-95[Note 5] Unit 5 - 0 Unit 6 - 0	0	Unit 4 - 80-95[Note 5] Unit 5 - 0 Unit 6 - 0	0	Med	Costs and biological benefits are for Unit 4 only. Includes the installation of new coarse mesh Ristroph screens and fish return system at the Unit 3 intake. (Section 6.1.1)
10. Continuous operation of existing traveling screens	▇	▇	Note 6	0	Note 6	0	Low	Considering the fairly low survival with the current operation mode of intermittent washes at Schiller Station, it would be expected that continuous washes would provide some improvement in impingement survival (Section 6.1.2.1).
11. Updated fish return system (w/ existing traveling screens)	▇	▇	Note 6	0	Note 6	0	Low	Considering the fairly low survival with the current fish return system at Schiller Station, it would be expected that an updated fish return system with the existing traveling water screens would provide some improvement in impingement survival (Section 6.1.2.2).
Variable Speed Pumps								
12. New circulating water pump motors and VFDs	▇	Note 3	Unit 4 - 12.0 Unit 5 - 5.7 Unit 6 - 13.0	Unit 4 -10.7 Unit 5 -10.9 Unit 6 -11.1	Unit 4 - 10.3 Unit 5 - 7.7 Unit 6 - 8.1	Unit 4 - 2.3 Unit 5 - 1.2 Unit 6 - 2.3	Low	VSP operation realizes up to 0.6 MWe savings over current operation. However, would significantly increase Station discharge temperatures above NPDES-permitted thermal discharge limits (Sections 6.6.1, 6.6.3).
13. Two-speed circulating water pump motors	▇	Note 2	Note 7	Note 7	Note 7	Note 7	Low	More costly than variable speed with less flexible operating parameters. Also, would significantly increase Station discharge temperatures above NPDES-permitted thermal discharge limits (Sections 6.6.2, 6.6.3).
Deterrence Systems								
14. Acoustic Fish Deterrence System	NA	NA	NA	NA	NA	NA	NA	Because species that respond to acoustic fish deterrence systems (FDSs) represent only 0.6% of recent impingement at Schiller Station, installation of FDS to reduce impingement mortality is determined to provide marginal to no biological benefits (Section 6.3).
Operational Measures								
15. Shift outages	NA	NA	NA	NA	NA	NA	NA	A change in the current outage is determined to provide marginal to no biological benefits (Section 6.7).

Notes:
1. Only technologies or operational measures deemed technologically feasible are listed in this matrix
2. Annual maintenance and/or operational cost not appreciably higher than existing component(s)
3. Annual maintenance and/or operational cost lower than existing component(s)
4. Annual cost based on 100% capacity factor; actual annual costs will correlate to capacity factor for a given year
5. Reducing through-screen velocity to 0.5 fps or less is equivalent to reducing impingement mortality by at least 80-95%, *See* 40 C.F.R. §§125.94(a)(1)(ii), 125.94(b)(1).
6. Specific biological benefits unavailable due to lack of data; however, considering the current fairly high impingement mortality, it would be expected that there would be some improvement in impingement survival.
7. Specific biological benefits not evaluated, but will be less than benefits for VFDs
8. The biological benefits presented are the average percentage reductions for the Station as a whole, unless noted otherwise.

7.2   Conclusion – Best Technology Available for Minimizing AEI from Schiller Station CWISs under CWA §316(b)

The following discussion reviews the technologies and operational measures that were evaluated as required by EPA in the §308 Letter, and, on the basis of the engineering evaluations presented in this Report and the biological data from the Station's monitoring programs, ranks them according to their ability to provide the greatest reductions in entrainment and impingement for the least associated initial capital and ongoing annual operating costs. This Report draws the following general conclusions about the potential technological feasibility and biological effectiveness at Schiller Station of the CWIS technologies and operational measures that that EPA identified for assessment in the §308 Letter:

1. Fine mesh wedgewire screens –

    This technology is one of the highest ranked of the alternative CWIS technologies evaluated for this Report in terms of biological benefits, with estimated associated reductions in EA impingement abundance of 80-95%[5] for fish and macrocrustaceans and reductions in EA entrainment abundance of 73-99% for fish and 100% for macrocrustaceans. Its annual operational costs are comparable to the costs of operating the Station's existing traveling screens, ▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮. A site specific study would be required to determine the appropriate wedgewire screen material and slot size to ensure that the screens would be able to withstand the aggressive marine environment without becoming clogged.

    The primary biological benefit of retrofitting fine mesh wedgewire screens at Schiller Station would be the potential to achieve additional entrainment reductions from baseline for fish, for which the existing CWIS configuration and operational measures presently provide an average annual reduction of 60.7% in EA entrainment mortality. Although conversion to closed loop cooling has the potential to reduce entrainment and impingement mortality by 100% or 96.9%, depending on the use of grey water or seawater for make-up water, the fine wedgewire screens have to potential to provide equivalent biological benefits for significantly less cost.

2. Unit 3 intake renovations –

    By renovating the Unit 3 intake and connecting it with the Unit 4 intake, the through-screen velocity for Unit 4 would be reduced to 0.46 fps at MLW, which would achieve significantly reduced impingement mortality (from the 34.7% reduction in EA impingement mortality of fish and 73.9% reduction in total impingement mortality of macrocrustaceans attributable to Unit 4's existing fish return system and operational flow reductions to estimated 80-95% reductions) and satisfy the now suspended Phase II Rule with respect to reducing impingement mortality. ▮▮ However, the renovation of the Unit 3 intake would not reduce entrainment at Unit 4, and would not reduce either entrainment or impingement mortality at Unit 5 or Unit 6.

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[5] Reducing through-screen velocity to 0.5 fps or less is equivalent to reducing impingement mortality by at least 80-95%, *See* 40 C.F.R. §§125.94(a)(1)(ii), 125.94(b)(1).

3. Coarse mesh Ristroph screens –

These screens would provide moderate reductions in EA fish impingement (i.e., approximately 74-76%), and, in combination with the renovation of the Unit 3 intake, would reduce the through-screen velocity for Unit 4 to below 0.5 fps at MLW, thus satisfying the now suspended Phase II Rule with respect to reducing impingement mortality. While it is difficult to quantify the potential biological benefits for macrocrustaceans from implementation of this technology, because of the lack of data, it is expected that there would be some improvement in impingement survival. The annual operational costs of these screens would be comparable to the costs of operating Schiller Station's existing traveling screens, ███████████████ ████████████████████████████████████ However, the biological benefits of coarse mesh Ristroph screens would not include any reductions in entrainment, and the current through-screen velocity at Unit 5 and Unit 6 would not be modified.

4. Conversion to closed loop cooling –

This conversion provides 100% reduction in impingement and entrainment if grey water is utilized, and approximately 97% reduction if seawater is utilized. Annual operating and maintenance costs are extremely high, estimated at up to approximately $21.3 million per year, and initial capital costs (including lost power production during implementation) are also extremely high, █████████████████████████████████████ ████████████████████

The incremental biological benefits that would be provided by conversion to closed-loop cooling as compared to retrofitting fine mesh wedgewire screens amounts to single digit percentages, even when utilizing historical capacity factors and flows. Initial capital costs are 22 to 24 times greater than wedgewire screens, and t██████████████████████████████ ████████████████████████████████ would place a tremendous ongoing burden on the Station. In short, the costs of conversion to closed-loop cooling are wholly disproportionate to the minimal biological benefits that closed-loop cooling potentially would provide compared to fine mesh wedgewire screens.

5. New circulating water pump motors and VFDs –

This technology would provide average reductions of 10.2% and 10.9% in EA fish impingement and entrainment, respectively. The average biological benefit of VSPs for macrocrustaceans would be a 1.9% reduction in impingement and an 8.7% reduction in EA entrainment. The initial capital costs are estimated at approximately $1.9 million. While the annual operating costs of utilizing new circulating water pump motors and VFDs would realize savings of up to 0.6 MWe over current operation, the new motors and VFDs would increase Station discharge temperatures above NPDES-permitted thermal discharge limits. Moreover, although the initial capital costs and annual maintenance costs for the new circulating water pump motors and VFDs would be slightly less than those for fine mesh wedgewire screens, the wedgewire screens have more than 9 times the impingement and entrainment mortality reduction potential.

6. Continuous operation of existing traveling screens –

It is difficult to quantify the specific biological benefits of continuous operation of the existing traveling water screens due to the lack of data. However, considering the fairly low fish survival with the current operation mode of intermittent washes at Schiller Station, it is expected that continuous washes would provide some improvement in impingement survival. The initial capital costs associated with the continuous operation of the existing traveling water screens are estimated ██████████████████████████, and by running the existing traveling water screens continuously, Schiller Station would increase its current maintenance costs by ████████████████. However, the biological benefits of continuous operation of the existing traveling screens would not include any reductions in entrainment.

7. Updated fish return system (with existing traveling screens) –

It is similarly difficult to quantify the specific biological benefits of an updated fish return system with the existing traveling water screens due to the lack of data. However, considering the fairly low fish survival with the current fish return system at Schiller Station, it is expected that an updated fish return system would provide some improvement in impingement survival. The annual operational costs are comparable to the costs of operating Schiller Station's existing fish return system, ██████████████████████████████. However, the biological benefits of an updated fish return system would not include any reductions in entrainment.

Per the Section 7.1 comparative matrix and the Report sections referenced therein, all other CWIS technologies and operational measures evaluated for this report were determined not to warrant comparison with the technologies and operational measures described above, on the grounds that each of those technologies or operational measures is either encompassed by (i.e., coarse mesh wedgewires versus fine mesh wedgewires), has such significant inherent disadvantages (i.e., flow reductions and their associated thermal discharge impacts), or has costs that are wholly disproportionate to the biological benefits that they potentially would provide (i.e., conversion to closed loop cooling), so as to not provide comparable benefits to the technologies directly compared.

In conclusion, for Schiller Station, the addition of fine mesh wedgewire screens would provide reductions in both impingement and entrainment comparable to closed-loop cooling, at a fraction of the initial capital and ongoing operational and maintenance costs required for a closed-loop cooling conversion. As such, if reductions in impingement and entrainment beyond those currently attained by the Station are deemed necessary, the addition of fine mesh screens is the optimum technology currently available.

8 References

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8.14 F-85448-1/F-95996-1, Rev. 1, General Arrangement of Two Rex Traveling Water Screens

8.15 Normandeau Associates, Inc., Proposal for Information Collection to Address Compliance with the Clean Water Act §316(b) Phase II Regulations at Schiller Station, Portsmouth, New Hampshire. 2006.

8.16 Popper, A. N., et al., Response of clupeid fish to ultrasound: a review, ICES Journal of Marine Science, 61: 1057-1061, 2004.

Attachment 1
Major Components: Vendor Data and References

This Attachment contains certain material that has been designated as Confidential Business Information by PSNH. It is therefore included in the Administrative Record document files, but it is not being made publicly available.

Attachment 2
Post-Modification Conceptual Drawings

This Attachment contains certain material that has been designated as Confidential Business Information by PSNH. It is therefore included in the Administrative Record document files, but it is not being made publicly available.

Attachment 3

Comparison of Current, Closed-Loop, and VSP Station Performance

1

1. Meteorological Data Recovery Rate

Wet-bulb temperature data is not available via onsite instrumentation; however, meteorological data, including wet-bulb temperature, is recorded at Pease International Tradeport Airport, a first order National Weather Service (NWS) observatory located approximately two miles from Schiller Station. Fifteen years (1993-2007) of meteorological data was obtained from the NWS via the National Climatic Data Center for use in the closed-loop analysis (Report Ref. 8.7). The NWS records data both hourly and periodically during special weather conditions; therefore, once the data was retrieved, a thorough review was conducted to remove superfluous data input during special weather conditions and to check for any missing hourly data. As even minor errors present in the meteorological data would propagate throughout the analysis, this review ensures that the most uniform hourly data set available, which excludes all erroneous data, is used as the basis for evaluation. Furthermore, there is nearly always a degree of data loss attributed with any long term meteorological monitoring. This data loss may be due to a number of causes (equipment failure, biological/human interference, etc.); however, the general guideline for meteorological data acceptance is that the data maintain an average 90% data recovery rate. Detailed in Table 3-1, the average annual recovery rate for the 15-year period analyzed was 96.9%; therefore, the data gathered from the Pease International Tradeport Airport is valid for use in this analysis.

Table 3-1 Pease International Tradeport Airport Meteorological Data Recovery Rate

Month	|	|	|	|	|	|	Meteorological Data Recovery Rate								
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
January	98.5%	100%	100%	100%	98.1%	90.7%	71.2%	95.3%	97.2%	98.7%	94.1%	95.7%	99.3%	97.0%	97.4%
February	98.7%	100%	100%	99.6%	97.9%	98.8%	71.6%	98.1%	97.6%	97.2%	93.0%	97.6%	98.2%	98.5%	98.1%
March	98.9%	100%	99.9%	99.9%	97.8%	97.8%	72.2%	97.3%	99.3%	97.2%	91.1%	98.5%	99.2%	98.9%	96.9%
April	99.0%	100%	100%	100%	97.9%	99.4%	70.6%	93.3%	95.1%	98.1%	95.4%	97.4%	98.8%	99.3%	97.9%
May	97.7%	100%	99.9%	99.9%	98.0%	98.4%	78.4%	98.3%	96.1%	97.7%	92.6%	98.4%	99.7%	96.8%	96.4%
June	97.4%	100%	99.7%	99.9%	98.3%	98.2%	76.5%	98.9%	96.0%	93.6%	95.3%	99.2%	99.0%	99.7%	99.4%
July	100%	100%	99.9%	99.7%	98.8%	99.1%	78.9%	99.1%	98.8%	96.1%	96.6%	97.0%	97.7%	99.3%	98.4%
August	100%	100%	99.9%	99.7%	99.7%	94.6%	75.7%	97.6%	97.6%	98.9%	93.7%	98.7%	98.0%	99.6%	96.0%
September	100%	100%	100%	100%	97.8%	98.3%	87.4%	94.7%	96.3%	97.2%	92.5%	97.6%	98.1%	99.0%	95.6%
October	100%	100%	99.9%	100%	98.4%	98.3%	97.4%	97.4%	98.1%	96.6%	95.4%	96.5%	99.6%	99.5%	98.9%
November	100%	100%	99.7%	97.1%	98.5%	95.3%	98.3%	96.0%	96.8%	97.6%	94.2%	98.1%	98.8%	99.6%	96.7%
December	100%	100%	99.9%	97.7%	95.8%	96.5%	94.0%	97.3%	98.4%	97.8%	92.7%	98.3%	98.0%	98.7%	99.3%
Annual	99.2%	100%	99.9%	99.5%	98.1%	97.1%	81.1%	96.9%	97.3%	97.2%	93.9%	97.7%	98.7%	98.8%	97.6%

2. Current Schiller Once-Through Operational Conditions

Current once-through operational conditions at Schiller Station are derived solely from daily values measured by the Station. Eight years of operational data were provided covering a measurement period from 2000 through 2007; however, several values provided contained atypical operational values or did not contain the necessary coincident data. To correct for these abnormalities, the daily summary values were sorted by net power generated (MWe), condenser inlet temperature, and condenser pressure, removing the erroneous data.

Once the daily summary values had been sorted for validity, critical operational conditions were examined with respect to the condenser inlet temperature to derive a specific numerical relationship. During this analysis particular focus was placed on the effect condenser inlet temperature has on condenser pressure and net power generated. Over the primary range of condenser inlet temperatures provided by PSNH and at design condenser flow rate (28,200 gpm for Unit 4, 29,000 gpm for Unit 5, and 29,000 gpm for Unit 6), Schiller Station exhibited a strong linear relationship between condenser inlet temperature and condenser pressure (Figures 3-1, 3-2, and 3-3) and a strong cubic relationship between condenser inlet temperature and net power generated (Figures 3-4, 3-5, and 3-6).
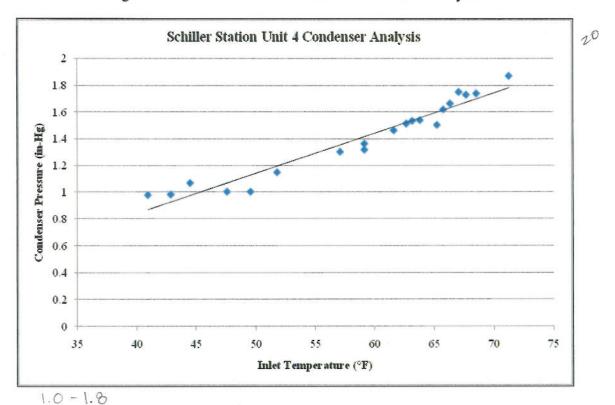
Figure 3-1   Schiller Station Unit 4 Condenser Analysis

Figure 3-2 Schiller Station Unit 5 Condenser Analysis

20

1-2
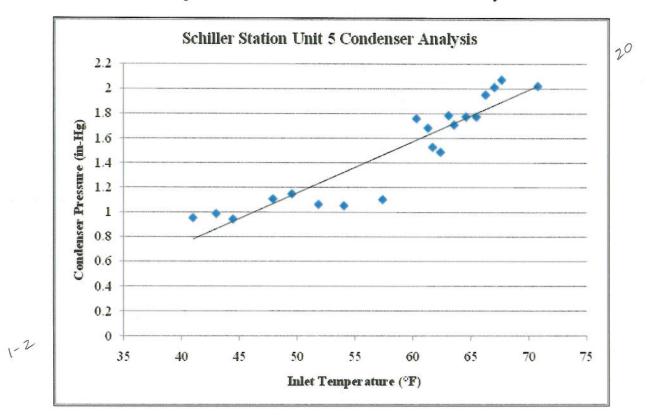
Figure 3-3   Schiller Station Unit 6 Condenser Analysis

1-2

21
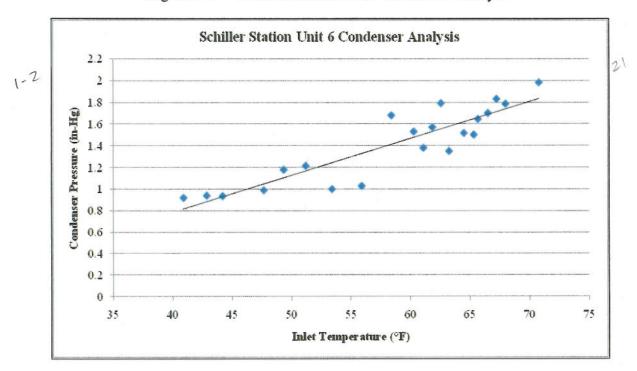
Figure 3-4   Schiller Station Unit 4 Performance Analysis
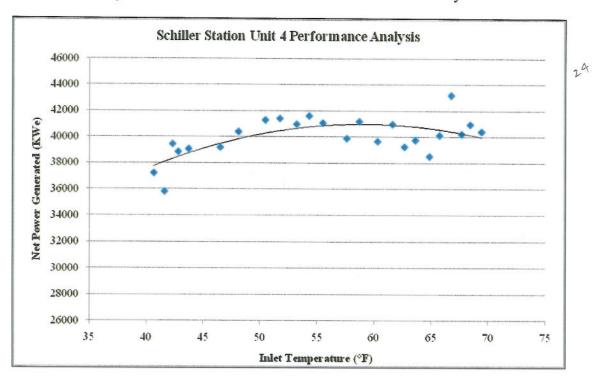
Figure 3-5   Schiller Station Unit 5 Performance Analysis
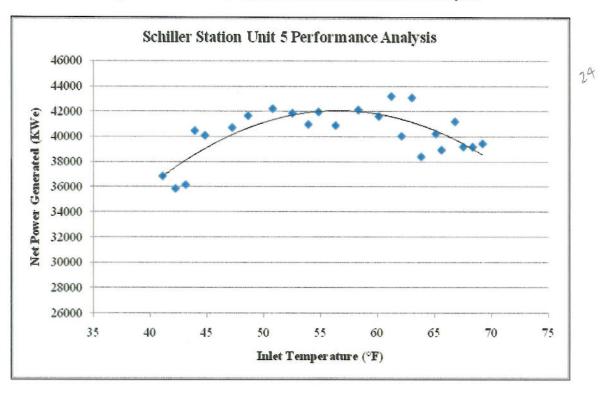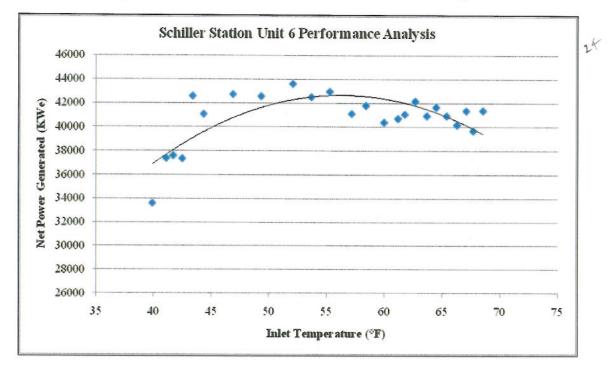
Figure 3-6   Schiller Station Unit 6 Performance Analysis

Schiller Station Unit 6 Performance Analysis

3. Schiller Closed-Loop Performance

The performance correlation defined in Figures 3-4, 3-5, and 3-6 is used to determine the power loss due to increased fuel consumption above the condenser design point (i.e., the loss of potential power generation from the increased fuel consumption above 1.5 in-Hg as compared to current once-through cooling). Utilizing this analysis, Tables 3-2, 3-3, and 3-4 provide monthly power loss values per year for Units 4, 5, and 6, respectively.

Table 3-2   Schiller Unit 4 Annual Closed-Loop Performance
(Estimated from Measured Wet Bulb Temperatures)

Month	Net Power Loss (MWe) at Design Flow Rate														
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
January	1.16	0.79	1.44	1.12	1.1	1.27	1.18	1.06	0.98	1.35	0.8	0.8	1.03	1.46	1.33
February	0.81	0.94	1.02	1.19	1.42	1.44	1.35	1.29	1.12	1.36	0.96	1.09	1.15	1.18	0.81
March	1.41	1.51	1.69	1.31	1.45	2.02	1.65	1.9	1.34	1.68	1.57	1.67	1.32	1.52	1.56
April	2.51	2.52	2.05	2.36	2.12	2.44	2.29	2.47	2.26	2.69	2.04	2.52	2.41	2.48	2.13
May	3.67	3.33	3.37	3.43	3.22	4.07	3.88	3.58	3.75	3.46	3.44	4.06	3.15	3.79	3.78
June	4.96	5.77	5.13	5.25	5.13	5.04	5.76	5.23	5.87	4.92	5.2	4.76	5.78	5.76	5.08
July	5.49	6.56	5.98	5.65	5.61	6.08	6.26	5.12	5.39	5.92	6.15	5.8	6.1	6.47	5.69
August	5.46	5.27	4.96	5.69	5.2	5.62	5.25	5.26	5.98	5.53	6.16	5.79	6.06	4.98	5.43
September	4.56	4.27	4	4.87	4.65	4.89	5.31	4.49	4.65	5.19	4.82	4.83	5.32	4.5	4.73
October	2.8	3.05	3.72	3.21	2.98	3.23	3.02	3.07	3.45	3.12	3.03	3.21	3.63	3.14	3.94
November	2.1	2.36	1.88	1.86	1.96	2.04	2.54	2.14	2.46	2.06	2.25	2.08	2.25	2.71	1.89
December	1.42	1.51	1.06	1.78	1.3	1.66	1.52	1.08	1.71	1.22	1.4	1.35	1.24	1.77	1.11
Annual	3.04	3.16	3.03	3.14	3.02	3.33	3.33	3.06	3.24	3.2	3.17	3.17	3.28	3.32	3.12

Table 3-3   Schiller Unit 5 Annual Closed-Loop Performance
(Estimated from Measured Wet Bulb Temperatures)

Net Power Loss (MWe) at Design Flow Rate

Month	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
January	4.19	3.14	4.97	4.07	4.03	4.52	4.24	3.89	3.69	4.76	3.16	3.15	3.81	5.04
February	3.21	3.55	3.8	4.29	4.92	5	4.73	4.58	4.08	4.77	3.64	4	4.17	4.26
March	4.92	5.2	5.7	4.64	5.03	6.55	5.57	6.27	4.74	5.65	5.33	5.65	4.68	5.22
April	7.91	7.93	6.66	7.51	6.85	7.73	7.32	7.79	7.24	8.37	6.64	7.92	7.65	7.83
May	10.9	9.99	10.1	10.24	9.71	11.93	11.44	10.64	11.09	10.32	10.26	11.89	9.5	11.19
June	13.81	15.89	14.24	14.55	14.22	14.02	15.85	14.5	16.15	13.69	14.41	13.29	15.89	15.85
July	14.84	17.56	16.11	15.26	15.15	16.35	16.81	13.9	14.59	15.94	16.53	15.64	16.41	17.35
August	14.64	14.14	13.33	15.23	13.97	15.05	14.08	14.11	15.96	14.81	16.4	15.47	16.15	13.4
September	12.51	11.78	11.05	13.32	12.73	13.35	14.45	12.31	12.74	14.15	13.21	13.22	14.46	12.35
October	8.59	9.27	11.03	9.68	9.06	9.73	9.17	9.3	10.3	9.41	9.2	9.69	10.76	9.48
November	6.81	7.49	6.2	6.14	6.4	6.66	7.97	6.91	7.78	6.68	7.21	6.76	7.22	8.43
December	4.92	5.18	3.94	5.92	4.62	5.58	5.22	3.97	5.73	4.37	4.87	4.75	4.42	5.89
Annual	8.94	9.25	8.92	9.22	8.9	9.73	9.72	9.01	9.49	9.37	9.27	9.28	9.56	9.7

Table 3-4   Schiller Unit 6 Annual Closed-Loop Performance
(Estimated from Measured Wet Bulb Temperatures)

Month	Net Power Loss (MWe) at Design Flow Rate														
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
January	3.83	2.79	4.62	3.72	3.68	4.17	3.89	3.54	3.34	4.41	2.82	2.81	3.46	4.68	4.65
February	2.86	3.2	3.46	3.94	4.57	4.64	4.38	4.22	3.73	4.42	3.29	3.65	3.82	3.91	3.2
March	4.56	4.84	5.34	4.29	4.67	6.17	5.21	5.91	4.39	5.29	4.97	5.29	4.32	4.87	5.31
April	7.38	7.4	6.15	6.98	6.33	7.21	6.8	7.27	6.72	7.84	6.12	7.39	7.12	7.3	6.89
May	10.61	9.72	9.82	9.96	9.44	11.63	11.15	10.36	10.8	10.04	9.99	11.59	9.24	10.9	11.15
June	13.74	15.78	14.17	14.47	14.15	13.95	15.75	14.42	16.04	13.62	14.33	13.23	15.79	15.75	14.12
July	15.02	17.7	16.27	15.44	15.33	16.51	16.96	14.1	14.78	16.1	16.68	15.81	16.56	17.5	15.35
August	15.01	14.52	13.72	15.59	14.35	15.41	14.46	14.49	16.31	15.18	16.74	15.83	16.5	13.79	14.54
September	12.85	12.13	11.41	13.65	13.07	13.68	14.76	12.65	13.07	14.46	13.54	13.54	14.77	12.69	12.94
October	8.28	8.95	10.69	9.36	8.75	9.41	8.85	8.99	9.97	9.09	8.89	9.37	10.42	9.16	11.58
November	6.44	7.11	5.83	5.77	6.03	6.29	7.58	6.54	7.4	6.3	6.83	6.39	6.84	8.04	6.23
December	4.56	4.82	3.59	5.56	4.27	5.22	4.86	3.62	5.36	4.02	4.51	4.39	4.07	5.52	4.08
Annual	8.76	9.07	8.75	9.05	8.72	9.55	9.54	8.84	9.3	9.19	9.09	9.1	9.38	9.52	9.16

4. Schiller VSP Operational Availability

As each Unit operates two single-speed pumps, measured performance data is limited to a design flow rate and a 50% design flow rate (i.e., two pump and one pump operation). Additionally, flow rate measurements for each Unit are reported daily instead of hourly; this decreases the resolution of any analysis on the effect that flow rate change has on each Unit's performance. The result of these limitations is an inability to accurately calculate each Unit's performance degradation resulting from operational flow reductions; however, the data is comprehensive enough to calculate the times at which any flow reduction would result in power reduction. Tables 3-5, 3-6, and 3-7 provide monthly VSP operational availability with no power reduction by year for each Unit.

Table 3-5   Schiller Unit 4 VSP Operational Availability with No Power Loss

Month	VSP Operational Availability with No Power Loss							
	2000	2001	2002	2003	2004	2005	2006	2007
January	100%	100%	100%	100%	100%	100%	100%	100%
February	100%	100%	100%	100%	100%	100%	100%	100%
March	100%	100%	100%	100%	100%	100%	100%	100%
April	100%	100%	100%	100%	100%	100%	100%	100%
May	96.7%	100%	100%	100%	88.9%	100%	96.6%	87.1%
June	30.0%	23.3%	37.9%	48.3%	26.7%	13.3%	0.0%	3.3%
July	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
August	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
September	23.3%	13.3%	0.0%	0.0%	0.0%	6.7%	13.3%	13.3%
October	96.7%	96.7%	95.0%	93.5%	83.9%	93.5%	86.7%	74.2%
November	100%	100%	100%	100%	100%	100%	100%	100%
December	100%	100%	100%	100%	100%	100%	100%	100%
Annual	70.1%	67.1%	71.5%	68.5%	62.9%	65.5%	63.1%	64.6%

Table 3-6   Schiller Unit 5 VSP Operational Availability with No Power Loss

Month	VSP Operational Availability with No Power Loss							
	2000	2001	2002	2003	2004	2005	2006	2007
January	100%	100%	100%	100%	100%	100%	100%	100%
February	100%	100%	100%	100%	100%	100%	100%	100%
March	100%	-	100%	100%	100%	100%	100%	100%
April	100%	100%	100%	100%	100%	100%	100%	100%
May	80.0%	71.0%	89.7%	82.6%	43.3%	93.5%	-	77.4%
June	0.0%	13.3%	0.0%	0.0%	0.0%	0.0%	-	0.0%
July	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
August	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
September	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
October	67.7%	61.3%	33.3%	45.2%	45.2%	38.7%	51.6%	4.5%
November	100%	100%	100%	100%	100%	100%	100%	100%
December	100%	100%	100%	100%	100%	100%	100%	100%
Annual	61.5%	56.3%	57.2%	59.3%	56.4%	60.3%	63.4%	57.2%

Table 3-7   Schiller Unit 6 VSP Operational Availability with No Power Loss

Month	VSP Operational Availability with No Power Loss							
	2000	2001	2002	2003	2004	2005	2006	2007
January	100%	100%	100%	100%	100%	100%	100%	100%
February	100%	100%	100%	100%	100%	100%	100%	100%
March	100%	100%	100%	100%	100%	100%	100%	100%
April	100%	100%	93.8%	-	100%	100%	100%	95.5%
May	100%	100%	100%	100%	93.5%	100%	96.8%	74.2%
June	21.4%	8.3%	40.7%	37.9%	26.7%	20.7%	0.0%	3.3%
July	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
August	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
September	33.3%	10.0%	0.0%	0.0%	0.0%	13.3%	13.3%	10.0%
October	100%	93.5%	77.8%	90.3%	80.6%	96.7%	100%	71.0%
November	100%	100%	100%	100%	100%	100%	100%	100%
December	100%	100%	100%	100%	100%	100%	100%	100%
Annual	66.3%	65.3%	65.7%	65.5%	63.7%	68.5%	67.1%	59.0%

5. Historical Schiller Performance Data

Eight years of daily Schiller performance data (2000-2007) was provided by the Station as input for both the closed-loop and VSP analysis. This data includes the measured CWIS flow rate, CWIS inlet temperature, discharge temperature, condenser pressure, and net power generated for each Unit. All eight years of performance data has been included within the attached CD as an archive entitled "Performance_Data.zip".

Attachment 4
Capital Cost Assessments

This Attachment contains certain material that has been designated as Confidential Business Information by PSNH. It is therefore included in the Administrative Record document files, but it is not being made publicly available.

Attachment 5
Figures (Cooling Water Intake Structure)

This Attachment contains certain material that has been designated as Confidential Business Information by PSNH. It is therefore included in the Administrative Record document files, but it is not being made publicly available.

Attachment 6

Normandeau Biological Assessment Tables and Correspondence

Table 6 - 1   Monthly and annual total impingement abundance (all fish species combined) by unit for Schiller Station at maximum generating flow and for each 5% reduction in flow.

Unit 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	353	128	89	1,505	68	209	51	26	61	151	424	487	3,553
95%	335	122	85	1,430	65	198	49	24	58	144	403	462	3,375
90%	318	116	80	1,355	61	188	46	23	55	136	381	438	3,198
85%	300	109	76	1,280	58	177	44	22	52	128	360	414	3,020
80%	283	103	72	1,204	55	167	41	20	49	121	339	389	2,842
75%	265	96	67	1,129	51	156	38	19	46	113	318	365	2,665
70%	247	90	63	1,054	48	146	36	18	43	106	297	341	2,487
65%	230	83	58	978	44	136	33	17	40	98	275	316	2,309
60%	212	77	54	903	41	125	31	15	37	91	254	292	2,132
55%	194	71	49	828	38	115	28	14	34	83	233	268	1,954
50%	177	64	45	753	34	104	26	13	31	76	212	243	1,776
45%	159	58	40	677	31	94	23	12	28	68	191	219	1,599
40%	141	51	36	602	27	83	20	10	25	60	169	195	1,421
35%	124	45	31	527	24	73	18	9	22	53	148	170	1,244
30%	106	39	27	452	20	63	15	8	18	45	127	146	1,066
25%	88	32	22	376	17	52	13	6	15	38	106	122	888
20%	71	26	18	301	14	42	10	5	12	30	85	97	711
15%	53	19	13	226	10	31	8	4	9	23	64	73	533
10%	35	13	9	151	7	21	5	3	6	15	42	49	355
5%	18	6	4	75	3	10	3	1	3	8	21	24	178

Unit 5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	91	33	71	183	49	69	74	210	117	106	102	34	1,139
95%	87	31	68	174	46	66	70	199	111	101	97	32	1,082
90%	82	29	64	165	44	62	67	189	105	95	92	31	1,025
85%	78	28	61	156	41	59	63	178	99	90	87	29	968
80%	73	26	57	146	39	55	59	168	94	85	82	27	912
75%	69	25	54	137	36	52	55	157	88	80	77	25	855
70%	64	23	50	128	34	48	52	147	82	74	72	24	798
65%	59	21	46	119	32	45	48	136	76	69	67	22	741
60%	55	20	43	110	29	41	44	126	70	64	61	20	684
55%	50	18	39	101	27	38	41	115	64	58	56	19	627
50%	46	16	36	92	24	35	37	105	58	53	51	17	570
45%	41	15	32	82	22	31	33	94	53	48	46	15	513
40%	37	13	29	73	19	28	30	84	47	42	41	14	456
35%	32	11	25	64	17	24	26	73	41	37	36	12	399
30%	27	10	21	55	15	21	22	63	35	32	31	10	342
25%	23	8	18	46	12	17	18	52	29	27	26	8	285
20%	18	7	14	37	10	14	15	42	23	21	20	7	228

2

15%	14	5	11	27	7	10	11	31	18	16	15	5	171
10%	9	3	7	18	5	7	7	21	12	11	10	3	114
5%	5	2	4	9	2	3	4	10	6	5	5	2	57

Unit 6	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	343	59	23	156	9	15	18	0	0	104	169	19	914
95%	326	56	22	148	8	14	17	0	0	99	160	18	868
90%	309	53	21	140	8	13	16	0	0	94	152	17	823
85%	291	50	20	132	8	13	15	0	0	88	143	16	777
80%	274	47	19	124	7	12	14	0	0	83	135	15	731
75%	257	45	17	117	7	11	13	0	0	78	127	14	686
70%	240	42	16	109	6	10	13	0	0	73	118	13	640
65%	223	39	15	101	6	10	12	0	0	68	110	12	594
60%	206	36	14	93	5	9	11	0	0	62	101	11	548
55%	189	33	13	86	5	8	10	0	0	57	93	10	503
50%	171	30	12	78	4	7	9	0	0	52	84	9	457
45%	154	27	10	70	4	7	8	0	0	47	76	8	411
40%	137	24	9	62	4	6	7	0	0	42	67	8	366
35%	120	21	8	54	3	5	6	0	0	36	59	7	320
30%	103	18	7	47	3	4	5	0	0	31	51	6	274
25%	86	15	6	39	2	4	4	0	0	26	42	5	229
20%	69	12	5	31	2	3	4	0	0	21	34	4	183
15%	51	9	3	23	1	2	3	0	0	16	25	3	137
10%	34	6	2	16	1	1	2	0	0	10	17	2	91
5%	17	3	1	8	0	1	1	0	0	5	8	1	46

January, April, July, and October are five-week periods; all other months are four-week periods. Estimates represent Schiller Station's existing cooling water intake system and were calculated from impingement rates and collection efficiencies observed during 5Oct06-27Sep07 (Normandeau 2008).

3

Table 6 - 2 Monthly and annual total equivalent adult impingement abundance (fish species combined) by unit for Schiller Station at maximum generating flow and for each 5% reduction in flow.

Unit 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	116	33	25	302	19	73	26	5	25	97	149	180	1,048
95%	110	31	24	287	18	70	25	5	24	92	141	171	996
90%	104	30	22	271	17	66	23	5	22	87	134	162	943
85%	98	28	21	256	16	62	22	4	21	82	126	153	891
80%	92	27	20	241	15	59	21	4	20	77	119	144	838
75%	87	25	19	226	14	55	20	4	19	72	111	135	786
70%	81	23	17	211	13	51	18	4	17	68	104	126	734
65%	75	22	16	196	12	48	17	3	16	63	97	117	681
60%	69	20	15	181	11	44	16	3	15	58	89	108	629
55%	64	18	14	166	10	40	14	3	14	53	82	99	576
50%	58	17	12	151	9	37	13	3	12	48	74	90	524
45%	52	15	11	136	8	33	12	2	11	43	67	81	472
40%	46	13	10	121	7	29	10	2	10	39	59	72	419
35%	40	12	9	106	7	26	9	2	9	34	52	63	367
30%	35	10	7	90	6	22	8	2	7	29	45	54	314
25%	29	8	6	75	5	18	7	1	6	24	37	45	262
20%	23	7	5	60	4	15	5	1	5	19	30	36	210
15%	17	5	4	45	3	11	4	1	4	14	22	27	157
10%	12	3	2	30	2	7	3	1	2	10	15	18	105
5%	6	2	1	15	1	4	1	0	1	5	7	9	52
Unit 5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	29	5	20	67	34	34	57	85	117	64	29	22	563
95%	27	4	19	64	33	33	54	81	111	61	27	21	535
90%	26	4	18	60	31	31	51	76	105	58	26	20	506
85%	24	4	17	57	29	29	49	72	99	55	24	19	478
80%	23	4	16	54	27	27	46	68	94	51	23	18	450
75%	22	3	15	50	26	26	43	64	88	48	22	16	422
70%	20	3	14	47	24	24	40	59	82	45	20	15	394
65%	19	3	13	44	22	22	37	55	76	42	19	14	366
60%	17	3	12	40	21	21	34	51	70	39	17	13	338
55%	16	3	11	37	19	19	31	47	64	35	16	12	309
50%	14	2	10	34	17	17	29	42	58	32	14	11	281
45%	13	2	9	30	15	15	26	38	53	29	13	10	253
40%	11	2	8	27	14	14	23	34	47	26	11	9	225
35%	10	2	7	24	12	12	20	30	41	23	10	8	197
30%	9	1	6	20	10	10	17	25	35	19	9	7	169
25%	7	1	5	17	9	9	14	21	29	16	7	5	141
20%	6	1	4	13	7	7	11	17	23	13	6	4	113

15%	4	1	3	10	5	5	9	13	18	10	4	3	84
10%	3	0	2	7	3	3	6	8	12	6	3	2	56
5%	1	0	1	3	2	2	3	4	6	3	1	1	28

Unit 6	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	144	20	0	35	2	9	10	0	0	92	42	19	372
95%	136	19	0	33	2	8	10	0	0	87	40	18	353
90%	129	18	0	31	2	8	9	0	0	83	38	17	335
85%	122	17	0	29	2	8	9	0	0	78	36	16	316
80%	115	16	0	28	2	7	8	0	0	73	34	15	297
75%	108	15	0	26	1	7	8	0	0	69	32	14	279
70%	101	14	0	24	1	6	7	0	0	64	29	13	260
65%	93	13	0	23	1	6	7	0	0	60	27	12	242
60%	86	12	0	21	1	5	6	0	0	55	25	11	223
55%	79	11	0	19	1	5	6	0	0	50	23	10	205
50%	72	10	0	17	1	4	5	0	0	46	21	9	186
45%	65	9	0	16	1	4	5	0	0	41	19	8	167
40%	57	8	0	14	1	4	4	0	0	37	17	8	149
35%	50	7	0	12	1	3	4	0	0	32	15	7	130
30%	43	6	0	10	1	3	3	0	0	28	13	6	112
25%	36	5	0	9	0	2	3	0	0	23	11	5	93
20%	29	4	0	7	0	2	2	0	0	18	8	4	74
15%	22	3	0	5	0	1	2	0	0	14	6	3	56
10%	14	2	0	3	0	1	1	0	0	9	4	2	37
5%	7	1	0	2	0	0	1	0	0	5	2	1	19

Equivalent adults include taxa accounting for >91% of the fish that would be impinged in a year at a uniform flow rate, estimated using instantaneous mortality rates, age at maturity, length at age, and length-frequency distributions from Normandeau (2008). January, April, July, and October are five-week periods; all other months are four-week periods. Estimates represent Schiller Station's existing cooling water intake system and were calculated from impingement rates and collection efficiencies observed during 5Oct06-27Sep07 (Normandeau 2008).

5

Table 6 - 3   Monthly and annual total entrainment abundance (in millions, for all fish species combined) by unit for Schiller Station at maximum generating flow and for each 5% reduction in flow.

Unit 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	2	4	3	1	7	16	9	8	0	0	0	0	50
95%	2	3	3	1	6	15	9	7	0	0	0	0	48
90%	2	3	3	1	6	14	8	7	0	0	0	0	45
85%	2	3	2	1	6	14	8	6	0	0	0	0	43
80%	2	3	2	1	5	13	8	6	0	0	0	0	40
75%	1	3	2	1	5	12	7	6	0	0	0	0	38
70%	1	3	2	1	5	11	7	5	0	0	0	0	35
65%	1	2	2	1	4	10	6	5	0	0	0	0	33
60%	1	2	2	1	4	10	6	5	0	0	0	0	30
55%	1	2	2	1	4	9	5	4	0	0	0	0	28
50%	1	2	1	1	3	8	5	4	0	0	0	0	25
45%	1	2	1	1	3	7	4	3	0	0	0	0	23
40%	1	1	1	1	3	6	4	3	0	0	0	0	20
35%	1	1	1	1	2	6	3	3	0	0	0	0	18
30%	1	1	1	0	2	5	3	2	0	0	0	0	15
25%	0	1	1	0	2	4	2	2	0	0	0	0	13
20%	0	1	1	0	1	3	2	2	0	0	0	0	10
15%	0	1	0	0	1	2	1	1	0	0	0	0	8
10%	0	0	0	0	1	2	1	1	0	0	0	0	5
5%	0	0	0	0	0	1	0	0	0	0	0	0	3

Unit 5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	2	4	3	1	6	16	9	7	0	0	0	0	50
95%	2	3	3	1	6	15	9	7	0	0	0	0	47
90%	2	3	3	1	6	14	8	7	0	0	0	0	45
85%	2	3	2	1	6	13	8	6	0	0	0	0	42
80%	2	3	2	1	5	13	7	6	0	0	0	0	40
75%	1	3	2	1	5	12	7	6	0	0	0	0	37
70%	1	3	2	1	5	11	7	5	0	0	0	0	35
65%	1	2	2	1	4	10	6	5	0	0	0	0	32
60%	1	2	2	1	4	10	6	4	0	0	0	0	30
55%	1	2	2	1	4	9	5	4	0	0	0	0	27
50%	1	2	1	1	3	8	5	4	0	0	0	0	25
45%	1	2	1	1	3	7	4	3	0	0	0	0	22
40%	1	1	1	1	3	6	4	3	0	0	0	0	20
35%	1	1	1	1	2	6	3	3	0	0	0	0	17
30%	1	1	1	0	2	5	3	2	0	0	0	0	15
25%	0	1	1	0	2	4	2	2	0	0	0	0	12
20%	0	1	1	0	1	3	2	1	0	0	0	0	10

15%	0	1	0	0	1	2	1	1	0	0	0	0	7
10%	0	0	0	0	1	2	1	1	0	0	0	0	5
5%	0	0	0	0	0	1	0	0	0	0	0	0	2
Unit 6	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
100%	2	4	3	1	6	16	9	7	0	0	0	0	50
95%	2	3	3	1	6	15	9	7	0	0	0	0	47
90%	2	3	3	1	6	14	8	7	0	0	0	0	45
85%	2	3	2	1	6	13	8	6	0	0	0	0	42
80%	2	3	2	1	5	13	7	6	0	0	0	0	40
75%	1	3	2	1	5	12	7	6	0	0	0	0	37
70%	1	3	2	1	5	11	7	5	0	0	0	0	35
65%	1	2	2	1	4	10	6	5	0	0	0	0	32
60%	1	2	2	1	4	10	6	4	0	0	0	0	30
55%	1	2	2	1	4	9	5	4	0	0	0	0	27
50%	1	2	1	1	3	8	5	4	0	0	0	0	25
45%	1	2	1	1	3	7	4	3	0	0	0	0	22
40%	1	1	1	1	3	6	4	3	0	0	0	0	20
35%	1	1	1	1	2	6	3	3	0	0	0	0	17
30%	1	1	1	0	2	5	3	2	0	0	0	0	15
25%	0	1	1	0	2	4	2	2	0	0	0	0	12
20%	0	1	1	0	1	3	2	1	0	0	0	0	10
15%	0	1	0	0	1	2	1	1	0	0	0	0	7
10%	0	0	0	0	1	2	1	1	0	0	0	0	5
5%	0	0	0	0	0	1	0	0	0	0	0	0	2

January, April, July, and October are five-week periods; all other months are four-week periods. Estimates represent Schiller Station's existing cooling water intake system and were calculated from entrainment densities observed during 28Sep06-27Sep07 (Normandeau 2008).

7

Table 6 - 4 Monthly and annual total equivalent adult entrainment abundance (in thousands, for fish species combined) by unit for Schiller Station at maximum generating flow and for each 5% reduction in flow.

Unit 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	35	45	70	33	11	6	22	23	4	0	11	2	262
95%	34	42	66	32	10	6	21	22	3	0	10	1	249
90%	32	40	63	30	10	6	20	21	3	0	10	1	236
85%	30	38	59	28	9	5	19	20	3	0	9	1	223
80%	28	36	56	27	9	5	18	18	3	0	9	1	210
75%	27	34	52	25	8	5	17	17	3	0	8	1	197
70%	25	31	49	23	7	4	16	16	2	0	8	1	183
65%	23	29	45	22	7	4	15	15	2	0	7	1	170
60%	21	27	42	20	6	4	13	14	2	0	7	1	157
55%	19	25	38	18	6	4	12	13	2	0	6	1	144
50%	18	22	35	17	5	3	11	12	2	0	5	1	131
45%	16	20	31	15	5	3	10	10	2	0	5	1	118
40%	14	18	28	13	4	3	9	9	1	0	4	1	105
35%	12	16	24	12	4	2	8	8	1	0	4	1	92
30%	11	13	21	10	3	2	7	7	1	0	3	0	79
25%	9	11	17	8	3	2	6	6	1	0	3	0	66
20%	7	9	14	7	2	1	4	5	1	0	2	0	52
15%	5	7	10	5	2	1	3	3	1	0	2	0	39
10%	4	4	7	3	1	1	2	2	0	0	1	0	26
5%	2	2	3	2	1	0	1	1	0	0	1	0	13

Unit 5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	35	44	69	33	11	6	22	23	3	0	11	2	259
95%	33	42	66	31	10	6	21	22	3	0	10	1	247
90%	32	40	62	30	9	6	20	21	3	0	10	1	234
85%	30	38	59	28	9	5	19	19	3	0	9	1	221
80%	28	35	55	27	8	5	18	18	3	0	9	1	208
75%	26	33	52	25	8	5	17	17	3	0	8	1	195
70%	25	31	49	23	7	4	16	16	2	0	8	1	182
65%	23	29	45	22	7	4	14	15	2	0	7	1	169
60%	21	27	42	20	6	4	13	14	2	0	6	1	156
55%	19	24	38	18	6	3	12	13	2	0	6	1	143
50%	18	22	35	17	5	3	11	11	2	0	5	1	130
45%	16	20	31	15	5	3	10	10	2	0	5	1	117
40%	14	18	28	13	4	3	9	9	1	0	4	1	104
35%	12	15	24	12	4	2	8	8	1	0	4	1	91
30%	11	13	21	10	3	2	7	7	1	0	3	0	78
25%	9	11	17	8	3	2	6	6	1	0	3	0	65
20%	7	9	14	7	2	1	4	5	1	0	2	0	52

8

15%	5	7	10	5	2	1	3	3	1	0	2	0	39
10%	4	4	7	3	1	1	2	2	0	0	1	0	26
5%	2	2	3	2	1	0	1	1	0	0	1	0	13

Unit 6	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	35	44	69	33	11	6	22	23	3	0	11	2	259
95%	33	42	66	31	10	6	21	22	3	0	10	1	247
90%	32	40	62	30	9	6	20	21	3	0	10	1	234
85%	30	38	59	28	9	5	19	19	3	0	9	1	221
80%	28	35	55	27	8	5	18	18	3	0	9	1	208
75%	26	33	52	25	8	5	17	17	3	0	8	1	195
70%	25	31	49	23	7	4	16	16	2	0	8	1	182
65%	23	29	45	22	7	4	14	15	2	0	7	1	169
60%	21	27	42	20	6	4	13	14	2	0	6	1	156
55%	19	24	38	18	6	3	12	13	2	0	6	1	143
50%	18	22	35	17	5	3	11	11	2	0	5	1	130
45%	16	20	31	15	5	3	10	10	2	0	5	1	117
40%	14	18	28	13	4	3	9	9	1	0	4	1	104
35%	12	15	24	12	4	2	8	8	1	0	4	1	91
30%	11	13	21	10	3	2	7	7	1	0	3	0	78
25%	9	11	17	8	3	2	6	6	1	0	3	0	65
20%	7	9	14	7	2	1	4	5	1	0	2	0	52
15%	5	7	10	5	2	1	3	3	1	0	2	0	39
10%	4	4	7	3	1	1	2	2	0	0	1	0	26
5%	2	2	3	2	1	0	1	1	0	0	1	0	13

Equivalent adults include taxa accounting for >99.5% of the fish eggs and larvae that would be entrained in a year at a uniform flow rate, estimated using instantaneous mortality rates and age at maturity from Normandeau (2008). January, April, July, and October are five-week periods; all other months are four-week periods. Estimates represent Schiller Station's existing cooling water intake system and were calculated from entrainment densities observed during 28Sep06-27Sep07 (Normandeau 2008).

Table 6 - 5   Monthly and annual total impingement abundance (all macrocrustacean species combined) by unit for Schiller Station at maximum generating flow and for each 5% reduction in flow.

Unit 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	886	176	141	1,981	1,182	1,251	593	497	336	508	1,277	1,523	10,350
95%	841	167	134	1,882	1,123	1,188	563	472	319	482	1,213	1,447	9,833
90%	797	158	127	1,783	1,064	1,126	534	447	302	457	1,150	1,371	9,315
85%	753	150	120	1,684	1,005	1,063	504	422	285	432	1,086	1,295	8,798
80%	709	141	113	1,585	946	1,001	474	397	269	406	1,022	1,218	8,280
75%	664	132	106	1,486	887	938	445	372	252	381	958	1,142	7,763
70%	620	123	99	1,387	828	876	415	348	235	355	894	1,066	7,245
65%	576	114	92	1,288	769	813	385	323	218	330	830	990	6,728
60%	531	106	85	1,189	709	750	356	298	201	305	766	914	6,210
55%	487	97	77	1,090	650	688	326	273	185	279	702	838	5,693
50%	443	88	70	990	591	625	296	248	168	254	639	762	5,175
45%	399	79	63	891	532	563	267	223	151	228	575	685	4,658
40%	354	70	56	792	473	500	237	199	134	203	511	609	4,140
35%	310	62	49	693	414	438	208	174	118	178	447	533	3,623
30%	266	53	42	594	355	375	178	149	101	152	383	457	3,105
25%	221	44	35	495	296	313	148	124	84	127	319	381	2,588
20%	177	35	28	396	236	250	119	99	67	102	255	305	2,070
15%	133	26	21	297	177	188	89	74	50	76	192	228	1,553
10%	89	18	14	198	118	125	59	50	34	51	128	152	1,035
5%	44	9	7	99	59	63	30	25	17	25	64	76	518
Unit 5	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
100%	49	7	21	185	244	183	175	113	117	215	237	147	1,694
95%	46	7	20	176	232	174	166	108	111	205	225	140	1,610
90%	44	6	19	167	220	165	158	102	105	194	213	132	1,525
85%	42	6	18	158	208	155	149	96	100	183	201	125	1,440
80%	39	6	17	148	195	146	140	91	94	172	189	118	1,356
75%	37	5	16	139	183	137	131	85	88	162	177	110	1,271
70%	34	5	15	130	171	128	123	79	82	151	166	103	1,186
65%	32	5	14	121	159	119	114	74	76	140	154	96	1,101
60%	29	4	13	111	146	110	105	68	70	129	142	88	1,017
55%	27	4	12	102	134	101	96	62	64	119	130	81	932
50%	24	4	11	93	122	91	88	57	59	108	118	74	847
45%	22	3	10	83	110	82	79	51	53	97	106	66	762
40%	20	3	8	74	98	73	70	45	47	86	95	59	678
35%	17	3	7	65	85	64	61	40	41	75	83	51	593
30%	15	2	6	56	73	55	53	34	35	65	71	44	508
25%	12	2	5	46	61	46	44	28	29	54	59	37	424
20%	10	1	4	37	49	37	35	23	23	43	47	29	339

15%	7	1	3	28	37	27	26	17	18	32	35	22	254
10%	5	1	2	19	24	18	18	11	12	22	24	15	169
5%	2	0	1	9	12	9	9	6	6	11	12	7	85

Unit 6	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	14	14	0	120	176	144	175	121	92	91	194	91	1,232
95%	13	13	0	114	167	137	166	115	87	86	184	86	1,170
90%	13	13	0	108	158	130	158	108	83	82	175	82	1,108
85%	12	12	0	102	149	123	149	102	78	77	165	77	1,047
80%	11	11	0	96	141	116	140	96	74	72	155	73	985
75%	10	11	0	90	132	108	131	90	69	68	146	68	924
70%	10	10	0	84	123	101	123	84	64	63	136	64	862
65%	9	9	0	78	114	94	114	78	60	59	126	59	801
60%	8	8	0	72	105	87	105	72	55	54	116	55	739
55%	8	8	0	66	97	79	96	66	51	50	107	50	677
50%	7	7	0	60	88	72	88	60	46	45	97	45	616
45%	6	6	0	54	79	65	79	54	41	41	87	41	554
40%	6	6	0	48	70	58	70	48	37	36	78	36	493
35%	5	5	0	42	62	51	61	42	32	32	68	32	431
30%	4	4	0	36	53	43	53	36	28	27	58	27	369
25%	3	4	0	30	44	36	44	30	23	23	49	23	308
20%	3	3	0	24	35	29	35	24	18	18	39	18	246
15%	2	2	0	18	26	22	26	18	14	14	29	14	185
10%	1	1	0	12	18	14	18	12	9	9	19	9	123
5%	1	1	0	6	9	7	9	6	5	5	10	5	62

January, April, July, and October are five-week periods; all other months are four-week periods. Estimates represent Schiller Station's existing cooling water intake system and were calculated from impingement rates observed during 5Oct06-27Sep07 (Normandeau 2008).

11

Table 6 - 6 Monthly and annual total entrainment abundance (in millions, for all macrocrustacean species combined) by unit for Schiller Station at maximum generating flow and for each 5% reduction in flow.

Unit 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	0	0	0	0	48	131	195	60	16	3	0	0	453
95%	0	0	0	0	46	124	185	57	15	3	0	0	431
90%	0	0	0	0	43	118	175	54	14	3	0	0	408
85%	0	0	0	0	41	111	166	51	14	3	0	0	385
80%	0	0	0	0	38	105	156	48	13	3	0	0	363
75%	0	0	0	0	36	98	146	45	12	2	0	0	340
70%	0	0	0	0	34	92	136	42	11	2	0	0	317
65%	0	0	0	0	31	85	127	39	10	2	0	0	295
60%	0	0	0	0	29	79	117	36	10	2	0	0	272
55%	0	0	0	0	26	72	107	33	9	2	0	0	249
50%	0	0	0	0	24	65	97	30	8	2	0	0	227
45%	0	0	0	0	22	59	88	27	7	1	0	0	204
40%	0	0	0	0	19	52	78	24	6	1	0	0	181
35%	0	0	0	0	17	46	68	21	6	1	0	0	159
30%	0	0	0	0	14	39	58	18	5	1	0	0	136
25%	0	0	0	0	12	33	49	15	4	1	0	0	113
20%	0	0	0	0	10	26	39	12	3	1	0	0	91
15%	0	0	0	0	7	20	29	9	2	0	0	0	68
10%	0	0	0	0	5	13	19	6	2	0	0	0	45
5%	0	0	0	0	2	7	10	3	1	0	0	0	23

Unit 5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	0	0	0	0	48	130	193	59	16	3	0	0	449
95%	0	0	0	0	45	123	183	56	15	3	0	0	427
90%	0	0	0	0	43	117	174	54	14	3	0	0	404
85%	0	0	0	0	40	110	164	51	13	3	0	0	382
80%	0	0	0	0	38	104	154	48	13	3	0	0	359
75%	0	0	0	0	36	97	145	45	12	2	0	0	337
70%	0	0	0	0	33	91	135	42	11	2	0	0	314
65%	0	0	0	0	31	84	125	39	10	2	0	0	292
60%	0	0	0	0	29	78	116	36	9	2	0	0	269
55%	0	0	0	0	26	71	106	33	9	2	0	0	247
50%	0	0	0	0	24	65	96	30	8	2	0	0	224
45%	0	0	0	0	21	58	87	27	7	1	0	0	202
40%	0	0	0	0	19	52	77	24	6	1	0	0	180
35%	0	0	0	0	17	45	68	21	6	1	0	0	157
30%	0	0	0	0	14	39	58	18	5	1	0	0	135
25%	0	0	0	0	12	32	48	15	4	1	0	0	112
20%	0	0	0	0	10	26	39	12	3	1	0	0	90

12

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
15%	0	0	0	0	7	19	29	9	2	0	0	0	67
10%	0	0	0	0	5	13	19	6	2	0	0	0	45
5%	0	0	0	0	2	6	10	3	1	0	0	0	22
Unit 6	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	0	0	0	0	48	130	193	59	16	3	0	0	449
95%	0	0	0	0	45	123	183	56	15	3	0	0	427
90%	0	0	0	0	43	117	174	54	14	3	0	0	404
85%	0	0	0	0	40	110	164	51	13	3	0	0	382
80%	0	0	0	0	38	104	154	48	13	3	0	0	359
75%	0	0	0	0	36	97	145	45	12	2	0	0	337
70%	0	0	0	0	33	91	135	42	11	2	0	0	314
65%	0	0	0	0	31	84	125	39	10	2	0	0	292
60%	0	0	0	0	29	78	116	36	9	2	0	0	269
55%	0	0	0	0	26	71	106	33	9	2	0	0	247
50%	0	0	0	0	24	65	96	30	8	2	0	0	224
45%	0	0	0	0	21	58	87	27	7	1	0	0	202
40%	0	0	0	0	19	52	77	24	6	1	0	0	180
35%	0	0	0	0	17	45	68	21	6	1	0	0	157
30%	0	0	0	0	14	39	58	18	5	1	0	0	135
25%	0	0	0	0	12	32	48	15	4	1	0	0	112
20%	0	0	0	0	10	26	39	12	3	1	0	0	90
15%	0	0	0	0	7	19	29	9	2	0	0	0	67
10%	0	0	0	0	5	13	19	6	2	0	0	0	45
5%	0	0	0	0	2	6	10	3	1	0	0	0	22

January, April, July, and October are five-week periods; all other months are four-week periods. Estimates represent Schiller Station's existing cooling water intake system and were calculated from entrainment densities observed during 28Sep06-27Sep07 (Normandeau 2008).

13

Table 6 - 7   Monthly and annual total equivalent adult entrainment abundance (in thousands, for macrocrustacean species combined) by unit for Schiller Station at maximum generating flow and for each 5% reduction in flow.

Unit 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	0	0	0	0	4	16	34	15	6	5	1	0	81
95%	0	0	0	0	3	15	33	15	6	4	1	0	77
90%	0	0	0	0	3	14	31	14	5	4	1	0	73
85%	0	0	0	0	3	13	29	13	5	4	1	0	69
80%	0	0	0	0	3	12	28	12	5	4	1	0	65
75%	0	0	0	0	3	12	26	11	5	4	1	0	61
70%	0	0	0	0	3	11	24	11	4	3	1	0	57
65%	0	0	0	0	2	10	22	10	4	3	1	0	53
60%	0	0	0	0	2	9	21	9	4	3	1	0	49
55%	0	0	0	0	2	9	19	8	3	3	1	0	44
50%	0	0	0	0	2	8	17	8	3	2	0	0	40
45%	0	0	0	0	2	7	16	7	3	2	0	0	36
40%	0	0	0	0	1	6	14	6	2	2	0	0	32
35%	0	0	0	0	1	5	12	5	2	2	0	0	28
30%	0	0	0	0	1	5	10	5	2	1	0	0	24
25%	0	0	0	0	1	4	9	4	2	1	0	0	20
20%	0	0	0	0	1	3	7	3	1	1	0	0	16
15%	0	0	0	0	1	2	5	2	1	1	0	0	12
10%	0	0	0	0	0	2	3	2	1	0	0	0	8
5%	0	0	0	0	0	1	2	1	0	0	0	0	4

Unit 5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	0	0	0	0	4	15	34	15	6	5	1	0	80
95%	0	0	0	0	3	15	32	14	6	4	1	0	76
90%	0	0	0	0	3	14	31	14	5	4	1	0	72
85%	0	0	0	0	3	13	29	13	5	4	1	0	68
80%	0	0	0	0	3	12	27	12	5	4	1	0	64
75%	0	0	0	0	3	12	26	11	4	4	1	0	60
70%	0	0	0	0	3	11	24	11	4	3	1	0	56
65%	0	0	0	0	2	10	22	10	4	3	1	0	52
60%	0	0	0	0	2	9	20	9	4	3	1	0	48
55%	0	0	0	0	2	8	19	8	3	3	1	0	44
50%	0	0	0	0	2	8	17	8	3	2	0	0	40
45%	0	0	0	0	2	7	15	7	3	2	0	0	36
40%	0	0	0	0	1	6	14	6	2	2	0	0	32
35%	0	0	0	0	1	5	12	5	2	2	0	0	28
30%	0	0	0	0	1	5	10	5	2	1	0	0	24
25%	0	0	0	0	1	4	9	4	1	1	0	0	20
20%	0	0	0	0	1	3	7	3	1	1	0	0	16

14

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
15%	0	0	0	0	1	2	5	2	1	1	0	0	12
10%	0	0	0	0	0	2	3	2	1	0	0	0	8
5%	0	0	0	0	0	1	2	1	0	0	0	0	4
Unit 6	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	0	0	0	0	4	15	34	15	6	5	1	0	80
95%	0	0	0	0	3	15	32	14	6	4	1	0	76
90%	0	0	0	0	3	14	31	14	5	4	1	0	72
85%	0	0	0	0	3	13	29	13	5	4	1	0	68
80%	0	0	0	0	3	12	27	12	5	4	1	0	64
75%	0	0	0	0	3	12	26	11	4	4	1	0	60
70%	0	0	0	0	3	11	24	11	4	3	1	0	56
65%	0	0	0	0	2	10	22	10	4	3	1	0	52
60%	0	0	0	0	2	9	20	9	4	3	1	0	48
55%	0	0	0	0	2	8	19	8	3	3	1	0	44
50%	0	0	0	0	2	8	17	8	3	2	0	0	40
45%	0	0	0	0	2	7	15	7	3	2	0	0	36
40%	0	0	0	0	1	6	14	6	2	2	0	0	32
35%	0	0	0	0	1	5	12	5	2	2	0	0	28
30%	0	0	0	0	1	5	10	5	2	1	0	0	24
25%	0	0	0	0	1	4	9	4	1	1	0	0	20
20%	0	0	0	0	1	3	7	3	1	1	0	0	16
15%	0	0	0	0	1	2	5	2	1	1	0	0	12
10%	0	0	0	0	0	2	3	2	1	0	0	0	8
5%	0	0	0	0	0	1	2	1	0	0	0	0	4

Equivalent adults include taxa accounting for >99% of the macrocrustaceans that would be entrained in a year at a uniform flow rate, estimated using instantaneous mortality rates and age at maturity from Normandeau (2008). January, April, July, and October are five-week periods; all other months are four-week periods. Estimates represent Schiller Station's existing cooling water intake system and were calculated from entrainment densities observed during 28Sep06-27Sep07 (Normandeau 2008).

Table 6 - 8 Monthly and annual total impingement mortality (all fish species combined) by unit for Schiller Station at maximum generating flow and for each 5% reduction in flow.

Unit 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	249	90	74	1,240	56	209	51	26	52	129	361	343	2,879
95%	236	86	70	1,178	53	198	49	24	50	122	343	326	2,735
90%	224	81	66	1,116	51	188	46	23	47	116	325	308	2,591
85%	211	77	63	1,054	48	177	44	22	44	109	307	291	2,448
80%	199	72	59	992	45	167	41	20	42	103	289	274	2,304
75%	186	68	55	930	42	156	38	19	39	97	271	257	2,160
70%	174	63	52	868	39	146	36	18	37	90	253	240	2,016
65%	162	59	48	806	37	136	33	17	34	84	235	223	1,872
60%	149	54	44	744	34	125	31	15	31	77	217	206	1,728
55%	137	50	41	682	31	115	28	14	29	71	199	188	1,584
50%	124	45	37	620	28	104	26	13	26	64	181	171	1,440
45%	112	41	33	558	25	94	23	12	24	58	162	154	1,296
40%	99	36	29	496	22	83	20	10	21	52	144	137	1,152
35%	87	32	26	434	20	73	18	9	18	45	126	120	1,008
30%	75	27	22	372	17	63	15	8	16	39	108	103	864
25%	62	23	18	310	14	52	13	6	13	32	90	86	720
20%	50	18	15	248	11	42	10	5	10	26	72	69	576
15%	37	14	11	186	8	31	8	4	8	19	54	51	432
10%	25	9	7	124	6	21	5	3	5	13	36	34	288
5%	12	5	4	62	3	10	3	1	3	6	18	17	144

Unit 5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	64	23	59	151	40	69	74	210	100	90	87	24	991
95%	61	22	56	143	38	66	70	199	95	86	83	23	942
90%	58	21	53	136	36	62	67	189	90	81	79	21	892
85%	55	20	50	128	34	59	63	178	85	77	74	20	842
80%	51	18	47	121	32	55	59	168	80	72	70	19	793
75%	48	17	44	113	30	52	55	157	75	68	65	18	743
70%	45	16	41	106	28	48	52	147	70	63	61	17	694
65%	42	15	38	98	26	45	48	136	65	59	57	16	644
60%	39	14	35	91	24	41	44	126	60	54	52	14	595
55%	35	13	32	83	22	38	41	115	55	50	48	13	545
50%	32	12	29	75	20	35	37	105	50	45	44	12	496
45%	29	10	26	68	18	31	33	94	45	41	39	11	446
40%	26	9	24	60	16	28	30	84	40	36	35	10	396
35%	23	8	21	53	14	24	26	73	35	32	31	8	347
30%	19	7	18	45	12	21	22	63	30	27	26	7	297
25%	16	6	15	38	10	17	18	52	25	23	22	6	248
20%	13	5	12	30	8	14	15	42	20	18	17	5	198

16

15%	10	3	9	23	6	10	11	31	15	14	13	4	149
10%	6	2	6	15	4	7	7	21	10	9	9	2	99
5%	3	1	3	8	2	3	4	10	5	5	4	1	50

Unit 6	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	241	42	19	128	7	15	18	0	0	89	144	13	716
95%	229	40	18	122	7	14	17	0	0	84	137	13	680
90%	217	38	17	115	7	13	16	0	0	80	129	12	644
85%	205	36	16	109	6	13	15	0	0	75	122	11	609
80%	193	33	15	103	6	12	14	0	0	71	115	11	573
75%	181	31	14	96	6	11	13	0	0	67	108	10	537
70%	169	29	13	90	5	10	13	0	0	62	101	9	501
65%	157	27	12	83	5	10	12	0	0	58	93	9	465
60%	145	25	11	77	4	9	11	0	0	53	86	8	430
55%	133	23	10	70	4	8	10	0	0	49	79	7	394
50%	121	21	10	64	4	7	9	0	0	44	72	7	358
45%	109	19	9	58	3	7	8	0	0	40	65	6	322
40%	97	17	8	51	3	6	7	0	0	35	58	5	286
35%	84	15	7	45	3	5	6	0	0	31	50	5	251
30%	72	13	6	38	2	4	5	0	0	27	43	4	215
25%	60	10	5	32	2	4	4	0	0	22	36	3	179
20%	48	8	4	26	1	3	4	0	0	18	29	3	143
15%	36	6	3	19	1	2	3	0	0	13	22	2	107
10%	24	4	2	13	1	1	2	0	0	9	14	1	72
5%	12	2	1	6	0	1	1	0	0	4	7	1	36

January, April, July, and October are five-week periods; all other months are four-week periods. Estimates represent Schiller Station's existing cooling water intake system and operating practices and were calculated from impingement rates, survival rates, and collection efficiencies observed during 5Oct06-27Sep07 (Normandeau 2008).

17

Table 6 - 9   Monthly and annual total equivalent adult impingement mortality (fish species combined) by unit for Schiller Station at maximum generating flow and for each 5% reduction in flow.

Unit 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	81	23	20	249	15	73	26	5	21	82	127	127	850
95%	77	22	19	236	15	70	25	5	20	78	120	120	808
90%	73	21	18	224	14	66	23	5	19	74	114	114	765
85%	69	20	17	211	13	62	22	4	18	70	108	108	723
80%	65	19	16	199	12	59	21	4	17	66	101	101	680
75%	61	17	15	186	11	55	20	4	16	62	95	95	638
70%	57	16	14	174	11	51	18	4	15	58	89	89	595
65%	53	15	13	162	10	48	17	3	14	53	82	82	553
60%	49	14	12	149	9	44	16	3	13	49	76	76	510
55%	45	13	11	137	8	40	14	3	12	45	70	70	468
50%	41	12	10	124	8	37	13	3	11	41	63	63	425
45%	37	10	9	112	7	33	12	2	10	37	57	57	383
40%	33	9	8	99	6	29	10	2	8	33	51	51	340
35%	28	8	7	87	5	26	9	2	7	29	44	44	298
30%	24	7	6	75	5	22	8	2	6	25	38	38	255
25%	20	6	5	62	4	18	7	1	5	21	32	32	213
20%	16	5	4	50	3	15	5	1	4	16	25	25	170
15%	12	3	3	37	2	11	4	1	3	12	19	19	128
10%	8	2	2	25	2	7	3	1	2	8	13	13	85
5%	4	1	1	12	1	4	1	0	1	4	6	6	43

Unit 5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	20	3	16	55	28	34	57	85	100	55	24	15	494
95%	19	3	15	53	27	33	54	81	95	52	23	15	469
90%	18	3	15	50	25	31	51	76	90	49	22	14	445
85%	17	3	14	47	24	29	49	72	85	47	21	13	420
80%	16	3	13	44	23	27	46	68	80	44	20	12	395
75%	15	2	12	42	21	26	43	64	75	41	18	12	370
70%	14	2	11	39	20	24	40	59	70	38	17	11	346
65%	13	2	11	36	18	22	37	55	65	36	16	10	321
60%	12	2	10	33	17	21	34	51	60	33	15	9	296
55%	11	2	9	30	16	19	31	47	55	30	13	8	272
50%	10	2	8	28	14	17	29	42	50	27	12	8	247
45%	9	1	7	25	13	15	26	38	45	25	11	7	222
40%	8	1	6	22	11	14	23	34	40	22	10	6	198
35%	7	1	6	19	10	12	20	30	35	19	9	5	173
30%	6	1	5	17	8	10	17	25	30	16	7	5	148
25%	5	1	4	14	7	9	14	21	25	14	6	4	123
20%	4	1	3	11	6	7	11	17	20	11	5	3	99

15%	3	0	2	8	4	5	9	13	15	8	4	2	74
10%	2	0	2	6	3	3	6	8	10	5	2	2	49
5%	1	0	1	3	1	2	3	4	5	3	1	1	25

Unit 6	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	101	14	0	29	2	9	10	0	0	78	36	13	292
95%	96	13	0	27	2	8	10	0	0	74	34	13	277
90%	91	13	0	26	1	8	9	0	0	70	32	12	263
85%	86	12	0	24	1	8	9	0	0	66	30	11	248
80%	81	11	0	23	1	7	8	0	0	63	29	11	233
75%	76	10	0	21	1	7	8	0	0	59	27	10	219
70%	71	10	0	20	1	6	7	0	0	55	25	9	204
65%	66	9	0	19	1	6	7	0	0	51	23	9	190
60%	61	8	0	17	1	5	6	0	0	47	21	8	175
55%	56	8	0	16	1	5	6	0	0	43	20	7	160
50%	51	7	0	14	1	4	5	0	0	39	18	7	146
45%	46	6	0	13	1	4	5	0	0	35	16	6	131
40%	40	6	0	11	1	4	4	0	0	31	14	5	117
35%	35	5	0	10	1	3	4	0	0	27	13	5	102
30%	30	4	0	9	0	3	3	0	0	23	11	4	88
25%	25	3	0	7	0	2	3	0	0	20	9	3	73
20%	20	3	0	6	0	2	2	0	0	16	7	3	58
15%	15	2	0	4	0	1	2	0	0	12	5	2	44
10%	10	1	0	3	0	1	1	0	0	8	4	1	29
5%	5	1	0	1	0	0	1	0	0	4	2	1	15

Equivalent adults include taxa accounting for >91% of the fish that would be impinged in a year at a uniform flow rate, estimated using instantaneous mortality rates, age at maturity, length at age, and length-frequency distributions from Normandeau (2008). January, April, July, and October are five-week periods; all other months are four-week periods. Estimates represent Schiller Station's existing cooling water intake system and operating practices, calculated from impingement rates, survival rates, and collection efficiencies observed during 5Oct06-27Sep07 (Normandeau 2008).

19

Table 6 - 10 Monthly and annual total entrainment mortality (in millions, for all fish species combined) by unit for Schiller Station at maximum generating flow and for each 5% reduction in flow.

Unit 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	1	1	1	1	6	16	6	1	0	0	0	0	33
95%	1	1	1	1	6	15	5	1	0	0	0	0	31
90%	1	1	1	1	5	14	5	1	0	0	0	0	29
85%	1	1	1	1	5	14	5	1	0	0	0	0	28
80%	1	1	1	1	5	13	5	1	0	0	0	0	26
75%	1	1	1	1	5	12	4	1	0	0	0	0	24
70%	0	1	1	0	4	11	4	1	0	0	0	0	23
65%	0	1	1	0	4	10	4	1	0	0	0	0	21
60%	0	1	1	0	4	10	3	1	0	0	0	0	20
55%	0	0	1	0	3	9	3	1	0	0	0	0	18
50%	0	0	0	0	3	8	3	0	0	0	0	0	16
45%	0	0	0	0	3	7	3	0	0	0	0	0	15
40%	0	0	0	0	2	6	2	0	0	0	0	0	13
35%	0	0	0	0	2	6	2	0	0	0	0	0	11
30%	0	0	0	0	2	5	2	0	0	0	0	0	10
25%	0	0	0	0	2	4	1	0	0	0	0	0	8
20%	0	0	0	0	1	3	1	0	0	0	0	0	7
15%	0	0	0	0	1	2	1	0	0	0	0	0	5
10%	0	0	0	0	1	2	1	0	0	0	0	0	3
5%	0	0	0	0	0	1	0	0	0	0	0	0	2
Unit 5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	1	1	1	1	6	16	6	1	0	0	0	0	32
95%	1	1	1	1	6	15	5	1	0	0	0	0	31
90%	1	1	1	1	5	14	5	1	0	0	0	0	29
85%	1	1	1	1	5	13	5	1	0	0	0	0	27
80%	1	1	1	1	5	13	4	1	0	0	0	0	26
75%	1	1	1	1	5	12	4	1	0	0	0	0	24
70%	0	1	1	0	4	11	4	1	0	0	0	0	23
65%	0	1	1	0	4	10	4	1	0	0	0	0	21
60%	0	1	1	0	4	9	3	1	0	0	0	0	19
55%	0	0	1	0	3	9	3	1	0	0	0	0	18
50%	0	0	0	0	3	8	3	0	0	0	0	0	16
45%	0	0	0	0	3	7	3	0	0	0	0	0	15
40%	0	0	0	0	2	6	2	0	0	0	0	0	13
35%	0	0	0	0	2	6	2	0	0	0	0	0	11
30%	0	0	0	0	2	5	2	0	0	0	0	0	10
25%	0	0	0	0	2	4	1	0	0	0	0	0	8
20%	0	0	0	0	1	3	1	0	0	0	0	0	6

20

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
15%	0	0	0	0	1	2	1	0	0	0	0	0	5
10%	0	0	0	0	1	2	1	0	0	0	0	0	3
5%	0	0	0	0	0	1	0	0	0	0	0	0	2

Unit 6	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	1	1	1	1	6	16	6	1	0	0	0	0	32
95%	1	1	1	1	6	15	5	1	0	0	0	0	31
90%	1	1	1	1	5	14	5	1	0	0	0	0	29
85%	1	1	1	1	5	13	5	1	0	0	0	0	27
80%	1	1	1	1	5	13	4	1	0	0	0	0	26
75%	1	1	1	1	5	12	4	1	0	0	0	0	24
70%	0	1	1	0	4	11	4	1	0	0	0	0	23
65%	0	1	1	0	4	10	4	1	0	0	0	0	21
60%	0	1	1	0	4	9	3	1	0	0	0	0	19
55%	0	0	1	0	3	9	3	1	0	0	0	0	18
50%	0	0	0	0	3	8	3	0	0	0	0	0	16
45%	0	0	0	0	3	7	3	0	0	0	0	0	15
40%	0	0	0	0	2	6	2	0	0	0	0	0	13
35%	0	0	0	0	2	6	2	0	0	0	0	0	11
30%	0	0	0	0	2	5	2	0	0	0	0	0	10
25%	0	0	0	0	2	4	1	0	0	0	0	0	8
20%	0	0	0	0	1	3	1	0	0	0	0	0	6
15%	0	0	0	0	1	2	1	0	0	0	0	0	5
10%	0	0	0	0	1	2	1	0	0	0	0	0	3
5%	0	0	0	0	0	1	0	0	0	0	0	0	2

January, April, July, and October are five-week periods; all other months are four-week periods. Estimates represent Schiller Station's existing cooling water intake system and were calculated from entrainment densities and survival rates observed during 28Sep06-27Sep07 (Normandeau 2008).

21

Table 6 - 11 Monthly and annual total equivalent adult entrainment mortality (in thousands, for fish species combined) by unit for Schiller Station at maximum generating flow and for each 5% reduction in flow.

Unit 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	17	19	31	14	5	5	6	5	3	0	11	2	118
95%	16	18	29	13	5	5	6	4	3	0	10	1	112
90%	15	17	28	13	5	4	6	4	3	0	10	1	106
85%	15	16	26	12	4	4	5	4	3	0	9	1	100
80%	14	15	25	11	4	4	5	4	3	0	9	1	94
75%	13	14	23	11	4	4	5	4	2	0	8	1	88
70%	12	13	22	10	4	3	4	3	2	0	8	1	82
65%	11	12	20	9	3	3	4	3	2	0	7	1	77
60%	10	11	18	8	3	3	4	3	2	0	7	1	71
55%	9	10	17	8	3	3	3	3	2	0	6	1	65
50%	9	10	15	7	3	2	3	2	2	0	5	1	59
45%	8	9	14	6	2	2	3	2	1	0	5	1	53
40%	7	8	12	6	2	2	3	2	1	0	4	1	47
35%	6	7	11	5	2	2	2	2	1	0	4	1	41
30%	5	6	9	4	2	1	2	1	1	0	3	0	35
25%	4	5	8	4	1	1	2	1	1	0	3	0	29
20%	3	4	6	3	1	1	1	1	1	0	2	0	24
15%	3	3	5	2	1	1	1	1	0	0	2	0	18
10%	2	2	3	1	1	0	1	0	0	0	1	0	12
5%	1	1	2	1	0	0	0	0	0	0	1	0	6

Unit 5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	17	19	31	14	5	5	6	5	3	0	11	2	117
95%	16	18	29	13	5	5	6	4	3	0	10	1	111
90%	15	17	27	13	4	4	6	4	3	0	10	1	105
85%	14	16	26	12	4	4	5	4	3	0	9	1	99
80%	14	15	24	11	4	4	5	4	3	0	9	1	93
75%	13	14	23	10	4	4	5	3	2	0	8	1	87
70%	12	13	21	10	3	3	4	3	2	0	8	1	82
65%	11	12	20	9	3	3	4	3	2	0	7	1	76
60%	10	11	18	8	3	3	4	3	2	0	6	1	70
55%	9	10	17	8	3	3	3	3	2	0	6	1	64
50%	9	9	15	7	2	2	3	2	2	0	5	1	58
45%	8	8	14	6	2	2	3	2	1	0	5	1	52
40%	7	8	12	6	2	2	3	2	1	0	4	1	47
35%	6	7	11	5	2	2	2	2	1	0	4	1	41
30%	5	6	9	4	1	1	2	1	1	0	3	0	35
25%	4	5	8	3	1	1	2	1	1	0	3	0	29
20%	3	4	6	3	1	1	1	1	1	0	2	0	23

22

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
15%	3	3	5	2	1	1	1	1	0	0	2	0	17
10%	2	2	3	1	0	0	1	0	0	0	1	0	12
5%	1	1	2	1	0	0	0	0	0	0	1	0	6

Unit 6	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	17	19	31	14	5	5	6	5	3	0	11	2	117
95%	16	18	29	13	5	5	6	4	3	0	10	1	111
90%	15	17	27	13	4	4	6	4	3	0	10	1	105
85%	14	16	26	12	4	4	5	4	3	0	9	1	99
80%	14	15	24	11	4	4	5	4	3	0	9	1	93
75%	13	14	23	10	4	4	5	3	2	0	8	1	87
70%	12	13	21	10	3	3	4	3	2	0	8	1	82
65%	11	12	20	9	3	3	4	3	2	0	7	1	76
60%	10	11	18	8	3	3	4	3	2	0	6	1	70
55%	9	10	17	8	3	3	3	3	2	0	6	1	64
50%	9	9	15	7	2	2	3	2	2	0	5	1	58
45%	8	8	14	6	2	2	3	2	1	0	5	1	52
40%	7	8	12	6	2	2	3	2	1	0	4	1	47
35%	6	7	11	5	2	2	2	2	1	0	4	1	41
30%	5	6	9	4	1	1	2	1	1	0	3	0	35
25%	4	5	8	3	1	1	2	1	1	0	3	0	29
20%	3	4	6	3	1	1	1	1	1	0	2	0	23
15%	3	3	5	2	1	1	1	1	0	0	2	0	17
10%	2	2	3	1	0	0	1	0	0	0	1	0	12
5%	1	1	2	1	0	0	0	0	0	0	1	0	6

Equivalent adults include taxa accounting for >99.5% of the fish eggs and larvae that would be entrained in a year at a uniform flow rate, estimated using instantaneous mortality rates and age at maturity from Normandeau (2008). January, April, July, and October are five-week periods; all other months are four-week periods. Estimates represent Schiller Station's existing cooling water intake system and were calculated from entrainment densities and survival rates observed during 28Sep06-27Sep07 (Normandeau 2008).

23

Table 6 - 12 Monthly and annual total impingement mortality (all macrocrustacean species combined) by unit for Schiller Station at maximum generating flow and for each 5% reduction in flow.

Unit 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	92	18	56	792	473	578	274	229	95	144	361	158	3,272
95%	88	17	54	753	449	549	260	218	90	137	343	150	3,108
90%	83	16	51	713	426	520	247	207	86	129	325	143	2,945
85%	78	16	48	674	402	491	233	195	81	122	307	135	2,781
80%	74	15	45	634	378	462	219	184	76	115	289	127	2,618
75%	69	14	42	594	355	433	205	172	71	108	271	119	2,454
70%	64	13	39	555	331	405	192	161	67	101	253	111	2,290
65%	60	12	37	515	307	376	178	149	62	93	235	103	2,127
60%	55	11	34	475	284	347	164	138	57	86	217	95	1,963
55%	51	10	31	436	260	318	151	126	52	79	199	87	1,800
50%	46	9	28	396	236	289	137	115	48	72	181	79	1,636
45%	41	8	25	357	213	260	123	103	43	65	163	71	1,472
40%	37	7	23	317	189	231	110	92	38	57	145	63	1,309
35%	32	6	20	277	166	202	96	80	33	50	127	55	1,145
30%	28	5	17	238	142	173	82	69	29	43	108	48	982
25%	23	5	14	198	118	144	68	57	24	36	90	40	818
20%	18	4	11	158	95	116	55	46	19	29	72	32	654
15%	14	3	8	119	71	87	41	34	14	22	54	24	491
10%	9	2	6	79	47	58	27	23	10	14	36	16	327
5%	5	1	3	40	24	29	14	11	5	7	18	8	164
Unit 5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	5	1	8	74	98	84	81	52	33	61	67	15	580
95%	5	1	8	70	93	80	77	50	32	58	64	15	551
90%	5	1	8	67	88	76	73	47	30	55	60	14	522
85%	4	1	7	63	83	72	69	45	28	52	57	13	493
80%	4	1	7	59	78	68	65	42	27	49	54	12	464
75%	4	1	6	56	73	63	61	39	25	46	50	11	435
70%	4	1	6	52	68	59	57	37	23	43	47	11	406
65%	3	0	5	48	63	55	53	34	22	40	44	10	377
60%	3	0	5	44	59	51	49	31	20	37	40	9	348
55%	3	0	5	41	54	46	44	29	18	34	37	8	319
50%	3	0	4	37	49	42	40	26	17	30	33	8	290
45%	2	0	4	33	44	38	36	24	15	27	30	7	261
40%	2	0	3	30	39	34	32	21	13	24	27	6	232
35%	2	0	3	26	34	30	28	18	12	21	23	5	203
30%	2	0	3	22	29	25	24	16	10	18	20	5	174
25%	1	0	2	19	24	21	20	13	8	15	17	4	145
20%	1	0	2	15	20	17	16	10	7	12	13	3	116

24

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
15%	1	0	1	11	15	13	12	8	5	9	10	2	87
10%	1	0	1	7	10	8	8	5	3	6	7	2	58
5%	0	0	0	4	5	4	4	3	2	3	3	1	29
Unit 6	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
100%	1	1	0	48	70	67	81	56	26	26	55	9	441
95%	1	1	0	46	67	63	77	53	25	24	52	9	419
90%	1	1	0	43	63	60	73	50	23	23	49	9	397
85%	1	1	0	41	60	57	69	47	22	22	47	8	375
80%	1	1	0	39	56	53	65	45	21	21	44	8	353
75%	1	1	0	36	53	50	61	42	20	19	41	7	331
70%	1	1	0	34	49	47	57	39	18	18	38	7	308
65%	1	1	0	31	46	43	53	36	17	17	36	6	286
60%	1	1	0	29	42	40	49	33	16	15	33	6	264
55%	1	1	0	26	39	37	44	31	14	14	30	5	242
50%	1	1	0	24	35	33	40	28	13	13	27	5	220
45%	1	1	0	22	32	30	36	25	12	12	25	4	198
40%	1	1	0	19	28	27	32	22	10	10	22	4	176
35%	1	1	0	17	25	23	28	19	9	9	19	3	154
30%	0	0	0	14	21	20	24	17	8	8	16	3	132
25%	0	0	0	12	18	17	20	14	7	6	14	2	110
20%	0	0	0	10	14	13	16	11	5	5	11	2	88
15%	0	0	0	7	11	10	12	8	4	4	8	1	66
10%	0	0	0	5	7	7	8	6	3	3	5	1	44
5%	0	0	0	2	4	3	4	3	1	1	3	0	22

January, April, July, and October are five-week periods; all other months are four-week periods. Estimates represent Schiller Station's existing cooling water intake system and operating practices, calculated from impingement rates and survival rates observed during 5Oct06-27Sep07 (Normandeau 2008).

25

Table 6 - 13 Monthly and annual total entrainment mortality (in millions, for all macrocrustacean species combined) by unit for Schiller Station at maximum generating flow and for each 5% reduction in flow.

Unit 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	0	0	0	0	11	29	44	14	4	1	0	0	102
95%	0	0	0	0	11	27	42	13	3	1	0	0	97
90%	0	0	0	0	10	26	40	13	3	1	0	0	92
85%	0	0	0	0	9	24	37	12	3	1	0	0	87
80%	0	0	0	0	9	23	35	11	3	1	0	0	82
75%	0	0	0	0	8	22	33	11	3	1	0	0	77
70%	0	0	0	0	8	20	31	10	2	1	0	0	72
65%	0	0	0	0	7	19	29	9	2	0	0	0	66
60%	0	0	0	0	7	17	26	8	2	0	0	0	61
55%	0	0	0	0	6	16	24	8	2	0	0	0	56
50%	0	0	0	0	6	14	22	7	2	0	0	0	51
45%	0	0	0	0	5	13	20	6	2	0	0	0	46
40%	0	0	0	0	4	12	18	6	1	0	0	0	41
35%	0	0	0	0	4	10	15	5	1	0	0	0	36
30%	0	0	0	0	3	9	13	4	1	0	0	0	31
25%	0	0	0	0	3	7	11	4	1	0	0	0	26
20%	0	0	0	0	2	6	9	3	1	0	0	0	20
15%	0	0	0	0	2	4	7	2	1	0	0	0	15
10%	0	0	0	0	1	3	4	1	0	0	0	0	10
5%	0	0	0	0	1	1	2	1	0	0	0	0	5

Unit 5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	0	0	0	0	11	28	44	14	3	1	0	0	101
95%	0	0	0	0	10	27	41	13	3	1	0	0	96
90%	0	0	0	0	10	26	39	12	3	1	0	0	91
85%	0	0	0	0	9	24	37	12	3	1	0	0	86
80%	0	0	0	0	9	23	35	11	3	1	0	0	81
75%	0	0	0	0	8	21	33	10	3	1	0	0	76
70%	0	0	0	0	8	20	30	10	2	1	0	0	71
65%	0	0	0	0	7	19	28	9	2	0	0	0	66
60%	0	0	0	0	7	17	26	8	2	0	0	0	61
55%	0	0	0	0	6	16	24	8	2	0	0	0	56
50%	0	0	0	0	6	14	22	7	2	0	0	0	51
45%	0	0	0	0	5	13	20	6	2	0	0	0	46
40%	0	0	0	0	4	11	17	6	1	0	0	0	40
35%	0	0	0	0	4	10	15	5	1	0	0	0	35
30%	0	0	0	0	3	9	13	4	1	0	0	0	30
25%	0	0	0	0	3	7	11	3	1	0	0	0	25
20%	0	0	0	0	2	6	9	3	1	0	0	0	20

26

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
15%	0	0	0	0	2	4	7	2	1	0	0	0	15
10%	0	0	0	0	1	3	4	1	0	0	0	0	10
5%	0	0	0	0	1	1	2	1	0	0	0	0	5
Unit 6	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	0	0	0	0	11	28	44	14	3	1	0	0	101
95%	0	0	0	0	10	27	41	13	3	1	0	0	96
90%	0	0	0	0	10	26	39	12	3	1	0	0	91
85%	0	0	0	0	9	24	37	12	3	1	0	0	86
80%	0	0	0	0	9	23	35	11	3	1	0	0	81
75%	0	0	0	0	8	21	33	10	3	1	0	0	76
70%	0	0	0	0	8	20	30	10	2	1	0	0	71
65%	0	0	0	0	7	19	28	9	2	0	0	0	66
60%	0	0	0	0	7	17	26	8	2	0	0	0	61
55%	0	0	0	0	6	16	24	8	2	0	0	0	56
50%	0	0	0	0	6	14	22	7	2	0	0	0	51
45%	0	0	0	0	5	13	20	6	2	0	0	0	46
40%	0	0	0	0	4	11	17	6	1	0	0	0	40
35%	0	0	0	0	4	10	15	5	1	0	0	0	35
30%	0	0	0	0	3	9	13	4	1	0	0	0	30
25%	0	0	0	0	3	7	11	3	1	0	0	0	25
20%	0	0	0	0	2	6	9	3	1	0	0	0	20
15%	0	0	0	0	2	4	7	2	1	0	0	0	15
10%	0	0	0	0	1	3	4	1	0	0	0	0	10
5%	0	0	0	0	1	1	2	1	0	0	0	0	5

January, April, July, and October are five-week periods; all other months are four-week periods. Estimates represent Schiller Station's existing cooling water intake system and were calculated from entrainment densities and survival rates observed during 28Sep06-27Sep07 (Normandeau 2008).

27

Table 6 - 14 Monthly and annual total equivalent adult entrainment mortality (in thousands, for macrocrustacean species combined) by unit for Schiller Station at maximum generating flow and for each 5% reduction in flow.

Unit 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	0	0	0	0	1	3	7	3	1	1	0	0	17
95%	0	0	0	0	1	3	7	3	1	1	0	0	16
90%	0	0	0	0	1	3	6	3	1	1	0	0	15
85%	0	0	0	0	1	3	6	3	1	1	0	0	14
80%	0	0	0	0	1	3	6	3	1	1	0	0	14
75%	0	0	0	0	1	2	5	2	1	1	0	0	13
70%	0	0	0	0	1	2	5	2	1	1	0	0	12
65%	0	0	0	0	0	2	5	2	1	1	0	0	11
60%	0	0	0	0	0	2	4	2	1	1	0	0	10
55%	0	0	0	0	0	2	4	2	1	1	0	0	9
50%	0	0	0	0	0	2	4	2	1	1	0	0	8
45%	0	0	0	0	0	1	3	1	1	0	0	0	8
40%	0	0	0	0	0	1	3	1	1	0	0	0	7
35%	0	0	0	0	0	1	3	1	0	0	0	0	6
30%	0	0	0	0	0	1	2	1	0	0	0	0	5
25%	0	0	0	0	0	1	2	1	0	0	0	0	4
20%	0	0	0	0	0	1	1	1	0	0	0	0	3
15%	0	0	0	0	0	0	1	0	0	0	0	0	3
10%	0	0	0	0	0	0	1	0	0	0	0	0	2
5%	0	0	0	0	0	0	0	0	0	0	0	0	1
Unit 5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	0	0	0	0	1	3	7	3	1	1	0	0	17
95%	0	0	0	0	1	3	7	3	1	1	0	0	16
90%	0	0	0	0	1	3	6	3	1	1	0	0	15
85%	0	0	0	0	1	3	6	3	1	1	0	0	14
80%	0	0	0	0	1	3	6	3	1	1	0	0	13
75%	0	0	0	0	1	2	5	2	1	1	0	0	13
70%	0	0	0	0	1	2	5	2	1	1	0	0	12
65%	0	0	0	0	0	2	5	2	1	1	0	0	11
60%	0	0	0	0	0	2	4	2	1	1	0	0	10
55%	0	0	0	0	0	2	4	2	1	1	0	0	9
50%	0	0	0	0	0	2	4	2	1	1	0	0	8
45%	0	0	0	0	0	1	3	1	1	0	0	0	8
40%	0	0	0	0	0	1	3	1	0	0	0	0	7
35%	0	0	0	0	0	1	2	1	0	0	0	0	6
30%	0	0	0	0	0	1	2	1	0	0	0	0	5
25%	0	0	0	0	0	1	2	1	0	0	0	0	4
20%	0	0	0	0	0	1	1	1	0	0	0	0	3

28

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
15%	0	0	0	0	0	0	1	0	0	0	0	0	3
10%	0	0	0	0	0	0	1	0	0	0	0	0	2
5%	0	0	0	0	0	0	0	0	0	0	0	0	1

Unit 6	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	0	0	0	0	1	3	7	3	1	1	0	0	17
95%	0	0	0	0	1	3	7	3	1	1	0	0	16
90%	0	0	0	0	1	3	6	3	1	1	0	0	15
85%	0	0	0	0	1	3	6	3	1	1	0	0	14
80%	0	0	0	0	1	3	6	3	1	1	0	0	13
75%	0	0	0	0	1	2	5	2	1	1	0	0	13
70%	0	0	0	0	1	2	5	2	1	1	0	0	12
65%	0	0	0	0	0	2	5	2	1	1	0	0	11
60%	0	0	0	0	0	2	4	2	1	1	0	0	10
55%	0	0	0	0	0	2	4	2	1	1	0	0	9
50%	0	0	0	0	0	2	4	2	1	1	0	0	8
45%	0	0	0	0	0	1	3	1	1	0	0	0	8
40%	0	0	0	0	0	1	3	1	0	0	0	0	7
35%	0	0	0	0	0	1	2	1	0	0	0	0	6
30%	0	0	0	0	0	1	2	1	0	0	0	0	5
25%	0	0	0	0	0	1	2	1	0	0	0	0	4
20%	0	0	0	0	0	1	1	1	0	0	0	0	3
15%	0	0	0	0	0	0	1	0	0	0	0	0	3
10%	0	0	0	0	0	0	1	0	0	0	0	0	2
5%	0	0	0	0	0	0	0	0	0	0	0	0	1

Equivalent adults include taxa accounting for >99% of the macrocrustaceans that would be entrained in a year at a uniform flow rate, estimated using instantaneous mortality rates and age at maturity from Normandeau (2008). January, April, July, and October are five-week periods; all other months are four-week periods. Estimates represent Schiller Station's existing cooling water intake system and were calculated from entrainment densities and survival rates observed during 28Sep06-27Sep07 (Normandeau 2008).

29

Table 6 - 15 Monthly and annual total impingement mortality (all fish species combined) by unit for Schiller Station at maximum generating flow and for each 5% reduction in flow, assuming installation of Ristroph screens.

Unit 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	115	38	28	523	26	77	17	11	31	42	118	173	1,198
95%	109	36	26	497	25	73	16	10	30	40	112	165	1,139
90%	103	34	25	471	23	69	15	10	28	38	106	156	1,079
85%	98	32	23	445	22	65	14	9	27	36	100	147	1,019
80%	92	30	22	419	21	61	14	8	25	34	94	139	959
75%	86	28	21	392	19	57	13	8	23	32	88	130	899
70%	80	27	19	366	18	54	12	7	22	30	82	121	839
65%	75	25	18	340	17	50	11	7	20	28	76	113	779
60%	69	23	17	314	16	46	10	6	19	25	71	104	719
55%	63	21	15	288	14	42	9	6	17	23	65	95	659
50%	57	19	14	262	13	38	8	5	16	21	59	87	599
45%	52	17	12	235	12	34	8	5	14	19	53	78	539
40%	46	15	11	209	10	31	7	4	13	17	47	69	479
35%	40	13	10	183	9	27	6	4	11	15	41	61	419
30%	34	11	8	157	8	23	5	3	9	13	35	52	360
25%	29	9	7	131	6	19	4	3	8	11	29	43	300
20%	23	8	6	105	5	15	3	2	6	8	24	35	240
15%	17	6	4	78	4	11	3	2	5	6	18	26	180
10%	11	4	3	52	3	8	2	1	3	4	12	17	120
5%	6	2	1	26	1	4	1	1	2	2	6	9	60
Unit 5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	44	10	28	59	12	13	28	82	23	22	38	8	368
95%	42	10	27	56	11	12	27	78	22	21	36	8	349
90%	39	9	25	53	11	11	25	74	21	20	34	7	331
85%	37	9	24	50	10	11	24	70	20	19	32	7	312
80%	35	8	22	47	10	10	22	66	19	18	30	6	294
75%	33	8	21	44	9	9	21	62	18	17	28	6	276
70%	31	7	20	42	8	9	20	58	16	16	26	6	257
65%	29	7	18	39	8	8	18	53	15	14	25	5	239
60%	26	6	17	36	7	8	17	49	14	13	23	5	221
55%	24	6	15	33	7	7	15	45	13	12	21	4	202
50%	22	5	14	30	6	6	14	41	12	11	19	4	184
45%	20	5	13	27	5	6	13	37	11	10	17	4	165
40%	18	4	11	24	5	5	11	33	9	9	15	3	147
35%	15	4	10	21	4	4	10	29	8	8	13	3	129
30%	13	3	8	18	4	4	8	25	7	7	11	2	110
25%	11	3	7	15	3	3	7	21	6	6	9	2	92
20%	9	2	6	12	2	3	6	16	5	4	8	2	74

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
15%	7	2	4	9	2	2	4	12	4	3	6	1	55
10%	4	1	3	6	1	1	3	8	2	2	4	1	37
5%	2	1	1	3	1	1	1	4	1	1	2	0	18

Unit 6	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	79	21	10	84	4	4	7	0	0	26	62	4	300
95%	75	20	10	80	4	4	7	0	0	24	59	4	285
90%	71	19	9	75	3	3	6	0	0	23	56	3	270
85%	67	18	9	71	3	3	6	0	0	22	53	3	255
80%	63	17	8	67	3	3	6	0	0	21	50	3	240
75%	59	16	8	63	3	3	5	0	0	19	47	3	225
70%	55	15	7	59	3	3	5	0	0	18	44	3	210
65%	51	14	7	54	3	2	5	0	0	17	40	2	195
60%	47	13	6	50	2	2	4	0	0	15	37	2	180
55%	43	12	6	46	2	2	4	0	0	14	34	2	165
50%	39	11	5	42	2	2	4	0	0	13	31	2	150
45%	35	10	5	38	2	2	3	0	0	12	28	2	135
40%	32	8	4	33	2	2	3	0	0	10	25	2	120
35%	28	7	4	29	1	1	2	0	0	9	22	1	105
30%	24	6	3	25	1	1	2	0	0	8	19	1	90
25%	20	5	3	21	1	1	2	0	0	6	16	1	75
20%	16	4	2	17	1	1	1	0	0	5	12	1	60
15%	12	3	2	13	1	1	1	0	0	4	9	1	45
10%	8	2	1	8	0	0	1	0	0	3	6	0	30
5%	4	1	1	4	0	0	0	0	0	1	3	0	15

January, April, July, and October are five-week periods; all other months are four-week periods. Estimates represent Schiller Station's cooling water intake system equipped with Ristroph screens, calculated from impingement rates and collection efficiencies observed during 5Oct06-27Sep07 (Normandeau 2008). Ristroph survival rates represent continuous screen washes and were estimated for each species impinged at Schiller Station from rates reported by Con Edison (1985) for morphologically similar species.

31

Table 6 - 16 Monthly and annual total equivalent adult impingement mortality (fish species combined) by unit for Schiller Station at maximum generating flow and for each 5% reduction in flow, assuming installation of Ristroph screens.

Unit 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	24	7	6	84	8	25	11	2	8	19	30	33	257
95%	23	6	6	80	7	24	10	2	8	18	29	31	244
90%	22	6	6	76	7	23	10	2	8	17	27	29	232
85%	21	6	5	72	7	21	9	2	7	16	26	28	219
80%	19	5	5	67	6	20	9	2	7	15	24	26	206
75%	18	5	5	63	6	19	8	1	6	14	23	25	193
70%	17	5	4	59	5	18	8	1	6	13	21	23	180
65%	16	4	4	55	5	16	7	1	5	12	20	21	167
60%	15	4	4	51	5	15	6	1	5	11	18	20	154
55%	13	4	3	46	4	14	6	1	5	10	17	18	142
50%	12	3	3	42	4	13	5	1	4	9	15	16	129
45%	11	3	3	38	4	11	5	1	4	8	14	15	116
40%	10	3	2	34	3	10	4	1	3	7	12	13	103
35%	8	2	2	30	3	9	4	1	3	6	11	11	90
30%	7	2	2	25	2	8	3	1	3	6	9	10	77
25%	6	2	2	21	2	6	3	0	2	5	8	8	64
20%	5	1	1	17	2	5	2	0	2	4	6	7	51
15%	4	1	1	13	1	4	2	0	1	3	5	5	39
10%	2	1	1	8	1	3	1	0	1	2	3	3	26
5%	1	0	0	4	0	1	1	0	0	1	2	2	13

Unit 5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	6	1	5	16	6	13	21	31	23	14	8	4	149
95%	6	1	5	15	6	12	20	30	22	13	7	4	142
90%	6	1	5	15	6	11	19	28	21	13	7	4	134
85%	5	1	4	14	5	11	18	27	20	12	6	3	127
80%	5	1	4	13	5	10	17	25	19	11	6	3	119
75%	5	1	4	12	5	9	16	24	18	11	6	3	112
70%	4	1	4	11	4	9	15	22	16	10	5	3	105
65%	4	1	3	11	4	8	14	20	15	9	5	3	97
60%	4	1	3	10	4	8	13	19	14	8	5	2	90
55%	3	1	3	9	3	7	12	17	13	8	4	2	82
50%	3	0	3	8	3	6	11	16	12	7	4	2	75
45%	3	0	2	7	3	6	10	14	11	6	3	2	67
40%	3	0	2	7	3	5	8	13	9	6	3	2	60
35%	2	0	2	6	2	4	7	11	8	5	3	1	52
30%	2	0	2	5	2	4	6	9	7	4	2	1	45
25%	2	0	1	4	2	3	5	8	6	4	2	1	37
20%	1	0	1	3	1	3	4	6	5	3	2	1	30

15%	1	0	1	2	1	2	3	5	4	2	1	1	22
10%	1	0	1	2	1	1	2	3	2	1	1	0	15
5%	0	0	0	1	0	1	1	2	1	1	0	0	7

Unit 6	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	29	4	0	14	1	3	4	0	0	21	13	4	92
95%	27	4	0	13	1	3	4	0	0	20	12	4	87
90%	26	4	0	13	1	3	3	0	0	19	11	3	83
85%	24	3	0	12	1	3	3	0	0	18	11	3	78
80%	23	3	0	11	1	2	3	0	0	17	10	3	74
75%	21	3	0	10	1	2	3	0	0	16	10	3	69
70%	20	3	0	10	1	2	3	0	0	15	9	3	64
65%	19	3	0	9	1	2	2	0	0	14	8	2	60
60%	17	2	0	8	1	2	2	0	0	13	8	2	55
55%	16	2	0	8	0	2	2	0	0	12	7	2	51
50%	14	2	0	7	0	1	2	0	0	11	6	2	46
45%	13	2	0	6	0	1	2	0	0	10	6	2	41
40%	11	2	0	6	0	1	2	0	0	9	5	2	37
35%	10	1	0	5	0	1	1	0	0	7	4	1	32
30%	9	1	0	4	0	1	1	0	0	6	4	1	28
25%	7	1	0	3	0	1	1	0	0	5	3	1	23
20%	6	1	0	3	0	1	1	0	0	4	3	1	18
15%	4	1	0	2	0	0	1	0	0	3	2	1	14
10%	3	0	0	1	0	0	0	0	0	2	1	0	9
5%	1	0	0	1	0	0	0	0	0	1	1	0	5

Equivalent adults include taxa accounting for >91% of the fish that would be impinged in a year at a uniform flow rate, estimated using instantaneous mortality rates, age at maturity, length at age, and length-frequency distributions from Normandeau (2008). January, April, July, and October are five-week periods; all other months are four-week periods. Estimates represent Schiller Station's cooling water intake system equipped with Ristroph screens, calculated from impingement rates and collection efficiencies observed during 5Oct06-27Sep07 (Normandeau 2008). Ristroph survival rates represent continuous screen washes and were estimated for each species impinged at Schiller Station from rates reported by Con Edison (1985) for morphologically similar species.

Table 6 - 17 Monthly and annual total impingement mortality (all fish species combined) by unit for Schiller Station at maximum generating flow and for each 5% reduction in flow, assuming installation of Beaudrey WIP screens and fish protection system.

Unit 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	39	14	10	166	8	23	6	3	7	17	47	54	391
95%	37	13	9	157	7	22	5	3	6	16	44	51	371
90%	35	13	9	149	7	21	5	3	6	15	42	48	352
85%	33	12	8	141	6	19	5	2	6	14	40	46	332
80%	31	11	8	132	6	18	5	2	5	13	37	43	313
75%	29	11	7	124	6	17	4	2	5	12	35	40	293
70%	27	10	7	116	5	16	4	2	5	12	33	37	274
65%	25	9	6	108	5	15	4	2	4	11	30	35	254
60%	23	8	6	99	5	14	3	2	4	10	28	32	234
55%	21	8	5	91	4	13	3	2	4	9	26	29	215
50%	19	7	5	83	4	11	3	1	3	8	23	27	195
45%	17	6	4	75	3	10	3	1	3	7	21	24	176
40%	16	6	4	66	3	9	2	1	3	7	19	21	156
35%	14	5	3	58	3	8	2	1	2	6	16	19	137
30%	12	4	3	50	2	7	2	1	2	5	14	16	117
25%	10	4	2	41	2	6	1	1	2	4	12	13	98
20%	8	3	2	33	2	5	1	1	1	3	9	11	78
15%	6	2	1	25	1	3	1	0	1	2	7	8	59
10%	4	1	1	17	1	2	1	0	1	2	5	5	39
5%	2	1	0	8	0	1	0	0	0	1	2	3	20
Unit 5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	10	4	8	20	5	8	8	23	13	12	11	4	125
95%	10	3	7	19	5	7	8	22	12	11	11	4	119
90%	9	3	7	18	5	7	7	21	12	11	10	3	113
85%	9	3	7	17	5	6	7	20	11	10	10	3	107
80%	8	3	6	16	4	6	7	18	10	9	9	3	100
75%	8	3	6	15	4	6	6	17	10	9	8	3	94
70%	7	3	5	14	4	5	6	16	9	8	8	3	88
65%	7	2	5	13	3	5	5	15	8	8	7	2	81
60%	6	2	5	12	3	5	5	14	8	7	7	2	75
55%	6	2	4	11	3	4	4	13	7	6	6	2	69
50%	5	2	4	10	3	4	4	12	6	6	6	2	63
45%	5	2	4	9	2	3	4	10	6	5	5	2	56
40%	4	1	3	8	2	3	3	9	5	5	5	1	50
35%	4	1	3	7	2	3	3	8	5	4	4	1	44
30%	3	1	2	6	2	2	2	7	4	4	3	1	38
25%	3	1	2	5	1	2	2	6	3	3	3	1	31
20%	2	1	2	4	1	2	2	5	3	2	2	1	25

34

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
15%	2	1	1	3	1	1	1	3	2	2	2	1	19
10%	1	0	1	2	1	1	1	2	1	1	1	0	13
5%	1	0	0	1	0	0	0	1	1	1	1	0	6
Unit 6	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	38	7	3	17	1	2	2	0	0	11	19	2	101
95%	36	6	2	16	1	2	2	0	0	11	18	2	96
90%	34	6	2	15	1	1	2	0	0	10	17	2	90
85%	32	6	2	15	1	1	2	0	0	10	16	2	85
80%	30	5	2	14	1	1	2	0	0	9	15	2	80
75%	28	5	2	13	1	1	1	0	0	9	14	2	75
70%	26	5	2	12	1	1	1	0	0	8	13	1	70
65%	25	4	2	11	1	1	1	0	0	7	12	1	65
60%	23	4	2	10	1	1	1	0	0	7	11	1	60
55%	21	4	1	9	1	1	1	0	0	6	10	1	55
50%	19	3	1	9	0	1	1	0	0	6	9	1	50
45%	17	3	1	8	0	1	1	0	0	5	8	1	45
40%	15	3	1	7	0	1	1	0	0	5	7	1	40
35%	13	2	1	6	0	1	1	0	0	4	6	1	35
30%	11	2	1	5	0	0	1	0	0	3	6	1	30
25%	9	2	1	4	0	0	0	0	0	3	5	1	25
20%	8	1	1	3	0	0	0	0	0	2	4	0	20
15%	6	1	0	3	0	0	0	0	0	2	3	0	15
10%	4	1	0	2	0	0	0	0	0	1	2	0	10
5%	2	0	0	1	0	0	0	0	0	1	1	0	5

January, April, July, and October are five-week periods; all other months are four-week periods. Estimates represent Schiller Station's cooling water intake system equipped with Beaudrey WIP screens and fish protection system, calculated from impingement rates and collection efficiencies observed during 5Oct06-27Sep07 (Normandeau 2008). WIP screen survival rates represent continuous washes and were estimated as 89% for all species, based on Beaudrey FPS survival testing at Le Blayais Nuclear Power Station in France.

Table 6 - 18 Monthly and annual total adult equivalent impingement mortality (fish species combined) by unit for Schiller Station at maximum generating flow and for each 5% reduction in flow, assuming installation of Beaudrey WIP screens and fish protection system.

Unit 4	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	13	4	3	33	2	8	3	1	3	11	16	20	115
95%	12	3	3	32	2	8	3	1	3	10	16	19	110
90%	11	3	2	30	2	7	3	1	2	10	15	18	104
85%	11	3	2	28	2	7	2	0	2	9	14	17	98
80%	10	3	2	27	2	6	2	0	2	8	13	16	92
75%	10	3	2	25	2	6	2	0	2	8	12	15	86
70%	9	3	2	23	1	6	2	0	2	7	11	14	81
65%	8	2	2	22	1	5	2	0	2	7	11	13	75
60%	8	2	2	20	1	5	2	0	2	6	10	12	69
55%	7	2	1	18	1	4	2	0	2	6	9	11	63
50%	6	2	1	17	1	4	1	0	1	5	8	10	58
45%	6	2	1	15	1	4	1	0	1	5	7	9	52
40%	5	1	1	13	1	3	1	0	1	4	7	8	46
35%	4	1	1	12	1	3	1	0	1	4	6	7	40
30%	4	1	1	10	1	2	1	0	1	3	5	6	35
25%	3	1	1	8	1	2	1	0	1	3	4	5	29
20%	3	1	1	7	0	2	1	0	1	2	3	4	23
15%	2	1	0	5	0	1	0	0	0	2	2	3	17
10%	1	0	0	3	0	1	0	0	0	1	2	2	12
5%	1	0	0	2	0	0	0	0	0	1	1	1	6
Unit 5	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100%	3	1	2	7	4	4	6	9	13	7	3	2	62
95%	3	0	2	7	4	4	6	9	12	7	3	2	59
90%	3	0	2	7	3	3	6	8	12	6	3	2	56
85%	3	0	2	6	3	3	5	8	11	6	3	2	53
80%	3	0	2	6	3	3	5	7	10	6	3	2	50
75%	2	0	2	6	3	3	5	7	10	5	2	2	46
70%	2	0	2	5	3	3	4	7	9	5	2	2	43
65%	2	0	1	5	2	2	4	6	8	5	2	2	40
60%	2	0	1	4	2	2	4	6	8	4	2	1	37
55%	2	0	1	4	2	2	3	5	7	4	2	1	34
50%	2	0	1	4	2	2	3	5	6	4	2	1	31
45%	1	0	1	3	2	2	3	4	6	3	1	1	28
40%	1	0	1	3	2	2	3	4	5	3	1	1	25
35%	1	0	1	3	1	1	2	3	5	2	1	1	22
30%	1	0	1	2	1	1	2	3	4	2	1	1	19
25%	1	0	1	2	1	1	2	2	3	2	1	1	15

36

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
20%	1	0	0	1	1	1	1	2	3	1	1	0	12
15%	0	0	0	1	1	1	1	1	2	1	0	0	9
10%	0	0	0	1	0	0	1	1	1	1	0	0	6
5%	0	0	0	0	0	0	0	0	1	0	0	0	3
Unit 6	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
100%	16	2	0	4	0	1	1	0	0	10	5	2	41
95%	15	2	0	4	0	1	1	0	0	10	4	2	39
90%	14	2	0	3	0	1	1	0	0	9	4	2	37
85%	13	2	0	3	0	1	1	0	0	9	4	2	35
80%	13	2	0	3	0	1	1	0	0	8	4	2	33
75%	12	2	0	3	0	1	1	0	0	8	3	2	31
70%	11	2	0	3	0	1	1	0	0	7	3	1	29
65%	10	1	0	2	0	1	1	0	0	7	3	1	27
60%	9	1	0	2	0	1	1	0	0	6	3	1	25
55%	9	1	0	2	0	1	1	0	0	6	3	1	22
50%	8	1	0	2	0	0	1	0	0	5	2	1	20
45%	7	1	0	2	0	0	1	0	0	5	2	1	18
40%	6	1	0	2	0	0	0	0	0	4	2	1	16
35%	6	1	0	1	0	0	0	0	0	4	2	1	14
30%	5	1	0	1	0	0	0	0	0	3	1	1	12
25%	4	1	0	1	0	0	0	0	0	3	1	1	10
20%	3	0	0	1	0	0	0	0	0	2	1	0	8
15%	2	0	0	1	0	0	0	0	0	2	1	0	6
10%	2	0	0	0	0	0	0	0	0	1	0	0	4
5%	1	0	0	0	0	0	0	0	0	1	0	0	2

Equivalent adults include taxa accounting for >91% of the fish that would be impinged in a year at a uniform flow rate, estimated using instantaneous mortality rates, age at maturity, length at age, and length-frequency distributions from Normandeau (2008). January, April, July, and October are five-week periods; all other months are four-week periods. Estimates represent Schiller Station's cooling water intake system equipped with Beaudrey WIP screens and fish protection system, calculated from impingement rates and collection efficiencies observed during 5Oct06-27Sep07 (Normandeau 2008). WIP screen survival rates represent continuous washes and were estimated as 89% for all species, based on Beaudrey FPS survival testing at Le Blayais Nuclear Power Station in France.

Table 6 - 19 Summary of entrainment effects of various mesh sizes for select fish at Schiller Station Unit 4

a. 1.0 mm mesh

Species[a]	Egg Diameter (mm) Range	Average	YSL Body Depth (mm)[b]	PYSL Body Depth (mm)[b]	Estimated Annual Raw Entrainment[c] Eggs	YSL	PYSL	YOY	TOTAL	1.0 mm Mesh % Reduction Eggs	YSL	PYSL	YOY	TOTAL
American sand lance	0.7-0.9	0.8	0.5	0.6		709,341	3,925,992		4,635,334	0%	0%	0%		0%
Atlantic herring	1.0-1.4	1.2	0.3	0.9			639,157		639,157	100%	0%	0%		0%
Atlantic mackerel	1.0-1.3	1.15	0.7	1.2	1,844,572		2,794		1,847,365	90%	0%	100%		90%
Cunner	0.8-1.0	0.9	0.4	0.8	23,029,445		10,067,466	17,736	33,114,646	0%		0%	100%	0%
Fourbeard rockling	0.7- 1.0	0.7	0.4	0.9	2,250,936	4,867	305,385		2,561,188	0%	0%	0%		0%
Grubby	1.5-1.7	1.6	1.0	1.4		233,396	1,032,971		1,266,367	100%	50%	100%		91%
Rainbow smelt		1.0	0.5	0.7		21,949	531,903		553,852	50%	0%	0%		0%
Rock gunnel		1.4	1.1	1.3		460,891	2,445,239		2,906,131	100%	50%	100%		92%
Urophycis species	0.7-0.8	0.7	0.4	1.2	469,217				469,217	0%	0%	100%		0%
Total Entrainment for Selected Species					27,594,170	1,430,445	18,950,908	17,736	47,993,258					
Overall raw entrainment reduction for various screen mesh sizes (%)									0%					11.5%

b. 0.8 mm mesh

Species[a]	Egg Diameter (mm) Range	Average	YSL Body Depth (mm)[b]	PYSL Body Depth (mm)[b]	Estimated Annual Raw Entrainment[c] Eggs	YSL	PYSL	YOY	TOTAL	0.8 mm Mesh % Reduction Eggs	YSL	PYSL	YOY	TOTAL
American sand lance	0.7-0.9	0.8	0.5	0.6		709,341	3,925,992		4,635,334	50%	0%	0%		0%
Atlantic herring	1.0-1.4	1.2	0.3	0.9			639,157		639,157	100%	0%	50%		50%
Atlantic mackerel	1.0-1.3	1.15	0.7	1.2	1,844,572		2,794		1,847,365	100%	0%	100%		100%
Cunner	0.8-1.0	0.9	0.4	0.8	23,029,445		10,067,466	17,736	33,114,646	100%	0%	50%	100%	85%
Fourbeard rockling	0.7- 1.0	0.7	0.4	0.9	2,250,936	4,867	305,385		2,561,188	0%	0%	100%		12%
Grubby	1.5-1.7	1.6	1.0	1.4		233,396	1,032,971		1,266,367	100%	100%	100%		100%
Rainbow smelt		1.0	0.5	0.7		21,949	531,903		553,852	100%	0%	50%		48%
Rock gunnel		1.4	1.1	1.3		460,891	2,445,239		2,906,131	100%	100%	100%		100%
Urophycis species	0.7-0.8	0.7	0.4	1.2	469,217				469,217	0%	0%	100%		0%
Total Entrainment for Selected Species					27,594,170	1,430,445	18,950,908	17,736	47,993,258					
Overall raw entrainment reduction for various screen mesh sizes (%)									0%					72.9%

c. 0.69 mm mesh

Species[a]	Egg Diameter (mm) Range	Average	YSL Body Depth (mm)[b]	PYSL Body Depth (mm)[b]	Estimated Annual Raw Entrainment[c] Eggs	YSL	PYSL	YOY	TOTAL	0.69 mm Mesh % Reduction Eggs	YSL	PYSL	YOY	TOTAL
American sand lance	0.7-0.9	0.8	0.5	0.6		709,341	3,925,992		4,635,334	100%	0%	0%		0%
Atlantic herring	1.0-1.4	1.2	0.3	0.9			639,157		639,157	100%	0%	100%		100%
Atlantic mackerel	1.0-1.3	1.15	0.7	1.2	1,844,572		2,794		1,847,365	100%	100%	100%		100%
Cunner	0.8-1.0	0.9	0.4	0.8	23,029,445		10,067,466	17,736	33,114,646	100%	0%	80%	100%	94%
Fourbeard rockling	0.7- 1.0	0.7	0.4	0.9	2,250,936	4,867	305,385		2,561,188	90%	0%	100%		91%
Grubby	1.5-1.7	1.6	1.0	1.4		233,396	1,032,971		1,266,367	100%	100%	100%		100%
Rainbow smelt		1.0	0.5	0.7		21,949	531,903		553,852	100%	0%	50%		48%
Rock gunnel		1.4	1.1	1.3		460,891	2,445,239		2,906,131	100%	100%	100%		100%
Urophycis species	0.7-0.8	0.7	0.4	1.2	469,217				469,217	90%	0%	100%		90%
Total Entrainment for Selected Species					27,594,170	1,430,445	18,950,908	17,736	47,993,258					
Overall raw entrainment reduction for various screen mesh sizes (%)									0%					85.0%

d. 0.6 mm mesh

Species[a]	Egg Diameter (mm) Range	Average	YSL Body Depth (mm)[b]	PYSL Body Depth (mm)[b]	Estimated Annual Raw Entrainment[c] Eggs	YSL	PYSL	YOY	TOTAL	0.60 mm Mesh % Reduction Eggs	YSL	PYSL	YOY	TOTAL
American sand lance	0.7-0.9	0.8	0.5	0.6		709,341	3,925,992		4,635,334	100%	0%	50%		42%
Atlantic herring	1.0-1.4	1.2	0.3	0.9			639,157		639,157	100%	0%	100%		100%
Atlantic mackerel	1.0-1.3	1.15	0.7	1.2	1,844,572		2,794		1,847,365	100%	100%	100%		100%
Cunner	0.8-1.0	0.9	0.4	0.8	23,029,445		10,067,466	17,736	33,114,646	100%	0%	100%	100%	100.0%
Fourbeard rockling	0.7- 1.0	0.7	0.4	0.9	2,250,936	4,867	305,385		2,561,188	100%	0%	100%		100%
Grubby	1.5-1.7	1.6	1.0	1.4		233,396	1,032,971		1,266,367	100%	100%	100%		100%
Rainbow smelt		1.0	0.5	0.7		21,949	531,903		553,852	100%	0%	100%		96%
Rock gunnel		1.4	1.1	1.3		460,891	2,445,239		2,906,131	100%	100%	100%		100%
Urophycis species	0.7-0.8	0.7	0.4	1.2	469,217				469,217	100%	0%	100%		100%
Total Entrainment for Selected Species					27,594,170	1,430,445	18,950,908	17,736	47,993,258					
Overall raw entrainment reduction for various screen mesh sizes (%)									0%					94.4%

[a] Listed species represent 96% of the total annual entrainment of fish eggs and larvae based on maximum generating flow
[b] Body depth represents the minimum based on smallest size ranges for each species and lifestage in the literature and is therefore highly conservative because larvae grow throughout their development
[c] Based on maximum generating flow (Unit 4 = 29,290 gpm, Units 5&6 = 29,000 gpm)

Table 6 - 20   Summary of entrainment effects of various mesh sizes for select fish at Schiller Station Unit 5

a. 1.0 mm mesh

Species[a]	Egg Diameter (mm) Range	Average	YSL Body Depth (mm)[b]	PYSL Body Depth (mm)[b]	Estimated Annual Raw Entrainment[c] Eggs	YSL	PYSL	YOY	TOTAL	1.0 mm Mesh % Reduction Eggs	YSL	PYSL	YOY	TOTAL
American sand lance	0.7-0.9	0.8	0.5	0.6		694,019	3,887,121		4,581,141	0%	0%	0%		0%
Atlantic herring	1.0-1.4	1.2	0.3	0.9			632,829		632,829	100%	0%	0%		0%
Atlantic mackerel	1.0-1.3	1.15	0.7	1.2	1,826,308		2,766		1,829,075	90%	0%	100%		90%
Cunner	0.8-1.0	0.9	0.4	0.8	22,801,430		9,967,788	17,560	32,786,779	0%	0%	0%	100%	0%
Fourbeard rockling	0.7- 1.0	0.7	0.4	0.9	2,228,650	4,819	302,362		2,535,830	0%	0%	0%		0%
Grubby	1.5-1.7	1.6	1.0	1.4		231,085	1,022,744		1,253,829	100%	50%	100%		91%
Rainbow smelt		1.0	0.5	0.7		21,732	526,636		548,368	50%	0%	0%		0%
Rock gunnel		1.4	1.1	1.3		456,328	2,421,029		2,877,357	100%	50%	100%		92%
Urophycis species	0.7-0.8	0.7	0.4	1.2	464,572				464,572	0%	0%	100%		0%
Total Entrainment for Selected Species					27,320,960	1,407,984	18,763,275	17,560	47,509,779					
Overall raw entrainment reduction for various screen mesh sizes (%)										0%				11.5%

b. 0.8 mm mesh

Species[a]	Egg Diameter (mm) Range	Average	YSL Body Depth (mm)[b]	PYSL Body Depth (mm)[b]	Estimated Annual Raw Entrainment[c] Eggs	YSL	PYSL	YOY	TOTAL	0.8 mm Mesh % Reduction Eggs	YSL	PYSL	YOY	TOTAL
American sand lance	0.7-0.9	0.8	0.5	0.6		694,019	3,887,121		4,581,141	50%	0%	0%		0%
Atlantic herring	1.0-1.4	1.2	0.3	0.9			632,829		632,829	100%	0%	50%		50%
Atlantic mackerel	1.0-1.3	1.15	0.7	1.2	1,826,308		2,766		1,829,075	100%	0%	100%		100%
Cunner	0.8-1.0	0.9	0.4	0.8	22,801,430		9,967,788	17,560	32,786,779	100%	0%	50%	100%	85%
Fourbeard rockling	0.7- 1.0	0.7	0.4	0.9	2,228,650	4,819	302,362		2,535,830	0%	0%	0%		12%
Grubby	1.5-1.7	1.6	1.0	1.4		231,085	1,022,744		1,253,829	100%	100%	100%		100%
Rainbow smelt		1.0	0.5	0.7		21,732	526,636		548,368	100%	0%	50%		48%
Rock gunnel		1.4	1.1	1.3		456,328	2,421,029		2,877,357	100%	100%	100%		100%
Urophycis species	0.7-0.8	0.7	0.4	1.2	464,572				464,572	0%	0%	100%		0%
Total Entrainment for Selected Species					27,320,960	1,407,984	18,763,275	17,560	47,509,779					
Overall raw entrainment reduction for various screen mesh sizes (%)										0%				72.9%

c. 0.69 mm mesh

Species[a]	Egg Diameter (mm) Range	Average	YSL Body Depth (mm)[b]	PYSL Body Depth (mm)[b]	Estimated Annual Raw Entrainment[c] Eggs	YSL	PYSL	YOY	TOTAL	0.69 mm Mesh % Reduction Eggs	YSL	PYSL	YOY	TOTAL
American sand lance	0.7-0.9	0.8	0.5	0.6		694,019	3,887,121		4,581,141	100%	0%	0%		0%
Atlantic herring	1.0-1.4	1.2	0.3	0.9			632,829		632,829	100%	0%	100%		100%
Atlantic mackerel	1.0-1.3	1.15	0.7	1.2	1,826,308		2,766		1,829,075	100%	100%	100%		100%
Cunner	0.8-1.0	0.9	0.4	0.8	22,801,430		9,967,788	17,560	32,786,779	100%	0%	80%	100%	94%
Fourbeard rockling	0.7- 1.0	0.7	0.4	0.9	2,228,650	4,819	302,362		2,535,830	90%	0%	100%		91%
Grubby	1.5-1.7	1.6	1.0	1.4		231,085	1,022,744		1,253,829	100%	100%	100%		100%
Rainbow smelt		1.0	0.5	0.7		21,732	526,636		548,368	100%	0%	50%		48%
Rock gunnel		1.4	1.1	1.3		456,328	2,421,029		2,877,357	100%	100%	100%		100%
Urophycis species	0.7-0.8	0.7	0.4	1.2	464,572				464,572	90%	0%	100%		90%
Total Entrainment for Selected Species					27,320,960	1,407,984	18,763,275	17,560	47,509,779					
Overall raw entrainment reduction for various screen mesh sizes (%)										0%				85.0%

d. 0.6 mm mesh

Species[a]	Egg Diameter (mm) Range	Average	YSL Body Depth (mm)[b]	PYSL Body Depth (mm)[b]	Estimated Annual Raw Entrainment[c] Eggs	YSL	PYSL	YOY	TOTAL	0.60 mm Mesh % Reduction Eggs	YSL	PYSL	YOY	TOTAL
American sand lance	0.7-0.9	0.8	0.5	0.6		694,019	3,887,121		4,581,141	100%	0%	50%		42%
Atlantic herring	1.0-1.4	1.2	0.3	0.9			632,829		632,829	100%	0%	100%		100%
Atlantic mackerel	1.0-1.3	1.15	0.7	1.2	1,826,308		2,766		1,829,075	100%	100%	100%		100%
Cunner	0.8-1.0	0.9	0.4	0.8	22,801,430		9,967,788	17,560	32,786,779	100%	0%	100%	100%	100.0%
Fourbeard rockling	0.7- 1.0	0.7	0.4	0.9	2,228,650	4,819	302,362		2,535,830	100%	0%	100%		100%
Grubby	1.5-1.7	1.6	1.0	1.4		231,085	1,022,744		1,253,829	100%	100%	100%		100%
Rainbow smelt		1.0	0.5	0.7		21,732	526,636		548,368	100%	100%	100%		96%
Rock gunnel		1.4	1.1	1.3		456,328	2,421,029		2,877,357	100%	100%	100%		100%
Urophycis species	0.7-0.8	0.7	0.4	1.2	464,572				464,572	100%	0%	100%		100%
Total Entrainment for Selected Species					27,320,960	1,407,984	18,763,275	17,560	47,509,779					
Overall raw entrainment reduction for various screen mesh sizes (%)										0%				94.4%

[a] Listed species represent 96% of the total annual entrainment of fish eggs and larvae based on maximum generating flow
[b] Body depth represents the minimum based on smallest size ranges for each species and lifestage in the literature and is therefore highly conservative because larvae grow throughout their development
[c] Based on maximum generating flow (Unit 4 = 29,290 gpm, Units 5&6 = 29,000 gpm)

Table 6 - 21 Summary of entrainment effects of various mesh sizes for select fish at Schiller Station Unit 6

a. 1.0 mm mesh

Species[a]	Egg Diameter (mm) Range	Average	YSL Body Depth (mm)[b]	PYSL Body Depth (mm)[b]	Estimated Annual Raw Entrainment[c] Eggs	YSL	PYSL	YOY	TOTAL	1.0 mm Mesh % Reduction Eggs	YSL	PYSL	YOY	TOTAL
American sand lance	0.7-0.9	0.8	0.5	0.6		694,019	3,887,121		4,581,141	0%	0%	0%		0%
Atlantic herring	1.0-1.4	1.2	0.3	0.9			632,829		632,829	100%	0%	0%		0%
Atlantic mackerel	1.0-1.3	1.15	0.7	1.2	1,826,308		2,766		1,829,075	90%	0%	100%		90%
Cunner	0.8-1.0	0.9	0.4	0.8	22,801,430		9,967,788	17,560	32,786,779	0%	0%	0%	100%	0%
Fourbeard rockling	0.7-1.0	0.7	0.4	0.9	2,228,650	4,819	302,362		2,535,830	0%	0%	0%		0%
Grubby	1.5-1.7	1.6	1.0	1.4		231,085	1,022,744		1,253,829	100%	50%	100%		91%
Rainbow smelt		1.0	0.5	0.7		21,732	526,636		548,368	50%	0%	0%		0%
Rock gunnel		1.4	1.1	1.3		456,328	2,421,029		2,877,357	100%	50%	100%		92%
Urophycis species	0.7-0.8	0.7	0.4	1.2	464,572				464,572	0%	0%	100%		0%
Total Entrainment for Selected Species					27,320,960	1,407,984	18,763,275	17,560	47,509,779					
Overall raw entrainment reduction for various screen mesh sizes (%)												0%		11.5%

b. 0.8 mm mesh

Species[a]	Egg Diameter (mm) Range	Average	YSL Body Depth (mm)[b]	PYSL Body Depth (mm)[b]	Estimated Annual Raw Entrainment[c] Eggs	YSL	PYSL	YOY	TOTAL	0.8 mm Mesh % Reduction Eggs	YSL	PYSL	YOY	TOTAL
American sand lance	0.7-0.9	0.8	0.5	0.6		694,019	3,887,121		4,581,141	50%	0%	0%		0%
Atlantic herring	1.0-1.4	1.2	0.3	0.9			632,829		632,829	100%	0%	50%		50%
Atlantic mackerel	1.0-1.3	1.15	0.7	1.2	1,826,308		2,766		1,829,075	100%	0%	100%		100%
Cunner	0.8-1.0	0.9	0.4	0.8	22,801,430		9,967,788	17,560	32,786,779	100%	0%	50%	100%	85%
Fourbeard rockling	0.7-1.0	0.7	0.4	0.9	2,228,650	4,819	302,362		2,535,830	0%	0%	100%		12%
Grubby	1.5-1.7	1.6	1.0	1.4		231,085	1,022,744		1,253,829	100%	100%	100%		100%
Rainbow smelt		1.0	0.5	0.7		21,732	526,636		548,368	100%	0%	50%		48%
Rock gunnel		1.4	1.1	1.3		456,328	2,421,029		2,877,357	100%	100%	100%		100%
Urophycis species	0.7-0.8	0.7	0.4	1.2	464,572				464,572	0%	0%	100%		0%
Total Entrainment for Selected Species					27,320,960	1,407,984	18,763,275	17,560	47,509,779					
Overall raw entrainment reduction for various screen mesh sizes (%)												0%		72.9%

c. 0.69 mm mesh

Species[a]	Egg Diameter (mm) Range	Average	YSL Body Depth (mm)[b]	PYSL Body Depth (mm)[b]	Estimated Annual Raw Entrainment[c] Eggs	YSL	PYSL	YOY	TOTAL	0.69 mm Mesh % Reduction Eggs	YSL	PYSL	YOY	TOTAL
American sand lance	0.7-0.9	0.8	0.5	0.6		694,019	3,887,121		4,581,141	100%	0%	0%		0%
Atlantic herring	1.0-1.4	1.2	0.3	0.9			632,829		632,829	100%	0%	100%		100%
Atlantic mackerel	1.0-1.3	1.15	0.7	1.2	1,826,308		2,766		1,829,075	100%	100%	100%		100%
Cunner	0.8-1.0	0.9	0.4	0.8	22,801,430		9,967,788	17,560	32,786,779	100%	0%	80%	100%	94%
Fourbeard rockling	0.7-1.0	0.7	0.4	0.9	2,228,650	4,819	302,362		2,535,830	90%	0%	100%		91%
Grubby	1.5-1.7	1.6	1.0	1.4		231,085	1,022,744		1,253,829	100%	100%	100%		100%
Rainbow smelt		1.0	0.5	0.7		21,732	526,636		548,368	100%	0%	50%		48%
Rock gunnel		1.4	1.1	1.3		456,328	2,421,029		2,877,357	100%	100%	100%		100%
Urophycis species	0.7-0.8	0.7	0.4	1.2	464,572				464,572	90%	0%	100%		90%
Total Entrainment for Selected Species					27,320,960	1,407,984	18,763,275	17,560	47,509,779					
Overall raw entrainment reduction for various screen mesh sizes (%)												0%		85.0%

d. 0.6 mm mesh

Species[a]	Egg Diameter (mm) Range	Average	YSL Body Depth (mm)[b]	PYSL Body Depth (mm)[b]	Estimated Annual Raw Entrainment[c] Eggs	YSL	PYSL	YOY	TOTAL	0.60 mm Mesh % Reduction Eggs	YSL	PYSL	YOY	TOTAL
American sand lance	0.7-0.9	0.8	0.5	0.6		694,019	3,887,121		4,581,141	100%	0%	50%		42%
Atlantic herring	1.0-1.4	1.2	0.3	0.9			632,829		632,829	100%	0%	100%		100%
Atlantic mackerel	1.0-1.3	1.15	0.7	1.2	1,826,308		2,766		1,829,075	100%	100%	100%		100%
Cunner	0.8-1.0	0.9	0.4	0.8	22,801,430		9,967,788	17,560	32,786,779	100%	0%	100%	100%	100.0%
Fourbeard rockling	0.7-1.0	0.7	0.4	0.9	2,228,650	4,819	302,362		2,535,830	100%	0%	100%		100%
Grubby	1.5-1.7	1.6	1.0	1.4		231,085	1,022,744		1,253,829	100%	100%	100%		100%
Rainbow smelt		1.0	0.5	0.7		21,732	526,636		548,368	100%	0%	100%		96%
Rock gunnel		1.4	1.1	1.3		456,328	2,421,029		2,877,357	100%	100%	100%		100%
Urophycis species	0.7-0.8	0.7	0.4	1.2	464,572				464,572	100%	0%	100%		100%
Total Entrainment for Selected Species					27,320,960	1,407,984	18,763,275	17,560	47,509,779					
Overall raw entrainment reduction for various screen mesh sizes (%)												0%		94.4%

[a] Listed species represent 96% of the total annual entrainment of fish eggs and larvae based on maximum generating flow

[b] Body depth represents the minimum based on smallest size ranges for each species and lifestage in the literature and is therefore highly conservative because larvae grow throughout their development

[c] Based on maximum generating flow (Unit 4 = 29,290 gpm, Units 5&6 = 29,000 gpm)

40

Table 6 - 22   Summary of entrainment effects of various mesh sizes for select EA fish at
Schiller Station Unit 4

a.   1.0 mm mesh

Species	Estimated Annual Number of EA[a]				1.0 mm			
	Eggs	YSL	PYSL	Total	Eggs	YSL	PYSL	Total
American sand lance	0	575	3,185	3,761		0%	0%	0%
Atlantic herring	0	0	807	807			0%	0%
Atlantic mackerel	5	0	0	5	90%		100%	90%
Cunner	1,800	0	25,195	26,995	0%		0%	0%
Fourbeard rockling	2,332	55	3,423	5,810	0%	0%	0%	0%
Grubby	0	4,110	18,192	22,303		50%	100%	91%
Rainbow smelt	0	285	6,916	7,201		0%	0%	0%
Rock gunnel	0	24,343	129,150	153,493		50%	100%	92%
Urophycis species	1	0	0	1	0%			0%
Total	4,137	29,369	186,868	220,375	0.1%	48.4%	78.8%	73.3%

b.   0.8 mm mesh

Species	Estimated Annual Number of EA[a]				0.8 mm			
	Eggs	YSL	PYSL	Total	Eggs	YSL	PYSL	Total
American sand lance	0	575	3,185	3,761		0%	0%	0%
Atlantic herring	0	0	807	807			50%	50%
Atlantic mackerel	5	0	0	5	100%		100%	100%
Cunner	1,800	0	25,195	26,995	100%		50%	53%
Fourbeard rockling	2,332	55	3,423	5,810	0%	0%	100%	59%
Grubby	0	4,110	18,192	22,303		100%	100%	100%
Rainbow smelt	0	285	6,916	7,201		0%	50%	48%
Rock gunnel	0	24,343	129,150	153,493		100%	100%	100%
Urophycis species	1	0	0	1	0%			0%
Total	4,137	29,369	186,868	220,375	43.6%	96.9%	89.5%	89.6%

c.   0.69 mm mesh

Species	Estimated Annual Number of EA[a]				0.69 mm			
	Eggs	YSL	PYSL	Total	Eggs	YSL	PYSL	Total
American sand lance	0	575	3,185	3,761		0%	0%	0%
Atlantic herring	0	0	807	807			100%	100%
Atlantic mackerel	5	0	0	5	100%		100%	100%
Cunner	1,800	0	25,195	26,995	100%		80%	81%
Fourbeard rockling	2,332	55	3,423	5,810	90%	0%	100%	95%
Grubby	0	4,110	18,192	22,303		100%	100%	100%
Rainbow smelt	0	285	6,916	7,201		0%	50%	48%
Rock gunnel	0	24,343	129,150	153,493		100%	100%	100%
Urophycis species	1	0	0	1	90%			90%
Total	4,137	29,369	186,868	220,375	94.4%	96.9%	93.7%	94.2%

Table 6 - 22   Summary of entrainment effects of various mesh sizes for select EA fish at Schiller Station Unit 4

d.   0.6 mm mesh

Species	Estimated Annual Number of EA[a]				0.6 mm			
	Eggs	YSL	PYSL	Total	Eggs	YSL	PYSL	Total
American sand lance	0	575	3,185	3,761		0%	50%	42%
Atlantic herring	0	0	807	807			100%	100%
Atlantic mackerel	5	0	0	5	100%		100%	100%
Cunner	1,800	0	25,195	26,995	100%		100%	100%
Fourbeard rockling	2,332	55	3,423	5,810	100%	0%	100%	99%
Grubby	0	4,110	18,192	22,303		100%	100%	100%
Rainbow smelt	0	285	6,916	7,201		0%	100%	96%
Rock gunnel	0	24,343	129,150	153,493		100%	100%	100%
Urophycis species	1	0	0	1	100%			100%
Total	4,137	29,369	186,868	220,375	100.0%	96.9%	99.1%	98.9%

[a] Number of equivalent adults based on maximum generating flow (Unit 4 = 29,290 gpm, Units 5&6 = 29,000 gpm) and derived from mortality rates compiled by Normandeau (2008).

42

Table 6 - 23   Summary of entrainment effects of various mesh sizes for select EA fish at Schiller Station Unit 5

a. 1.0 mm mesh

Species	Estimated Annual Number of EA[a]				1.0 mm			
	Eggs	YSL	PYSL	Total	Eggs	YSL	PYSL	Total
American sand lance	0	563	3,154	3,717		0%	0%	0%
Atlantic herring	0	0	799	799			0%	0%
Atlantic mackerel	5	0	0	5	90%		100%	90%
Cunner	1,782	0	24,946	26,728	0%		0%	0%
Fourbeard rockling	2,309	54	3,389	5,752	0%	0%	0%	0%
Grubby	0	4,070	18,012	22,082		50%	100%	91%
Rainbow smelt	0	283	6,847	7,130		0%	0%	0%
Rock gunnel	0	24,102	127,871	151,973		50%	100%	92%
Urophycis species	1	0	0	1	0%			0%
Total	4,096	29,071	185,018	218,186	0.1%	48.5%	78.8%	73.3%

b. 0.8 mm mesh

Species	Estimated Annual Number of EA[a]				0.8 mm			
	Eggs	YSL	PYSL	Total	Eggs	YSL	PYSL	Total
American sand lance	0	563	3,154	3,717		0%	0%	0%
Atlantic herring	0	0	799	799			50%	50%
Atlantic mackerel	5	0	0	5	100%		100%	100%
Cunner	1,782	0	24,946	26,728	100%		50%	53%
Fourbeard rockling	2,309	54	3,389	5,752	0%	0%	100%	59%
Grubby	0	4,070	18,012	22,082		100%	100%	100%
Rainbow smelt	0	283	6,847	7,130		0%	50%	48%
Rock gunnel	0	24,102	127,871	151,973		100%	100%	100%
Urophycis species	1	0	0	1	0%			0%
Total	4,096	29,071	185,018	218,186	43.6%	96.9%	89.5%	89.6%

c. 0.69 mm mesh

Species	Estimated Annual Number of EA[a]				0.69 mm			
	Eggs	YSL	PYSL	Total	Eggs	YSL	PYSL	Total
American sand lance	0	563	3,154	3,717		0%	0%	0%
Atlantic herring	0	0	799	799			100%	100%
Atlantic mackerel	5	0	0	5	100%		100%	100%
Cunner	1,782	0	24,946	26,728	100%		80%	81%
Fourbeard rockling	2,309	54	3,389	5,752	90%	0%	100%	95%
Grubby	0	4,070	18,012	22,082		100%	100%	100%
Rainbow smelt	0	283	6,847	7,130		0%	50%	48%
Rock gunnel	0	24,102	127,871	151,973		100%	100%	100%
Urophycis species	1	0	0	1	90%			90%
Total	4,096	29,071	185,018	218,186	94.4%	96.9%	93.7%	94.2%

43

Table 6 - 23 Summary of entrainment effects of various mesh sizes for select EA fish at Schiller Station Unit 5

d. 0.6 mm mesh

Species	Estimated Annual Number of EA[a]				0.6 mm			
	Eggs	YSL	PYSL	Total	Eggs	YSL	PYSL	Total
American sand lance	0	563	3,154	3,717		0%	50%	42%
Atlantic herring	0	0	799	799			100%	100%
Atlantic mackerel	5	0	0	5	100%		100%	100%
Cunner	1,782	0	24,946	26,728	100%		100%	100%
Fourbeard rockling	2,309	54	3,389	5,752	100%	0%	100%	99%
Grubby	0	4,070	18,012	22,082		100%	100%	100%
Rainbow smelt	0	283	6,847	7,130		0%	100%	96%
Rock gunnel	0	24,102	127,871	151,973		100%	100%	100%
Urophycis species	1	0	0	1	100%			100%
Total	4,096	29,071	185,018	218,186	100.0%	96.9%	99.1%	98.9%

[a] Number of equivalent adults based on maximum generating flow (Unit 4 = 29,290 gpm, Units 5&6 = 29,000 gpm) and derived from mortality rates compiled by Normandeau (2008).

44

Table 6 - 24 Summary of entrainment effects of various mesh sizes for select EA fish at Schiller Station Unit 6

a. 1.0 mm mesh

Species	Estimated Annual Number of EA[a]				1.0 mm			
	Eggs	YSL	PYSL	Total	Eggs	YSL	PYSL	Total
American sand lance	0	563	3,154	3,717		0%	0%	0%
Atlantic herring	0	0	799	799			0%	0%
Atlantic mackerel	5	0	0	5	90%		100%	90%
Cunner	1,782	0	24,946	26,728	0%		0%	0%
Fourbeard rockling	2,309	54	3,389	5,752	0%	0%	0%	0%
Grubby	0	4,070	18,012	22,082		50%	100%	91%
Rainbow smelt	0	283	6,847	7,130		0%	0%	0%
Rock gunnel	0	24,102	127,871	151,973		50%	100%	92%
Urophycis species	1	0	0	1	0%			0%
Total	4,096	29,071	185,018	218,186	0.1%	48.5%	78.8%	73.3%

b. 0.8 mm mesh

Species	Estimated Annual Number of EA[a]				0.8 mm			
	Eggs	YSL	PYSL	Total	Eggs	YSL	PYSL	Total
American sand lance	0	563	3,154	3,717		0%	0%	0%
Atlantic herring	0	0	799	799			50%	50%
Atlantic mackerel	5	0	0	5	100%		100%	100%
Cunner	1,782	0	24,946	26,728	100%		50%	53%
Fourbeard rockling	2,309	54	3,389	5,752	0%	0%	100%	59%
Grubby	0	4,070	18,012	22,082		100%	100%	100%
Rainbow smelt	0	283	6,847	7,130		0%	50%	48%
Rock gunnel	0	24,102	127,871	151,973		100%	100%	100%
Urophycis species	1	0	0	1	0%			0%
Total	4,096	29,071	185,018	218,186	43.6%	96.9%	89.5%	89.6%

c. 0.69 mm mesh

Species	Estimated Annual Number of EA[a]				0.69 mm			
	Eggs	YSL	PYSL	Total	Eggs	YSL	PYSL	Total
American sand lance	0	563	3,154	3,717		0%	0%	0%
Atlantic herring	0	0	799	799			100%	100%
Atlantic mackerel	5	0	0	5	100%		100%	100%
Cunner	1,782	0	24,946	26,728	100%		80%	81%
Fourbeard rockling	2,309	54	3,389	5,752	90%	0%	100%	95%
Grubby	0	4,070	18,012	22,082		100%	100%	100%
Rainbow smelt	0	283	6,847	7,130		0%	50%	48%
Rock gunnel	0	24,102	127,871	151,973		100%	100%	100%
Urophycis species	1	0	0	1	90%			90%
Total	4,096	29,071	185,018	218,186	94.4%	96.9%	93.7%	94.2%

45

Table 6 - 24   Summary of entrainment effects of various mesh sizes for select EA fish at
Schiller Station Unit 6

d. 0.6 mm mesh

Species	Estimated Annual Number of EA[a]				0.6 mm			
	Eggs	YSL	PYSL	Total	Eggs	YSL	PYSL	Total
American sand lance	0	563	3,154	3,717		0%	50%	42%
Atlantic herring	0	0	799	799			100%	100%
Atlantic mackerel	5	0	0	5	100%		100%	100%
Cunner	1,782	0	24,946	26,728	100%		100%	100%
Fourbeard rockling	2,309	54	3,389	5,752	100%	0%	100%	99%
Grubby	0	4,070	18,012	22,082		100%	100%	100%
Rainbow smelt	0	283	6,847	7,130		0%	100%	96%
Rock gunnel	0	24,102	127,871	151,973		100%	100%	100%
Urophycis species	1	0	0	1	100%			100%
Total	4,096	29,071	185,018	218,186	100.0%	96.9%	99.1%	98.9%

[a] Number of equivalent adults based on maximum generating flow (Unit 4 = 29,290 gpm, Units 5&6 = 29,000 gpm) and derived from mortality rates compiled by Normandeau (2008).

Table 6 - 25   Summary of entrainment effects of various mesh sizes for select macrocrustaceans at Schiller Station Unit 4

a. 1.0 mm mesh

Species	Zoea length[a]	Megalopa width[b]	Estimated Annual Raw Entrainment[d]				1.0 mm Mesh % Reduction			
			zoea	megalopa	Juv	TOTAL	zoea	megalopa	Juv	TOTAL
American lobster	7.5[c]	NA	19,222			19,222	100%			100%
Atlantic rock crab	1.2	1.2		505,818	21,011	526,829	100%	100%	100%	100%
Cancer sp.	1.2	1.2	189,844,965	21,234		189,866,199	100%	100%	100%	100%
Green crab	1.4	1.2	257,734,193	2,712,431	104,271	260,550,895	100%	100%	100%	100%
Jonah crab	1.2	1.2		82,142	7,153	89,295	100%	100%	100%	100%
Total Entrainment for Selected Species[e]			447,598,381	3,321,626	132,434	451,052,440				
Overall entrainment reduction (%) for various mesh sizes						0%				100%

b. 0.8 mm mesh

Species	Zoea length[a]	Megalopa width[b]	Estimated Annual Raw Entrainment[d]				0.8 mm Mesh % Reduction			
			zoea	megalopa	Juv	TOTAL	zoea	megalopa	Juv	TOTAL
American lobster	7.5[c]	NA	19,222			19,222	100%			100%
Atlantic rock crab	1.2	1.2		505,818	21,011	526,829	100%	100%	100%	100%
Cancer sp.	1.2	1.2	189,844,965	21,234		189,866,199	100%	100%	100%	100%
Green crab	1.4	1.2	257,734,193	2,712,431	104,271	260,550,895	100%	100%	100%	100%
Jonah crab	1.2	1.2		82,142	7,153	89,295	100%	100%	100%	100%
Total Entrainment for Selected Species[e]			447,598,381	3,321,626	132,434	451,052,440				
Overall entrainment reduction (%) for various mesh sizes						0%				100%

c. 0.69 mm mesh

Species	Zoea length[a]	Megalopa width[b]	Estimated Annual Raw Entrainment[d]				0.69 mm Mesh % Reduction			
			zoea	megalopa	Juv	TOTAL	zoea	megalopa	Juv	TOTAL
American lobster	7.5[c]	NA	19,222			19,222	100%			100%
Atlantic rock crab	1.2	1.2		505,818	21,011	526,829	100%	100%	100%	100%
Cancer sp.	1.2	1.2	189,844,965	21,234		189,866,199	100%	100%	100%	100%
Green crab	1.4	1.2	257,734,193	2,712,431	104,271	260,550,895	100%	100%	100%	100%
Jonah crab	1.2	1.2		82,142	7,153	89,295	100%	100%	100%	100%
Total Entrainment for Selected Species[e]			447,598,381	3,321,626	132,434	451,052,440				
Overall entrainment reduction (%) for various mesh sizes						0%				100%

d. 0.6 mm mesh

Species	Zoea length[a]	Megalopa width[b]	Estimated Annual Raw Entrainment[d]				0.60 mm Mesh % Reduction			
			zoea	megalopa	Juv	TOTAL	zoea	megalopa	Juv	TOTAL
American lobster	7.5[c]	NA	19,222			19,222	100%			100%
Atlantic rock crab	1.2	1.2		505,818	21,011	526,829	100%	100%	100%	100%
Cancer sp.	1.2	1.2	189,844,965	21,234		189,866,199	100%	100%	100%	100%
Green crab	1.4	1.2	257,734,193	2,712,431	104,271	260,550,895	100%	100%	100%	100%
Jonah crab	1.2	1.2		82,142	7,153	89,295	100%	100%	100%	100%
Total Entrainment for Selected Species[e]			447,598,381	3,321,626	132,434	451,052,440				
Overall entrainment reduction (%) for various mesh sizes						0%				100%

[a] Zoea length (mm) was defined as the limiting dimension and was measured from the tip of the rostral spine to the tip of the dorsal spine of the first zoea molt

[b] Megalops carapace width (mm) was defined as the limiting dimension.

[c] Entrained lobster larvae were all stage I or stage II (Herrick 1895). For this table, stage I land II obster larvae are considered synonomous with the zoeal stages of other decapods because they use thoracic appendages for locomotion (Factor 1995).

[d] Based on maximum generating flow (Unit 4 = 29,290 gpm, Units 5&6 = 29,000 gpm).

[e] Selected species represent 99.5% of total larval macrocrustacean entrainment at maximum generating flow

* All crustacean measurements obtained from Roff et al. (1984)

Table 6 - 26   Summary of entrainment effects of various mesh sizes for select macrocrustaceans at Schiller Station Unit 5

a. 1.0 mm mesh

Species	Zoea length[a]	Megalopa width[b]	Estimated Annual Raw Entrainment[d]				1.0 mm Mesh % Reduction			
			zoea	megalopa	Juv	TOTAL	zoea	megalopa	Juv	TOTAL
American lobster	7.5[c]	NA	19,032			19,032	100%			100%
Atlantic rock crab	1.2	1.2		500,810	20,803	521,613	100%	100%	100%	100%
Cancer sp.	1.2	1.2	187,965,312	21,024		187,986,336	100%	100%	100%	100%
Green crab	1.4	1.2	255,182,369	2,685,575	103,238	257,971,183	100%	100%	100%	100%
Jonah crab	1.2	1.2		81,329	7,082	88,411	100%	100%	100%	100%
Total Entrainment for Selected Species[e]			443,166,714	3,288,738	131,122	446,586,574				
Overall entrainment reduction (%) for various mesh sizes						0%				100%

b. 0.8 mm mesh

Species	Zoea length[a]	Megalopa width[b]	Estimated Annual Raw Entrainment[d]				0.8 mm Mesh % Reduction			
			zoea	megalopa	Juv	TOTAL	zoea	megalopa	Juv	TOTAL
American lobster	7.5[c]	NA	19,032			19,032	100%			100%
Atlantic rock crab	1.2	1.2		500,810	20,803	521,613	100%	100%	100%	100%
Cancer sp.	1.2	1.2	187,965,312	21,024		187,986,336	100%	100%	100%	100%
Green crab	1.4	1.2	255,182,369	2,685,575	103,238	257,971,183	100%	100%	100%	100%
Jonah crab	1.2	1.2		81,329	7,082	88,411	100%	100%	100%	100%
Total Entrainment for Selected Species[e]			443,166,714	3,288,738	131,122	446,586,574				
Overall entrainment reduction (%) for various mesh sizes						0%				100%

c. 0.69 mm mesh

Species	Zoea length[a]	Megalopa width[b]	Estimated Annual Raw Entrainment[d]				0.69 mm Mesh % Reduction			
			zoea	megalopa	Juv	TOTAL	zoea	megalopa	Juv	TOTAL
American lobster	7.5[c]	NA	19,032			19,032	100%			100%
Atlantic rock crab	1.2	1.2		500,810	20,803	521,613	100%	100%	100%	100%
Cancer sp.	1.2	1.2	187,965,312	21,024		187,986,336	100%	100%	100%	100%
Green crab	1.4	1.2	255,182,369	2,685,575	103,238	257,971,183	100%	100%	100%	100%
Jonah crab	1.2	1.2		81,329	7,082	88,411	100%	100%	100%	100%
Total Entrainment for Selected Species[e]			443,166,714	3,288,738	131,122	446,586,574				
Overall entrainment reduction (%) for various mesh sizes						0%				100%

d. 0.6 mm mesh

Species	Zoea length[a]	Megalopa width[b]	Estimated Annual Raw Entrainment[d]				0.60 mm Mesh % Reduction			
			zoea	megalopa	Juv	TOTAL	zoea	megalopa	Juv	TOTAL
American lobster	7.5[c]	NA	19,032			19,032	100%			100%
Atlantic rock crab	1.2	1.2		500,810	20,803	521,613	100%	100%	100%	100%
Cancer sp.	1.2	1.2	187,965,312	21,024		187,986,336	100%	100%	100%	100%
Green crab	1.4	1.2	255,182,369	2,685,575	103,238	257,971,183	100%	100%	100%	100%
Jonah crab	1.2	1.2		81,329	7,082	88,411	100%	100%	100%	100%
Total Entrainment for Selected Species[e]			443,166,714	3,288,738	131,122	446,586,574				
Overall entrainment reduction (%) for various mesh sizes						0%				100%

[a] Zoea length (mm) was defined as the limiting dimension and was measured from the tip of the rostral spine to the tip of the dorsal spine of the first zoea molt

[b] Megalops carapace width (mm) was defined as the limiting dimension.

[c] Entrained lobster larvae were all stage I or stage II (Herrick 1895). For this table, stage I land II obster larvae are considered synonomous with the zoeal stages of other decapods because they use thoracic appendages for locomotion (Factor 1995).

[d] Based on maximum generating flow (Unit 4 = 29,290 gpm, Units 5&6 = 29,000 gpm).

[e] Selected species represent 99.5% of total larval macrocrustacean entrainment at maximum generating flow

* All crustacean measurements obtained from Roff et al. (1984)

48

Table 6 - 27   Summary of entrainment effects of various mesh sizes for select macrocrustaceans at Schiller Station Unit 6

a.   1.0 mm mesh

Species	Zoea length[a]	Megalopa width[b]	Estimated Annual Raw Entrainment[d]				1.0 mm Mesh % Reduction			
			zoea	megalopa	Juv	TOTAL	zoea	megalopa	Juv	TOTAL
American lobster	7.5[c]	NA	19,032			19,032	100%			100%
Atlantic rock crab	1.2	1.2		500,810	20,803	521,613	100%	100%	100%	100%
Cancer sp.	1.2	1.2	187,965,312	21,024		187,986,336	100%	100%	100%	100%
Green crab	1.4	1.2	255,182,369	2,685,575	103,238	257,971,183	100%	100%	100%	100%
Jonah crab	1.2	1.2		81,329	7,082	88,411	100%	100%	100%	100%
Total Entrainment for Selected Species[e]			443,166,714	3,288,738	131,122	446,586,574				
Overall entrainment reduction (%) for various mesh sizes						0%				100%

b.   0.8 mm mesh

Species	Zoea length[a]	Megalopa width[b]	Estimated Annual Raw Entrainment[d]				0.8 mm Mesh % Reduction			
			zoea	megalopa	Juv	TOTAL	zoea	megalopa	Juv	TOTAL
American lobster	7.5[c]	NA	19,032			19,032	100%			100%
Atlantic rock crab	1.2	1.2		500,810	20,803	521,613	100%	100%	100%	100%
Cancer sp.	1.2	1.2	187,965,312	21,024		187,986,336	100%	100%	100%	100%
Green crab	1.4	1.2	255,182,369	2,685,575	103,238	257,971,183	100%	100%	100%	100%
Jonah crab	1.2	1.2		81,329	7,082	88,411	100%	100%	100%	100%
Total Entrainment for Selected Species[e]			443,166,714	3,288,738	131,122	446,586,574				
Overall entrainment reduction (%) for various mesh sizes						0%				100%

c.   0.69 mm mesh

Species	Zoea length[a]	Megalopa width[b]	Estimated Annual Raw Entrainment[d]				0.69 mm Mesh % Reduction			
			zoea	megalopa	Juv	TOTAL	zoea	megalopa	Juv	TOTAL
American lobster	7.5[c]	NA	19,032			19,032	100%			100%
Atlantic rock crab	1.2	1.2		500,810	20,803	521,613	100%	100%	100%	100%
Cancer sp.	1.2	1.2	187,965,312	21,024		187,986,336	100%	100%	100%	100%
Green crab	1.4	1.2	255,182,369	2,685,575	103,238	257,971,183	100%	100%	100%	100%
Jonah crab	1.2	1.2		81,329	7,082	88,411	100%	100%	100%	100%
Total Entrainment for Selected Species[e]			443,166,714	3,288,738	131,122	446,586,574				
Overall entrainment reduction (%) for various mesh sizes						0%				100%

d.   0.6 mm mesh

Species	Zoea length[a]	Megalopa width[b]	Estimated Annual Raw Entrainment[d]				0.60 mm Mesh % Reduction			
			zoea	megalopa	Juv	TOTAL	zoea	megalopa	Juv	TOTAL
American lobster	7.5[c]	NA	19,032			19,032	100%			100%
Atlantic rock crab	1.2	1.2		500,810	20,803	521,613	100%	100%	100%	100%
Cancer sp.	1.2	1.2	187,965,312	21,024		187,986,336	100%	100%	100%	100%
Green crab	1.4	1.2	255,182,369	2,685,575	103,238	257,971,183	100%	100%	100%	100%
Jonah crab	1.2	1.2		81,329	7,082	88,411	100%	100%	100%	100%
Total Entrainment for Selected Species[e]			443,166,714	3,288,738	131,122	446,586,574				
Overall entrainment reduction (%) for various mesh sizes						0%				100%

[a] Zoea length (mm) was defined as the limiting dimension and was measured from the tip of the rostral spine to the tip of the dorsal spine of the first zoea molt

[b] Megalops carapace width (mm) was defined as the limiting dimension.

[c] Entrained lobster larvae were all stage I or stage II (Herrick 1895). For this table, stage I land II obster larvae are considered synonomous with the zoeal stages of other decapods because they use thoracic appendages for locomotion (Factor 1995).

[d] Based on maximum generating flow (Unit 4 = 29,290 gpm, Units 5&6 = 29,000 gpm).

[e] Selected species represent 99.5% of total larval macrocrustacean entrainment at maximum generating flow

* All crustacean measurements obtained from Roff et al. (1984)

49

Table 6 - 28   Summary of entrainment effects of various mesh sizes for select EA macrocrustaceans at Schiller Station Unit 4

a. 1.0 mm mesh

Species	Estimated Annual Number of EA[a]				1.0 mm			
	zoea	megalopa	Juv	Total	zoea	megalopa	Juv	Total
American lobster	23			23	100%			100%
Atlantic rock crab		1,750	2,106	3,856		100%	100%	100%
Cancer sp.	413	73		487	100%	100%		100%
Green crab	40,321	24,738	10,453	75,512	100%	100%	100%	100%
Jonah crab		284	717	1,001		100%	100%	100%
Total	40,757	26,845	13,277	80,879	100%	100%	100%	100%

b. 0.8 mm mesh

Species	Estimated Annual Number of EA[a]				0.8 mm			
	zoea	megalopa	Juv	Total	zoea	megalopa	Juv	Total
American lobster	23			23	100%			100%
Atlantic rock crab		1,750	2,106	3,856		100%	100%	100%
Cancer sp.	413	73		487	100%	100%		100%
Green crab	40,321	24,738	10,453	75,512	100%	100%	100%	100%
Jonah crab		284	717	1,001		100%	100%	100%
Total	40,757	26,845	13,277	80,879	100%	100%	100%	100%

c. 0.69 mm mesh

Species	Estimated Annual Number of EA[a]				0.69 mm			
	zoea	megalopa	Juv	Total	zoea	megalopa	Juv	Total
American lobster	23			23	100%			100%
Atlantic rock crab		1,750	2,106	3,856		100%	100%	100%
Cancer sp.	413	73		487	100%	100%		100%
Green crab	40,321	24,738	10,453	75,512	100%	100%	100%	100%
Jonah crab		284	717	1,001		100%	100%	100%
Total	40,757	26,845	13,277	80,879	100%	100%	100%	100%

d. 0.6 mm mesh

Species	Estimated Annual Number of EA[a]				0.6 mm			
	zoea	megalopa	Juv	Total	zoea	megalopa	Juv	Total
American lobster	23			23	100%			100%
Atlantic rock crab		1,750	2,106	3,856		100%	100%	100%
Cancer sp.	413	73		487	100%	100%		100%
Green crab	40,321	24,738	10,453	75,512	100%	100%	100%	100%
Jonah crab		284	717	1,001		100%	100%	100%
Total	40,757	26,845	13,277	80,879	100%	100%	100%	100%

[a] Number of equivalent adults based on maximum generating flow (Unit 4 = 29,290 gpm, Units 5&6 = 29,000 gpm) and derived from mortality rates compiled by Normandeau (2008).

Table 6 - 29   Summary of entrainment effects of various mesh sizes for select EA macrocrustaceans at Schiller Station Unit 5

a. 1.0 mm mesh

Species	Estimated Annual Number of EA[a]				1.0 mm			
	zoea	megalopa	Juv	Total	zoea	megalopa	Juv	Total
American lobster	23			23	100%			100%
Atlantic rock crab		1,733	2,086	3,818		100%	100%	100%
Cancer sp.	409	73		482	100%	100%		100%
Green crab	39,922	24,493	10,350	74,765	100%	100%	100%	100%
Jonah crab		281	710	991		100%	100%	100%
Total	40,354	26,579	13,145	80,079	100%	100%	100%	100%

b. 0.8 mm mesh

Species	Estimated Annual Number of EA[a]				0.8 mm			
	zoea	megalopa	Juv	Total	zoea	megalopa	Juv	Total
American lobster	23			23	100%			100%
Atlantic rock crab		1,733	2,086	3,818		100%	100%	100%
Cancer sp.	409	73		482	100%	100%		100%
Green crab	39,922	24,493	10,350	74,765	100%	100%	100%	100%
Jonah crab		281	710	991		100%	100%	100%
Total	40,354	26,579	13,145	80,079	100%	100%	100%	100%

c. 0.69 mm mesh

Species	Estimated Annual Number of EA[a]				0.69 mm			
	zoea	megalopa	Juv	Total	zoea	megalopa	Juv	Total
American lobster	23			23	100%			100%
Atlantic rock crab		1,733	2,086	3,818		100%	100%	100%
Cancer sp.	409	73		482	100%	100%		100%
Green crab	39,922	24,493	10,350	74,765	100%	100%	100%	100%
Jonah crab		281	710	991		100%	100%	100%
Total	40,354	26,579	13,145	80,079	100%	100%	100%	100%

d. 0.6 mm mesh

Species	Estimated Annual Number of EA[a]				0.6 mm			
	zoea	megalopa	Juv	Total	zoea	megalopa	Juv	Total
American lobster	23			23	100%			100%
Atlantic rock crab		1,733	2,086	3,818		100%	100%	100%
Cancer sp.	409	73		482	100%	100%		100%
Green crab	39,922	24,493	10,350	74,765	100%	100%	100%	100%
Jonah crab		281	710	991		100%	100%	100%
Total	40,354	26,579	13,145	80,079	100%	100%	100%	100%

[a] Number of equivalent adults based on maximum generating flow (Unit 4 = 29,290 gpm, Units 5&6 = 29,000 gpm) and derived from mortality rates compiled by Normandeau (2008).

51

Table 6 - 30   Summary of entrainment effects of various mesh sizes for select EA macrocrustaceans at Schiller Station Unit 6

a. 1.0 mm mesh

Species	Estimated Annual Number of EAa				1.0 mm			
	zoea	megalopa	Juv	Total	zoea	megalopa	Juv	Total
American lobster	23			23	100%			100%
Atlantic rock crab		1,733	2,086	3,818		100%	100%	100%
Cancer sp.	409	73		482	100%	100%		100%
Green crab	39,922	24,493	10,350	74,765	100%	100%	100%	100%
Jonah crab		281	710	991		100%	100%	100%
Total	40,354	26,579	13,145	80,079	100%	100%	100%	100%

b. 0.8 mm mesh

Species	Estimated Annual Number of EAa				0.8 mm			
	zoea	megalopa	Juv	Total	zoea	megalopa	Juv	Total
American lobster	23			23	100%			100%
Atlantic rock crab		1,733	2,086	3,818		100%	100%	100%
Cancer sp.	409	73		482	100%	100%		100%
Green crab	39,922	24,493	10,350	74,765	100%	100%	100%	100%
Jonah crab		281	710	991		100%	100%	100%
Total	40,354	26,579	13,145	80,079	100%	100%	100%	100%

c. 0.69 mm mesh

Species	Estimated Annual Number of EAa				0.69 mm			
	zoea	megalopa	Juv	Total	zoea	megalopa	Juv	Total
American lobster	23			23	100%			100%
Atlantic rock crab		1,733	2,086	3,818		100%	100%	100%
Cancer sp.	409	73		482	100%	100%		100%
Green crab	39,922	24,493	10,350	74,765	100%	100%	100%	100%
Jonah crab		281	710	991		100%	100%	100%
Total	40,354	26,579	13,145	80,079	100%	100%	100%	100%

d. 0.6 mm mesh

Species	Estimated Annual Number of EAa				0.6 mm			
	zoea	megalopa	Juv	Total	zoea	megalopa	Juv	Total
American lobster	23			23	100%			100%
Atlantic rock crab		1,733	2,086	3,818		100%	100%	100%
Cancer sp.	409	73		482	100%	100%		100%
Green crab	39,922	24,493	10,350	74,765	100%	100%	100%	100%
Jonah crab		281	710	991		100%	100%	100%
Total	40,354	26,579	13,145	80,079	100%	100%	100%	100%

[a] Number of equivalent adults based on maximum generating flow (Unit 4 = 29,290 gpm, Units 5&6 = 29,000 gpm) and derived from mortality rates compiled by Normandeau (2008).

References Cited

Con Edison (Consolidated Edison Company of New York, Inc.). 1985. Biological evaluation of a Ristroph screen at Indian Point Unit 2. June 1985.

EPRI (Electric Power Research Institute). 2003. Evaluating the effects of power plant operations on aquatic communities. Summary of impingement survival studies. Final report no. 1007821, Oct. 2003.

Normandeau (Normandeau Associates, Inc.). 2008. Entrainment and impingement studies performed at Schiller Generating Station from September 2006 through September 2007. Prepared for Public Service of New Hampshire.

Attachment 7

Construction Schedule

Construction Schedule
Conversion of Schiller Station To Closed-Loop Cooling

The construction schedule on the following page is based on an 18-month overall construction timeframe and a twelve (12) week plant outage. Although the 18-month construction time period is somewhat arbitrarily due to inherent flexibility in man-loading, the twelve week outage time period is considered largely inflexible due to the complexities and man-power loading restrictions associated with the outage critical-path activities, including completion of the intake and discharge embayments with their associated sluice gates, substation power tie-ins at the switchyard, and reroute and tie-ins of the existing circulating water to the discharge and intake embayments for the CWIS.

These complexities partly stem from the fact that the circulating water return flow from the cooling tower must pass under the existing large bore circulating water discharge piping. This excavation and undermining of the existing large bore piping cannot be performed while the Station is on line.
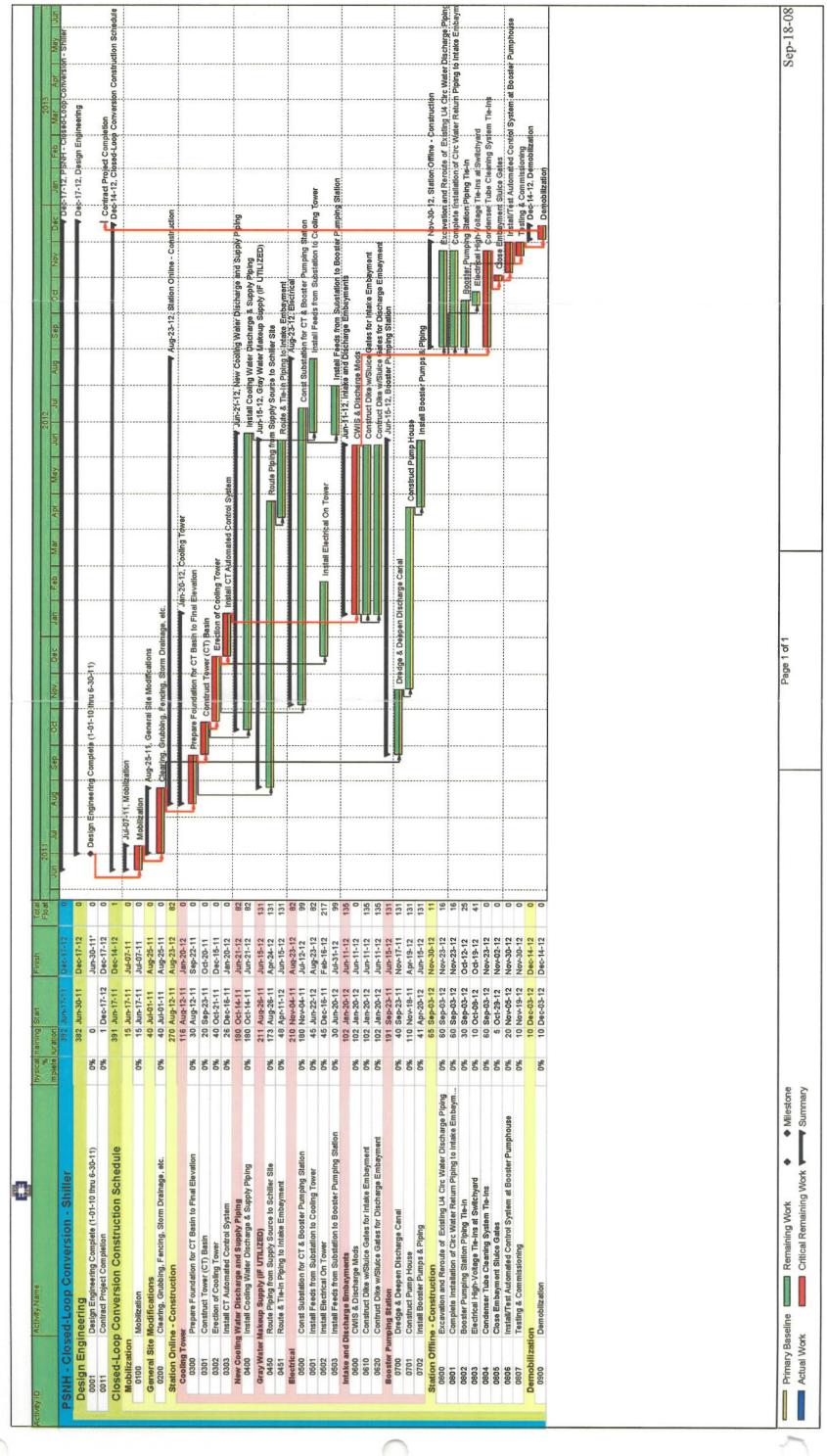
Other tasks that must be performed while offline are the installation and testing of the sluice gates in the dikes forming the discharge and intake embayments that isolate the circulating water pumps and booster pumping station from the river, and installing cooling tower makeup pump and valves that will draw makeup water from the river (or grey water source) and into the intake embayment.

Tasks that must be completed during the twelve week Station outage include:

- High-voltage tie-ins at the switchyard to supply the new substation.
- Condenser tube-cleaning system tie-ins at existing intakes
- Testing of newly installed components at the CWIS and booster pumping station prior to placement into service
    - Electrical switchgear
    - Cooling tower make-up pump and valves
    - Greywater supply source tie-in (if utilized)
    - Booster pumps (circ water supply to tower)
    - Cooling tower blowdown system
    - Automated PLC control system, including level control in the embayments

It is believed that the 12 week outage duration is conservative, representing best-case construction scenarios, and that emergent issues and/or weather based delays may extend the projected outage duration considerably. Likewise, it is believed that the proposed overall construction schedule may extend beyond the duration indicated, as it is based on heavy man-loading and best-case construction conditions.

2

Activity ID	Activity Name	Physical % Complete	Original Duration	Start	Finish	Total Float
	PSNH - Closed-Loop Conversion - Shiller		392	Jun-17-11	Dec-17-12	0
	Design Engineering		382	Jun-30-11	Dec-17-12	0
0001	Design Engineering Complete (1-01-10 thru 6-30-11)	0%	0		Jun-30-11*	0
0011	Contract Project Completion	0%	1	Dec-17-12	Dec-17-12	0
	Closed-Loop Conversion Construction Schedule		391	Jun-17-11	Dec-14-12	1
	Mobilization		15	Jun-17-11	Jul-07-11	0
0100	Mobilization	0%	15	Jun-17-11	Jul-07-11	0
	General Site Modifications		40	Jul-01-11	Aug-25-11	0
0200	Clearing, Grubbing, Fencing, Storm Drainage, etc.	0%	40	Jul-01-11	Aug-25-11	0
	Station Online - Construction		270	Aug-12-11	Aug-23-12	82
	Cooling Tower		116	Aug-12-11	Jan-20-12	82
0300	Prepare Foundation for CT Basin to Final Elevation	0%	30	Aug-12-11	Sep-22-11	0
0301	Construct Tower (CT) Basin	0%	20	Sep-23-11	Oct-20-11	0
0302	Erection of Cooling Tower	0%	40	Oct-21-11	Dec-15-11	0
0303	Install CT Automated Control System	0%	26	Dec-16-11	Jan-20-12	0
	New Cooling Water Discharge and Supply Piping		180	Oct-14-11	Jun-21-12	82
0400	Install Cooling Water Discharge & Supply Piping	0%	180	Oct-14-11	Jun-21-12	82
	Gray Water Makeup Supply (IF UTILIZED)		211	Aug-26-11	Jun-15-12	131
0450	Route Piping from Supply Source to Schiller Site	0%	173	Aug-26-11	Apr-24-12	131
0451	Route & Tie-In Piping to Intake Embayment	0%	48	Apr-11-12	Jun-15-12	131
	Electrical		210	Nov-04-11	Aug-23-12	82
0500	Const Substation for CT & Booster Pumping Station	0%	180	Nov-04-11	Jul-12-12	99
0501	Install Feeds from Substation to Cooling Tower	0%	45	Jun-22-12	Aug-23-12	82
0502	Install Electrical On Tower	0%	45	Dec-16-11	Feb-16-12	217
0503	Install Feeds from Substation to Booster Pumping Station	0%	30	Jun-20-12	Jul-31-12	99
	Intake and Discharge Embayments		102	Jan-20-12	Jun-11-12	135
0600	CWIS & Discharge Mods	0%	102	Jan-20-12	Jun-11-12	0
0610	Construct Dike w/Sluice Gates for Intake Embayment	0%	102	Jan-20-12	Jun-11-12	135
0620	Construct Dike w/Sluice Gates for Discharge Embayment	0%	102	Jan-20-12	Jun-11-12	135
	Booster Pumping Station		191	Sep-23-11	Nov-17-11	131
0700	Dredge & Deepen Discharge Canal	0%	40	Sep-23-11	Nov-17-11	131
0701	Construct Pump House	0%	110	Nov-18-11	Apr-16-12	131
0702	Install Booster Pumps & Piping	0%	41	Apr-20-12	Jun-15-12	131
	Station Offline - Construction		65	Sep-03-12	Nov-30-12	11
0800	Excavation and Reroute of Existing U4 Circ Water Discharge Piping	0%	60	Sep-03-12	Nov-23-12	16
0801	Complete Installation of Circ Water Return Piping to Intake Embaym…	0%	60	Sep-03-12	Nov-23-12	16
0802	Booster Pumping Station Piping Tie-In	0%	30	Sep-03-12	Oct-12-12	25
0803	Electrical High-Voltage Tie-Ins at Switchyard	0%	10	Oct-08-12	Oct-19-12	41
0804	Condenser Tube Cleaning System Tie-Ins	0%	60	Sep-03-12	Nov-23-12	0
0805	Close Embayment Sluice Gates	0%	5	Oct-29-12	Nov-02-12	0
0806	Install/Test Automated Control System at Booster Pumphouse	0%	20	Nov-05-12	Nov-30-12	0
0807	Testing & Commissioning	0%	10	Nov-19-12	Nov-30-12	0
	Demobilization		10	Dec-03-12	Dec-14-12	0
0900	Demobilization	0%	10	Dec-03-12	Dec-14-12	0

Legend:
- Primary Baseline
- Actual Work
- Remaining Work
- Critical Remaining Work
- Milestone
- Summary

Sep-18-08

Page 1 of 1

3

Attachment 8

Grey Water Cooling

Water Discharge Permits (PCS)
You are here: EPA Home Envirofacts PCS

Detailed Reports

PCS   Results are based on data extracted on MAR-21-2008

Facility

FACILITY NAME (1) :	PORTSMOUTH-PIERCE ISLAND WWTP	NPDES :	NH0100234
FACILITY NAME (2) :			
STREET 1 :	PIERCE ISLAND TREATMENT PLANT	SIC CODE :	4952 = SEWERAGE SYSTEMS
CITY :	PORTSMOUTH	MAJOR / MINOR :	M = Major
COUNTY NAME :	ROCKINGHAM	TYPE OF OWNERSHIP :	PUB = PUBLIC
STATE :	NH	INDUSTRY CLASS :	M
ZIP CODE :	03801	ACTIVITY STATUS :	A = Active
REGION :	01	INACTIVE DATE :	
LATITUDE :	+4304230		
LONGITUDE :	-07044270	TYPE OF PERMIT ISSUED :	E = EPA
LAT/LON CODE OF ACCURACY :	2 = NEAREST SECOND	PERMIT ISSUED DATE :	18-JAN-1985
LAT/LON METHOD :	A = MAP INTERPOLATION	PERMIT EXPIRED DATE :	30-MAR-1992
LAT/LON SCALE :	3 = 24,000	ORIGINAL PERMIT ISSUE DATE :	22-JUL-1977
LAT/LON DATUM :	1 = NAD27		
LAT/LON DESCRIPTION :	01099		
USGS HYDRO BASIN CODE :		STREAM SEGMENT :	0260
FLOW :	4.8	MILEAGE IND :	19870
RECEIVING STREAM CLASS CODE :		FEDERAL_GRANT_IND :	
RECEIVING WATERS :	PISCATAQUA RIVER	FINAL LIMITS IND :	F = FINAL
PRETREATMENT CODE :			
SLUDGE INDICATOR :		SLUDGE CLASS FAC IND :	
SLUDGE RELATED PERMIT NUM :		ANNUAL DRY SLUDGE PROD :	
MAILING NAME :	CITY OF PORTSMOUTH		
MAILING STREET (1) :	DEPARTMENT OF PUBLIC WORKS	MAILING STREET (2) :	680 PEBBLERLY HILL RD
MAILING CITY :	PORTSMOUTH	MAILING STATE :	NH
MAILING ZIP CODE :	03801		
SLUDGE COMMERCIAL HANDLER :			
SLUDGE HANDLER STREET (1) :		SLUDGE HANDLER STREET (2) :	
SLUDGE HANDLER CITY :		SLUDGE HANDLER STATE :	
SLUDGE HANDLER ZIP CODE :			
COGNIZANT OFFICIAL :	DAVID S. ALLEN, CITY ENGINEER	COGNIZANT OFFICIAL TEL :	603-427-1530

Permit Documents

FACILITY NAME (1) : PORTSMOUTH-PIERCE ISLAND WWTP NPDES : NH0100234
FACILITY NAME (2) :

No Permit Documents Found.

Permit Tracking

FACILITY NAME (1) : PORTSMOUTH-PIERCE ISLAND WWTP NPDES : NH0100234
FACILITY NAME (2) :   PERMIT ISSUED BY : E = EPA
PERMIT ISSUED DATE : 18-JAN-1985   ORIGINAL DATE OF ISSUE : 22-JUL-1977
PERMIT EXPIRED DATE : 30-MAR-1992
Permit Tracking Events:

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2

http://oaspub.epa.gov/enviro/pcs_det_reports.pcs_tst?
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Water Discharge Permits (PCS)

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Detailed Reports

PCS   Results are based on data extracted on MAR-21-2008

Facility

FACILITY NAME (1) :	HAMPTON W W T P	**NPDES :**	NH0100625
FACILITY NAME (2) :			
STREET 1 :	LEAVITT E. MAGRATH W W T P	**SIC CODE :**	4952 = SEWERAGE SYSTEMS
CITY :	HAMPTON FALLS	**MAJOR / MINOR :**	M = Major
COUNTY NAME :	ROCKINGHAM	**TYPE OF OWNERSHIP :**	PUB = PUBLIC
STATE :	NH	**INDUSTRY CLASS :**	M
ZIP CODE :	03842	**ACTIVITY STATUS :**	A = Active
REGION :	01	**INACTIVE DATE :**	
LATITUDE :	+4255310		
LONGITUDE :	-07049030	**TYPE OF PERMIT ISSUED :**	E = EPA
LAT/LON CODE OF ACCURACY :	2 = NEAREST SECOND	**PERMIT ISSUED DATE :**	29-MAR-2001
LAT/LON METHOD :	A = MAP INTERPOLATION	**PERMIT EXPIRED DATE :**	30-APR-2006
LAT/LON SCALE :	3 = 24,000	**ORIGINAL PERMIT ISSUE DATE :**	
LAT/LON DATUM :	1 = NAD27		
LAT/LON DESCRIPTION :	01099		
USGS HYDRO BASIN CODE :		**STREAM SEGMENT :**	0280
FLOW :	4.7	**MILEAGE IND :**	02850
RECEIVING STREAM CLASS CODE :		**FEDERAL_GRANT_IND :**	$ = FEDERAL GRANT
RECEIVING WATERS :	TIDE MILL CREEK VIA TRIBUTARY	**FINAL LIMITS IND :**	F = FINAL
PRETREATMENT CODE :			
SLUDGE INDICATOR :		**SLUDGE CLASS FAC IND :**	
SLUDGE RELATED PERMIT NUM :		**ANNUAL DRY SLUDGE PROD :**	
MAILING NAME :	TOWN OF HAMPTON		
MAILING STREET (1) :	DEPARTMENT OF PUBLIC WORKS	**MAILING STREET (2) :**	136 WINNICUNNET ROAD
MAILING CITY :	HAMPTON	**MAILING STATE :**	NH
MAILING ZIP CODE :	03842		
SLUDGE COMMERCIAL HANDLER :			
SLUDGE HANDLER STREET (1) :		**SLUDGE HANDLER STREET (2) :**	
SLUDGE HANDLER CITY :		**SLUDGE HANDLER STATE :**	
SLUDGE HANDLER ZIP CODE :			
COGNIZANT OFFICIAL :	JOHN R. HANGEN, DIRECTOR - DPW	**COGNIZANT OFFICIAL TEL :**	603-926-4402

Permit Documents

FACILITY NAME (1) : HAMPTON W W T P **NPDES :** NH0100625
FACILITY NAME (2) :

No Permit Documents Found.

Permit Tracking

FACILITY NAME (1) :	HAMPTON W W T P	**NPDES :**	NH0100625
FACILITY NAME (2) :		**PERMIT ISSUED BY :**	E = EPA
PERMIT ISSUED DATE :	29-MAR-2001	**ORIGINAL DATE OF ISSUE :**	
PERMIT EXPIRED DATE :	30-APR-2006		

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PCS Detailed Reports   Page 1 of 31

Water Discharge Permits (PCS)

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You are here: EPA Home   EnvirnFacts PCS

Detailed Reports

Results are based on data extracted on MAR-21-2008

Facility

FACILITY NAME (1) :	DERRY W W T P	**NPDES :**	NH0100056
FACILITY NAME (2) :			
STREET 1 :	TRANSFER STATION ROAD	**SIC CODE :**	4952 = SEWERAGE SYSTEMS
CITY :	DERRY /T/	**MAJOR / MINOR :**	M = Major
COUNTY NAME :	ROCKINGHAM	**TYPE OF OWNERSHIP :**	PUB = PUBLIC
STATE :	NH	**INDUSTRY CLASS :**	M
ZIP CODE :	03038	**ACTIVITY STATUS :**	A = Active
REGION :	01	**INACTIVE DATE :**	
LATITUDE :	+4252150		
LONGITUDE :	-07120070	**TYPE OF PERMIT ISSUED :**	E = EPA
LAT/LON CODE OF ACCURACY :	2 = NEAREST SECOND	**PERMIT ISSUED DATE :**	11-AUG-2004
LAT/LON METHOD :	A = MAP INTERPOLATION	**PERMIT EXPIRED DATE :**	31-JUL-2009
LAT/LON SCALE :	3 = 24,000	**ORIGINAL PERMIT ISSUE DATE :**	
LAT/LON DATUM :	1 = NAD27		
LAT/LON DESCRIPTION :	01099		
USGS HYDRO BASIN CODE :		**STREAM SEGMENT :**	0080
FLOW :	4	**MILEAGE IND :**	00000
RECEIVING STREAM CLASS CODE :		**FEDERAL_GRANT_IND :**	
RECEIVING WATERS :	MERRIMACK RIVER	**FINAL LIMITS IND :**	F = FINAL
PRETREATMENT CODE :	Y = APPROVED PRET PGM		
SLUDGE INDICATOR :		**SLUDGE CLASS FAC IND :**	
SLUDGE RELATED PERMIT NUM :		**ANNUAL DRY SLUDGE PROD :**	
MAILING NAME :	TOWN OF DERRY		
MAILING STREET (1) :	TOWN HALL	**MAILING STREET (2) :**	14 MANNING ST
MAILING CITY :	DERRY	**MAILING STATE :**	NH
MAILING ZIP CODE :	03038		
SLUDGE COMMERCIAL HANDLER :			
SLUDGE HANDLER STREET (1) :		**SLUDGE HANDLER STREET (2) :**	
SLUDGE HANDLER CITY :		**SLUDGE HANDLER STATE :**	
SLUDGE HANDLER ZIP CODE :			
COGNIZANT OFFICIAL :	THOMAS A. CARRIER, SUPERINTENDE	**COGNIZANT OFFICIAL TEL :**	603-432-6100

Permit Documents

FACILITY NAME (1) : DERRY W W T P **NPDES :** NH0100056
FACILITY NAME (2) :

Text of the actual NPDES Permit: NPDES PERMIT (pdf file)
Background and Rationale used to develop the NPDES permit: FACT SHEET (pdf file)

Permit Tracking

FACILITY NAME (1) :	DERRY W W T P	**NPDES :**	NH0100056
FACILITY NAME (2) :		**PERMIT ISSUED BY :**	E = EPA
PERMIT ISSUED DATE :	11-AUG-2004	**ORIGINAL DATE OF ISSUE :**	

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4

PCS Detailed Reports   Page 1 of 91

Water Discharge Permits (PCS)

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Detailed Reports

PCS   Results are based on data extracted on MAR-21-2008

Facility

FACILITY NAME (1) :	EXETER W W T F	NPDES :	NH0100871
FACILITY NAME (2) :			
STREET 1 :	WASTEWATER TREATMENT FACILITY	SIC CODE :	4952 = SEWERAGE SYSTEMS
CITY :	EXETER /T/	MAJOR / MINOR :	M = Major
COUNTY NAME :	ROCKINGHAM	TYPE OF OWNERSHIP :	PUB = PUBLIC
STATE :	NH	INDUSTRY CLASS :	M
ZIP CODE :	03833	ACTIVITY STATUS :	A = Active
REGION :	01	INACTIVE DATE :	
LATITUDE :	+4259050		
LONGITUDE :	-07056510	TYPE OF PERMIT ISSUED :	E = EPA
LAT/LON CODE OF ACCURACY :	2 = NEAREST SECOND	PERMIT ISSUED DATE :	05-JUL-2000
LAT/LON METHOD :	A = MAP INTERPOLATION	PERMIT EXPIRED DATE :	31-MAR-2006
LAT/LON SCALE :	3 = 24,000	ORIGINAL PERMIT ISSUE DATE :	26-MAR-1982
LAT/LON DATUM :	1 = NAD27		
LAT/LON DESCRIPTION :	01099		
USGS HYDRO BASIN CODE :		STREAM SEGMENT :	0250
FLOW :	3	MILEAGE IND :	06040
RECEIVING STREAM CLASS CODE :		FEDERAL_GRANT_IND :	
RECEIVING WATERS :	SQUAMSCOTT RIVER	FINAL LIMITS IND :	F = FINAL
PRETREATMENT CODE :			
SLUDGE INDICATOR :		SLUDGE CLASS FAC IND :	
SLUDGE RELATED PERMIT NUM :		ANNUAL DRY SLUDGE PROD :	
MAILING NAME :	TOWN OF EXETER		
MAILING STREET (1) :	DEPARTMENT OF PUBLIC WORKS	MAILING STREET (2) :	10 FRONT STREET
MAILING CITY :	EXETER	MAILING STATE :	NH
MAILING ZIP CODE :	03833		
SLUDGE COMMERCIAL HANDLER :			
SLUDGE HANDLER STREET (1) :		SLUDGE HANDLER STREET (2) :	
SLUDGE HANDLER CITY :		SLUDGE HANDLER STATE :	
SLUDGE HANDLER ZIP CODE :			
COGNIZANT OFFICIAL :	KEITH NOYES, D.P.W. DIRECTOR	COGNIZANT OFFICIAL TEL :	603-778-0591

Permit Documents

FACILITY NAME (1) : EXETER W W T F NPDES : NH0100871
FACILITY NAME (2) :

No Permit Documents Found.

Permit Tracking

FACILITY NAME (1) : EXETER W W T F NPDES :   NH0100871
FACILITY NAME (2) :   PERMIT ISSUED BY :   E = EPA
PERMIT ISSUED DATE : 05-JUL-2000   ORIGINAL DATE OF ISSUE : 26-MAR-1982
PERMIT EXPIRED DATE : 31-MAR-2006
Permit Tracking Events:

EVENT CODE	EVENT DESCRIPTION	ACTUAL DATE

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5

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Water Discharge Permits (PCS)

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Detailed Reports

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PCS

Results are based on data extracted on APR-16-2008

Facility

FACILITY NAME (1) :	DURHAM W W T F	**NPDES :**	NH0100455
FACILITY NAME (2) :			
STREET 1 :	WASTEWATER TREATMENT FACILITY	**SIC CODE :**	4952 = SEWERAGE SYSTEMS
CITY :	DURHAM /T/	**MAJOR / MINOR :**	M = Major
COUNTY NAME :	STRAFFORD	**TYPE OF OWNERSHIP :**	PUB = PUBLIC
STATE :	NH	**INDUSTRY CLASS :**	M
ZIP CODE :	03824	**ACTIVITY STATUS :**	A = Active
REGION :	01	**INACTIVE DATE :**	
LATITUDE :	+4308060		
LONGITUDE :	-07054130	**TYPE OF PERMIT ISSUED :**	E = EPA
LAT/LON CODE OF ACCURACY :	2 = NEAREST SECOND	**PERMIT ISSUED DATE :**	15-DEC-1999
LAT/LON METHOD :	A = MAP INTERPOLATION	**PERMIT EXPIRED DATE :**	29-JAN-2005
LAT/LON SCALE :	3 = 24,000	**ORIGINAL PERMIT ISSUE DATE :**	
LAT/LON DATUM :	1 = NAD27		
LAT/LON DESCRIPTION :	01099		
USGS HYDRO BASIN CODE :		**STREAM SEGMENT :**	0210
FLOW :	2.5	**MILEAGE IND :**	03270
RECEIVING STREAM CLASS CODE :		**FEDERAL GRANT IND :**	$ = FEDERAL GRANT
RECEIVING WATERS :	OYSTER RIVER ESTUARY	**FINAL LIMITS IND :**	F = FINAL
PRETREATMENT CODE :			
SLUDGE INDICATOR :		**SLUDGE CLASS FAC IND :**	
SLUDGE RELATED PERMIT NUM :		**ANNUAL DRY SLUDGE PROD :**	
MAILING NAME :	TOWN OF DURHAM		
MAILING STREET (1) :	DEPARTMENT OF PUBLIC WORKS	**MAILING STREET (2) :**	100 STONE QUARRY DRIVE
MAILING CITY :	DURHAM	**MAILING STATE :**	NH
MAILING ZIP CODE :	03824		
SLUDGE COMMERCIAL HANDLER :			
SLUDGE HANDLER STREET (1) :		**SLUDGE HANDLER STREET (2) :**	
SLUDGE HANDLER CITY :		**SLUDGE HANDLER STATE :**	
SLUDGE HANDLER ZIP CODE :			
COGNIZANT OFFICIAL :	TODD I SELIG, TOWN ADMINISTRAT	**COGNIZANT OFFICIAL TEL :**	603-868-2274

Permit Documents

FACILITY NAME (1) : DURHAM W W T F **NPDES :** NH0100455
FACILITY NAME (2) :

No Permit Documents Found.

Permit Tracking

FACILITY NAME (1) : DURHAM W W T F **NPDES :** NH0100455
FACILITY NAME (2) :   **PERMIT ISSUED BY :** E = EPA
PERMIT ISSUED DATE : 15-DEC-1999   **ORIGINAL DATE OF ISSUE :**
PERMIT EXPIRED DATE : 29-JAN-2005
Permit Tracking Events:

EVENT CODE	EVENT DESCRIPTION	ACTUAL DATE
P5099	PERMIT EXPIRED	29-JAN-2005
P1099	APPLICATION RECEIVED	11-JUN-2004
P4099	PERMIT ISSUED	15-DEC-1999
P3099	DRAFT PERMIT/PUBLIC NOTICE	01-OCT-1999

Inspections

FACILITY NAME (1) : DURHAM W W T F **NPDES :** NH0100455
FACILITY NAME (2) :

http://oaspub.epa.gov/enviro/pcs_det_reports.pcs_tst?npdesid=NH0100455&npvalue=1&np... 6/3/2008

Water Discharge Permits (PCS)

http://oaspub.epa.gov/enviro/pcs_det_reports.pcs_tst?
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Detailed Reports

                                                                    Report an Error

PCS   Results are based on data extracted on MAR-21-2008

Facility

FACILITY NAME (1) :	SEABROOK	**NPDES :**	NH0101303
FACILITY NAME (2) :			
STREET 1 :	WRIGHTS ISLAND	**SIC CODE :**	4952 = SEWERAGE SYSTEMS
CITY :	SEABROOK /T/	**MAJOR / MINOR :**	M = Major
COUNTY NAME :	ROCKINGHAM	**TYPE OF OWNERSHIP :**	PUB = PUBLIC
STATE :	NH	**INDUSTRY CLASS :**	M
ZIP CODE :	03874	**ACTIVITY STATUS :**	A = Active
REGION :	01	**INACTIVE DATE :**	
LATITUDE :	+4252220		
LONGITUDE :	-07248300	**TYPE OF PERMIT ISSUED :**	E = EPA
LAT/LON CODE OF ACCURACY :		**PERMIT ISSUED DATE :**	30-SEP-1999
LAT/LON METHOD :	A = MAP INTERPOLATION	**PERMIT EXPIRED DATE :**	30-OCT-2004
LAT/LON SCALE :	U = UNKNOWN	**ORIGINAL PERMIT ISSUE DATE :**	
LAT/LON DATUM :	1 = NAD27		
LAT/LON DESCRIPTION :	01099		
USGS HYDRO BASIN CODE :		**STREAM SEGMENT :**	
FLOW :	1.8	**MILEAGE IND :**	
RECEIVING STREAM CLASS CODE :		**FEDERAL_GRANT_IND :**	
RECEIVING WATERS :	OCEAN DISCHARGE	**FINAL LIMITS IND :**	F = FINAL
PRETREATMENT CODE :		**SLUDGE CLASS FAC IND :**	1 = CLASS I MAJOR
SLUDGE INDICATOR :			
SLUDGE RELATED PERMIT NUM :	MEL000001	**ANNUAL DRY SLUDGE PROD :**	
MAILING NAME :	SEABROOK WATER & SEWER DEPT.		
MAILING STREET (1) :	99 LAFAYETTE ROAD	**MAILING STREET (2) :**	P.O. BOX 456
MAILING CITY :	SEABROOK	**MAILING STATE :**	NH
MAILING ZIP CODE :	03874		
SLUDGE COMMERCIAL HANDLER :	BROWNING-FERRIS IND., INC.		
SLUDGE HANDLER STREET (1) :	D/B/A HAWK RIDGE COMPOST FAC.	**SLUDGE HANDLER STREET (2) :**	RFD 1, BOX 1682
SLUDGE HANDLER CITY :	UNITY	**SLUDGE HANDLER STATE :**	ME
SLUDGE HANDLER ZIP CODE :	04988		
COGNIZANT OFFICIAL :	PHILIPPE J.G. MALTAIS, CHIEF	**COGNIZANT OFFICIAL TEL :**	603-474-8012

Permit Documents

FACILITY NAME (1) : SEABROOK **NPDES :** NH0101303
FACILITY NAME (2) :

No Permit Documents Found.

Permit Tracking

FACILITY NAME (1) : SEABROOK **NPDES :** NH0101303
FACILITY NAME (2) : **PERMIT ISSUED BY :** E = EPA
PERMIT ISSUED DATE : 30-SEP-1999 **ORIGINAL DATE OF ISSUE :**
PERMIT EXPIRED DATE : 30-OCT-2004

http://oaspub.epa.gov/enviro/pcs_det_reports.pcs_tst?npdesid=NH0101303&npvalue=1&n... 3/31/2008

. **TABLE 1-1. STUDY AREA WASTEWATER TREATMENT FACILITIES**

	FACILITY	NPDES NO.	RECEIVING WATERS	DESIGN FLOW (MGD)
1	DOVER WWTF	NH0101311	PISCATAQUA RIVER	4.7
2	DURHAM WWTF	NH0100455	OYSTER RIVER	2.5
3	EPPING WWTF	NH0100692	LAMPREY RIVER	0.5
4	EXETER WWTF	NH0100871	SQUAMSCOTT RIVER	3.0
5	FARMINGTON WWTF	NH0100854	COCHECO RIVER	0.35
6	HAMPTON WWTF	NH0100625	TIDE MILL CREEK	4.7
7	MILTON WWTF	NH0100676	SALMON FALLS RIVER	0.1
8	NEWFIELDS WWTF	NH0101192	SQUAMSCOTT RIVER	0.117
9	NEWINGTON WWTF	NH0101141	PISCATAQUA RIVER	0.29
10	NEWMARKET WWTF	NH0100196	LAMPREY RIVER	0.85
11	PEASE DEVELOPMENT AUTHORITY WWTF	NH0090000	PISCATAQUA RIVER	1.2
12	PEIRCE ISLAND WWTF	NH0100234	PISCATAQUA RIVER	4.8
13	ROCHESTER WWTF	NH0100668	COCHECO RIVER	5.03
14	ROCKINGHAM COUNTY WWTF	NH0100609	ICE POND BROOK	0.084
15	ROLLINSFORD WWTF	NH0100251	SALMON FALLS RIVER	0.15
16	SEABROOK WWTF	NH0101303	GULF OF MAINE	1.8
17	SOMERSWORTH WWTF	NH0100277	SALMON FALLS RIVER	2.41

Many of the WWTF's in the study area discharge to receiving waters with a very low level of dilution available. Consequently, high level of removal of various pollutants is required. Nutrient discharges are also beginning to be regulated, which may lead to additional treatment needs.

As the discharge permits for the treatment plants are typically renewed in a 5-year cycle, some are expected to face new limits with each round of permit renewals. This has required some of the plants to be upgraded on a nearly continuous piecemeal basis, without a long-term plan. For other communities, it has result in endless studies and evaluations in an effort to address effluent limits that are a "moving target."

1.1.2 Population Growth Demands
While investments in WWTF's were made, the study area was experiencing continued growth in population, with the associated increase in need for water supply and waste disposal.

In those areas served by individual septic systems, the growth in population has resulted in an increase in the volume of septage requiring treatment. While some of the area treatment plants accept septage from the surrounding areas, others do not.

1 - 3

Water Discharge Permits (PCS)

http://oaspub.epa.gov/enviro/pcs_det_reports.pcs_tst?npdesid=NH0100196&npvalue=1&npvalue=2&npvalue=3&npvalue=4&npvalue=5&npvalue=12&npvalue=6&npvalue=7&npvalue=9&npvalue=20&npval=ue=33

You are here: EPA Home   Envirofacts PCS

Detailed Reports

Results are based on data extracted on MAR-21-2008

Facility

FACILITY NAME (1) :	NEWMARKET W P C F	**NPDES :**	NH0100196
FACILITY NAME (2) :			
STREET 1 :	WATER POLLUTION CONTROL FACLTY	**SIC CODE :**	4952 = SEWERAGE SYSTEMS
CITY :	NEWMARKET /T/	**MAJOR / MINOR :**	M = Major
COUNTY NAME :	ROCKINGHAM	**TYPE OF OWNERSHIP :**	PUB = PUBLIC
STATE :	NH	**INDUSTRY CLASS :**	M
ZIP CODE :	03857	**ACTIVITY STATUS :**	A = Active
REGION :	01	**INACTIVE DATE :**	
LATITUDE :	+4304310		
LONGITUDE :	-07056060	**TYPE OF PERMIT ISSUED :**	E = EPA
LAT/LON CODE OF ACCURACY :	2 = NEAREST SECOND	**PERMIT ISSUED DATE :**	27-APR-2000
LAT/LON METHOD :	A = MAP INTERPOLATION	**PERMIT EXPIRED DATE :**	31-MAY-2005
LAT/LON SCALE :	3 = 24,000	**ORIGINAL PERMIT ISSUE DATE :**	
LAT/LON DATUM :	1 = NAD27		
LAT/LON DESCRIPTION :	01099		
USGS HYDRO BASIN CODE :		**STREAM SEGMENT :**	0230
FLOW :	.85	**MILEAGE IND :**	00650
RECEIVING STREAM CLASS CODE :		**FEDERAL GRANT IND :**	
RECEIVING WATERS :	LAMPREY RIVER	**FINAL LIMITS IND :**	F = FINAL
PRETREATMENT CODE :			
SLUDGE INDICATOR :		**SLUDGE CLASS FAC IND :**	
SLUDGE RELATED PERMIT NUM :		**ANNUAL DRY SLUDGE PROD :**	
MAILING NAME :	TOWN OF NEWMARKET		
MAILING STREET (1) :	BOARD OF SEWER COMMISSIONERS	**MAILING STREET (2) :**	TOWN HALL 186 MAIN STREET
MAILING CITY :	NEWMARKET	**MAILING STATE :**	NH
MAILING ZIP CODE :	03857		
SLUDGE COMMERCIAL HANDLER :			
SLUDGE HANDLER STREET (1) :		**SLUDGE HANDLER STREET (2) :**	
SLUDGE HANDLER CITY :		**SLUDGE HANDLER STATE :**	
SLUDGE HANDLER ZIP CODE :			
COGNIZANT OFFICIAL :	GEORGE F LANEY, SUPERINTENDENT	**COGNIZANT OFFICIAL TEL :**	603-659-3093

Permit Documents

FACILITY NAME (1) : NEWMARKET W P C F **NPDES :** NH0100196
FACILITY NAME (2) :

No Permit Documents Found.

Permit Tracking

FACILITY NAME (1) :	NEWMARKET W P C F	**NPDES :**	NH0100196
FACILITY NAME (2) :		**PERMIT ISSUED BY :**	E = EPA
PERMIT ISSUED DATE :	27-APR-2000	**ORIGINAL DATE OF ISSUE :**	

http://oaspub.epa.gov/enviro/pcs_det_reports.pcs_tst?npdesid=NH0100196&npvalue=1&n... 3/31/2008

PCS Detailed Reports   Page 1 of 128

http://oaspub.epa.gov/enviro/pcs_det_reports.pcs_tst?
npdesid=NH0100692&npvalue=1&npvalue=2&npvalue=3&npvalue=4&npvalue=5&npvalue=12&npvalue=6&npvalue=7&npvalue=8&npvalue=9&npvalue=10&npvalue=

Water Discharge Permits (PCS)

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Detailed Reports

PCS   Results are based on data extracted on MAR-21-2008

Facility

FACILITY NAME (1) :	EPPING	NPDES :	NH0100692
FACILITY NAME (2) :			
STREET 1 :	LAGOON ROAD	SIC CODE :	4952 = SEWERAGE SYSTEMS
CITY :	EPPING /T/	MAJOR / MINOR :	M = Major
COUNTY NAME :	ROCKINGHAM	TYPE OF OWNERSHIP :	PUB = PUBLIC
STATE :	NH	INDUSTRY CLASS :	M
ZIP CODE :	030422440	ACTIVITY STATUS :	A = Active
REGION :	01	INACTIVE DATE :	
LATITUDE :	+4301599		
LONGITUDE :	-07104001	TYPE OF PERMIT ISSUED :	E = EPA
LAT/LON CODE OF ACCURACY :	6 = NEAREST 10 MINUTES	PERMIT ISSUED DATE :	16-FEB-2000
LAT/LON METHOD :	U = UNKNOWN	PERMIT EXPIRED DATE :	31-MAR-2005
LAT/LON SCALE :	U = UNKNOWN	ORIGINAL PERMIT ISSUE DATE :	
LAT/LON DATUM :	U = UNKNOWN		
LAT/LON DESCRIPTION :			
USGS HYDRO BASIN CODE :		STREAM SEGMENT :	0230
FLOW :	.5	MILEAGE IND :	00650
RECEIVING STREAM CLASS CODE :		FEDERAL_GRANT_IND :	
RECEIVING WATERS :	LAMPREY RIVER	FINAL LIMITS IND :	F = FINAL
PRETREATMENT CODE :			
SLUDGE INDICATOR :		SLUDGE CLASS FAC IND :	
SLUDGE RELATED PERMIT NUM :		ANNUAL DRY SLUDGE PROD :	
MAILING NAME :	TOWN OF EPPING		
MAILING STREET (1) :	157 MAIN STREET	MAILING STREET (2) :	
MAILING CITY :	EPPING	MAILING STATE :	NH
MAILING ZIP CODE :	030422440		
SLUDGE COMMERCIAL HANDLER :			
SLUDGE HANDLER STREET (1) :		SLUDGE HANDLER STREET (2) :	
SLUDGE HANDLER CITY :		SLUDGE HANDLER STATE :	
SLUDGE HANDLER ZIP CODE :			
COGNIZANT OFFICIAL :	BLAINE COX, DIRECTOR	COGNIZANT OFFICIAL TEL :	603-679-5441

Permit Documents

FACILITY NAME (1) : EPPING   NPDES : NH0100692
FACILITY NAME (2) :

No Permit Documents Found.

Permit Tracking

FACILITY NAME (1) :   EPPING   NPDES :   NH0100692
FACILITY NAME (2) :   PERMIT ISSUED BY :   E = EPA
PERMIT ISSUED DATE : 16-FEB-2000   ORIGINAL DATE OF ISSUE :
PERMIT EXPIRED DATE : 31-MAR-2005
Permit Tracking Events:

EVENT CODE	EVENT DESCRIPTION	ACTUAL DATE
P5099	PERMIT EXPIRED	31-MAR-2005
P4099	PERMIT ISSUED	16-FEB-2000
P3099	DRAFT PERMIT/PUBLIC NOTICE	18-OCT-1999
P1099	APPLICATION RECEIVED	21-MAY-1998

http://oaspub.epa.gov/enviro/pcs_det_reports.pcs_tst?npdesid=NH0100692&npvalue=1&n...   3/31/2008

http://oaspub.epa.gov/enviro/pcs_det_reports.pcs_tst?
npdesid=NH0100609&npvalue=1&npvalue=2&npvalue=3&npvalue=4&npvalue=5&npvalue=12&npvalue=6&npvalue=7&npvalue=9&npvalue=10&npvalue=

Water Discharge Permits (PCS)

You are here: EPA Home   Envirofacts PCS

Detailed Reports

Report an Error

PCS

Results are based on data extracted on APR-16-2008

Facility

FACILITY NAME (1):	ROCKINGHAM COUNTY HOME	**NPDES:**	NH0100609
FACILITY NAME (2):			
STREET 1:	WASTEWATER TREATMENT FACILITY	**SIC CODE:**	4952 = SEWERAGE SYSTEMS
CITY:	BRENTWOOD /T/	**MAJOR / MINOR:**	
COUNTY NAME:	ROCKINGHAM	**TYPE OF OWNERSHIP:**	PUB = PUBLIC
STATE:	NH	**INDUSTRY CLASS:**	M
ZIP CODE:	03833	**ACTIVITY STATUS:**	A = Active
REGION:	01	**INACTIVE DATE:**	
LATITUDE:	+4258491		
LONGITUDE:	-07059028	**TYPE OF PERMIT ISSUED:**	E = EPA
LAT/LON CODE OF ACCURACY:	6 = NEAREST 10 MINUTES	**PERMIT ISSUED DATE:**	16-DEC-2003
LAT/LON METHOD:	D = ZIP CODE CENTROID	**PERMIT EXPIRED DATE:**	30-NOV-2008
LAT/LON SCALE:	A = 100,000	**ORIGINAL PERMIT ISSUE DATE:**	02-APR-1977
LAT/LON DATUM:	U = UNKNOWN		
LAT/LON DESCRIPTION:			
USGS HYDRO BASIN CODE:		**STREAM SEGMENT:**	
FLOW:	.178	**MILEAGE IND:**	
RECEIVING STREAM CLASS CODE:		**FEDERAL GRANT IND:**	$ = FEDERAL GRANT
RECEIVING WATERS:	ICE POND BROOK	**FINAL LIMITS IND:**	
PRETREATMENT CODE:			
SLUDGE INDICATOR:		**SLUDGE CLASS FAC IND:**	
SLUDGE RELATED PERMIT NUM:		**ANNUAL DRY SLUDGE PROD:**	
MAILING NAME:	ROCKINGHAM COUNTY		
MAILING STREET (1):	BOARD OF COMMISSIONERS	**MAILING STREET (2):**	116 NORTH ROAD
MAILING CITY:	BRENTWOOD	**MAILING STATE:**	NH
MAILING ZIP CODE:	03833		
SLUDGE COMMERCIAL HANDLER:			
SLUDGE HANDLER STREET (1):		**SLUDGE HANDLER STREET (2):**	
SLUDGE HANDLER CITY:		**SLUDGE HANDLER STATE:**	
SLUDGE HANDLER ZIP CODE:			
COGNIZANT OFFICIAL:	JOHN HARNDEN, CHIEF OPERATOR	**COGNIZANT OFFICIAL TEL:**	603-679-5335

Permit Documents

FACILITY NAME (1): ROCKINGHAM COUNTY HOME **NPDES:** NH0100609
FACILITY NAME (2):

Text of the actual NPDES Permit: NPDES PERMIT (pdf file)
Background and Rationale used to develop the NPDES permit: FACT SHEET (pdf file)

Permit Tracking

FACILITY NAME (1):	ROCKINGHAM COUNTY HOME **NPDES:**		NH0100609
FACILITY NAME (2):		**PERMIT ISSUED BY:**	E = EPA
PERMIT ISSUED DATE:	16-DEC-2003	**ORIGINAL DATE OF ISSUE:**	02-APR-1977
PERMIT EXPIRED DATE:	30-NOV-2008		

Permit Tracking Events:

EVENT CODE	EVENT DESCRIPTION	ACTUAL DATE
P5099	PERMIT EXPIRED	30-NOV-2008
P4099	PERMIT ISSUED	16-DEC-2003
P3099	DRAFT PERMIT/PUBLIC NOTICE	23-OCT-2003
P1099	APPLICATION RECEIVED	13-MAR-2002

Inspections

FACILITY NAME (1): ROCKINGHAM COUNTY HOME **NPDES:** NH0100609

http://oaspub.epa.gov/enviro/pcs_det_reports.pcs_tst?npdesid=NH0100609&npvalue=1&np... 6/4/2008

PCS Detailed Reports   Page 1 of 89

Water Discharge Permits (PCS)

http://oaspub.epa.gov/enviro/pcs_det_reports.pcs_tst?
npdesid=NH0101192&npvalue=1&npvalue=2&npvalue=3&npvalue=4&npvalue=5&rvalue=12&npvalue=6&npvalue=7&npvalue=8&npvalue=9&npvalue=10&npvalue=11

You are here: EPA Home   Envirofacts PCS

Detailed Reports

Results are based on data extracted on MAR-21-2008

Facility

FACILITY NAME (1) :	NEWFIELDS VILLAGE S.D.	NPDES :	NH0101192
FACILITY NAME (2) :			
STREET 1 :	HERVEY COURT	SIC CODE :	4952 = SEWERAGE SYSTEMS
CITY :	NEWFIELDS	MAJOR / MINOR :	
COUNTY NAME :	ROCKINGHAM	TYPE OF OWNERSHIP :	PUB = PUBLIC
STATE :	NH	INDUSTRY CLASS :	M
ZIP CODE :	03856	ACTIVITY STATUS :	A = Active
REGION :	01	INACTIVE DATE :	
LATITUDE :			
LONGITUDE :		TYPE OF PERMIT ISSUED :	E = EPA
LAT/LON CODE OF ACCURACY :		PERMIT ISSUED DATE :	17-JUN-1996
LAT/LON METHOD :		PERMIT EXPIRED DATE :	30-JUN-2001
LAT/LON SCALE :		ORIGINAL PERMIT ISSUE DATE :	
LAT/LON DATUM :			
LAT/LON DESCRIPTION :			
USGS HYDRO BASIN CODE :		STREAM SEGMENT :	
FLOW :	.115	MILEAGE IND :	
RECEIVING STREAM CLASS CODE :		FEDERAL_GRANT_IND :	$ = FEDERAL GRANT
RECEIVING WATERS :		FINAL LIMITS IND :	F = FINAL
PRETREATMENT CODE :			
SLUDGE INDICATOR :		SLUDGE CLASS FAC IND :	
SLUDGE RELATED PERMIT NUM :		ANNUAL DRY SLUDGE PROD :	
MAILING NAME :	NEWFIELDS W W T F		
MAILING STREET (1) :	P.O. BOX 301	MAILING STREET (2) :	TOWN HALL
MAILING CITY :	NEWFIELDS	MAILING STATE :	NH
MAILING ZIP CODE :	03856		
SLUDGE COMMERCIAL HANDLER :			
SLUDGE HANDLER STREET (1) :		SLUDGE HANDLER STREET (2) :	
SLUDGE HANDLER CITY :		SLUDGE HANDLER STATE :	
SLUDGE HANDLER ZIP CODE :			
COGNIZANT OFFICIAL :	RAY BUXTON, JR. CHAIRMAN	COGNIZANT OFFICIAL TEL :	603-778-8213

Permit Documents

FACILITY NAME (1) : NEWFIELDS VILLAGE S.D. NPDES : NH0101192
FACILITY NAME (2) :

No Permit Documents Found.

Permit Tracking

FACILITY NAME (1) :	NEWFIELDS VILLAGE S.D.	NPDES :	NH0101192
FACILITY NAME (2) :		PERMIT ISSUED BY :	E = EPA
PERMIT ISSUED DATE :	17-JUN-1996	ORIGINAL DATE OF ISSUE :	
PERMIT EXPIRED DATE :	30-JUN-2001		

Permit Tracking Events:

EVENT CODE	EVENT DESCRIPTION	ACTUAL DATE
P5099	PERMIT EXPIRED	30-JUN-2001

http://oaspub.epa.gov/enviro/pcs_det_reports.pcs_tst?npdesid=NH0101192&npvalue=1&n...   3/31/2008

12

Newington Water Treatment Plant

Certificate of Approval No. 0941-5SSJU4 (June 2004)
Works No. 220008051

- 2005 Annual Report -

Prepared by:
Caneau Water and Sewage Operations Inc.
15005 County Road 2
RR#3 Ingleside, ON
K0C 1M0
Operations Manager:_____
Chris Eamon

13

NEWINGTON WATER TREATMENT PLANT

2005 COMPLIANCE REPORT

Facility description:	Communal ground water supply system
Capacity:	328 m^3/day
Service area:	Village of Newington
Service population:	150
In-service date:	1937
Water source:	Ground water
Disinfection method:	Sodium Hypochlorite (liquid chlorine)
Operations manager:	Chris Eamon (613)-551-2720

The Newington water works draws groundwater from two wells located within the Newington Fairgrounds. The supply/treatment and storage works (STSW) consists of the two wells and disinfection by sodium hypochlorite.

The wells are operated in series. The first well, known as the "Kraft" well is the primary source of water. It is a dug well which was originally installed in 1937. The well equipment was upgraded in 1988, including pump upgrade, pressure tanks, chlorination equipment, etc.

In dry periods, when the water level hits a minimum depth in the Kraft Well, the pump in the second well, the "Fairgrounds" well, is activated to pump water to the Kraft Well. The Fairgrounds Well is a drilled well originally installed in 1979.

Additional descriptions of the wells and disinfection system are provided in the following sub-sections.

Well #1 – The Kraft Well

Well #1 is a dug well installed at a reported depth of 5.2 m. It is located on Lot 7 of Concession Road 8, Township of South Stormont.

The Permit to Take Water limit for Well #1 is 326.9 m^3/d. Groundwater is pumped from one of two submersible pumps (capacity 3.8 L/s @ TDH 52.7 m) each installed in 200 mm diameter well casing. A check valve is located on the discharge of the pumps to prevent backflow. The well discharge is connected to the lift station via 6 meters of 75 mm diameter schedule 80 PVC pipe. Flow is measured by an online Magnetic flow meter.

Well #2 – The Fairgrounds Well

The Fairgrounds Well is located on lot 7 Concession Road 8, Township of South Stormont, approximately 330m north of the Kraft Well. Groundwater is pumped by a single submersible pump. The capacity of the pump is 1.4 l/s @ TDH 30.5 m of head. The Permit to Take Water limit for the well is 65.5 m^3/day. The well casing is 200 mm diameter and the well is drilled to a reported depth of 14 m. The piping from the Fairgrounds Well to the pump station is 38 mm Schedule 40 PVC. There is approximately 470 m of piping between the Fairgrounds Well and the water treatment plant. The piping leaves the well, enters the front end of the lift station, passes through the mechanical flow meter, through a 3 – way valve to be either discharged to the drainage system for the purpose of purging the line and then discharges to the Kraft Well. The Fairgrounds Well is currently operated only manually.

14

Attachment 9
PSNH Power Costs

This Attachment contains certain material that has been designated as Confidential Business Information by PSNH. It is therefore included in the Administrative Record document files, but it is not being made publicly available.